COMMITTEE MEETING

before

ASSEMBLY COUNTY GOVERNMENT AND REGIONAL AUTHORITIES COMMITTEE

on

ASSEMBLY BILL 1778

(Provides for a resource recovery investment tax
on solid waste disposal at sanitary landfills)

Held:
May 14, 1984
State House Annex
Trenton, New Jersey

MEMBERS OF COMMITTEE PRESENT:

Assemblyman Harry A. McEnroe, Chairman
Assemblyman Thomas A. Pankok, Vice Chairman
Assemblyman Anthony P. Vainieri
Assemblyman John T. Hendrickson, Jr.
Assemblyman Gerald Zecker

ALSO PRESENT:

Peggy McNutt, Research Assistant
Office of Legislative Services
Aide, Assembly County Government and
Regional Authorities Committee

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ASSEMBLY, No. 1778

STATE OF NEW JERSEY

INTRODUCED MARCH 15, 1984

By Assemblymen McENROE, VAINIERI, HENDRICKSON, ZECKER, Assemblywoman COOPER, Assemblyman ROD, Assemblywoman OGDEN, Assemblymen FORTUNATO, OTLOWSKI, GALLO, LaROCCA, Assemblywoman KALIK, Assemblymen LONG and PANKOK

An Act concerning solid waste disposal and resource recovery, amending P. L. 1975, c. 326, P. L. 1970, c. 40 and P. L. 1971, c. 198 and supplementing P. L. 1970, c. 39 and P. L. 1976, c. 68.

Be it enacted *by the Senate and General Assembly of the State of New Jersey:*

1. (New section) The Legislature finds and declares that the State's capacity to safely dispose of solid waste at sanitary landfills is rapidly diminishing; that the recovery of any potential resource in solid waste, especially its conversion to useable energy, is in the public interest; that the acquisition, construction or operation of resource recovery facilities is characterized by high initial capital expenditures and initially high costs of disposal which may be stabilized or decreased based upon a return on energy generated, all of which require long-term financial arrangements and a steady and secure flow of waste; that to encourage the use of resource recovery it is necessary to attain the most advantageous financing and ownership structures for implementation of resource recovery projects by units of local government while maintaining strict financial and programmatic scrutiny by agencies of State government; and that it is necessary to provide for funding of the solid waste management programs of the State and of the solid waste management districts, all as hereinafter provided.

Explanation—Matter enclosed in bold-faced brackets [thus] in the above bill is not enacted and is intended to be omitted in the law.
Matter printed in italics *thus* is new matter.

2. (New section) As used in this act:

a. "Contracting unit" means any county; any municipality; or any board, commission, committee, authority or agency, which is not a State board, commission, committee, authority or agency, and which has administrative jurisdiction over any district other than a school district, project, or facility, included or operating in whole or in part, within the territorial boundaries of any county or municipality which exercises functions which are appropriate for the exercise by one or more units of local government, and which has statutory power to make purchases and enter into contracts or agreements for the performance of any work or the furnishing or hiring of any materials or supplies usually required, the contract price of which is to be paid with or out of public funds;

b. "County" means any county of this State of whatever class;

c. "Department" means the Department of Environmental Protection;

d. "Director" means the Director of the Division of Taxation in the Department of Treasury;

e. "District" means a solid waste management district as designated by section 10 of P. L. 1975, c. 326 (C. 13:1E-19);

f. "District investment tax fund" means a District Resource Recovery Investment Tax Fund established pursuant to subsection b. of section 15 of this act;

g. "Division" means the Division of Taxation in the Department of Treasury;

h. "Franchise" means the exclusive right to control the disposal of solid waste within a district as awarded by the Board of Public Utilities;

i. "Independent public accountant" means a certified public accountant, a licensed public accountant or a registered municipal accountant;

j. "Investment tax" means the resource recovery investment tax imposed pursuant to subsection b. of section 3 of this act;

k. "Investment tax fund" means the Resource Recovery Investment Tax Fund containing subaccounts for each county pursuant to the provisions of section 14 of this act;

l. "Out-of-district solid waste" means any solid waste accepted for disposal in a district which was generated outside the receiving district;

m. "Person or party" means any individual, public or private corporation, company, partnership, firm, association, political subdivision of this State, or any State, bi-state, or interstate agency or authority;

n. "Resource recovery facility" means a solid waste facility constructed and operated for the collection, separation, recycling, and recovery of metals, glass, paper, and other materials for reuse or for energy production;

o. "Sanitary landfill facility" means a solid waste facility at which solid waste is deposited on or in the land as fill for the purpose of permanent disposal or storage for a period exceeding six months, except that it shall not include any waste facility approved for disposal of hazardous waste;

p. "Services tax" means the solid waste services tax imposed pursuant to subsection a. of section 3 of this act;

q. "Services tax fund" means the Solid Waste Services Tax Fund established pursuant to section 12 of this act in which the receipts from the services tax and any interest thereon will be deposited;

r. "Subfranchise" means the exclusive right, as awarded by a district, of a vendor to control the disposal of solid waste within all or any portion of a district; and

s. "Vendor" means any person or party financially qualified for, and technically and administratively capable of, undertaking the design, financing, construction, operation, or maintenance of a resource recovery facility or of providing resource recovery services.

3. (New section) a. There is levied upon the owner or operator of every sanitary landfill facility a solid waste services tax. The services tax shall be imposed on the owner or operator at the initial rate of $0.25 per cubic yard of solids and $0.003 per gallon of liquids on all solid waste accepted for disposal at a sanitary landfill facility. On the first day of the 13th month following the imposition of the services tax and annually thereafter, the rate of the services tax shall be increased by $0.01 per cubic yard of solids.

b. (1) There is levied upon the owner or operator of every sanitary landfill facility a resource recovery investment tax. The investment tax shall be levied on the owner or operator at an initial rate of $0.28 per cubic yard of solids and $0.004 per gallon of liquids on all solid waste, other than waste products resulting from the operation of a resource recovery facility, accepted for disposal at a sanitary landfill facility.

(2) Unless the rate is otherwise adjusted pursuant to section 11 of this act, the rate of the investment tax shall be increased pursuant to the following schedule:

  (a) On the first day of the 18th month following the imposition of the investment tax, the rate of the investment tax shall increase to $0.56 per cubic yard of solids;

(b) On the first day of the 30th month following the imposition of the investment tax, the rate of the investment tax shall increase to $0.84 per cubic yard of solids; and

(c) On the first day of the 42nd month following the imposition of the investment tax, the rate of the investment tax shall increase to $1.12 per cubic yard of solids.

The investment tax shall no longer be levied on the owner or operator of a sanitary landfill facility on and after the first day of the first month of the 11th year following the imposition of the investment tax.

c. (1) There is levied upon the owner or operator of every sanitary landfill facility a surcharge on the investment tax. The surcharge shall be imposed on the owner or operator at a rate of $0.21 per cubic yard of solids and $0.003 per gallon of liquids on all out-of-district solid waste, other than waste products resulting from the operation of a resource recovery facility, accepted for disposal at a sanitary landfill facility.

(2) If the department shall determine that a district has failed to fulfill its solid waste management planning responsibilities pursuant to section 17 of this act, the rate of the surcharge on the investment tax levied pursuant to paragraph (1) of this subsection shall, upon notification to the Board of Public Utilities and to the director, immediately be increased to a rate determined by the department, not to exceed $0.42 per cubic yard of solids or $0.006 per gallon of liquids.

d. If any owner or operator of a sanitary landfill measures the solid waste accepted for disposal by a measure other than cubic yards or gallons, the taxes and surcharges imposed by the provisions of this section shall be levied at a rate equivalent thereof as determined by the director.

e. No taxes or surcharges shall be levied on the owner or operator of a sanitary landfill facility for the acceptance of solid waste generated exclusively by any agency of the federal government if a solid waste collector submits to the owner or operator a copy of the contract with the federal agency indicating the effective date of the contract was before the effective date of this act. Taxes and surcharges shall be levied on the owner or operator for acceptance of solid waste generated by a federal agency if the contract between the federal agency and the solid waste collector was entered into, or renewed, on or after the effective date of this act.

4. (New section) a. Every owner or operator of a sanitary landfill facility which accepts solid waste for disposal and which is subject to the taxes and surcharges imposed pursuant to section 3

of this act, shall register with the director on forms prescribed by him within 20 days after the first acceptance of that waste.

b. The director shall prepare and transmit to each owner or operator of a sanitary landfill facility forms for the rendering of a tax return. The form shall be structured in a manner and form determined by the director and shall provide for the following information, and any other information he may deem necessary to be rendered in the return:

(1) The total number of cubic yards of solids and gallons of liquids accepted for disposal during the previous month;

(2) The number of cubic yards of solids and gallons of liquids accepted and place of origin of out-of-district waste accepted for disposal during the previous month; and

(3) The amount of each tax or surcharge paid according to the amount of solid waste accepted.

The director may prescribe a consolidated form for reporting the taxes and surcharges imposed under this act and the taxes imposed pursuant to P. L. 1981, c. 278 (C. 13:1E-91 et seq.) and P. L. 1981, c. 306 (C. 13:1E-100 et seq.).

5. (New section) Every owner or operator of a sanitary landfill facility shall, on or before the 20th day of each month, render a return under oath to the director and pay the full amount of taxes and surcharges due as stated in the return.

6. (New section) a. If a return required by this act is not filed, or if a return when filed is incorrect or insufficient in the opinion of the director, the amount of tax due shall be determined by the director from such information as may be available. Notice of such determination shall be given to the taxpayer liable for the payment of the tax. Such determination shall finally and irrevocably fix the tax unless the person against whom it is assessed, within 30 days after receiving notice of such determination, shall apply to the director for a hearing, or unless the director on his own motion shall redetermine the same. After such hearing, the director shall give notice of his determination to the person to whom the tax is assessed.

b. Any taxpayer who shall fail to file his return when due or to pay any tax when the same becomes due, as herein provided, shall be subject to such penalties and interest as provided in the "state tax uniform procedure law," Subtitle 9 of Title 54 of the Revised Statutes. If the director determines that the failure to comply with any provision of this section was excusable under the circumstances, it may remit such part or all of the penalty as shall be appropriate under such circumstances.

c. (1) Any person failing to file a return, failing to pay the tax, or filing or causing to be filed, or making or causing to be made, or giving or causing to be given any return, certificate, affidavit, representation, information, testimony or statement required or authorized by this act, or rules or regulations adopted hereunder which is willfully false, or failing to keep any records required by this act or rules and regulations adopted hereunder, shall, in addition to any other penalties herein or elsewhere prescribed, be guilty of a crime of the fourth degree.

(2) The certificate of the director to the effect that a tax has not been paid, that a return has not been filed, that information has not been supplied or that inaccurate information has been supplied pursuant to the provisions of this act or rules or regulations adopted hereunder shall be presumptive evidence thereof.

7. (New section) In addition to any other powers authorized by this act, the director shall have the following powers:

a. To delegate to any officer or employee of the division any powers or responsibilities required by this act as he may deem necessary;

b. To promulgate and distribute any forms necessary for the implementation of this act; and

c. To adopt any rules and regulations pursuant to the "Administrative Procedure Act," P. L. 1968, c. 410 (C. 52:14B-1 et seq.) as he may deem necessary to effectuate the purposes of this act.

8. (New section) The taxes imposed by this act shall be governed in all respects by the provisions of the "state tax uniform procedure law," Subtitle 9 of Title 54 of the Revised Statutes, but only to the extent that a specific provision of this act or any rule or regulation required to be promulgated by this act may be in conflict therewith.

9. a. (New section) Notwithstanding the provisions of any law to the contrary, the owner or operator of a sanitary landfill facility may collect the taxes and surcharges levied and imposed pursuant to this act by imposing an automatic surcharge on any tariff established pursuant to law for the solid waste disposal operations of the sanitary landfill facility.

b. For the purposes of this act, all municipal, county, and State contracts for solid waste collection and disposal shall be considered tariffs for solid waste collection, and shall be subject to any adjustment of tariffs resulting from the provisions of this act.

10. (New section) a. The Board of Public Utilities shall, within 60 days of the effective date of this act, issue an order adjusting

the tariffs established pursuant to law for solid waste collection operations by an amount equal to the total amount of the increase in the adjusted tariffs for solid waste disposal operations to take effect on the date on which the tax is imposed.

b. The Board of Public Utilities shall, by the date of any increase in the services tax or the investment tax required in subsection a. of section 3 of this act, issue an order adjusting the tariffs established pursuant to law for solid waste collection operations by an amount equal to the total amount of the increase in the tariffs for solid waste disposal operations that shall be adjusted on that date.

c. The Board of Public Utilities shall, within 60 days of notification by the department that an additional surcharge shall be imposed on an owner or operator of a sanitary landfill facility or that the investment tax rate shall be adjusted in a manner other than by the rate adjustments provided in subsection b. of section 3 of this act, issue an order adjusting the tariffs established pursuant to law for solid waste collection operations by an amount equal to the total amount of the increase in the tariffs for solid waste disposal operations.

d. In issuing any order required by this section, the Board of Public Utilities shall be exempt from the provisions of R. S. 48:2-21.

11. (New section) a. Each district, in consultation with the department, may conduct a study to determine the tax rate estimated to be necessary to be paid into the district investment tax fund so as to lower the cost of resource recovery facility services to a level which is competitive with the cost of disposal in a sanitary landfill utilized by the district.

b. After completion of the study, the district may request the department to adjust the investment tax rate set forth in section 3 of this act to a rate, not to exceed $2.80 per cubic yard, or the equivalent thereof, which is consistent with the conclusions drawn in the study and with the plan developed pursuant to subsection d. of section 15. The district may request the department to adjust the rate, subject to that maximum rate, on an annual basis in accordance with the conclusions drawn as a result of a review of the study and any additional information gained during the previous year.

c. The provisions of any law to the contrary notwithstanding, two or more districts may conduct a joint study and establish a single investment tax rate for the districts.

d. The department shall, upon approval of a request by a district, notify the Board of Public Utilities and the director of the investment tax rate adjustment in that district.

12. (New section) There is created a nonlapsing Solid Waste Services Tax Fund to be the depository for the services tax moneys, and any interest thereon, paid to the director pursuant to this act and disbursed as provided herein.

13. (New section) a. Before any moneys in the services tax fund are appropriated as provided hereunder, the cost of administration and collection of the tax shall be paid out of that fund.

b. The moneys collected in the services tax fund shall be appropriated to the Department of Environmental Protection and shall be used only in the following manner:

(1) By the department for solid waste planning, permitting, regulation, enforcement and research, pursuant to the provisions of the "Solid Waste Management Act," P. L. 1970, c. 39 (C. 13:1E-1 et seq.);

(2) By the department for reviewing the economic aspects of solid waste management;

(3) By the department for administering the services tax fund; and

(4) To provide State aid to solid waste management districts for preparing, revising, and implementing solid waste management plans. At least 50% of the annual balance of the services tax fund shall be used for State aid and shall be distributed in amounts proportionate to the population of each district, except that no district shall receive less than 2% of the amount apportioned to aid all districts. In the event that the department determines pursuant to section 17 of this act that any district shall fail to fulfill its solid waste management planning responsibilities, the department may withhold for the entire year or until the district fulfills its responsibilities, all or a portion of the amount of moneys that district would have received in any year pursuant to this paragraph. Any moneys withheld for the entire year shall be distributed among the remaining districts in the same proportion as the other moneys were distributed.

14. (New section) There is created a Resource Recovery Investment Tax Fund to contain subaccounts for each district to be held by the State Treasurer, to be the depository for:

a. The investment tax revenues collected by the director resulting from the amount of solid waste generated from within each county;

b. The surcharge revenues collected by the director resulting from the acceptance of out-of-district waste;

c. The investment tax revenues collected by the director not otherwise deposited in another investment tax fund subaccount pursuant to subsections a. and b. of this section shall be deposited in the receiving district's subaccount; and

d. Any interest thereon.

The moneys deposited in each district subaccount fund shall be disbursed as provided herein.

15. (New section) a. Before the moneys in each investment tax fund subaccount are appropriated as provided hereunder, the cost of administration and collection of the tax and surcharge shall be paid by the moneys in the subaccounts.

b. Each district shall create a District Resource Recovery Investment Tax Fund, to be the depository of the moneys appropriated to each district pursuant to this section to be administered by the governing body of each county, and the Hackensack Commission, in the case of the Hackensack Meadowlands District.

c. The moneys collected in each investment tax fund subaccount shall be appropriated to each district for deposit in its district investment tax fund and shall be used only in accordance with a plan prepared and approved pursuant to subsection d. of this section and only for the following purposes:

(1) To reduce the rates charged by a resource recovery facility serving the district in order to provide gradual transition between resource recovery facility rates and sanitary landfill facility rates. Any reductions may be achieved through use of investment tax fund money; to pay construction costs and related facility start-up costs, or to pay directly part of the fees charged for disposal at a resource recovery facility.

(2) To cover any expenses directly related to the planning, designing, financing, construction, operation or maintenance of a resource recovery facility or the acquisition of the services of a resource recovery facility, including expenses incurred if a study is conducted pursuant to section 11 of this act;

(3) To design, finance, construct, operate, maintain environmentally sound sanitary landfill facilities to be utilized for:

(a) Disposing of those solid wastes which cannot be processed by a resource recovery facility or which result from the operation of a resource recovery facility;

(b) Disposal of solid waste, on an interim basis, until a resource recovery facility becomes operational; and

(c) Disposal of solid waste, on a long term basis, in those districts which demonstrate to the satisfaction of the department that utilization of a resource recovery facility is not feasible for disposal of the solid waste generated in that district; and

(4) To administer the investment tax fund, provided that not more than two percent of the annual balance shall be used for administration.

d. Within two years of the effective date of this act, and prior to the disbursal of any funds, each district shall prepare a plan, including a schedule, which shall outline the proposed uses of the moneys in the district investment tax fund as well as describe the manner in which those moneys will be disbursed. Each plan shall be adopted as an amendment to the district solid waste management plan required pursuant to the provisions of the "Solid Waste Management Act," P. L. 1970, c. 39 (C. 13:1E-1 et seq.). This plan may be amended, as necessary, in accordance with the procedures provided therefor pursuant to the "Solid Waste Management Act," P. L. 1970, c. 39 (C. 13:1E-1 et seq.).

e. Each district shall, by October 31 of each year in which moneys remain in its district investment tax fund, file an audit of the district investment tax fund and any expenditures therefrom with the Local Finance Board in the Division of Local Government Services in the Department of Community Affairs. The audit shall be conducted by an independent public accountant.

f. Upon approval by the department, two or more districts may establish a joint investment tax fund to receive the investment tax fund revenues and any surcharge collected pursuant to section 3 of this act.

16. (New section) If the department shall determine that a district has failed to fulfill its solid waste management planning responsibilities pursuant to section 17 of this act, the department may assume the administration of the district investment tax fund of that district and may use the moneys in the fund for the purposes permitted in subsection c. of section 15 of this act for the benefit of that district.

17. (New section) The department may determine that a district has failed to fulfill its solid waste management planning responsibilities as required by sections 11 and 12 of P. L. 1975, c. 326 (C. 13:1E-20 and 13:1E-21) and by subsection d. of section 15 of this act. A determination of failure shall include a finding that the district has not made a good faith effort toward fulfilling its planning responsibilities.

18. (New section) Notwithstanding the provisions of any law, rule or regulation to the contrary, as an alternative to any other procedure provided for by law, the design, financing, construction, operation or maintenance, or any combination thereof, of a resource recovery facility or the provision of resource recovery facility

services may be procured by a contracting unit in accordance with the provisions of sections 19 through 27 of this act.

19. (New section) Any contract between a vendor and a contracting unit for the design, financing, construction, operation or maintenance, or any combination thereof, of a resource recovery facility or for the provision of the services of such a facility may be awarded for a period not to exceed 40 years.

20. (New section) a. The contracting unit shall issue a request for qualifications of vendors which shall include the date, time of day and place by which qualifications shall be received and the minimum acceptable qualifications, and which shall be made available to all potential vendors through adequate public notice which shall include publication in at least one appropriate trade or professional journal and a newspaper of general circulation in the jurisdiction of the contracting unit. In addition to all other factors bearing on qualification, the contracting unit may consider information which might result in debarment or suspension of a vendor from State contracting and may disqualify a vendor if the vendor has been debarred or suspended by any State agency.

b. The contracting unit shall publish, in the same publications in which notice of the request for qualifications appeared, a list of qualified vendors and a statement setting forth the basis for their selection.

21. (New section) a. The contracting unit shall issue a request for proposals to the qualified vendors which shall include a description of the services and facilities required, the specific information and data required, and a statement as to the relative importance of price and other evaluation factors.

b. The contracting unit shall fix a date, time of day and place by which proposals shall be received and shall specify the format and procedure for submission of proposals. The contracting unit may extent the time for submission of proposals provided that any extension shall apply to all qualified vendors and the contracting unit shall provide simultaneous written notice of any extension to all qualified vendors.

22. (New section) a. Proposals shall be reviewed by the contracting unit so as to avoid disclosure of contents to competing vendors during the process of proposal review. A list of proposals shall be prepared and shall be open for public inspection in the offices of the contracting unit at reasonable hours for at least 30 days after the contract award.

b. As shall be provided in the request for proposals, discussions may be conducted with qualified vendors who submit proposals for the purpose of clarification to assure full understanding of, and responsiveness to, the solicitation requirements. Any revisions in the request for proposals which may be developed in the course of those discussions shall immediately be communicated to all qualified vendors. Revisions to proposals may be permitted after submissions and prior to award for the purpose of obtaining best and final offers. In conducting discussions, there shall be no disclosure of any information derived from proposals submitted by competing vendors.

23. (New section) a. The contracting unit shall designate the qualified vendor, or two vendors if simultaneous negotiation is to be conducted, whose proposal or proposals are determined in writing to be the most advantageous to the public, taking into consideration price and the evaluation factors set forth in the request for proposals. No other factors or criteria shall be used in the evaluation. The contract file shall include the basis on which the designation is made.

b. The contracting unit may negotiate a proposed contract, which shall include the accepted proposal, with the designated vendor.

24. (New section) Any contract to be awarded to a vendor pursuant to the provisions of sections 19 through 27 of this act or pursuant to the "Local Public Contracts Law," P. L. 1971, c. 198 (C. 40A:11-1 et seq.) or any other contracting procedure authorized by law for resource recovery facilities, shall include where applicable, but not be limited to, provisions concerning:

a. Allocation of the risks of financing and constructing a resource recovery facility, such risks to include:

(1) Delays in project completion;

(2) Construction cost overruns and change orders;

(3) Changes necessitated by revisions in laws, rules or regulations;

(4) Failure to achieve the required operating performance;

(5) Loss of tax benefits; and

(6) The need for additional equity contributions.

b. Allocation of the risks of operating and maintaining a resource recovery facility, such risks to include:

(1) Excess downtime or technical failure;

(2) Excess labor or materials costs due to underestimation;

(3) Changes in operating procedure necessitated by revisions in laws, rules or regulations;

(4) Changes in the amount or composition of the solid waste delivered for disposal;

(5) Excess operation or maintenance costs due to poor management; and

(6) Increased costs of disposal of the resource recovery facility residue.

c. Allocation of the risks associated with circumstances beyond the control of any party to the contract;

d. Allocation of the revenues from the sale of energy;

e. Default and termination of the contract;

f. The periodic preparation by the vendor of an operating performance report and an audited financial statement of the facility which shall be submitted to the contracting unit, the department and the Division of Local Government Services in the Department of Community Affairs;

g. The intervals at which the contract shall be renegotiated; and

h. Employment of current employees of the contracting unit whose positions will be affected by the terms of the contract.

25. (New section) Any new or substantially renegotiated contract to be awarded to a vendor pursuant to this act shall be the subject of a public hearing to be held by the contracting unit in the jurisdiction of the contracting unit, prior to submission of the contract for the approvals required in section 26 of this act, in accordance with the following procedure:

a. The contracting unit shall provide adequate public notice of the proposed contract award to prospective consumers and other interested parties, which shall include publication in at least one newspaper of general circulation in the jurisdiction of the contracting unit;

b. The contracting unit shall schedule a meeting to be held within 45 days of publication of the public notice with consumer representatives and other interested parties in order to present and explain the terms and conditions of the contract and to receive written questions which shall become part of the hearing record;

c. The contracting unit shall hold a public hearing within 90 days of providing notice of the proposed contract award at which the questions submitted at the meeting held pursuant to subsection b. of this section shall be addressed. At the hearing, interested parties may submit statements or additional questions concerning the terms and conditions of the proposed contract;

d. The contracting unit shall, within 30 days of the close of the hearing record, publish a hearing report which shall include all issues and questions raised at the hearing and the contracting unit's response thereto; and

e. The hearing report and the determination of the contracting unit concerning the terms and conditions of the contract shall be provided to all interested parties and hearing attendees at least 15 days prior to submission of the contract for the approvals required in section 26 of this act.

26. (New section) a. Any new or substantially renegotiated contract to be awarded to a vendor and a copy of the public hearing report shall be submitted to the department which shall approve or disapprove the proposed contract based on its being consistent with the district solid waste management plan adopted pursuant to the provisions of the "Solid Waste Management Act," P. L. 1970, c. 39 (C. 13:1E-1 et seq.) within 60 days of receipt. If the department shall disapprove the proposed contract, the contracting unit may prepare an amended contract and, if the amendments are substantial, hold a public hearing thereon pursuant to the provisions of section 25 of this act. Thereafter the amended contract may be resubmitted for approval. In the alternative, the district solid waste management plan may be amended so as to be consistent with the proposed contract.

b. Any new or substantially renegotiated contract to be awarded to a vendor and a copy of the public hearing report shall be submitted to Division of Local Government Services in the Department of Community Affairs which shall approve or disapprove the proposed contract within 60 days of receipt. The Division of Local Government Services shall approve the contract if the division finds, in writing, that the contract meets the requirements of section 24 of this act concerning the contents of the contract and that the contract comports with the fiscal and financial capabilities of the contracting unit. If the Division of Local Government Services disapproves the proposed contract, the division shall inform the contracting unit, in writing, of the changes necessary for approval. The contracting unit may then prepare an amended contract and, if the amendments are substantial, hold a public hearing thereon pursuant to the provisions of section 25 of this act. Thereafter, the amended contract may be resubmitted for approval.

c. Any new or substantially renegotiated contract to be awarded to a vendor pursuant to this act, pursuant to the "Local Public Contracts Law," P. L. 1971, c. 198 (C. 40A:11-1 et seq.) or pursuant to any other contracting procedure authorized by law for resource recovery facilities, shall be filed with the Board of Public Utilities along with a copy of the public hearing report. The Board of Public Utilities shall, within 90 days of receipt, review any contract filed with it and approve that contract if the board finds the contract to be in the public interest. If the Board of Public Utilities disapproves the contract because the contract is not in the public interest, the board shall notify the contracting unit in writing of the changes needed in the contract in order for it to be in the public interest. The contracting unit may prepare an amended contract and, if the amendments are substantial, hold a public hearing thereon pursuant to the provisions of section 25 of this act. Thereafter the amended contract may be resubmitted for approval.

In reviewing and approving the contract, the Board of Public Utilities shall not determine a rate base for, or otherwise regulate the tariffs or return of, the proposed resource recovery facility. The board shall not, thereafter, conduct any further review of the contract.

d. Notwithstanding the provisions of subsection c. of this section, all parties to any contract may request the board to determine a rate base for the proposed resource recovery facility, in which case the board may make that determination and the terms of any contract so approved shall remain subject to the continuing jurisdiction of the board.

27. (New section) The contracting unit may award a contract for resource recovery facilities or services to a vendor only after a public hearing thereon and upon approval by the department, the Division of Local Government Services, and the Board of Public Utilities.

28. (New section) Whenever the Division of Rate Counsel in the Department of the Public Advocate represents the public interest in a proceeding held to consider a contract awarded pursuant to sections 19 through 27 of this act, the Director of the Division of Rate Counsel may assess the vendor in the manner provided for in section 20 of P. L. 1974, c. 27 (C. 52:27E-19).

29 (New section) A contracting unit may lease or sell the site for a resource recovery facility to a vendor which has been awarded a contract pursuant to this act or pursuant to the "Local Public Contracts Law," P. L. 1971, c. 198 (C. 40A:11-1 et seq.) or pursuant to any other contracting procedure authorized by law for resource recovery facilities.

30. (New section) Any contracting unit which has substantially and materially complied with the provisions of sections 20 through 23 of this act, prior to the effective date of this act, as determined by the department, may award contracts pursuant to the provisions of this act.

31. (New section) a. Each district which is awarded a franchise pursuant to the provisions of section 6 of P. L. 1970, c. 40 (C. 48:13A-5) may award subfranchises to one or more persons en-

gaged in operating a resource recovery facility in all or any part of that district, provided that any subfranchise so awarded does not alter the terms of any franchise awarded by the Board of Public Utilities and that the subfranchise shall conform to the solid waste management plan for that district as approved by the department.

b. Subfranchises awarded pursuant to this section shall be of sufficient area to support the estimated technical and economic needs of the resource recovery facility which is to serve the district or portion thereof.

32. (New section) a. The department may adopt any rules and regulations pursuant to the provisions of the "Administrative Procedure Act," P. L. 1968, c. 410 (C. 52:14B-1 et seq.) as it may deem necessary to effectuate the purposes of this act.

b. The Board of Public Utilities may adopt any rules and regulations pursuant to the provisions of the "Administrative Procedure Act," P. L. 1968, c. 410 (C. 52:14B-1 et seq.) as it may deem necessary to effectuate the purposes of this act.

c. The Division of Local Government Services in the Department of Community Affairs may adopt any rules and regulations pursuant to the provisions of the "Administrative Procedure Act," P. L. 1968, c. 410 (C. 52:14B-1 et seq.) as it may deem necessary to effectuate the purposes of this act.

33. (New section) Any additional expenditures made by a municipality or county necessary to comply with an order, issued by the department pursuant to the provisions of the "Solid Waste Management Act," P. L. 1970, c. 39 (C. 13:1E-1 et seq.) and the Board of Public Utilities pursuant to the "Solid Waste Utility Control Act of 1970," P. L. 1970, c. 40 (C. 48:13A-1 et seq.), to transport solid waste to a resource recovery facility, or any expenditures necessary to reflect adjustment in rates, fees or other charges made in connection with the taxes and surcharges imposed pursuant to section 3 of P. L. c. (C.) (now pending before the Legislature as Assembly Bill No. 1778 of 1984), or the provisions of a contract entered into pursuant to the provisions of P. L. , c. (C.), (now pending before the Legislature as Assembly Bill No. 1778 of 1984), shall, for the purposes of P. L. 1976, c. 68 (C. 40A:4-45.1 et seq.), be considered an expenditure mandated by State law.

34. Section 11 of P. L. 1975, c. 326 (C. 13:1E-20) is amended to read as follows:

11. a. (1) Within 360 days after the effective date of this amendatory and supplementary act, the respective boards of chosen freeholders, in the case of counties, and the Hackensack Com-

mission, in the case of the Hackensack Meadowlands District, shall develop and formulate, pursuant to the procedures herein contained, a solid waste management plan for each respective solid waste management district; provided, however, that the commissioner may extend such period for a maximum of 45 additional days upon the certification of the board of chosen freeholders or the Hackensack Commission, as the case may be, of the causes of the delay in developing and formulating a plan, and upon the commissioner's determination that an extension will permit the development and formulation of a solid waste management plan as required herein. Within 90 days of the effective date of this act, each district shall make the necessary personnel, financial and legal arrangements to assure the development and formulation of the plan within 360 days of the effective date of this act. Every such solid waste management plan shall be developed and formulated to be in force and effect for a period of *not less than* 10 years, upon the expiration of which a new plan shall be developed and formulated pursuant to the procedures herein contained; provided, however, that every such plan shall contain provisions for automatic review thereof not less than once every two years following the approval thereof by the department, which review shall be undertaken by the board of chosen freeholders or the Hackensack Commission, as the case may be; and, provided further, however, that every such plan may be reviewed at any time by the department. Upon such review, if the board of chosen freeholders, the Hackensack Commission, or the department, as the case may be, determines that any solid waste management plan, or any part thereof, is inadequate for the purposes for which it was intended, such board of chosen freeholders or the Hackensack Commission, as the case may be, shall develop and formulate a new solid waste management plan, or any part thereof, and such new plan, or part thereof, shall be adopted thereby pursuant to the procedures contained in section 14 of this amendatory and supplementary act.

Nothing herein contained shall be construed as to prevent any board of chosen freeholders or the Hackensack Commission from readopting a solid waste management plan upon the expiration of same in a solid waste management district; provided, however, that any such readoption shall be pursuant to the provisions of section 14 of this amendatory and supplementary act.

(2) Any two or more districts may formulate and adopt a single solid waste management plan which shall meet all the requirements of this act for the combined area of the cooperating solid waste management districts.

h. (1) To assist each board of chosen freeholders in the development and formulation of the solid waste management plans required herein, an advisory solid waste council shall be constituted in every county and shall include municipal mayors or their designees, persons engaged in the collection or disposal of solid waste and environmentalists. The respective size, composition and membership of each such council shall be designated by the respective boards of chosen freeholders. In the Hackensack Meadowlands District, the Hackensack meadowlands municipal committee, established pursuant to article 4 of P. L. 1968, c. 404 (C. 13:17-7 and 13:17-8), is hereby designated an advisory solid waste council for the purposes of this amendatory and supplementary act; provided, however, that nothing herein contained shall be construed as in any way altering the powers, duties and responsibilities of the Hackensack Meadowlands municipal committee except as herein specifically provided. The respective boards of chosen freeholders and the Hackensack Commission shall consult with the relevant advisory solid waste council at such stages in the development and formulation of the solid waste management plan as each such board of chosen freeholders or the Hackensack Commission, as the case may be, shall determine; provided, however, that a solid waste management plan shall be adopted as hereinafter provided only after consultation with the relevant advisory solid waste council.

(2) In the development and formulation of a solid waste management plan for any solid waste management district, the board of chosen freeholders or the Hackensack Commission, as the case may be, shall:

(a) Consult with the county or municipal government agencies concerned with, or responsible for, water pollution control, water policy, water supply, or zoning or land use within the solid waste management district;

(b) Review such plans for solid waste collection and disposal proposed by, or in force in, any municipality or municipalities within the solid waste management district, to determine the suitability of any such plan, or any part thereof, for inclusion within the solid waste management plan of the solid waste management district; and

(c) Consult with persons engaged in solid waste collection and disposal in the solid waste management district.

35. Section 6 of P. L. 1970, c. 40 (C. 48:13A-5) is amended to read as follows:

6. a. The Board of Public [Utility Commissioners] *Utilities* shall, after hearing, by order in writing, when it finds that the public

interest requires, designate any municipality as a franchise area to be served by one or more persons engaged in solid waste collection and *may award* any solid waste management district [as] a franchise [area to] *which shall* be served by one or more persons engaged in solid waste disposal at rates and charges published in tariffs or contracts accepted for filing by the board; provided, however, that the proposed franchise area for solid waste collection or *the proposed franchise* for solid waste disposal conforms to the solid waste management plan of the solid waste management district in which such franchise area is to be located *or such franchise is to be awarded,* as such plan shall have been approved by the Department of Environmental Protection.

b. Upon application by any solid waste management district, the Board of Public Utilities shall, by order in writing, award a solid waste management district, or two or more districts, a franchise which shall be served by a person engaged in operating a resource recovery facility, provided that the proposed franchise shall conform to the solid waste management plan, as approved by the department, of the solid waste management district or districts to which the franchise will be awarded.

Each district awarded a franchise pursuant to this subsection may award subfranchises pursuant to the provisions of section 31 of P. L. c. (C.) (now pending before the Legislature as Assembly Bill No. 1778 of 1984), provided the subfranchises do not alter the terms of a franchise awarded pursuant to this subsection.

c. Franchises awarded pursuant to this section shall be of sufficient area to support the estimated technical and economic needs of the resource recovery facility which is to serve the district or portion thereof.

d. For the purposes of this section, franchise shall mean the exclusive right to control the disposal of solid waste within a district as awarded pursuant to this section.

e. The board shall encourage the consolidation of all accounts, customers, routes and facilities by persons engaged in solid waste collection [or] *within franchise areas or in* solid waste disposal [within such] *pursuant to a* franchise [areas].

Nothing in section 11 of this act (C. 48:13A-10) shall be interpreted to prevent the implementation of this section by the Board of Public [Utility Commissioners] *Utilities.*

36. Section 15 of P. L. 1971, c. 198 (C. 40A:11-15) is amended to read as follows:

15. Duration of certain contracts. All purchases, contracts or

agreements *for the performing of work or the furnishing of materials, supplies or services* shall be made for a period not to exceed 12 consecutive months, except that contracts or agreements may be entered into for longer periods of time as follows:

(1) Supplying of

(a) Fuel for heating purposes, for any term not exceeding in the aggregate, two years;

(b) Fuel or oil for use of airplanes, automobiles, motor vehicles or equipment for any term not exceeding in the aggregate, two years;

(c) Thermal energy produced by a cogeneration facility, for use for heating or air conditioning or both, of ar any term not exceeding 40 years, when the contract is approved by the Board of Public Utilities. For the purposes of this paragraph, "cogeneration" means the simultaneous production in one facility of electric power and other forms of useful energy such as heating or process steam.

(2) (Deleted by amendment*; P. L. 1977, c. 53.)*

(3) The collection and disposal of garbage and refuse, for any term not exceeding in the aggregate, five years;

(4) The recycling of solid waste, for any term not exceeding 25 years, when such contract is in conformance with a solid waste management plan approved pursuant to P. L. 1970, c. 39 (C. 13:1E-1 et seq.), and with the approval of the Division of Local Government Services and the Department of Environmental Protection;

(5) Data processing service, for any term of not more than three years;

(6) Insurance, for any term of not more than three years;

(7) Leasing or servicing of automobiles, motor vehicles, [electronic communications equipment,] machinery and equipment of every nature and kind, for a period not to exceed three years; provided, however, such contracts shall be entered into only subject to and in accordance with the rules and regulations promulgated by the Director of the Division of Local Government Services of the Department of Community Affairs;

(8) The supplying of any product or the rendering of any service by a telephone company which is subject to the jurisdiction of the Board of Public Utilities for a term not exceeding five years;

(9) Any single project for the construction, reconstruction or rehabilitation of any public building, structure or facility, or any public works [projects] *project*, including the retention of the services of any architect or engineer in connection therewith, for the length of time authorized and necessary for the completion of the actual construction;

(10) The providing of food services for any term not exceeding three years;

(11) On-site inspections undertaken by private agencies pursuant to the "State Uniform Construction Code Act" (P. L. 1975, c. 217; C. 52:27D-119 et seq.) for any term of not more than three years;

(12) The performance of work or services or the furnishing of materials or supplies for the purpose of conserving energy in buildings owned by, or operations conducted by, the contracting unit, the entire price of which to be established as a percentage of the resultant savings in energy costs, for a term not to exceed 10 years; provided, however, that such contracts shall be entered into only subject to and in accordance with rules and regulations promulgated by the Department of Energy establishing a methodology for computing energy cost savings**[.]***;*

(13) The performance of work or services or the furnishing of materials or supplies for the purpose of elevator maintenance for any term not exceeding three years;

(14) Leasing or servicing of electronic communications equipment for a period not to exceed five years; provided, however, such contract shall be entered into only subject to and in accordance with rules and regulations promulgated by the Director of the Division of Local Government Services of the Department of Community Affairs;

(15) Leasing of motor vehicles, machinery and other equipment primarily used to fight fires, for a term not to exceed seven years, when the contract includes an option to purchase, subject to and in accordance with rules and regulations promulgated by the Director of the Division of Local Government Services of the Department of Community Affairs;

(16) The provision of solid waste disposal services by a resource recovery facility, or the design, construction, operation or maintenance of a resource recovery facility for a period not to exceed 40 years when the contract is approved by the Division of Local Government Services in the Department of Community Affairs, the Board of Public Utilities, and the Department of Environmental Protection; and when the facility is in conformance with a solid waste management plan approved pursuant to P. L. 1970, c. 39 (C. 13:1E-1 et seq.). For the purposes of this subsection, "resource recovery facility" means a solid waste facility for the collection, separation, recycling and recovery of metals, glass, paper and other materials for reuse or for energy production.

All multi-year leases and contracts entered into pursuant to this section 15, except contracts for the leasing or servicing of equipment supplied by a telephone company which is subject to the jurisdiction of the Board of Public Utilities [or], *contracts for thermal energy authorized pursuant to subsection (1) above,* construction contracts authorized pursuant to subsection (9) above, or contracts and agreements for the [provisions] *provision* of work or the supplying of equipment to promote energy conservation authorized pursuant to subsection (12) above, *or contracts for resource recovery services or a resource recovery facility authorized pursuant to subsection (16) above* shall contain a clause making them subject to the availability and appropriation annually of sufficient funds as may be required to meet the extended obligation, or contain an annual cancellation clause.

The Division of Local Government Services shall adopt and promulgate rules and regulations concerning the methods of accounting for all contracts that do not coincide with the fiscal year.

37. This act shall take effect immediately except for section 3 which shall take effect the first day of the third month following enactment.

STATEMENT

The State's capacity to dispose of its non-hazardous solid waste through landfilling is rapidly diminishing. As required under the "Solid Waste Management Act," P. L. 1970, c. 39 (C. 13:1E-1 et seq.), each solid waste management district has prepared a plan for solid waste management. Most of the plans developed provide for the establishment of resource recovery facilities to replace the sanitary landfills currently in use. Resource recovery facilities provide an environmentally acceptable means of solid waste disposal and also will convert waste to energy and thereby be more economically efficient than landfilling.

The construction and initial operation of resource recovery facilities are highly capital intensive and, therefore, the owners or operators of the facilities may need to charge disposal fees which, at least initially, will be substantially higher than landfill disposal fees. In order to encourage and facilitate the provision of resource recovery services, it is necessary to reduce the initially high cost of these disposal services so that the fees are more competitive with landfill disposal fees.

This bill provides for a resource recovery investment tax on solid waste disposal at sanitary landfills to be placed in a resource recovery investment fund in each solid waste district for later use in subsidizing the transition to resource recovery. The tax will be levied on all solid waste generated within each district at an initial rate of $0.28 per cubic yard of waste. Thereafter, the tax will be automatically increased by $0.28 at 18 months, 30 months, and 42 months after the tax is first imposed unless otherwise adjusted by the district with the approval of the Department of Environmental Protection. In addition, the bill provides for a surcharge on the tax to be levied on all out-of-district waste received in a district at a rate of $0.21 per cubic yard. The funds generated by the surcharge will be retained in the resource recovery fund of the receiving district as compensation for accepting solid waste from another district and to provide an incentive to districts that send waste to another district to discontinue that practice.

This bill also provides for the imposition of an additional tax to be levied on all solid waste accepted at landfills at a rate of $0.25 per cubic yard. At least 50% of the funds generated by this additional tax will be distributed among the 22 solid waste management districts for the purpose of preparing, revising, and implementing solid waste management plans. The remaining funds will be used by the Department of Environmental Protection for research, planning, permitting, regulating and enforcing the provisions of the Solid Waste Management Act and for administering the services tax fund.

To attract private sector financing of resource recovery facilities, it is necessary to remove any institutional impediments which now exist. This bill would encourage private sector financing of resource recovery facilities by establishing a method of procurement by local government through the use of long term negotiated contracts, designated franchises and simplified rate setting as an alternative to traditional public utility regulation. This process would be subject to strict scrutiny by the Department of Environmental Protection, the Board of Public Utilities and the Department of Community Affairs.

ASSEMBLYMAN HARRY A. McENROE (Chairman): I would like to begin our deliberations, and to welcome all of you here this morning to our Committee Meeting. This is the Assembly County Government and Regional Authorities Committee. We are convening this morning to consider the aspects of Assembly Bill 1778 as they relate to air quality resulting from the development of energy-recovered facilities in the State of New Jersey.

This is the fourth hearing we have held; the first three were concerned with the general references made within the body of the bill as far as franchising, procurement, raising of revenue, and the responsibilities of various counties under solid waste management law are concerned. During those deliberations, the Committee was impressed with the concern of the public relating to air emissions. We thought the responsible thing to do was to convene a final public meeting, at which time we would consider that particular point.

This, of course, is a densely populated state, enduring a monumental crisis in the management of solid waste. We want to do it properly, and we have had a leadership role thrust upon us. Many states across the country will be observing how Essex County addresses this considerable problem.

I would like to introduce the members of the Committee who are here. Assemblyman Hendrickson will not be joining us; he is involved in another committee hearing. On my immediate right is the Vice Chairman of our Committee, Assemblyman Thomas Pankok. On his right is Assemblyman Anthony Vainieri, and on my extreme left is Assemblyman Gerald Zecker.

I would like to call our first witness who is one of our colleagues. He has introduced legislation specifically in the area of air emissions and the siting of facilities in Middlesex County. I would like to ask Assemblyman Frank Pelly to join us at the table.

Assemblyman Pelly, our Committee has convened to consider A-1778, and any related material or concerns you may have.

ASSEMBLYMAN FRANK M. PELLY: I understand. Thank you, Mr. Chairman and members of the Committee. I appreciate the opportunity to speak to you this morning, and of course, I commend you, as well as the DEP and the Administration, for having the foresight to initiate legislation of this nature.

As the statement in the legislation suggests, our State is rapidly reaching its landfill capacity. It has the obligation to address this issue, and to address it in a very aggressive manner. As your statement continues, the construction and initial operation of resource recovery facilities -- as we are all finding out in our respective districts -- are highly capital-intensive. Your legislation addresses that, and in a rather substantial fashion, so that we can move from our current landfill types of disposal to resource recovery.

The Resource Recovery Investment Tax on solid waste at sanitary landfills will certainly be an appropriate mechanism for dealing with the issue, as well as the surcharges that are implemented on out-of-district waste.

As I was coming here this morning, I heard a piece of news on our local radio station, expressing the fact that over $1 billion will be spent on resource recovery in the State of New Jersey when it is finally brought to fruition. We hadn't anticipated that in Middlesex County as being a final number, although our $100 million figure was hard to comprehend.

As we proceed in the area of resource recovery, we have problems. We are experiencing problems in our respective solid waste management districts. Those problems are coming from the people in general who are concerned with the siting, the construction, and the stack emissions that are potentially going to be coming out of the resource recovery plants.

During last session, I introduced a piece of legislation, which was Assembly Bill 1966. This bill was introduced during this session, and it is waiting in your Committee. It is currently Assembly Bill 1719. This bill requires the Department of Environmental Protection to adopt rules and regulations for the siting, construction, and operation of resource recovery incinerators, including the development of air emission standards. I submit to everyone on the Committee, that until we do those things, until we require the Department of Environmental Protection to adopt strict regulations, not guidelines, with respect to where these resource recovery plants are going to be located, how they are to be constructed, and strict regulations with respect to tolerant air emission standards, we are going to continue, both individually and collectively, to struggle with these issues. We are going to struggle with the questions of: Where are we going to put resource recovery plants; how are they going to be constructed; and, who is going to monitor acceptable air emission standards? In fact, what are acceptable air emission standards?

Hardly a week goes by that one group or another, in one county or another, does not express its fears and apprehensions about the location of these plants. The fears and apprehensions are real, and they are genuine. Once again, what I am suggesting to this Committee is that they consider incorporating an amendment into Assembly Bill 1778, which would provide the provisions of the bill I discussed, Assembly Bill 1719.

That is basically what I am here to suggest to the Committee. I would ask that the Committee take this recommendation under advisement. I have had problems in Middlesex County, and they deal with the three areas I mentioned. We have all had problems, and we are going to continue having those problems until these issues are addressed -- not to our satisfaction, but to the public's satisfaction.

Thank you for the opportunity, Mr. Chairman and members of the Committee.

ASSEMBLYMAN McENROE: Thank you, Assemblyman Pelly. Are there any questions from any of the members? (no response)

Mr. Pelly, I appreciate your coming before the Committee. Your concerns are understandable, and one of the reasons why we convened today's meeting was to address the questions of: Is it a matter of semantics and terminology, or are we, indeed, only providing general guidelines when we should have particular regulations of these kinds of facilities? I appreciate your concern. I know that the county you represent is in a central location where air emission from any kind of stack emission is of concern. I assure you that your concern -- and, we have discussed it informally -- about the intent of A-1719 is exactly the point of why this meeting was convened today.

ASSEMBLYMAN PELLY: Thank you very much. I appreciate the opportunity.

In closing, I just want to mention that as we all know, this is not a parochial issue. What we do in Middlesex County is going to affect surrounding counties, and perhaps even other states.

I'm suggesting that if we are going to do it once, let's do it right to begin with, rather than having to listen to other legislators suggest piecemeal legislation, such as not within 500 yards or 1000 yards of a school, and then not within 1000 yards of a hospital, etc. Certainly, all of those things need to be brought together into one regulation, rather than letting legislators do it on a piecemeal basis.

Thank you once again.

ASSEMBLYMAN McENROE: Thank you. Now I would like to call Mr. Steven Kuhrtz, Director of the Division of Environmental Quality in the Department of Environmental Protection.

Mr. Kuhrtz, your Department has been quite busy this past year regarding the quality of life in our State. This is a considerable effort on the part of the Legislature, with the Administration, in developing a new direction for solid waste management. Air quality has come to the forefront as a major concern of everyone. As the Assemblyman just mentioned, we are concerned with the question of guidleines. Are they stringent? Do they directly impact on our interest in providing a continuing improvement to the quality of life in New Jersey?

Now, we would like to hear from you.

STEVEN KUHRTZ: Thank you, Mr. Chairman and members of the Committee. Before I start, I have a package here to hand out.

Mr. Chairman, my name is Steven Kuhrtz, and I am the Director of the Division of Environmental Quality within the Department of Environmental Protection. My Division has jurisdiction for the State's air pollution control programing. I appreciate the opportunity to participate in this meeting to discuss some of the issues which have arisen as a result of the development of county waste management plans which rely primarily upon resource recovery technology.

I have a prepared statement which I would like to present to the Committee, and then I would be happy to try to answer any questions you may have.

Before I go into some of the specific aspects of the air emissions from resource recovery facilities and the controls we will require to reduce those emissions, I would like to comment on how the air issue relates to Assembly Bill 1778 and to the Department's overall plan to encourage environmentally-acceptable waste disposal practices.

The introduction of resource recovery, as a major waste disposal alternative for this State, faces a number of key obstacles. Ensuring that air emissions from the plants are not harmful is one major issue; institutional reluctance and strong public opposition to facility siting is another. The cost of planning, developing, and operating facilities is a third. A-1778, developed with input from the counties of our State, from a number of State agencies, and from various technical and financial experts, addresses only the financial and procurement aspects of the introduction of this technology into the State. It does not deal with the choice of disposal methods, emission control technology, or the regulation of air emissions.

In the simplest of terms, A-1778 makes it financially possible for country government to seriously consider future alternatives for waste disposal, but it does not prescribe those alternatives.

With respect to the air pollution issues associated with resource recovery and municipal waste incineration, let me note that the emissions from these plants are regulated by the New Jersey Air Pollution Control Act and the rules contained in Title 7, Chapter 27 of the New Jersey Administrative Code. Nine of the State's 17 air pollution control regulations are applicable to solid waste incineration.

In addition to establishing quantitative emission limitations for sulfur dioxide and particulates, the State rules also require: preconstruction permits; air quality modeling analyses; offsetting emission reductions in areas where air quality standards are being exceeded; control of toxic volatile organic substances; prohibition of odors; compliance with ambient air quality standards; and, standby plans to follow in the case of air pollution emergencies.

ASSEMBLYMAN McENROE: Mr. Kuhrtz, I have one question, please. Regarding these nine requirements, do they conflict, are they more stringent than any Federal regulations, or do they just follow the Federal regulations?

MR. KUHRTZ: These codes don't conflict with each other, and they don't conflict with Federal regulations. They essentially complement each other to create a regulatory process where we feel we will establish the tightest emission standards in the country, barring one or two other example states. For the most part, they are more stringent than those required by Federal regulations.

ASSEMBLYMAN McENROE: In other words, can we assume, that say the State of Delaware, where there are considerable chemical and petrochemcial facilities -- do they have rules that regulate or guide emissions comparable to these, or aren't they as stringent as what we have in New Jersey?

MR. KUHRTZ: Mr. Chairman, I am not personally familiar with the Delaware air pollution control regulations; however, I would guess that their regulations are not as stringent as ours. Generally, we have observed this across the board. New Jersey's regulations tend to be the most stringent in the country.

The State of California has developed emission limitation guidelines for incinerators, which are similar to ours.

ASSEMBLYMAN McENROE: They have followed our lead, in a sense. Is that fair to say?

MR. KUHRTZ: I don't think California would acknowledge that they followed our lead, but we have been working essentially in the same time frame. Certain of their standards appear to be somewhat more stringent than ours.

ASSEMBLYMAN McENROE: Okay, thank you. You may proceed.

MR. KUHRTZ: Certainly. In addition to the State's air pollution control regulations, the Department is now administering Federal regulations designed to prevent significant deterioration of existing air quality, and which mandate extensive technical review of new major sources of air pollution.

These so-called PSD requirements include:

1. Full opportunity for public review and comment;

2. Extensive site specific modeling to demonstrate protection of air quality;

3. Use of the best available air pollution control technology for all pollutants emitted in significant amounts;

4. A comprehensive alternatives' analysis which evaluates the pollution control options, taking into account environmental, energy, and cost factors;

5. An analysis of source impacts on visibility, soils, and vegetation; and,

6. If necessary, monitoring of air quality in the vicinity of the proposed plant site.

One of the most effective State air pollution regulations, from the standpoint of controlling solid waste incinerators, is the regulation requiring preconstruction permits and operating certificates. This rule mandates that operators of new or altered equipment, which causes air pollution, demonstrate compliance with all applicable State and Federal regulations, and most importantly, demonstrate that the equipment incorporates advances in the art of air pollution control technology. This requirement that new and altered pollution control equipment incorporates state-of-the-art technology is a statutory requirement. It is not derived solely from regulation. The state-of-the-art permit requirement has been successfully used to continuously upgrade the degree and sophistication of air pollution control required for new sources constructed in New Jersey. The emission rates and equipment design standards which result from the application of advanced control technology are incorporated into a permit, which is a legally enforceable document.

In March of 1983, the Department supplemented its air pollution control codes and general state-of-the-art permit requirement by publishing a document entitled, Air Pollution Control Guidelines for Resource Recovery Facilities and Incineration. This document contains guidelines for review of incinerator permit applications in the form of design and emission standards, which we determined to reflect state-of-the-art control technology. The guidelines have the full force and effect of rules since they specifically and clearly set forth our position on the definition of state-of-the-art air pollution control devices. Public hearings on the guidleines were conducted in May of 1983 to seek comment from the public, prospective applicants, and equipment vendors.

As a result of this input, the guidelines are being expanded and clarified, but will remain essentially as proposed, as far as air pollution control technology requirements are concerned.

First, the permit review guidelines mandate baghouses or highly efficient electrostatic precipitators to control particulate emissions, including toxic heavy metals and condensible organic emissions.

Second, they require the installation of scrubbers to reduce acid gas emissions, primarily sulfur dioxide and hydrochloric acid.

Third, they mandate combustion design standards to control carbon monoxide and organic compound emissions, including dioxins and all other toxic volatile organic compounds. Combustion requirements include minimum operating temperatures, combustion gas residence times, and continuous monitoring for temperature, oxygen, and carbon monoxide.

Most other states are only mandating the less stringent Federal standards for particulate emissions; however, some add other requirements during the permit review process on a case-by-case basis. The California Air Resources Board, like New Jersey, has also proposed air pollution permit review guidelines which will effectively require a combination of control equipment identical to that required by the New Jersey Department of Environmental Protection. Other states are looking toward New Jersey and California as examples of stringent requirements for incineration. New Jersey and California are in this leadership position because legislation in both states requires new sources to incorporate advances in the art of air pollution control technology.

I am going to skip over the next two pages, which outline the permit process, and continue on Page 10.

From the perspective of evaluating the health effects of incinerator emissions, pollutants may be divided into two categories. One of these categories consists of the so-called criteria pollutants for which national and State ambient air quality standards have been established. These pollutants include particulates, sulfur dioxide, nitrogen oxides, carbon monoxide, photochemical oxidants, and lead. Stack emissions are mathematically modeled to predict ground-level concentrations, which are then compared to the ambient air quality standards, taking into account existing background levels. Such analyses are required both by Federal and State law.

As an example, the projected quarterly lead concentration from the Essex County facility is about 0.01 micrograms per cubic meter. This is less than one percent of the Federal health-related air quality standards and less than two percent of existing background lead levels throughout most of New Jersey.

ASSEMBLYMAN McENROE: Mr. Kuhrtz, is this projected?

MR. KUHRTZ: That is correct.

ASSEMBLYMAN McENROE: In other words, you are making an analysis based on data. How would you develop that kind of data, so that you would be able to determine the impact from an energy recovery/resource recovery facility in Essex County?

MR. KUHRTZ: The analysis is based on data and information which is submitted to us by the project applicant. In this case, the Essex County applicant has undertaken a very extensive environmental impact analysis. Based on the lead contents of the refuse that will be going into the facility, the combustion parameters of the facility, and the emission control devices of the facility, we can estimate what the net concentration of lead will be coming out of the stack of the incinerator.

Then we use fairly complex and sophisticated air quality dispersion models -- computer models -- where, based on the emission rate, we can determine the height of the stack, the temperature of the stacks, and the gases coming out. We evaluate the ground-level ambient concentration resulting from those stack emissions, and we can then compare that to monitored air quality data for lead concentrations in the atmosphere.

ASSEMBLYMAN McENROE: Thank you.

MR. KUHRTZ: In addition to emissions of the criteria pollutants, refuse incinerators have the potential to release to the atmosphere much smaller quantities of other heavy metals and organic substances which are potentially carcinogenic and toxic. Unlike the case of the criteria pollutants, formal national ambient air quality standards have not been developed for these contaminants. However, assessment of the health risks and environmental effects of these emissions is an important aspect of evaluating and permitting resource recovery facilities.

The approach being used to evaluate heavy metal emissions also involves the modeling of their emission rates in order to predict maximum ground-level concentrations. Such concentrations may then be evaluated through the application of a number of different methodologies. For the carcinogenic metals beryllium, nickel, arsenic, cadmium, and chromium, conservative cancer risk factors published by the Cancer Assessment Group of the Federal EPA can be used in combination with the predicted ground-level concentration to estimate the relative cancer risk attributable to the emissions of the contaminants in question. Emission standards for certain sources of mercury and beryllium have been established under the Federal Hazardous Air Pollutants Program. These emission limitations are based upon prescribed ambient concentrations necessary to protect public health. These ambient concentrations can then be used to establish limitations on mercury and beryllium emissions from incinerators, even though the Federal regulations technically are not applicable to such sources.

Much attention has also been given to the release of trace amounts of toxic organic compounds, particularly tetrachlorodibenzodioxins (TCDD), commonly known as dioxin and chlorinated dibenzofurans, which have been detected in emissions from refuse incinerators. The United States Environmental Protection Agency conducted an intermin evaluation of the potential health problems associated with trace emissions of dioxin. After quantifying stack emissions at five sites and applying mathematical models to estimate resultant ground-level concentrations, the EPA concluded that the emission levels of dioxin from the five United States sites studied do not present a public health hazard. This conclusion was reached on the basis of a very conservative risk assessment methodology, including the evaluation of the 70-year exposures to predicted maximum annual ground-level concentrations and the assumption that the total amount of dioxin emitted was 2, 3, 7, 8 TCDD, the most toxic isomer identified.

By the way, I believe there are about 22 isomers or different forms of dioxin when one refers to dioxin generically.

Emissions from newer New Jersey facilities with more stringent combustion design and operating requirements should result in even lower emissions of organic molecules, including dioxin. Combustion efficiencies for modern, well-designed and well-operated incinerators are greater than 99.5%, which can be continuously monitored. EPA and others are continuing to test solid waste incinerators for dioxin and other toxic emissions. Some tests have shown higher dioxin emissions than found in the interim evaluation. Literature and recent communication with the EPA indicate that such organic compound emissions, including dioxins and furans, are associated with poor combustion conditions, including low temperatures, too low or too high quantities of combustion air, and high carbon monoxide emission levels. Achievement of high combustion efficiencies will ensure that resource recovery facility emissions are reasonably safe, even considering the small amounts of hazardous materials which may be present in municipal waste streams.

In conclusion, cancer risk assessment appears to be an extremely stringent way to evaluate air contaminant emissions from resource recovery facilities. While risk assessment is not an exact science, the methodology is extremely conservative. For example, no individual could possibly be exposed to the maximum ground-level concentration for 70 years.

We believe that facility-specific evaluations of worst case emissions of metals and organic substances can be used to evaluate emissions of greatest concern to the public and confirm the results of preliminary evaluations done to date. Facility-specific evaluations will be included in every facility permit review and will be available for full public review and comment. A separate public hearing will be held on each major facility.

Thank you, Mr. Chairman.

ASSEMBLYMAN McENROE: Thank you very much. Are there any questions? (no response) For the record, we would like to acknowledge Assemblyman John Hendrickson's presence.

ASSEMBLYMAN HENDRICKSON: My apologies for being late, but as I explained, I was at another meeting.

ASSEMBLYMAN McENROE: Right. Are there any questions? Mr. Zecker?

ASSEMBLYMAN ZECKER: Yes. Mr. Kuhrtz, environmentalist groups have come up constantly with, "What is the difference between regulations and guidelines?" They have emphasized that guidelines are not rules.

On Page 6 of your presentation, you give us the assurance that "guidelines have the full force and effect of rules since they specifically and clearly set forth our position on the definition of state-of-the-art pollution control devices for resource recovery facilities." You also advised that public hearings on the guidelines were conducted in May of 1983.

At those hearings, did you have testimony from various environmental groups?

MR. KUHRTZ: Yes, definitely. We had testimony from the full range of the public sector.

The confusion seems to be over whether or not we have the legal and regulatory authority to enforce these guidelines. Perhaps it was a poor choice of words, but guidelines have the connotation of rough rules of thumb that one might try to target for.

The intent of these guidelines is to establish design and engineering targets for the applicants who are developing resource recovery facilities in order to identify the minimum level of control that we will accept under our general state-of-the-art requirement for permits. We deal with hundreds of different types of sources every year, and they are all required to obtain an air pollution control permit from the Department, and meet state-of-the-art requirements.

Generally, the regulatory decision in implementating that state-of-the-art requirement ends up, unfortunately, in weeks and months of debate between the applicants and our air pollution control staff, as you may well understand. We generally have a record of applying the most stringent requirements in the country.

Because of the broad scope of the development of the resource recovery program and the large amount of interest statewide, we felt it would be useful to identify up front what our determination was, in a general sense, as to what the state-of-the-art pollution control technology should be for these incinerators at this time. The state of the art is a very dynamic thing, and it changes from year to year. It is one of the reasons why we prefer to retain the general state-of-the-art requirement as part of the permit review process, rather than binding ourselves through a rule that, under the administrative review process, might take months or years to revise as technology improves.

This approach gives us the flexibility to continually evalute how air pollution control technology is changing, and to require more stringent standards as they develop.

ASSEMBLYMAN ZECKER: So then, your use of the word "guidelines" is for the protection of the environmental status, rather than restricting it.

MR. KUHRTZ: That is correct. We, perhaps, would have been better advised to name those guidelines "minimum acceptable standards," or something like that.

Generally, we are criticized more for maintaining, rather than implementing, this state-of-the-art requirement in our permit regulations, because it does create an element of uncertainty for the industrial sector in terms of identifying the permit requirements. It is a continual moving target for them to know what we will accept as available technology.

ASSEMBLYMAN McENROE: Thank you. Are there any other questions? (no response)

I just have one, if I may. If we discount the confusion created by possible traffic, noise, and all those kinds of circumstances, and the concern is strictly with the quality of air emitted from a facility, is it the Department's policy that they could recommend the location of a facility in a populated area, or should it be way off in a rural area of the State? Can we have them in populated urban areas?

MR. KUHRTZ: Well, from the standpoint of ambient air quality standards that have been established -- ambient concentrations of air pollutants in the air -- we believe that these facilities are clean enough to be located in urban areas, as well as cleaner rural areas, without violating those ambient air quality standards.

With respect to pollutants -- as I mentioned, certain toxic, organic, and metal pollutants -- the question comes down to the issue of incremental health threats or health concerns. Since there are no standards, it is difficult; there is no measure for me to say, "Well, in a certain urban area, we're too close to the standard, and we can't afford anymore emissions from the pollutant." In a clean area, we can afford to stand more contribution.

The question comes down to an incremental health effect -- an added burden from this particular source. That is a question I can't answer. I think generally, from an air pollution standpoint, we take the position that these facilities can be located in urban areas. There may be some locations in some urban areas where the added contribution of pollution from these facilities would not allow them to be located.

ASSEMBLYMAN McENROE: Even in a circumstance where a facility is located within an urban area, the threat to the well-being of individuals in the area is well below any level that would concern us?

MR. KUHRTZ: Yes, we believe that based on our risk assessment of the added contribution of the contaminants from these sources that the health impacts from these sources are almost insignificant. They are measurable because of the nature of the analysis that one has to go through. When you are dealing with carcinogenic substances, you assume they will have an effect at any concentration above zero. Therefore, if any of this substance comes out of the stack from the incinerator, there is going to be a measurable or calculable concentration at the ground level, and that will be associated with a certain risk. That is a result of the calculus that you go through to determine the risk.

ASSEMBLYMAN McENROE: Thank you, Mr. Kuhrtz. I appreciate your testimony very much. I think it will make good reading for each of us as we assess the impact of this bill. Your testimony was very well-done.

MR. KUHRTZ: Thank you.

ASSEMBLYMAN McENROE: The next individual we would like to hear from is Mr. Richard Shapiro, the Director of Public Interest in the Department of the Public Advocate.

Mr. Shapiro, I would like to introduce the members of the Committee: Mr. Zecker, Mr. Hendrickson, Mr. Pankok, and Mr. Vainieri.

RICHARD SHAPIRO: Thank you very much, Mr. Chairman and members of the Committee. Unfortunately, I am a substitute for the expert in our Division, who has studied this area extensively. She is out of town this week, so my remarks will be somewhat general, although the Department is preparing a much more detailed presentation for the Committee.

ASSEMBLYMAN McENROE: In fairness to the individual whom you haven't named -- you described her credentials -- could we have some written testimony from that expert before we consider the bill?

MR. SHAPIRO: Yes, we're hoping, within the next week, to have a submission that will supplement the Commissioner's testimony which was presented to you on April 26.

ASSEMBLYMAN McENROE: We have not received the-- We recorded the comments of the Commissioner at our hearing in Salem County, and we appreciate them, but we have not received any formal--

MS. McNUTT: We received it.

ASSEMBLYMAN McENROE: Oh, we have received it.

MR. SHAPIRO: Subsequent to the hearing, we compiled a written presentation that summarized the major points made by the Commissioner.

ASSEMBLYMAN McENROE: So, we'll have your testimony today. Will you name the other individual for our record?

MR. SHAPIRO: Okay, she is an Assistant Deputy Public Advocate named Susan Remis, and she has conducted an extensive study over the past few months of many of the hazards associated with resource recovery facilities. She has prepared a paper documenting the results of her research.

ASSEMBLYMAN McENROE: Thank you.

MR. SHAPIRO: On April 26, the Public Advocate appeared before this Committee and recommended that the solid waste crisis of the State be viewed in a comprehensive manner. He recommended that rather than approaching one technology, such as resource recovery, we should approach the problem in terms of recycling, sewer separation, and other methods which will reduce the waste flow, as well as safeguard the public health and welfare of the citizens of the State.

Additionally, the Public Advocate recommended stringent and comprehensive environmental standards for the design and operation of resource recovery facilities prior to their operation.

Today, I would like to briefly discuss how we arrived at these recommendations. When we first approached the area of resource recovery, we received a variety of conflicting information about the state of health and environmental hazards from both people working for State government, particularly in the Department of Environmental Protection, and members of the environmental community. So, we had a tremendous amount of data to evaluate. During the course of evaluating this data, we determined that there were very, very serious hazards -- health and environmental hazards -- connected with resource recovery. This is logical because resource recovery, in fact, involves the burning of garbage. Now, since we landfill most of our garbage, there are serious environmental hazards. If we are going to figure out another way of disposing of this, there are going to be problems created by that method, as well, because the problem lies in the nature of our garbage. That is going to create problems too, whether it is going to be leaching through landfills or burning through resource recovery facilities.

In our studies, we determined there were serious toxic air contaminants ranging from the particulates, which were described by the Department of Environmental Protection's representative, heavy metals, acid gases, and toxic organic compounds. These respresent a serious danger in resource recovery facilities because the fly-ash particles in resource recovery facilities can be microscopic. They can be inhaled at distances quite far from the site, whereas in landfills, you often have leaching into nearby water supplies. In resource recovery facilities, you can have a wide-range effect on people at some distance from the facility.

In addition, many of these substances presented very, very serious health and environmental hazards. For example, dioxin, which Mr. Kuhrtz talked about, -- he cited the United States Environmental Protection Agency's study, which indicated that a particular dioxin isomer may not present a health hazard-- While there have been studies, there is a series of conflicting information in the field, and there is a lot of criticism of the EPA approach to dioxin and the EPA results of those studies. We think, in the interest of a full discussion of this area, all of this information should be considered by this Committee. We'll present some of the conflicting data in our report to you.

It should also be studied by the Department of Environmental Protection, and commented on by them. If the criticisms are not appropriate, or are questionable, then we should have a public statement which explains why the EPA study should be accepted over other critical evaluations.

By the same token, our major concern with what seems to be the regulatory approach in the State to the resource recovery facilities is that there is not a firm record of the information base that went into whatever standards DEP is currently using to regulate. There really aren't clear standards. Until today, I think most people assumed -- and, there has been wide-range concern -- that the so-called resource recovery air guidelines were just that; they were guidelines, with very little effect upon the operators of resource recovery facilities.

Today, we learned that maybe they are not really guidelines; they are something more. But, what that "something more" is, is still unclear. I think this is an area where the technology is uncertain, and where the hazards have been presented. Even if there is a dispute in the scientific community about some of the hazards, it is absolutely necessary to regulate as stringently as possible and under the best available control technology.

ASSEMBLYMAN McENROE: May I ask you a question? In May of 1983, according to the testimony by Mr. Kuhrtz, the Department of Environmental Protection held some hearings on guidelines as they relate to energy-recovered facilities. Did your Department represent itself at that hearing, and did you present these views? Were they available at that time?

MR. SHAPIRO: No, at that time, we had not undertaken the type of investigation and analysis of the entire area of resource recovery that we had taken prior to the Commissioner's testimony before this Committee. We were not in a position at that time to present the--

ASSEMBLYMAN McENROE: (interrupting) So, you did not have the concern a year ago that you have today.

MR. SHAPIRO: No, we had a serious concern, but we also felt that, at that time, it would be inappropriate without a proper information base of our own and without conducting the necessary studies and an analysis consultation with a wide range of people in this area. We felt it would be inappropriate to go in and comment until we were, in our minds, informed enough about the issue to make intelligent statements on behalf of the public. We didn't want to just express our sentiments or feelings without any sound information as a basis.

ASSEMBLYMAN McENROE: Is your study at this point conclusive? In other words, have you prepared sufficient data, so that you can now say, "This is what we found out, and this is our level of concern. We want you to turn guidelines into regulations."

MR. SHAPIRO: We will try to generate a debate in the very near future on these issues. There has been information presented about the environmental hazards and concerns of resource recovery, and there has been a position taken by the Department of Environmental Protection. I'm hoping the information we've provided and developed will allow for an intelligent debate and discussion on this issue. If our information turns out to be the subject of criticism, then that should be something we should be aware of. Then we can move on and try to work with what the DEP has developed, and we can accept their assumptions.

However, on the other hand, if it turns out that way, in the area of dioxin where the EPA study has been cited as support-- But, the critical studies, to my knowledge, have not been fully evaluated, or at least weren't discussed here today. Those studies can be considered, and we can have an intelligent debate. We can move through the variety of areas that are involved in resource recovery, ranging from air emissions to the other area, which has been touched on today and maybe is beyond the scope of this Committee's concern. But, it is a major environmental problem, and that is ash residue. There is a problem, because in resource recovery facilities, there will be a residue. This residue will contain the most hazardous substances because it will be those substances that have not been fully combusted during the course of incineration. There is going to be a problem with disposing of that ash residue. How is that problem being addressed? To my knowledge, there aren't any regulations or guidelines in effect now that deal with the specific problem of the disposal of ash residue. Will they be considered in the same manner as hazardous waste under the hazardous waste regulations? It is somewhat unclear to us at the present time.

In summary, from our investigation and analysis of this area, we hope to create information where there can be a debate between the Department of Environmental Protection, members of the environmental community, and the Public Advocate's office to ensure that whatever decisions are made about resource recovery and the regulation-- I talked about ash residue. There is also air pollution, and there is the question about how long the substances will be burned and at what temperature. Regarding those, our investigation has indicated that the DEP regulations are somewhat less stringent than what is recommended in California or other more recent studies, such as the report in New York.

There are problems that need to be brought to the surface, need to be discussed, need to be fully analyzed, and need to be fully investigated before we launch into the operation of resource recovery facilities.

Fundamentally, our recommendation has been that the approach to solid waste is not to just look into new technology; the way to solve the problem of solid waste is to reduce the waste stream. That is why the Commissioner recommended the consideration of mandatory recycling and a sewer separation program as part of every resource recovery operating permit when he testified before this Committee.

This reduction in our waste stream will reduce the dependency on landfills, and it will allow us to downsize resource recovery facilities, which is a major problem. The larger the plan is, obviously, the larger the dangers are. As we downsize them, we can also reduce the amount of toxic air contaminants and also the amount of residue.

It will also improve the efficiency of resource recovery facilities because many of the substances you will remove from resource recovery facilities are the substances that will create environmental hazards, such as plastics, which will reduce the burning efficiency of the resource recovery facilities. If you remove some of these metals, plastics, and other substances, you can increase the burning efficiency and the capability of resource recovery.

Again, our Department submits that there is a need for a comprehensive set of environmental regulations. In the hazardous waste area, the Federal government regulates from what is called "the cradle to the grave." Certainly, in the solid waste area, we should make sure we have the same kind of regulations that control all aspects of this new technology, from the movement of the substances into the facility through the landfilling or other disposal methods of the ash residue.

In conclusion, while ending our dependency on landfills is vitally important, and resource recovery appears to be a worldwide solution which is acceptable to people in Europe, Japan, and the United States, we must ensure that the toxic air contaminants and other hazards of this technology are controlled by the best-available control technology. This must be done so that public health and the environment are adequately protected, and at the same time, so that we can effectively manage our solid waste problem in the State.

Thank you.

ASSEMBLYMAN McENROE: Thank you very much. Are there any questions? Mr. Vainieri?

ASSEMBLYMAN VAINIERI: Mr. Shapiro, to your knowledge, do you know of any resource recovery plants that are operating in the United States right now?

MR. SHAPIRO: Yes, there are a number of them.

ASSEMBLYMAN VAINIERI: How are they fairing out as far as what we are proposing to do? Do they have any objections to any toxic materials?

MR. SHAPIRO: Yes, there have been some.

ASSEMBLYMAN VAINIERI: May I ask which state has this objection?

MR. SHAPIRO: As I understand it, in New York there have been some concerns about toxic air pollutants. There have been concerns in Europe and Japan where they really have used the most refined technology in developing their resource recovery facilities. There still have been some serious concerns voiced about emissions, particularly dioxin emissions.

ASSEMBLYMAN McENROE: Thank you.

ASSEMBLYMAN HENDRICKSON: I have one question. You mentioned sewer separation quite frequently. Have you actively supported the Office of Recycling here in the State of New Jersey, as far as sending our communications to the municipalities, etc. regarding your position on sewer separation?

MR. SHAPIRO: No, we haven't done that.

ASSEMBLYMAN HENDRICKSON: I think it would be a fine opportunity, because of your objections, to help the municipalities by pointing them towards resource recovery. I know I, as a mayor and a former mayor, worked for years in trying to speak before the Community of Mayors and other organizations to show the reasonableness of resource recovery and sewer separation -- just on the tipping fees. Your side would be very helpful. That recycling program is going on and is getting better all the time. There are more municipalities coming into recycling everyday, but they need help.

You have a strong objection to what we are trying to do, which is to try to relieve a crisis. I think we should all be pulling in the same direction. You kind of kept saying, "Debate, debate." I, for one, would like to see your recommendations for this garbage crisis, as far as helping the citizenry, the counties, and the municipalities are concerned.

I think we can go on and on and debate, but many debates never resolve anything. I would say if your objections are strong, then make recommendations as to what we can do about those emissions. You are doing a lot of studies, but the studies just seem to foster debates. If we're in a crisis situation, we ought to move along.

MR. SHAPIRO: I appreciate that. That is precisely what we're trying to do.

First of all, when the Commissioner testified, as I recall, I think he recommended that part of the investment tax which would be created under the bill before this Committee should also be used for recycling and other types of sewer separation methods to provide the same kind of economic incentives for recycling that are now provided for resource recovery.

We also have a series of recommendations we will submit to the Committee that address the entire area of recyclying and make very specific suggestions about how to approach recycling. Now that we have conducted the kind of study that is appropriate for the Public Advocate to undertake before we take a position on the issue, I think we will take a much more active and meaningful role in both public education and the awareness of the importance of recycling.

ASSEMBLYMAN McENROE: Thank you, Mr. Shapiro. I have just one comment. The Commissioner's testimony, I felt, was generally favorable to the bill.

MR. SHAPIRO: Yes, it is favorable.

ASSEMBLYMAN McENROE: And, yours is also?

MR. SHAPIRO: Yes.

ASSEMBLYMAN McENROE: The only point I would like to reaffirm is what Mr. Hendrickson said regarding the crisis. You know, we, in New Jersey, are confronted with a recognizable crisis in solid waste management. We can't afford a long debate, and we simply can't tolerate it. As legislators, we have to take action, and this is what we feel is an appropriate direction at this point.

My only concern is that we have testimony-- You have an excellent reputation and a good mandate to help us provide the proper decisions on behalf of the citizenry, but it has to be done without any delay whatsoever.

MR. SHAPIRO: I meant to suggest that we were presenting additional information which, in certain ways, conflicts with some of the assumptions under which the Department of Environmental Protection is operating. We firmly believe that our information is substantial. It supports the need for immediate and across-the-board regulations. The only debate that would occur would be if the Department disagrees with our data.

Thank you.

ASSEMBLYMAN McENROE: Thank you, I appreciate that. Mr. Zecker?

ASSEMBLYMAN ZECKER: Mr. Chairman, I think the public should understand the difficulty in scheduling these types of hearings. You know, the last time it was in Trenton, it was over in 45 minutes. Am I correct?

ASSEMBLYMAN McENROE: That is correct.

ASSEMBLYMAN ZECKER: Today I had a meeting at nine o'clock, we had this one scheduled at ten o'clock, and I have another one scheduled at noon. Judging from the size of the audience and the list of speakers, how well do you think we are going to hold to a twelve-o'clock adjournment?

ASSEMBLYMAN McENROE: We're going to try very hard. (laughter)

ASSEMBLYMAN ZECKER: You know, with the importance of the subject matter, I don't mean for the speakers to speed up. Certainly, the testimony has been very informative, but what general plan do you have to extend the meeting beyond--

ASSEMBLYMAN McENROE: (interrupting) We're going to extend the courtesy to our colleague, Mrs. Ogden, who has some matter she would like to bring before the Committee. We're going to call on Dr. Wei from the University of California, who is a professor of toxicology, and then we will hear from some other individuals: Mr. Herb Otte, representing the engineering aspect from Browning-Ferris, Inc.; Mr. James Morford, representing the Chamber of Commerce; and, Andrew Szurgot, representing Signal RESCO.

ASSEMBLYMAN ZECKER: Just those introductions are going to take about forty-five minutes.

ASSEMBLYMAN McENROE: But, I want you to know how important they are. That is the main thing.

ASSEMBLYMAN ZECKER: I know they are all important, and I don't mean to speed this up, but realistically, it looks like we could hear testimony like we did in Newark from 10 o'clock-- I had to leave at 2 o'clock.

ASSEMBLYMAN McENROE: We will certainly be here another hour.

ASSEMBLYMAN ZECKER: Okay, but I think if the speakers understand the problems that most of us are confronted with, perhaps their presentations could be--

ASSEMBLYMAN McENROE: (interrupting) Yes.

ASSEMBLYMAN ZECKER: I don't want to say it.

ASSEMBLYMAN McENROE: Very good. Also, we're going to hear from Jennifer Nash from the Delaware Valley Clean Air Council. If there are any meetings you must attend, I can totally appreciate your responsibilities. We appreciate your taking the time to be here today.

I would now like to call on our colleague, Assemblywoman Maureen Ogden, who would like to appear before the Committee and offer her thoughts relative to the legislation as it impacts on the quality of air in this great State of New Jersey. Assemblywoman?

ASSEMBLYWOMAN MAUREEN OGDEN: Thank you very much, Mr. Chairman and members of the Committee. I'll speak briefly and quickly.

I would like to begin by thanking you for allowing me to testify at this hearing, and to express my support for your Bill, A-1778. I would just like to touch briefly on one of my bills that I feel dovetails with this.

We certainly all know that New Jersey's past performance in solid waste management has not been one of great success, and it is a practice that can no longer be tolerated by the State's residents and its elected officials. The time has come to move forward, and I feel very strongly that your bill provides the needed incentive to make this change occur.

Many people have expressed concerns over possible air pollution from resource recovery plants, and I too share these same concerns. We know that the Department of Environmental Protection has mandated that the Essex County resource recovery facility must have a scrubber system. The DEP ruling is thus setting the standard for all future resource recovery plants which will be built in the State. While a State mandate of these controls is good, and I certainly share everyone's concern about breathing good air, we don't feel it should fall totally on the county to pick up the cost.

The air pollution controls are very expensive; the estimate is that they cost up to 15% of the total construction costs. Therefore, I recently introduced a bill, A-1850, which creates the Pollution Control Service Loan Act. This would provide a $50 million bond act to make low-interest loans available to counties for the acquisition, development, or construction of pollution control systems. In order to provide as many counties as possible with the opportunity of funding, the bill places up to a 25% "cap" on the loans for the cost of these systems.

Therefore, under current estimates, if the moneys were appropriated all at once, between five and seven projects could be funded.

I also understand, Mr. Chairman, that in your bill, there is a provision through tax incentives and accelerated depreciation for private dollars to entirely fund the construction of the resource recovery plants. Needless to say, I am always in favor of private dollars being spent, as opposed to public dollars. If it works out as is anticipated in your bill, I think that would be wonderful. Then something like this would not be needed.

On the other hand, if it doesn't work out, and this is a large, extra cost-- I know in Union County, this was what tipped them as to whether or not they would go ahead. It is important, because this is something that is required by the State -- that we help.

Basically, my proposal is a back-up measure. If things work out as far as your bill is concerned, I think that is wonderful, but if they don't work out entirely as we anticipate, then I think this should be in the wings waiting to help.

Thank you, Mr. Chairman.

ASSEMBLYMAN McENROE: Thank you very much. I appreciate your testimony. Are there any questions?

ASSEMBLYMAN HENDRICKSON: I would just like to thank you, Assemblywoman Ogden, for your testimony. It was very good and very constructive. It is going in the right direction to help the crisis.

ASSEMBLYMAN McENROE: Assemblywoman, do you have any thoughts regarding the projected surplus? (laughter) That is public money at this moment, and it might become private money later on.

Thanks very much.

ASSEMBLYWOMAN OGDEN: Thank you.

ASSEMBLYMAN McENROE: Now we would like to hear from Dr. Edward Wei, Professor of Toxicology, School of Public Health, University of California.

Dr. Wei, welcome. This is an Assembly Committee meeting convened to consider A-1778, which is to assist in the orderly development of energy-recovered facilities in our State. I'm sure you are aware that we are enduring somewhat of a crisis in our management of solid waste.

These are the members of the Committee: Mr. Zecker; Mr. Hendrickson; Mr. Pankok, our Vice Chairman; Mr. Vainieri; and I am Mr. McEnroe. Thank you for coming.

DR. EDWARD WEI: Thank you, Mr. Chairman. My name is Edward Wei, and I am from the University of California at Berkeley. I am here today as a consultant for Signal RESCO to present to you a report I have prepared on the possible health effects of resource recovery facilities. The report shown here is a review of the published scientific literature on the subject, which is current up to June of last year.

From this review, I have concluded that emissions from resource recovery facilities, such as those proposed for cities like San Francisco and San Diego, will not adversely affect the public's health; that is, people living within the vicinity of such facilities.

One can predict with a high degree of confidence that such emissions are not dangerous.

ASSEMBLYMAN McENROE: Will both of those facilities be located within the general area of San Diego and San Francisco?

DR. WEI: They are being proposed, sir. They are both in urbanized areas.

ASSEMBLYMAN McENROE: Within 10 miles of the center of each of those cities?

DR. WEI: Yes.

ASSEMBLYMAN HENDRICKSON: Are we all going to get a copy of Dr. Wei's report?

ASSEMBLYMAN McENROE: Yes. Dr. Wei, do you have just the one report?

DR. WEI: Yes, I am sorry. More copies will be made available.

ASSEMBLYMAN McENROE: We would appreciate that.

DR. WEI: I am submitting this report for your consideration. There is a large body of knowledge on questions of this type that address uncertainties related to emissions, air quality, and public health. Complex questions of this type cannot be easily resolved by open public discussion, but they can be written and documented with appropriate references to scientific literature. They can be submitted for scientific review and analysis. I hope this review will be useful to you, sir.

That is all I have to say.

ASSEMBLYMAN McENROE: Thank you. But, you are saying that we should listen to the experts and not really concern ourselves--

DR. WEI: (interrupting) No, I think--

ASSEMBLYMAN McENROE: (continuing) It is a dilemma that we are confronted with.

DR. WEI: I think the experts will differ in their opinions, as well as you, but I think the experts should have their opinions carefully written. From these conflicting opinions, there should be a synthesis and a resolution by a third, perhaps impartial, panel of experts, if you like. I think generally you will find that people come to the same conclusions after looking over the questions. But, I really think they should be written and documented, and all the numbers should be there.

For example, earlier today you heard about things such as metals, etc. If one looked at the numbers, one would find that things such as these metals -- lead, mercury, arsenic-- The amount you would pick up is perhaps, at the most, one percent to two percent of what you are normally exposed to in your diet already. The quantities are very small, and whether they are insignificant or not is a value judgment that is attached to these numbers. At least a scientist can give you an idea of what the magnitude of hazard is. I also think that all the scientists will come to the same conclusions.

ASSEMBLYMAN McENROE: Some of us have a knowledge of the old dumps that were burning for years. Rubber tires and whatever were causing the combustion below the surface, and they were emitting smoke and gas into the atmosphere. This happened for years and years, and it was endured by the people without any real concern.

Do you have any knowledge about the emissions from those kinds of circumstances in years past? How do they compare with what could be anticipated from an energy-recovery facility?

DR. WEI: I think those would be much denser in concentration, because they are not subjected to the best-available control technology and the careful type of control over combustion. Those are uncontrolled combustions, where here, I think you have a situation where there is an attempt to remove the particles and to keep the air as clean as possible.

ASSEMBLYMAN McENROE: In California, there are unique experiences which none of you enjoy. They are called fire storms that occur with the Santa Ana winds. These fires create some great difficulties for Californians, among other things. Do those fire storms -- the wind, the smoke, and the flames -- create a comparable hazard? What kinds of carcinogenics would be incorporated in those kinds of winds?

DR. WEI: Any time you burn anything-- For example, they deliberately burn rice and straw in the Sacramento Valley. There is a large amount of dense, dark smoke generated. If one analyzed these types of smokes, one can qualitatively attribute tremendous hazards to these smokes, because one can give all these chemical names to what might be present. But, in terms of actual hazards, the dilution factors are so great that it is very hard to breathe in very large quantities of materials to receive a sufficient amount in order to worry about it. Even for these fire storms, there is no evidence at all that they result in any significant health effects.

ASSEMBLYMAN McENROE: Thank you very much, Dr. Wei. Are there any further questions? (no response) Will you leave your report with our Committee Aide?

DR. WEI: Yes.

ASSEMBLYMAN McENROE: Thank you very much. We appreciate your testimony. May we now hear from Jennifer Nash, who is the Executive Director of the Delaware Valley Clean Air Council?

Hi, how are you? Have you met the members of the Committee?

JENNIFER NASH: Yes, I have. Thank you very much. I am very happy to be here.

The Delaware Valley Clean Air Council has been studying the issue of resource recovery for about three years. My own expertise in this area comes from reading available reference material on both sides of the issue, and working closely with communities in which proposed resource recovery facilities have been sited. It is to that issue I would like to address myself.

Municipal solid waste disposal will cause air pollution no matter what method is used. Landfills emit foul odors from methane gas. Composting can do the same.

The Delaware Valley Clean Air Council commends the New Jersey Department of Environmental Protection for the emission guidelines it has developed for new resource recovery facilities. Yet, even if these guidelines are rigorously adhered to, large facilities will emit thousands of tons of pollutants annually. Simply put, municipal solid waste represents an environmental hazard.

How do we mitigate the harmful environmental impact of solid waste disposal? Recycling must be seriously pursued. Too often planners reject the benefits offered by recycling programs on the grounds that these programs are difficult to establish, administer, and maintain. Resource recovery facilities, because they are centralized "high technology," and can handle large volumes of waste, appear to be a simple solution to the waste disposal problem. Yet, when it comes to siting a specific facility, and obtaining acceptance from the affected community, the apparent simplicity that made this technology so attractive can quickly evaporate.

Community opposition to large-scale resource recovery is so strong in Philadelphia that it now appears impossible to consider this option. Smaller plants of approximately 500 TPD capacity, which will distribute air pollution and other adverse impacts throughout the City, are now being studied. Yet, given the public's tremendous sensitivity to the potential health hazards posed by dioxin, formaldehyde, cadmium, vinyl chloride, and other pollutants associated with emissions from resource recovery facilities, the siting of any facility promises to be extremely difficult.

ASSEMBLYMAN McENROE: Excuse me. You know, you are making a point on behalf of Philadelphia, which I can appreciate, although I don't live there or represent Philadelphia. I have to submit that the position of the City of Philadelphia and its citizenry is certainly an economic one, because they are disposing of their waste in New Jersey at a cost of about 30% of what it would cost if they were to dispose of it in their own state. So, I would have to submit that their concern with the environment is tempered somewhat with their concern for their pocketbooks.

MS. NASH: Right.

ASSEMBLYMAN HENDRICKSON: If I may, Mr. Chairman, is New Jersey receiving their solid waste?

ASSEMBLYMAN McENROE: Yes.

MS. NASH: I appreciate that concern. For the record, the Delaware Valley Clean Air Council has conditionally supported resource recovery as a method of waste disposal. We do not feel that landfills are an acceptable option.

I would briefly like to go into the program we have developed for working with communities, because it is our belief that this program will help reduce pollution from any proposed resource recovery plant. The program hinges on the concept of community oversight. It is only through active, informed community oversight of the planning and operation of resource recovery facilities that the public's health will be fully protected.

The first step in this program is to assess existing health conditions in the area of the proposed site. The assessment should include a community health survey to determine existing rates of cancer and other diseases which could be caused by air pollution.

The second step is to conduct an investigation of the extent to which the proposed plant will produce toxic and other emissions, and the impact of these emissions upon the health of the host community.

The third step is to examine all available means of municipal waste disposal, including recycling, landfilling, composting, waste separation and processing, and incineration with energy recovery. All realistic alternatives should be examine in terms of their impact upon environment and health.

Normally the health survey, emission's inventory, and alternative's analysis would be conducted by the local or State Health Department, with assistance from the Department of Environmental Protection. A steering committee of community residents must be organized to oversee the development of these studies. In Philadelphia, the City administration has agreed to provide funding for the community steering committee to allow the group to hire its own qualified, independent expert to review and evaluate the finding of the studies.

Government must agree at the outset that it will not proceed with its resource recovery project until all surveys and studies have been completed, and the community is satisfied that the project will not adversely affect health.

Finally, the owner and operator of the resource recovery facility must agree to develop a relationship with the community regarding the oversight of operations at the plant. For example, the operator may determine it would be advantageous to allow members of the community to inspect the plant on a regular basis, review records of temperature levels in the incinerator, the tonnage of waste processed, and emission levels.

Some may argue that the Department of Environmental Protection is already prepared to undertake many of the activities outlined here. If the Department is planning to carefully review health conditions and toxic emissions from each resource recovery facility, then it should not be difficult to adapt this information to the community's needs. While we commend the Department's attention to the mitigation of environmental damage caused by resource recovery plants, we feel that the Department's vigilance cannot match that of the residents of the community in which such a plant will be built. The level of commitment to ensure that emissions are minimized will be highest among those whose health is at stake.

Some may argue that involving the community in planning and operating resource recovery facilities is time-consuming and dangerous, because it allows a community to say "no" to a resource recovery plant. Some may argue that the Department of Environmental Protection regulations and state-of-the-art technology will take care of pollution problems. We must not underestimate the distrust any community will experience if it feels that a waste plant is being forced upon it. By establishing a process whereby community residents can obtain accurate information about the benefits and risks involved in a resource recovery plant, residents will be equipped to make informed, rather than emotional, decisions. Community oversight provides a framework for the clean operation of resource recovery plants. It may also provide a method to site, build, and operate such facilities.

Thank you.

ASSEMBLYMAN McENROE: Thank you very much. I would like to address your concern about community oversight. As a part of the bill which we are considering, we are raising revenue. Part of it is in the category called the Solid Waste Services Tax Revenue. Under present discussion, there is the concern you mentioned regarding community oversight. We are considering emphasizing that the Solid Waste Services Tax Revenue, in which 50% would be returned to the counties for enforcement, management, and regulation of solid waste in their districts, be specifically addressed as -- if that is your term -- community oversight revenue. The inhabitants of the area, the county, and the municipality would be informed regarding any circumstance that might change, how the facility is operated, or any new direction in which the traffic might flow. It would be directed specifically to keep the public informed of any changes in rules or regulations.

MS. NASH: That sounds very beneficial.

ASSEMBLYMAN McENROE: We appreciate your concern, but it does coincide with our own particular thinking.

Mr. Hendrickson?

ASSEMBLYMAN HENDRICKSON: I appreciate the concerns of the Clean Air Council of Delaware Valley because I live in the Pinelands. Are you going to let us have a copy of your statement?

MS. NASH: Yes, I have several copies.

ASSEMBLYMAN HENDRICKSON: What areas do you represent? What do you consider as the Delaware Valley when you conduct your studies? How successful have you been in the municipalites you've worked with regarding sewer separation and recycling?

MS. NASH: The Delaware Valley, as we define it, consists of Philadelphia, the four suburban counties, southern New Jersey, including Atlantic County, and the State of Delaware.

This program of community oversight has been developed for Philadelphia.

ASSEMBLYMAN HENDRICKSON: I understand the oversight. What I am interested in is sewer separation. How successful has that been? You said you've been working in communities with recycling. What successes have you had?

MS. NASH: Actually, we have not been working with communities in the area of recycling. That is something which certainly needs to be done, but with our limited staff, we only provide technical expertise to communities dealing with what we call "trash-to-steam proposals," or resource recovery proposals. We haven't been directly involved in helping to set up recycling programs.

ASSEMBLYMAN HENDRICKSON: My only concern is that I am a resident of the Pinelands, and we are a recipient of an awful lot of it.

MS. NASH: I know. It certainly needs to be done.

ASSEMBLYMAN McENROE: Thank you, Ms. Nash. We appreciate your comments.

MS. NASH: Thank you.

ASSEMBLYMAN McENROE: We will now hear from Mr. Herb Otte, Vice President of Engineering for the Browning-Ferris Company. Am I pronoucing your name correctly?

HERB OTTE: Yes, any way you want. We are the Energy Systems Division of Browning-Ferris, which is the vendor under negotiations with the Port Authority for the project in Essex County.

Again, thank you for the invitation. Before I get to any specific comments, the purpose of the meeting this morning is primarily to talk about the air pollution consequences of resource recovery. I don't think the conversation should be limited to just that, without recognizing that without resource recovery -- whether it be material recovery, or energy from waste projects -- it leaves you with only the alternative to continue to landfill.

The water pollution aspects of continued landfilling are well-known and have been discussed many, many times, but there are obviously also air pollution consequences to landfilling, such as diesel exhausts and truck exhausts when waiting to dispose of material at the tip; the airborne particulate that is released in daily cover; the final cover; mining of the cover material; spreading of the trash; and, the airborne pollutants that are generated during the decomposition of the organic material when it decomposes below grade.

All of this says, yes, there is a potential or a perceived problem, at least as far as resource recovery is concerned. One should not obviate the ongoing concerns and effects of landfilling, if resource recovery is not implemented.

Obviously, if I and the rest of the vendor community, which is associated with resource recovery, have an interest in materials and energy from waste facilities -- notwithstanding from a perspective point of view that that relationship to landfilling should be maintained--

There are two alternatives for disposal of waste: one, materials recovered; and, two, energy from waste or incineration. Even the best of materials recovery facilities that have been planned, while they do tend to remove a minimize volume to a certain degree, there is still a residue that remains from material recovery facilities, which, again, has to go into a landfill. Those residues are very often highly putrescible, which then adds to the contribution from landfills.

We, at BFI, and other vendors who are associated with the energy-recovery field, are applying technology that has been used and demonstrated in Europe and worldwide. Indeed, most of the energy-recovery technology that is being implemented is representative of European technology.

We are cognizant of the sensitivities of the public to incineration. We think the recognition comes from a twofold approach: the short-term being emotional sensitivities to toxic contaminations from things like 2, 3, 7, 8, TCDD; and, others associated with the so-called "bad acters," which were the incineration plants of two or three decades ago -- well before the implementation of regulatory procedures here in the United States.

One should remember that the technologies that we, as a vendor community, are representing were developed at the same time in Europe that the so-called "bad acters" were being used and implemented here in the states. Overseas, because of an earlier interest and concern with the environment, other technologies were being developed using incineration, but with appropriate attention being paid to combustion control, as well as gas clean up of the flue gases that are generated through combustion.

When the community expresses its sensitivity to incineration, we should, as a group, try to focus the attentions into the track record of technologies that have been applied overseas, and the fairly good track record that exists of large incineration facilities equipped with energy recovery that have been sited in Europe.

There are well over 500 plants representing European technologies that have been sited overseas. That probably constitutes well over 1000 individual furnaces. We, at BFI, are representing the German Babcock group, and have access to about 60 plants, which represent some 150 furnaces. Many of them are sited within the community itself. When I say "community," I mean the community within striking distance of a hospital, a food processing market, or a school.

The bottom line is that after over 20 years of being in operation, these facilities are still considered to be good neighbors. They are not the polluters they are perceived to be by some of the interest groups here in the State.

I want to digress for just a moment and address one of the comments that was made earlier today regarding what should be looked at as far as siting a facility is concerned. From our experiences overseas, we don't feel it is a problem to site close in. Obviously, there is an economic impact if the negative is taken, i.e., siting it further out in the community.

There are sufficient guidelines and rules as far as pollution control apparatus and operating procedures are concerned. These suggest that the economic impact to the community does not have to be imposed by putting a plant out in the back woods. A facility located close in where the truck traffic can be minimized and time and dollars for waste, collection, and transport are minimized, presents no undue risk to the community in which that facilitiy is sited.

The generic technology, as far as mass burning is concerned, developed overseas. It looked at the environmental impacts probably in a threefold manner. One is designing a combustion control system wherein the proper amount of air is introduced and wherein proper furnace temperatures and residence times are effected. This was the number one approach to mitigate environmental impact.

Coupled with that, is the application of highly efficient cleaning devices for the acid components, as well as the particulate components. And third, of course, is the release of the clean gases to the environment by means of a high stack for dilution.

It sounds very easy. One could say, "Well, build an incinerator, put all of these good things into it, and we will have a clean facility." Unfortunately, it is not quite that easy. The real world is never quite that easy. One of the problems we face is that the trash stream itself is highly variable. It is not homogeneous material. It is made up of a number of components, which day-by-day, hour-by-hour vary in their respective quantities. However, when that material is incinerated, the characteristics of the individual components are fairly well understood. For example, we know that an inert introduced into the beginning of the furnace will stay an inert; we are not changing the characteristic of the material, whereas if a material has a tendency to boil at a certain temperature, and evaporate, it will boil, regardless of the quantity that is in there.

Consequently, we know from our experiences overseas, as well as what has been researched in literature in the United States and tested at various plants, that if we take a specific component, say the carbon element in trash, that that carbon, under a proper combustion operation, will result in carbon dioxide. Similarly, hydrogen will form water; similarly, a material like mercury will evaporate and stain a vapor phase all the way through the gas stream, unless it is quenched back down and allowed to condense.

What has been shown, is that many of the toxic materials, the so-called "heavy metals," have known and traceable characteristics of evaporating and forming on particulates. They condense again. All of the partial pressures in the chemistry of those specific components are well below the conditions that would allow them to be released into the atmosphere in a vapor state. It is known that these materials, such as lead, vermilion, and cadmium, the heavy metals, will be released during the incineration process, and will, in turn, reform and absorb onto particulates. In other words, the dust. The proper way of controlling the emission rate of those materials is to make sure that the facility is in compliance with the dust emission rate of the plant. By doing that, there are adequate forecasts that can be made as to what the emission rate will be for any of the components, whether they be criteria or non-criteria pollutants, as was talked about earlier this morning by DEP.

Obviously, in our pursuit of the Essex County project, we are working very closely with DEP and, believe me, the guidelines are not just something very soft. We are having a very difficult time with the rule aspects of those guidelines. Notwithstanding that, we feel there is a forward motion in progress and we are coming to the state where what constitutes proven technology is recognized by the regulatory agency. We recognize the sensitivities required by the community and the State, and I believe that the plant, when it gets built in Essex County, should not be considered a negative to the community. Indeed, it should be considered an asset.

ASSEMBLYMAN McENROE: Excuse me. How do the requirements imposed on you at this point by DEP compare to what you have experienced in Europe?

MR. OTTE: Right now, they tend to be a little more stringent than Europe in the area of residence time for some of the temperatures. They tend to be almost equal in the area of acid gas control, and in particulates, they tend to be just a little more stringent than what I found in Europe.

ASSEMBLYMAN McENROE: And, that was the concern of the Public Advocate -- particulates.

MR. OTTE: Right. The European requirement is 100 milligrams per cubic meter, which equates to an emission factor of about .035 grains per standard cubic foot. The New Jersey guideline right now is .03, and the permit condition will be set at .03, so it is somewhat more stringent.

ASSEMBLYMAN McENROE: Have you had any experience with California?

MR. OTTE: California is requiring a .01, which is presently in the state of the art. It is not just a subjective number. There is technology available to get down to .01. As a vendor, we can get there, but there will be a cost consequence. When you deviate from normal routine, or standard technology, if you will, from an engineer, you can design anything. What risk you assess then when overstepping the bounds of past practice is a question mark which becomes a business risk.

So, yes, something tighter than .03 is attainable, but on the other side it will cost more. There is an attendant risk to an implementation of something tighter. On the third side, which probably is the most pronounced one, or the one that really should be addressed, is it necessary, because, indeed, by going from .03 to .02, what is then the consequential impact on the community when that material emanates from the stack and then goes to a dispersion?

There is a trend and a feeling that these plants must become as clean as possible. We of the community which supplies them do not argue that; we share that attitude. However, there is something called proven technology, and there is something which is called nonproven technology. When one looks at providing 28 guarantees -- substantial business guarantees and parent guarantees to a project -- one has to look at the threshold of proven to nonproven technology as to who takes the long-term risk.

We believe that the guidelines, rules, whatever, which have been used by DEP in establishing our input to the permit requirements, and which will then result in the permits as far as requirments to operate within certain limits are concerned, constitute a very high degree of safeguard for the community. In combination with a scrubber and a high efficiency EP, this plant will probably be one of the cleanest in operation worldwide.

We recognize the other aspect of community sensitivity, the dioxin issue. We think, given the amount of testing that has been done on dioxins as to what were the precursors of operation and materials, that resultant dioxin emissions, vis-a-vis those plants which constitute the majority of them which do not have dioxin emissions--

It appears that the exercising of proper combustion controls, i.e., the time temperature relationships, and a high degree of dust cleanup, will be the mitigating measures, or the control measures for minimizing dioxin emissions. Unfortunately, the formation is not really understood by anyone in the scientific community.

Just as a closing point, the dioxin issue is a highly-charged and emotional issue. It can be blown, and has been blown out of perspective by a number of interest groups. The fact of the matter is, it is my understanding that there have been no deaths ever reported from dioxin. The most toxic, 2, 3, 7, 8 has a known consequence on laboratory animals; however, as far as its impact on human life, yes, there is chloracne, and there is a potential, but not proven, that emission rates of the level we are talking about will never cause a high cancer risk, albeit that the cancer risk is now being backpacked and laid at the door of the emission rate. That's fine; we can live with things along those lines.

Later on in the afternoon, we can talk, if you wish, about the impact, specifically in Essex County. However, the words I would like to leave you with -- and I am trying to go a little faster-- Proven European technology, when implemented in the United States, has a more than adequate track record to make accurate predictions on what the emission levels of materials that come out of the stack will be, albeit recognizing, again as I said, the changes in waste composition. When one looks at those changes and ties them back to emission control, and that's particulate, we are fairly confident, I think as an industry, that most of the requirements that are implemented, or required by the State, will be met, and the plants, therefore, should not be considered as polluters, as so many people are now saying. We also have to recognize the alternatives, i.e., landfills.

ASSEMBLYMAN McENROE: You mentioned the smoke pots of the 1950's and 1960's; is there any effort being made to clean them up at this point?

MR. OTTE: Oh, yes. Most of the old municipal incinerators of the 1950's and 1960's lie dormant now, because they would need extensive rehabilitation and the addition of gas-cleaning equipment.

However, when they were built, even the Federal government did not really have any guidelines for emission control on particulates. They were very often built undersized for the waste flow. The operator was then told, "You have a 200 ton a day plant, but it really has to burn 300 tons a day." That means that the auxiliaries were not sized adequately. The first thing cut from his budget was his maintenance allocation, so they hobbled along for five or ten years, whatever, generating an awful lot of smoke, under a poorly-run, overloaded operation.

I think that is the sensitivity; I think that is the public view of what incineration was, the black belching smoke. The plants of today, the designs of today have sufficient-- We are very careful that we do not overload. We are very sure that there is a reasonably accurate solid waste study prepared before we go after a project which identifies the amount of trash available in the area. We make provisions for growth over time, so that the overloading capability really doesn't impact on us. There is much more attention, as is done in Europe, placed on the design of primary and secondary air systems to provide sufficient air to completely combust all the material, and to remove the potential of carbon monoxide formations and dust leaving the plant. So, yes, to answer your question specifically, much has been done overseas, as well as here now, to minimize or virtually eliminate the possibility of visible smoke coming out of the plants.

ASSEMBLYMAN McENROE: Thank you very much. Are there any questions from the members of the Committee?

ASSEMBLYMAN ZECKER: Mr. Chairman?

ASSEMBLYMAN McENROE: Assemblyman Zecker.

ASSEMBLYMAN ZECKER: Your first reference was to overseas, and then you narrowed it down to Europe. It sounds like--

MR. OTTE: (interrupting) Well, it's overseas -- Europe, Asia and the Far East.

ASSEMBLYMAN ZECKER: It sounds as if they are 10 or 15 years ahead of us.

MR. OTTE: At least.

ASSEMBLYMAN ZECKER: As they are in many things. Are there any specific references; in other words, to cities or to plants, you know, where this Committee could possibly--

MR. OTTE: (interrupting) It would depend on which vendor you wanted to talk to. As far as BFI, our licensee is German Babcock, and we have facilities right in the middle of Dusseldorf.

ASSEMBLYMAN ZECKER: Herb Otte -- I figured it would be from Germany.

MR. OTTE: Most of us in this business are from Germany or Switzerland. We have plants right in the middle of Offenbach, Dusseldorf, not too far outside of Kempten, and Kiel, which is right next to a food processing facility. The reference list we all have as vendors would give you an idea of what major cities we are in.

ASSEMBLYMAN ZECKER: Could the Committee be supplied with specific references?

MR. OTTE: Oh, sure.

ASSEMBLYMAN ZECKER: And, I'm sure they come out with public relations material.

ASSEMBLYMAN McENROE: We might be able to send you over to Germany.

ASSEMBLYMAN ZECKER: I was thinking of Mr. Karcher. (laughter) Here we were thinking of going to Long Island; now, maybe we could send one of our Democratic majority to Europe for five or six months. (laughter)

ASSEMBLYMAN McENROE: We were trying to prevent this, you know. This is a bipartisan effort.

ASSEMBLYMAN ZECKER: I think the concerns many of us have, you know, hearing both sides of the argument, could be better addressed if we could see how these concerns are addressed in Germany and other countries which are many years ahead of us in this type of facility. Wouldn't you agree?

MR. OTTE: Yes. We have seen, pretty consistently, that when an individual has an opportunity to touch and feel, many of his concerns go away. Unfortunately, we cannot take the entire community in every project area to Europe to touch and feel. We have to work--

ASSEMBLYMAN ZECKER: (interrupting) I am not looking for a trip to Europe, but I think perhaps a lot of our questions could be answered. I think we could see from a lot of that information where we will be 5, 10, or 15 years from today.

ASSEMBLYMAN McENROE: We have had a presentation offered to the Committee of a 35-minute film. Is that correct, Peggy?

MS. McNUTT: No, I think it was slides.

ASSEMBLYMAN McENROE: Slides, I'm sorry. It was a presentation that would demonstrate the state of the art in facilities. We are holding that, possibly, for the entire Legislature, if they would like to avail themselves of it.

ASSEMBLYMAN ZECKER: I would not be against four or five Democrats being sent over to Germany for five or six months.

ASSEMBLYMAN McENROE: We have already noted that. (laughter)

MR. OTTE: As I say, if you have any specific questions on the Essex County project, or what we have been going through as far as the review process with DEP is concerned, we would be more than happy to answer those questions, subsequent to the meeting, if you like.

ASSEMBLYMAN McENROE: Thank you very much for your testimony.

MR. OTTE: Thank you.

ASSEMBLYMAN McENROE: We will now ask Mr. Andrew Szurgot, an Environmental Engineer with Signal RESCO, to come up here and have a seat. Mr. Szurgot, welcome. We will also be hearing from Mr. James Lanard, from the New Jersey Environmental Lobby, and Mr. James Morford will be here later.

Now, you are Mr. Szurgot, Environmental Engineer with Signal RESCO, Inc. I know that is a large company interested in solid waste development. Mr. Szurgot, the members of the Committee are: on my right, Assemblyman Zecker; I am Assemblyman McEnroe; and, on my left, are Assemblymen Pankok and Vainieri.

ANDREW M. SZURGOT: Thank you, Mr. Chairman, and members of the Committee. I have prepared some written testimony, which I believe you have, and I will be reading that testimony now.

My name is Andrew M. Szurgot. I am an Environmental Engineer for Signal RESCO, Incorporated. Signal RESCO designs, builds, owns, and operates resource recovery facilities which process municipal solid waste and recover energy and metals values. We have proposed to construct a facility to process up to 1,500 tons of refuse per day in Middlesex County, New Jersey.

Signal RESCO uses a common and well-proven concept of resource recovery, that is, the combustion of as-received refuse, known as mass burning, and recovery of heat generated in the form of steam, which can be sold or used to generate electricity. As with any fuel burning process, the combustion of refuse generates flue gases which contain air pollutants. I would like to explain the specific technology that Signal RESCO uses, as an example of how resource recovery projects can be designed with state-of-the-art combustion and air pollution control equipment, and operated within air quality control requirements.

Please refer to the cross-sectional view of a combustion unit on Page 5.

Refuse is received at the facility in trucks and emptied into a refuse pit. An overhead crane transfers refuse to the feed hopper from where it is charged onto a grate system. Drying and combustion of the refuse takes place on and directly above the grates, which tumble and agitate the refuse to promote even and complete burning. Flue gases pass through boiler and heat recovery sections before moving to the air pollution control system.

The grate and combustion system technology that Signal RESCO uses, the von Roll system, is one of the well-proven mass burning systems and has been utilized at over 180 installations worldwide. It is not experimental technology and performs reliably. Including scheduled outages for maintenance, we will process 80% of design refuse throughput capacity over an annual period.

Typically, an electrostatic precipitator is used to efficiently remove particulates from the flue gas stream before it is discharged to the atmosphere. The New Jersey Department of Environmental Protection guidelines, however, require additional controls for acidic gases. For the Middlesex County facility, Signal RESCO has proposed a spray dryer absorber/fabric filter system which will remove sulfur dioxide and hydrogen chloride to DEP guideline levels. In this system, flue gases are contacted in the spray dryer absorber by an alkaline reagent solution which neutralizes the acidic gases. Entrained particles and fly ash are then removed in the fabric filter. In our facilities, this system will be furnished by Signal's Wheelabrator-Frye Air Pollution Control Division, utilizing experience from our fabric filter pilot plant located in our Saugus, Massachusetts facility.

Let me describe some of the additional features of the design and operation which promote the control of air contaminant emissions, as follows:

1. The furnace is designed to promote complete combustion and minimize organic and carbon monoxide emissions by providing adequate residence time, temperatures in excess of 1800 degrees Fahrenheit, firebox turbulence, and excess oxygen. Good combustion is in our own interest because of the specifications that we must meet on putrescible and combustibles content of the residue which remains after burning.

2. Air from the receiving and refuse pit areas serve as the source of combustion air for the furnace. In this way, any odors from this area are drawn into the furnace and destroyed.

3. The refuse pit cranes are used to remove any unacceptable wastes and mix the refuse inventory, promoting uniformity of refuse feed.

4. Sophisticated controls, instrumentation, and monitoring devices are employed in the facility design. Combustion air is controlled and supplied both underneath and over the grate. Instrument readouts and alarms are provided in the operator control room which allow for constant monitoring of the combustion system and air pollution control equipment. Monitors are provided for furnace and flue gas temperatures, stack opacity, flue gas oxygen level, and pollutant emissions.

5. The spray dryer absorber/fabric filter system has the further benefit of quenching the flue gases. This allows removal of condensable pollutants. The fabric filter collects fine particles with the equally high efficiencies that it collects larger particles.

In order for the preconstruction and operation approvals to be granted for the Middlesex County facility, we must: (1) prepare an environmental impact report; (2) demonstrate that the facility will meet prevention of significant deterioration, best available control technology, and ambient air quality criteria for regulated pollutants, including particulates, lead, sulfur dioxide, nitrogen oxides, and carbon monoxide; and, (3) provide DEP with an assessment for the emissions of metals -- arsenic, beryllium, cadmium, chromium, mercury, nickel -- dioxin, and other substances to ensure that these emissions will not pose a significant health risk. Construction and operation permit conditions will specify any requirements for testing and monitoring of facility emissions.

In summary, resource recovery facilities can be designed and operated with state-of-the-art combustion and air pollution control equipment which reduce the generation and emission of air pollutants. These facilities provide a benefit to the communities which are seeking an alternative to landfilling of refuse.

ASSEMBLYMAN McENROE: Thank you, Mr. Szurgot; we appreciate your testimony. Your final statement, in some areas, you know is debatable: "These facilities provide a benefit to the communities which are seeking an alternative to landfilling of refuse." How about community acceptance? Have you had any genuine difficulty in siting these facilities?

MR. SZURGOT: Of course, we have. It is what we know as a "NIMBY" syndrome, "Not in my back yard." People have some misconceptions of what these facilities look like, how they operate, and the pollutants that come from them. So, there is some reluctance in some areas to accept them, especially in those areas, and with those people who are immediately surrounding the facility.

ASSEMBLYMAN McENROE: Will the 1,500 ton facility you propose in Middlesex County be the largest undertaking of Signal RESCO?

MR. SZURGOT: No; in fact, a facility which we now operate in Pinellas County, Florida, is currently rated at 2,100 tons per day, and we will be adding another 1,050 ton per day unit at that facility.

ASSEMBLYMAN McENROE: That has been in operation for two years or so?

MR. SZURGOT: It has been in operation since May of last year.

ASSEMBLYMAN McENROE: May of last year.

MR. SZURGOT: We also have a facility at Saugus, Massachusetts, which processes 1,400 tons of refuse per day. This facility is two units at a 700 ton per day capacity, a very similar size to the Middlesex County proposal.

ASSEMBLYMAN McENROE: Is there a continuing program in Pinellas County and in Saugus, Massachusetts, to inform the neighborhoods, the surrounding communities, of any changes or any improvements in the running of the facilities?

MR. SZURGOT: Of course; we have operating permit conditions to be met at both of those facilities, which include annual compliance testing. For example, at Pinellas we have received very little feedback from the community, at least that I am aware of, with regard to the operation of the facility. In fact, the permitting process for the third unit down there went quite smoothly.

ASSEMBLYMAN McENROE: Thank you very much. Are there any questions from the Committee? (negative response) We appreciate your testimony, Mr. Szurgot, thank you.

We also have Mr. Adam Stern, of the Environmental Defense Fund, listed on our speakers' list. He has notified the Committee that he will not be available to testify today. Now, I would like to call on James Lanard, who is, I believe, the Executive Director of the New Jersey Environmental Lobby. Mr. Lanard, you are a person we have met when you came before other Committees and at other times, so I am sure you are aware of who the Assemblymen are.

JAMES LANARD: Yes, I am; thank you. For the record, my name is James Lanard; I work for the New Jersey Environmental Lobby as their Legislative Agent.

I would like to address the air quality issue, and relate that to the community participation programs that we have talked about a little bit today. Then, I will conclude with some final remarks.

It should be clear from the outset that when we consider resource recovery facilities, what we are considering doing is creating an additional risk in the community, a risk that was not existent, and has not existed in New Jersey in any meaningful way. That risk is the potential for air emissions to threaten public health.

ASSEMBLYMAN McENROE: Do you dismiss entirely the comment made by Mr. Otte regarding existing air emissions from current sanitary landfill operations having somewhat of an impact on the health of the communities?

MR. LANARD: Well, the second half of my comment on risk creation, is that right now there are existing risks from landfills that have to be addressed too. It seems that what is starting will be a balancing, but I just want to mention that we do have some risks. Now, the Legislature may be choosing a method that they deem less risk generating. But, the Legislature should understand, I think, that they are now making a decision, balancing different risks. They should also understand that they are not eliminating the existing risks, because, as Commissioner Hughey testified before this Committee, there will still be a need for 158 acres each year of new landfull for the waste that will be taken from these facilities.

The Environmental Lobby, which has spoken to many of the environmental groups around New Jersey, has decided that it seems right now that incineration is the lesser of the two evils between incineration and landfilling. However, we do have some concerns, and we want to reduce those risks as much as possible. For instance, the American Lung Association reported that in 1982, there were 15 million tons of waste taken to landfills. But, also in the same year, 1982, there were four million tons of air pollutants emitted into communitiy air.

Concerning the air quality issue before this Committee today, the Lobby would urge that the Legislature ensure that DEP will strive for the lowest achievable emission rates -- which is a term of art defined in the Clean Air Act -- which we think may go further than what is defined as "best available control tecnology," because of the economic considerations that are taken into account when we look at lowest-achievable emission rate versus best-available control technology, LAER versus BACT.

The issues that obviously have to be addressed concern heavy metals and acid gases, which I would like to address for a second. The proposed New Jersey guidelines call for a 90% reduction of the hydrogen chloride gases emitted from a facility. However, the Federal government, in its hazardous waste regulations, mandates that 99% of the hydrogen chloride emissions be reduced, and in a DEP report itself, DEP acknowledged that 99.5% emission reduction of hydrogen chloride is achievable. Whereas their report calls for 99.5% -- or says that it is achievable -- they only require 90% in their guidelines. Just to give you an idea of what that means going into community air, for the Essex County facility, we estimate that as much as one ton per day of hydrogen chloride gases will be emitted into the community. Obviously, we will want to look at chlorinated organics as well, and we are concerned about whether there are meaningful, or any, guidelines for formaldehyde.

The American Lung Association also proposed emission limits for arsenic, vermilion, cadmium, chromium, lead, mercury, and nickel. It is our understanding that the guidelines do not require these emission limits right now.

Concerning dioxin and the dioxin assessment, there should be a dioxin assessment and a regulatory strategy performed and adopted by DEP. In the EPA study which is used by the Essex facility, and by most of the experts supporting a rather fast-tracking approach to resource recovery, we are concerned that EPA only addressed one type of dioxin. It doesn't mean much to me, but what it was, was 2, 3, 7, 8, TCDD, which also has been defined by the head of EPA's own Office of Cancer and Research as by far the greatest tumor promoter known. This was in 1983, under the current EPA Administration.

Concerning dioxin, again, for the record let it be known that on Monday of last week, the plaintiffs in the Agent Orange case settled a $180 million claim against the manufacturers of dioxin-contaminated pollutants. One hundred and eighty million dollars is now going to be paid to victims of dioxin exposure. We should make sure that we are not creating anything like the possibilities that have occurred due to Agent Orange exposure.

ASSEMBLYMAN McENROE: Mr. Lanard, I just want to address one point. I understand, and I think I share your concern about insisting that the environment be regulated and our air emissions and our people protected as best we can. But, there is testimony, it seems to me from responsible people, who have indicated that the dioxin levels, in their judgment, would be well within manageable limits. We're talking about on a scale of 100, and they say the exposure is in the range of 1% to 2% of what is a reasonable limit of toleration for the people exposed.

MR. LANARD: Shall I respond to that?

ASSEMBLYMAN McENROE: Yes, in fairness, because I have had an opportunity to discuss this matter on various panels with responsible members of the community. Invariably there will be one person who will wave the dioxin flag, will confront the Committee, and will direct the entire discussion to the one aspect, the concern with dioxin -- which we all share. I would really like you to address it. I know where you are coming from; I respect you for it. But, I really want you to help us to arrive at some reasonable solution to this situation.

MR. LANARD: I think by the end of my testimony I will have given a direction for the Committee to consider. Concerning dioxin exposure, I do not mean to make it a red flag that would stop this whole consideration, but I would say that there are people who consider carcinogens not to have any safe human threshold level. That is one point. The second point has to do with the reports you mentioned, which are the reports that the experts mentioned. These reports seem to have ignored some of the dioxin isomers. We need a better understanding of whether the studies done on the isomers are adequate, and representative of all dioxin isomers, or whether the behavior of the non-studied isomers react differently in the human body. We just need to know that answer, and I think some research could be performed relatively quickly.

Another report that the American Lung Association made before a hearing, looked at DEP figures, and found that for a 2,000 ton a day resource recovery facility with a scrubber, the particulate matter would be about double that of an existing oil-fired boiler, and almost three times that of a new coal-fired boiler. For hydrogen chloride emissions from the same facility, comparing it again to oil-fired boilers and new coal-fired boilers, we found out that the units are 365 as compared to 2.4 for oil and 29 for new coal. For lead, the units are 36, as compared to .6 for oil-fired, and .7 for new coal-fired. So, we are exchanging risks now when we create energy. I understand the other risks about trying to dispose of the solid waste.

As far as the issue of temperature is concerned, let me drop down to a comment that I understood DEP to make this morning. I understood DEP to say that the New Jersey guidelines are identical to the California Air Resources Board guidelines. That is what I understood.

ASSEMBLYMAN McENROE: They didn't say that.

ASSEMBLYMAN PANKOK: No, they didn't say that.

ASSEMBLYMAN VAINIERI: I didn't hear them.

MR. LANARD: I am going to compare them now, because I thought maybe I misunderstood what they said. The California Air Resources Board, on temperature, has proposed 1800 degrees Fahrenheit, plus or minus 190 degrees; the New Jersey guidelines include 1500 degrees Fahrenheit. Now, to be fair, there are different times when you would test the temperature, and what not, and it is not clear to me exactly what that difference represents. But, I think the Committee needs to get some direction for that.

When we have higher temperature incineration, which is what we need to get rid of the dioxins, we also vaporize the heavy metals. Here we get into a "Catch-22." If we have a high enough temperature, we have no more dioxin problems, or very, very reduced dioxin threats. However, we will have vaporized heavy metals, which are going to attach themselves to particulates and come out of the stack, unless there is a mandatory process to cool down the flue gases adequately enough so that the vaporized heavy metals recondense and can be captured through other pollution control devices. We do not understand why, right now, the guidelines include a mandatory sort of recirculation of the gases.

As far as the comparison between DEP and CARB, the California Air Resources Board is concerned, we read the California Air Resources Board to have a standard for very small micron particles, which we call the "less than two" micron particles. There is a standard of .008 dry cubic feet. The small particles are those that are most threatening to public health, because they avoid almost all of the body's defenses. The small microns can pass the filters in the nose, the nasal hairs, and can pass the filters in the upper lung, which I think are the cilia, and get deeply imbedded in the lower part of the lung. Now, these small particles by themselves may not be such a risk, but, unfortunately, they are transportation for these vaporized gases and other heavy metals which attach themselves to the dust. The California Air Resources Board, understanding that there is a need for this health consideration, has now included in their guidelines a standard for small microns. DEP has no standard for small microns.

In California, they have now acknowledged that state-of-the-art technology for electrostatic precipitators is no longer state-of-the-art ESP's, but rather they are requiring fabric filters to be used. We think that this should be investigated also, to determine if fabric filters are indeed state of the art versus the electrostatic precipitators.

As far as residence time is concerned, we understand, and again, there are differences in what you mean by residence time. DEP seems to be looking at a one-second residence time under certain minimum conditions, whereas California has up to a four-second residence time.

Concerning the question of whether guidelines or regulations are adequate, again I understood DEP to say that, because the guidelines are eventually going to be incorporated into the permits, they will have the effect of a law. So many community residents, and so many environmental organizations are calling for these guidelines to be adopted as regulations and standards, why not have some duplication and give a lot of people peace of mind? Even if there is duplication, why don't we do it? It is not very expensive, and it would not result in a delay of any kind in the development. If it is not duplication, then we have to understand why it isn't.

ASSEMBLYMAN McENROE: I think you are making a very good point.

MR. LANARD: As far as lead is concerned, we are very concerned about lead emissions. It seems that there may be as much as 283 pounds of lead emitted a year when some of these facilities are constructed. I think that figure is wrong; I will have to get it clarified. I think that might be tons -- 283 tons per year -- but I am not sure.

ASSEMBLYMAN McENROE: The other thing I think you should clarify too, is that since you have indicated there are 15 million tons of waste disposed of in a year in New Jersey-- You also mentioned the American Lung Association. They are concerned with four million tons of emissions into the air. Now, that is not from energy recovery; that is from all pollutants in the air.

MR. LANARD: Yes, that is just talking about a community loading of community resources and land versus air.

ASSEMBLYMAN McENROE: But, you can't bring the four million ton figure to the door of a resource recovery facility and say, "We drove up 13 million tons of garbage in trucks, and you put four million tons of that 13 million tons back into the air." I mean, that is just an unfair comparison.

MR. LANARD: I did not mean to imply that it was a comparison. There is no relationship between the two. I was just giving you an idea of what pollutant loading--

ASSEMBLYMAN McENROE: (interrupting) There is substantial pollution in the air in any community, under any circumstances.

MR. LANARD: Now, what I would propose, if there are going to be resource recovery facilities, would be the adoption of interim standards; that is, that DEP regulations, if we could ever get them to adopt regulations -- and I think Assemblyman Pelly's bill should be considered very seriously, and we support it wholeheartedly-- There should also be a provision in that law, or as you incorporate this into Assembly Bill 1778, that there be an adoption of interim standards. The interim standards would be in effect, say, for a three-year period. This would be written into any contract you would have if you had a privatization relationship where you had a 40-year contract. In the contract, and in the DEP regulation, would be a provision that said that after three years, DEP would review the existing state-of-the-art technology and determine whether there needed to be changes to these facilities. If you do not have that kind of call-up provision right in the bill, then you are leaving it to the private contractors. But, if you have it in the bill, and in the DEP regulations, you can be guaranteed that as state of the art improves, we will not get stuck with what could be a 40-year outdated facility by the end of its operating life.

ASSEMBLYMAN McENROE: But, aren't you ignoring the fact that there is a body called the Legislature which represents the people of New Jersey? If they are conscientious at all, and I think I can certainly represent that the ones I have known are, they will be very much alert to the interests of the public and to a concern to continually build a better world. Certainly, in New Jersey, solid waste management is a matter of concern to myself, and to my colleagues on this Committee. So, we are going to be very alert. DEP, if they ever calculated the number of phone calls they receive from legislators on behalf of their constituencies, would see that they were a substantial part of their business.

MR. LANARD: Yes, but the problem is that the Legislature does not have the right, unfortunately, to interfere with a contract between municipalities and private operators and owners of these facilities. Once you give them the right -- the municipalities -- to enter into these contracts, you have agreed, essentially, to step out of the decision-making process, and let the municipalities, or the counties, or the regional authorities negotiate for themselves what the contents of those contracts will be. All I am suggesting is that in your role as legislators, you put in, as one of the mandatory provisions of the contract, a DEP call-up provision which analyzes state-of-the-art technology. Maybe it should be more than just after the first three years.

ASSEMBLYMAN McENROE: Most of the matters we address concerning how businesses are run in New Jersey-- We often hear from business and industry that we are over-regulating. The trucking industry, right now, can't come to us and say, "You know, we never anticipated a raise in licensing fees, which you are now imposing on us. That is at variance with the contract we have with a particular company to deliver their goods somewhere." We, as the elected representatives of the people, have the right to impose regulations on existing industries, businesses, and various community efforts.

MR. LANARD: But, you can't make laws to affect existing contracts. That is in the United States Constitution and in the New Jersey Constitution. Once a contract is set, unless there is a very serious overriding public interest, which would be hard to analyze in this case, you can't do it.

ASSEMBLYMAN McENROE: It seems to me that we constantly address these concerns. Where overriding public interest is concerned, we, as a responsible body, normally respond to it.

MR. LANARD: I do not want to belabor the point, but you know that you are setting precedent by allowing 40-year contracts in New Jersey between municipalities and private operators. You may be presented now with a unique set of circumstances.

ASSEMBLYMAN McENROE: That is correct. I recognize that it is a long-term commitment, but I see the other side of it being necessary for the development.

MR. LANARD: The last technical point I want to raise on air quality has to do with whether mixing the gas stream in relationship to the refuse and oxygen has been considered adequately to ensure as complete combustion as possible. The air pollution control equipment is capturing the bad actors, the dioxins, the heavy metals, and what not. They are being captured as waste. It seems to me so obvious that if it is not going up the stack because it is very harmful to public health, then it can't go into our landfills. That waste must be defined as hazardous waste pursuant to New Jersey law, because if you don't define it as such, you are saying, "It is not good to breathe, but it is okay to put in our sanitary landfills," which we know are leaking all the time. I would ask the Committee to consider a definition of the waste from these facilities as hazardous, or to consider some type of mandatory analysis that would indicate whether there is a toxic threat as a result of this waste.

Now, we will move into resource recovery. The Lobby has taken a strong position that meaningful recycling programs, and the creation of markets for those recycled goods, have to be a part of it. We hope that some of your economic incentives can be redirected so that we can use some of that money for recycling projects.

ASSEMBLYMAN McENROE: That is certainly under consideration.

MR. LANARD: Great. Source separation, waste reduction-- Regarding the can and bottle bill, you know, if I had my druthers, I would say that this bill should be amended to have deposit legislation, because we can guarantee a 5% reduction in the waste stream by putting this in. That is probably another fight, to be fought at another time.

ASSEMBLYMAN McENROE: More than another hearing, too.

MR. LANARD: Concerning oversight and public participation, I think what this bill could do with some of those funds you're raising -- and you implied that this is under consideration -- would be to develop a technical assistance program, but the technical assistance program that I would propose would include funds to community groups. In essence, I am almost suggesting that you create a fund that could be subject to bid, to fund the opponents of these facilities, and the concerned citizens of the community. Then, you could have a structure so they would have to hire from some type of an approved list, DEP contractors, who could do engineering and site analysis to determine whether the specific application was adequate. There needs to be a mechanism, however, to get State money to the community organizations. I am suggesting that you by-pass the municipal government, not because of anything inherent in the systems of the municipal governments, but because of the perception, which I submit we will never overcome, that community residents will have a hard time accepting some of the decisions made by the municipalities, especially if there is some economic incentive.

This is not a novel idea I am proposing. Although I am not familiar with it, I just learned on Friday that the Virginia State Legislature has passed a hazardous waste facility siting law which includes a technical assistance program to community groups with public bidding. I believe that law may have been based on something that the

Massachusetts Legislature did. Let's get creative. I think the best way to ensure that we have good environmental protection is to give the resources to the community, which does not have the resources that industry has. The struggle we went through to get as far as we are today was enormous. The things that we had to give up were disappointing, to say the least.

As far as enforcement is concerned -- and this is the conclusion of my comments -- we think there has to be a mandate for regular monitoring of the chemicals that are suspected of being the most dangerous. I think that something more than annual monitoring would be appropriate. These tests are very expensive. I am told that one chemical analysis could cost as much as $250,000. I think that the potential risk justifies the expense.

There should be regular citizen access to the facility. The citizen group should have access to touring it on a regular basis, and should have access to the records. That can be done; it has been done on a voluntary basis around this country, and we have negotiated those settlements for community groups. It works out very favorably to both the industry and to the community.

Maybe there should even be the creation of an advisory committee to the facility, which would include the harshest critics of the proposal. There should also be some additional rights, which we do not need to get into.

I think the State DEP has to be the lead agency to enforce the air standards. We cannot delegate that to county or local governments. The State has the technical expertise and, if it doesn't have the resources, then this Legislature should be informed as soon as possible so that we can incorporate some additional funding in budget resolutions. Also, there should be a very strong provision in this law that would allow for the loss of a permit of an operator for serious violations. We have a problem when there is a municipal government running the facility, because there is not as much of an incentive to do things properly. We want to make sure that the private operator has more of an incentive.

In conclusion, I would like to state that you have been very open in this process. You have held, as you said, four hearings, and you are really interested in hearing all of the perspectives. I agree with you, we have to act reasonably quickly to resolve these problems. One of the needs for that is to make sure that the issue does not become more polarized than it is now. I am sure, and I am convinced, that the communities have very real and legitimate concerns, and they have to be addressed. It does not seem that just hearing the experts from the other side is going to swage their concerns. We have to find some other mechanism to do that if we want community support, which I think is necessary.

The American Lung Association concluded its testimony by stating they thought the State should proceed slowly. They urged that just one or two facilities with different technologies be permitted to be constructed, and that the State do an assessment of their operation so we can find out whether we need changes before we build too many.

Let me suggest in my final comment, that maybe this Committee could prepare a survey, a series of questions, to concerned communities, environmental groups, citizens, and the industries, asking what they think is appropriate technology, and what they think would be the risks community residents might be faced with. Then, compare them, and we may find that we are reasonably close together. If that is the case, then it seems that if you want consensus, or something close to consensus, we should have some negotiations between the communities, the opponents, the concerned citizens, and the supporters of this. But, I think that survey might show-- For instance, if you asked, "What should the total of suspended particulate standard be?" the community might say .01. Industry, as we heard today, said .03, but also said they could meet .01, but it would be expensive. If they can meet it, and the community wants it and is told what those costs will be, maybe they should take the responsibility for assuming those costs.

The concerns of citizens in towns especially like Manville, which has very, very serious asbestos problems-- They feel that they have been overburdened with pollution problems for too long, and they are now being given the opportunity to have a resource recovery facility in their community. Something has to be provided to them so that they can participate in the decision making. They are so afraid for their health right now. They are so concerned that their children, and their children's offspring are going to be affected because of the asbestos problem. Now, all of a sudden, resource recovery is proposed for their community, and they are not given any technical assistance as to whether those risks are real or perceived.

Thank you.

ASSEMBLYMAN McENROE: Thank you, Mr. Lanard. Are there any questions for Mr. Lanard? (negative response) We appreciate your comprehensive testimony; we have taken your recommendations very seriously in the past, and we will certainly do the same on this matter. Thank you very much.

The next speaker was to have been Mr. James Morford, who represents the New Jersey Chamber of Commerce. In his place, we would like to hear from Mr. David Shadle, Chairman of their Environment Committee. Mr. Shadle will be our final witness.

DAVID C. SHADLE: I am pleased to say that I got a promotion out of this. I am not the Chairman, but I would be happy to take that seat next year.

I am going to pass out some copies of testimony that Jersey Central, where I am employed, submitted during the recent New Jersey Clean Air Council and Advisory Council on Solid Waste hearings on the very same topic we are discussing today. This presents, in detail, most of the comments I am going to briefly rehash.

I have a real challenge before me after this comprehensive hearing to present any new information. I would submit that the Chairman and the rest of the Committee are to be congratulated on the airing of all this information. I found it to be extremely useful in comparing resource recovery to other alternatives we face and, indeed, we always have to make a comparison. With any new technology that comes along, we have to choose between what we are doing now, landfilling, and its environmental consequences, and move away from that technology to something such as resource recovery. Indeed, any industry brings with it some pollution, but it appears evident from the discussions of the technology that went on today, that the risk to the public can be very adequately controlled.

Speaking on behalf of the Chamber of Commerce Environment Committee, I would submit that the Chamber is very supportive of resource recovery. This certainly includes, and is compatible with recycling. They can operate hand in hand, and we believe marked forces will result with the adoption of this bill.

I guess most of my comments are going to be a summary of what went on today. To rehash what DEP has indicated, and what we learned back in May, 1983, the guidelines, as they have been unfortunately named, indeed become enforceable standards, as far as we are aware, and will do effectively the same thing as an adopted rule, which has been suggested. We believe they are by and large the most stringent anywhere in the country. In some cases, some minor instances take issue with that, but certainly the State is pushing advances in the state-of-the-art technology. We have watched, frequently at the same meetings, members of the Department of Environmental Protection updating themselves, and finding all the latest information on resource recovery and its associated impacts. They feel that their final package will be the most effective means to protect the public.

I just have a few comments to make on the air pollution impacts of resource recovery and, in particular, some of the pollutants which have been mentioned today. Briefly, I will give you a few more statistics to use for comparison. First, we have particulates. The proposed New Jersey standard, or guideline, is two and a half times more stringent than the Federal New Source Performance Standards, because the technology that will be used to meet these standards is available. It has been applied on facilities of the size you would see with resource recovery facilities. We believe the guidelines, or standards, are achievable. They will control greater than 98% of the particulates emitted from resource recovery facilities, and I believe they will control some micron-size particles, which have been mentioned to be of concern today.

We have done some extensive modeling, using the most available materials, and comparing all the known standards and studies of resource recovery. The modeling reviewed a 2,000 ton per day resource recovery facility, and we found that the particulate emissions from such a facility would make up 2% of the ambient air quality standard designed to protect public health. Regarding heavy metals, we have gone over that today. We have had a pretty thorough explanation in all of these areas, and anyone listening got a real education. But, heavy metals, which may or may not be volatilized during the combustion process frequently -- in most cases -- recrystalize and are absorbed, or adsorbed to particulates. They will also be controlled very effectively with baghouses or electrostatic precipitators. Of particular concern, lead emissions have been identified on a number of occasions, using the same advanced modeling techniques which Mr. Kuhrtz referred to this morning. We have estimated that the impacts from the lead emissions -- although they are significantly higher than what you might see from a fuel source that has no lead at all -- turn out to be less than 2% of the three-month ambient air quality standard. If you want to look at that on a 24-hour basis, which may be easier to evaluate for the individual, they are 4,285 times lower than the 24-hour workplace threshold limit value. I would say that is a fair margin of safety. The DEP's separate studies have indicated that they will make up about 1% of the standards, so we were very consistent in our evaluations.

Mercury is the one noteable pollutant that may not recrystalize. Our calculations show that mercury emissions may make up up to 1/20,000 of the workplace threshold limit value that is designed to protect workers.

ASSEMBLYMAN PANKOK: We are going to have to ask you to summarize your comments now, if you will.

MR. SHADLE: Okay. All the other heavy metal emissions we found have been less than 1/25,000 of the threshold limit value. In terms of organic substances, we agree with the information presented today by Dr. Wei, and feel that dioxin and other chlorinated compounds can be effectively controlled using the State's technology.

The other issue I was going to discuss was the acid gas controls. Although we feel that the application of scrubbers to resource recovery facilities is pushing the state of the art, it may be necessary from a political standpoint to do so, and the public just needs to be aware that it will result in additional costs.

ASSEMBLYMAN McENROE: Thank you, Mr. Shadle. We appreciate your testimony.

MR. SHADLE: Thank you.

ASSEMBLYMAN McENROE: This concludes our consideration of A-1778 as it relates to public hearings. To the other individuals who have attended our meeting, we are most appreciative of your interest. I think we have received some substantially important information which will be given very careful scrutiny before the bill is considered by the Committee, which will be, at this point, tentatively set for June 18.

Thank you all.

(MEETING CONCLUDED)

APPENDIX

Attachments

1. New Jersey Air Pollution Control Regulations relevant to Municipal Waste Incineration
2. Law on Permits
3. Air Pollution Control Guidelines for Resource Recovery Facilities and Incineration
4. March 19, 1984 Testimony before Clean Air and Solid Waste Management Advisory Councils
5. April 9, 1984 supplemental testimony for Clean Air and Solid Waste Management Advisory Councils
6. State of New Jersey Incinerator Study, Volume III, Technical Review and Regulatory Analysis of Municipal Incineration.

ATTACHMENT 1

NEW JERSEY AIR POLLUTION CONTROL REGULATIONS RELEVANT TO MUNICIPAL WASTE INCINERATION

N.J.A.C. 7:27-5, Prohibition of Air Pollution

N.J.A.C. 7:27-8, Permits and Certificates*

N.J.A.C. 7:27-9, Sulfur Dioxide Caused by the Combustion of Fuel

N.J.A.C. 7:28-10, Sulfur in Solid Fuels

N.J.A.C. 7:27-11, Incinerators

N.J.A.C. 7:27-12, Prevention and Control of Air Pollution Emergencies

N.J.A.C. 7:27-13, Ambient Air Quality Standards

N.J.A.C. 7:27-17, Control and Prohibition of Air Pollution by Toxic Substances

N.J.A.C. 7:27-18, Emission Offset Rule

* Also, see Guidelines for Air Pollution Control for Resource Recovery Facilities and Incinerators proposed 3/23/83.

NEW JERSEY STATE DEPARTMENT OF ENVIRONMENTAL PROTECTION

NEW JERSEY ADMINISTRATIVE CODE

TITLE 7, CHAPTER 27

SUBCHAPTER 5

PROHIBITION OF AIR POLLUTION

Filed: October 27, 1960
Effective: January 1, 1961
Revision Promulgated: August 5, 1977
Revision Effective: October 12, 1977

Subchapter 5, PROHIBITION OF AIR POLLUTION, of Title 7, Chapter 27, New Jersey Administrative Code, which became effective January 1, 1961, is hereby repealed. This repeal shall not affect actions, proceedings, or departmental orders pending or outstanding on the effective date of the new regulation; said actions, proceedings or departmental orders may be prosecuted, defended and continued in the same manner and to the same effect as if the new regulation had not been adopted. The text of the new regulation follows.

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7:27-5.1 DEFINITIONS

"Air pollution" means the presence in the outdoor atmosphere of one or more air contaminants in such quantities and duration as are, or tend to be, injurious to human health or welfare, animal or plant life or property, or would unreasonably interfere with the enjoyment of life or property throughout the State and in such territories of the State as shall be affected thereby and excludes all aspects of employer-employee relationship as to health and safety hazards.

"Economic poisons" means those chemicals used as insecticides, rodenticides, fungicides, herbicides, nematocides or defoliants.

7:27-5.2 GENERAL PROVISIONS

(a) Notwithstanding compliance with other Subchapters of this Chapter, no person shall cause, suffer, allow or permit to be emitted into the outdoor atmosphere substances in quantities which shall result in air pollution as defined herein.

(b) The provisions of subsection (a) of this Section shall not apply to the use of economic poisons.

NEW JERSEY STATE DEPARTMENT OF ENVIRONMENTAL PROTECTION

NEW JERSEY ADMINISTRATIVE CODE

TITLE 7, CHAPTER 27

SUBCHAPTER 8

PERMITS AND CERTIFICATES

Filed: November 15, 1967
Effective: January 15, 1968
Amendment Filed: January 4, 1973
Amendment Effective: March 5, 1973
Second Amendment Filed: March 29, 1976
Second Amendment Effective: June 1, 1976

Subchapter 8, PERMITS and CERTIFICATES, of Title 7, Chapter 27, New Jersey Administrative Code, which became effective March 5, 1973, is hereby repealed. This repeal shall not affect actions, proceedings, or departmental orders pending or outstanding on the effective date of the new regulation; said actions, proceedings or departmental orders may be prosecuted, defended and continued in the same manner and to the same effect as if the new regulation had not been adopted. The text of the new regulation follows.

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7:27-8.1 Definitions

The following words and terms, when used in this Subchapter, shall have the following meanings, unless the context clearly indicates otherwise.

"Air contaminant" means solid particles, liquid particles, vapors or gases which are discharged into the outdoor atmosphere.

"Alteration" means any change made to equipment or control apparatus or the use thereof, or in a process; including but not limited to any physical change, change in material being processed or a change in the rate of production except where such a production rate change does not increase the quantity of air contaminant emitted or does not change the quality or nature of the air contaminant emitted.

"Commercial fuel" means solid, liquid, or gaseous fuel normally produced, manufactured, used or sold for the purpose of creating useful heat.

"Control appartus" means any device which prevents or controls the emission of any air contaminant.

"Department" means the Department of Environmental Protection.

"Equipment" means any device capable of causing the emission of an air contaminant into the open air, and any stack, chimney, conduit, flue, duct, vent or similar device connected or attached to, or serving the equipment. This shall include equipment in which the preponderance of the air contaminants emitted is caused by the manufacturing process.

"Equivalent stack diameter" means the diameter of a circular cross section having the same area as the non-circular cross sections at the point of emission discharge.

"Incinerator" means any device, apparatus, equipment or structure used for destroying, reducing or salvaging by fire any material or substance including but not limited to refuse, rubbish, garbage, trade waste, debris or scrap or a facility for cremating human or animal remains.

"Liquid particles" means particles which have volume but are not of rigid shape and which upon collection tend to coalesce and create uniform homogeneous films upon the surface of the collecting media.

"Manufacturing process" means any action, operation or treatment embracing chemical, industrial, manufacturing, or processing factors, methods or forms including, but not limited to, furnaces, kettles, ovens, converters, cupolas, kilns, crucibles, stills, dryers, roasters, crushers, grinders, mixers, reactors, regenerators, separators, filters, reboilers, columns, classifiers, screens, quenchers, cookers, digesters, towers, washers, scrubbers, mills, condensers or absorbers.

"Non-commercial fuel" means solid, liquid or gaseous fuel not normally produced, manufactured, used or sold for the purpose of creating useful heat.

"Particles" means any material, except uncombined water, which exists as liquid particles or solid particles at standard conditions.

"Person" includes corporations, companies, associations, societies, firms, partnerships and joint stock companies, as well as individuals, and shall also include all political subdivisions of this State or any agencies or instrumentalities thereof.

"Solid fuel" means a fuel which is fired as a solid, such as anthracite or semianthracite coal, bituminous or sub-bituminous coal, lignite, coke breeze, wood or any solid by-product of a manufacturing process that may be substituted for any of the above specifically mentioned fuels.

"Solid particles" means particles of rigid shape and definite volume.

"Source operation" means any manufacturing process or any identifiable part thereof emitting an air contaminant into the outdoor atmosphere through one or more stacks or chimneys.

"Stack or chimney" means a flue, conduit or opening designed, constructed, and/or utilized for the purpose of emitting air contaminants into the outdoor air.

"Stack diameter" means the internal diameter of a circular stack at the point of emission discharge.

"Standard conditions" shall be 70°F and one atmosphere pressure (14.7 psia or 760 mm Hg).

7:27-8.2 Permits and Certificates Required

(a) Control apparatus and equipment for which a permit to construct and a certificate to operate are required include:

1. All control apparatus;

2. Equipment used in a manufacturing process involving surface coating, including but not limited to spray and dip painting, roller coating, electrostatic depositing or spray cleaning, which emits air contaminants into the open air and in which the quantity of material used in any source operation is in excess of 10 pounds in any one hour;

3. Equipment used in a manufacturing process involving surface cleaning or preparation, including but not limited to degreasing, etching, pickling, or plating, which emits air contaminants into the open air from a tank or vessel, the capacity of which is in excess of one hundred gallons;

4. Equipment, used in a manufacturing process, other than as set forth in subsections (a)2 and (a)3 of this Section, which emits air contaminants into the open air either directly or indirectly and in which the combined weight of all materials, excluding air and water, introduced into any one source operation is in excess of 50 pounds in any one hour;

5. Tanks, reservoirs, containers and bins used for the storage of:

   i. Liquids except water, including, but not limited to, acids, solvents, diluents or thinners, inks, colorants, lacquers, enamels, varnishes, liquid resins, gasolines, crude oils, petrochemicals, commercial fuels, non-commercial fuels and petroleum derivatives; and having a capacity in excess of 10,000 gallons;

   ii. Solid particles including, but not limited to, binders, fillers, foodstuffs, detergents, fluxes, catalysts, mineral wools, resins, plastics, pigments, construction materials and solid fuels; and having a capacity in excess of 2,000 cubic feet;

6. Stationary material handling equipment using pneumatic, bucket or belt conveying systems which emit air contaminants into the open air either directly or indirectly;

7. Commercial fuel burning equipment having a heat input rate of 1,000,000 BTU per hour or greater to the burning chamber;

8. Any equipment used for the burning of non-commercial fuel, crude oil or process by-products in any form;

9. Any incinerator, except incinerators constructed, installed or used in one or two-family dwellings or in multi-occupied dwellings containing (6) six or less family units, one of which is owner occupied.

7:27-8.3 General Provisions

(a) No person shall construct, install or alter any equipment or control apparatus without first having obtained a "Permit to Construct, Install or Alter Control Apparatus or Equipment" from the Department. Such permits may be cancelled if construction, installation or alteration is not begun within one year from the date of issuance.

(b) No person shall use or cause to be used any new or altered equipment or control apparatus without first having obtained a "Certificate to Operate Control Apparatus or Equipment" from the Department. Such certificates shall be valid for a period of five years unless sooner revoked by the Department, and such certificates may be renewed only after application to the Department not less than 90 days prior to their expiration date.

(c) Upon receipt of an application for the issuance of a "Certificate to Operate Control Apparatus or Equipment" or any renewal thereof, the Department may issue a temporary certificate valid for a period not to exceed 90 days.

(d) Any person in possession of a "Certificate to Operate Control Apparatus or Equipment" shall maintain said certificate readily available on the operating premises.

(e) No person shall use or cause to be used any equipment or control apparatus unless:

1. all conditions and provisions of the "Permit to Construct, Install or Alter Control Apparatus or Equipment" and "Certificate to Operate Control Apparatus or Equipment" are fulfilled and;

2. all components connected or attached to, or serving the equipment and/or control apparatus are functioning properly and are in use in accordance with the "Permit to Construct, Install or Alter Control Apparatus or Equipment" and "Certificate to Operate Control Apparatus or Equipment."

(f) A "Certificate to Operate Control Apparatus or Equipment" shall not be transferable either from one location to another or from one piece of control apparatus or equipment to another. A transfer from one person to another is permissible provided such transfer is reported to the Department within 90 days of the occurrence.

(g) The possession of a "Certificate to Operate Control Apparatus or Equipment" does not relieve any person from the obligation to comply with all other provisions of this Chapter.

(h) Permits and certificates issued under this Subchapter are based on emissions of air contaminants only and do not in any way void the applicant's obligation to obtain necessary permits from other governmental agencies.

(i) The provisions of subsections (a) and (b) of this Section shall not apply to structural changes, repairs or maintenance, if such changes, repairs or maintenance will not change the quality, nature or quantity of the air contaminant emitted.

7:27-8.4 Applications for Permits and Certificates

(a) Applications for a "Permit to Construct, Install or Alter Control Apparatus or Equipment" or a "Certificate to Operate Control Apparatus or Equipment" shall be made to the Department on forms provided by the Department.

(b) The Department may require such details regarding the equipment or control apparatus as it considers necessary to determine that the equipment or control apparatus is designed to operate without causing a violation of any provisions of the New Jersey Air Pollution Control Act or any provisions of codes, rules or regulations promulgated thereunder and that the equipment or control apparatus incorporates advances in the art of air pollution control developed for the kind and amount of air contaminant emitted by the applicant's equipment. Such information may include description of processes, raw materials used, operating procedures, physical and chemical nature of air contaminants, volume of gas discharge and such other information as the Department considers necessary.

(c) Before a "Certificate to Operate Control Apparatus or Equipment" or any renewal thereof is issued, the Department may require the applicant to conduct such tests as are necessary in the opinion of the Department to determine the kind and/or amount of air contaminants emitted from the equipment or control apparatus. Such tests shall be conducted in a manner approved by the Department and shall be made at the expense of the applicant who shall give the Department no less than 48 hours advance notice of the time of the start of the test. The test results shall be reviewed and certified by a New Jersey licensed Professional Engineer, or by an Industrial Hygienist who has been certified by the American Board of Industrial Hygiene.

(d) Any person applying for a "Certificate to Operate Control Apparatus or Equipment" or a renewal thereof, or to whom such certificate has been issued shall, when requested by the Department, provide such sampling facilities exclusive of instrumentation and sensing devices as may be necessary for the Department to determine the kind and/or amount of air contaminants emitted from the equipment or control apparatus. During such testing by the Department, the equipment and/or control apparatus shall be operated under such conditions within their capacities as may be requested by the Department. The facilities may be either permanent or temporary, at the discretion of the person responsible for their provision, and shall conform to all applicable laws and regulations concerning safe construction and safe practice.

7:27-8.5 Service Fees

(a) Any person subject to the provisions of this Subchapter, except as noted in subsection 8.5 (g), shall submit with each application for a "Permit to Construct, Install or Alter Control Apparatus or Equipment", as an integral part thereof, a service fee in accordance with the following schedule:

$40.00 Base fee per "Permit to Construct, Install or Alter Control Apparatus or Equipment" which fee shall also include the associated initial temporary "Certificate to Operate" and initial permanent "Certificate to Operate Control Apparatus or Equipment".

Plus

An Incremental Additional Service Fee to be derived from the following Table:

INCREMENTAL ADDITIONAL SERVICE FEE

Stack Diameter or Equivalent Stack Diameter		Additional Fee
1	2	3
Not Less Than	But Less Than	
—	5ft.	$ 0.00
5	7	50.00
7	9	100.00
9	12	150.00
12	15	250.00
15	20	350.00
20ft. and Greater		450.00

INSTRUCTIONS

1. Determine the stack diameter range or equivalent stack diameter range (feet).
2. From Columns 1 and 2, locate the applicable stack diameter range.
3. Add the additional service fee in the corresponding entry of Column 3 to the base fee.

(b) Any person subject to the provisions of this Subchapter shall submit with an application for renewal for a permanent "Certificate to Operate Control Apparatus or Equipment", as an integral part thereof, a service fee of $20.00 for each such renewal.

(c) Any person applying for a transfer of title from one person to another for a permanent or a temporary "Certificate to Operate Control Apparatus or Equipment" shall submit a service fee of $10.00 as an integral part of each group of such applications, regardless of the number of Certificates affected by such applications.

(d) Service fees shall be submitted in the form of a certified check or postal order payable to the order of the New Jersey Bureau of Air Pollution Control.

(e) No service fee(s) or portions thereof rendered in accordance with any provisions of this Subchapter shall be returnable except in the case of overpayment due to miscalculation of the required fee.

(f) No additional service fee(s) will be levied if the information on the first submittal is found deficient and the applicant is required to provide additional information provided the additional information does not affect the service fee established in subsection 8.5 (a).

(g) Any person submitting an application for a "Permit to Construct, Install or Alter Control Apparatus or Equipment" for any storage tank shall include, as an integral part thereof, a service fee of $10.00 provided that such an application is solely for the painting of said storage tank subject to the provisions of Subchapter 16 of this Chapter.

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TITLE 27, CHAPTER 27
SUBCHAPTER 9
SULFUR IN FUELS

CONTROL AND PROHIBITION OF AIR POLLUTION FROM SULFUR DIOXIDE CAUSED BY THE COMBUSTION OF FUEL

Filed: January 12, 1968
Effective: May 1, 1968
Revision Promulgated: August 10, 1978
Revision Effective: June 4, 1979
Revision Promulgated: December 6, 1982
Revision Operative: February 4, 1983

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7:27-9.1 Definitions

The following words and terms, when used in this subchapter, shall have the following meanings, unless the context clearly indicates otherwise.

"Aerodynamic downwash" means the rapid descent of a plume to ground level with little dilution and dispersion as a result of alteration of background air flow characteristics caused by the presence of buildings or other obstacles in the vicinity of the emission point.

"Air quality simulation model" means a mathematical procedure for predicting the ambient air concentration of pollutants resulting from the dispersive properties of the atmosphere.

"Ambient Air Quality Standard" means a limit on the concentration of a contaminant in the general outdoor atmosphere, which cannot be exceeded without causing or tending to cause injury to human health, welfare, animal or plant life or property, or unreasonably interfering with the enjoyment of life and property, excluding all aspects of employer-employee relationship as to health and safety hazards.

"Carbon Dioxide (CO_2)" means a colorless, odorless gas at standard conditions, having a molecular composition of one carbon atom and two oxygen atoms.

"Fuel" means gaseous, liquid, or liquefiable petroleum product (excluding coal) which is produced, manufactured, used or sold for the purpose of creating useful heat.

"Fuel oil" means a liquid or liquefiable petroleum product burned for lighting or for the generation of heat or power and derived directly or indirectly from crude oil.

"Mathematical combination" means the summation of the emissions from two or more stacks or chimneys and the regulation of those emissions as if they came from the same sources venting through a single stack.

"Motor vehicle" means any vehicle propelled otherwise than by muscular power, excepting such vehicles as run only upon rails or tracks.

"Municipal Solid Waste (MSW)" means residential, commercial, and institutional non-hazardous solid waste.

"Solid fuel" means solid material or any substance derived from solid material used or to be used for the purpose of creating useful heat and includes, but is not limited to, coal, gasified coal, liquified coal, solid solvent-refined coal, municipal solid waste, refuse-derived fuel, and wood.

"SSU viscosity" means the number of seconds it takes 60 cubic centimeters of an oil to flow through the standard orifice of a Saybolt Universal viscometer at 100 degrees Fahrenheit.

"Stack or chimney" means a flue, conduit or opening designed, constructed, and/or utilized for the purpose of emitting air contaminants into the outdoor air.

"Sulfur Dioxide (SO_2)" means a colorless gas at standard conditions, having a molecular composition of one sulfur atom and two oxygen atoms.

"Viscosity" means the measure of a fluid's resistance to flow.

"Zone 1" means Atlantic, Cape May, Cumberland, and Ocean Counties.

"Zone 2" means Hunterdon, Sussex, and Warren Counties.

"Zone 3" means Burlington, Camden, Gloucester, and Mercer Counties except those municipalities included in Zone 6.

"Zone 4" means Bergen, Essex, Hudson, Middlesex, Monmouth, Morris, Passaic, Somerset, and Union Counties.

"Zone 5" means Salem County.

"Zone 6" means in Burlington County, the municipalities of Bass River Township, Shamong Township, Southampton Township, Tabernacle Township, Washington Township, Woodland Township, and in Camden County, Waterford Township.

7:27-9.2 Sulfur content standards

(a) No person shall store, offer for sale, sell, deliver or exchange in trade for use in New Jersey fuel which contains sulfur in excess of a percentage by weight set forth in Table 1, of this section, except as provided in subsections (c), (d), and (e) below and N.J.A.C. 7:27-9.5.

(b) No person shall use fuel which contains sulfur in excess of a percentage by weight set forth in Table 1, of this section, except as provided in subsections (c), (d), and (e) below and N.J.A.C. 7:27-9.5.

TABLE 1 - MAXIMUM ALLOWABLE SULFUR IN FUEL

Typical Grades of Fuel Oil	Classification by SSU Viscosity at 100°F	Percent Sulfur by Weight			
		Zone 1	Zone 2 & Zone 5	Zone 3	Zone 4 & Zone 6
No. 2 & lighter	Less than or equal to 45, including gases	0.3%	0.3%	0.2%	0.2%
No. 4	Greater than 45 but less than 145	2.0%	0.7%	0.3%	0.3%
No. 5, No. 6 & heavier	Equal to or greater than 145	2.0%	1.0%	0.5%	0.3%

(c) The provisions of (a) and (b) above shall not apply to fuels whose combustion causes sulfur dioxide emissions from any stack or chimney into the outdoor atmosphere which are demonstrated to the Department as not exceeding, at any time, those quantities of sulfur dioxide expressed in pounds per 1,000,000 British Thermal Units (BTU) gross heat input, set forth in Table 2 of this section.

TABLE 2 - MAXIMUM ALLOWABLE SULFUR DIOXIDE EMISSIONS

Typical Grades of Fuel Oil	Classification by SSU Viscosity at 100°F	SO_2 Emissions (lbs./10^6BTU)			
		Zone 1	Zone 2 & Zone 5	Zone 3	Zone 4 & Zone 6
No. 2	Less than or equal to 45	0.32	0.32	0.21	0.21
No. 4	Greater than 45 but less than 145	2.10	0.74	0.32	0.32
No. 5, No. 6 & heavier	Equal to or greater than 145	2.10	1.05	0.53	0.32

(d) The provisions of (a) and (b) above shall not apply to fuels included in an alternative emission control plan based on a mathematical combination approved by the Department. Application for such approval shall be made to the Department in writing and must include:

1. Certification that all source operations to be included in the mathematical combination are under the control of, or operated by, one person; and

2. Certification that the total sulfur dioxide emissions from the mathematical combination during each 24-hour period will not exceed the quantity of sulfur dioxide expressed in pounds per million BTU gross heat input set forth in Table 2 of this section; and

3. Certification that the total sulfur dioxide emissions from the mathematical combination during each 24-hour period will not exceed the maximum total weight of sulfur dioxide that all the sources in the mathematical combination were allowed to emit at the time of applying; and

4. Identification of each fuel burning unit and stack to be included in the mathematical combination; and

5. Identification of the grades of fuel to be burned in each unit, the maximum sulfur content of each fuel to be burned in each unit, the maximum gross heat input rate for each unit, the higher heating value of each fuel, and the annual fuel use and operating hours per year for each unit; and

6. Applications for Permits to Construct and Certificates to Operate, pursuant to the requirements of N.J.A.C. 7:27-8, for any fuel burning unit which must be altered or for any fuel burning unit in which fuel is to be burned having a sulfur content in excess of the applicable limits specified in Table 1 of this section; and

7. A demonstration by air quality simulation modelling acceptable to the Department, including aerodynamic downwash modelling, unless waived in accordance with the provisions of N.J.A.C. 7:27-9.4, that increases in air contaminants resulting from use of the alternative emission control plan will not cause any ambient air quality standard to be exceeded, or cause any allowable prevention of significant deterioration ambient air increment as established by the United States Environmental Protection Agency to be exceeded; and in areas where an ambient air quality standard is already exceeded, will not cause an increase in ambient air concentrations greater than the threshold increases set forth in Table 1 of N.J.A.C. 7:27-18.3; and

8. Sufficient information to evaluate aerodynamic downwash effects including a site plan, heights of all structures within 1000 feet (305 meters) of the stacks in the mathematical combination, and the topography of the area within 1000 feet (305 meters) of the stacks in the mathematical combination; and

9. A guarantee that fuel analyses will be submitted at intervals specified by the Department.

(e) The provisions of (a), (b), (c), and (d) above shall not apply whenever a person responsible for sulfur dioxide emissions from a facility, into the outdoor air, resulting from the combustion of facility by-products alone, or from the combustion of facility by-products combined with fuels conforming with this section, can demonstrate to the Department that the facility's emissions are predictable and will in no case exceed 310 ppm by volume adjusted to 12 percent carbon dioxide by volume. In such cases, the Department may establish conditions as it deems appropriate including, but not limited to, requiring sampling and analysis of emissions of sulfur dioxide, periodic fuel analysis, and the periodic submission of data.

(f) If the identified grade of fuel oil does not agree with the classification by viscosity set forth in Table 1 and Table 2, then the allowable percent sulfur by weight shall be determined by the viscosity classification.

7:27-9.3 Exemptions

(a) The provisions of this subchapter shall not apply to fuel used by ocean going vessels or in motor vehicles.

(b) The Department will set such standards for the sulfur contents of fuel as may be necessary to prevent violation of air quality standards where it is determined that an aerodynamic downwash problem exists as the result of emissions from a source or sources of air pollution.

7:27-9.4 Waiver of air quality modelling

(a) The Department may waive the air quality simulation modelling requirements of N.J.A.C. 7:27-9.2(d) if the applicant demonstrates that:

1. The effective heights, as determined in accordance with the provisions of (b) below, of the stacks to be included in the mathematical combination are equal, or that the emissions from the fuel having the greatest sulfur content will be discharged to the atmosphere from the stack having the greatest effective height; and

2. The total maximum SO_2 emission rate for all source gases to be included in the mathematical combination is no greater than 800 pounds per hour (363 Kg/hr); and

3. No stack in the mathematical combination is separated from any other stack by a distance, measured from the stack center lines, greater than three times the least effective stack height of any stack included in the mathematical combination; and

4. No stack in the mathematical combination is separated from any other stack by a distance greater than the allowable separation as determined from Figure 1 of this section.

(b) Procedure for Using Figure 1:

1. Determine the effective stack heights in accordance with the provisions of (c) below.

2. Locate the least effective stack height on the left side of Figure 1 of this section.

3. Find the intersection of the least effective stack height and maximum total SO_2 emission rate. Interpolation is permitted.

4. Draw a vertical line from this point to the bottom of the chart to find the maximum allowable separation of the stacks.

(c) The effective stack height of a given stack for the purposes of this subchapter is the lesser of the following values:

1. 650 feet; or

2. The sum of the physical stack height and the plume rise. Plume rise is calculated from the formula:

$$h = \frac{9.5}{u}\left[\frac{vd^2(T-68)}{T+460}\right]^{0.75} \quad \text{where:}$$

h is the plume rise in feet,

u is 12 if the physical stack height is less than 65 feet; u is 5 for physical stack heights of 65 feet or greater,

v is the actual exit velocity of the stack gas in feet per second,

d is the inside diameter of the stack exit in feet, and

T is the temperature of the stack gas at the stack exit, in degrees Fahrenheit.

7:27-9.5 Incentive for conversion to coal or other solid fuel

(a) The Department may authorize a person to store, offer for sale, sell, deliver, exchange in trade or use fuel oils having a sulfur content in excess of the maximum allowable amounts set forth in Table 1 of N.J.A.C. 7:27-9.2 provided that:

1. The fuel burning unit in which the high-sulfur oil is used, or a unit of comparable capacity at the same facility, will burn coal

or other solid fuel in accordance with a schedule approved by the Department; and

2. The high-sulfur oil will be burned for no longer than a period of two years if an existing fuel burning unit is converted from burning oil or gas, or three years if the conversion is accomplished by the installation of a new fuel burning unit; and

3. The applicant demonstrates by air quality simulation modelling or other methods acceptable to the Department that increases in the emissions of air contaminants resulting from the use of the high-sulfur oil will not cause any ambient air quality standard to be exceeded, and in areas where an ambient air quality standard is already exceeded, will not cause an increase in ambient air concentrations greater than the threshold increases set forth in Table 1 of N.J.A.C. 7:27-18.3; and

4. The sulfur dioxide emissions from the burning of coal or other solid fuel will not exceed 0.3 pounds of sulfur dioxide per million BTU gross heat input; and

5. The applicant obtains an approved Permit to Construct and Certificate to Operate, in accordance with the provisions of N.J.A.C. 7:27-8, for the conversion to coal or other solid fuel; and

6. The applicant agrees that if the conversion does not take place pursuant to (a)1 above, he will pay to the Department a sum of money no less than the difference between the cost of the high-sulfur oil used pursuant to the provisions of this section and the cost of the same grade oil which would otherwise be required under the provisions of N.J.A.C. 7:27-9.2. Such payment shall be in addition to, and not in lieu of, any penalty which may be required pursuant to the New Jersey Air Pollution Control Act, N.J.S.A. 26:2C-1 et seq.; and

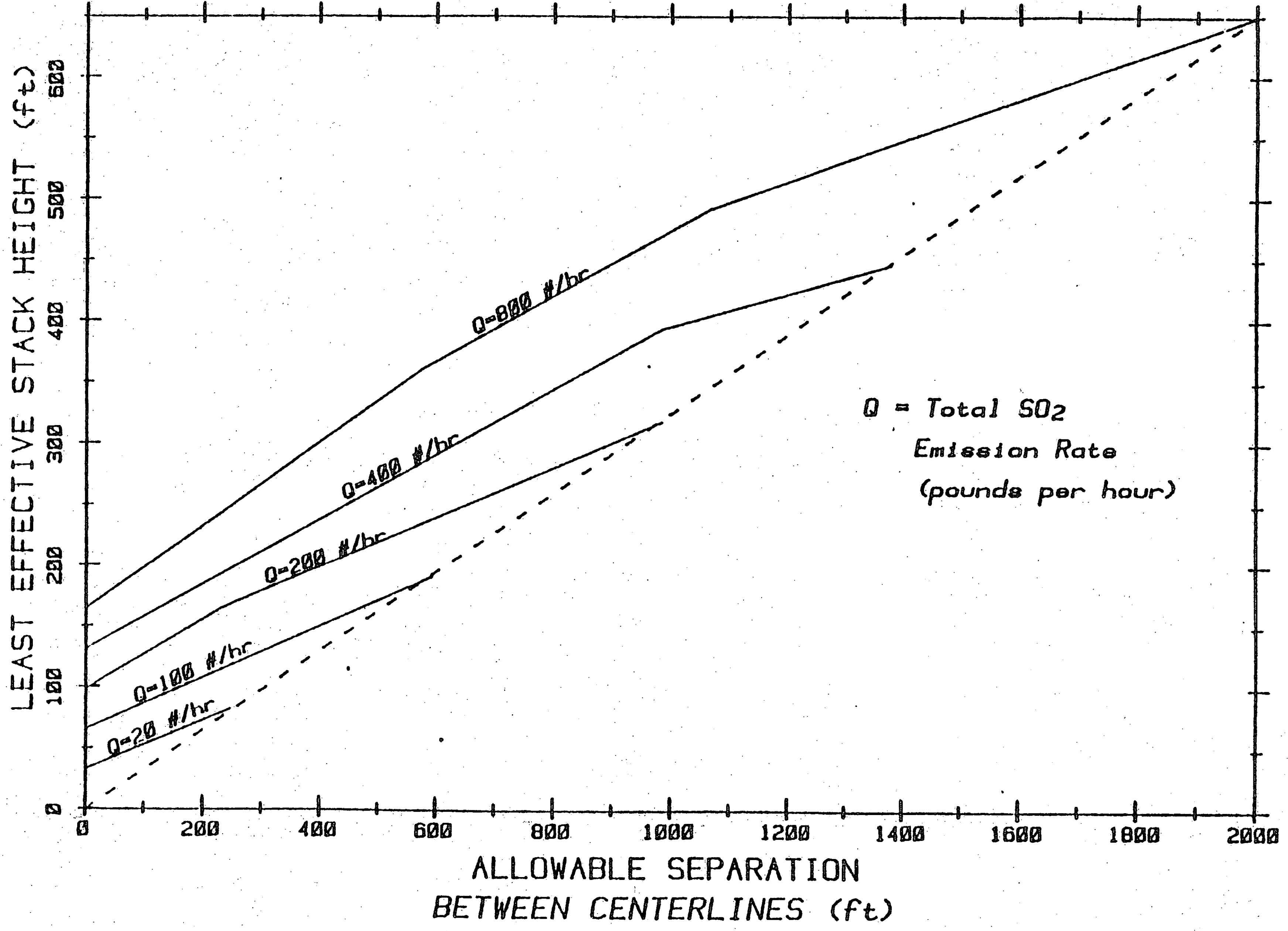
7. The applicant will furnish to the Department a written monthly report stating the quantity of high-sulfur oil used, the cost of such oil, and the cost of an equivalent quantity of the same grade oil which conforms to the provisions of N.J.A.C. 7:27-9.2; and

8. The applicant attests to his commitment to honor and comply with all of the provisions of this section and any other provisions the Department deems appropriate, by entering into a Consent Order, which shall so state, with the Department; and

9. Such Consent Order shall be subject to modification or revocation by the Department if the Department determines that the emissions from the burning of high-sulfur oil contribute to a contravention of any applicable ambient air quality standard, or significantly degrade ambient air quality, or that the applicant has failed to honor or comply with its provisions in part or in whole.

Figure 1

ALLOWABLE SEPARATION BETWEEN CENTERLINES OF STACKS



NEW JERSEY STATE DEPARTMENT OF ENVIRONMENTAL PROTECTION

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SUBCHAPTER 10

SULFUR IN SOLID FUELS

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Revision Effective: July 14, 1981

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7:27-10.1 DEFINITIONS

The following words and terms, when used in this Subchapter, shall have the following meanings, unless the context clearly indicates otherwise.

"Anthracite coal" means coal that is classified as anthracite according to the American Society for Testing and Materials Standard Specification for Classification of Coals by Rank, ASTM D 388-77.

"Approved stack-gas cleaning process" means a process which removes sulfur dioxide from the products of combustion of solid fuel and which has been approved by the Department.

"Bituminous coal" means coal that is classified as bituminous according to the American Society for Testing and Materials Standard Specification for Classification of Coals by Rank, ASTM D 388-77.

"Coal" means anthracite coal, bituminous coal, coke, lignite, nonbanded coal, and subbituminous coal.

"Coke" means a fused, cellular, porous structure that remains after free moisture and the major portion of the volatile materials have been distilled from bituminous coal and other carbonaceous material by the application of heat in the absence of air or in the presence of a limited supply of air.

"Control apparatus" means any device which prevents or controls the emission of any air contaminant.

"Lignite" means coal that is classified as lignite A or B according to the American Society for Testing and Materials Standard Specification for Classification of Coals by Rank, ASTM D 388-77.

"Nonbanded coal" means coal that is classified as nonbanded according to the American Society for Testing and Materials Standard Definition of Terms Relating to Megascopic Description of Coal and Coal Beds and Microscopical Description and Analysis of Coal, ASTM D 2796-77.

"Potential combustion emission rate" means the theoretical emission rate that would result from the combustion of a fuel in an uncleaned state without control apparatus.

"Reconstruction" means the replacement of components of an existing facility to such an extent that the fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct an entirely new comparable facility.

"Resource recovery facility" means a facility that combusts more than 75 percent non-fossil fuel based on the moving average of heat input during 3-month periods.

"Solid fuel" means solid material or any substance derived from solid material used or to be used for the purpose of creating useful heat and includes, but is not limited to, coal, gasified coal, liquified coal, solid solvent-refined coal, municipal solid waste, refuse-derived fuel, and wood.

"Stack or chimney" means a flue, conduit or opening designed, constructed, and/or utilized for the purpose of emitting air contaminants into the outdoor air.

"Steam generating unit" means any furnace, boiler, or other device used for combusting fuel for the purpose of producing steam.

"Subbituminous coal" means coal that is classified as subbituminous according to the American Society for Testing and Materials Standard Specification for Classification of Coals by Rank, ASTM D 388-77.

"Sulfur dioxide (SO_2)" means a colorless gas at standard conditions, having a molecular composition of one sulfur atom and two oxygen atoms.

"Zone One" means Atlantic, Cape May, Cumberland, and Ocean Counties.

"Zone Two" means Hunterdon, Sussex, and Warren Counties.

"Zone Three" means Burlington, Camden, Gloucester, Mercer, and Salem Counties.

"Zone Four" means Bergen, Essex, Hudson, Middlesex, Monmouth, Morris, Passaic, Somerset, and Union Counties.

7:27-10.2 SULFUR CONTENT STANDARDS

(a) No person shall store, offer for sale, sell, deliver or exchange in trade, for use in New Jersey, solid fuel which contains sulfur in excess of the percentages by weight set forth in Table 1, except as provided otherwise in this Subchapter.

(b) No person shall use in New Jersey, solid fuel which contains sulfur in excess of the percentages by weight set forth in Table 1.

TABLE 1

EXISTING SOLID FUEL BURNING UNITS

Type Fuel	Maximum Allowable Percent Sulfur by Weight (Dry Basis)			
	Zone One	Zone Two	Zone Three	Zone Four
Anthracite Coal and Coke	0.8	0.8	0.8	0.8
All other solid fuels	1.0	1.0	0.2	0.2

(c) The provisions of subsections (a) and (b) of this Section shall not apply to solid fuel whose combustion causes sulfur dioxide (SO_2) emissions from any stack or chimney into the outdoor atmosphere which are demonstrated to the Department as not exceeding, at any time, those quantities of sulfur dioxide expressed in pounds per 1,000,000 British Thermal Units (BTU) gross heat input, set forth in Table 2.

TABLE 2

EXISTING SOLID FUEL BURNING UNITS

Type Fuel	Maximum Allowable SO_2 Emissions (pounds/million BTU)			
	Zone One	Zone Two	Zone Three	Zone Four
Anthracite Coal and Coke	1.2	1.2	1.2	1.2
All other solid fuels	1.5	1.5	0.3	0.3

(d) Any solid fuel-fired steam generating unit which is located in Zone Three or Zone Four, having a rated hourly capacity of greater than 200,000,000 British Thermal Units (BTU) gross heat input and any group of units at one facility which is located in Zone Three or Zone Four, having a combined rated hourly capacity of greater than 450,000,000 British Thermal Units (BTU) gross heat input, and which were in operation prior to May 6, 1968, shall be subject to the standards specified in Table 1 for Zone One.

(e) Any person responsible for the use of bituminous coal who believes that bituminous coal containing a maximum allowable percent sulfur by weight as set forth in Table 1 cannot be used in a specific steam generating unit may submit data to the Department setting forth justification for a less restrictive percent of sulfur content by weight in bituminous coal. The Department may authorize the use of a less restrictive percent of sulfur by weight in bituminous coal. Any less restrictive percent of sulfur content by weight in bituminuous coal authorized by the Department shall not exceed 1.5 percent, except as provided in subsection (f) of this Section.

(f) The Department may authorize the use of bituminous coal not exceeding a maximum sulfur content of 3.5 percent by weight (dry basis) at existing facilities in Zone One if:

1. The person responsible for the use of bituminous coal demonstrates that bituminous coal, containing one percent sulfur or less by weight and suitable for use in the specific steam generating unit, is not reasonably available in sufficient quantities; and

2. Sulfur dioxide levels in the ambient atmosphere will at no time exceed or jeopardize the ambient air quality standards set forth in Subchapter 13 of this Chapter; and

3. The sulfur content of the bituminous coal burned at the facility represents the minimum sulfur content coal which can be used by the facility and is reasonably available in sufficient quantity; and

4. The person responsible for the use of bituminous coal agrees to such monitoring and reporting requirements as the Department may deem appropriate to ensure compliance with the conditions set forth in this subsection; and

5. The person responsible for the use of bituminous coal submits to the Department for such authorization an application which considers and addresses as a minimum, in addition to the above, the following criteria:

i. Physical surroundings of the coal-fired steam generating unit;

ii. Population density of the surrounding area;

iii. Dispersion characteristics of the source;

iv. Topography of the immediate vicinity; and

v. Aesthetic and nuisance effects.

(g) Authorizations granted pursuant to subsection (f) of this Section shall be valid for a period not to exceed five years from the date of issuance and may be renewed upon application to the Department, setting forth reasons and justifications for such renewal, including a demonstration of continued conformance with the provisions of subsection (f) of this Section.

7:27-10.3 EXPANSION, RECONSTRUCTION OR CONSTRUCTION OF SOLID FUEL BURNING UNITS

(a) No person shall expand or reconstruct an existing solid fuel-fired steam generating unit or construct a new solid fuel-fired steam generating unit having a rated hourly capacity that exceeds, or would exceed, as a result of expansion, construction, and/or reconstruction, 250,000,000 British Thermal Units (BTU) gross heat input unless it is demonstrated to the Department that:

1. The sulfur dioxide emissions caused by the combustion of solid fuel from any stack or chimney into the outdoor atmosphere, except as provided under subsections (a) 2 or (a) 3 of this Section, do not exceed 0.60 pounds of sulfur dioxide per 1,000,000 British Thermal Units (BTU) gross heat input and 30 percent of the potential combustion emission rate of sulfur dioxide determined as a 30-day rolling average; or

2. The sulfur dioxide emissions from a unit which combusts anthracite coal exclusively do not exceed 1.20 pounds of sulfur dioxide per 1,000,000 British Thermal Units (BTU) gross heat input determined as a 30-day rolling average; or

3. The sulfur dioxide emissions, if the unit is a resource recovery facility, do not exceed 1.20 pounds of sulfur dioxide per 1,000,000 British Thermal Units (BTU) gross heat input determined as a 30-day rolling average.

(b) Compliance with the standards of subsection (a) of this Section shall be determined in accordance with the provisions of 40 CFR Part 60 Subpart Da.

(c) No person shall expand or reconstruct an existing solid fuel-fired steam generating unit or construct a new solid fuel-fired steam generating unit, not subject to the provisions of subsection (a) of this Section, having a rated hourly capacity that equals or exceeds, or would equal or exceed as a result of expansion, construction, and/or reconstruction, 1,000,000 British Thermal Units (BTU) gross heat input unless it is demonstrated to the Department that:

1. The sulfur dioxide emissions, caused by the combustion of solid fuel, excluding coke and anthracite coal, from any stack or chimney into the outdoor atmosphere can be controlled to levels that do not exceed at any time 0.30 pounds of sulfur dioxide per 1,000,000 British Thermal Units (BTU) gross heat input; or

2. The solid fuel, excluding coke and anthracite coal, used to fire such a facility will at no time contain more than 0.20 percent sulfur by weight; or

3. Anthracite coal or coke used to fire such a facility will at no time contain more than 0.8 percent sulfur by weight; or

4. The sulfur dioxide emissions, if the unit is a resource recovery facility, do not exceed 1.20 pounds of sulfur dioxide per 1,000,000 British Thermal Units (BTU) gross heat input determined as a 30-day rolling average.

7:27-10.4 EXEMPTIONS

(a) The provisions of this Subchapter shall not apply to coal used by ocean-going vessels.

(b) In any case in which it is demonstrated to the Department that a bona fide pilot installation of an approved stack-gas cleaning process is to be made, the use of nonconforming solid fuel to the extent necessary, in the judgement of the Department, to evaluate the effectiveness of the process will not be prohibited by this Subchapter.

(c) Nonbanded coal containing not more than 1.0 percent sulfur by weight may be burned solely for heating purposes in one or two family residences only in combustion equipment in use for such purposes prior to October 1, 1971.

NEW JERSEY STATE DEPARTMENT OF ENVIRONMENTAL PROTECTION

NEW JERSEY ADMINISTRATIVE CODE

TITLE 7, CHAPTER 27

SUBCHAPTER 11

INCINERATORS

Promulgated: June 12, 1968
Effective: August 15, 1968

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7:27-11.1 DEFINITIONS

The following words and terms, when used in this Subchapter, shall have the following meanings, unless the context clearly indicates otherwise.

"Auxiliary fuel" means fuel other than waste materials used to attain temperatures sufficiently high to dry and ignite waste materials, to maintain ignition, or to effect complete combustion of combustible solids, vapors and gases.

"Common incinerator" means an incinerator designed and used to burn waste materials of Types 0, 1, 2, and 3 only, in all capacities not exceeding 2,000 pounds per hour of waste material input.

"Control apparatus" means any device which prevents or controls the emission of any air contaminant.

"Department" means the State Department of Environmental Protection.

"Existing incinerator" means an incinerator purchased, acquired, or used before the effective date of this Subchapter.

"Incinerator" means any device, apparatus, equipment or structure used for destroying, reducing or salvaging by fire any material or substance including but not limited to refuse, rubbish, garbage, trade waste, debris or scrap or a facility for cremating human or animal remains.

"Liquid particles" means particles which have volume but are not of rigid shape and which upon collection tend to coalesce and create uniform homogeneous films upon the surface of the collecting media.

"Multiple chamber incinerator" means an incinerator with two or more refractory-lined combustion chambers in series physically separated by refractory walls, interconnected by gas passages, and employing adequate design parameters necessary for maximum combustion of the waste materials.

"Municipal incinerator" means an incinerator owned or operated by government or by a person who provides incinerator service to government or others, and designed and used to burn waste materials of any and all types, 0 to 6 inclusive.

"New incinerator" means an incinerator purchased or constructed after the effective date of this Subchapter.

"Particles" means any material, except uncombined water, which exists in a finely divided form as liquid particles or solid particles at standard conditions.

"Pathological waste incinerator" means an incinerator designed and used to burn Type 4 waste materials, primarily human and animal remains, in all burning capacities. Crematoriums are included in this category.

"Ringelmann smoke chart" means the "Ringelmann Scale for Grading the Density of Smoke" published by the United States Bureau of Mines or any chart, recorder, indicator or device for the measurement of smoke density which is approved by the Department as the equivalent of the Ringelmann Scale.

"Single flue-fed incinerator" means an incinerator provided with a single flue which serves as both the charging chute and the flue to transport products of combustion to the atmosphere.

"Smoke" means and includes small gas-borne and airborne particles arising from a process of combustion in sufficient number to be observable.

"Solid particles" means particles of rigid shape and definite volume.

"Special incinerator" means a municipal, pathological waste, or trade waste incinerator of any burning capacity, or any incinerator with a burning capacity in excess of 2,000 pounds per hour.

"Standard conditions" means 70 degrees Fahrenheit and one atmosphere pressure (14.7 psia or 760 mm Hg).

"Trade waste incinerator" means an incinerator designed and used to burn waste material primarily of Types 5 and 6, either separately or together with waste materials of Types 0, 1 and 3.

"Type 0 waste" means trash, a mixture of highly combustible waste such as paper, cardboard, cartons, wood boxes and combustible floor sweepings, containing approximately ten percent moisture and five percent incombustible solids, and having a heating value of approximately 8500 British Thermal Units per pound as fired, and deriving from commercial and industrial activities. The mixtures contain up to ten percent by weight of plastic bags, coated paper, laminated paper, treated corrugated cardboard, oily rags, and plastic or rubber scraps.

"Type 1 waste" means rubbish, a mixture of combustible waste such as paper, cardboard cartons, wood scraps, foliage and combustible floor sweepings, containing approximately 25 percent moisture and ten percent incombustible solids and having a heating value of approximately 6500 British Thermal Units per pound as fired, and deriving from domestic, commercial and industrial activities. The mixture contains up to 20 percent by weight of restaurant or cafeteria waste, but contains little or no treated paper, plastic or rubber wastes.

"Type 2 waste" means refuse, consisting of an approximately even mixture of rubbish and garbage by weight, containing up to 50 percent moisture and approximately 4300 British Thermal Units per pound as fired, and commonly deriving from apartment and residential occupancy.

"Type 3 waste" means garbage, consisting of animal and vegetable wastes containing up to 70 percent moisture and up to five percent incombustible solids and having a heating value of approximately 2500 British Thermal Units per pound as fired and deriving from restaurants, cafeterias, hotels, hospitals, markets, and like installations.

"Type 4 waste" means human and animal remains, consisting of carcasses, organs and solid organic wastes from hospitals, laboratories, abattoirs, animal pounds, and similar sources, consisting of up to 85 percent moisture and approximately five percent incombustible solids and having a heating value of approximately 1,000 British Thermal Units per pound as fired.

"Type 5 waste" means by-product waste, gaseous, liquid or semi-liquid, such as tar, paints, solvents, sludge, fumes, and so forth, from industrial operations.

"Type 6 waste" means solid by-product waste, such as rubber, plastics, wood waste and so forth, from industrial operations.

7:27-11.2 CONSTRUCTION STANDARDS

(a) No person shall construct, install, use or cause to be used any existing or new incinerator unless such incinerator is of the multiple chamber type or of a type approved by the Department as being equally effective for the purpose of air pollution control.

(b) Two years from the effective date of this Subchapter, no person shall use or cause to be used an existing incinerator unless such incinerator is of multiple chamber type or type approved by the Department as being equally effective for the purpose of air pollution control.

(c) No person shall construct, install, use, or cause to be used any new single flue-fed incinerator.

7:27-11.3 EMISSION STANDARDS

(a) Particles emission standards shall be as follows:

1. No person shall construct, install, use, or cause to be used any new common incinerator or alter or relocate and use or cause to be used any existing

common incinerator which will emit more than 0.2 grains of particles including ash per cubic foot of dry flue gas at standard conditions corrected to 12 percent carbon dioxide by volume excluding the contribution of auxiliary fuel.

2. No person shall construct, install, use, or cause to be used any new special incinerator or alter or relocate and use or cause to be used any existing special incinerator which will emit more than 0.1 grains of particles including ash per cubic foot of dry flue gas at standard conditions corrected to 12 percent carbon dioxide by volume excluding the contribution of auxiliary fuel.

3. Two years from the effective date of this Subchapter no person shall use or cause to be used any existing common incinerator which will emit more than 0.2 grains of particles, including ash per cubic foot of dry flue gas at standard conditions corrected to 12 percent carbon dioxide by volume excluding the contribution of auxiliary fuel.

4. Two years from the effective date of this Subchapter no person shall use or cause to be used any existing special incinerator which will emit more than 0.1 grains of particles, including ash per cubic foot of dry flue gas at standard conditions corrected to 12 percent carbon dioxide by volume excluding the contribution of auxiliary fuel.

(b) Smoke emission standards shall be as follows:

1. The provisions of Subchapter 3 (Smoke) of this Chapter insofar as they relate to smoke from incinerators are superseded by this subsection.

2. No person shall cause, suffer, allow or permit smoke from any incinerator the shade or appearance of which is darker than Number 1 of the Ringelmann Smoke Chart.

i. To be emitted into the open air; or

ii. To be emitted of such opacity within a stack or chimney, or exclusive of water vapor, of such opacity leaving a stack or chimney to a degree greater than the emission designated at Number 1 of the Ringelmann Smoke Chart.

3. The provisions of paragraph 2 of this Subsection shall not apply to:

i. Smoke emitted during the building of a new fire the shade or appearance of which is not greater than Number 2 of the Ringelmann Smoke Chart for a period of three consecutive minutes; or

ii. Emissions of such opacity within a stack or chimney, or exclusive of water vapor, of such opacity leaving a stack or chimney to a degree greater than the emission designated as Number 2 of the Ringelmann Smoke Chart for a period not greater than three consecutive minutes.

(c) No person shall cause, suffer, allow, or permit the emission of particles of unburned waste or ash from any common incinerator or from any special incinerator which are individually large enough to be visible while suspended in the atmosphere.

(d) No person shall construct, install, use or cause to be used any common incinerator or any special incinerator which will result in odors being detectable by sense of smell in any area of human use or occupancy.

(e) Stack test emission standards shall be as follows:

1. Any person responsible for the construction, installation, alteration, or use of an incinerator shall, when ordered by the Department, provide the facilities and necessary equipment for determining the density of smoke being discharged from a stack or chimney and shall conduct such smoke tests using methods approved by the Department. All smoke test data shall be recorded in a permanent log at such time intervals as specified by the Department. The data shall be maintained for a period of not less than one year and shall be available for review by the Department.

2. Any person responsible for the use of a new or existing incinerator shall upon request of the Department provide such sampling facilities and testing facilities exclusive of instruments and sensing devices as may be necessary for the Department to determine the nature and quantity of emissions from such incinerators and shall during such testing, operate the incinerator at a charging rate of waste no less than the designed capacity of the incinerator using materials representative of the types of wastes normally burned. Such facilities may be either permanent or temporary, at the discretion of the person responsible for their provision, and shall conform to all applicable laws and regulations concerning safe construction or safe practice.

7:27-11.4 PERMIT TO CONSTRUCT: CERTIFICATE TO OPERATE

(a) No person shall construct or install any new incinerator, or any new control apparatus, or alter any existing incinerator, or any existing control apparatus without first having obtained a permit to construct, install or alter control apparatus or equipment from the Department, in accordance with the provisions of Subchapter 8 (Permits and Certificates) of this Chapter.

(b) No person shall use or cause to be used any new or altered incinerator, or any new or altered control apparatus without first having obtained a certificate to operate control apparatus or equipment from the Department, in accordance with the provisions of Subchapter 8 (Permits and Certificates) of this Chapter.

7:27-11.5 OPERATION

(a) Written procedures to be followed for proper operation and maintenance for a new incinerator, or an altered existing incinerator, shall be submitted to the Department for review and approval together with the application for a certificate to operate.

(b) Any person in possession of a certificate to operate an incinerator shall maintain said certificate readily available on the operating premises. Operating procedures and rated burning capacity of the incinerator shall be posted at a convenient place as near as practical to the point of operation.

(c) No person shall use or cause to be used any incinerator unless all components connected, or attached to, or serving the incinerator, including control apparatus, are functioning properly and are in use, in accordance with the permit to construct, and the certificate to operate.

7:27-11.6 EXCEPTIONS

The provisions of this Subchapter shall not apply to incinerators installed or used in one or two-family dwellings or in multi-occupied dwellings containing six or less family units one of which is owner occupied.

NEW JERSEY STATE DEPARTMENT OF ENVIRONMENTAL PROTECTION

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TITLE 7, CHAPTER 27

SUBCHAPTER 12

PREVENTION AND CONTROL OF AIR POLLUTION EMERGENCIES

Promulgated: August 25, 1969
Effective: October 24, 1969

Revision Promulgated: January 27, 1972
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7:27-12.1 DEFINITIONS

The following words and terms, when used in this Subchapter, shall have the following meanings, unless the context clearly indicates otherwise.

"Air contaminant" means solid particles, liquid particles, vapors or gases which are discharged into the outdoor atmosphere.

"Chemical and allied products industries" means establishments engaged in the manufacture of:

1. Basic chemicals such as acids, alkalies, salts, industrial gases and organic chemicals;

2. Chemical products to be used in further manufacturing such as synthetic fibers, plastics, dry colors and pigments.

3. Finished chemical products to be used for ultimate consumption such as drugs, cosmetics, soap, paints, fertilizers and explosives.

"Glass, clay and concrete products industries" means establishments engaged in the manufacture of glass, glassware, textile fibers, glass insulation wool, structural clay products, concrete products, gypsum and plaster products, lime, abrasives and asbestos.

"Paper and allied products industries" means establishments engaged in manufacturing wood pulp from wood or other materials and the manufacture of paper, paperboard and building papers.

"Petroleum refining and related industries" means establishments engaged in petroleum refining, the manufacture of paving and roofing materials from petroleum products and compounding paving and building materials from petroleum products.

"Primary metals industries" means establishments engaged in the smelting, refining, sintering and alloying of ferrous and nonferrous metals from ore, pig or scrap, and the manufacture of castings, forgings, powdered metals and other basic products of ferrous or nonferrous metals, including the production of coke.

7:27-12.2 EMERGENCY CRITERIA

(a) A condition justifying proclamation by the Governor of an air pollution alert, air pollution warning, or air pollution emergency shall be deemed to exist whenever the Commissioner determines that the accumulation of air contaminants in any place, locality, county or other area in the State is attaining or has attained levels which could, if such levels are sustained or exceeded, lead to a threat to the health of the public.

(b) Such determinations shall be in accordance with criteria published in the New Jersey Register and on file with the Department.

7:27-12.3 CRITERIA FOR EMERGENCY TERMINATION

In making a determination that the threat resulting from the accumulation of air contaminants no longer exists, the Commissioner shall be guided by measurements of air quality and advisories provided by the United States Weather Service.

7:27-12.4 STANDBY PLANS

(a) Any person responsible for the operation of a source of air contamination as set forth in Table 1 of this Section shall prepare standby plans, consistent with good industrial practice and safe operating procedures, for reducing the emission of air contaminants into the outdoor atmosphere during periods of an air pollution alert, air pollution warning, and air pollution emergency. Standby plans shall be designed to reduce or eliminate emissions of air contaminants into the outdoor atmosphere in accordance with the objectives set forth in Tables I-III which are made a part of this Section.

(b) Any person responsible for the operation of a source of air contamination not set forth in Table 1 of this Section, shall, when requested by the Department in writing, prepare standby plans, consistent with good industrial practice and safe operating procedures, for reducing the emission of air contaminants into the outdoor atmosphere during periods of an air pollution alert, air pollution warning, and air pollution emergency. Standby plans shall be designed to reduce or eliminate emissions of air contaminants into the outdoor atmosphere in accordance with the objectives set forth in Tables I-III.

(c) Standby plans as required under subsections (a) and (b) of this Section shall be in writing and show the source of air contamination, the approximate amount of reduction of contaminants and a brief description of the manner in which the reduction will be achieved during an air pollution alert, air pollution warning, and air pollution emergency.

(d) During a condition of air pollution alert, air pollution warning and air pollution emergency, standby plans as required by this Section shall be made available on the premises to any person authorized to enforce the provisions of the Air Pollution Emergency Control Act.

(e) Standby plans as required by this Section shall be submitted to the Department upon request within 30 days of the receipt of such request; such standby plans shall be subject to review and approval by the Department. If, in the opinion of the Department, such standby plans do not effectively carry out the objectives as set forth in Tables I-III, the Department may disapprove said standby plans, state its reason for disapproval and order the preparation of amended standby plans within the time period specified in the order. Any person aggrieved by the order requiring the preparation of a revised plan is entitled to a hearing in accordance with C.26:2C-14.1 of the Air Pollution Control Act. If the person responsible fails within the time period specified in the order to submit an amended standby plan which in the opinion of the Department meets the said objectives, the Department may revise the standby plan to cause it to meet these objectives. Such revised plan will thereafter be the standby plan which the person responsible will put into effect upon the issuance of an appropriate order by the Governor.

7:27-12.5 STANDBY ORDERS

(a) The following are standby orders which might be appropriate for use by the Governor upon his declaration that an air pollution emergency exists:

1. Air pollution alert:

i. Any person responsible for the operation of a source of air contamination as set forth in Table I of Section 4 (Standby plans) of this Subchapter shall take all air pollution alert actions as required for such source of air contamination; and shall particularly put into effect the standby plans for an air pollution alert:

ii. There shall be no open burning by any persons of tree waste, vegetation, refuse or debris in any form;

iii. The use of incinerators for the disposal of any form of solid or liquid waste shall be limited to hours between 12:00 Noon and 4:00 p.m.;

iv. Persons operating fuel-burning equipment which requires boiler lancing or soot blowing shall perform such operations only between the hours of 12:00 Noon and 4:00 p.m.

2. Air pollution warning:

i. Any person responsible for the operation of a source of air contamination as set forth in Table II of Section 4 (Standby plans) of this Subchapter shall take all air pollution warning actions as required for such source of air contamination; and shall particularly put into effect the standby plans for an air warning:

ii. There shall be no open burning by any persons of tree waste, vegetation, refuse or debris in any form;

iii. The use of incinerators for the disposal of any form of solid waste or liquid waste shall be prohibited;

iv. Persons operating fuel-burning equipment which requires boiler lancing or soot blowing shall perform such operations only between the hours of 12:00 Noon and 4:00 p.m.

3. Air pollution emergency:

i. Any person responsible for the operation of a source of air contamination as described in Table III of Section 4 (Standby plans) of this Subchapter shall take all air pollution emergency actions as listed as required for such source of air contamination; and shall particularly put into effect the standby plans for an air pollution emergency;

ii. All manufacturing establishments except those included in subparagraph i. of this paragraph will institute such action as will result in maximum reduction of air contaminants from their operations by ceasing, curtailing or postponing operations which emit air contaminants to the extent possible without causing injury to persons or damage to equipment;

iii. All places of employment described in this subparagraph shall immediately cease operations:

(1) Mining and quarrying of nonmetallic minerals;

(2) All contract construction work except that which must proceed to avoid physical harm;

(3) Wholesale trade establishments, that is places of business primarily engaged in selling merchandise to retailers, to industrial, commercial, institutional or professional users, or to other wholesalers, or acting as agents in buying merchandise for or selling merchandise to such persons or companies;

(4) All offices of local, county and State government including authorities, joint meetings and any other public body; except to the extent that such offices must continue to operate in order to enforce the requirements of this order pursuant to statute;

(5) All retail trade establishments except pharmacies and stores primarily engaged in the sale of food;

(6) Banks; credit agencies other than banks; securities and commodities brokers, dealers, exchanges and services; offices of insurance carriers, agents and brokers; real estate offices;

(7) Wholesale and retail laundries; laundry services and cleaning and dyeing establishments; photographic studios; beauty shops, barber shops; shoe repair shops;

(8) Advertising offices; consumer credit reporting, adjustment and collection agencies; duplicating, addressing, blueprinting; photocopying, mailing, mailing list and stenographic services; equipment rental services; commercial testing laboratories;

(9) Automobile repair, automobile services, garages;

(10) Establishments rendering amusement and recreation services including motion picture theaters;

(11) Elementary and secondary schools, colleges, universities, professional schools, junior colleges, vocational schools and public and private libraries.

iv. There shall be no open burning by any person of tree waste, vegetation, refuse or debris in any form;

v. The use of incinerators for the disposal of any form of solid or liquid waste shall be prohibited;

vi. The use of motor vehicles is prohibited except in emergencies with the approval of local or State police.

TABLE I - EMISSION REDUCTION OBJECTIVES

Source of Air Contamination	Air Pollution Alert
1. Coal or oil-fired electric power generating facilities.	a. Substantial reduction by utilization of fuels having lowest available ash and sulfur content. b. Maximum utilization of mid-day (12:00 Noon to 4:00 p.m.) atmospheric turbulence for boiler lancing and soot blowing. c. Substantial reduction by diverting electric power generation to facilities outside of Alert Area.
2. Coal or oil-fired process steam generating facilities having a capacity to burn in excess of four tons of coal per hour or 600 gallons of fuel oil per hour.	a. Substantial reduction by utilization of fuels having lowest available ash and sulfur content. b. Maximum utilization of mid-day (12:00 Noon to 4:00 p.m.)atmospheric turbulence for boiler lancing and soot blowing. c. Reduction of steam load demands consistent with continuing plant operations.
3. A. Manufacturing industries of the following classifications which employ more than twenty (20) employees at any one location: Primary Metals Industries Petroleum Refining and Related Industries Chemical and Allied Products Industries Paper and Allied Products Industries Glass, Clay and Concrete Products Industries AND B. Other persons required by the Department to prepare standby plans.	a. Substantial reduction of air contaminants from manufacturing operations by curtailing, postponing, or deferring production and allied operations. b. Maximum reduction by deferring trade waste disposal operations which emit particles, gases, vapors or malodorous substances. c. Reduction of heat load demands for processing consistent with continuing plant operations. d. Maximum utilization of mid-day (12:00 Noon to 4:00 p.m.) atmospheric turbulence for boiler lancing or soot blowing.
4. Municipal and commercial refuse disposal operations.	a. Maximum reduction by prevention of open burning on all refuse disposal areas. b. Substantial reduction by limiting burning of refuse in incinerators to the hours between 12:00 Noon and 4:00 p.m.

TABLE II - EMISSION REDUCTION OBJECTIVES

Source of Air Contamination	Air Pollution Warning
1. Coal or oil-fired electric power generating facilities.	a. Maximum reduction by utilization of fuels having lowest available ash and sulfur conten
	b. Maximum utilization of mid-day (12:00 Noo to 4:00 p.m.) atmospheric turbulence for boil lancing and soot blowing.
	c. Maximum reduction by diverting electric power generation to facilities outside of Warning Area.
2. Coal or oil-fired process steam generating facilities having a capacity to burn in excess of four tons of coal per hour or 600 gallons of fuel oil per hour.	a. Maximum reduction by utilization of fuels having the lowest available ash and sulfur content.
	b. Maximum utilization of mid-day (12:00 Noon to 4:00 p.m.) atmospheric turbulence for boil lancing and soot blowing.
	c. Reduction of steam load demands consisten with continuing plant operations.
	d. Making ready for use a plan of action to taken if an emergency develops.
3. A. Manufacturing industries of the following classifications which employ more than twenty (20) employees at any one location: Primary Metals Industries Petroleum Refining and Related Industries Chemical and Allied Products Industries Paper and Allied Products Industries AND B. Other persons required by the Department to prepare standby plans.	a. Maximum reduction of air contaminants fro manufacturing operatons by, if necessary, assuming reasonable economic hardship by postponing production and allied operations.
	b. Maximum reduction by deferring trade wast disposal operations which emit particles, gas vapors or malodorous substances.
	c. Reduction of heat load demands for processing consistent with continuing plant operati
	d. Maximum utilization of mid-day (12:00 Noo to 4:00 p.m.) atmospheric turbulence for boil lancing or soot blowing.
4. Municipal and commercial refuse disposal operations.	a. Maximum reduction by prevention of open burning on all refuse disposal areas.
	b. Complete elimination of the use of incinerators.

TABLE III - EMISSION REDUCTION OBJECTIVES

Source of Air Contamination	Air Pollution Emergency
1. Coal or oil-fired electric power generating facilities.	a. Maximum reduction by utilization of fuels having lowest available ash and sulfur content. b. Maximum utilization of mid-day (12:00 Noon to 4:00 p.m.) atmospheric turbulence for boile lancing and soot blowing. c. Maximum reduction by diverting electric power generation to facilities outside of Emergency Area.
2. Coal or oil-fired process steam generating facilities having a capacity to burn in excess of four tons of coal per hour or 600 gallons of fuel oil per hour.	a. Maximum reduction by reducing heat and steam demands to absolute necessities consistent with preventing equipment damage. b. Maximum utilization of mid-day (12:00 Noon to 4:00 p.m.) atmospheric turbulence for boile lancing and soot blowing. c. Taking the action called for in the emergency plan.
3. A. Manufacturing industries of the following classifications which employ more than twenty (20) employees at any one location: Primary Metals Industries Petroleum Refining and Related Industries Chemical and Allied Products Industries Paper and Allied Products Industries AND B. Other persons required by the Department to prepare standby plans.	a. Elimination of air contaminants from manufacturing operations by ceasing, curtailing, postponing or deferring production and allied operations to the extent possible without causing injury to persons or damage to equipment. b. Elimination of air contaminants from trade waste disposal processes which emit particles, gases, vapors or malodorous substances. c. Maximum reduction of heat load demands for processing. d. Maximum utilization of mid-day (12:00 Noon to 4:00 p.m.) atmospheric turbulence for boiler lancing or soot blowing.
4. Municipal and commercial refuse disposal operations.	a. Maximum reduction by prevention of open burning on all refuse disposal areas. b. Complete elimination of the use of incinerators.

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TITLE 7, CHAPTER 27

SUBCHAPTER 13

AMBIENT AIR QUALITY STANDARDS

Promulgated: October 23, 1969
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Revision Promulgated: January 4, 1973
Revision Effective: March 5, 1973

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7:27-13.1 DEFINITIONS

The following words and terms, when used in this Subchapter, shall have the following meanings, unless the context clearly indicates otherwise.

"Air contaminant" means solid particles, liquid particles, vapors or gases which are discharged into the outdoor atmosphere.

"Ambient air quality standard" means a limit on the concentration of a contaminant in the general outdoor atmosphere, which cannot be exceeded without causing or tending to cause injury to human health, welfare, animal or plant life or property, or unreasonably interfering with the enjoyment of life and property, excluding all aspects of employer-employee relationship as to health and safety hazards.

"Carbon monoxide (CO)" means a colorless, odorless, tasteless gas at standard conditions, having a molecular composition of one carbon atom and one oxygen atom and which, for purposes of this Subchapter, shall be collected and analyzed by procedures adopted and published by the Department.

"Department" means the Department of Environmental Protection.

"Hydrocarbons" means gas phase organic compounds consisting of carbon and hydrogen and the oxidation products of such compounds which serve as precursors of photochemical oxidants and which, for purposes of this Subchapter, shall be collected and analyzed by procedures adopted and published by the Department.

"Nitrogen dioxide (NO_2)" means a gaseous compound at standard conditions, having a molecular composition of one nitrogen atom and two oxygen atoms and which, for purposes of this Subchapter, shall be collected and analyzed by procedures published and adopted by the Department.

"Photochemical oxidants" means compounds resulting from atmospheric reactions between reactive organic substances and nitrogen oxides in the presence of sunlight and ozone and which, for purposes of this Subchapter, shall be collected and analyzed by procedures published and adopted by the Department.

"Primary air quality standard" means an ambient air quality standard intended to protect the public health.

"Secondary air quality standard" means an ambient air quality standard intended to protect the public welfare.

"Standard conditions" shall be 70 degrees Fahrenheit and one atmosphere pressure (14.7 psia or 760 mm Hg).

"Sulfur dioxide (SO_2)" means a colorless gas at standard conditions, having a molecular composition of one sulfur atom and two oxygen atoms and which, for purposes of this Subchapter, shall be collected and analyzed by procedures adopted and published by the Department.

"Suspended particulate matter" means any solid or liquid matter dispersed in the outdoor atmosphere which, for purposes of this Subchapter, shall mean the material collected and analyzed by procedures adopted and published by the Department.

7:27-13.2 GENERAL AMBIENT AIR QUALITY STANDARDS

(a) Whereas air is vital to life and contamination of it to any degree is a condition to be endured reluctantly; and whereas our knowledge of the long-term harmful effects of low levels of contamination is incomplete and uncertain; therefore, it is the air quality objective of the Department to assure, at all times and throughout the territory of the State, ambient air of the highest purity achievable by the installation and diligent operation and maintenance of pollution source control devices and methods consistent with the lawful application of the most advanced state of the art.

(b) Furthermore, it is the objective of the Department, by prevention and correction, so to enhance the quality of our outdoor air that as a minimum, and throughout the State, air quality will be in accord at least with the numerical air quality standards for specific pollutants set forth in subsequent Sections of this Subchapter.

(c) An implementation plan of action to meet air quality standards will be adopted by the Department and, from time to time, amended as necessary. The plan will incorporate all pertinent air pollution control regulations which limit or prevent the emission into the atmosphere of air contaminants for which air quality standards have been adopted. The plan also will include interim air quality objectives whose achievement through rigorous enforcement can then be predicted.

7:27-13.3 AMBIENT AIR QUALITY STANDARDS FOR SUSPENDED PARTICULATE MATTER

(a) Primary air quality standards are:

1. During any 12-consecutive months, the geometric mean value of all 24-hour averages of suspended particulate matter concentrations in ambient air shall not exceed 75 micrograms per cubic meter; and

2. During any 12-consecutive months, 24-hour average concentrations may exceed 260 micrograms per cubic meter no more than once.

(b) Secondary air quality standards are:

1. During any 12-consecutive months, the geometric mean value of all 24-hour averages of suspended particulate matter concentrations in ambient air shall not exceed 60 micrograms per cubic meter; and

2. During any 12-consecutive months, 24-hour average concentrations may exceed 150 micrograms per cubic meter no more than once.

7:27-13.4 AMBIENT AIR QUALITY STANDARDS FOR SULFUR DIOXIDE

(a) The primary air quality standards are:

1. During any 12-consecutive months, the arithmetic mean concentration of sulfur dioxide in ambient air shall not exceed 80 micrograms per cubic meter (0.03 ppm): and

2. During any 12-consecutive months, 24-hour average concentrations may exceed 365 micrograms per cubic meter (0.14 ppm) no more than once.

(b) The secondary air quality standards are:

1. During any 12-consecutive months, the arithmetic mean concentration of sulfur dioxide in ambient air shall not exceed 60 micrograms per cubic meter (0.02 ppm); and

2. During any 12-consecutive months, 24-hour average concentrations may exceed 260 micrograms per cubic meter (0.1 ppm) no more than once; and

3. During any 12-consecutive months, three-hour average concentrations may exceed 1,300 micrograms per cubic meter (0.5 ppm) no more than once.

7:27-13.5 AMBIENT AIR QUALITY STANDARDS FOR CARBON MONOXIDE

(a) The primary and secondary air quality standards are:

1. During any 12-consecutive months, the eight-hour average concentration of carbon monoxide in ambient air may exceed ten milligrams per cubic meter (9 ppm) no more than once; and

2. During any 12-consecutive months, one-hour average concentrations may exceed 40 milligrams per cubic meter (35 ppm) no more than once.

7:27-13.6 AMBIENT AIR QUALITY STANDARD FOR PHOTOCHEMICAL OXIDANTS

During any 12-consecutive months, the one-hour average concentration of photochemical oxidants in ambient air may exceed 160 micrograms per cubic meter (0.08 ppm) no more than once.

7:27-13.7 AMBIENT AIR QUALITY STANDARD FOR HYDROCARBONS

During any 12-consecutive months, the average concentration of hydrocarbons, except methane, in ambient air during the three-hour period from 6:00 A.M. to 9:00 A.M. may exceed 160 micrograms per cubic meter (0.24 ppm) no more than once.

7:27-13.8 AMBIENT AIR QUALITY STANDARD FOR NITROGEN DIOXIDE

During any 12-consecutive months, the arithmetic mean concentration of nitrogen dioxide in ambient air shall not exceed 100 micrograms per cubic meter (0.05 ppm).

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SUBCHAPTER 17

CONTROL AND PROHIBITION OF AIR POLLUTION BY TOXIC SUBSTANCES

Promulgated: June 13, 1977
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Revision Effective: December 17, 1979

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7:27-17.1 DEFINITIONS

The following words and terms, when used in this Subchapter, shall have the following meanings, unless the context clearly indicates otherwise.

"Aerodynamic downwash" means the rapid descent of a plume to ground level with little dilution and dispersion due to alteration of background air flow characteristics caused by the presence of buildings or other obstacles in the vicinity of the emission point.

"Air contaminant" means solid particles, liquid particles, vapors or gases which are discharged into the outdoor atmosphere.

"Asbestos" means actinolite, amosite, anthophyllite, chrysotile, crocidolite, tremolite.

"Control apparatus" means any device which prevents or controls the emission of any air contaminant.

"Department" means the Department of Environmental Protection.

"Equipment" means any device capable of causing the emission of an air contaminant into the outdoor atmosphere, and any stack, chimney, conduit, flue, duct, vent or similar device connected or attached to, or serving the equipment. This shall include equipment in which the preponderance of the air contaminants emitted is caused by a manufacturing process.

"Gasoline" means any petroleum distillate having a Reid vapor pressure of four pounds (207 millimeters of mercury) or greater and used as an automotive fuel.

"Liquid particles" means particles which have volume but are not of rigid shape and which upon collection tend to coalesce and create uniform homogeneous films upon the surface of the collecting media.

"Manufacturing process" means any action, operation or treatment embracing chemical, industrial, manufacturing, or processing factors, methods or forms including, but not limited to, furnaces, kettles, ovens, converters, cupolas, kilns, crucibles, stills, dryers, roasters, crushers, grinders, mixers, reactors, regenerators, separators, filters, reboilers, columns, classifiers, screens, quenchers, cookers, digesters, towers, washers, scrubbers, mills, condensers or absorbers.

"Open top tank" means any vessel in which a manufacturing process, or any part thereof, takes place during which there is an opening to the atmosphere greater than 25 percent of the surface area of any liquid substance contained therein.

"Organic substance" means any chemical compound or mixture of chemical compounds of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbonates, metallic carbides, and ammonium carbonate.

"Person" means corporations, companies, associations, societies, firms, partnerships and joint stock companies as well as individuals, and also shall include all political subdivisions of this State or any agencies or instrumentalities thereof.

"Reid vapor pressure" means the absolute vapor pressure of a petroleum product at 100°F (37.8°C) as measured by the standard test method set forth in the American Society for Testing and Materials (ASTM) Designation D 323 or approved equivalent.

"Solid particles" means particles of rigid shape and definite volume.

"Source operation" means any manufacturing process, or any identifiable part thereof, emitting an air contaminant into the outdoor atmosphere through one or more stacks or chimneys.

"Stack or chimney" means a flue, conduit or opening designed, constructed, and/or utilized for the purpose of emitting air contaminants into the outdoor atmosphere.

"Standard conditions" means or shall be 70°F (21.1°C) and one atmosphere pressure (14.7 pounds per square inch absolute or 760.0 millimeters of mercury).

"Storage tank" means any tank, reservoir, or vessel which is a container for liquids or gases, wherein no manufacturing process, or part thereof, takes place.

"Surface cleaner" means a device to remove unwanted foreign matter from the surfaces of non-porous or non-absorbent materials by using VOS solvents in liquid or vapor state.

"Surface coating formulation" means the material including, but not limited to, paint, varnish, ink and adhesive to be applied to a solid surface.

"Surface coating operation" means the application and solidification of a surface coating formulation.

"Tank" means any container whose walls are constructed of material which is rigid and self-supporting.

"Toxic volatile organic substance," herein abbreviated as TVOS, means a substance listed in Table 1 of this Subchapter.

"Transfer operation" means the moving of any substance from any storage tank, manufacturing process vessel, or delivery vessel into any receiving vessel.

"Vapor" means the gaseous form of substances which, under standard conditions, are in the solid or liquid state and which can be changed to these states by either increasing the pressure or decreasing the temperature.

"Vapor pressure" means the pressure of the vapor phase of a substance, or the sum of the partial pressures of the vapor phases of individual substances in a mixture of substances, when in equilibrium with the non-vapor phase of the substance or substances.

"Volatile organic substances," herein abbreviated as VOS, means any organic substances, mixture of organic substances, or mixture of organic and inorganic substances including, but not limited to, petroleum crudes, petroleum fractions, petrochemicals, solvents, diluents, and thinners, excluding methane, which have vapor pressures or partial pressures of organic substances of 0.02 pounds per square inch absolute (1.0 millimeter of mercury) or more measured at standard conditions; and in the case of surface coating formulations, includes any coalescing or other agent, regardless of vapor pressure, which evaporates from the coating during the drying phase.

7:27-17.2 ASBESTOS SURFACE COATING

No person shall cause, suffer, allow or permit surface coating by spraying on any building, structure, facility, installation or internal or external portion thereof, asbestos or friable material containing in excess of 0.25% by weight of asbestos.

7:27-17.3 STORAGE, TRANSFER, AND USE OF TOXIC VOLATILE ORGANIC SUBSTANCES

(a) No person shall cause, suffer, allow or permit any TVOS listed in Table 1 to be emitted from any source operation, storage tank, or transfer operation into the outdoor atmosphere unless such equipment and operation is registered with the Department within six months of the effective date of this Subchapter. Such registration shall include information relating to vessel sizes, transfer rates, emission rates, operating procedures and other information required by the Department and shall be made on forms provided by the Department.

(b) In cases where the Department determines that the equipment or operating procedures as described in the registration do not represent advances in the art of control for the types and kinds of TVOS emitted, the Department will so notify the registrant.

(c) Within three months of such notification, the registrant must advise the Department of measures to be taken for reducing the TVOS emissions to a rate or concentration equivalent to advances in the art of control and the schedule for completing such measures.

(d) Upon notification by the Department that the measures and schedule submitted pursuant to subsection (c) of this Section are acceptable, the registrant shall implement such measures in accordance with the schedule.

(e) If, in the opinion of the Department, the measures or schedule submitted pursuant to subsection (c) of this Section are not acceptable, the Department shall state its reasons and may order the registrant to resubmit, within the time specified in the order, measures to be taken and the schedule for same. If the registrant fails within the time specified to make an acceptable resubmittal, the Department may order the registrant to implement such measures as it deems appropriate within a specified time.

TABLE 1

TOXIC VOLATILE ORGANIC SUBSTANCES

Benzene (Benzol)
Carbon tetrachloride (Tetrachloromethane)
Chloroform (Trichloromethane)
Dioxane (1,4-Diethylene dioxide)
Ethylenimine (Aziridine)
Ethylene dibromide (1,2-Dibromoethane)
Ethylene dichloride (1,2-Dichloroethane)
1,1,2,2-Tetrachloroethane (sym Tetrachloroethane)
Tetrachloroethylene (Perchloroethylene)
1,1,2-Trichloroethane (Vinyl trichloride)
Trichloroethylene (Trichloroethene)

7:27-17.4 DISCHARGE OF TOXIC VOLATILE ORGANIC SUBSTANCES

(a) No person shall cause, suffer, allow or permit any TVOS to be emitted from any source operation into the outdoor atmosphere unless such discharge is:

1. No less than 40 feet (12.2 meters) above grade; and

2. No less than 20 feet (6.1 meters) higher than any area of human use or occupancy within 50 feet (15.2 meters); and

3. Directed vertically upward at a discharge velocity of 3,600 feet per minute (1,097 meters per minute) or greater.

(b) No person shall cause, suffer, allow or permit the emission of a TVOS into the outdoor atmosphere from a system, equipment, or control apparatus not approved by the Department as being effective in preventing aerodynamic downwash.

7:27-17.5 OPERATING INSTRUCTIONS

(a) No person shall cause, suffer, allow or permit the use of TVOS in any open top tank or surface cleaner unless such use is in conformity with written operating, inspection and maintenance instructions prepared in accordance with guidelines issued by the Department.

(b) Any person subject to the provisions of subsection (a) of this Section shall maintain a training program to ensure that all personnel associated with the use or operation of the open top tank or surface cleaner understand and follow the specified procedure.

(c) Copies of operating instructions and maintenance instructions must be located at the open top tank or surface cleaner. Copies shall be supplied to the Department when requested and must be accompanied by similar documents supplied by the equipment manufacturer, with explanations for differences between the two.

(d) The written procedures required by this Section shall be submitted to the Department upon request within 10 days of the receipt of such request; such procedure shall be subject to review and approval by the Department. If, in the opinion of the Department, such procedure does not fulfill the requirements of this Section, the Department may state its reason for disapproval and order the preparation of an amended procedure within the time period specified in the order. If the person responsible fails within the time period specified in the order to submit an amended procedure which, in the opinion of the Department, fulfills the said requirements, the Department may revise the procedure accordingly. Such revised procedure will thereafter be that to which the person responsible must conform.

(e) Any person subject to the provisions of this Section shall notify the Department in writing within 5 days of any revision or alteration of a procedure approved pursuant to the provisions of subsection (d) of this Section. Such written notification shall include a detailed description of the changes in the procedure and the reasons therefor. Such amended procedure shall be subject to review and approval by the Department.

(f) The provisions of this Section shall become effective on January 1, 1981.

7:27-17.6 EMISSION INFORMATION AND TESTS

(a) Any person responsible for the manufacture, application or use of any coating, applied on or after August 15, 1977, which the Department, or any agent thereof, has reason to believe contains asbestos shall, when requested by the Department, conduct such tests as are necessary in the opinion of the Department to determine the presence and the amount and/or kinds of asbestos in the coating. Such tests shall be conducted in a manner approved by the Department and shall be made at the expense of the person responsible.

(b) The Department may waive the testing requirements of subsection (a) of this Section upon receipt of a materials specification report from the material manufacturer certifying that the asbestos content of the surface coating for which testing is required complies with the provisions of Section 17.2 of this Subchapter.

(c) Any person responsible for the emission of TVOS shall, upon request of the Department, provide:

1. Information relating to the location, rate, duration, composition, and properties of the effluent and such other information as the Department may prescribe.

2. Facilities and necessary equipment for determining the quantity and identity of TVOS emitted into the outdoor atmosphere and shall conduct such tests using methods approved by the Department. Test data shall be recorded in a permanent log at such time intervals as specified by the Department and shall be maintained for a period of not less than two years and shall be available for review by the Department.

3. Sampling facilities and testing facilities exclusive of instrumentation and sensing devices as may be necessary for the Department to determine the nature and quantity of TVOS being emitted into the outdoor atmosphere. During such testing by the Department, the equipment and all components connected, or attached to, or serving the equipment shall be used and operated under normal routine operating conditions or under such other conditions as may be requested by the Department. The facilities may be either permanent or temporary, at the discretion of the person responsible for their provision, and shall conform to all applicable laws and regulations concerning safe construction and safe practice.

7:27-17.7 PERMIT TO CONSTRUCT AND CERTIFICATE TO OPERATE

(a) No person shall construct or install any new equipment, or any new control apparatus, or alter any existing equipment or control apparatus from which TVOS are emitted into the outdoor atmosphere without first having obtained a "Permit to Construct, Install or Alter Control Apparatus or Equipment" from the Department, in accordance with the provisions of Subchapter 8 (Permits and Certificates) of this Chapter.

(b) No person shall use or cause to be used any new or altered equipment, or any new or altered control apparatus from which TVOS are emitted into the outdoor atmosphere without first having obtained a "Certificate to Operate Control Apparatus or Equipment" from the Department, in accordance with the provisions of Subchapter 8 (Permits and Certificates) of this Chapter.

(c) No person shall use or cause to be used any equipment or control apparatus from which TVOS are emitted into the outdoor atmosphere unless all components connected, or attached to, or serving the equipment, including control apparatus, are functioning properly and are in use in accordance with any relevant "Permit to Construct, Install or Alter Control Apparatus or Equipment" and any relevant "Certificate to Operate Control Apparatus or Equipment."

7:27-17.8 APPLICABILITY

(a) Operations and equipment covered by this Subchapter shall include, but not be limited to, storage tanks, transfer operations, open top tanks, surface cleaning, surface coating, organic chemical manufacture, pharmaceutical manufacture, petroleum refining, and miscellaneous organic solvent uses in which one or more of the toxic substances in Table 1 are stored, used, or manufactured.

(b) Whenever persons, equipment, control apparatus or TVOS subject to the provisions of this Subchapter are also subject to the provisions of any other Subchapters of this Chapter, the requirements of the relevant provisions of this Subchapter and all Subchapters of this Chapter will apply.

(c) Whenever a TVOS subject to the provisions of this Subchapter is also subject to the provisions of any other Subchapters of this Chapter, the relevant provisions of the Subchapter requiring the lowest allowable rate will apply.

7:27-17.9 EXCEPTIONS

(a) The provisions of Sections 17.3, 17.4, and 17.6(c) of this Subchapter shall not apply to the benzene constituent of gasoline which is discharged to the atmosphere from storage tanks or transfer operations.

(b) The provisions of this Subchapter shall not apply to any TVOS which:

1. Was not added to or deliberately formed in a raw material or a finished product; and

2. Does not exceed 0.25 percent by weight of any raw material or finished product; and

3. Is not emitted from any source operation, storage tank, or transfer operation at a rate in excess of 0.1 pounds (45.4 grams) per hour.

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SUBCHAPTER 18

CONTROL AND PROHIBITION OF AIR POLLUTION FROM NEW OR ALTERED SOURCES AFFECTING AMBIENT AIR QUALITY IN NONATTAINMENT AREAS (EMISSION OFFSET RULE)

Promulgated: July 3, 1980
Effective: September 8, 1980

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18.1 DEFINITIONS

"Air contaminant" means solid particles, liquid particles, vapors or gases which are discharged into the outdoor atmosphere.

"Air quality simulation model" means a mathematical procedure for predicting the ambient air contamination resulting from the dispersive properties of the atmosphere.

"Allowable emission" means the rate at which an air contaminant may be emitted into the outdoor atmosphere. For the purposes of this Subchapter, the allowable emissions shall be based on the maximum rated capacity of the equipment or on enforceable permit conditions which limit the operating rate, hours of operations, or both, and on the most stringent of the following:

1. Applicable new source performance standards as set forth in 40 CFR Part 60.

2. Applicable standards for hazardous pollutants as set forth in 40 CFR Part 61.

3. Applicable emission, equipment, and operating standards as set forth in this Chapter; and

4. The maximum emission rate specified as a condition of the last applicable permit in effect prior to an emission reduction approved by the Department for an emission offset or for banking.

"Alteration" means any change made to equipment or control apparatus or the use thereof, or in a process, including, but not limited to, any physical change, change in material being processed, or a change in the rate of production except where such a production rate change does not increase the quantity of air contaminants emitted or does not change the quality or nature of the air contaminant emitted.

"Attainment area" means any area determined by the Department as one in which the ambient air concentration for a criteria pollutant does not exceed a primary or secondary NAAQS.

"Banking" means reserving approved emission reductions for future use as emission offsets.

"Control apparatus" means any device which prevents or controls the emissions of any air contaminant.

"Criteria Pollutant" means ozone (O_3), total suspended particulate matter (TSP), sulfur oxides measured as sulfur dioxide (SO_2), nitrogen dioxide (NO_2), volatile organic substances (VOS) measured as non-methane hydrocarbons, carbon monoxide (CO), or lead (Pb), or any other air contaminant for which national ambient air quality standards have been adopted.

"Department" means the Department of Environmental Protection.

"Emission offset" means a legally enforceable reduction, approved by the Department, in the rate of actual emissions from an existing facility to offset the increase in the allowable emissions of air contaminants from a new or altered facility.

"Employee commuter travel control measures" means methods used by an employer to reduce the amount of air contaminant emissions due to travel of his employees getting to and from the place of employment. Such methods may include, but are not limited to, ride sharing programs (car pooling or van pooling), preferential parking programs, employee incentives to use mass transportation, staggered work hours, and vehicle emission control programs.

"Employer business travel control measures" means methods used by an employer to reduce the amount of air contaminant emissions due to company related travel. Such methods may include, but are not limited to, ride sharing programs, optimization of delivery schedules, staggered work hours, vehicle emission control programs, alternative fuel and alternative propulsion systems.

"Equipment" means any device capable of causing the emission of an air contaminant into the open air and any stack, chimney, conduit, flue, duct, vent or similar device connected or attached to, or serving the equipment.

"Facility" means the combination of all structures, buildings, equipment, and other operations located on one or more contiguous or adjacent properties owned or operated by the same person.

"Fugitive emissions" means any emissions of an air contaminant into the open air other than through any stack, chimney, conduit, flue or other device.

"Lowest Achievable Emission Rate" (LAER) means that rate of emission from any equipment, facility, or control apparatus which incorporates advances in the art of air pollution control developed for the kind and amount of air contaminant emitted by the equipment or facility. For the purposes of this Subchapter, advances in the art of air pollution control shall result in an emission limitation at least as stringent as:

1. The most stringent emission limitation which is contained in the implementation plan of any State for such class or category of equipment or facility, unless the owner or operator of the proposed equipment or facility demonstrates that such limitations are not achievable; or

2. The most stringent emission limitation which is achieved in practice by such class or category of equipment or facility;

whichever is more stringent. In no event shall the application of this term permit proposed new or altered equipment or facilities to emit any pollutant in excess of the amount allowable under applicable federal new source standards of performance.

"Minimum offset ratio" means the minimum acceptable ratio of emission offsets from an existing facility to increases in allowable emissions from a new or altered facility.

"NAAQS" means national ambient air quality standard.

"Nonattainment area" means any area determined by the Department as one in which the ambient air concentration of a criteria pollutant exceeds a NAAQS.

"Permit" means a "Permit to Construct, Install, or Alter Control Apparatus or Equipment" as required in accordance with the provisions of the Air Pollution Control Act (N.J.S.A. 26:2C-1 et seq.) and Subchapter 8 (Permits and Certificates) of this Chapter.

"Person" includes corporations, companies, associations, societies, firms, partnerships and joint stock companies as well as individuals, and shall also include all political subdivisions of this State or any agencies or instrumentalities thereof.

"Reasonable further progress" means annual incremental reductions in emissions to the outdoor atmosphere of a criteria pollutant which are sufficient, in the judgment of the Department, to provide for attainment of the NAAQS as required by the Clean Air Act, as amended August, 1977 (42 U.S.C. 7401 et seq.).

"Resource recovery source" means any equipment used for processing solid waste (including refuse-derived fuel and sewage sludge) for the purpose of extracting, converting to energy, or otherwise separating and preparing solid waste for reuse. For the purposes of this Subchapter, energy conversion equipment must use solid waste to provide more than 50% of the heat input to be considered a resource recovery source.

"Secondary emissions" means emissions to the outdoor atmosphere which occur as a result of the construction or operation of a new or altered facility and which affect the same general area for the purposes of this Subchapter as emissions resulting from the new or altered equipment within the facility. Emissions resulting from motor vehicle or aircraft traffic generated by the new or altered facility are not secondary emissions for the purposes of this Subchapter. Secondary emissions include, but are not limited to:

1. Emissions from marine vessels or from vehicles running upon rails or tracks where such vessels or vehicles are associated with the construction or operation of the facility; and

2. Emissions from off-site support facilities which would be constructed or whose rate of emissions would otherwise increase as a result of the construction or operation of the primary facility.

"Significant emission increase" means an increase, since December 21, 1976, in the rate of allowable emissions, including fugitive emissions, at a facility of any criteria pollutant greater than or equal to 100 tons per year, 1,000 pounds per day, or 100 pounds per hour, not including decreases in the rates of allowable emissions except where such decreases are contemporaneous with emission increases. The increase in the rates of allowable emissions shall be the cumulative total of increases from all new or altered equipment for which permits have been issued on or after December 21, 1976 and for which permit applications have been received by the Department, and the fugitive emissions associated with that equipment. The hourly and daily rates shall apply only with respect to a pollutant for which a national ambient air quality standard for a period not exceeding 24 hours has been established.

18.2 GENERAL PROVISIONS

(a) No person shall cause, suffer, allow, or permit an emission increase in any area of the State, which will cause a threshold increase in a nonattainment area, of a criteria pollutant, not including volatile organic substances, for which the area is nonattainment, as determined by the air quality impact review required by Section 18.3 of this Subchapter, unless compliance with subsection (c) of this Section is demonstrated.

(b) No person shall cause, suffer, allow or permit a significant emission increase, in a nonattainment area, of a criteria pollutant for which that area is nonattainment, unless compliance with subsection (c) of this Section is demonstrated.

(c) Any person required by subsections (a) or (b) of this Section to comply with this subsection shall demonstrate that:

1. Each new or altered equipment and facility is controlled to the degree which represents the lowest achievable emission rate (LAER) for the relevant criteria pollutant; and

2. All existing facilities owned or operated by the person (or an entity controlling, controlled by, or under common control with the person) in New Jersey are in compliance with the provisions of this Chapter and with all applicable emission limitations and standards of the federal Clean Air Act as amended August, 1977, 42 U.S.C. 7401 et seq., or are in conformance with an enforceable compliance schedule approved by the Department; and

3. Emission offsets in accordance with the provisions set forth in Section 18.4 (Emission Offset Demonstration) of this Subchapter are secured from existing facilities; and

4. All employer business travel control measures and employee commuter travel control measures have been analyzed to assess the feasibility of their use at the subject facility. Analysis of ride-sharing shall include participation in the state ride-sharing program; and

5. For a new or altered facility which would cause a significant emission increase in volatile organic substances, an analysis has been made of alternative sites, sizes, production processes, and environmental control techniques for such facility demonstrating that the benefits of the proposed facility significantly outweigh the environmental and social costs imposed as a result of its location, construction or alteration.

(d) No person shall cause, suffer, allow or permit an emission increase which has been determined, in accordance with subsection 18.3(a) of this Subchapter, to cause a new violation of a NAAQS, unless emission offsets, in accordance with the provisions of Section 18.4 of this Subchapter (Emission Offset Demonstration), have been secured to eliminate such predicted violation.

(e) Once a facility is permitted to cause a significant emission increase in a nonattainment area for a criteria pollutant for which that area is nonattainment and has complied with the requirements of this Section:

1. The requirements of subsections (c)3, (c)4, and (c)5 of this Section shall again become applicable when proposed new construction or alterations at the facility would cause the increase in the rate of allowable emissions of that criteria pollutant to again exceed 100 tons per year, 1,000 pounds per day, or 100 pounds per hour, whichever is most restrictive. The accumulation of increases in the rate of allowable emissions shall resume from zero after each application of subsections (c)3 and (c)4 of this Section; and

2. The requirements of subsections (c)1 and (c)2 of this Section shall be applicable to each subsequent construction or alteration which increases the rate of allowable emissions for the relevant criteria pollutant.

(f) Once a facility is permitted to offset a threshold increase in a nonattainment area, for a criteria pollutant for which that area is nonattainment, and has complied with the requirements of this Section:

1. The requirements of subsections (c) 3, (c) 4, and (c) 5 of this Section shall again become applicable if proposed new construction or alterations at the facility would again cause a threshold increase in a nonattainment area, for a criteria pollutant for which that area is nonattainment, as determined by the air quality impact review required by Section 18.3 of this Subchapter; and

2. The requirements of subsections (c) 1 and (c) 2 of this Section shall be applicable to each subsequent construction or alteration which increases the rate of allowable emissions for the relevant criteria pollutant.

18.3 AIR QUALITY IMPACT REVIEW

(a) Any person who proposes to cause an increase since December 21, 1976 in the rate of allowable emissions at a facility, of any criteria pollutant, not including volatile organic substances (VOS), greater than or equal to 50 tons per year, 1,000 pounds per day, or 100 pounds per hour, not including decreases in the rates of allowable emissions except where such decreases are contemporaneous with emission increases; such increase in the rates of allowable emissions to be the cumulative total of increases from all new or altered equipment, for which permits have been issued on or after December 21, 1976 and for which permit applications have been received by the Department; must determine, by use of an air quality simulation model approved by the Department, whether the emission increase would cause:

1. A threshold increase in ambient air concentration, as set forth in Table 1, to be exceeded in any nonattainment area for the criteria pollutant, not including volatile organic substances, for which that area is nonattainment; and

2. A new violation of a National Ambient Air Quality Standard (NAAQS).

TABLE 1

Threshold Increases in Ambient Air Concentrations For Nonattainment Areas

	Averaging Time				
Pollutant	Annual	24-Hour	8-Hour	3-Hour	1-Hour
SO_2	1.0 ug/m^3	5 ug/m^3		25 ug/m^3	
TSP	1.0 ug/m^3	5 ug/m^3			
NO_2	1.0 ug/m^3				
CO			0.5 mg/m^3		2 mg/m^3

(b) The determinations required by subsection (a) of this Section shall:

1. Consider all increases and contemporaneous decreases in the rate of allowable emissions since December 21, 1976 at the facility except for increases offset under the provisions of subsections 18.2 (c)3 and 18.2 (d) of this Subchapter; and

2. Be required with each permit which causes the cumulative total of increases in the rates of allowable emissions of a criteria pollutant to exceed a multiple of 50 tons per year, 1,000 pounds per day, or 100 pounds per hour, not including increases offset under the provisions of subsections 18.2 (c)3 and 18.2 (d) of this Subchapter.

18.4 EMISSION OFFSET DEMONSTRATION

(a) Any person required to secure emission offsets in accordance with the requirements of this Subchapter must achieve such offsets on or before the commencement of operation of the new or altered facility by:

1. Installing air pollution control equipment which reduces the rate of the actual emissions to less than that of the allowable emissions; or

2. Applying fugitive emission control measures which reduce the rate of the actual emissions to less than that of the allowable emissions; or

3. Reducing production rate or operating hours to less than the actual rates or hours for the year immediately preceding such reductions or for any representative year within 5 years of the reductions. For volatile organic substances (VOS), winter reductions of actual emissions may not be used to offset summer increases in allowable emissions; or

4. Establishing and supporting employer business travel control measures or employee commuter travel control measures, provided that the reductions are quantifiable and enforceable and that they are not already required by the New Jersey State Implementation Plan for attaining and maintaining national ambient air quality standards; or

5. Adopting any other measures approved by the Department for reducing the rate of the actual emissions to less than that of the allowable emissions.

(b) Emission offsets required by this Subchapter must:

1. Exceed the Minimum Offset Ratio and be within the respective distance specified in Table 2; and

2. Be of like quality and nature to the emissions being offset; and

3. Have an effective stack height no greater than that of the emissions being offset in the cases of sulfur dioxide and suspended particulates; and

4. Be provided in a manner that will not cause summer increases of allowable volatile organic substances (VOS) emissions to be offset by winter reductions of actual emissions.

TABLE 2

Distance of Offsets from Facility (miles)		Minimum Offset Ratio
VOS & NO_2	SO_2 TSP, CO	
0 - 100	0 - 0.5	1.00 : 1
100 - 250	0.5 - 1.0	1.5 : 1
250 - 500	1.0 - 2.0	2.0 : 1

(c) The Minimum Offset Ratios specified in Table 2 shall not apply if the Department determines that reasonable further progress toward attainment of the National Ambient Air Quality Standard (NAAQS) allows or requires that different minimum offset ratios be applied. Any person may petition the Department for the application of an emission offset different from those specified in Table 2 if it is shown by an air quality simulation model that a net air quality benefit would result from the proposed emission offset.

18.5 EMISSION OFFSET POSTPONEMENT

Any person responsible for a significant emission increase from a resource recovery source, equipment which must switch fuels because of fuel availability, or equipment altered to comply with a state or federal regulation or directive, may apply to the Department for a postponement for complying with the provisions of subsection 18.2 (c)3 of this Subchapter provided the person demonstrates that emission offsets are not immediately available. The Department may authorize such a postponement until such time as emission offsets become available at which time the person must secure such offsets without delay.

18.6 EMISSION OFFSET EXEMPTION

The provisions of subsection 18.2 (c)3 of this Subchapter shall not apply to emissions from temporary facilities including, but not limited to, portable facilities which will be relocated outside of the nonattainment area within six months of commencement of operations and pilot plants which will cease production of an experimental product within six months of commencement of operation.

18.7 BANKING OF EMISSIONS

(a) The Department may credit a person with emission reductions achieved in accordance with the provisions of subsection 18.4(a) of this Subchapter. To obtain such credit, documentation of emission reductions achieved after the effective date of this Subchapter must be submitted to the Department within 6 months after the emission reduction occurs. Such emission reductions, if approved by the Department, shall become an enforceable operating restriction for the facility. Such banked emission reductions will be adjusted in accordance with the allowable emission rates in effect at the time when the banked emission reductions are offered to offset emissions from new or altered facilities.

(b) The provisions of subsection (a) of this Section shall not apply to emission reductions ocurring:

1. before August 7, 1977; or

2. between August 7, 1977 and the effective date of this Subchapter unless documentation of the emission reductions is submitted to the Department within six months of the effective date of this Subchapter.

18.8 SECONDARY EMISSIONS

(a) Any person who, as a result of the construction of or alteration to a facility, is required to meet the provisions of Section 18.2 must certify that any sources of secondary emission increases which are:

1. Under his control and which are associated with the facility, will meet all the provisions of Section 18.2 of this Subchapter as well; and

2. Not under his control and which are associated with the facility, will meet the provisions of subsection 18.2 (c)3 of this Subchapter as well.

18.9 EXEMPTION FOR ALTERNATIVE FUEL

Where a person has demonstrated that the use of alternative fuels in existing fuel burning equipment will not cause a threshold increase, in a nonattainment area, of a criteria pollutant for which that area is nonattainment for a primary National Ambient Air Quality Standard (NAAQS) and will not prevent reasonable further progress toward attaining any secondary NAAQS, the Department may, in its discretion, exempt a person from compliance with the provisions of this Subchapter upon a further demonstration that:

(a) The equipment was capable of burning such fuel before December 21, 1976; or

(b) The equipment must use such fuel by reason of an order in effect under Sections 2(a) and (b) of the Energy Supply and Environmental Coordination Act of 1974 (15 U.S.C. 792 *et seq.*) or under any superseding legislation, or by reason of a natural gas curtailment plan in effect pursuant to the Federal Power Act of 1978 (16 U.S.C. 791a *et seq.*); or

(c) The alternative fuel is derived from municipal solid waste; or

(d) The alternative fuel is to be used by reason of an order or rule issued under the provisions of Section 125 of the Clean Air Act as amended August, 1977 (42 U.S.C. 7425).

18.10 APPLICABILITY

(a) Whenever persons, facilities, equipment, control apparatus, or air contaminants subject to the provisions of this Subchapter are also subject to the provisions of any other Subchapters of this Chapter, the requirements of the relevant provisions of this Subchapter and all Subchapters of this Chapter shall apply.

ATTACHMENT 2

NEW JERSEY
AIR POLLUTION CONTROL LAWS

Published by the New Jersey State Department of Health, Air Pollution Control Program, John Fitch Plaza, Trenton, N. J. 08625.

LAW ON PERMITS

A portion of c. 106, P. L. 1967 (Title 26, 2C:9.2) Supplements Air Pollution Control Act (P. L. 1954, c. 212).

NOTE: Other portions of the 1954 Act, as amended, and other air pollution laws are available. They include:

- General Provisions of 1954 Act as amended
- Motor Vehicle Law
- Emergency Control Act
- Air Pollution Scholarship and Intern Program
- Tax Exemption for Air and Water Pollution Control Equipment
- Mid-Atlantic States Air Pollution Control Compact

Provisions concerning application for and granting of permits to construct, install or alter equipment or control apparatus, and concerning operating certificates and emissions testing.

C. 26: 2C-9.2

(a) No person shall construct, install or alter any equipment or control apparatus, in other than a one or 2-family dwelling or a dwelling of 6 or less family units one of which is owner-occupied, until an application including plans and specifications, has been filed with the department and an installation or alteration permit issued by the department, in accordance with any codes, rules and regulations of the department except that subject to any such codes, rules and regulations the department may dispense with the filing of applications, plans and specifications. Information relating to secret processes or methods of manufacture or production is exempted from the plans and specifications and other pertinent information to which the department is entitled under this section.

(b) No person shall use or cause to be used for any such new or altered equipment or control apparatus for which an installation or alteration permit is required or issued until an operating certificate has been issued by the department.

(c) No operating certificate or renewal thereof, required by this act, shall be issued by the department unless the applicant shows to the satisfaction of the department that the equipment is designed to operate without causing a violation of any provision of this act or of any codes, rules and regulations promulgated thereunder and that, except in the case of a renewal certificate, the equipment incorporates advances in the art of air pollution control developed for the kind and amount of air contaminant emitted by the applicant's equipment.

(1) Before an operating certificate or any renewal thereof is issued, the department may require the applicant to conduct such tests as are necessary in the opinion of the department to determine the kind or amount of the air contaminant emitted from the equipment or whether the equipment or fuel or the operation of the equipment is in violation of any of the provisions of this act or of any codes, rules and regulations promulgated thereunder. Such tests shall be made at the expense of the applicant and shall be conducted in a manner approved by the department and the test results shall be reviewed and professionally certified.

(2) An operating certificate or any renewal thereof shall be valid for a period of 5 years from the date of issuance, unless sooner revoked by order of the department, and may be renewed upon application to the department.

(3) Upon receipt of an application for the issuance of an operating certificate or any renewal thereof, the department, in its discretion, may issue a temporary operating certificate valid for a period not to exceed 90 days.

ATTACHMENT 3

AIR POLLUTION CONTROL GUIDELINES FOR RESOURCE RECOVERY FACILITIES AND INCINERATORS

Maximum Air Contaminant Emission Rates and Minimum Design Standards

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New Jersey Department of Environmental Protection
Air Pollution Control Program
CN027
Trenton, NJ 08625

March 1983

I. Background

This document has been prepared as a guide for persons making applications to the Bureau of Air Pollution Control for permits to construct and certificates to operate resource recovery facilities and incinerators. As required by the Air Pollution Control Act provision concerning permits for air pollution control equipment, N.J.S.A. 26:2C-9.2, it is the responsibility of an applicant to demonstrate to the satisfaction of the New Jersey Department of Environmental Protection (department) that equipment incorporate advances in the art of air pollution control developed for the kind and amount of air contaminant emitted by the applicant's equipment. To assist applicants in submitting permits and insure that best available control technology is used, the department is proposing permit review guidelines for resource recovery facilities and incinerators based on its estimate of current state-of-the-art emission levels and air pollution control design standards.

II. Summary

Following are maximum emission levels and minimum design standards achievable using state-of-the-art air pollution control technology. Efficient air pollution control equipment includes baghouses or electrostatic precipitators, wet or dry scrubbers, and auxiliary burners. The department intends that air pollution control technology on resource recovery facilities and incinerators which have a total capacity greater than 800 pounds of waste per hour meet these standards at a minimum. Additional requirements and more stringent emission limitations may be set based on case-by-case review of the individual permit applications. Guidelines for facilities smaller than 800 pounds per hour are discussed in section IV of this document.

A. Particulates

1) 0.03 grains per dry standard cubic feet (gr/dscf) at 7% oxygen (O_2) measured by United States Environmental Protection Agency (EPA) Test Method 5, C.F.R. Part 60, Appendix A.

2) 0.10 gr/dscf at 12% carbon monoxide (CO_2) measured by the department test method for incinerators.

3) Continuous opacity monitoring.

B. Lead and Other Heavy Metals

1) Demonstration that lead emissions will not cause, or significantly contribute to, a violation of the national ambient air quality standard (NAAQS).

2) Evaluation of predicted ambient concentrations of the metals arsenic, beryllium, cadmium, chromium, mercury, and nickel.

C. Organic Substances and Carbon Monoxide

1) At least 1800°F combustion gas design temperature after secondary air injection. 1500°F minimum operating temperature.

2) At least one second combustion gas residence time calculated at 1800°F after secondary air injection.

3) Auxiliary burner to maintain 1500°F combustion gas temperature after secondary air injection for at least one second. Capability to raise temperature to 1800°F for one second combustion gas residence time.

4) Applicant must specify maximum carbon monoxide, maximum total organic emissions, and minimum oxygen on permit application. Pesticides, toxic volatile organic substances, combustion by-products and refractory organics must also be addressed.

5) Continuous oxygen and carbon monoxide monitoring and recording.

6) No odor from the facility is permitted in any area of public use or occupancy pursuant to air pollution regulation concerning incinerators, N.J.A.C. 7:27-11.3(d).

D. Acid Gases

1) Minimum of 90% hydrochloric acid (HCl) control efficiency or maximum of 50 ppmv HCl at 7% O_2 wet from stack.

2) Maximum of 0.32 lbs of sulfur dioxide (SO_2) per million BTU heat input.

E. Nitrogen Oxides

1) Specify maximum nitrogen oxides emissions and demonstrate that the national ambient air quality standard will not be exceeded.

III. Discussion

A. Particulates

N.J.A.C. 7:27-11 limits particulate emissions to 0.1 grains per dry standard cubic feet (gr/dscf) of stack gas corrected to 12% CO_2. The New Jersey test method includes the impinger catch and excludes the CO_2 from any auxiliary fuel.

The federal New Source Performance Standard (NSPS), C.F.R. Part 60, Subpart E, limits particulate emissions to 0.08 gr/dscf at 12% CO_2. EPA Test Method 5 excludes the impinger catch and does not correct for auxiliary fuel.

Current state-of-the-art for control of particulates, required by the air pollution control regulation concerning permits, N.J.A.C. 7:27-8, is estimated to be 0.03 gr/dscf at 7% O_2 measured by EPA test method 5. (7% O_2 is approximately equivalent to 12% CO_2, and O_2 is a more appropriate continuous flue gas measurement for control of emissions than CO_2.)

A particulate emission concentration of 0.03 gr/dscf is approximately equivalent to the existing NSPS limit on sewage sludge incinerators. Large resource recovery facilities without control emit up to about 2 gr/dscf, and baghouses or high efficiency electrostatic precipitators (ESP's) for such incinerators can achieve emission levels in the .01 to .02 gr/dscf range. The State of Maryland has already adopted a 0.03 gr/dscf emission standard. The municipal solid waste incinerator at Framingham, Massachusetts, controlled by a baghouse was confirmed by stack testing to meet 0.03 gr/dscf after startup and after 2 years of operation. Wheelabrator-Frye has specified 0.015 gr/dscf in its application for a resource recovery facility in New Jersey with ESP control.

Continuous monitoring for opacity is proposed. Particulate emissions from resource recovery facilities can be controlled to levels which are not detectable by the eye. The department does not propose to make its 20% opacity standard more stringent, but seeks comment on this matter. A 10% opacity standard has been specified for resource recovery facilities in some other states. The continuous opacity monitor will assist the department and operators to maintain operating conditions so that the 0.03 gr/dscf particulate emission standard will be continuously achieved.

B. Lead and Other Heavy Metals

Maximum emissions of lead per hour must be specified on the permit. Dispersion modelling must show that the three month average lead level, including background levels, will not exceed the NAAQS, which is 1.5 ug/m^3. Subsequent stack tests will be required to verify lead emissions specified on the permit. Ambient monitoring may be required if existing background air quality data are not sufficient to determine compliance with the lead NAAQS.

If background lead levels exceed 1.5 ug/m^3, the maximum increase in ground level lead concentration due to the resource recovery facility may not exceed 0.1 ug/m^3, 24 hour average, which is the de minimus level for ambient monitoring for the federal prevention of significant deterioration (PSD) rule. The 0.1 ug/m^3, 24 hour average, is proposed herein to be the maximum allowable ambient increase from a single source in an area where the NAAQS for lead is violated. At this time the department is developing a state implementation plan to attain and maintain the lead NAAQS. All of the state, with the possible exception of areas within a few kilometers of a few major point sources of lead, appear to meet the lead NAAQS.

The department expects the applicant to evaluate the ambient effects of other heavy metal emissions and to specify maximum hourly emission rates for at least nickel (Ni), chromium (Cr), cadmium (Cd), mercury (Hg), arsenic (As), and beryllium (Be). The department seeks comment on the use of risk assessment to evaluate incremental increases in ambient metal concentrations.

C. Organic Substances and Carbon Monoxide

Organic emissions can be controlled by adequate temperature, oxygen, residence time, and turbulence. Minimum design standards and an auxiliary burner to maintain combustion gas temperature at up to 1800°F, during start-up and periods of burning high moisture content waste, are proposed as state-of-the-art requirements.

1) Minimum combustion gas design temperature: 1800°F
2) Minimum combustion gas operating temperature: 1500°F
3) Minimum combustion gas residence time: 1 second at 1500°F. Capability of 1 second at 1800°F.

The department has historically required 1500 degrees and 1/2 second in a secondary chamber for particulate and odor control of incinerators. Two distinct chambers may not be necessary for large, modern resource recovery units with highly efficient particulate air pollution control devices, but high temperature and residence time are still necessary to ensure destruction of toxic organic and odorous components of the gaseous emissions. Since there is little control over residence time after an incinerator is constructed, the department proposes that new units be conservatively designed with the capability of at least 1 second residence time at 1800°F.

The department intends to set for each unit a minimum operating combustion gas temperature based on stack emission testing; but not lower than 1500°F. The 1500°F combustion gas temperature should control odors and substantially destroy toxic refractory organic substances which might at times be introduced into the incinerator in small amounts. Higher than 1500°F combustion gas temperatures for 1 second gas residence time will not be mandated unless specifically shown to be needed by stack test or monitoring results. However, the incinerator should be designed to be able to maintain combustion gases at a minimum of 1800°F for 1 second in case emission levels of toxic organic substances at lower operating temperatures are determined to be unacceptable.

The department proposes that one or more auxiliary fossil fuel fired burners be installed in the combustion chamber. This burner would not operate continuously, but would automatically fire should the combustion gas temperature measured at the exit end of the high temperature zone approach the minimum combustion gas temperature set by the department (usually 1500°F). Such an auxiliary burner will control organic emissions and the associated smoke and odor during start-up and periods of burning high moisture content waste. The high temperature zone for purposes of calculating residence time is that portion of the incinerator after introduction of secondary (overfire) air where combustion gases are maintained for at least 1 second at the minimum combustion gas temperature set by the department.

Also, while there is no easy way to quantify turbulence for regulatory purposes, adequate mixing of secondary air and primary combustion gases is necessary and must be addressed in the application.

Finally, no odor from the facility will be permitted in any area of public use or occupancy, pursuant to the requirements of N.J.A.C. 7:27-11.3(d).

While the department expects that organic emissions from well designed mass burning facilities will be sufficiently low, there is little available data on organic emissions from such facilities. Consequently, the department will require that representative organic substances be specified on the permit application and tested for as part of the stack test requirements. The list of substances required to be specified on the permit is expected to include carbon monoxide, total organic substances, and representative compounds of the following organic substance categories:

1) Refractory organics
2) Toxic volatile organic substances
3) Combustion by-products
4) Organic pesticides

The department seeks comment on the specific substances to be addressed. The stack test results will be used to determine if combustion gas temperature greater than 1500°F shall be required. The department also seeks comment on the setting of maximum allowable concentrations for carbon monoxide and total organic substances in the stack gases and a minimum oxygen content in the combustion gases after secondary air injection.

D. Acid Gases

1) Hydrochloric Acid (HCl)

An acid gas control efficiency for removal of HCl of at least 90% or a maximum emission level of 50 ppmv wet of HCl at 7% O2, whichever is least stringent, is proposed. This standard should be readily achievable if wet or dry scrubbers (acid gas control devices) are installed. Such scrubbers will also control emissions of hydrofluoric acid (HF). The department believes that the HCl emission standard will also provide state-of-the-art control of HF. Within this document, the term dry scrubber refers to the injection of an alkaline slurry or solution into the flue gases, the evaporation of the water in the hot gases, and the subsequent dry collection of salt particles by a baghouse or ESP.

2) Sulfur Dioxide (SO_2)

Maximum allowable SO_2 emission levels for resource recovery units are set by N.J.A.C. 7:27-10 at 1.2 lb per million British Thermal Units (BTU) heat input. The department proposes to set a 0.32 lb SO_2 per million BTU heat input standard for new resource recovery facilities designed to combust more than 800 pounds per hour of waste.

Municipal solid waste contains up to about 0.25 percent sulfur, giving 1.0 lbs SO_2 per million BTU at a heating value of 5000 BTU's per pound. Acid gas control devices to control HCl also would control SO_2 if the reagent is alkaline, but to a lesser removal efficiency than for HCl. Dry scrubbers remove over 70% of the SO_2; wet alkaline scrubbers over 90%. 70% SO_2 control results in about 0.30 lbs of SO_2 per million BTU, which is slightly less than the 0.32 lb SO_2 per million BTU standard for the use of low sulfur heavy oil in the metropolitan northeastern portion of the state.

Since resource recovery facilities generally replace oil fired boiler capacity, a 0.32 lb SO_2 per million BTU emission limitation is an appropriate baseline for state-of-the-art control of large resource recovery facilities. An alternative minimum SO_2 removal efficiency standard may be set during the review of the permit application. The department seeks comment on whether a stack gas concentration limit or an efficiency of SO_2 removal standard, rather than the 0.32 pound per million BTU proposal, should be the basis for the SO_2 standard.

3) Facility Emissions of Acid Gas

The department has estimated emissions from a 2000 ton per day resource recovery facility and from an equivalent sized (on a heat input basis) oil-fired facility. With acid gas control, emissions of the acid gases HCl and SO_2 from a resource recovery facility would be less than the SO_2 emissions from an equivalent low sulfur oil-fired boiler. (Oil contains insignificant quantities of chlorine.) Consequently, since resource recovery facilities will produce steam or electricity and replace oil-fired capacity, a resource recovery facility with acid gas control may reduce net acid gas emissions in New Jersey. However, without acid gas control, a resource recovery facility will emit about five times more acid gas than an equivalent size low sulfur oil boiler.

4) Cumulative Acid Gas Emissions

The department has also estimated HCl and SO_2 acid gas emissions for the entire 22,000 tons per day of solid waste burning now planned for New Jersey. These calculations are available from the department. The results are summarized as follows:

a. Total planned resource recovery facilities without acid gas control would emit about 40,000 tons per year of hydrochloric acid and 40,000 tons per year of sulfur dioxide.

b. Total planned resource recovery facilities with acid gas control would emit less than 4,000 tons per year of hydrochloric acid and 12,000 tons per year of sulfur dioxide.

c. Acid gas control would reduce combined hydrochloric acid and sulfur dioxide emissions from planned resource recovery facilities by about 64,000 tons per year.

d. Estimated statewide sulfur dioxide emissions from all sources are 315,000 tons per year. The statewide industrial hydrochloric acid emission total is under 5000 tons per year. Consequently, a 80,000 ton per year acid gas emission increase without scrubbers might represent as much as a 25 percent increase in statewide acid gas emissions. In comparison the 16,000 ton per year acid gas emission increase with scrubbers represents a 5 percent increase in statewide acid gas emissions. These estimates do not consider sulfur dioxide emissions which would be offset by energy sales which replace oil-fired boiler capacity. As previously stated, if such offsets are considered, resource recovery with acid gas control could actually reduce acid gas emissions in New Jersey.

The above emission estimates assume constant 0.5% chlorine and 0.25% sulfur contents in the waste. In Germany the chlorine content is generally greater than in the United States because more polyvinyl chloride (PVC) plastic is used. If PVC plastic use in the United States increases, as some sources have predicted, the hydrochloric acid emissions would also increase. This potential underestimation of future HCl emissions is offset by the use of relatively conservative values for chlorine and sulfur contents in waste and the assumption that all the chlorine and sulfur are emitted as acid gas.

5) State-of-the-Art

The Air Pollution Control Act provision concerning permits for sources of air contaminants, N.J.S.A. 26:2C-9.2, requires that new and altered sources be constructed such that equipment and control apparatus incorporate advances in the art of air pollution control developed for the kind and amount of air contaminant emitted. Acid gas air pollution control technology is both available and in use for resource recovery facilities. Acid gases from resource recovery facilities are being controlled with scrubbers on units operating in Europe and Japan. Acid gases are also being controlled from many other categories of stationary sources in the United States. In New Jersey industrial control of hydrochloric acid emissions averages over 98 percent control of potential emissions, with hundreds of scrubbers currently operating.

The use of scrubbers on new resource recovery facilities has been required in West Germany since 1974. In excess of 30 units are now equipped with either wet or dry scrubbers. In Japan, over 30 existing incinerator units have reportedly been retrofitted with dry scrubbing systems.

In the United States, acid gas control is used on new coal fired power plants, manufacturing sources which emit acids, and hazardous waste incinerators. One municipal solid waste incinerator in the United States with acid gas control is the Framingham, Massachusetts facility which has been operating with a dry scrubbing system for over 3 years. New resource recovery facilities in California and Oregon will reportedly be constructed with acid gas control. Currently, the department is reviewing a permit application for an 80 ton per day mass burning facility with baghouse and wet scrubber air pollution controls.

6) Health Effects

There is no National Ambient Air Quality Standard for HCl, the major component of acid gas emissions from resource recovery facilities. With high enough stacks, ground level concentrations will not be in excess of a small fraction of the workplace standards for HCl, intended to protect nearly all workers. Also, resource recovery facilities aren't expected to cause exceedances of the health standard for SO_2 if high stacks are used, even if acid gas control is not used. Rather than rely solely on high stacks to disperse the acid gases and given the uncertainties concerning health effects of low levels of air contamination, the department has determined that scrubbers should be installed to minimize acid gas emissions.

7) Prevention of Significant Deterioration

Acid gas control will reduce the consumption of prevention of significant deterioration (PSD) increments and minimize sulfur dioxide emission growth. Minimizing SO_2 emissions from a major new source category is prudent, especially in view of potential SO_2 emission increases from increased use of coal in New Jersey. With acid gas control and high stacks, increases in ambient SO_2 levels are predicted to be less than the 1 ug/m^3 annual and 5 ug/m^3 24 hour levels, which EPA has defined as de minimus ambient increases.

8) Waste Disposal

Wet scrubbers produce a salty effluent which in some cases can be discharged directly to a large publicly owned treatment works. In other cases salt must be removed from the effluent before discharge to the sewer. This is usually accomplished by settling which produces a salt sludge. Disposal of the salt sludge may require dewatering. Dewatering systems in some German resource recovery facilities have experienced severe corrosion. Further evaluation of second generation dewatering systems may be necessary before a wet scrubber which relies on dewatering is constructed in New Jersey.

Dry scrubbers produce a dry salt which is collected in the particulate control device along with the flyash. Lime injection in dry scrubbers appears to provide the added advantage of reducing the leachability of metals in the flyash, thus making landfilling of the flyash more environmentally acceptable.

9) Reliability of Scrubbers

Applicants have questioned the reliability of scrubbers to operate effectively for long periods. Some scrubbers have had corrosion and other operational problems. Operators in Germany indicated that most problems have been solved with changes in operational and maintenance procedures. Annual availability of many scrubbers is greater than 90%. A dry scrubber has been operating on the Framingham, Massachusetts, municipal incinerator without problem for over three years.

E. Nitrogen Oxides (NO_x)

The applicant must specify NO_x emissions and explain the means employed to minimize such emissions. Also, emissions of NO_x must be addressed in the air quality modelling required by N.J.A.C. 7:27-18.3. Nitrogen oxide emissions from resource recovery facilities are expected to be less than nitrogen oxide emissions from equivalent heat input oil firing, which most resource recovery facilities will replace.

IV. Small Facilities

A. Particulates

Unlike large mass burning municipal incinerators, which without air pollution control equipment emit up to 2 gr/dscf of flue gas, properly designed two chamber incinerators capable of combusting relatively small quantities of refuse and pathological waste generate about 0.075 gr/dscf of particulate emissions (EPA Test Method 5). These smaller units, generally with capacities of less than 10 tons per day, are reportedly capable of meeting the standards presently contained in N.J.A.C. 7:27-11 without add-on pollution control equipment. However, add-on control equipment such as baghouses, electrostatic precipitators, or scrubbers would be necessary to achieve the proposed 0.03 gr/dscf state-of-the-art limit, which the department originally intended to apply to all new incinerators, regardless of size.

Claiming relatively high cost for controlling small quantities of particulate emissions, several applicants and equipment vendors requested that the department consider a small source size or low emission rate exclusion from the proposed 0.03 gr/dscf state-of-the-art limit. In the case of some small units, the cost of controlling emissions from 0.075 gr/dscf to 0.03 gr/dscf reportedly exceeds 50% of the cost of the incinerator. After reviewing emissions data on small municipal and pathological incinerators, the department is proposing not to apply the 0.03 gr/dscf standard to facilities which are designed to combust less than 800 pounds per hour of waste. The department proposes that such new units be subject to a limit of 0.1 gr/dscf as measured by the New Jersey test method. In the case of pathological incinerators, the standard is unchanged from that which currently exists in N.J.A.C. 7:27-11. For municipal refuse incinerators with feed rates of less than 2,000 pounds per hour, the current allowable standard of 0.2 gr/dscf will be halved.

Calculations relative to the combustion of typical municipal refuse indicate that a unit which emits particulate at a concentration of 0.1 gr/dscf at 12% CO_2, as measured by the New Jersey test method, releases particulate at a rate of approximately 0.12 pounds per 100 pounds of refuse charged. Therefore, an 800 pound per hour unit will emit approximately 1.0 pounds per hour of particulate without add-on air pollution control equipment. The 800 pound per hour unit design capacity corresponds to 9.6 tons per day of waste combusted in the case of a unit which is operated continuously. In order to discourage the construction of several small units at one site in an attempt to avoid a more stringent emission limitation for a single larger unit, the department intends to apply the 800 pound per hour exclusion size on a per facility basis.

The department seeks comment on both the appropriateness and cutoff point for the small incinerator standards.

B. Acid Gas

With regard to acid gas emission standards for small incinerators, the department proposes to exempt any unit which emits less than 4.0 pounds per hour of hydrogen chloride (HCl) from the state-of-the-art scrubbing standards discussed in Section III.D of this document. In the June 24, 1982 interim final standards for hazardous waste incinerators, issued pursuant to the Resource Conservation and Recovery Act, EPA provided an exemption from their 99% HCl scrubbing requirement for hazardous waste incinerators if they emit less than 4.0 pounds per hour of HCl. The department is proposing a similar exemption for non-hazardous waste incinerators.

Since municipal refuse typically contains up to about 0.5 percent chlorine, a mass emission of rate of approximately 4.0 pounds per hour of HCl would result from the combustion of 800 pounds per hour of refuse. Consequently, a less than 800 pounds per hour facility burning municipal solid waste will not require add-on control equipment provided its design and operation result in less than 4 pounds per hour hydrochloric acid emissions and 0.1 gr/dscf (wet and dry catch) particulate emissions.

It should be noted that the exemption from scrubbing acid gases is based on a mass emision rate and <u>not</u> on the facility design capacity. The reason for this distinction is that the chlorine content of industrial and commercial waste streams may vary significantly. It will be the applicant's responsibility to determine expected HCl emission rates based upon the type of waste stream which is to be combusted. The 4.0 pounds per hour exclusion may necessitate the installation of scrubbers on less than 800 pounds per hour facilities. Conversely, scrubbers may not be required on larger than 800 pounds per hour facilities if the applicant can demonstrate that the chlorine content of a particular waste stream is such that the 4.0 pounds HCl per hour de minimus emission rate will not be exceeded.

V. Acid Gas Control Bypass

Several inquiries have been received by the department from prospective applicants and public interest groups regarding the enforcement policy relative to periods of incinerator air pollution control equipment malfunctions. Provisions of the Air Pollution Control Act empower the department to revoke the operating certificate for any facility which does not operate in accordance with an approved permit. It further empowers the department to seek immediate injunctive relief to prevent violations of permit requirements, N.J.S.A. 26:2C-19. The department has traditionally evaluated upsets and emission excursions on a case-by-case basis. Factors such as the quality and quantities of resultant emissions, the nature of the upset, the frequency of such upsets, and the anticipated duration of substandard performance are evaluated in determining appropriate enforcement action.

With regard to the operation of air pollution control equipment for reducing emissions from resource recovery facilities, the department intends not to allow continued operation of a facility in the event of a complete failure of the particulate control device. However, in the case of acid gas control equipment, consideration is being given to allowing continued incinerator operation for limited periods of time without properly functional acid gas control devices.

The reasoning behind this approach is twofold. Firstly, the acid gas emission standards are based primarily on technological capability and the goal to reduce long term emissions of acid gases, rather than from the standpoint of documented concerns over short-term human exposures to uncontrolled acid gas concentrations. With a high enough stack, short-term human exposures to uncontrolled acid gas emissions from resource recovery should not cause any quantifiable health risk. Also, the goal of reducing long-term exposures to low acid gas concentrations can be achieved so long as the acid gas control equipment is functional for most of time the incinerator is operated.

Secondly, acid gas control equipment has not been installed on many municipal solid waste incineration facilities in the United States. Therefore, operating flexibility for scrubbers on resource recovery facilities is desirable for at least the period of introduction of the technology in the United States, so facilities can guarantee sufficient availability to process a minimum amount of waste per year.

The department seeks comments on appropriate temporary acid gas control bypass provisions to be included as conditions of each facility operating permit.

VI. Costs and Benefits

Preliminary estimates of air pollution control costs for major facilities indicate that capital cost for the particulate control equipment and scrubbers will total about 15 percent of the entire facility capital cost, with each control device accounting for about half the cost. The cost of auxiliary burners and continuous monitoring is expected to be small compared to the cost of particulate and acid gas control equipment. The cost of the particulate control is not an issue because particulate control is accepted practice in the United States. The cost of scrubbers for acid gas control is an issue because scrubbers have not been widely used on resource recovery facilities constructed in the United States. Consequently, the remainder of this section will briefly address the acid gas control cost issue.

The capital cost of acid gas control is expected to be about 5 to 10 percent of the total capital cost of a major resource recovery facility. The total amortized cost of acid gas control including capital, interest, and operating costs is expected to be about $5 per ton of solid waste processed. Although total facility costs and revenues have not been fully documented, we assume a $45 per ton of waste total processing cost without acid gas control and $25 per ton energy sales revenue, for purpose of an initial comparison with the cost of acid gas control. Using these assumed costs and revenues, the addition of acid gas control would represent 10 percent of total waste processing cost with acid gas control and 20 percent of the tipping fee after energy sales. Note that as the value of energy sales increases, the tipping fee decreases causing any fixed cost's percentage of the tipping fee to increase. Therefore, the comparison of a fixed cost, such as acid gas control, to the total waste processing cost is most relevant.

The costs of acid gas control can be balanced against the acid gas emission reductions which would be achieved. These are discussed in detail in section III.D of this document. A simplified cost/benefit analysis is possible by comparing the cost of removing the acid gases against the amount of acid gases which would be captured and neutralized by the scrubber. As previously stated, the total amortized cost of acid gas control is expected to be about $5 per ton of waste. This compares with the benefit of about 9 pounds of hydrochloric acid and 7 pounds of sulfur dioxide removed by the scrubber, based on 90 percent control of 0.5 percent chlorine in the waste and 70 percent control of 0.25 percent sulfur in waste. Based on these values, the cost/benefit ratio of scrubbers on resource recovery facilities would be about 31 cents per pound of acid gas removed. This cost is reasonable compared with the cost of air pollution control devices required on other new sources. Generally, air pollution control costs are considered unreasonable somewhere in the range of $1 to $10 per pound of pollutant removed depending on the source operation and contaminant emitted. The cost/benefit ratio would increase as the potential acid gas emissions decrease and decrease as the control efficiency increases.

ATTACHMENT 4

CLEAN AIR AND SOLID WASTE MANAGEMENT ADVISORY COUNCILS HEARING

March 19, 1984

Testimony by the NJDEP Air Pollution Control Program

The Air Program welcomes this opportunity provided by the Clean Air Council and the Solid Waste Management Advisory Council for public comment on the effects of resource recovery technologies on air quality. Since the purpose of this hearing is to provide the department with new information on the air pollution effects of disposal technologies, the air program will limit its oral testimony to a summary of what is known now and an update on the status of its rulemaking and permitting activities. We will also submit written technical information responsive to the questions raised in the public hearing notice.

Long-term disposal of municipal solid waste is one of the key issues confronting state, county and municipal officials in New Jersey. The shortage of environmentally acceptable sanitary landfill sites in the state, and public opposition to landfills, precludes continued widespread use of this disposal technique. Alternatives to landfilling include refuse incineration, composting, and recycling. Although small-scale studies on composting municipal waste have been completed, this technology has yet to gain widespread acceptance and is incapable of treating many components of a typical waste stream. Recycling has the potential to reduce the overall volume of the waste stream and may significantly reduce the concentrations of certain contaminants in the refuse.

However, recycling also does not provide a feasible disposal method for the bulk of the waste stream. Consequently, the decrease in the number of landfill sites near highly populated areas and the increased cost of energy have combined to stimulate a great deal of interest in the incineration of municipal waste for purposes of volume reduction and the simultaneous recovery of energy.

All waste disposal and resource recovery operations cause the emissions of air contaminants. While emissions from mass burning, that is the combustion of untreated refuse, have received the most attention, landfilling and composting also generate air pollution. Both have been responsible for the release of odorous gases which have generated nuisance complaints from local residents. Of more concern, the gases released by landfilling operations contain small quantities of carcinogenic organic compounds such as benzene, trichloroethane, and tetrachloroethane. Also, the mechanical operations of landfilling cause particulates to become airborne and available for transport from the site. Because little is known about the quantity and quality of emissions from landfilling and composting operations, the program will welcome any additional information which may be received on such emissions. Our comments at this hearing concentrate on municipal waste incineration.

Although the primary purpose of <u>municipal incineration</u> is volume reduction of the waste, associated energy recovery is an important financial benefit for operators of these sources. For this reason, and because incinerators may displace existing and planned oil and coal-fired boilers, it is relevant to compare incinerator emissions to those typically associated with fossil fuel combustion. We have compared emissions of the major contaminants from resource recovery facilities with those from existing oil-fired boilers and new coal-fired boilers, on an equivalent heat input rate basis. The results of this analysis, in tabular form, are contained in written testimony being submitted by the air program.

Nitrogen oxide emissions from municipal incinerators are approximately one-half those from oil and coal units. Sulfur dioxide emissions are slightly less than those from low sulfur oil combustion and approximately one-half the amount from coal combustion with scrubber control. Particulate emissions from refuse incineration are approximately 3 times higher than from burning coal, 2 times higher than from burning 0.3 percent sulfur oil, and slightly less than from burning 1 percent sulfur oil. Hydrogen chloride emissions are greater from refuse by factors of 100 and 10 than from oil and coal, respectively. Lead emissions from refuse are 50 to 100 times greater than from either fossil fuel. Ten to 15 times more carbon monoxide will be emitted from refuse combustion. The emissions of volatile organic substances will be approximately the same for all three fuels.

In summary, the emissions of sulfur dioxide and nitrogen oxides, two pollutants associated with long-range acid rain problems, will be less from refuse incineration than from fossil fuel combustion. Particulate and organic emission rates will be about the same. Lead, carbon monoxide, and hydrogen chloride emissions will be substantially greater. However, these higher emission levels are expected to result in groundlevel concentrations well within the National Ambient Air Quality Standards.

Additionally, incineration, like other combustion sources, results in the release to the atmosphere of small quantities of other heavy metals, polycyclic organic compounds and other organic substances which are potentially carcinogenic and toxic in low concentrations. Emission estimates and modelling has been used to predict maximum groundlevel concentrations of heavy metals. Each proposed major facility is required to conduct such air quality modelling. For facilities with tall stacks and state-of-the-art particulate control, comparison of maximum annual groundlevel concentrations of heavy metals with conservative cancer risk factors, indicates a negligible increased risk of cancer, even for 70 year exposures to predicted maximum annual groundlevel concentrations. Rates of deposition and accumulation of heavy metals in the soil also must be addressed by applicants as required by the federal rules for Prevention of Significant Deterioration.

Little emission data is available for specific organic substances. Dioxin emissions have received a great deal of attention, and, therefore, through testing of facilities in Europe and the United States, increasing amounts of data are being generated. The United States Environmental Protection Agency has done risk assessments of dioxin emissions from incinerators and has indicated the risk of cancer is negligible, even when using very conservative risk assessment methodology.

While dioxin may be the most toxic substance emitted by resource recovery facilities, we are also interested in receiving additional test information on other toxic organic emissions. With such information, risk assessments could be done for substances for which there are cancer risk factors developed by the

Environmental Protection Agency's Cancer Assessment Group. The department expects that with state-of-the-art combustion design technology and auxiliary equipment, the increased risk of all organic emissions from large mass burning incinerators will be negligible.

Two points on this matter are important to note. First, cancer risk assessment, using the conservative procedures of the Cancer Assessment Group, appears to be the most stringent way to evaluate air contaminant emissions from resource recovery facilities. Such sources will easily meet national ambient air quality standards for criteria pollutants and will be orders of magnitude under workplace standards for other contaminants. Therefore, if facility specific evaluations of worst case emissions of metals and organic substances continue to confirm the low risk levels shown by preliminary evaluations done to date, we believe most of the public health concerns about mass burning incinerators will have been addressed.

Secondly, with the possible exception of a recent proposal by the California Air Resources Board, the NJDEP is implementing more stringent air pollution standards for new resource recovery facilities than any other state in the country. The program is requiring better air pollution control of acid gas, particulate, and organic emissions from new facilities than is now used on most existing facilities in the United States. Therefore, if risk assessment shows acceptable emissions at such existing facilities, the emissions and risk from newer and better controlled New Jersey facilities will be even less.

Although the preconstruction permit review process will insure that state-of-the-art air pollution control technology is used and risks to the exposed public are minimized, it is equally important that means exist to verify the successful performance of such equipment after the facility is operational. The department intends that proper operation of the facility be determined by a combination of performance stack testing, continuous monitoring and recording, and visual inspections.

Performance testing refers to physical measurements of contaminant concentrations in the stack during normal operation of the facility. Such tests are used to verify that the permitted emission rates, upon which air quality modelling and risk assessments were based, are not being exceeded. Performance testing in accordance with approved test procedures will be required of the applicant, upon startup of the facility, and prior to each renewal of the five-year operating certificate for the facility. Additionally, the department will conduct performance tests itself at any time should improper operation be suspected.

Continuous monitoring and recording requirements will provide the department and the operator with the means to constantly judge system performance and adjust key operating parameters as becomes necessary. Temperature, carbon monoxide concentration, and oxygen concentration monitors will provide an indication of the combustion efficiency of the incinerator. An opacity monitor to measure light transmission through the stack plume will qualitatively indicate the efficiency of the particulate control device. Also, monitoring of certain physical variables associated with operation of the air pollution control equipment will be required, the specifics of which will depend upon the type of technology employed.

In anticipation of receiving more than 10 preconstruction permit applications for municipal incinerators of various sizes and types, air program staff conducted an extensive review of municipal incineration throughout the world. Also, EPA contracted with a private consulting firm to conduct a technical review and regulatory analysis of municipal incineration for New Jersey. We will provide a copy of that report to the councils. On May 18 and 19, 1983, the department conducted public hearings to inform the public of our intent to require highly efficient control of particulate, acid gas, and organic emissions from new resource recovery facilities and municipal refuse incinerators. Maximum allowable emission levels and minimum design standards, which we determined to be state-of-the-art air pollution control technology, were proposed in a document entitled "Air Pollution Control Guidelines for Resource Recovery Facilities and Incinerators". In response to a great deal of public concern raised at the hearings, staff have been carefully reviewing the large volume of testimony received, as well as more recent published information regarding municipal incineration. It is anticipated that revised guidelines and a report of the May, 1983, hearings will be issued in about a month.

Information received at this hearing could be used to make further revisions to the permit review guidelines. It is our intent that the guideline document be a dynamic position paper, which can continually be updated to incorporate the latest available information on advances in the state-of-the-art of air pollution control for mass-burning incinerators. Such an approach has an advantage over formal rulemaking in that requirements can be strengthened in view of new data without waiting for completion of lengthy rulemaking processes.

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF ENVIRONMENTAL QUALITY
JOHN FITCH PLAZA, CN027, TRENTON, N.J. 08625

April 9, 1984

Dr. William Klepper P.O. Box 8068
Mercer County Administration Bldg.
640 South Broad Street
Trenton, NJ ~~08611~~ 08650

Dear Dr. Klepper:

Enclosed is written testimony prepared by the air program to be included in the record of the March 19, 1984 public hearing on resource recovery. This written testimony supplements my testimony at the hearing.

The package addresses questions listed in the public hearing notice. Attachments include copies of existing regulations relevant to municipal incineration. Should you have any questions concerning this material, please contact Mr. Gary Pierce at 609-984-3023.

Thank you again for this opportunity to comment on this important issue.

Very truly yours,

William O'Sullivan, Chief
Engineering & Technology
Air & Noise Quality

sw
cc: H. Wortreich
L. Pereira
M. Debonis
G. Pierce
J. Bielomowicz
J. Elston

CLEAN AIR COUNCIL HEARING

WRITTEN TESTIMONY

The Air Program is submitting additional comments to the Clean Air and Solid Waste Management Advisory Councils on the effects of resource recovery technologies on air quality. The following written testimony on the specific questions raised in the public notice, supplements the oral statement of Mr. William O'Sullivan at the March 19, 1984 public hearing.

Emissions Question #4: How do emissions from resource recovery facilities compare with emissions from other sources with regard to hazards, concentrations, quantities, et cetera?

Compared to fuel oil and coal, the two fossil fuels whose combustion refuse incineration will most likely displace, refuse is a relatively low heating value fuel. The department has performed calculations, on an equivalent heat input rate basis, in order to compare the emissions of criteria pollutants and hydrogen chloride from the total capacity of planned resource recovery facilities in the state with the emissions from an equivalent capacity of both existing oil-fired units and new coal-fired units.

The results of this analysis are contained in Attachment ~~1~~ a. In summary, the emissions of sulfur dioxide and nitrogen oxides, two pollutants associated with long-range acid rain problems, will be less from refuse incineration that from fossil fuel combustion. Particulate, lead, carbon monoxide, and hydrogen chloride emissions will be substantially greater. However, these higher emissions levels are expected to result in groundlevel concentrations well within the National Ambient Air Standards.

Emission Questions #2 and #5: What should be considered as acceptable health risks and environmental effects from emissions? Can the emissions from a resource recovery facility be made reasonably safe, considering the hazardous materials which may be present in municipal and small business waste streams?

In addition to emissions of the criteria pollutants and hydrogen chloride, well-controlled and properly designed refuse incinerators result in the release to the atmosphere of small quantities of heavy metals in addition to lead, polycyclic organic compounds, and other organic substances which are potentially carcinogenic and toxic in low concentrations. Assessment of the health risks and environmental effects of these emissions is an important aspect of permitting resource recovery facilities.

The approach being used to evaluate heavy metals emissions involves the modelling of the emission rates in order to predict maximum groundlevel concentrations. Such concentrations may then be used in combination with conservative cancer risk factors published by the Cancer Assessment Group of the

Federal Environmental Protection Agency to estimate the increased risk of cancer attributable to the emissions of the contaminants in question. Cancer risk factors have been published for the metals beryllium, nickel, arsenic, cadmium, and chromium. From facilities with tall stacks and state-of-the-art particulate control, the analyses described above indicates a negligible increased risk of cancer, even for 70 year exposures to the predicted maximum annual groundlevel concentrations. In the case of proposed facilities, it is the goal of the air program to limit the increased cancer risk from each of the 5 metals to less than 1 in a million per individual. It should be noted that while risk assessment as described above is far from being an exact science, the methodology is extremely conservative in that no individual could possibly be exposed to the maximum groundlevel concentration for 70 years.

Much attention has also been given to the release of low levels of toxic organic compounds, particularly tetrachlorodibenzodioxins (TCDD) and chlorinated dibenzofurans, which have been detected in emissions from municipal incinerators. The United States Environmental Protection Agency (USEPA) evaluated the potential health problems associated with low levels of emissions of TCDD. After quantifying TCDD stack emissions at five sites and applying mathematical models to estimate resultant groundlevel concentrations, the USEPA concluded that the emission levels of TCDD from the five U.S. sites studied do not present a public health hazard. This conclusion was reached on the basis of very conservative risk assessment methodology, including the evaluation of 70 year exposures to predicted maximum annual groundlevel concentrations and the assumption that the total amount of TCDD emitted was 2, 3, 7, 8 - TCDD, the most toxic isomer identified. Emissions from newer New Jersey facilities with more stringent combustion design and operating requirements should result in even lower emissions of organic molecules, including TCDD. Combustion efficiencies for modern incinerators are greater than 99.5 percent. Achievement of such combustion efficiencies will ensure that resource recovery facility emissions are reasonably safe, considering the small amounts of hazardous materials which may be present in municipal and small business waste streams.

Two points on this matter are important to note. First, cancer risk assessment, using the conservative procedures of the Cancer Assessment Group, appears to be the most stringent way to evaluate air contaminant emissions from resource recovery facilities. Such sources will easily meet national ambient air quality standards for criteria pollutants and will be orders of magnitude under workplace standards for other contaminants. Therefore, if facility specific evaluations of worst case emissions of metals and organic substances continue to confirm the low risk levels shown by preliminary evaluations done to date, we believe most of the public health concerns about mass burning incinerators will have been addressed.

Secondly, with the possible exception of a recent proposal by the California Air Resources Board, the NJDEP is implementing more stringent air pollution standards for new resource recovery facilities than any other state in the country. These standards are in part, based upon the final report (Attachment ~~2~~ 6) of a USEPA contract with a private consulting firm which conducted a technical review and regulatory analysis of municipal incineration for New Jersey. The NJDEP is requiring better air pollution control of acid gas, particulate, and organic emissions from new facilities than is now used on existing facilities in the United States. Therefore, if risk assessment shows acceptable emissions at such existing facilities, the emissions and risk from newer and better controlled New Jersey facilities will be even less.

Emissions Question #3: Should specific air contaminants be selected for testing? Should they be controlled by specifying maximum allowable emission rates or by applying state-of-the-art control technology?

To assist applicants in the submittal of air pollution permit applications, the air program has developed a study plan (Attachment ~~3~~ b) which outlines the requirements for permitting sewage sludge and municipal solid waste incinerators. Section B of the outline contains a listing of pollutants for which the applicant should specify uncontrolled and controlled emission rates. The controlled emission rates must reflect the result of applying advances in the art of air pollution control and are subsequently used on the basis for air quality modelling and risk assessment analyses. Upon permit approval, these levels become the maximum allowable emission rates for the facility. For pollutants for which insufficient test data is available post construction testing must confirm negligible risk.

Although the preconstruction permit review process will insure that state-of-the-art air pollution control technology is used and risks to the exposed public are minimized, it is equally important that means exist to verify the successful performance of such equipment after the facility is operational. The department intends that proper operation of the facility be determined by a combination of performance stack testing, continuous monitoring and recording, and visual inspections.

Performance testing refers to physical measurements of contaminant concentrations in the stack during normal operation of the facility. Such tests are used to verify that the permitted emission rates, upon which air quality modelling and risk assessments were based, are not being exceeded. Performance testing in accordance with approved test procedures will be required of the applicant, upon startup of the facility, and prior to each renewal of the five-year operating certificate for the facility. Additionally, the department will conduct performance tests itself at any time should improper operation be suspected.

Technology Question #4: What key operating parameters need to be monitored continuously and why?

Continuous monitoring and recording requirements will provide the department and the operator with the means to constantly judge system performance and adjust key operating parameters as becomes necessary. Temperature, carbon monoxide concentration, and oxygen concentration monitors will provide an indication of the combustion efficiency of the incinerator. An opacity monitor to measure light transmission through the stack plume will qualitatively indicate the efficiency of the particulate control device. Also, monitoring of certain physical variables associated with operation of the air pollution control equipment will be required, the specifics of which will depend upon the type of technology employed. Sulfur dioxide concentration in the flue gas or pH of the scrubbing liquor for a wet scrubber or feed rate of reagent to a dry scrubber can be monitored to indicate the performance of the selected acid gas control system.

Emissions Question #1: What are the costs of controlling air pollution from resource recovery operations? To what extent should costs be considered in developing control strategies?

The benefits realized from efficiently controlling air pollution from resource recovery facilities are not without costs. These costs include the capital and operating costs associated with the operation of a particulate matter control device, acid gas control equipment, auxilliary burner, and monitoring and recording devices for various pollutants and operating parameters. Total cost will be dependent upon the capacity of the facility, the specific air pollution control technology which is selected, and continuous monitoring and recording requirements imposed by the air program.

Information has been obtained from equipment vendors relative to controlling European, Japanese, and some U.S.A. plants. Based upon this information, it is estimated that air pollution control costs will constitute approximately 10 percent of the total cost of processing municipal refuse through a mass-burning incineration facility. The percentage may be slightly higher for a smaller (less than 600 ton per day) facility and slightly lower for a larger plant. This estimate assumes that the cost of control will range from $4 to $6 per ton of waste processed, versus a total processing cost of from $40 to $60 per ton, not including revenue from energy sales.

Technology Question #1: What standards are needed for contingency plans in case of malfunction

Malfunction of required air pollution control equipment is an issue which the program intends to resolve on a case-by-case basis during the permit review process. Total failure of a particulate control device will undoubtedly result in predicted exceedances of short-term ambient air quality standards. Therefore, such malfunctions will necessitate shutdown of the incineration unit. However, in the case of acid gas control equipment, short periods of malfunction are unlikely to result in violations of air quality standards. Provided that air quality modelling predicts no such exceedances with one or more acid gas scrubbers inoperative, consideration will be given through permit conditions to allowing continued operation of the facility for predefined limited periods of time while maintenance is performed to correct the situation.

ATTACHMENT X a

COMPARISON OF TOTAL PLANNED RESOURCE RESOURCE FACILITY EMISSIONS WITH TOTAL STATE EMISSIONS

OCTOBER 1982

	Emissions (Tons/Year)		
Pollutant	Resource Recovery 22,000 tons/day (with scrubber)	Estimated Statewide Emissions	Resource Recovery % of Statewide
Total Particulates	3,170	160,000	2%
Lead	400	unknown	-
Nitric Oxides	12,050	540,000	2%
Carbon Monoxide	16,060	1,770,000	1%
Organic Gases	440	610,000	0.1%
Sulfur Dioxide (SO_2)	38,540(11,560)	315,000	12% (4%)
Hydrochloric Acid (HCl)	40,150(4,015)	unknown	-
SO_2 + HCl	78,690(15,575)	315,000*	25% (5%)*

*Assuming no HCl from other existing sources

COMPARISON OF TOTAL PROPOSED RESOURCE RECOVERY FACILITY EMISSIONS WITH EQUIVALENT LOW SULFUR OIL FIRING

	Emissions (Ton/Yr)	
Pollutant	Resource Recovery 22,000 tons/day (with scrubber)	Equivalent Low Sulfur[3] #6 Oil
Total Particulate	3,170	1,610
Sulfur Dioxide	38,540(11,560)[1]	12,850
Hydrochloric Acid	40,150(4,015)[2]	26
Nitric Oxides	12,050	20,210
Lead	400	8
Carbon Monoxide	16,060	1,340
Organic Gases	440	270

1. 70% SO_2 control, 0.24% sulfur MSW
2. 90% HCl control, 0.50% chlorine MSW
3. 0.3% sulfur

COMPARISON OF TOTAL RESOURCE RECOVERY FACILITY EMISSIONS WITH EQUIVALENT OIL AND COAL FIRING CAPACITY

A. Comparisons:

1. Existing oil-fired boilers of same heat rate - This is the most relevant comparison because the resource recovery facilities' steam and/or electricity sales will result in reduced use of oil-fired boilers. Therefore, emissions from the resource recovery facilities will be offset by emission decreases from oil fired facilities of equal heat input.

2. New coal fired boilers of same heat rate - This is a good comparison because new large boilers are likely to be coal fired and air pollution controls required are similar to controls required for resource recovery facilities.

3. Total Emissions for State - This is not a fair comparison because single source categories usually do not constitute a significant portion of an entire state's emissions.

B. Calculations of emission rates from 22,000 ton/day estimated capacity of proposed resource recovery facilities according to approved district solid waste management plans:

(a) Particulates

22,000 ton/day x 365 day/yr x 128 [(dscf/min)/
1 (ton/day)]* x .03 gr/dscf x 60 min/hr x 24 hr/day
x lb/7000gr x ton/2000lb = 3,170 tons particulates/year

*Page VI-7, Volume III, Preliminary Environmental Assessment Document Edgeboro Resco. Note that this document specifies 0.015 gr/dscf which would cut the above estimate of particulate emissions in half.

(b) Sulfur dioxide

22,000 ton/day x 365 day/yr x .0024 ton S*/ton waste
x 2 SO_2/1S = 38,540 tons SO_2/yr without scrubber

Assume 70% efficient scrubber

38,450 tons/yr x 0.15 = 11,560 tons SO_2/yr with scrubber

*"Study of Municipal Solid Waste Quantity, Composition and Fuel Characteristics", SCS Engineers for Port Authority; Assume all sulfur converted to SO_2.

(c) Hydrochloric Acid

22,000 ton/day x 365 day/yr x .005 ton HCl^8/ton waste = 40,150 tons HCl/yr without scrubber

Assume 90% efficient scrubber

40,150 tons/yr x 0.10 = 4,015 tons HCl/yr with scrubber

*"Study of Municipal Solid Waste Quantity, Composition and Fuel Characteristics", SCS Engineers for Port Authority; assume all chlorine converted to HCl.

(d) Nitrogen oxides

22,000 TPD x 3 lb*/ton x ton/2000lb x 365 day/yr = 12,050 tons NO_x/yr

*AP42 (12/77)

(e) Pb (Assume 330 ppm* of feed is potential emission rate before particulate control.)

330 tons/10^6 tons x 22,000 TPD x 365 day/yr = 2,650 tons Pb/yr uncontrolled

if 85% control: 400 tpy with baghouse or ESP

*Bureau of Mines, R.I. 8314, Sources of Metals in the Combustible Fraction of MSW.

(f) CO

4 lb/ton* x 22,000 ton/day x ton/2000lb x 365 day/yr = 16,060 tons CO/yr

*Smith, E.M. "Municipal Incinerators-Current Knowledge" cited by G. Pierce, Mass Burning of Municipal Refuse

(g) Organics

0.11 lb VOS/ton* x 22,000 ton/day x ton/2,000 lb x 365 day/yr = 442 ton/yr

*Wheelabrator-Frye generated emission factor for mass burning resource recovery facility.

C. Calculations of Emission Rates from Other Sources:

1. Oil fired boilers with same heat rate as the resource recovery plants.

22,000 tpd of MSW at 5000 BTU/lb yields 220 billion BTU/day

Convert to gallons per day and gallons/yr of #6 oil:

1 gal/150,000 BTU/ 220 x 10^9 BTU/day = 1463 x 10^3 gpd
= 539 x 10^6 gpy

(a) Particulates (PM)

Particulate emissions estimated using AP42 (4/77)

PM = (10S + 3) lb/1000 gal where S is sulfur percent

PM = (.03 x 10) + 3 = 6 lb/1000 gal

6 lb/1000 gal x 53.9 x 10^7 gal/yr x 1 ton/2000 lb = 1,610 ton PM/yr

(b) SO_2

0.32 lb $SO_2/10^6$ BTU* x 220 x 10^9 BTU/day x 365 day/yr x ton/2000 lb = 12,850 ton SO_2/yr

*N.J.A.C. 7:27-9 allowable SO_2 emission rate.

(c) HCl

12 lb Cl*/10^6 lb fuel x 539 x 10^6 gal/yr x 8 lb/gal x ton/2000 lb = 26 ton HCl/yr

*Vol. III, Emission Assessment of Conventional Stationary Systems, TRW for EPA, January 1981.

(d) NO_x: use the AP42 (4/77) average value of

75 lb/1000 gal for residual oil

75 lb/1000 gal x 53.9 10^7 gal/yr x 1/2000 = 20,210 $\frac{\text{ton NO}_x}{\text{yr}}$

(e) Lead:

3.5 lb Pb*/10^6 lb fuel x 539 x 10^6 gal/yr x 8 lb/gal x ton/2000 lb = 8 ton Pb/yr

*Vol. III, Emission Assessment of Convention Stationary Systems.

(f) CO: use AP42 (4/77) value of 5 lb/1000 gal

5 lb/1000 gal x 539 x 10^6 gal/yr x 1 ton/2000 lb = 1,340 ton CO/yr

(g) Organics:

0.001 lb/gal* x 539 x 10^6 gal/yr x 1 ton/2000 lb = 270 ton/yr

*AP42 (4/77)

2. New coal fired boilers with same heat rate as the resource recovery plants:

220 Billion BTU/day

Determine equivalent tons per day of bituminous coal @ 12,500 BTU/lb.

220 x 10^9 BTU/day x (1/12,500) lb/BTU x (1/2000) ton/lb = 8,800 tpd coal

(a) PM - emission rate of 0.03 lb/million BTU (NSPS)

0.03 lb/10^6 BTU x 220 x 10^9 BTU/day x 365 day/yr x 1/2000 ton/lb = 1,110 $\frac{\text{ton P.M.}}{\text{yr}}$

(b) SO_2 - emission rate of 0.6 lb/million BTU (N.J.A.C. 7:27-10 allowable emission rate for new large coal fired boilers)

0.6 lb/10^6 BTU x 220 x 10^9 BTU/day x 365 days/yr x 1/2000 ton/lb = 24,090 ton SO_2/yr (with scrubber)

Assume 2% sulfur coal 8,800 tons/day x .04 ton SO_2/ton x 365 day/yr = 128,480 tons SO_2/yr (uncontrolled)

(c) HCl - 0.1% chlorine content (Illinois State Geol. Survey, 1974)

0.001 ton/ton x 8,800 tpd x 365 day/yr = 3,212 tpy

(neglect wt of combining H_2)

Assume the required scrubber will remove 90% of the HCl.

0.10 x 3,212 tpy = 321 ton HCl/yr

(d) NO_x - 18 lbs/ton per AP42 (4/77)

18 lb/ton x 8,800 ton/yr x 1/2000 ton/lb x 365 day/yr = 28,600 ton NO_x/yr

(e) CO - 1 lb/ton per AP42 (4/77)

1 lb/ton x 8,800 tpd x 365 day/yr x 1/2000 ton/lb = 1,606 ton CO/yr

(f) Organics - 0.3 lb/ton AP42 (4/76)

0.3 lb/ton x 8,800 tpd x 365 day/yr x 1 ton/2000 lb = 480 ton/yr

(g) Lead - 10 ton Pb*/10^6 ton coal x 8800 tpd x 365 day/yr x 0.2 (control efficiency factor) = 6.4 tons of lead per year

*Occurrence and Distribution of Potentially Volatile Trace Elements in Coal, Illinois State Geol. Survey.

3. Total Emissions for New Jersey

pollutant	tons/year
Particulates	159,454
SO_2	314,987
HCl	-
NO_x	540,423
Pb	-
CO	1,770,379
VOS	690,739

Particulates data source is a screened run of APEDS (NJ) data. The sulfur dioxide emission rate is NEDS (EPA) data, representative of 1975-1976. The NO_x, CO and VOS totals are unedited 1980 inventory figures used in the 1982 SIP. HCl and Pb are not included in the inventory.

TABLE 1

COMPARISON OF AIR POLUTION CONTROL DEVICES USED BY NEW FUEL BURNING FACILITIES

	Air Pollution Controls
Resource Recovery Facilities	ESP and Scrubber or Dry scrubber and Baghouse
Oil Fired Boilers	None
New Coal Fired Boilers	ESP and Scrubber or Dry scrubber and Baghouse

TABLE 2

COMPARISON OF EMISSIONS FROM 22,000 TPD MSW COMBUSTION AND EQUIVALENT HEAT CONTENT COMBUSTION OF LOW SULFUR OIL AND BITUMINOUS COAL

	EMISSIONS IN TONS/YEAR						
	Particulate Matter	SO_2	HCl	NO_x	Lead	CO	VOS
22,000 ton/day Resource Recovery Facilities with Scrubbers (9163 million BTU/hr)	3,170	11,560	4,015	12,050	400	16,060	442
Existing Oil-Fired Boilers (9163 million BTU/hr)	1,610	12,850	26	20,210	8	1,340	270
New Coal-Fired Boiler (9163 million BTU/hr)	1,110	24,090	321	28,600	6	1,606	480
Total New Jersey	159,454	314,987	-	540,423	-	1,770,379	609,739

TABLE 3

COMPARISON OF TOTAL ACID GAS EMISSIONS WITH AND WITHOUT SCRUBBERS

Facility	Total HCl and SO_2 Emissions (ton/yr)		
	Without Scrubber	With Scrubber	Control Level
Proposed 22,000 ton/day Resource Recovery Facilities	78,690	15,575	90% HCl 70% SO_2
Equivalent Oil Fired Boilers	12,876	12,876 (no scrubber)	None
Equivalent Coal Fired Boilers	128,480*	24,410	90% HCl NSPS SO_2

*Based on 2% sulfur coal

State of New Jersey
Department of Environmental Protection
Solid Waste Administration

1982
LISTING

PROPOSED SOLID WASTE DISPOSAL FACILITIES

ACCORDING TO APPROVED DISTRICT SOLID WASTE MANAGEMENT PLANS

NA - Not Available   T/D - Tons per Day

COUNTY/DISTRICT	FACILITY TYPE	ESTIMATED CAPACITY	ESTIMATED OPERATION DATE
ATLANTIC	Modular Incinerator Landfill	8 - 20 Tons Regional	1984 Jan. 1986
BERGEN	Resource Recovery	3000 T/D	1983
BURLINGTON	Resource Recovery Landfill	1500 T/D Regional	1985 1983
CAMDEN	Resource Recovery Landfill	400-600 T/D Regional	1985 NA
CAPE MAY	Landfill Resource Recovery	200 acre 50 T/D	Jan. 1983 1985
CUMBERLAND	Eastern Landfill Western Landfill Resource Recovery	350 T/D (36 acre) 80 T/D (10 acre) NA	Dec. 1982 Dec. 1982 NA
ESSEX	Resource Recovery	2000-2500 T/D	1985
GLOUCESTER	Resource Recovery Landfill	NA NA	1985 NA
HMDC	Landfill	Regional	1983
HUDSON	Resource Recovery	1500-2000 T/D	1985
HUNTERDON	Transfer Station	300 T/D	1983
MERCER	Resource Recovery Landfill	1125 T/D 190 acres 750 T/D	1985 NA

State of New Jersey
Department of Environmental Protection
Solid Waste Administration

PROPOSED SOLID WASTE DISPOSAL FACILITIES

ACCORDING TO APPROVED DISTRICT SOLID WASTE MANAGEMENT PLANS

NA - Not Available T/D - Tons per Day

COUNTY/DISTRICT	FACILITY TYPE	ESTIMATED CAPACITY	ESTIMATED OPERATION DATE
MIDDLESEX	Resource Recovery	1200 T/D	1985
	Landfill #1	100 acre	1982
	Landfill #2	100 acre	1983
MONMOUTH	Reclamation Center	1800 T/D	Operational
	Resource Recovery	1800 T/D	1986
MORRIS	Resource Recovery	1500 T/D	Jan. 1985
	Landfill	1500 T/D	July 1983
OCEAN	Ocean Cty. Landfill Corp.	400+ acres	1983
	So. Ocean Landfill	283 acres	1983
	Resource Recovery	600-1000 T/D	late 1980's
PASSAIC	Resource Recovery	1100 T/D	1985
	Landfill	Regional	NA
SALEM	Landfill	95 acre 250 T/D	June 1983
SOMERSET	Resource Recovery	650 T/D	1985
	Landfill	120 acre	1983
SUSSEX	Resource Recovery	1000 T/D	Jan. 1985
	Landfill	500 T/D	Jan. 1983
UNION	Resource Recovery	1750 T/D	1985
WARREN	Resource Recovery	1000 T/D	1984
	High Point Expansion (landfill)	Regional	1982

Note on Proposed Solid Waste Disposal Facilities

Modular Incineration - smaller capacity combustion unit with material and/or energy recovery capabilities.

Resource Recovery - large capacity combustion unit (water-wall combustion) with material and/or energy recovery capabilities.

Reclamation Center - (Monmouth County) shredder, ferrous separator, tire shredder, landfill.

RANGE OF TPD 20,335 to 21,935

ATTACHMENT ~~8~~ 6

September 19, 1983

DRAFT OUTLINE OF PLAN OF STUDY FOR AIR POLLUTION ASPECTS OF INCINERATING SEWAGE SLUDGE AND MUNICIPAL SOLID WASTE

A. Establish fuel composition (metals, pesticides, PCB's, plastics, etc.)

Sludge: Use quality assurance reports and literature. Consider secondary treatment, if being implemented, and modify data to obtain maximum hourly emissions.

Solid waste: Sampling plus literature search. Use conservative values.

Determine if sewage sludge is classified hazardous.

Submit above to DEP for review.

B. Determine uncontrolled emissions (maximum annual and maximum hourly) of selected pollutants. (This will be necessary for Section G of the New Jersey air permit application.)

1. carbon monoxide
2. sulfur dioxide
3. nitrogen oxides
4. particulate matter
5. total hydrocarbons
6. lead
7. beryllium
8. mercury
9. nickel
10. chromium
11. arsenic
12. cadmium
13. hydrogen chloride
14. hydrogen fluoride
15. PCB's and PBB's
16. pesticides (from Quality Assurance Rpts)
17. N.J.A.C. 7:27-17, Toxic Volatile Organic Substances
18. acetaldehyde
19. chlorophenols
20. formaldehyde

(The above list of substances may be modified by the Department. The intent is to obtain emission rates for criteria pollutants, heavy metals, refractory hydrocarbons, and combustion by-products, which are likely to be present in flue gas emissions from resource recovery facilities.)

Other substances: water vapor, carbon dioxide, and oxygen.

Submit to NJDEP for review. Show basic data, assumptions, and calculations.

C. Evaluate existing air quality (attainment/nonattainment) for carbon monoxide, sulfur dioxide, nitrogen oxides, particulates and lead).

D. Determine controlled emissions.

1. Regulatory overview

a. NJ Regulations

N.J.A.C. 7:27-5	Prohibition of Air Pollution
N.J.A.C. 7:27-8	Permits & Certificates
N.J.A.C. 7:27-11	Incinerators
N.J.A.C. 7:27-13	Ambient Air Quality Standards
N.J.A.C. 7:27-17	Control and Prohibition of Air Pollution by Toxic Substances
N.J.A.C. 7:27-18	Control and Prohibition of Pollution from New or Altered Sources Affecting Ambient Air Quality in Nonattainment Areas (Emission Offset Rule)

b. EPA Regulations; New Jersey Review

NESHAPS: limits on mercury and beryllium

NSPS (New Source Performance Standards) Subparts E & O (Incinerators and Sludge Incinerators)

PSD (Prevention of Significant Deterioration)

c. EPA Review

PCBs: sludge containing 50 ppm or more of PCB's is categorized as PCB waste, requires special treatment (Federal Register, May 31, 1979). Contact Jehuda Menczel, Region II, EPA 212-264-4479.

2. Best Available Control Technology (BACT) Review (state-of-the-art demonstration). See Air Pollution Control Guidelines, March, 1983.

3. List maximum hourly and annual controlled emission rates for each emission point for all pollutants in Section 3.

E. Air Quality Dispersion Modelling: Required by N.J.A.C. 7:27-18 if regulated pollutant emission is greater than 50 tons per year. Also, required if facility is PSD affected.

Modelling analysis will entail a detailed study of the facility's air quality impact for all pollutants, plus a determination of the need for air quality monitoring. Prior to any modelling, meet with NJDEP to agree on specifics. Refer to EPA modelling guidelines.

For any modelling, as well as for the air permit application, basic stack parameters must be known. These include ACFM and gas temperature (at max., min., and average load) and height and diameter. Also, nearby building(s) height, width and length must be known for downwash studies.

In general, modelling will start with a screening model of the area enclosed within a 50 km circle centered on the source to establish the area of significant impact. Terrain features and nearby major sources will have to be considered, and modelling results should be stack specific so weight ratioing of pollutants will be possible. Concentrations of criteria pollutants predicted must be added to background levels to be compared with NAAQS.

Pollutant concentrations at locations of maximum concentrations, at monitoring sites and at state boundary lines must be determined.

Sensitive receptors (hospitals, houses, schools, nursing homes, parks and playgrounds) within 1/2 km of the location of maximum concentration, plus developed areas and environmentally sensitive areas (forest, prime farmlands, wildlife management areas and refuges, state parks and national recreation areas) within the area of significant impact should be identified.

F. Offset Applicability: results of items D and E above will determine if offsets are required. If required, an assessment of available offsets should be done. Also, a re-evaluation of control technology to determine Lowest Achievable Emission Rate would be required if offset applicable.

Robert Yeates William O'Sullivan

State of New Jersey

DEPARTMENT OF THE PUBLIC ADVOCATE
CN 850
TRENTON, NEW JERSEY 08625

JOSEPH H. RODRIGUEZ
PUBLIC ADVOCATE

TEL. 609-292-7087

Assembly County Government and
Regional Authorities Committee
State House Annex
Trenton, New Jersey 08625

Dear Committee Members:

Enclosed is a position paper of the Department of the Public Advocate on the environmental aspects of resource recovery facilities. Our Department submits this paper so it can be included in the Assembly Bill 1778 record.

The Department of the Public Advocate recognizes that the State of New Jersey faces a solid waste disposal crisis and that we must seek alternatives to landfill disposal. Resource recovery facilities are an alternative which will reduce our waste stream and convert our solid waste into valuable energy. These facilities should, therefore, be a part of a comprehensive approach to solid waste disposal in New Jersey.

However, as our position paper explains, the State of New Jersey should adopt a comprehensive and rigorous set of environmental standards to reduce the emissions of harmful pollutants from resource recovery facilities and address the hazardous nature of the residue.

In addition, the State should encourage and provide incentives for other waste control methods such as mandatory recycling and source separation programs.

On behalf of our Department, I want to express our gratitude to the Committee for seeking solutions to the solid waste problem in New Jersey. I hope the Committee will feel free to call on me or my staff for any further assistance we can provide on an issue of such significance to the public interest of the State's citizens.

Sincerely,

Joseph H. Rodriguez

Joseph H. Rodriguez

JHR:NH
Enclosure

The Environmental Aspects of Resource Recovery Facilities:

A Position Paper of the Department of the Public Advocate

JOSEPH H. RODRIGUEZ
PUBLIC ADVOCATE

By: Susan C. Remis
Division of Public Interest Advocacy

May, 1984

TABLE OF CONTENTS

I. INTRODUCTION

New Jersey is one of the first states in the country to experience a solid waste crisis.[1] According to the New Jersey Department of Environmental Protection, only two and a half years of landfill capacity exist throughout the State.[2] In response to this severe solid waste problem, eighteen of the twenty-two solid waste management districts in New Jersey[3] have proposed the construction of resource recovery facilities to handle their county's solid waste.[4] In addition, legislation was recently introduced which is designed to provide significant economic incentives for the construction and operation of resource recovery plants.[5]

The Department of the Public Advocate has a long-standing interest in solid waste management issues. The Public Advocate recently testified on resource recovery facilities and solid waste disposal before the Assembly County Government and Regional Authorities Committee.

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[1] Report of the Assembly Energy and Natural Resources Committee on Recycling, "Resource Recovery and Effective Solid Waste Management in New Jersey," at 1 (June 1983).

[2] Telephone conversations of Susan Remis, Division of Public Interest Advocacy on March 20, 1984 with Edward Londers, Assistant Director for Engineering and Licensing Elements in the N. J. DEP, and with Michael Debonis, Assistant Director of Planning and Resource Management in the N. J. DEP.

[3] Barbara Eisler, Throwing It Away in New Jersey: A Comprehensive Look at Waste Disposal at 36 (1983).

[4] A resource recovery facility is a solid waste disposal plant which incinerates garbage and produces steam or hot water as a byproduct. The steam or hot water can then be used to generate electricity.

[5] On March 15, 1984, Assemblyman McEnroe introduced Assembly Bill 1778 in the Assembly County Government and Regional Authorities Committee.

Our Division of Rate Counsel actively participates in proceedings to ensure that affordable landfill rates are balanced against the need for safe, adequate, and environmentally acceptable facilities, as required by New Jersey law. Moreover, the Division of Public Interest Advocacy reviews all solid waste management plans and amendments filed by New Jersey's twenty-one counties and by the Hackensack Meadowlands District to determine if the proposed plans and amendments represent sound planning and management. In addition, the Public Advocate participated in the Resource Recovery Generic Proceedings before the New Jersey Board of Public Utilities and recommended to the New Jersey Department of Environmental Protection a number of revisions and increased protections in regulations implementing the Sanitary Landfill Facility Contingency Fund Act. N.J.S.A. 13:1E-100 et seq.

This white paper presents the Department of the Public Advocate's position on the environmental aspects of resource recovery facilities. As part of our investigation on resource recovery and solid waste disposal alternatives, the Department met with a wide variety of experts, including combustion engineers, toxicologists, solid waste planners, environmentalists, businessmen involved with recycling, manufacturers and vendors of resource recovery facilities, and community organizations. The Department reviewed a wide range of scientific literature which included epidemiological and toxicological studies, engineering data, and environmental impact analyses. The Public Advocate also reviewed a number of books and articles on the policy aspects of solid waste management.

As a result of this investigation, the Department of the Public Advocate advances two central points. First, the State of New Jersey should permit the construction and operation of resource recovery facilities only with the most stringent and comprehensive of environmental regulations. While resource recovery facilities may be one component of a comprehensive solid waste disposal plan, we must acknowledge that resource recovery facilities create a host of potential health and environmental hazards from the air emissions and residue from incinceration. New Jersey should, therefore, require a comprehensive and rigorous set of environmental standards to reduce emissions of harmful pollutants and address the hazardous nature of the residue.

Second, the use of resource recovery facilities is only one method of handling solid waste disposal and should not be pursued in the absence of other waste control methods. Specifically, the State of New Jersey should encourage and require mandatory and aggressive recycling and source separation programs as well as other waste reduction programs.

This position paper will present information on some of the environmental hazards associated with the emissions from resource recovery facilities. In particular, it will discuss the presence of heavy metals, toxic organic compounds, and acid gases in the gaseous emissions and residue from resource recovery plants. In each of these three areas, this paper will explain the recent studies on the environmental and health hazards associated with these pollutants and the absence of adequate regulatory controls or standards to reduce emissions of these toxic substances. The Department of the Public Advocate's recommendations focus on the need for mandatory and specific regulations in the areas of the operation and design of resource recovery facilities, emissions testing and permissible emission rates for heavy metals, organics, and acid gases, and the landfilling of the fly ash and bottom ash residues from resource recovery facilities.

This paper will also discuss methods of recycling, waste reduction, and source separation. If the State of New Jersey adopted these material recovery programs, our waste stream will be significantly reduced.

As a result, we would need less landfill space, and fewer and smaller resource recovery plants could be built at a lower capital and operational cost. Since less refuse will be incinerated in a smaller facility, the emissions of toxic pollutants in the air and residue would be substantially reduced.

Recycling programs will also reduce toxic emissions from resource recovery plants in another manner. If certain items, such as plastics and metals, are removed from the waste stream before incineration, there will be a reduction in the emissions of toxic organic substances, heavy metals, and acid gases. Moreover, certain waste components such as glass and metals have a higher resource value if they are reprocessed rather than burned for energy. When these materials are removed, the remaining solid waste will have an improved energy content.

In short, the adoption of rigorous environmental standards and a comprehensive materials recovery program would not only benefit our environment and public health, but would also reduce the costs and increase the efficiency of resource recovery facilities.

II. Emissions from Resource Recovery Facilities Which May Endanger The Environment and Our Public Health

The incineration of municipal solid waste raises serious problems related to the presence of highly toxic micropollutants and gases in the emissions from resource recovery facilities. In particular, scientists have consistently found heavy metals and trace organic compounds (dioxins and furans) in stack and fly ash samples and the release of vast quantities of acid gases from resource recovery facilities in both the United States and in Europe.[6]

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[6] The following scientists report the emission of heavy metals from resource recovery facilities: Paul Giodano and Allan Behel, et al., "Mobility in Soil and Plant Availability of Metals Derived from Incinerated Municipal Refuse," 17 Environ. Sci. Technol. 193 (1983); M. Hutton, "A Prospective Atmospheric Emission Inventory for Cadmium - The European Community as a Study Area," 29 Sci. of Total Environ. 29 (1983); Robert Greenberg and William H. Zoller et al., "Composition and Size Distributions of Particles Released in Refuse Incineration," 12 Envir. Sci. and Tech. 566 (1978).

The following scientists report the emission of dioxins and furans from resource recovery facilities: C. Chiu, R. S. Thomas, et al., "Polychlorinated Hydrocarbons from Power Plants, Wood Burning, and Municipal Incinerators," Environment Canada, 12 Chemosphere 607 (1983); O. Bronzetti, C. Bauer, and C. Casi et al., "Mutagenicity Study of TCDD and Ashes from Urban Incinerator 'In Vitro' and 'In Vivo' Using Yeast D7 Strain," 12 Chemosphere 549 (1983); M. Rizzardini, M. Rumano, and F. Gizzi, "Toxicological Evaluation of Urban Waste Incincerator Emissions," 12 Chemosphere 559 (1983); A. J. Teller and J. D. Hauber, "Control of Dioxin Emissions from Incinceration," presented at the 76th Annual Meeting and Exhibition of Air Pollution Control Association, Atlanta, Georgie (June 19-24, 1983); Essex County Resource Recovery Project, Environmental Impact Statement, Technical Appendix Vol. 4 at 10 (1983); Air Pollution Control at Resource Recovery Facilities, Calif. Air Resources Board at 210-237 (1983); EPA's Interim Evaluation of Health Risks Associated with Emission of Tetrachlorinated Dioxins from Municipal Waste Resource Recovery Facilities at 12 (No. D ((1981); J. E. Huff and J. A. Moore, "Long-Term Hazards of Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans," 36 Environmental Health Perspectives, 221, 222 (1980); M. Esposito, T. Tiernan, and F. Dryden, Dioxins, EPA Report 600/2-80-297, November 1980, p. 187. (continued on page 6)

A. Heavy Metals

1. The Presence and Toxicity of Heavy Metals in the Emissions

Refuse burning facilities can emit significant quantities of metallic compounds to the atmosphere.[7] Scientists have found "excessive amounts" of cadmium and lead in fly ash and bottom ash residues from refuse-burning plants.[8] According to the New Jersey DEP, resource recovery facilities are expected to generate 283 tons of lead emissions each year by 1990. Sludge and resource recovery incineration facilities together are projected to account for 15% of total lead emissions in 1986 and for 21% of the total lead emissions in 1990.[9] One scientific study concluded that resource recovery will be the major source of cadmium, and antimony in many urban

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[6] (continued from page 5)

The following scientists report the release of acid gases from resource recovery facilities into the environment: R. Rollins and J. B. Homolya, "Measurement of Gaseous Hydrogen Chloride Emissions from Municipal Refuse Engergy Recovery Systems in the United States," 13 Env. Sci. and Tech. 1380 (November 1979); T. Miyanohara and S. Kitami, "Present Situation of HCl Gas Removal Technology in Municipal Refuse Incineration Plants in Japan," Recycling Berlin 179, Springer-Verlag, Berlin, West German, 504 (1979); Daryl Mills, Air Pollution Control of Municipal Solid Waste Incinerators, Cal. Air Resources Board, at 5 (March 1984); Testimony of William O'Sullivan, N. J. DEP Air Pollution Control Program before the Clean Air Council and Solid Waste Management Advisory Council (March 19, 1984); Jack Lamber, The Need for Best Available Control Technology for Resource Recovery Facilities, New York State Department of Environmental Conservation (May 1983).

[7] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 208 (Nov. 1983).

[8] Paul Giordano and Allan Behel, Tennessee Valley Authority, "Mobility in Soil and Plant Availability of Metals Derived from Incinerated Municipal Refuse," 17 Envir. Sci. Technol. 193 (1983).

[9] Proposed New Jersey State Implementation Plan for Attainment and Maintenance of the National Ambient Air Quality Standards for Lead at 19 (Jan. 1984).

areas.[10] Another study found that waste incineration in Europe produced 31 metric tons of cadmium emissions each year.[11] This made waste incineration the second largest cadmium emitter in Europe (second only to iron and steel production).[12] Refuse fly ash, suspended particles, and gaseous emissions show high concentrations of other metals such as arsenic, chromium, manganese, mercury, copper, nickel and tin.[13]

These metallic compounds are extremely toxic to people. For example, lead is a toxic metal which affects the gastrointestinal system, liver, kidneys, blood, and central nervous system and has been identified as an animal carcinogen and cocarcinogen.[14] Antimony produces adverse cardiovascular, pulmonary, reproductive, and developmental effects,[15] and cadmium is a toxic metal identified by the EPA as a carcinogen.[16]

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[10] Robert Greenberg and William Zoller, "Composition and Size Distribution of Particles Released in Refuse Incineration," 12 Envir. Sci. and Tech. 566, 571 (1978).

[11] M. Hutton, "A Prospective Atmospheric Emission Inventory for Cadmium - The European Community as a Study Area," 29 Sci. of Total Envir. 29, 41 (1983).

[12] *Id*. at 41.

[13] Robert Greenberg and William Zoller, "Composition and Size Distributions of Particles Released in Refuse Incineration," 12 Env. Sci. and Tech. 566, 568 (1978).

[14] *Air Pollution Control at Resource Recovery Facilities*, Cal. Air Resources Board at 186.

[15] *Id*. at 186.

[16] EPA, *The Carcinogen Assessment Group's List of Carcinogens*, July 14, 1980.

Many metallic elements, including lead, cadmium, antimony, arsenic, and tin adhere and concentrate on the fine particulate matter emitted from the refuse.[17] These small particles are especially hazardous to public health since they are harder to control with air pollution equipment, travel easily on air currents, and are readily inhaled and imbedded in the lungs.[18]

B. Dioxin and Furan Emissions (Toxic Organic Substances)

Scientists have also consistently found polychlorinated dibenzo-p-dioxins (PCDDs or dioxins) and polychlorinated dibenzofurans (PCDFs or furans) mixtures in stack and fly ash samples from resource recovery plants in both the United States and in Europe.[19] Like heavy metals, dioxins and furans are mostly found on microscopic fly ash particles which are easily inhaled into the deepest part of the lungs and can then be absorbed into the body.[20]

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[17] Air Pollution Control at Resource Recovery Facilities, Cal. Air. Resources Board at 186; R. P. Greenberg and W. H. Zoller, et al., "Composition and Size Distributions of Particles Released in Refuse Incineration," 12 Env. Sci. & Tech. 566 (1978).

[18] Air Pollution Control at Resource Recovery Facilities, Calif. Air Resources Board at 3; James Hilbert, "Resource Recovery - Can It Really Dispose of Garbage Without Hazard," (January 4, 1984); Report of the Citizens Task Force on Resource Recovery at 12 (April 1984); Nancy J. Sell, Industrial Pollution Control at 6 (1981).

[19] Id. at footnote 6.

[20] James Hilbert, "Resource Recovery - Can It Really Dispose of Garbage Without Hazard," (Jan. 4, 1984); Report of the Citizen Task Force on Resource Recovery in New York State at 12 (April 1984); Nancy J. Sell, Industrial Pollution Control, at 6 (1981).

1. Toxicity of dioxins and furans

Dioxins, especially the 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), are among the most acutely toxic substances known to man.[21] Extremely small doses of 2,3,7,8 TCDD in laboratory animals cause, among other things, genetic damage, liver damage, cancer, general debilitation, and death.[22]

In humans, toxicity due to 2,3,7,8-tetra-CDD has been reported after occupational exposure and industrial accidents. Chloracne is one of the most constant and prominent features of 2,3,7,8 TCDD exposure.[23] Chloracne is a severe type of skin disorder characterized by epidermal cysts, comedones (plugs of oily or fatty matter capped with a blackened mass of dust and epithelial debris), and pustules (skin elevations containing pus), with eventual scarring. Chloracne frequently originates on the face and sometimes spreads to other parts of the body. Many patients also have inflamed eyelids and inflammation of other mucous membranes. Sometimes the chloracne is preceded by redness of the skin and skin lesions.[24]

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[21] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board (November 15, 1983) at 210; J. E. Huff and J. A. Moore, et al., "Long Term Hazards of Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans." supra at 222; A. J. Teller and J. D. Lamber, "Control of Dioxin Emissions from incineration," supra at 1.

[22] Memorandum from Commissioner J. Richard Goldstein, M.D., Department of Health to All Physicians, dated June 1983; G. Bronzetti, C. Bauer, and C. Corsi, "Mutagenicity Study of TCDD and Ashes from Urban Incinerator 'In Vitro' and "In Vivo' Using Yeast D7 Strain," supra, at 549; J. E. Huff and J. A. Mouse, "Long-Term Hazards of Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans," supra at 223.

[23] Id. at 227; Memorandum of J. Richard Goldstein, M.D., Commissioner of the New Jersey Department of Health, to All Physicians, dated June 1983.

[24] J. E. Huff and J. A. Moore, "Long Term Hazards of Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans," supra at 227.

Chloracne is extremely resistant to treatment.[25] In addition, exposed subjects have been found to develop a wide variety of other serious symptoms, including inflammation of the spinal nerves, wasting of muscles, liver damage, sensorial impairments, and cancer.[26]

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[25] Letter of Commissioner J. Richard Goldstein, M.D., Department of Health, supra.

[26] J. E. Huff and J. A. Moore, "Long Term Hazards of Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans," supra at 232-233. According to J. Richard Goldstein, Commissioner of the State of New Jersey Department of Health, exposure to dioxins may result in the following diseases and symptoms:

Skin
Chloracne
Hyperpigmentation
Hypertrichosis
Edema and erythema
Blepharoconjunctivitis
Conjunctival cysts
Sties

Neuropsychological
Headache
Lower extremity weakness
Difficulty in walking
Ataxia
Paresis
Hearing loss
Loss of sense of taste, odor
Lack of vigor, drive
Easy fatigability
Insomnia
Hypersomnolence
Personality change
Emotional instability
Depression
Diminished ability to learn
Memory deficits
Decreased libido
Impotence
Abnormalities in psychological tests
Abnormalities in tests of motor and sensory peripheral nerve function
Abnormalities in nerve biopsy
(Footnote 26 continued on page 10)

The EPA Carcinogen Assessment Group states that dioxin should be regarded as both an initiator and promoter of carcinogenicity,[27] and the director of EPA's Office of Research and Development has stated that 2,3,7,8-TCDD is "by far the greatest [tumor] promoter known."[28]

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[26] (continued from page 9)

Liver
Clinical Findings
    Hepatomegaly
    Right upper quadrant tenderness, pain
    Hepatitis
    Hepatic porphyria
    Increased excretion uroprophyrins
    Porphyria Cutanea Tardea
    Liver function test abnormalities
        Alkaline phosphate, SGOT, SGPT
        Bilirubin, Bromosulfophthalein

    Liver Biopsy Findings
        Mild steatosis
        Periportal fibrosis
        Chronic venostatis with Kupffer cell activation
        Red fluorescence

Gastrointestinal
Weight loss
Anorexia
Abdominal pain
Post prandial flatulence
Nausea/vomiting
Gastritis

Cardiovascular
Case report rapidly progressive atherosclerosis
Increase cholesterol and/or triglycerides

Kidney and Urinary Tract
Case report hemorrhagic cystitis

Memorandum of Commissioner J. Richard Goldstein, Department of Health to All Physicians, re: Dioxins, dated June 1983.

[27] Environmental Protection Agency, Dioxins at 187 (1980).

[28] Statement of Bernard D. Goldstein to the Annual Meeting of the Air Pollution Control Association, 17 Environ. Sci. Technol. 397A (1983)

In addition, polychlorinated dibenzofurans exhibit many of the same acute effects as the dioxins.[29]

2. Dioxins and Furans at Refuse-Burning Facilities

No one disputes that dioxins and furans exist in the particulate and gaseous emissions of resource recovery facilities.[30] Scientists suspect that dioxins and furans are created when heat is applied to certain chemicals found in refuse, and these chemicals are not completely destroyed by the temperatures of the combustion process.[31] These chemical compounds, referred to as precursors of dioxin and furan, are believed to include PCBs (polychlorinated biphenols), chlorinated phenoxy acids, chlorophenols, and chlorobenzenes.[32] Discarded plastic is considered a potential major source of these chemical precursors.[33]

There are conflicting reports on how much dioxin and furans are produced at resource recovery plants and on whether these emissions can be effectively controlled by high temperatures and environmental control devices. While our Department lacks the technical expertise and resources to evaluate the conflicting data to determine its validity, it is

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[29] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 210 (November 15, 1983).

[30] *See* footnote 6.

[31] Essex County Resource Recovery Project, Environmental Impact Statement, Technical Appendix, Vol. 4 at 10.

[32] *Id.*

[33] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board, at 227; Barry Commoner and Theodore Goldfarb, A Preliminary Assessment of the Brooklyn Navy Yard Resources Recovery Project at 3 (April 13, 1982).

undisputed that prominent scientists have concluded that a number of reports have drastically understated the levels of dioxins found in resource recovery fly ash and stack emissions. For example, the United States Environmental Protection Agency issued a report in November 1981, entitled Interim Evaluation of Health Risks Associated with Emissions of Tetrachlorinated Dioxins from Municipal Waste Resource Recovery Facilities. This EPA report is widely cited by advocates for resource recovery since the report concludes that dioxin levels in the emissions of municipal waste combustors "do not present a public health hazard for residents living in the immediate vicinity." Id. at 12.[34]

However, a leading dioxin expert criticized the EPA report since the report only evaluated the presence of 2,3,7,8 TCDD isomers.[35] This isomer is only one of 75 dioxin isomers and is a "very minor constituent" in the fly ash emissions compared to the other dioxin isomers which are also "highly toxic."[36] Moreover, EPA assumed that the risk of cancer from a dioxin dose delivered to people via the lungs can be computed from the results of experiments in which animals were

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[34] The New Jersey DEP, in a statement before the Assembly Committee on County Government and Regional Authorities, placed exclusive reliance on this EPA report when it concluded that dioxin emissions from resource recovery plants do not present a public health hazard. Statement of the N.J.DEP concerning Air Pollution Control of Resource Recovery Facilities presented to the Assembly Committee on County Government and Regional Authorities, at 13 (May 14, 1984). As the discussion in the text will demonstrate, the results of the EPA report have been seriously questioned and more research of the public health hazards of dioxin is clearly warranted before any definitive statements can be made about dioxin.

[35] Letter of Christopher Rappe, Professor of Organic Chemistry, University of UMEA to Mr. James Johnson, Jr., Oregon City Commissioner, criticizing the EPA Interim Report on Dioxin Emissions dated December 15, 1981. A Mitre Corporation Study entitled "Preliminary Study of Health Effects Associated With Stack Emissions from Proposed Montgomery County, Maryland Energy Recovery Facility" suffers from the same defect as the EPA study since it also limits its examination of dioxins to the 2,3,7,8 TCDD isomer.

[36] Letter of Christopher Rappe, supra; See Essex County Resource Recovery Project, EIS, Technical Appendix, Vol. 4 at 57.

administered dioxin via their food.[37] However, the biological effect of a toxic substance is much more severe when the substance is inhaled rather than ingested. No testing has ever been conducted on what affect inhalation of PCDD or PCDF may have on toxicity.[38]

Two scientists, A. J. Teller and J. D. Lauber have criticized the sample-gathering techniques employed in many dioxin studies. These scientists report that dioxin collected in the fly ash may only be a portion of total dioxins emitted because dioxin concentration in the flue gas (gaseous emissions) are 10 to 1,000 times greater than in the fly ash.[39] Furthermore, the focus on fly ash collected by electrostatic precipitators (ESPs) is not sufficient since ESPs do not effectively remove the small submicron particles that have the highest concentration of absorbed dioxin pollutants.[40]

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[37] Barry Commoner and Theodore Goldferd, A Preliminary Assessment of the Navy Yard Resource Recovery Project, at 8 (April 13, 1982).

[38] Essex County Resource Recovery Project, EIS, Technical Appendix, Vol. 4 at 76.

[39] A. J. Teller and J. D. Lauber, Control of Dioxin Emissions from Incineration, presented at 76th Annual Meeting and Exhibition, Air Pollution Control Association (June 1983).

[40] Id.

C. Hydrogen Chloride and Hydrogen Fluoride (Acid Gases)

1. The Presence of Hydrogen Chloride and Hydrogen Fluoride Emissions in Resource Recovery Plants

In addition, resource recovery facilities can produce substantial quantities of hydrogen chloride and hydrogen fluoride.[41] These acid gases are formed from the chlorine and fluorine in refuse. Uncontrolled emissions of hydrogen chloride from refuse burning facilities average five to six pounds per ton of refuse burned and can be as high as 10 pounds per ton.[42] At a large resource recovery facility such as the proposed Essex County facility (a 2250 tons/day facility), uncontrolled hydrogen chloride emissions could be as high as 22,500 pounds of hydrogen chloride per day. Even if Essex County reduced their hydrogen chloride emissions by 90%, as required by the New Jersey DEP guidelines, hydrogen chloride emissions could still equal 2,250 pounds of hydrogen chloride daily. According to the New Jersey DEP, Air Pollution Control Program, hydrogen chloride emissions from refuse are 100 times greater than hydrogen chloride emissions from oil and 10 times greater than hydrogen chloride emissions from coal.[43]

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[41] Daryl R. Mills, Air Pollution Control of Municipal Solid Waste Incinerators, Cal. Air Resources Board at 84-37.2 (March 1984); Testimony of William O'Sullivan, New Jersey DEP Air Pollution Control Program to the Clean Air Council and Solid Waste Management Advisory Council Hearing (March 19, 1984).

[42] Daryl R. Mills, Air Pollution Control of Municipal Solid Waste Incinerators, Cal. Air Resources Board at 84-37.2 (March 1984).

[43] Testimony of William O'Sullivan, N. J. DEP Air Pollution Control Program to the Clean Air Council and Solid Waste Management Advisory Council Hearing (March 19, 1984).

2. Adverse Effects of Acid Gases

(a) Health Effects

The presence of hydrogen chloride in the air can produce the following short term health effects:[44]

At .07 parts per million (ppm),[45] hydrogen chloride causes immediate changes in the rhythm and depth of respiratory movement;

At .134 ppm, hydrogen chloride will sting the eyes;

At 35 ppm, hydrogen chloride will irritate the throat;

At 50-100 ppm, the effects from hydrogen chloride exposure are intolerable and immediate evacuation is necessary; and

An exposure to 1100 to 2000 ppm of hydrogen chloride is lethal.

Moreover, a long term exposure to a low level of hydrogen chloride can damage a person's tooth enamel.[46]

(b) Acid Deposition

When hydrogen chloride and hydrogen fluoride are released and react with the moisture in the air, acid rain or fog is produced.[47] The acid nature of hydrogen chloride and hydrogen fluoride also will corrode metals and alloys. In addition, prolonged exposure to hydrogen

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[44] Memo of William O'Sullivan, N. J. DEP Air Pollution Control Program, re: Hydrogen Chloride from Municipal Solid Waste Combustion, dated May 1, 1981.

[45] Note: 30.6 ppm of hydrogen chloride is equivalent to an emission factor of .5 lb. of hydrogen chloride per ton of refuse.

[46] Memo of William O'Sullvan, *supra*.

[47] *Air Pollution Control at Resource Recovery Facilities*, Cal. Air Resources Board at 108; Memo of William O'Sullivan, N. J. DEP Air Pollution Control Program at 2.

chloride may cause deterioration of structures and vehicles.[48]

(c) Effect on Vegetation

Hydrogen chloride and hydrogen fluoride are known to cause direct damage to vegetation.[49] For example, tomatoes are damaged by hydrogen chloride exposure after only 20 hours of exposure at .7 ppm of hydrogen chloride. Higher concentrations of hydrogen chloride cause acute damage after only two hours.[50] Plants are even more sensitive to fluoride damage. Peaches, grapes, pine, oats, rye, gladioli, wheat, and corn are especially sensitive. These plants will be injured by fluoride exposures of .0015 ppm for a week.[51]

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[48] Jack Lauber, "The Need for Best Available Control Technology for Resource Recovery Facilities," N. Y. State Department of Environmental Conservation (May 1983).

[49] Memo of William O'Sullivan, N. J. DEP Air Pollution Control Program at 2.

[50] Id.

[51] Id.

III. Current New Jersey Law Fails to Adequately Regulate and Reduce The Toxic Metals, Organics and Acid Gases Which Are Released From the Incineration of Refuse

A. Problem 1: New Jersey Regulations Contain No Standards For The Design and Operation of Resource Recovery Facilities

At present, the State of New Jersey Department of Environmental Protection has not issued any standards to govern the design or operation of resource recovery facilities. Although the N. J. DEP is currently drafting such regulations, mandatory and specific standards should be issued before resource recovery facilities are constructed or allowed to operate.

Recommendation 1: The State of New Jersey Should First Promulgate Design and Operational Standards Before Issuing Any Licenses to Operate Resource Recovery Facilities

Explanation:

New Jersey DEP should issue regulations which specify what constitutes the best available control technology (BACT) to reduce toxic emissions and should require applicants to incorporate such technology into their plant design before receiving a permit to operate a resource recovery facility. The BACT requirements should be frequently updated to incorporate improved air pollution control techniques and designs.

The present New Jersey Air Pollution Control Act, N.J.S.A 26:2C-9.2, does state that

> [no] operating certificate . . . shall be issued . . . unless the applicant shows to the satisfaction of the department that . . . the equipment incorporates advances in the art of air pollution control developed for the kind and amount of air contaminant emitted by the applicant's equipment.

While DEP frequently maintains that N.J.S.A. 26:2C-9.2 requires resource recovery applicants to employ "state of the art" technology,[52] this provision gives DEP total discretion as to what controls are required and falls short of a clear and mandatory best available control technology requirement. For example, the California Air Resources Board states in their proposed guidelines that metal-enriched fine fly ash is best removed by the use of fabric filter systems (an environmental control device) and by the cooling of the flue gas in the particulate matter control equipment to between 300-445°F. to reduce the amount of metals which vaporize into the air.[53] However, under New Jersey's operating certificate requirements, these BACT air pollution control methods are not required.

In March 1983, DEP's Air Pollution Control Program issued guidelines for resource recovery facilities and incinerators. These guidelines are not incorporated into the air pollution regulations and are not mandatory rules. Rather, these guidelines are intended to assist applicants who seek permits to construct and operate resource recovery facilities and incinerators.[54]

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[52] See e.g., Statement of the New Jersey DEP Concerning Air Pollution Control of Resource Recovery Facilities Presented to the Assembly Committee on County Government and Regional Authorities at 5-7 (May 14, 1984); Air Pollution Control Guidelines for Resource Recovery Facilities and Incinerators, III(D)(5).

[53] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 209.

[54] It is significant to note the extensive scope and completeness of the California guidelines compared to the New Jersey guidelines. The California Air Resources Board issued a comprehensive, 237-page report which surveys the air pollution control technologies for resource recovery facilities, provides guidelines for appropriate control levels for pollutants released from resource recovery plants, and discusses ways to reduce toxic emissions. This report contains 385 references, an extensive bibliography of the scientific literature used in preparing the report, and lengthy appendices which set forth the methodology and data used by the California Air Resources Board to make their determinations. In contrast, the New Jersey DEP guidelines are completely contained in only eleven pages. The guidelines do not discuss specific technologies in any detail, provid only general reasons behind the recommended measures, and give no indication o the methodologies or references used in drafting the guidelines.

These resource recovery guidelines are inadequate to protect our health and environment since they also do not incorporate the best available control technology. According to the California Air Resources Board, a properly designed fabric filter system is capable of reducing overall particulate matter to .01 grains per day standard cubic foot and reducing fine particulate emissions (diameter size 2 microns) to below .008 grains per day standard cubic foot.[55] In contrast, under the New Jersey guidelines, no distinction is made between large and fine particles, and a resource recovery plant may emit .03 grains for each dry standard cubic foot of flue gas emitted.[56] This figure is more easily understood if placed in context. According to DEP's Environmental Quality Division, a resource recovery facility will emit 8,656 dry standard cubic feet of flue gas for every 100 pounds of refuse.[57] In a large resource recovery facility such as the one proposed by Essex County (a 2250 tons/day facility), <u>1620 pounds</u> of particulates may be emitted each day under the .03 New Jersey standard.[58] Since this level of particulate emissions may be very detrimental to our public health, DEP should issue operational and design regulations which require resource recovery plants to operate with the Best Available Control Technology.

These BACT regulations should separately address the reduction of heavy metal, toxic organic, and acid gas emissions since different factors control the emissions of these substances.

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[55] Id. at 9.

[56] Air Pollution Control Guidelines for Resource Recovery Facilities and Incinerators, II(A)(1).

[57] Telephone conversation between Susan Remis, Division of Public Interest Advocacy and Gary Pierce, Department of Environmental Protection, Environmental Quality Division, dated April 10, 1984.

[58] Id.

(a) The Control of Heavy Metal Emissions

The BACT regulations should address the three factors which influence metal enrichment on the fly ash from resource recovery facilities: particle size, flue gas temperature, and the number of particles in the combustion and post-combustion zones.[59]

(1) Particle Size

It is especially important that the BACT regulations limit the emission of small particles (diameter size of two microns or less) since many elements, including lead, cadmium, antimony, arsenic, and tin adhere and concentrate on the fine particulate matter emitted from the combustion of refuse.[60] Moreover, the small particles are especially hazardous to public health since they travel easily on air currents and can be readily inhaled and imbedded in the lungs.[61]

(2) Temperature

The BACT regulations for heavy metals should also specify a flue gas temperature in the particulate control equipment area since this also affects the amount of metal emissions from a resource recovery plant. A properly designed and operated plant should have low temperature levels in the particulate control equipment areas. Otherwise, many toxic metals will vaporize and be emitted through the stacks in gaseous form.[62]

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[59] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 193.

[60] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 193; R. P. Greenberg and W. H. Zoller et al., "Composition and Size Distribution of Particles Released in Refuse Incineration," 12 Env. Sci. & Tech. 566, 567 (1978).

[61] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 3; James Hilbert, "Resource Recovery - Can it Really Dispose of Garbage Without Hazard," (January 4, 1984); Report of the Citizens Task Force on Resource Recovery in New York State at 12 (April 1984); Nancy J. Sell, Industrial Pollution Control at 6 (1981).

[62] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 198.

(3) Number of Particles

In addition, the number or density of the small particles in the combustion and post-combustion zone affect metal emissions since vaporized metals are more likely to adhere to densely-packed fine particles.[63] The BACT regulations should require installation of the most effective environmental controls to guarantee that the maximum number of particles are captured by the pollution control equipment.

(4) Pre-combustion Separation

New Jersey regulations should also require pre-combustion separation techniques such as the removal of metals from the waste stream for recycling in order to reduce metal emissions.

b. The Control of Dioxins and Furans

With regard to dioxins and furans, New Jersey should issue Best Available Control Technology regulations which require the greatest level of fine particle capture and require the most efficient combustion process possible. Fine particulate control equipment will capture those particles with the highest concentrations of dioxins and furans, and a highly efficient combustion process will destroy more of the dioxin and furan compounds released during incineration.[64]

(1) Particulate Size

Toxic substances emitted from resource recovery facilities are predominantly found on the surface of fine particles (particles less than 2

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[63] Id. at 193.

[64] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 229; Essex County Resource Recovery Project, EIS, Technical Appendix, Vol. 4 at 31.

microns in diameter).[65] Dioxins, furans, and other organic compounds concentrate on the fine particles.[66] Particles of the 2 micron size are harder to capture with air pollution control equipment, travel further in air currents, and can easily be inhaled into the lungs where the compounds can be transferred with high efficiency into the blood system.[67]

Based on the increased danger that fine particulates pose to the public health, the Public Advocate recommends that the New Jersey DEP promulgate more stringent standards for fine particulate emissions. DEP guidelines currently require .03 grains for each dry standard cubic foot of flue gas emitted from a resource recovery facility.[68] According to the California Air Resources Board, a properly designed fabric filter system could reduce overall particulate matter to .01 grains per dry standard cubic foot and reduce fine particulate emissions (size of 2 microns) to below .008 grains per dry standard cubic foot.

In light of the dangers of dioxin and furan exposure, the New Jersey DEP should issue Best Available Control Technology regulations which require this high level of submicron particle capture.

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[65] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 3 (November 1983).

[66] Id. at 237; A. J. Teller and J. D. Lanber, Control of Dioxin Emissions, at 1 (June 1983); Report of the Citizen Task Force on Resource Recovery in New York State at 12 (April 1984).

[67] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 7-8; Report of the Citizen Task Force on Resource Recovery in New York State at 12; Nancy Sell, Industrial Pollution Control at 6-7.

[68] Air Pollution Control Guidelines for Resource Recovery Facilities and Incinerators, II (A)(1).

(2) Combustion Efficiency

The State should also adopt standards to ensure that resource recovery plants have combustion systems which are properly designed, operated, and maintained.

Four factors control combustion efficiency: (1) reaction temperature within the combustion zone and post-combustion zone; (2) residence time in the combustion and post-combustion zones; (3) turbulence or mixing efficiency; and (4) air to fuel ratio.[69] DEP should promulgate regulations which specifically address these factors.

(a) Temperature

Organic compounds, such as dioxins and furans, decompose with exposure to high temperatures.[70] The 1500°F. operating temperature currently required by DEP guidelines may be too low to destroy dioxins and furans.[71] Scientists disagree on the proper temperature level for resource recovery plants. A. J. Teller, from Teller Environmental Systems, Inc. and J. D. Lauber, from the New York State Department of Environmental Conservation, report that thermal destruction of dioxins (99.95%) occurs with exposure to a temperature of 2192°F.[72] California's

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[69] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 229; Essex County Resource Recovery Project, EIS, Technical Appendix, Vol. 4 at 31.

[70] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 229; Report of The Citizen Task Force on Resource Recovery in New York State at 11 (April 1984).

[71] Air Pollution Control Guidelines for Resource Recovery Facilities and Incinerators II(c)(1) (March 1983).

[72] A. J. Teller and J. D. Lauber, Control of Dioxin Emissions from Incineration, *supra* at 4.

proposed guidelines state that refuse-burning facilities should be maintained at 1800°F.± 190°F.[73] Essex County reports in their Environmental Impact Statement for a proposed facility that dioxins require 1600°F. and dibenzofurans require temperatures of 1750°F.[74] According to a chart contained in the Essex County EIS, a temperature of 1776°F. may be too low to destroy organic components since dioxin and furan emissions were still substantial in eighteen resource recovery facilities which operated at an average temperature of 1776°F.[75]

In sum, the DEP current guideline of 1500°F. appears very low, and DEP should not license resource recovery facilities until proper temperature levels for operating facilities are determined and required.

(b) Residence Time

Residence time in a furnace is defined as the amount of time it takes a molecule of fuel (refuse) to move the length of the furnace.[76] In general, longer residence times increase destruction efficiencies. A. J. Teller and J. D. Lauber recommend a 2-3 second residence time for dioxins (at 2160°F.).[77] Essex County states that dioxins and furans

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[73] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 236.

[74] Essex County Resource Recovery Project, EIS, Technical Appendix, Vol. 4 at p. 45.

[75] *Id*. at 141.

[76] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 233.

[77] A. J. Teller and J. D. Lauber, *supra* at 4.

should have a two second residence time (at 1472°F.),[78] and California's proposed guidelines state destruction of dioxins and furans occur at up to 4 seconds residence time (at 1300°F.).[79]

DEP guidelines only require a one second residence time (at 1500°F.).[80] Again, DEP should carefully analyze the technical literature to assess what proper residence time is necessary to destroy dioxin and furan compounds. In general, reasonable doubts should be resolved in favor of more, not less, stringent standards.

(c) Turbulence or Mixing Efficiency

Highly efficient mixing of the gas stream allows for closer contact between refuse and oxygen and therefore increases destruction efficiency.[81] According to the California Air Resources Board, a well-mixed gas stream will show less than 30% variation in carbon monoxide and oxygen concentrations across the face of the economizer exit, which is a part of the boiler. New Jersey DEP guidelines should address the mixing efficiency as a standard for resource recovery plants.

(d) Air to Fuel Ratios

Efficient combustion also requires that fuel (refuse) be exposed to a sufficient concentration of oxygen. Since refuse is a relatively low

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[78] Essex County Resource Recovery Project, EIS, Technical Appendix, Vol. 4 at 11.

[79] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 232.

[80] Air Pollution Control Guidelines for Resource Recovery Facilities and Incinerators, II(c)(2) and (3).

[81] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 232.

quality fuel,[82] more oxygen may be necessary for the combustion process to be complete in a resource recovery facility. The DEP should issue standards that address this air to fuel ratio factor.

(3) Pre-Combustion Separation

And finally, the State of New Jersey should also consider the use of a pre-combustion separation program, especially designed for removal of the precursors to dioxins and furans. Key components of a separation program could include recycling of plastics as well as prescreening, sorting, and picking of the solid waste to remove as much plastic and other refuse with high chlorine content as possible before these items enter the furnace area.

c. Acid Gas Control at Resource Recovery Facilities

Emissions of hydrogen chloride and hydrogen fluoride can be reduced by the use of of flue gas control equipment such as wet scrubbers and dry scrubbers and by precombustion removal of refuse with high chloride and fluoride content.

(1) Flue Gas Controls

The State of New Jersey should require the installation of flue gas controls which achieve the highest possible reductions in hydrogen chloride.

Flue gas controls are the most conventional means of reducing acid gas emissions at resource recovery facilities. The various technologies can be classified into two groups, wet scrubbing systems or dry scrubbing systems. Wet scrubbing systems use liquid solutions to absorb or "scrub" acid gases from the gas stream. Dry scrubbers inject dry powders on an alkaline slurry which, in the hot flue gas, dries to a powder and is subsequently collected.[83]

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[82] Low quality fuels are characterized by high moisture and ash content and low hydrogen content. Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board, at 34.

[83] Daryl Mills, Air Pollution Control of Municipal Solid Waste Incinerators, Cal. Air Resources Board at 6 (March 1984).

Both wet and dry scrubbers have been used successfully at refuse burning facilities in Europe, Japan, and in the United States.

According to the N.J. DEP Air Pollution Control Program, air pollution control equipment can remove up to 99.5% of the acid gas from a resource recovery plant's gas stream.[84] The federal government requires that hazardous waste incinerators achieve a 99% hydrogen chloride removal rate. 46 Fed. Reg. 7666. An incinerator study prepared for the New Jersey Air Pollution Control Program stated that by the year 2000, a 97% hydrogen chloride control efficiency may be required to protect air quality.[85]

In contrast to the 99.5% maximum achievable reduction, the 99% reduction required for hazardous waste incinerators, and the 97% recommended reduction level, the New Jersey guidelines only require a 90% reduction of hydrogen chloride, or 50 parts per million by volume, whichever is less stringent.[86] This standard could permit a huge quantity of hydrochloric acid to be emitted into our air. The New Jersey DEP estimates that, without acid gas controls, proposed resource recovery facilities will emit about 40,000 tons of hydrochloric acid each year. A 90% reduction requirement will permit 4,000 tons of hydrochloric acid to be released into our environment. The proposed Essex County resource recovery plant alone could release over a ton of hydrochloric acid daily.[87]

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[84] Memorandum of William O'Sullivan, N.J. DEP Air Pollution Control Program at 2.

[85] State of New Jersey Incinerator Study, Volume III, "Technical Review and Regulatory Analysis of Sewage Sludge Incineration," GCA for U.S. EPA, Contract No. 68-02-3168, at 40 (1980).

[86] New Jersey Guidelines II.D.(1).

[87] This figure is obtained by multiplying 2250 tons per day times 10 pounds of hydrogen chloride emitted per ton, divided by 90%.

In light of the dangers that acid gases cause to our public health and environment, New Jersey regulations should parallel the federal hydrogen chloride reduction requirements for hazardous waste disposal. Moreover, it should be easier for a resource recovery plant to achieve a 99% reduction in hydrogen chloride since municipal waste has a much lower chlorine content than hazardous waste. The DEP acknowledges that a 99% reduction of hydrogen chloride from resource recovery plants is possible, and in view of the potential danger to public health and the environment, this level of reduction should be required. DEP should also require emissions testing to ensure that actual emissions conform to those projected in the air permit application and the environmental impact statement. If emissions are higher than projected, the operator of the resource recovery plant should bear the costs of reducing emissions to the required level.

(2) Recycling and Source Separation

It is also imperative that the State of New Jersey adopt recycling and source separation programs to reduce chlorine and fluoride in the refuse stream -- as well as to save and recover valuable resources. According to the California Air Resources Board, 61% of all chlorine can be eliminated by removal of plastic items from the waste stream. Assuming a 67% conversion of chlorine to hydrogen chloride, this represents a 41% reduction in hydrogen chloride.[88]

Recycling plastics is difficult since mixtures of plastics perform poorly as raw materials for most uses. However, recent work in Japan demonstrates that some types of plastic may be separated by dissolution in toluene followed by a solvent separation. Other processes separate plastics on the basis of density, electrical conductivity, or other properties.[89] In light of the high

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[88] Daryl Mills, "Air Pollution Control of Municipal Solid Waste Incinerators," Cal. Air Resources Board at 5.

[89] Air Pollution Control at Resource Recovery Facilities, Cal. Air Resources Board at 121.

potential reductions in hydrogen chloride, the Public Advocate recommends that the State of New Jersey investigate recycling of plastics as a means of reducing hydrogen chloride emissions.

B. Problem 2: Additional Emissions Data is Necessary to Assess The Risks from Resource Recovery Facilities

Only a few resource recovery plants in the United States have been tested for emissions of dioxins, furans, heavy metals, and other hazardous substances.[90] Although the available data from emissions testing suggests that hazardous pollutants are emitted from resource recovery facilities, additional data could reveal that even greater health and environmental risks are associated with the operation of resource recovery facilities. DEP even acknowledged in its summary of guidelines that "there is little available data on organic emissions from such facilities."[91]

Recommendation 2: Further Emission Testing Should Be Conducted Before the State of New Jersey Issues Permits To Operate Resource Recovery Facilities

Explanation:

Additional emission testing should be conducted before New Jersey embarks on a major drive to operate resource recovery facilities. Additional emissions data is necessary to better characterize emissions from refuse incineration and allow the State to assess the risks from resource recovery facilities. Once the emission data is gathered, scientists and engineers should investigate the relationships between emission rates for specific organic and metal compounds and key plant design and operating parameters. This information will allow the State to draft regulations which require the design of more efficient incineration units with lower emissions.

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[90] Draft Assessment of Emissions of Specific Compounds from a Resource Recovery Municipal Refuse Incinerator, prepared by Midwest Resource Institute for the EPA, Office of Pesticides and Toxic Substances, at 3 (November 1983).

[91] Resource Recovery Plant Guidelines, II.C.

The DEP should also require regular emission testing once a resource recovery plant is in operation. Such testing is important to determine if actual emissions conform to those projected in the environmental impact statement and on the air permit application. If emissions are higher than projected, the operator of a resource recovery plant should bear the costs of reducing emissions to an acceptable level.

C. Problem 3: Definitive Data on the Long-term Health Effects of Dioxin, Furan, Heavy Metal, and Acid Gas Emissions is Simply Unavailable

The dangers of exposure to the toxic pollutants from resource recovery plants are substantial.[92] Yet, long-term health data on exposure to these substances is not available.[93] For example, the focus of virtually every study on dioxins is on the 2,3,7,8-TCDD isomer. Most of the other 74 polychlorinated dibenzo-p-dioxin isomers have not been studied for their toxicological effect, and data is even scarcer on the toxicological nature of dioxin mixtures.[94] Yet, many of the other dioxin isomers are considered "highly toxic" and are present in much larger quantities than 2,3,7,8-TCDD in the emissions from resource recovery facilities.[95]

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[92] *See* discussion on pages 5 - 17.

[93] *Report of the Citizens Task Force on Resource Recovery in New York State* at 2 (April 1984); Memorandum of William O'Sullivan, N. J. DEP Air Pollution Control Program at 1; Essex County Resource Recovery Project, Environmental Impact Statement, Vol. 4, Technical Appendix at 2.

[94] Rizzardini, M. Romano, and F. Gizzi, "Toxicological Evaluation of Urban Waste Incinerator Emissions," 12 *Chemosphere* 559 (1983); *Draft Assessment of Emissions of Specific Compounds from a Resource Recovery Municipal Refuse Incinerator*, prepared for EPA, Office of Pesticides and Toxic Substances at 3 (1983).

[95] Letter of Christopher Rappe, Professor of Organic Chemistry, University of UMEA, to Mr. James Johnson, Jr., Oregon City Commissioner, dated December 15, 1982.

C. Recommendation 3: Further Study is Needed on the Health Effects of Exposure to Heavy Metals, Acid Gases and Toxic Organic Substances to Determine if Resource Recovery is Hazardous to the General Public

Explanation:

Our Department is not aware of any health studies which directly examine the effects of resource recovery emissions on human health. To date, all studies have examined only animal health effects or have reached conclusions using biochemical models. The Department recommends that the Legislature and the New Jersey DEP complete health studies on the effect of exposure to resource recovery plant emissions before permitting resource recovery facilities to operate.

D. Problem 4: New Jersey Has No Regulations Which Specifically Control or Limit the Heavy Metals or Toxic Organic Substances Emitted from Resource Recovery Plants

The New Jersey DEP has not issued any specific, permissible emission rates for lead, cadmium, antimony, or any of the other metallic compounds emitted from resource recovery facilities. Nor has the State issued regulations or guidelines which specifically limit the emission of dioxin and furans from resource recovery plants. Although DEP's position is that resource recovery facilities are adequately regulated by the New Jersey Air Pollution Control Act, N.J.S.A. 26:2C-1 et seq., and the rules promulgated under that Act, N.J.A.C. Title 7, Chapter 27, with the exception of lead, these statutory provisions and regulations do not specify ambient air standards or emission rates for heavy metals, dioxins, and furans which are emitted from resource recovery facilities.

With regard to lead, the resource recovery guidelines only require that a permit applicant make a "demonstration that lead emissions will not cause or significantly contribute to, a violation of the national ambient air quality standard."[96] In practical terms, this means that resource recovery permit applicants need only demonstrate compliance with the New Jersey proposed Lead State Implementation Plan. However, the Lead SIP relies on the negotiation of various permit applications and consent orders instead of establishing _specific_ emission standards. Consequently, the public still has no assurance that lead emissions from resource recovery facilities will be reduced.

With regard to other heavy metals, the resource recovery guidelines merely state that a permit applicant must make an "[e]valuation of predicted ambient concentrations of the metals arsenic, beryllium, cadmium, chromium, mercury, and nickel."[97] Such a provision does not require that a permit applicant even _attempt_ to design or operate a resource recovery facility in a manner that limits metallic emissions. Moreover, the guidelines do not even mention antimony, arsenic, manganese, copper, or tin, which are metals that could be emitted in toxic quantities from resource recovery facilities.

With regard to dioxins and furans, an applicant is merely required to "_specify_ . . . maximum total organic emissions . . . on permit application . . . ."[98] This provision does not require a permit applicant to take any steps to design or operate his resource recovery facility in a manner which limits the emission of dioxins, furans, or other toxic organic substances.

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[96] _Guidelines_ at LL.B.(1).

[97] _New Jersey Guildelines_, II.B.(2).

[98] _New Jersey Guidelines_, II.C.(4).

Although DEP maintains that New Jersey law requires regular stack testing of all resource recovery facilities to determine conformance with the permit conditions, the application, and air pollution control codes,[99] a close review of the regulations reveal that such testing is not mandatory. Specifically, N.J.A.C. 7:27-8.4(c) states that: "[b]efore a 'Certificate to Operate Control Apparatus or Equipment' or any renewal thereof is issued, the Department may require the applicant to conduct such tests as are necessary in the opinion of the Department to determine the kind and/or amount of air contaminants emitted . . . ." (emphasis supplied) Thus, stack testing of resource recovery facilities is presently within DEP's complete discretion.

Recommendation 4: The State of New Jersey Should Issue Regulations Which Establish Specific, Permissible Emission Rates for Heavy Metals, Dioxins, and Furans

Explanation:

The Public Advocate recommends that DEP issue regulations that specify both ambient air standards and emission rates for the heavy metals, dioxins, and furans which are emitted from resource recovery facilities. An applicant should be required to demonstrate that the anticipated emissions will be below the maximum emission limits set by law and that the anticipated emissions will not violate the ambient air standards established by the State.

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[99] Statement of the N. J. DEP Concerning Air Pollution Control of Resource Recovery Facilities, presented to the Assembly Committee on County Government and Regional Authorities at 9-10 (May 14, 1984).

In setting ambient air standards and emission rates for dioxins and furans, DEP should examine the precedents set by Canada, the Netherlands, and New York State. The Ministry of the Environment, Ontario, Canada, has developed guidelines for dioxin and furan exposure in the environment.[100] The Government of the Netherlands has established an exposure level of 2,3,7,8-TCDD that is designed to meet a Virtually Safe Level (VSL).[101] And finally, the New York State Department of Environmental Conservation has adopted a performance guideline which relates to ground level concentration impacts for TCDD.[102]

With regard to heavy metal emissions, it may be that health data which indicates safe levels of metal emissions is unavailable. If this is the case, the State of New Jersey DEP should first ascertain what levels of heavy metal emissions are dangerous to our health and environment and then issue standards to limit the emissions to a safe level <u>before</u> approving the construction and operation of resource recovery facilities.

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[100] The Ontario, Canada, annual guidelines are based on a 30,000 x 10^{-15} grams per cubic meter ambient air concentrations for all polychlorinated dioxins (PCDD) and 1,500,000 x 10^{-15} grams per cubic meters of ambient air concentrations for all polychlorinated furans (PCDF).

[101] The Netherlands annual guideline is 12,000 x 10^{-15} grams per cubic meter of ambient air.

[102] The New York State annual criteria is 92 x 10^{-15} grams per cubic meter of ambient air.

E. Problem 5: New Jersey Law Does Not Adequately Address the Potential Disposal Problems of the Residual Ash from Resource Recovery Plants

The ash residues that result from refuse incinceration at resource recovery facilities generally must be landfilled. Although up to 75% of municipal waste is combustible, and the volume reduction is about 90%, some scientists have expressed concern that the remaining 10% of the residual ash will be enriched with heavy metals and toxic organics,[103] and will pose a danger of leaching into soil, vegetation, and groundwater. The Tennessee Valley Authority, Division of Agricultural Development, recently released a report which concluded that landfilling of the ash residues, especially the fly ash, which results from refuse incineration may constitute a hazard to the water supply and vegetation due to the leaching of cadmium and lead into the surrounding soil.[104] Essex County admits in the environmental impact statement for their proposed facility that the residual ash may be declared hazardous waste because of the presence of heavy metals, particularly lead and cadmium.[105]

However, the existing New Jersey regulations do not adequately address the problems of disposal of toxic fly ash generated from resource recovery facilities for two reasons. First, under N.J.A.C.

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[103] Paul Giorano and Allen Behel, et at., "Mobility in Soil and Plant Availability of Metals Derived from Incincerated Municipal Refuse," Tennessee Valley Authority, 17 Env. Sci. & Tech. 193 (1983).

[104] Id. at 193 and 197.

[105] Essex County Resource Recovery Project, Environmental Impact Statement at 456.

7:26-8.5, a resource recovery plant operator, like all solid waste generators, determines whether the solid waste generated by his operation is "hazardous waste." Although all generator determinations are subject to DEP review, N.J.A.C. 7:26-8.5(e), a resource recovery plant operator may simply conclude that his waste is not hazardous. Consequently, the ash residue generated by the resource recovery plant may never be subjected to the EPA Toxicity test set forth in N.J.A.C. 7:26-8.12. In this way, residual ash, which may actually constitute hazardous waste, may be landfilled in a non-hazardous landfill site.

Second, the New Jersey hazardous waste regulations, N.J.A.C. 7:26-8.1 et seq., specifically exempt household waste from the subchapter. N.J.A.C. 7:26-8.2. Yet, approximately 30% of all municipal waste streams is comprised of household waste,[106] and the New Jersey regulations do not clearly state whether the residue from resource recovery plants may, as a result of the household waste exemption, also be exempt from the provisions of the hazardous waste regulations.

Recommendation 5: The State of New Jersey Should Issue Regulations Which Require Testing the Residue of Resource Recovery Facilities to Determine if Toxic Components are Leached Into Surrounding Soil or Groundwater

Explanation:

DEP should issue regulations concerning the disposal of residual ash from resource recovery plants. These regulations should require testing of the residual ash to determine whether the ash is toxic and should be treated as hazardous waste. The regulations should also require that an operator test the surrounding area to determine if any

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[106] Daniel Knapp, "Mining the Urban Ore," Sierra at 46 (May/June 1982).

of the hazardous heavy metals or organics from the ash leached into the soil or groundwater near the facility. If leaching has occurred, the operator of the resource recovery facility should bear the costs of the cleanup. In addition, the New Jersey hazardous waste regulation, N.J.A.C. 7:26-8.1 et seq., should be amended to clearly state that resource recovery plant residue is not exempt from the subchapter provisions.

F. Problem 6: The State of New Jersey Has Not Issued Standards for Siting Resource Recovery Facilities

The technology of resource recovery is still new, and the effectiveness of environmental controls is still uncertain. Certainly, the hazards of operating a resource recovery facility may be minimized by selecting sites for the plants which are technically feasible, environmentally sound, and protective of the public health of nearby residents. However, the New Jersey DEP has not issued any statewide criteria for selecting resource recovery plant sites.

Recommendation 6: The New Jersey Department of Environmental Protection Should Promulgate Well-drawn and Enforceable Standards To Assist Boards of Chosen Freeholders in Selecting Resource Recovery Plant Sites

Explanation:

As a first step, DEP should develop a statewide policy for selecting sites for a resource recovery facility. Once a general statement of policy is adopted, DEP must translate this broad statement into precisely defined criteria to assess proposed sites. The set of criteria should address technical, economic, and environmental concerns and assure an adequate margin of error and safety if they are to protect nearby residents. For example, DEP could issue standards which require a district to build solid waste facilities at a specific distance from homes, schools, and hospitals and could require districts to select hauler routes which minimize contact with residents.
In the environmental area, DEP could require a district to consider a number of factors before selecting a site such as the permeability of the

soil and the effect of a resource recovery facility on the area's air and water quality. While it is beyond the scope of this position paper to detail all the factors which should be included in DEP's site selection standards, we strongly recommend that the DEP enlist the assistance of solid waste experts, environmentalists, public health experts, and planners to ensure that site standards encompass the proper criteria.

G. Problem 7: The New Jersey DEP Should Develop A Comprehensive Program For Reducing the Size of the Waste Stream Through Solid Waste Disposal Methods Such as Recycling, Source Separation, and Composting.

Each year, New Jersy communities generate 6.2 million tons of municipal solid waste.[107] Effective disposal of this waste requires a comprehensive and multifaceted approach which combines a series of waste disposal methods such as recycling,[108], source separation,[109] and composting.[110]

Resource recovery facilities, no matter how well-implemented, can only incinerate a portion of the total waste stream.

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[107] Recycling in the 1980's: The Report on Recycling in New Jersey, State Advisory Committee on Recycling (Sept. 1980).

[108] Recycling is defined as "any process by which materials which would otherwise become solid waste are collected, separated, or processed and returned to the economic mainstream in the form of raw materials or products." Recycling Act, N.J.S.A. 13:1E-94(c).

[109] Source separation is defined as "the setting aside of recyclable materials at their point of generation (home, place of business, etc.) by the generator." David Cohen, A National Survey of Separate Collection Programs, U.S.EPA at 8 (1979).

[110] Composting is a natural process of breaking down complex organic matter into simple, more stable organic matter called humus. The breakdown is accomplished by organisms ranging from microscopic bacteria to earthworms, with different organisms working at different stages in the process. Special Report - Composting: Alternative to Traditional Methods. Sanitation Industry Yearbook at 58 (1983).

Approximately twenty-five percent of all municipal waste is not combustible and must be removed from the waste stream before the incinceration process begins in a resource recovery facility.[111] An additional 10% of the waste, by volume, is converted into ash residue from the incineration process.[112] DEP Commissioner Hughey recently testified that even if resource recovery plants are operating in New Jersey, the State will still need an additional 158 acres of landfill space each year.[113] The proposed Essex County resource recovery plant alone is expected to generate 219,000 tons of ash residue each year.[114] As mentioned earlier in this paper, potential problems exist with the toxic nature of this residue.

Moreover, even if the State of New Jersey decides to encourage resource recovery facilities as the primary method of solid waste facility, the earliest on-line date for the first resource recovery plant in New Jersey is still three and a half years away.[115] Yet, according to the DEP, only two and a half years of landfill capacity remain in this State.[116]

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[111] Paul Giordano and Allan D. Behel, "Mobility in Soil and Plant Availability of Metals Derived from Incinerated Municipal Refuse," Tennessee Valley Authority 17 Env. Sci Tech. 193 (1983).

[112] Id.

[113] Testimony of DEP Commissioner Hughey to the Assembly County Government and Regional Authorities Committee, dated March 15, 1984.

[114] Essex County Resource Recovery Project, E.I.S. at 402.

[115] Comments of Marwan Sadat, Director of the DEP Solid Waste Management Division made at the Waste Management Advisory Group Meeting, March 23, 1984.

[116] Id.

Recommendation 7: An Aggressive Waste Reduction Program That Incorporates Mandatory Recycling, Source Separation, and Composting Can Substantially Reduce the Amount of Waste Requiring Incineration in Resource Recovery Facilities or Disposal in Landfills

An effective waste reduction program requires a strong State commitment to eliminate the institutional barriers which inhibit recycling, source separation, and composting efforts. Our recommendations focus on the absence of a mandatory waste reduction program in the State of New Jersey and the lack of financial assistance and economic incentives which are necessary to obtain the full potential for recycling waste materials.

1. Mandatory Waste Reduction

In the Recycling Act, *N.J.S.A.* 13:1E-92 *et seq.*, the New Jersey Legislature declared that:

> The recycling of waste materials decreases waste flow to landfill sites, recovers valuable resources, conserves energy in the manufacturing process, and offers a supply of domestic raw materials for the State's industries.

N.J.S.A. 13:1E-93.

According to the New Jersey Advisory Committee on Recycling, New Jersey residents throw the following recyclable materials into the waste stream each year:

64,000 tons of aluminum
258,000 tons of ferrous cans
621,000 tons of glass
434,000 tons of used newspaper
582,000 tons of corrugated paper
80,000 tons of high grade paper
781,000 tons of mixed paper

65,000 tons of assorted plastics, and

24,000,000 gallons of recoverable motor oil.[117]

However, New Jersey citizens presently recycle only 8% of the waste stream or .5 million tons of material each year. The State Advisory Committee on Recycling projects that the State could recycle 55% of its waste stream through municipally-supported curbside collection,[118] and the State Office on Recycling has established an annual 25% recycling rate as its state-wide recycling goal. Some municipalities could recycle even more than 55% of their refuse. For example, an environmental consultant to the City of Newark concluded that 82% of Newark's waste stream could be reduced by recycling or composting.[119]

The benefits from waste reduction programs are enormous. The Office of Recycling estimates that if New Jersey recycles an additional 800,000 tons of material each year (25% recycling rate), the State would reduce required landfill space by 1,400 acre feet per year at a savings of $16 million a year and reduce resource recovery plant capacity needs by 2,700 tons per day at a savings of $135 million. As a result, fewer and smaller resource recovery facilities could dispose of New Jersey's solid waste. Smaller resource recovery plants would incinerate less refuse, emit less pollutants into the air, and reduce ash residue. Moreover, a down-sized resource recovery plant would require much lower capital and operational costs. For example, Essex County has down-sized their

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[117] Recycling in the 1980's; The Report on Recycling in New Jersey, State Advisory Committee on Recycling at 11 (September 1980).

[118] Id. at 11.

[119] Memorandum of Maurice Sampson to Frank Sudol, Supervising Environmental Specialist, City of Newark, Department of Engineering at 2 (September 8, 1983).

proposed resource recovery plant by 15% as a result of anticipated recycling programs. Essex County reports that this 15% reduction in plant size will reduce ash residue by at least 39,000 tons each year and result in a savings of $20 million or more on construction costs.[120]

Recycling programs could also improve the burning efficiency of resource recovery facilities. Certain waste components such as metals, glass, plastic, oil, fiber, and organic matter have a higher resource value if they are recycled or reprocessed rather than incinerated for energy. When these materials are removed from the waste stream, the remaining solid waste will have an improved energy content.[121]

Recovering materials for recycling also saves energy in another manner since less energy is needed to produce products from recycled raw materials than from virgin raw materials. For example, the manufacturing process requires less energy if recycled materials are used to make aluminum products, 60% less energy for paper products, and up to 25% less energy for glass products.[122] New Jersey citizens could save 1.9 million barrels of oil each year if they separated 25% of their municipal waste.

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[120] The Integration of Energy and Material Recovery in the Essex County Solid Waste Management Program at iii (April 1983).

[121] Report of the Citizen Task Force on Resource Recovery in New York State at 5 (April 1984); Testimony of Neil Seldman, Ph.D., before the public hearing "Trash to Steam," Philadelphia Clean Air Council, (January 28, 1984).

[122] Barbara Eisler, Throwing It Away in New Jersey, A Comprehensive Look At Waste Disposal, American Lung Assoc. of N.J. at 31 (1983).

Waste reduction programs will also create a number of jobs. A 1,000 ton per day recycling program could employ several hundred workers in the collection and processing of materials.[123] Essex County anticipates that its materials recovery program alone will create at least 50 new jobs in collection and material processing.[124]

Despite the wide-ranging benefits of recycling, present New Jersey law does not require resource recovery facilities, municipalities or townships to source separate reusable materials from the waste stream. In order to achieve the recycling benefits described above, the Public Advocate recommends that DEP require each resource recovery plant applicant to incorporate a waste reduction program into the plant's operating plan before the facility is permitted to operate.

The Public Advocate also recommends that DEP require each county to adopt a mandatory waste reduction program as part of its Solid Waste Management Plan. In this way, each county can tailor its program to meets local markets and the individual needs of its community. To assist each county in developing and implementing its waste reduction program, the Office of Recycling should provide technical assistance which enables a county to determine what method of operation it should use, which recyclables to collect, and what equipment it would need.[125]

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[123] Garbage to Energy: The False Panacea, Sonoma County, Calif. Community Recycling Center at 45 (1980).

[124] The Integration of Energy and Material Recovery in the Essex County Solid Waste Management Program at ii (April 1, 1983).

[125] The Office of Recycling currently provides information and field evaluations to communities that are either planning to establish recycling programs or actually operating them. Testimony of Mary Sheil, Administrator of the New Jersey Office of Recycling before the New Jersey Assembly Energy and Natural Resources Committee (February 24, 1983).

Mandatory recycling programs have been successfully adopted in fifty-two New Jersey municipalities.[126]. A description of a few of these programs will illustrate what can be accomplished through the use of a mandatory, multi-material collection system. Montclair, New Jersey, operates a mandatory curbside collection program, a 24-hour per day recycling center, and a compost site.[127] In 1983, Montclair recycled close to 4,000 tons of material and produced over $78,000 in solid waste disposal savings.[128] Berlin Township in Camden County started a recycling program in 1980 with only $96 in start-up costs. The township collects newspaper, glass, corrugated paper, and aluminum through a curbside program. In 1982, Berlin Township recycled 25% of its waste stream at a savings of $26,047 in solid waste disposal costs.[129]

The City of Woodbury operates the most comprehensive and successful mandatory recycling program. Woodbury recycles six categories of materials -- mixed paper, clear glass, colored glass, ferrous metal, non-ferrous metal and yard waste. Each year this community has increased the percentage of refuse it recycles. In 1981, the first year of the City's mandatory recycling program, Woodbury recycled 35% of

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[126] Testimony of Mary Sheil, Administrator of the New Jersey Office of Recycling before the New Jersey Assembly Energy and Natural Resources Committee (February 24, 1983).

[127] Case Studies of Selected New Jersey Recycling Programs, 1984, New Jersey Office of Recycling at 18.

[128] Montclair Recycling Report for 1983.

[129] Case Studies of Selected New Jersey Recycling Programs, 1984, New Jersey Office of Recycling at 15-16.

its waste stream.[130] That percentage increased to 45% in 1982 and 55% in 1983.[131] Woodbury accomplished this large waste reduction with only minimal expenditures. The City purchased no special equipment to begin their mandatory program which functions with the City's one trailer, two dump trucks, and two conventional trash trucks.[132] Although Woodbury is only a small town (population 10,500), the City produces $18,755 a year from sales of its recycled goods and saves over $46,000 a year in avoided disposal costs.[133] Based on the recycling efforts of the few municipalities described above, it is clear that a statewide mandatory program could vastly reduce New Jersey's waste stream and result in higher savings in avoided disposal costs.

In addition to requiring that counties recycle their waste, the State of New Jersey should also institute a mandatory recycling program of its own. On December 2, 1983, Governor Kean signed Executive Order 57 which requires all State facilities to institute an office waste paper recycling program. The Public Advocate applauds Governor Kean's action, and we recommend that each State facility take steps to implement the office paper recycling program outlined in this Executive Order. According to the EPA, 30 to 70% of waste in office buildings is highgrade paper, most of which

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[130] Source Separation, The Woodbury Way, City of Woodbury at 60, (1982).

[131] Testimony of Mary Sheil, Administrator of the New Jersey Office of Recycling before the New Jersey Assembly Energy and Natural Resources Committee (February 24, 1983); Telephone conversation with Councilman Donald Sanderson, President of the Woodbury City Council and Chairman of the Woodbury Recycling Committee.

[132] "Woodbury's Trash is Nothing But Cash," Philadelphia Inquirer (January 22, 1984).

[133] Case Studies of Selected New Jersey Recycling Programs, 1984, New Jersey Office of Recycling at 25.

is reclaimable.[134] The Office of Recycling estimates that the adoption of an office paper recycling program would save the State of New Jersey between $300,000 to $600,000 from the sale of recovered materials and avoided solid waste costs.[135] Such a program is now successfully operating in the Labor and Industry Building in Trenton, the Governor's Office of Management Services, the Department of Law and Public Safety, Division of Systems and Communications, and the Departments of Health and Agriculture.[136] In addition, over 100 Federal government buildings and some 20 state governments have implemented office paper recycling programs.[137]

We recommend mandatory recycling for two reasons. First, recycling should be an integral and major component of the state's solid waste management program. A mandatory program is desirable since it would achieve the maximum amount of materials recovery and the most significant reduction of waste requiring landfill disposal.[138]

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[134] "Office Paper Recovery - An Implementation Manual," United States Environmental Protection Agency.

[135] Testimony of Mary T. Sheil, Administrator of the New Jersey Office of Recycling before the New Jersey Assembly Energy and Natural Resources Committee (February 24, 1983).

[136] Id.

[137] Materials and Energy from Municipal Waste, Office of Technology Assessment at 81 (July 1979).

[138] Recycling in the 1980's, Report on Recycling in New Jersey, the State Advisory Committee on Recycling at 30 (September 1980).

Second, mandatory recycling programs generally have twice the level of participation as voluntary programs.[139] A brief review of compliance rates of several mandatory recycling programs reveals the high level of community participation.

The City of Woodbury estimates that 85% of all residents participate in the City's curbside separation program. Although North Brunswick has operated a mandatory recycling program for only a year, that city estimates that 77% of their residents comply with their mandatory program.[140] In Nottingham, New Hampshire, 95% of the residents participate in that community's mandatory recycling program.[141] And in Groton, Connecticut, 85-90% of all residents participate in mandatory recycling.[142] These figures demonstrate that a mandatory recycling program would receive enthusiastic cooperation from a majority of residents.

2. Economic Incentives and Financial Assistance to Encourage Materials Recovery Programs

As we have described above, waste reduction methods, such as recycling, composting, and source separation, could significantly reduce the size of New Jersey's waste stream, allow fewer and smaller resource

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[139] Neil Seldman, "Fresno: Building a Closed Loop System," Institute for Local Self-Reliance, Compost Science/Land Utilization at 40 (Sept./Oct. 1980); See Richard Tichenor, "Compliance in a Mandatory Source Separation Recycling System," Recycling and Conservation, Inc., Compost Science/Land Utilization at 20 (July/August 1978).

[140] Jim Craner, "A Study of Four Mandatory Curbside Recycling Programs in New Jersey: Recommendations for Implementation of Mandatory Recycling and Solid Waste Reduction in Princeton Borough," Princeton Environmental Action at 6 (March 30, 1984).

[141] Richard Tichenor, "Compliance in a Mandatory Source Separation Recycling System," supra, at 21.

[142] Walter Blanker, Director of Public Works, Groton, Connecticut, "Refuse Volume Reduction Through Mandatory Recycling," Public Works at 58 (August 1983).

recovery facilities to be built, and extend the life of the State's diminishing number of landfills. In light of these substantial benefits, the Public Advocate recommends that the State consider implementing the following measures that will create a favorable economic environment for waste reduction and materials recovery programs:

(1) Assembly Bill 1778, Introduced by Assemblyman McEnroe Should be Amended to Ensure That Substantial Funds Are Available for Waste Reduction and Materials Recovery Programs

If enacted, Assembly Bill 1778 will impose a series of new taxes and surcharges on solid waste disposal to raise roughly $24 million a year to subsidize the costs of constructing, operating, and maintaining resource recovery facilities. Although a "resource recovery facility" is defined in the bill to include materials recovery, the bill does not provide the same economic incentives for recycling programs that it does for resource recovery facilities. The Public Advocate recommends that A. 1778 be amended so that a portion of the money collected in the Resource Recovery Investment Tax Fund (Sections 14 and 15 of the bill) be available for waste reduction and materials recovery programs.

(2) Assembly Bills 447 and 457 Should Also be Amended to Ensure That Substantial Funds Are Available for Recycling Programs

On February 27, 1984, Assemblyman McEnroe introduced Assembly Bill 447. This bill would appropriate $45,000,000 in loans to Bergen, Camden, Essex and Hudson Counties for the design, acquisition, and construction of resource recovery facilities. On May 21, 1984, the Assembly favorably reported A. 457. This bill would appropriate a $15,000,000 loan to Essex County for the design, acquisition, and construction of resource recovery facilities. In order to provide economic incentives and financial assistance to counties who want to implement recycling programs, we recommend that the Legislature amend A. 447 and A. 457 to provide similar loans for recycling projects.

(3) The Recycling Tax on Sanitary Landfill Facilities Should Be Extended Beyond December 31, 1986

The New Jersey Recycling Act, N.J.S.A. 13:1E-92, *et seq*., establishes a five year program for awarding recycling grants to municipalities based on the total number of tons recycled in the municipality. A recycling tax on sanitary landfill facilities provides the money for the grants. N.J.S.A. 13:1E-96. In its first year of operation, the recycling tax generated a little more than $4.6 million dollars (including interest).[143] This program provides the sort of incentives and financial assistance necessary to promote recycling, and the Public Advocate recommends that the Legislature extend the program beyond its December 31, 1986 expiration date and increase the recycling taxes levied upon sanitary landfill facilities.

(4) The State Should Consider Other Financial Incentives for Recycling Programs

The State should consider offering a variety of other financial incentives to induce the collection and use of recycled goods. Such incentives could take the form of tax credits for recycling businesses, direct grants, low-interest loans, and sales tax exemptions on equipment purchased for the collection, storage or processing of recycled goods. The Board of Public Utilities should also consider restructuring solid waste collection rates to encourage recycling. For example, BPU could allow municipalities a rebate or reduction in landfill fees based on the percentage of the waste stream the municipality recycles. These incentives are necessary to provide the proper economic and financial climate for recycling.

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[143] Testimony of Mary Sheil, Administrator of the New Jersey Office of Recycling, before the New Jersey Assembly Energy and Natural Resources Committee (February 24, 1983).

(5) The State Should Aggressively Seek to Develop Markets for Recycled Goods

The State could develop new markets for recycled goods by changing its own procurement policies. Initially, the Office of Recycling should conduct a study to determine what recycled goods could be used by State offices and facilities. Procurement guidelines could then be drafted which require the State to purchase such recycled goods whenever economically feasible. Moreover, new markets for recycled goods should develop once the State of New Jersey adopts economic incentives for the use of recycled goods.[144]

While the State should take additional measures to increase the markets for recycled goods, New Jersey presently has a large number of markets available to purchase recycled goods. According to the State Advisory Committee on Recycling, New Jersey's secondary materials industry is the largest in the nation and could purchase a much greater percentage of the State's recovered waste products than it currently does.[145] The Office of Recycling maintains and publishes a directory which allows municipalities and private organizations to locate potential markets for the different materials they intend to recover. According to Mary Sheil, this directory is the most comprehensive listing of its type in the Northeast, if not in the country.[146] The Office of Recycling also publishes a current listing of all recycling programs in New Jersey which enables recycling businesses to identify potential customers. Ms. Sheil states that she is not aware of a single major municipal program that had to discontinue its operations because of inactive markets.[147] Under these circumstances, we have concluded that there is no empirical basis for assuming that recycling is not feasible due to limited markets for recycled goods.

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[144] Recycling in the 1980's, supra, at 8.

[145] Id. at 8.

[146] Testimony of Mary Sheil, supra.

[147] Id.

CONCLUSION

The Department of the Public Advocate initiated its investigation of resource recovery facilities because of a concern that the operation of these facilities may cause public health and environmental damage. We wanted to participate in the resource recovery debate to recommend measures that the State of New Jersey should adopt to reduce the hazards associated with resource recovery facilities. Our investigation has revealed a significant amount of scientific literature which concludes that resource recovery facilities emit a host of pollutants into the air and residue including heavy metals, dioxins, furans, and acid gases. These toxic substances are released at rates and in forms that may result in chronic adverse health effects and environmental damage. In light of the potential dangers associated with resource recovery plant emissions, the Department of the Public Advocate has reached the following conclusions:

(1) The State of New Jersey should require the most stringent and comprehensive of environmental regulations to reduce emissions of harmful pollutants and address the hazardous nature of the residue. Specifically,

a. The State of New Jersey, Department of Environmental Protection, should promulgate standards for the design and operation of resource recovery facilities before a resource recovery facility is permitted to operate;

b. These operation and design standards should require applicants to incorporate into the design of the facility the best available control technology to reduce toxic emissions;

c. Additional testing should be conducted on the toxicity of resource recovery plant emissions and on the health effects that result from exposure to these emissions;

d. The State of New Jersey should issue regulations which specify both ambient air standards and emission rates for the heavy metals, dioxins, and furans that are emitted from resource recovery facilities;

e. The State should also require testing of the residue of resource recovery plants to determine if the ash is toxic and to determine if any toxic substances leach into surrounding soil or groundwater; and

f. The State should issue standards to assist boards of chosen freeholders in selecting resource recovery plant sites.

(2) Effective disposal of waste requires a multifaceted approach which incorporates a series of waste reduction methods such as recycling, source separation, and composting. Specifically,

a. The State of New Jersey should require each resource recovery plant applicant to incorporate a waste reduction program into the plant's operating plan before the facility is permitted to operate;

b. New Jersey should require each county to adopt a mandatory waste reduction program as part of its Solid Waste Management Plan; and

c. The State should provide economic incentives and financial assistance to counties, municipalities and private businesses in order to realize the full potential of waste reduction and materials recovery programs.

The Department of the Public Advocate recognizes that resource recovery facilities may be an important part of our approach to solid waste disposal. However, our concern is that the term "resource recovery" is considered synonomous with large incinerator facilities. Instead, it is the Department's position that "resource recovery" should be defined more broadly. The term "resource recovery" should be viewed as a comprehensive and multifaceted approach to solid waste disposal which encompasses waste reduction and recycling methods as well as incineration.

This approach to our solid waste crisis has two principal benefits. It will substantially reduce our waste stream and will extract considerable value, in the form of recyclable goods and energy, from the solid waste generated by our society.

Resource recovery, in the broad sense that we have defined it, must be conducted in an environmentally safe manner and with appropriate financial incentives for recycling. Such a response to our solid waste crisis will not only benefit our environment and public health, but will also reduce our dependency on landfills.

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*NJ AND NY BARS

May 14, 1984

Hon. Harry A. McEnroe
New Jersey General Assembly
County Government & Regional Authorities
Committee
State House Annex
Room 420
Trenton, NJ 08625

RE: Resource Recovery

Dear Chairman McEnroe and Committee Members:

I represent East Brunswick Township in connection with solid waste matters. The following is being submitted by the Township for consideration in connection with the Committee's public hearing on the pollution hazards associated with resource recovery facilities.

A location in East Brunswick has been identified as a potential site for a mass-burning incinerator, although the proposal is highly inappropriate for several reasons. As a result, the municipality has conducted an extensive review of the procedures that are being utilized for the selection of sites as well as the proposed waste disposal technologies.

Attached is a copy of the Statement that was presented on behalf of East Brunswick to the Middlesex County Board of Chosen Freeholders on March 8, 1984 which summarizes the Township's views concerning the issues and hazards associated with the manner in which resource recovery siting decisions are being made. Also attached is a copy of the municipality's March 19, 1984 Testimony to the Clean Air Council and the Advisory Council on Solid Waste Management, two advisory agencies within the Department of Environmental Protection (DEP).

East Brunswick's basic concern is that in the current rush to judgment respecting the construction of incinerator facilities, several important issues related to environmental protection have not been thoughtfully considered. These include:

1. The DEP's refusal to adopt and enforce specific administrative regulations applicable to resource recovery facilities. The enforceability of so-called "guidelines" raises serious questions.

2. The absence of specific standards for the emission of dioxins and other hazardous contaminants, even in trace amounts.

3. The DEP's failure to adopt procedural rules for processing applications for resource recovery facilities. The public and affected municipalities have not been advised as to the procedures that will be utilized for processing these applications. This situation results in ad hoc and arbitrary decision-making.

4. The unwillingness of the DEP to specify the manner in which local concerns should be integrated in the siting process.

5. The absence of an adopted enforcement protocol defining when monetary penalties and mandatory shutdowns will be required. The need for performance bonds to assure compliance on a continuous basis.

6. The desirability of having one model facility constructed, operated and tested before others go forward. At present, several facilities are being advanced on a simultaneous basis and it is uncertain whether the technology will conform with the equipment manufacturer's claims.

* * * * *

East Brunswick believes that it is in the public interest that the foregoing recommendations form the basis for binding legislation. In this way, some very expensive and harmful problems will be avoided.

Very truly yours,

Lewis Goldshore

LEWIS GOLDSHORE

Enclosures

JCP&L / GPU

Jersey Central Power & Light Company
Madison Avenue at Punch Bowl Road
Morristown, New Jersey 07960
(201) 455-8200

March 16, 1984

New Jersey Clean Air Council
CN027
Trenton, NJ 08625

Attention: Mrs. Helen Benedetti

Dear Mrs. Benedetti:

Subject: Public Hearing - Resource Recovery

Jersey Central Power & Light Co. (JCP&L) would like to thank the N.J. Clean Air Council and the N.J. Advisory Council on Solid Waste Management for the opportunity to provide comments concerning the extremely important topic of the Effects of Resource Recovery Technologies on Air Quality.

Resource recovery is the only practical approach to handle the tremendous volumes of solid waste that is generated in New Jersey today. From an environmental standpoint, key advantages of resource recovery through incineration as compared to composting and landfilling are the superior destruction efficiency of the incineration process and the reduced likelihood of long term pollution problems.

JCP&L is a strong advocate of the concept of generating energy by the process of resource recovery. The Company is excited that this technology where garbage is incinerated and energy produced in the process, has become a key part of the State's long-term solution to our present solid waste management problems. We believe resource recovery can be implemented at reasonable costs while maintaining fully adequate protection to human health and the environment.

Before we begin, JCP&L believes that to keep the subject topic in proper perspective, we must all recognize that any new industrial facility will affect the atmosphere to some extent. However, with proper design and control measures, the potential deleterious effects resulting from these pollutants can be maintained within acceptable levels. A major impediment to the construction of resource recovery facilities is the emotionalism that surrounds the issue of solid waste incineration. A comprehensive public education process is necessary in order to separate this emotionalism from the science. JCP&L commends the N.J. Clean Air Council and N.J. Advisory Council on Solid Waste Management for holding this hearing which will inaugurate this education process. We also believe that the NJDEP could further this process by disseminating scientific information on topics such as health risks from dioxin emissions at resource recovery facilities. Avoiding emotional issues such as acid rain to justify additional pollution controls on resource recovery facilities would also be prudent.

The following comments are organized to first discuss how resource recovery facilities can affect air quality. The major types of air pollutants from these facilities are reviewed individually. These dicussions are followed by specific comments concerning monitoring of operating and emission parameters, scrubber malfunctions, pollution control costs, ambient monitoring requirements, and risk assessments.

Hydrogen Chloride (HCl)

The main contributors to HCl emissions when burning solid waste are plastics, particularly polyvinyl-chloride (PVC). PVC is generally utilized in products that have long term uses (pipes, vinyl seat covers) and therefore its content in solid waste would not be expected to increase dramatically in the near future. In February 1983, the NJ Department of Environmental Protection (NJDEP) proposed a minimum requirement of 90% removal of HCl emissions or a maximum stack gas emission level of 50 ppm for larger resource recovery facilities. The NJDEP indicates that the chlorine content of industrial and commercial waste streams may vary significantly. However, the NJDEP is basing its proposed standards on a 0.5% total chlorine content in solid waste which we consider to be high. Their resulting emission factor of 10 lbs/ HCl/ton of solid waste assumes that all chlorine in the solid waste is converted to HCl during the incineration process and that all of the HCl is released from the stack. Several studies, however, have shown that a considerable portion of the chlorine in MSW is retained on collected flyash (Giordano, 1983. Kaiser, 1975) JCP&L believes that the NJDEP is overestimating HCl emissions because of the "worst case" assumptions they are using. Based on our review of the literature, we feel that an emission factor of 5-7 lb/ HCl/ton of solid waste may be more representative which uses a lower solid waste chlorine content and considers the amount of chlorine retained on the collected ash.

JCP&L has performed an extensive review of HCl health effects. The lowest HCl concentration (long and short term) which we have found in the literature to have health or epidemiological effects is 0.4 ppm. The NJDEP HCl proposed emission limitations, however, were developed in order to meet a 24-hour HCl ambient concentration of 0.014ppm. This level is 350 times more stringent than the OSHA HCl workplace health standard (5ppm) which is intended to protect nearly all workers. By comparison, a frequently used safety factor for translating a workplace health standard to an ambient concentration limit is in the range of 50 to 100.

As a preferable alternative to the HCl proposed limitations, we suggested that the NJDEP adopt a 0.05-0.1 ppm 24-hour acceptable ambient concentration for HCl from new resource recovery facilities. This range provides a safety factor of between 50 and 100 when compared to the OSHA standard, and provides levels which are lower than any HCl concentration that has been reported in the literature to cause human health or epidemiological effects. Incidentally, even this recommended standard is more stringent than New York State's 0.1 ppm annual average Acceptable Ambient Level (AAL) for HCl concentrations near new facilities. Finally, the HCl ambient concentrations near resource recovery facilities could vary substantially, depending on the size of the facility,the chlorine content of the solid waste, and the amount of chlorine retained on the collected ash. Therefore, the HCl scrubbing requirement should only be applied to facilities which must scrub their exhaust gas to meet a reasonably established ambient concentration. Other alternatives to reduce HCl emissions from resource recovery facilites, such as source separation of polyvinyl chloride (PVC) which contributes a substantial portion of the chlorine content in solid waste, should also be given consideration.

Sulfur dioxide (SO_2)

Compared to most fuels, the sulfur levels in municipal solid waste are relatively low. Several studies have reported sulfur concentrations in solid waste equal to or less than 0.15% (Wheelabrator Frye, 1983. Kaiser. 1975). This corresponds to an SO_2 emission rate of approximately 0.6 lbs SO_2/Million BTUs, assuming a 5000 BTU/lb heat content of MSW. The NJDEP has proposed a maximum SO_2 emission rate of 0.32 lb/million BTU for these facilities. The NJDEP is assuming an MSW 0.25 sulfur content in their emission calculations. This corresponds to an emission rate of 1.0 lb. SO_2/million BTU.

Air dispersion modeling studies by the NJDEP and JCP&L have shown that uncontrolled SO_2 emissions from resource recovery facilities would result in ambient SO_2 concentrations which are significantly less than SO_2 health standards. Nevertheless, the NJDEP has proposed the 0.32 lb SO_2/million BTU emission limitiation. This limitation is 4 times more stringent than the Federal New Source Performance Standard (NSPS) for SO_2 from resource recovery incinerators, 2 times more stringent than the NJDEP SO_2 emission standards for large coal burning facilities and more stringent than SO_2 emission limitations for residual oil burning facilities in four out of six zones in New Jersey. Indeed, the proposed SO_2 emission limitation for resource recovery incinerators appears to discourage the construction of these dual purpose facilities.

With respect to SO_2, we believe that an appropriate emission limitation for resource recovery facilities is 0.6 lb/million Btu. This is equivalent to the SO_2 emission standards for new coal facilities. We also suggest that any SO_2 emission limitation for resource recovery facilities be based on a 24 hour averaging period due to the variability of the composition of solid waste. In most cases, this SO_2 emission limitation could be met without controls. Standards more stringent than the present State standard for large coal fired facilities should be avoided. Such stringent standards would only be appropriate if New Jersey was in violation of the SO_2 ambient standards. Clearly, this is not the case.

To meet both the SO_2 and HCl proposed limits, scrubbers would have to be installed on all larger resource recovery facilities. A problem that appears to be ignored regarding the use of scrubbers on resource recovery facilities is the reduction of stack gas exit temperatures by approximately 165°F. This temperature reduction could significantly reduce the dispersion of pollutants emitted from the stack and thus result in higher ground level concentrations of other pollutants (i.e. particulates, heavy metals, organic compounds) near the facility. Although reheating of the stack gases could be performed, this would add substantial costs. As a result, further justification should be provided for controlling HCl and SO_2 emissions from these facilities, since without controls, HCl and SO_2 emissions would not pose a health problem. Finally, it is our belief that justifying scrubbers on resource recovery facilities because they may contribute to Acid Rain, as the State has implied, is a erroneous issue.

Particulate Emissions

Substantial quantities of ash are generated during the combustion of solid waste. That portion of the ash which is carried with the flue gas stream (fly ash) would be considered particulate emissions when released from the stack. Electrostatic precipitators and baghouses however, are typically used to remove more than 98% of these particulate emissions prior to their release.

The NJDEP has proposed a 0.03 gr/dscf particulate standard for resource recovery facilities. However, it has been brought to our attention that the 0.03 gr/dscf particulate standard may be difficult to meet on a continuous basis using electrostatic precipitators (ESP) or baghouses at resource recovery facilities. We suggest that the averaging period for this emission limitation be 24 hours to prevent unavoidable noncompliances. Incidently, the Federal New Source Performance Standard for incinerator provide a less stringent 0.08 gr/dscf particulate emission limitation.

JCP&L has performed refined air dispersion modeling studies on a 2000 ton/day resource recovery facility. Based on a 0.744 lb/ton particulate emission factor (equivalent to 0.3gr/dscf), the ambient air quality impact would, as a worst case, be equivalent to only 2% of the particulate ambient air quality standards. Therefore, it is apparent that particulate emissions from a large resource recovery facility will have an insignificant effect on air quality.

Heavy Metal Emissions

Heavy metals such as lead, beryllium, arsenic, cadmium, chromium and nickel are primarily associated with fly ash which would be removed from flue gases by the particulate control device. Due to the high efficiency of particulate control on these facilities, heavy metal emissions should not be a problem.

By regulation, the lead emissions from a resource recovery facility must not result in lead ambient air quality levels that exceed the 3-month 1.5 ug/m^3 NAAQS. JCP&L has performed detailed air dispersion modeling on a 2000 ton/day resource recovery facility which predicted that the maximum 24-hour concentration of lead would only be .035 ug/m^3. This concentration is also substantially less than the 24-hour 0.1 ug/m^3 de minimus level for ambient monitoring for the federal Prevention of Significant Deterioration (PSD) rule. Incidentally, air dispersion modeling would predict a much lower 3-month average lead concentration as compared to the predicted 24-hour concentration. This analysis indicates that lead emissions from resource recovery facilities would not pose a health problem. As a result, JCP&L believes that pre-construction monitoring of lead near new resource recovery facilities is unnecessary unless dispersion modeling demonstrates that the 24-hour ambient lead concentration exceeds 0.1 ug/m^3. However, we do acknowledge that subsequent stack tests would be prudent to document that the level of lead emissions used in the modeling studies continue to be representative.

The emissions of mercury are generally not associated with fly ash since mercury is highly volatile under high temperature conditions. Mercury emissions from a resource recovery facility would have to meet the 3200 g/day National Emissions Standaards for Hazardous Pollutants (NESHAPS). Using a mercury emission factor of 1.67 x 10^{-3} lb/ton MSW (estimated for the Essex County Resource recovery facility), approximately 1516 g/day of mercury would be emitted from a 2000 ton/day resource recovery facility. Refined modeling has shown that these emissions, under worst case conditions, would result in a maximum 24-hour mercury concentration of 0.0023 ug/m^3. This concentration accounts for less than 1/20,000th of the 50 ug/m^3 workplace Threshold Limit Value (TLV) to protect workers. In comparison, the 3-month lead ambient air quality standard is 1/100 of its 150 ug/m^3 TLV. It is therefore apparent that mercury emissions from a resource recovery facility would not be expected to pose a health threat.

JCP&L also determined the impact of beryllium, arsenic, cadmium, chromium and nickel emissions from a 2000 ton/day resource recovery facility through modeling. In all cases, the predicted maximum 24-hour ambient concentrations accounted for less than 1/25,000th of the appropriate TLV. Again, these results indicate that heavy metal emissions from resource recovery facilities would not be expected to pose a health threat. However, as with lead emissions, periodic stack tests should be performed on the above mentioned heavy metals to verify that the emission levels used in the modeling studies are accurate.

Organic Substances and Carbon Monoxide

Numerous studies conducted by the NJDEP and USEPA have shown that proper temperatures, oxygen levels, and residence times in the burning chamber effectively control odor and organic emissions from resource recovery facilities. The NJDEP has proposed minimum combustion design and operating temperatures of 1800°F and 1500°F respectively, a minimum combustion gas residence time of 1 second, and an auxiliary burner as state-of-the-art for resource recovery facilities. JCP&L supports these criteria since our review of the literature has revealed that these criteria should adequately control the release of volatile organic emissions.

Emissions of dioxin from these facilities is a major public concern. However, since dioxin is associated with the fly ash, the high efficiency particulate control devices will effectively minimize dioxin emissions. Based on a survey of dioxin emissions from 6 operating resource recovery plants, the U.S. EPA concluded that the health risks associated with dioxin emissions should cause no concern, given the current rates of emissions. In addition, the level of dioxin destruction during incineration is reported to increase with increasing temperature. Therefore, dioxin emissions from a new facility in New Jersey would be expected to be less when compared to the previously surveyed facilities, due to the high operating temperatures the NJDEP is requiring.

Carbon monoxide is the most abundant gaseous pollutant emitted from the incineration of municipal solid waste, resulting from incomplete combustion. Improved design of over-fire nozzles in the combustion chamber has reduced the amount of incomplete combustion. Air dispersion modeling of a 2000 ton/day facility showed that maximum carbon monoxide concentrations near the facility would account for less than 0.2% of the carbon monoxide ambient air quality standards. This indicates that carbon monoxide emissions from a major resource recovery facility would essentially pose a zero health risk.

As is evidenced by existing data on emission projections and health risks, routine emissions from resource recovery facilities do not appear to present a health problem. Moreover, since the very small quantities of hazardous materials that may be within the solid waste stream are efficiently destroyed in a well designed and operated incineration unit, we do not believe that these materials will present any health threat to the public.

SPECIFIC COMMENTS

Monitoring of Operating and Emissions Parameters

JCP&L believes that continuous monitoring of oxygen (O_2) and carbon monoxide (CO) as well as temperature, are the most appropriate parameters for demonstrating that the incinerator is operating properly. These parameters have been shown to be more reliable indicators of incinerator combustion efficiency when compared to parameters such as total organic emissions. However, it might be prudent to perform yearly stack sampling to determine emission levels of representative trace organics which are known to be emitted by these facilities to demonstrate the safety of resource recovery facilities.

Pollution Control Costs

Wet or dry scrubbers are the only control technologies available to meet the proposed HCl and SO_2 limitations. Significant additional Capital and Operating Maintenance (O&M) costs are associated with scrubbers. We have estimated that a dry scrubber and its associated appurtenances, utilized to remove HCl and SO_2, could increase the capital cost of a 2000 ton per day facility by 15% and the O & M costs by 20%. Regardless of the exact magnitude of the increase, it should be apparent that this increase in operating and maintenance costs will be borne by the waste disposer, and subsequently the public, since energy and recovered material revenues will remain approximately the same with or without a scrubber. The levelized incremental capital and O & M costs of a scrubber system will be equal to or greater than the present landfill waste disposal tipping fees.

Scrubber Malfunctions

Although JCP&L does not believe scrubbers are necessary everwhere, if used, there should be a provision to bypass the scrubbing equipment. Due to the extremely limited operating experience with scrubbing equipment on solid waste incineration facilities in the United States, scrubber malfunctions may significantly contribute to facility down time. With wet scrubbing systems, it will be extremely difficult to maintain proper reaction chemistry because of the variability of the solid waste fuel characteristics as compared to conventional fuels (e.g. coal) Due to the normally low sulfur concentration in solid waste and the present state-of-the-art absorber controls, it is our belief that the absorber reactants will frequently be fed at levels significantly above the required stoichiometric ratio. This may lead to tremendous problems of plugging, scaling, and corrosion. There is limited experience with dry scrubbing systems on conventional boilers, let alone solid waste incinerators which burn a more variable fuel. Therefore, JCP&L strongly encourages a scrubber bypass provision. Without the bypass provision for potential scrubber malfunctions, the reliability of these facilities to process wastes and produce energy would be impaired. Furthermore, the fact that the NJDEP has indicated that a scrubber bypass provision should not result in any quantifiable health risk provides added support for a scrubber bypass provision and indicates that a contingency plan is not necessary.

It is hoped that the NJDEP will adopt a bypass provision to account for scrubber malfunctions which reflects the limited operating experience with those control systems on incinerators in the US . Maximum expected reliability should not be greater 80-85% since these reliabilities have been demonstrated on similar, single control modules used to scrub coal power plant emissions. It should be noted that, even if the NJDEP was not considering a reasonable bypass provision which would allow for continued waste processing during scrubber repairs, a bypass of at least one hour would be required to provide for a safe and orderly shutdown of a facility when a scrubber upset occurs.

Ambient Air Quality Monitoring

One full year of pre-construction ambient air quality monitoring will be required of all Prevention of Significant Deterioration (PSD) affected resource recovery facilities (facilities which emit more than 100 tons of any pollutant). In some cases, the monitoring network presently operated by the NJDEP will suffice for regulatory purposes. The applicant will also have to perform all stack sampling required by his permit. JCP&L does not believe that any additional ambient air quality monitoring should have to be performed by the applicant due to the high costs of this monitoring. Air quality monitoring consultants have provided estimates for JCP&L to perform 1 year of PSD pre-construction monitoring. For three monitoring stations recording SO_2 and TSP and one monitoring station recording only NOx the cost has been estimated to be approximately $400,000. Obviously, the monitoring of other non-conventional pollutants would substantially increase this cost estimate. Should any additional ambient air quality monitoring be deemed necessary, we believe that it should be incorporated into existing NJDEP or USEPA ambient monitoring programs.

Risk Assessments

In order to develop emission limitations for unregulated pollutants (heavy metals, organic emissions) scientific risk assessments would have to be prepared by the NJDEP. However, risk assessments often use a combination of assumptions that would predict unrealistic estimates of the public's level of exposure to a particular pollutant. For example, an assumption often used in air quality risk assessments is that all individuals in a population are exposed for a 70 year period to the maximum ambient pollutant level predicted by an air dispersion model. Obviously, these circumstances would never occur. JCP&L therefore believes that if risk assessments are prepared, realistic "worst case" estimates of exposure to the pollutant should be considered rather than exposure estimates which could not possibly occur.

In summary, in order to solve our state-wide solid waste problem through resource recovery, the NJDEP and other State agencies must step back and look at the whole picture. Any emission limitations for these facilities should be scientifically established at levels which will protect human health and the environment, taking into consideration the cost of implementation. Control requirements and the definition of state-of-the-art technology should not be applied across the board where potential uncontrolled emissions are known to vary widely. Additionally, we should not specify control technology for resource recovery facilities without a better understanding of the cost and operation of these systems on the type and size of resource recovery facilities to be installed in New Jersey. The public should also not be burdened by unreasonable waste disposal fees required to pay for emission control equipment if it is not necessary. Finally, a public education process by the NJDEP is necessary to dispell potential public misconceptions concerning resource recovery facilities.

Thank you for the opportunity to present Jersey Central Power & Light Company's views concerning the effect of Resource Recovery Technologies on air quality. Should you have any questions concerning this submission, please contact Jim Merriam at 201-455-8915.

Very truly yours,

David C Sholler for

James E. Anderson, Manager
Environmental Affairs

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NEW JERSEY
BUILDERS
ASSOCIATION

May 14, 1984

To Members of the Assembly
County Government Committee

RE: A-1778

Assembly Bill 1778 encourages the establishment of resource recovery and waste to energy facilities by: (1) creating an investment tax fund to subsidize the transition to resource recovery, compensate districts for receiving out-of-district waste, and support the implementation of county Solid Waste Management Plans; and (2) promoting the priviate sector financing of resource recovery facilities by removing certain institutional barriers which currently exist.

The New Jersey Builders Association is vitally concerned with the State's critical need to address our future waste disposal methods. We strongly support efforts to encourage the transition from current landfilling practices to more efficient resource recovery and waste to energy facilities.

The bill, however, proposes an elaborate surcharge (investment tax) and solid waste services tax structure that may lack the necessary accountability to make it an effective funding mechanism. In this regard, we caution the Committee, and recommend that the applicable sections be carefully evaluated to insure the efficient adminstration of surcharges and service taxes, and that such taxes in fact raise funds necessary to accomplish the purposes of the legislation.

Although the NJBA wholeheartedly supports the concept of privatization of waste disposal facilities, we question the methods of procurement and franchising provisions. Recognizing the complex nature of such processes, we urge the Committee to assure that A-1778 will indeed promote private sector financing of waste disposal facilities.

Thank you for you attention to these concerns.

Very truly yours,

Philip J. Cocuzza

Philip J. Cocuzza, CAE
Executive Vice President

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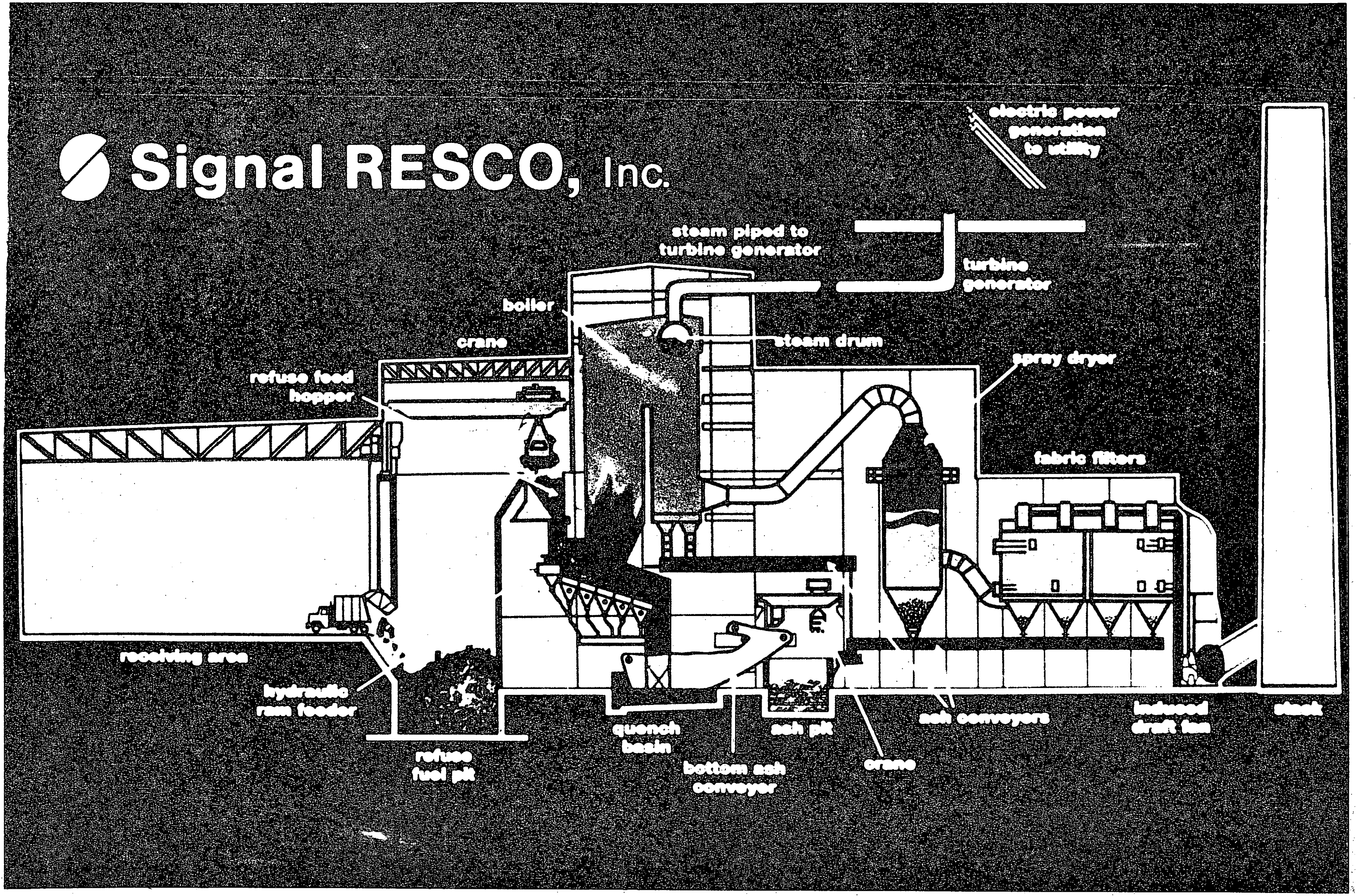
"No man has the moral right to withhold his support from an organization that is striving to improve conditions within his trade sphere." — Theodore Roosevelt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ash pit
crane
ash conveyors
induced draft fan
stack

Review of the Literature

Resource Recovery Facilities, Air Pollution, and Public Health Safety

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E.T. Wei

Jan. 11, 1984

DO NOT DUPLICATE THIS REPORT

Contents

Chapter 1. Aims of this Review

The need for innovative methods of disposing of and recovering energy from municipal solid wastes has been presented in several reviews (10,23,79*,90). The purpose of this report is to analyze one aspect of facilities that burn refuse and produce energy in the form of steam. The central question is: will air pollutants released from such facilities have adverse effects on the health of the community living in the vicinity of the plant?

Issues of environmental health have occupied the public's attention for much of the past two decades. It is therefore appropriate that public officials examine the emissions of resource recovery facilities to determine if air pollutants emitted from such facilities are hazardous to health. This report will survey, reference, and summarize much of the published information on this subject up to June 30, 1983. This review is intended as an introduction and a source of information for scientists who wish to consider this subject in greater detail.

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* Items with asterisks have text that are quoted in "References".

Chapter 2. Framework for Analysis

Introduction

Toxicology is the science which studies the adverse effects of chemicals on living organisms. When toxicology is applied to problems of environmental exposure to chemicals, the objective of the analysis is to predict, under a given set of exposure conditions, the likelihood of adverse response in the exposed population. It is a maxim in toxicology that the response of the organism to chemicals is proportional to the magnitude of the dose (5,24). If the dose is too small to produce a response, the dose is said to be below the threshold dose, and such doses, by definition, can be called "safe". If the dose exceeds the threshold dose then again, by definition, the dose is considered to be "unsafe".

The analysis of information on resource recovery facilities begins by considering:

1. The projected level of emissions of specific chemicals from resource recovery facilities. These emission factors, when combined with dispersion factors, determine the ground-level concentrations of the chemical in air.

2. The projected dose at ground level. This number is proportional to the ground-level concentration of the chemical multiplied by an intake factor.

3. The likelihood of response. To assess this probability, it is necessary to compare and relate the projected dose to information on: a) empirical dose-response studies of the chemical which have been conducted in animals, b) studies on the mechanisms by which the chemical produces its toxic effects and c) human experience with the chemical.

A brief description of some basic concepts of toxicology are given below.

Units of Chemicals in the Environment and the Concept of Dose

Chemicals exist as solids, liquids or gases. The units which describe chemicals in the environment quantify the amount of the chemical in air, food, or water. The units describing the chemical in the environment are chosen so that they best represent the potential biological activity of the chemical. A favorite unit used by many is the expression "parts per million" or "parts per billion." One part per billion is simply one part in one billion parts. When the units of the numerator and denominator are not specified, the term ppm or ppb can cause confusion.

Typically, for gaseous mixtures, one part per billion describes each unit on a volume:volume basis and is on the order of 1 ug/m3:

$$ug/m3 = ppb \times MW/RT$$

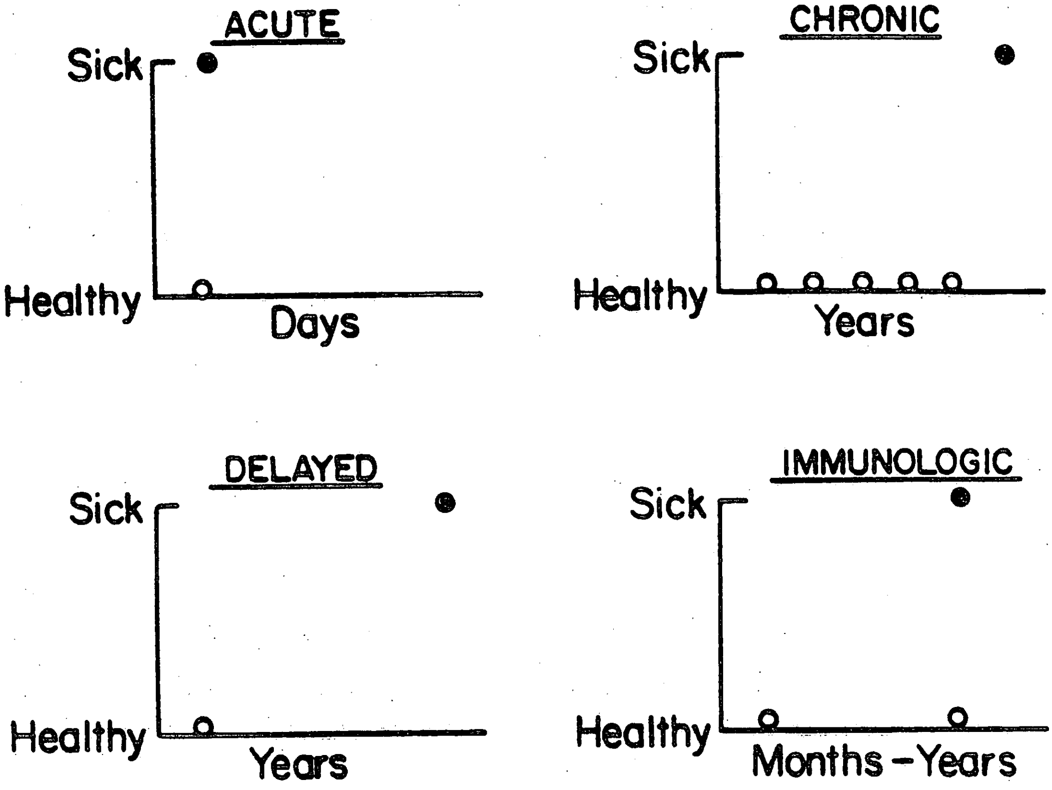
where RT = 22.4 L/mole at 0 degrees Centigrade and 1 atm, and RT = 24.5 L/mole at 25 degrees Centigrade and 1 atm and MW = molecular weight in grams. For liquid materials, a weight:volume basis is most commonly used and 1 ppb = 1 ug/L (approximately 1 ug/Kg for liquids with densities near 1). For solid materials, a weight:weight basis is most commonly used and 1 ppb = 1 ug/Kg (4).

The dose is the quantity of bioactive chemical received by an organism from its environment. The dose is a product of: the levels of chemical in the environment (food, air, water) x duration of exposure x intake factor x retention factor. For environmental exposures to airborne materials, the levels of chemicals are usually expressed on a volume:volume basis for a gas and on a weight:volume basis for particles. The duration of exposure is assumed to be an average life-span of 72 years. The intake factor is the volume of air breathed per day, assumed to be 20 cubic meters per day, and the retention of the inhaled chemical is assumed to be 40% for inhaled particles and 100% for gases. The units of dose are generally given as the amount of chemical delivered per unit body weight. An average adult body weight of 70 Kg (150 lbs) is frequently used in sample calculations.

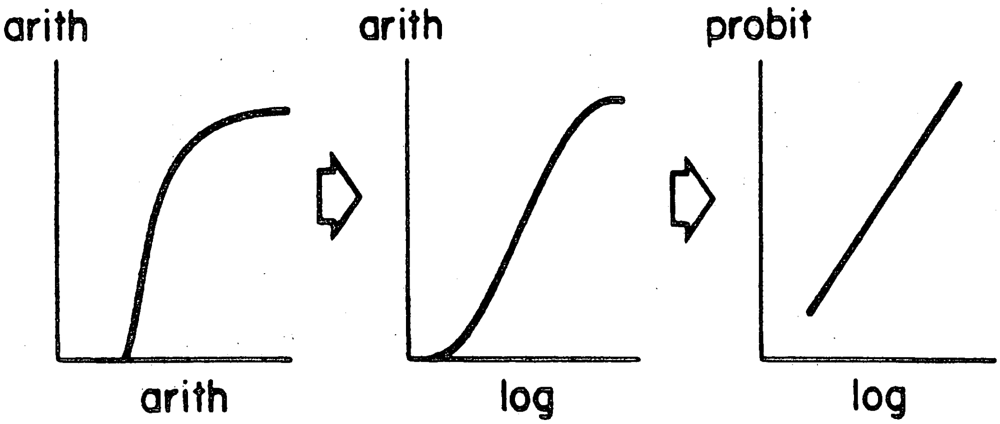
Biological Response

The response of biological organisms to toxic chemicals can be classified according to the number of doses received by the organism in relationship to the time of appearance of the response. Four distinct categories of toxic response are recognized (Fig. 1):

1. Acute toxicity occurs when the organism becomes ill within seconds, minutes, hours, days, and up to three months after single dose or short-term exposure to the chemical.



Classification of toxic effects



Dose-Response relationships

Chapter 3. Projected Levels of Emissions

Introduction

Resource recovery facilities generate a number of air pollutants including particles, oxides of nitrogen and sulfur, carbon monoxide, hydrogen chloride and small to trace quantities of other materials (78). To assess the possible effects of these chemicals on man, it is necessary to measure how much chemicals are emitted from the stack and to estimate what concentrations of chemicals will be present at ground level. The concentration of chemicals at ground level is proportional to the likelihood of biological response.

In this section, the background data for projected emission levels will be described. Because polychlorinated dioxins have received much public attention in connection with resource recovery facilities, this family of chemicals will be considered in greater detail. In subsequent chapters, issues of ground level concentrations and potential health effects will be addressed.

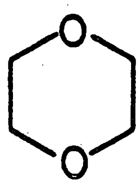
Estimates of Emission Rates of Pollutants

Data on the emissions of air pollutants from modern resource recovery facilities have been compiled by W.L. O'Connell et al. of Battelle's Columbus Laboratories (78). These emissions factors are derived for modern mass burning, waterwall plants equipped with an electrostatic precipitator. These facilities generally have the capacity to burn 1200 to 1500 tons of refuse per day. Battelle's summary of emission factors is presented in Table 3a. These are averaged values from the literature. Obviously, for specific plants, design and operating conditions would influence emission factors. As an example, data for the Oregon City facility is given here (82a) (Table 3b). Other examples are given in later chapters.

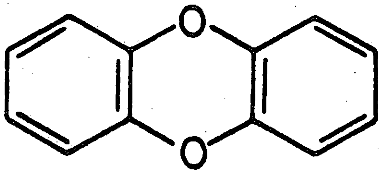
Polychlorinated Dibenzo-p-dioxin (PCDD) Emissions

A recent review on "Dioxins" is appended to this report to provide the reader with background information on this complex subject.

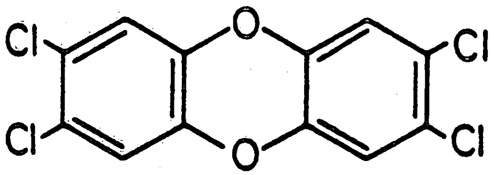
A brief note on the nomenclature of "dioxins" may help clarify some of the issues of environmental measurements (16,52). Properly speaking, the six-membered ring $C_4H_4O_2$ is dioxane (see Figure); when the two oxygen atoms occupy positions opposite to each other in the ring, it is p-dioxane. When four of the hydrogen atoms are two benzene rings, the compound is dibenzo-p-dioxin. The term "chlorinated dibenzo-p-dioxins"



p-Dioxane



Dibenzo-p-dioxin



2,3,7,8-tetrachlorodibenzo-p-dioxin
(2,3,7,8-TCDD)

Table 3a. Summary of Emission Factors (78)

Pollutant	Concentrations ppm or (gr/dscf)	lb/ton
particles	(0.02)*	0.34
sulfur dioxide	80	2.4
nitrogen oxides	75	1.6
carbon monoxide	150	1.9
hydrocarbons	16	0.12
hydrochloric acid	200	3.4
fluorides	6.5	0.06
lead	(6.8x10-4)*	0.012
mercury	(2.4x10-4)*	0.0064
beryllium	(3.0x10-9)*	5.1x10-8
sulfur acid mist	(.0023)*	0.04
TCDD		1x10-8
polynuclear aromatics		1x10-5
polychlorinated biphenyls		1.3x10-4

* corrected to 12% CO2

Table 3b. Maximum Emission Limits for Oregon Facility (82a)*

Pollutant	Pounds/Hour	Tons/Year
total particulate matter	26	84
volatile organic compounds	10	36
sulfur dioxide	60	210
nitrogen oxides	300	1050
carbon monoxide	120	420
mercury	0.21	0.74
lead	0.63	2.2
fluorides	1.4	4.5
hydrogen chloride	56	202
tetrachlorinated dioxins	0.0000018	0.0000057

* The proposed Energy Recovery facility would consist of three mass burning units. The three units would be designed to burn a maximum of 2010 tons/day or 600,000 tons/year of municipal refuse from the greater Portland Metropolitan Area...Each unit would be equipped with separate air pollution control equipment and a baghouse to remove particles. The exhaust gases from the three units would be discharged through three separate flues contained within a single 250 foot high stack.

Table 3c. Trace Organics Emission Levels 10-6 lb/ton (56)

PCDD	Hutzinger's Survey	ASME Revie
2,3,7,8-TCDD	0.035*	
TCDD	0.35	0.02 - 0.34
penta-CDD	0.90	0.009, 0.017
hexa-CDD	1.55	0.034, 0.015
hepta-CDD	1.55	0.068, 0.003
octa-CDD	0.35	0.0004, 0.0136

* 10% of total TCDD

refers to 75 isomers that differ in the number and position of attached chlorine atoms to dibenzo-p-dioxin. Each of the chlorinated dioxins has its own unique identity and toxic properties. 2,3,7,8-Tetrachlordibenzo-p-dioxin (2,3,7,8-TCDD) is considered to be the most toxic of the polychlorinated dibenzo-p-dioxin (PCDD) isomers and it has been comprehensively studied for its toxicological properties. There are 22 possible isomers of TCDD, although the term TCDD has frequently been used only in reference to the 2,3,7,8-TCDD isomer (52). Discussions of health risks are generally focused on the 2,3,7,8-TCDD isomer.

Data on PCDD emissions from resource recovery facilities come from two main sources:

1. Analysis of fly ash samples from plants in Western Europe.

2. Analysis of stack effluent samples from plants in the U.S.A. These studies were conducted mainly under the sponsorship of the EPA.

TCDD levels in fly ash from U.S. samples are generally lower than the European levels (53), but the reasons for the differences have not yet been ascertained. Emission rates of TCDD per ton of refuse burned have been projected in a number of reports.

1. Battelle's Report. The following paragraph is from O'Connell et al.'s review (78): "Considering the available data, we conclude that the best estimate of TCDD emissions possible is 1 x10-9 to 5 x10-7 lb/ton of refuse burned and that total dioxin emissions are possibly a factor of 10 higher. Data presented by Cavallarao and others indicate that the concentration of the toxic isomer 2,3,7,8-TCDD will be about 5 percent of the total TCDD concentration or about 5 x10-10 lb/ton of refuse burned."

2. A.D. Little's Reports (56). TCDD emission values were derived from Hutzinger's survey of European data which included a review of 25 incinerators and 80 test results (Table 3c). These data were also utilized in a report for the American Society of Mechanical Engineers which included other sources of data (4). Projected emission levels of 2,3,7,8-TCDD were 3.4 x 10-8 lb/ton of refuse. In this review, it was assumed that the 2,3,7,8-TCDD isomer was 10% of the total TCDD content.

3. Systech Corp. (45). Report to the U.S. EPA Office of Solid Waste. G.M. Higgins of Systech Corporation describes, with excellent clarity and detail, how dioxin emissions from refuse-thermal processing facilities are calculated from measurements of TCDD in the sample, sample volume, and stack flow rate.

In the Systech report, the 2,3,7,8-TCDD isomer ratio to total TCDD is again different and we quote from page 48 of the report: (TCDD and TCDF Isomer Analysis) "The data obtained on TCDD and TCDF isomer composition of stack gas samples showed that the maximum amounts of TCDDs and TCDFs identified by packed column chromatography as the 2,3,7,8 isomers and coelutors averaged 41 and 44 percent, respectively. The amounts confirmed as 2,3,7,8 isomers by capillary column GC/HRMS were considerably lower, at 13 percent for TCDD and 24 percent for TCDF. In general, it appears that employing packed column GC/HRMS analysis for the identification of 2,3,7,8 isomers provides an useful "worst case" assessment of the amounts of these isomers actually present. The data presented in Appendix C of this report also show that nearly all the 22 TCDD isomers and many of the TCDF isomers were routinely detected at nearly equal concentrations in samples analyzed by capillary column GC/HRMS."

4. The EPA's Report. The EPA's current positon on the topic of TCDD emissions from municipal solid waste incinerators was presented by Barnes (6,7). His data on emission levels are shown in Tables 3d and 3e.

5. The Department of Environmental Quality of the State of Oregon has also estimated TCDD emissions for a proposed Energy Recovery Facility (82a). For units designed to burn a maximum of 2010 tons/day or 600,000 tons/year of municipal refuse from the greater Portland Metropolitan Area, it projected a worst case estimate of TCDD emissions of 8.6 gm/year, based on "the Northwest Chicago data obtained by the EPA." This value corresponds to 3.2 x 10-8 lb/ton or 27 x 10-8 g/sec of TCDD (without corrections for the 2,3,7,8-isomer) and is within the estimates of Battelle, A.D. Little and the EPA.

Summary

Individual plants would vary in their emission factors. In order to discuss potential health effects, we will assume, from the values cited above, that the approximate emission rate of 2,3,7,8-TCDD is equivalent to 1 x 10-8 lb (4.5 ug/ton) of refuse. To derive ground level concentrations of pollutants it is customary to express emission factors as grams of pollutant emitted per second. To convert data from lb/ton to g/sec for a facility that burns, for example, 1200 tons of refuse/day, one multiplies lb/ton x 454 g/lb x 1200 ton/day x day/24 hr x hr/60 min x 60 sec/min = g/sec. Thus, the estimate for 2,3,7,8-TCDD emission rates for such a facility would be 6.3 x 10-8 g/sec.

Table 3d. Range of Parameters Represented by 5 Combustors Tested (6,7)

Parameter	Range
feed rate (kg/hr)	1000-17,000
combustion temperature (° C)	555-1200
stack temperature (° C)	139-232
flue gas flow rate (dscm/sec)	3.7-83.3
stack height (meters)	10-75

Table 3e. Range of Stack Concentrations (6,7)

Pollutant(s)	Range (ng/dscm)
2,3,7,8-TCDD	ND[a]-3.5[b]
total TCDD	ND -8.5

[a] not detected

[b] the analytical method used could not distinguish 2,3,7,8-TCDD from several of the other TCDD isomers. It is recognized that some molecular forms may be co-eluting with the 2,3,7,8- isomer; therefore, this value could be an overestimate of the amount of the 2,3,7,8-TCDD present

Chapter 4. Projected Ground Level Concentrations

Air Pollutant Dispersion Models

Chemicals emitted from resource recovery facilities are dispersed and diluted by air. A number of models are available for simulating the transport and dispersion of air pollutants. The objective of modelling is to predict ground level concentrations of the pollutant. Ground level concentrations are proportional to dose and hence the magnitude of the health risk. Some of the equations used for forecasting the dispersion of air pollutants have been described (96,103,106) and an example is given below to familiarize readers with these procedures.

The principal independent variables in dispersion models are source strength, effective source emission height and wind speed. We have discussed source strength in the previous chapter. Of course, for each resource recovery facility, plant design, air pollution control equipment, stack height, and meterological conditons will influence the projected ground level concentrations of emitted chemicals. The following excerpt from the World Meterological Organization Technical Note No. 121, "Dispersion and Forecasting of Air Pollution." presents a description of how emission factors are related to ground level concentrations (106):

"The diffusion of pollution downwind from an elevated continuous point source is often represented by the following expression:

$$ux/\ Q = \frac{1}{\pi\ sy\ sx}\ \exp\ (-y^2/2sy^2)\ \left\{\exp-\frac{(z-h)^2}{2\ sx^2} + \exp-\frac{(z+h)^2}{2\ sz^2}\right\}$$

where u is the mean horizontal wind speed (m/sec) (the x-axis is oriented in the direction of the wind), x is the ground-level concentration (units/m3), Q is the source strength (units/sec), sy, sz, are the standard deviations of the distributions of concentrations in the y (cross-wind) and z (vertical) directions, and are functions of downwind distance x, h is the effective source emission height (meters).

This model is based on the following assumptions:

a. Steady-state conditions, i.e., no time changes in wind or turbulence;

b. Homogeneous flow, i.e., no space changes in wind or turbulence;

c. An inert passive pollutant, i.e., no atmospheric chemical reactions and no gravity fall-out;

d. Perfect reflection of the plume at the underlying surface, i.e., no ground absorption;

e. Statistical Gaussian forms for the cross-wind and vertical distributions of pollution, implying a sampling time of at least ten minutes to ensure that irregularities and instantaneous "peaks" are smoothed away;

f. A non-zero wind speed so that diffusion in the x direction can be neglected in comparison with forward transport and stretching by the wind.

An excellent handbook on the practical applications of this equation is given by D. Bruce Turner in "Workbook of Atmospheric Dispersion Estimates", Office of Air Programs Publication No. AP-26, the U.S. EPA (103). In his manual there are many "Example Problems" and applications of the above general equation.

From the emission data given in Chapters 3 and 5, a number of projected estimates of ground level concentrations of pollutants have been derived for different facilities and meterological conditions. In later chapters, we also use for the purposes of discussion a dispersion factor of 0.5 to convert source strength, given in units of gm/sec, to ambient annual maximum ground level concentrations, given in units of ug/m3. This dispersion factor gives a rough, conservative approximation of the dilution of source strength at ground level for most facilities. The subject of PCDD and 2,3,7,8-TCDD ground level concentrations is reviewed in the next section.

Projected Dioxin Concentrations at Ground Levels

A number of ground level concentrations of 2,3,7,8-TCDD have been projected based on varying assumptions of emission rates, plant specifications and dispersion models. These estimates are summarized below.

1. The ASME report projected a ground level concentration of 0.1 pg/m3 based on the following assumptions: the possible presence of 2,3,7,8-TCDD in the stack effluent at levels approximating 1 pg/g on a mass basis, a 30.5 m (100 ft stack), wind speed of 5 m/sec, and a 1 km distance from stack to point of measurement (4).

2. The EPA used a computer model (PTMAX Computer Air Dispersion Model) to estimate the range of annual maximum average ground level concentrations of dioxin isomers projected from thermal-refuse processing plants. A value of "up to 0.038 pg/m3" was derived (6,7).

3. In a report prepared by A.D. Little for O'Brien and Gere Engineers, Inc. for the Onondaga County Resource Recovery Project in New York, estimates were made for a plant designed to burn 60 tons per hour and a TSP emission level of 0.03 gr/dscf. The annual concentration of 2,3,7,8-TCDD at ground level was estimated to be 0.011 pg/m3 for a 61 m stack and 0.004 pg/m3 for a 91 m stack (56).

4. The Oregon Department of Environmental Quality modeled the worst case impacts of TCDD for its proposed resource recovery facility and projected a maximum annual ground level concentration of 6.5 x 10-8 ug/m3 or 0.00065 pg/m3 (82a).

5. Using the ASME assumptions, but a different dispersion model, Crocker and Steiner reported that the consulting firm of KVB calculated an average ground level concentration of 0.0084 pg/m3 2,3,7,8-TCDD for the proposed South East Resource Recovery Facility (19).

Collectively, these data provide a range of estimates of projected ground level concentrations of 2,3,7,8-TCDD. Surprisingly, the range of estimates .00065, .004, .0084, .011, .038, and .1 pg/m3 do show some degree of agreement on the concentrations to be expected at ground level. At least, the numbers are sufficiently close to allow discussion of health risks with reference to a single value. For the purposes of subsequent discussion, we will assume, for a given resource recovery facility, that the annual ground level concentrations of 2,3,7,8-TCDD derived has an average value of 0.04 pg/m3.

Chapter 5. Criteria Pollutants

Introduction

Criteria pollutants are chemicals for which emission standards have been set by regulatory authorities. The National Ambient Air Quality Standards (NAAQS) for criteria pollutants are listed in Table 5a (30a). In addition to the NAAQS, some States may have their own ambient air quality standards.

For each resource recovery project, emissions of criteria pollutants are examined by local, state and federal air pollution regulatory authorities. An air quality impact analysis for each project would have to show that projected emissions of pollutants would not contribute to violations of, nor interfere with attainment or maintenance of, any federal or state ambient air quality standard. Under these circumstances of regulatory control, it is unlikely that criteria pollutants would be emitted in quantities exceeding standards that protect the public's health. In this chapter, the emissions of criteria pollutants will be briefly reviewed.

Data Presentation

The impact of resource recovery facilities on air quality and health can be presented in several ways. For health concerns, the example in Table 5b illustrates how one can obtain an immediate overview of the relative contribution of resource recovery facilities to criteria pollutants in air.

This table appears in the draft of the Environmental Impact Report for the SANDER resource recovery project in San Diego, a project that is regulated by the San Diego Air Pollution Control District, the California Air Resources Board and the U.S. Environmental Protection Agency (32). The summary states that:

"The new Air Resources Board emissions estimates lead to the following results for percent of the most-stringent standard at the point of maximum ground-level concentration under worst-case meteorology (short- term) and average meteorology (annual average) (see Table 5b)... Based on the current ARB-staff emission estimates, the annual average at the point of maximum ground-level concentration are all less than 1% of the most-stringent standard; the short-term

Table 5a. Federal Ambient Air Quality Standards (30a).

Primary Standards (human health)

1. sulfur oxides (sulfur dioxide)
    a. 80 micrograms per cubic meter (0.03 ppm) *- annual arithmetic mean
    b. 365 micrograms per cubic meter (o.14 ppm) - maximum 24 hour concentration not be exceeded more than once per year
2. particulate matter
    a. 75 micrograms per cubic meter- annual geometric mean
    b. 260 micrograms per cubic meter - maximum 24 hour concentration not be exceeded more than once per year
3. carbon monoxide
    a. 10 milligrams per cubic meter (9 ppm) - maximum 8 hour concentration not to be exceeded more than once per year
    b. 40 milligrams per cubic meter (35 ppm) - maximum 1 hour concentration not to be exceeded more than once per year
4. nitrogen dioxide
    a. 100 micrograms per cubic meter (0.05 ppm) - annual arithmetic mean
5. lead
    a. 1.5 micrograms per cubic meter maximum arithmetic mean averaged over a calendar quarter

Secondary Standards (all other effects)

1. sulfur oxides
   - a. 1,300 micrograms per cubic meter (0.05 ppm) - maximum 3 hour concentrations not to be exceeded more than once per year
2. particulate matter
   - a. 60 micrograms per cubic meter annual geometric mean
   - b. 150 micrograms per cubic meter - maximum 24 hour concentration not be exceeded more than once per year

* All measurements of air quality are corrected to a reference temperature of 25 degrees Centigrade and to a reference pressure of 760 millimeters of mercury (1,013.2 millibars).

Table 5b. Proposed San Diego Project, Pollutant as % NAAQS (32).

Pollutant	Annual Av.	Short-term Av.
nitrogen dioxide	0.84%	4.40%
sulfur dioxide	0.49	0.69
suspended particles	0.16	1.50
carbon monoxide	-	0.10
hydrocarbons	-	1.56

averages are between 0.10% and 1.6% of the most- stringent standard, except for nitrogen dioxide, which is at 4.4%."

Similar percentage calculations are shown for facilities proposed in New York (56) and Oregon (82a) (Table 5c,5d).

From these tables, it is apparent that resource recovery facilities, by themselves, do not emit sufficient criteria pollutants into the air to exceed air quality standards. It should be noted, however, that these emissions are superimposed upon background levels of pollutants. The background levels of criteria pollutants for some major cities are shown in Table 5e (30a). The data show variations in levels of pollutants among locations so the relative importance of specific pollutants would vary according to site. For example, in the San Diego area, sulfur dioxide concentrations are much lower than in Boston, thus increments of sulfur dioxide from the SANDER facility will have a smaller impact than a similar facility built in the Boston area. For most facilities, the increments plus background levels of pollutants do not exceed ambient air quality standards.

Discussion

In the following section, some additional information on specific criteria pollutants are presented.

H. Freeman of the U.S. EPA (36), in a review published in 1978, commented on the emissions of criteria pollutants from resource recovery facilities. He stated that:

"Waste-to-energy conversion system emissions include particulate matter, sulfur oxides, nitrogen oxides, hydrogen chloride, hydrocarbons, carbon monoxide, and trace elements.

Of these pollutants, particulate matter is the most significant in terms of environmental regulations. Particulate matter is any solid or liquid material in the gas stream, except uncombined water. It consists of fly ash, dust, aerosols (microscopic-size particles) and mists. Emission rates for particulate matter vary widely depending on moisture and ash content of the fuel, unit design, and combustion parameters. However, uncontrolled rates of from 15-24 lb of particulate matter per ton of refuse fired are generally produced by waterwall incinerators.

National pollution control standards (New Stationary Source Performance Standards) are presently in effect for particulate emissions from waste-to-energy conversion systems built since 1971. For incineration, the standard is 0.08 gr/dscf corrected to 12% C02, which corresponds to approximately 1.9 lb of particulate per ton of refuse fired. Several operating units have complied with this standard (A figure showing the emissions for Saugus, Mass., Nashville,

Table 5c. Proposed Onondaga, N.Y. Facility, Pollutant as % NAAQS (56).

Pollutant	Fed. Std. (ug/m3)	Annual Av. (ug/m3)	Percent
sulfur dioxide			
max 24 hr	365	27	7.4
annual	80	1.3	1.6
particulate			
annual	75	0.34	0.5
nitrogen oxides			
annual	100	1.0	1.0
carbon monoxide			
max. 8 hr	10,000	140	1.4

Table 5d. Proposed Oregon City Facility, Pollutant as % Standard (82a).

Pollutant	State Std. (ug/m3)	Max. Impact (ug/m3)	Percent
sulfur dioxide			
max 24 hr	260	20	7.7
annual	60	1.3	2.2
particulate			
annual	60	0.6	1.0
nitrogen oxides			
annual	100	7.7	7.7
carbon monoxide			
max. 1 hr	40,000	150	0.4

Table 5e. Background Levels of Criteria Pollutants (30a)*.

Pollutant	S. Francisco	Seattle	S. Diego	Boston
nitrogen dioxide	43.0	-	51.0	-
sulfur dioxide	6.6	23.0	6.2	38.8
particles	56.0	87.4	91.7	55.3
carbon monoxide	1.9	2.2	1.3	2.1
lead	.5	1.2	1.1	-

* values represent the mean, units are ug/m3, data from EPA Air Quality Data, 1981 Annual Statistics.

Tenn., Braintree, Mass., and Norfolk, Va., gave values of 0.07, 0.026, 0.032, and 0.04 gr/dscf, respectively.)...

Gaseous emissions from waste-to-energy conversions are not presently viewed as a significant environmental problem. Refuse is a low-sulfur fuel, averaging only about 0.3% sulfur (as compared to 1-3% for coal). Consequently, sulfur dioxide production is minimal.

...Unburned hydrocarbons (HCs) and carbon monoxide (CO) are usually present in significant amounts only if proper combustion is not taking place. Proper flame turbulence, ample combustion times, and sufficient temperature will reduce the quantities of CO and HCs to negligible levels.

Hydrogen chlorides have been detected in the stacks from waste combustion systems and contribute to increased equipment corrosion. It is not presently believed, however, that these emissions represent a hazard to the environment significant enough to require control."

The relative impact of nitrogen dioxide and carbon monoxide emissions should be put into perspective as current research recognizes the important contribution of indoor air pollutants to human dose (70,107). The projected emissions of nitrogen dioxide from resource recovery facilities contribute, on an annual average, less than 10 ug/m3 to outdoor air (Table 5b-d). In a recent review of this subject (70), it was noted that "peak nitrogen dioxide concentrations up to 1 ppm (about 1880 ug/m3) and 1-hr averages of 0.25-0.50 ppm (about 470-940 ug/m3) are reached in a closed kitchen with no external ventilation...normal (gas) stove operations frequently resulted in nitrogen dioxide concentrations in the kitchens averaging over 100 ug/m3 for the 2-wk sampling periods...indoor CO concentrations are generally higher than corresponding outdoor levels in all residences monitored."

Conclusion

The supervision of regulatory authorities, the accumulated experience and familiarity with criteria pollutants, and the low levels of pollutants predicted by air quality impact analysis provide assurance that emissions of criteria pollutants from resource recovery projects will not affect the public's health.

Chapter 6. Non-Criteria Pollutants. A. Dioxins: Toxicology

Introduction

Non-criteria pollutants are chemicals for which emission standards have not yet been fully developed. Lack of scientific information and lack of direct human experience are two of the reasons standards have not been established for these pollutants. Furthermore, some chemicals are emitted in relatively small quantities, so it is not clear if sufficient time, expense, and effort should be devoted to the development of criteria and controls for these chemicals which may have limited, if any, effects on human health. The term "micropollutants" has also been used to describe the non-criteria pollutants emitted from resource recovery plants. This term was chosen presumably because the quantities of chemicals emitted are small relative to other "macropollutants" such oxides of sulfur, nitrogen and carbon.

When resource recovery facilities are reviewed for possible adverse effects on human health, non-criteria pollutants merit consideration because, although these chemicals are emitted in fairly small quantities, some of these chemicals are toxic to man and laboratory animals at low doses. The methodology used for analyzing the potential health risks from micropollutants are similar to those developed for macropollutants and are based on the fundamental concepts of toxicology described in Chapter 2. Essentially, predictions of the likelihood of biological responses is based on an assessment of the potential dose of the chemical to the individual living in the vicinity of the resource recovery facility. Information and conclusions based on dose-response relationships are presented in quantitative and probabilistic terms. The term "safe" will refer to the relative absence of the likelihood of harm at a given dose range.

References on Dioxins

The principal non-criteria pollutant of importance to resource recovery facilities is the class of chemicals known as dioxins. Concern about dioxins arises because of its toxicity and its presence in emissions. Numerous reviews, monographs, and symposia have covered the chemistry, analytical detection, animal toxicology, human poisonings, environmental pollution, and epidemiological investigations of these compounds. A special Chemical & Engineering News issue on dioxin and a selected bibliography on this subject are included in this report (3,4,7,9,13,16,25,33,34,43,46,49,50,52,59,66,85,87,97). We review here aspects of dioxin toxicology that are pertinent to emissions from resource recovery facilities. To persons not familiar with this topic, a recent article by Dr. D.G. Barnes of the U.S.E.P.A. provides an excellent survey of this subject (7).

Chemistry of Dioxins

The nomenclature of "dioxins" has been described in Chapter 3. Here we focus our discussion primarily on 2,3,7,8- tetrachlorodibenzo-p-dioxin (2,3,7,8- TCDD), the prototype dioxin which has been most thoroughly studied.

2,3,7,8-TCDD is a colorless crystalline solid at room temperature, and a molecule which is chemically stable at temperatures up to 700 degrees Centigrade (33). The unique characteristics of 2,3,7,8-TCDD are its biological activities.

Toxicity in Animals

Acute Toxicity. A commonly used measure of acute toxicity is the median lethal dose (LD50), which is the dose at which 50% of the test species die due to exposure of the chemical. On a molecular basis, low doses of TCDD are sufficient to produce lethality in many species (see Table from Kociba and Schwetz, ref. 52). A wide range of sensitivies is observed: the guinea pig is the most sensitive in contrast to the hamster which is approximately 2000 times less sensitive than the guinea pig. In these short-term (acute), single-dose studies, 2,3,7,8-TCDD produced changes in the liver, pancreas, central nervous sytem and thymus. Animals do not manifest overt or immediate signs of toxicity but lose weight rapidly and deaths occurs approximately two to three weeks after dosing.

Chronic Toxicity. In longer term (chronic) studies in animals, complex effects on different organ systems were produced by 2,3,7,8-TCDD (dissolved in acetone) added to the diet. Adverse effects included a decrease in body weight and changes in the pattern of cells in the blood, liver, secretory epithelium, and skin. Atrophy of the bone marrow, thymus and testicle were observed at some of the higher doses of 2,3,7,8-TCDD that were tested.

Delayed Toxicity. 2,3,7,8-TCDD can affect the fetus of experimental animals. Mice are especially sensitive. When 2,3,7,8-TCDD is given at doses of 0.25 to 9 ug/kg during gestation, at the most sensitive periods for studies on teratogenic effects, birth defects and death of pups are produced in utero. The most frequent morphologic changes produced by 2,3,7,8- TCDD in mice were cleft palate and hydronephrosis (kidney damage). Daily doses of 0.01 ug/kg of 2,3,7,8- TCDD given to female rodents negatively affected fertility, survival, and growth of pups.

In addition to the toxic effects described above, 2,3,7,8-TCDD also produced neoplasia, including cancer, when tested in mice and rats. In a frequently cited study, Kociba et al. (51) showed that 2,3,7,8-TCDD administered at doses of 0.01 and 0.1 ug/kg/day for two years produced an increased incidence of tumors in the liver, lung, oral and nasal cavities, and tongue of female rats. Male rats were less susceptible. A dose level of 0.001 ug/kg/day was inactive. Surprisingly, female animals treated with the higher doses of 2,3,7,8-TCDD also showed a reduced incidence of spontaneous tumors of the pituitary, uterus, and mammary glands.

Mechanisms of Toxicity

Molecules that roughly fit into a rectangle 3 x 10 Angstroms with halogen atoms in the four corners of the rectangle (a "pool table" model) bind to cytosol receptors (biological macromolecules) and initiate the toxic responses characteristic of 2,3,7,8- TCDD (87). Like most potent substances, a high degree of steric specificity is required for binding and toxicity. Of the 75 possible chlorine-substituted dibenzo-p-dioxin isomers tested, only the 1,2,3,7,8-pentachlorodibenzo-p-dioxin isomer exhibits a comparable degree of toxicity to 2,3,7,8-TCDD.

The basic histopathologic change is hyperplasia (increased cellularity) and/or altered differentiation (metaplasia) of secretory epithelium of the skin and mucosa. The hyperplasia is frequently accompanied by keratinization. These changes account for the chloracne, other skin lesions, and gastrointestinal signs seen in primates.

McConnell (58) gives a clear description of pathogenetic mechanisms in the skin. He notes that: "In general the microscopic changes observed in the skin (chloracne), eyelids and ear canal (of monkeys) have a common pathogenesis. They are all related to changes in sebaceous or modified sebaceous glands as the case may be and associated hair follicles. In essence the sebaceous glands undergo atrophy with a metaplastic change to a keratinizing form of stratified squamous epithelium. Later, all that remains is the central duct which enlarges due to impaction with keratinaceous debris, and it may eventually rupture with secondary granulomatous inflammation. Therefore, the function of the oily secretions normally provided by these glands is abated and leads to the clinical manifestations of dry skin, chloracne, excess lacrimation, photophobia and crusty debris in the external auditory canal. Concomitantly, there is hyperkeratosis of hair follicles with resultant dilatation. The reported appearance of a dull hair coat and alopecia which have been reported in spontaneous poisonings by the chemicals in horses and cattle may also be related to changes in the hair follicles and sebaceous glands, but this has not been studies in the same depth as in monkeys and rabbits. Severe as these lesions may be, they are apparently reversible if exposure ceases."

At higher exposure levels, effects other than chloracne which may be seen in man are alterations in liver function and lipid metabolism. The cellular mechanisms for these effects are not understood. In some species, 2,3,7,8-TCDD produce thymic involution and loss of the seminiferous tubules. Large doses also produce pancytopenia and hemorrhage in monkeys. These atrophic responses and changes in hematology have not been observed in man.

Toxicity in Man

Information concerning the acute toxic effects of 2,3,7,8-TCDD in man comes from three sources: 1. accidental worker exposure to TCDD during the manufacture of chlorinated phenols (18,42,62,63,82,99,108), 2. an incident at Seveso, Italv, where it was estimated that 2 kg (approximately 4 lbs) of TCDD was accidentally discharged into an urban area of approximately one thousand acres (14,34,59,91), and 3. an incident in Missouri where industrial waste oil contaminated with TCDD was sprayed over a horse arena and a family was exposed to the contaminated soil (89).

Of these three sources, industrial accidents provide the most detailed clinical documentation of the toxic effects of 2,3,7,8-TCDD in man. Accidental exposure, however, only yields descriptive information of toxic effects and seldom report information on levels of exposure that provide dose- response data. In addition, industrial accidents generally involve exposure to more than one chemical. Thus, information derived from human exposure cannot be readily translated to data for the establishment of standards. Nevertheless, clinical experience do provide qualitative descriptions of effects to be expected when man is exposed to large doses of TCDD.

Acute Toxicity (46). The immediate effects on man of exposure to high levels of TCDD are burning sensations of the mucous membranes of the eye, nose, and throat. Itching, swelling, and redness of the face may occur just prior to chloracne, the earliest sign of TCDD poisoning. Chloracne, a condition similar to acne vulgaris, was observed in some Seveso children within two days after exposure. Normally, however, in industrial situations, chloracne develops in the weeks and months after exposure. Chloracne may appear first on the face and then spread to the arms, neck, and trunk, depending on the extent of exposure. The minimal dose 2,3,7,8-TCDD for producing chloracne in man was reported, without documentation, to be 20 ug per person (59). Doses of 0.2 to 16 ug per person have been administered with no apparent reactions (76). Because low doses of TCDD are sufficient to induce chloracne, an exposed individual can transmit through clothing, hands, or other close contact sufficient TCDD to produce chloracne in close associates such as family members (62).

Other symptoms resulting from short-term, high dose exposure include arthralgia (pain in the joints without associated arthritic changes), extreme fatigue, insomnia, loss of libido, irritability, and nervousness. Emotional disorders, difficulties with muscular and mental coordination, blurred vision, and loss of taste and smell have been described. Objective signs of poisoning which may develop include: elevated levels of blood cholesterol and lipoproteins, liver dysfunction, hyperpigmentation, and hirsutism (increased growth of hair). Disorders of the cardiovascular, urinary, respiratory, and pancreatic systems, along with disorders of fat and carbohydrate metabolism have also been reported. In spite of 2,3,7,8-TCDD's potent lethal effects in animals, reports describing human fatalities from dioxin exposure are difficult to find and apparently number less than ten cases (33,43). In the case described by Thiess et al. (99), pancreatic damage was noted.

Chronic Toxicity. The longer-term manifestations of TCDD poisoning in man are extensions of the signs and symptoms described above. Thus, mild chloracne will heal but severe chloracne may persist and leave scars on the skin. Some exposed workers complain of muscle weakness, malaise and fatigue. Abnormalities of liver and metabolic indices may continue and residual neuropsychiatric disorders may develop. The question of residual effects are not clear, but can be assessed from the follow-up studies listed below.

Delayed Toxicity. Although animal studies show that 2,3,7,8-TCDD is toxic to the fetus and produces cancer in laboratory animals, so far there is no convincing evidence that these effects have occurred in man as a consequence of industrial or environmental exposures. Recently, the possibility has been raised that TCDD may increase the risk of soft-tissue sarcomas in man (42,45a). This subject is still being debated, but the earlier observations have not been re-confirmed by studies on other populations with possible TCDD exposures (65,95a). References to some of these issues are provided in the bibliography.

Follow-up Studies of TCDD Exposure in Man

Extensive follow-up studies have been conducted on human populations exposed to TCDD. So far, there is little evidence of chronic or delayed toxicity for low dose exposures other than signs of chloracne. There are, however, limitations to the sensitivity of epidemiological methods (93a). The results from some of these studies are given below.

1. F. Caramaschi, G. Del Corno, C. Favaretti, S.E. Giambelluca, E. Montesarchio, and G.M. Fara. Chloracne following environmental contamination by TCDD in Seveso, Italy. International Journal of Epidemiology 10:135-143, 1981.

Abstract: Data are presented on the occurrence of chloracne, clinical symptoms and biochemical changes in 164 children following environmental contamination by TCDD from an industrial accident in Seveso, Italy. An overall positive association was found between the territorial distribution of chloracne cases and the different levels of soil contamination in the affected area. Individual risk factors such as condition and length of exposure, intake via contaminated foods, etc. were evaluated; no single factor appeared to be associated with chloracne. Disturbances of the gastrointestinal tract were more frequently observed in children affected with chloracne than in those from the same areas having no skin lesions. However, no clinically definable systemic disease has been diagnosed.

2. G. May. Chloracne from the accidental production of tetrachlorodibenzodioxin. British Journal of Industrial Medicine 30:276-283, 1973. Second study: G. May. Tetrachlorodibenzodioxin: a survey of subjects ten years after exposure. British Journal of Industrial Medicine 39:128-135, 1982.

Abstract of Second Study: Ten years after an incident following which 79 workers developed chloracne due to exposure to tetrachlorodibenzodioxin a study was undertaken to establish the current state of health of the affected employees remaining in the company's employment. The opportunity was used to examine effects on mortality, morbidity, carcinogenesis, reproduction, teratogenicity, fetotoxicity, biochemistry, immunology, and genetic change. Concurrently, control groups were established with which to make comparison. The control groups selected from within the works matched the study group in respect of sex and age but it was not possible to match them for occupation and social status. Half the affected subjects still have minor chloracne. Other than this there is no evidence that they have been adversely affected in any way.

Note: The procedures under which these studies were conducted have been challenged (43).

3. A.M. Thiess, R. Frentzel-Beyme and R. Link. Mortality study of persons exposed to dioxin in a trichlorphenol-process accident that occurred in the BASF AG on November 17, 1953. American Journal of Industrial Medicine 3:179-189, 1982.

Abstract. Twenty-seven years after an accident which occurred in the BASF, Ludwigshafen plant in 1953, a mortality study of persons exposed to dioxin in an uncontrolled reaction during a trichlorphenol process was undertaken. The follow-up was 100% successful and involved 74 persons. Overall mortality (21 deaths) did not differ in this group from the rate expected in three external reference populations or from that observed in two internal comparison groups, where 18-20 deaths were observed. Of the 21 deceased persons, 7 had cancer, compared with 4.1 expected. In addition, two other cases of cancer (one bronchial carcinoma, and one carcinoma of the prostate) are still alive. Three deaths due to stomach cancer, at ages 64, 66, and 69 years, were found, compared with 0.6 expected from regional mortality data. One stomach cancer occurred among 148 individuals in the two comparison cohorts.

Additonal Examples of Follow-up Studies

G.M. Fara. The work of the international steering committee for the study of the health effects of the Seveso accident: its methodology, its issues and its conclusions. Chemosphere 12: 785-790, 1983.

J.C. Townsend, K.M. Bodner, P.F. van Peenen, R.D. Olson and R.R. Cook. Survey of reproductive events of wives of employees exposed to chlorinated dioxins. American Journal of Epidemiology 115:695-713, 1982.

A.H. Smith, D.O. Fisher, N. Pearce, and C.J. Chapman. Congenital defects and miscarriages among New Zealand 2,4,5-T sprayers. Archives Environ. Health 37: 197-200, 1982.

J.A. Zack and R.R. Suskind. The mortality experience of workers exposed to tetrachlordibenzodioxin in a trichlorophenol process accident. Journal of Occupational Medicine 22:11-14, 1980.

R.R. Cook, F.C. Townsend, M.G. Ott, L.G. Silverstein. Mortality experience of employees exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Journal of Occupational Medicine 22:530-532, 1980.

M.G. Ott, B.B. Holder, R.D. Olson. A mortality analysis of employees engaged in the manufacture of 2,4,5- trichlorophenoxyacetic acid. Journal of Occupational Medicine 22:47-50, 1980.

C. Hardell and A. Sandstrom. A case-control study: soft-tissue sarcomas and exposure to phenoxyacetic acids or chlorphenols. British Journal of Cancer 39:711-717, 1979.

P.A. Honchar, and W.E. Halperin. 2,4,5-T, Trichlorophenol and soft tissue sarcoma. Lancet 1: 268-269, 1981.

A.H. Smith, D.O. Fisher, N. Pearce, and C.A. Teague. Do agricultural chemicals cause soft tissue sarcoma? Initial findings of a case-control study in New Zealand. Community Health Studies 6: 114-119, 1982.

A.P. Poland, D. Smith, G. Meter and P.A. Possick. A health survey of workers in a 2,4-D and 2,4,5-T plant with special attention to chloracne, porphyria cutanea tarda and psychologic parameters. Archives of Environmental Health 22: 316-327, 1971.

Chapter 7. Non-criteria Pollutants A. Dioxins: Standards

Introduction

Environmental standards are set after complex evaluation of scientific and socio-economic issues. From the viewpoint of the public's health, a key scientific question to address is the amount of dioxins that is not likely to produce adverse effects in the exposed population. Although 2,3,7,8-TCDD is a potent poison, there is a point at which the dose of 2,3,7,8-TCDD is so small that it will not produce toxicity. If it can be shown that the amount of 2,3,7,8-TCDD produced by resource recovery facilities is below this dose, then one can presume that operations of such facilities will not adversely affect the public's health. Conversely, if one wishes to postulate hazard then it is necessary to have evidence to show that the exposure dose exceeds a defined threshold dose.

Dose-response analysis can only go so far. There are limitations to the accuracy of the numbers that form the data base for analysis. A second source of information for the establishment of standards can be derived from qualitative assessments of the mechanisms of toxicity and human experience. Here, the line of reasoning should adhere to scientific principles and common sense. The two approaches stated here, dose-response analysis and evaluation of mechanisms, will be discussed here in the assessment of dioxin emissions from resource recovery facilities.

Dose-Response and Threshold

Empirical data on the "no observable effect level (NOEL)" or "no adverse effect level" for 2,3,7,8-TCDD have been primarily obtained from long-term feedings studies in rodents (mice and rats). These data have been recently reviewed by Kociba and Schwetz (52), and these statements appear in the summary:

"TCDD (the 2,3,7,8 isomer) causes a dose-related teratogenic response (primarily cleft palate) in mice, with the no-adverse-effect level of 0.1 ug/kg/day. In rats, TCDD does not cause teratogenic effects, but it does cause embryo- and feto-toxicity at higher dose levels...Multigeneration reproduction and lifetime chronic toxicity studies have been completed with TCDD in rats with the no-adverse-effect-level found to be 0.001 ug/kg/day...TCDD has been studied for its carcinogenic potential in both rats and mice. The results show good correlation, with a carcinogenic response noted in both species only after long-term ingestion of higher dose levels that induce organ toxicity. No carcinogenic response occurred at continuous dose levels of 0.001-.0014 ug TCDD/kg/day in rats and 0.001-0.003 ug TCDD/kg/day in mice."

These animal studies on TCDD, using multiple dose levels, have provided the data base for the establishment of standards. To facilitate discussion of these numbers, we note here that 1 microgram (ug) = 1000 nanograms (ng), 1 nanogram = 1000 picograms (pg), and 1 picogram = 1000 femtograms (fg).

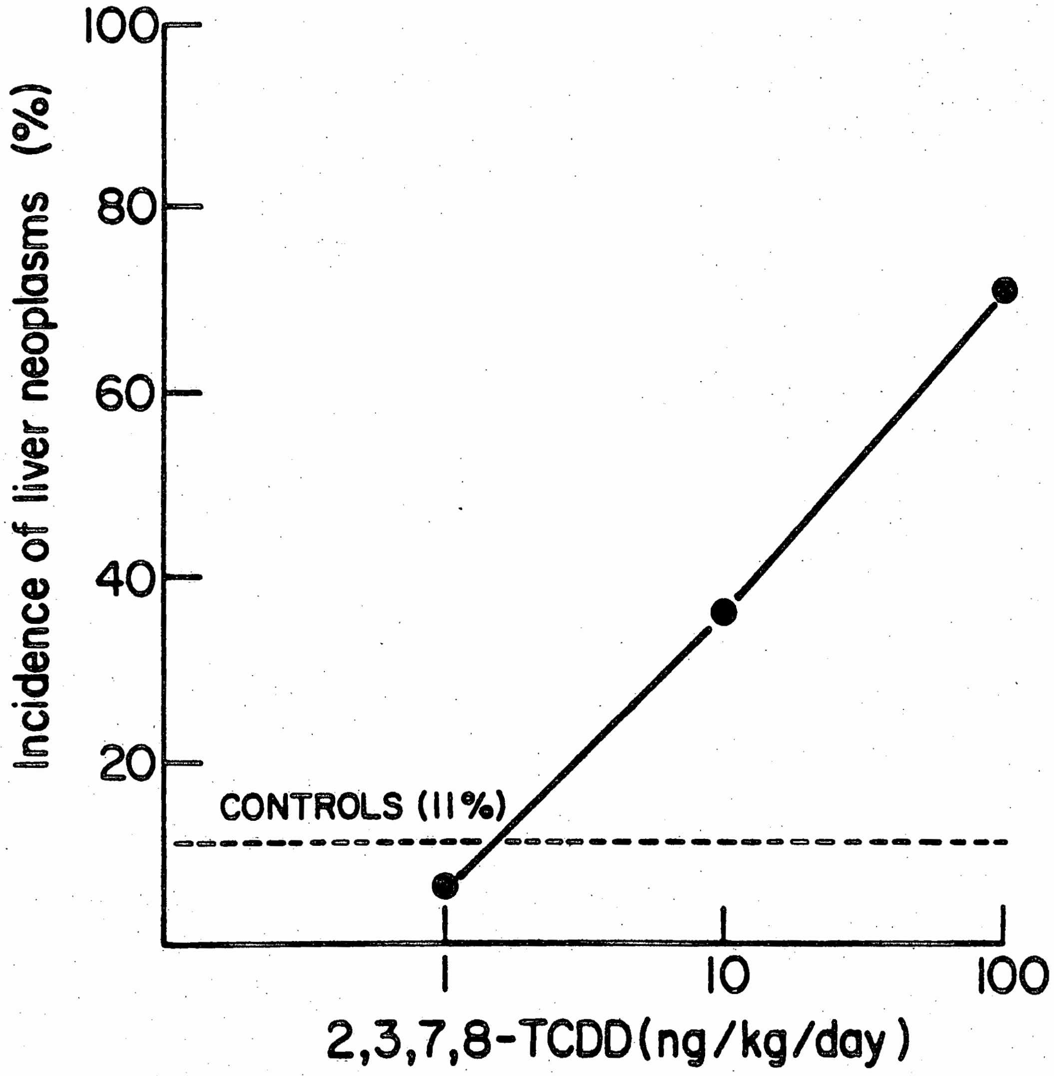
Officials of the Netherlands have taken the NOEL of 1 ng 2,3,7,8-TCDD/kg/day derived from the animal studies and simply divided this number by a "safety factor" of 250 to come to an allowed standard of 1000 pg/250 = 4 pg TCDD/kg/day (80). This procedure, although arbitrary, is frequently used in the choice of acceptable levels. For example, in the workplace, a safety factor of 10 is generally considered to be adequate if the chemical produces only acute effects and the toxicological data are based on human experience. For food additives, a safety factor of 100 (10x for differences in suceptibility between animals and man and 10x for individual differences in susceptibility) is applied to data based on lifetime toxicity studies in animals. The use of safety factors has historical precedence and is applicable to the acute and chronic toxic effects of chemicals, but more elaborate analysis is used for chemicals that produce delayed toxicity and have carcinogenic risks (39a).

The National Research Council of Canada have reviewed the literature on dioxins and an attempt was made to establish a "virtually safe dose" for 2,3,7,8-TCDD based on the animal studies conducted by Kociba et al. (51). Because the U.S. EPA also utilizes this data set, a brief description of Kociba et al.'s results will be presented. Additional details may be found in the original papers.

Kociba et al. (51) conducted a standard 2-year feeding study on rats. Male and female rats were given 0.001, 0.01 and 0.1 ug of 2,3,7,8-TCDD/kg/day in the diet mix with 50 male and 50 female rats at each dose level. A control group consisted of 85 male and 85 female rats. Toxic effects of 2,3,7,8-TCDD were observed in animals receiving the 0.01 and 0.1 ug/kg/day dosages but no significant toxic effects were observed in the 0.001 ug/kg/day group (the NOEL).

There were changes in the incidence of neoplasms, both increases and decreases depending on the organ, in female animals receiving the two higher 2,3,7,8-TCDD dose levels. Changes in the incidence of liver lesions were used as an index of carcinogenicity. An increase in liver cancer was observed at the 0.1 ug/kg/day dose, in female rats (11/50 animals versus 1/85 for controls) but not in male rats. At the 0.01 ug/kg/day dose there was an increase in the incidence of hyperplastic hepatic nodules, which are non-malignant lesions, but again only in female rats (18/50 versus 8/85 in controls).

Based on these data, the dose-response relationship was calculated as: number of animals with tumors/ number of animals examined, 9/85 (controls), 3/50 (0.001 ug/kg/day), 18/50 (0.01 ug/kg/day), and 34/48 (0.1 ug/kg/day) (66). Converting to percentages, the incidence for female rats at the different dose levels were: 11% (controls), 6% (0.001 ug/kg/day), 36% (0.01 ug/kg/day) and 71% (0.1 ug/kg/day). These data are illustrated in the graph below.



The tumor incidence data were then analyzed by models that presume that there are no threshold doses for carcinogens. That is, in models that assume that there is a slope in the dose-response relationship at doses approaching zero dose (1). Extrapolating from the 0.01 ug/kg/day dose level to zero dose, it was estimated that the dose for an one in one million risk (ED.0001 or an incidence of .0001%) was between 30 and 90 fg/kg/day or 0.03-.09 pg/kg/day.

If one took the average of the extrapolated values (0.03 + 0.09 divided by 2), we have 0.06 pg/kg/day. This "virtually safe dose" can be compared to the NOEL in animal studies of 1000 pg/kg/day. It can be seen that the Canadian value, with its assumptions about the incidence of neoplasms and with its mathematical formulations, has a factor which is 16,667 (1000/0.06) smaller than the NOEL.

EPA Assumptions for Risk Estimates

1. The carcinogenic properties and reproductive effects of all TCDDs are the same as that of 2,3,7,8-TCDD.
2. The PTMAX air dispersion model adquately represents the transport of the emissions to ground level.
3. The composition of emission products found at ground level is identical to the composition (but not the concentration) found in the stack.
4. Seventy-five percent of the inhaled emission particles (to which the TCDDs are generally attached) are retained in the body.
5. All the TCDDs that are retained in the body are biologically available to the organism.
6. The population is exposed to the maximum annual average ground level concentration from the source for 24 hours a day throughout a 70 year lifetime.
7. Humans are of comparable sensitivity to the animals tests.

The U.S. EPA has also analyzed Kociba et al.'s data (51). Details of the cancer incidence data for modelling were not given but the results were stated in detail by Barnes (7). Assuming the upper range of 2,3,7,8-TCDD concentration in air to be 9.2 x 10-5 ng/m3 (0.092 pg/m3), and by using various mathematical models for extrapolation, it was estimated that the cancer risk for lifetime exposure was between zero to 8-19 (average 14.2, upper bound) chances in one million at 95% confidence.

These estimates were reached with an explicit set of assumptions (see above).

Assumptions 1, 5, and 6 overestimate the risk and are "conservative, worst case assumptions." For assumption 1, it is known that other TCDDs tested lack the potency of 2,3,7,8-TCDD. For assumption 5, there are experiments to show that 2,3,7,8-TCDD adsorbed on particles are less active than 2,3,7,8-TCDD dissolved in solvents (8,86). The improbable nature of assumption 6 is self-evident. On the other hand, the EPA underestimates risk by not factoring in exposures to non-tetra isomeric halogenated dioxins and dibenzofurans (7). If these congeners are included, the total toxicity of samples may be 8-80 fold greater than the toxicity of its 2,3,7,8-TCDD content. These overestimates and underestimates tend to offset each other.

Barnes (7) emphasized that the figures reached by the EPA are not predictions of risk. The upper bound figure of 8-19/million "denote a level of risk that the actual risk is not likely to exceed; hence the term "upper bound". The actual risk should fall somewhere between zero and the estimated upper bound."

Based on these assumptions and modelling, the U.S. EPA has reached the conclusion that exposure to 0.092 pg/m3 of 2,3,7,8-TCDD or 0.092 pg/m3 x 20 m3/day x 1/70 kg person = 0.026 pg/kg/day does not "represent an unreasonable risk to public health and the environment." Compared to the NOEL found in animal studies, we have here a factor of 1000/0.026 = 38,461.

If we assume, from our previous review of the literature, that there may be 0.04 pg of 2,3,7,8-TCDD/m3 in air, then the dose is 0.04 pg/m3 x 20 m3/day x 1/70 kg person = 0.011 pg/kg/day. This value is 90,909 times (1000/0.011) smaller than the NOEL and can be considered "safe" according to the criteria developed by the authorities of the Netherlands, Canada and the U.S. EPA.

Mechanisms of Toxicity and Human Experience

From the previous considerations of emissions, projected ground level air concentrations, and dosages of 2,3,7,8-TCDD, we reached the conclusion that the amount of TCDD in air from resource recovery facilities would be too small to produce adverse effects in man. This conclusion, however, should be tempered by several caveats about unknowns for which there are no conclusive scientific answers. Namely, there are uncertainties about: the statistical distributions of the emissions factors; the dose-response relationship, if any, between exposure to 2,3,7,8-TCDD and soft-tissue sarcoma risks; and the quantitative significance of TCDD congeners to dosage. One may therefore ask: if the above estimates and conclusions were wrong, and if TCDD levels became excessive, what effects might result in the exposed population?

It is generally accepted that chloracne is the most sensitive sign of acute TCDD poisoning in man (3). This conclusion is based on studies of TCDD accidents in industry and in Seveso, a town in Italy where TCDD was accidentally released into urban air. In these episodes, TCDD produced chloracne in people, but no other clearcut clinical signs of toxicity could be documented in follow-up studies (34,63).

The American Medical Association has stated (3) that "chloracne is the clinical marker of TCDD exposure." This statement may, to some extent, allay anxiety about exposure to TCDD because mild chloracne, even if it were to occur, is a reversible condition that can serve to warn the population of excessive exposure. The AMA statement should not, however, be interpreted to mean that TCDD poisoning is invariably (100%) accompanied by chloracne. The possibility of delayed toxicity, without chloracne, cannot be completely ruled out (see Kimbrough and Huff et al. below). At this time, one can conclude that, in the large majority of cases of TCDD exposure in man, chloracne is the first and most commonly observed sign of toxicity, but like most scientific observations, this empirical relationship is not absolute.

The statements of the AMA (3), Kimbrough (50), and Huff et al. (46) are quoted below.

Council on Scientific Affairs, American Medical Association. Health Effects of Agent Orange and Dioxin Contaminants. Journal of the American Medical Association 248: 1895-1897, 1983.

"Two of the more pronounced biologic effects of some of the chlorinated dioxins are their tendency to cause chloracne (especially in the rabbit, nude mouse, monkey and man) and the accumulation of fluid in the pericardium and peritoneal cavity of chicks.

Chloracne is man is typified by comedones in a malar distribution; the preauricular and postauricular portions are often accompanied by hirsutism and sometimes by melanosis and secondary inflammation. The disease was first described in 1899; its cause was discovered in 1918 to be due to contact with certain chlorinated hydrocarbons. Chloracne has now become one of the more common forms of occupational dermatitis. Other acute toxic reactions to dioxin include liver and renal damage, porphyria cutanea tarda, hyperpigmentation, hirsutism, polyneuropathies (e.g., sensory impairments and weakness in legs), and neurasthenic or depressive syndromes. Thus far, longterm effects, except for persistent chloracne, have not been seen.

Chloracne is not caused by 2,4,5-T and 2,4-D per se; if the condition occurs on exposure to either or both of these compounds, it is most likely that the contaminant TCDD is responsible. Chloracne usually appears within two to three weeks after the first exposure. Mild chloracne clears up within several months after cessation of exposure; severe chloracne, on the other hand, has been known to persist for as long as 30 years following the last exposure. Persons most susceptible are those who are prone to development of acne vulgaris. If exposure to TCDD is severe enough, formation of cysts and scarring will occur. If there is no history of chloracne, then the likelihood of a significant exposure to, or adverse health effects from TCDD is remote. Hence, chloracne is the clinical marker of TCDD exposure."

R.D. Kimbrough. Occupational Exposure. In Kimbrough (ed.) Halogenated biphenyls, terphenyls, napthalenes, dibenzodioxins and related products. Elsevier/North-Holland Biomedical Press, 1980. Chapter 9c, pg. 373-397.

"...Most of the persons exposed in industrial settings were exposed to a mixture of chemicals, such as 2,4,5- trichlorophenol, TCDD, 2,4,5-trichlorphenoxyacetic acid, and, in the episode reported by Jirasek et al.(1976), also to pentachlorophenol. It is, therefore, not clear whether all effects were solely caused by TCDD. Only the three laboratory workers studied by Oliver (1975) had exposure to pure TCDD.

Systemic illness is usually reported only in workers with chloracne. However, Jirasek et al. (1976) cite 4 workers with systemic illness without chloracne. From the other published reports, it is not clear whether all exposed workers were examined for systemic illness or whether they were selected on the basis of chloracne which may have led to the perhaps erroneous assumption that in humans, illness caused by TCDD must always be accompanied by chloracne."

J.E. Huff, J.A. Moore, R. Saracci, and L. Tomatis. Long-term hazards of polychlorinated dibenzodioxins and polychlorinated dibenzofurans. Environmental Health Perspectives 36, 221-240, 1980.

"Chloracne, one of the most constant and prominent features of 2,3,7,8-TCDD exposure, has been described as a refractory acne characterized by inclusion cysts, comedones and pustules, with eventual scarring of the skin, more frequently originating on the face and sometimes spreading to other parts of the body. Many patients also have belpharoconjunctivitis and irritation of other mucuous membranes. Sometimes the chloracne is preceded by erythematous and edmatous skin lesions. The latent period between exposure and the appearance of clear signs of chloracne ranges from a few weeks to several months.

An important and unique episode revolves around three scientists who were self-exposed to 2,3,7,8-TCDD (107): one heated trichlorphenol in an alkaline solution, a second heated potassium trichlorphenate, and a third worked in the same laboratory as the second and used a diluted solution of the synthesized dioxin. The first two scientists developed chloracne eight weeks after exposure, whereas the third showed no evidence of the characteristic acneform lesions. Delayed symptoms, probably due to 2,3,7,8-TCDD, developed approximately two years later, and the second two scientists showed personality changes (mainly loss of energy and drive); impairment of vision, taste, and muscular coordination; sleep disturbances; gastrointestinal symptoms; and hirsutism. The first of the three experienced none of these adverse effects. All three exhibited hypercholesterolemia (300+ mg/100ml).[8]

Note: The study cited by Huff et al. (ref. 107) is by R.M. Oliver: Toxic effects of 2,3,7,8-tetrachlorodibenzo 1,4 dioxin in laboratory workers. British Journal of Industrial Medicine 32, 49-53, 1975.

Chapter 8. Non-Criteria Pollutants A. Dioxins: Risks

Nature of Risks

To assess the risks associated with exposure to any chemical, it is necessary to state the nature of the toxic response to the chemical and the probability of occurrence of the response under a given set of exposure conditions. From clinical experience, the principal short-term (acute) and long-term (chronic) toxic effects of 2,3,7,8-TCDD are chloracne and changes in liver function. From animal studies, the data indicate that exposure to 2,3,7,8-TCDD may increase the risks of neoplasia, but only in certain organs and the likelihood of effect may depend on gender.

The probability of these responses is determined the dose of 2,3,7,8-TCDD and its congeners. From the previous estimates of the amounts of TCDD emitted from resource recovery facilities, it can be categorically stated that the chances of developing acute or chronic toxicity from dioxins are virtually non-existent. From clinical experience and animal studies, it is known that acute and chronic toxic effects have thresholds. The femtogram/kg/day dosage that one might receive from resource recovery facilities are approximately one hundred thousand times below the nanogram/kg/day dosages required for acute and chronic toxicity.

The issue of delayed toxicity (carcinogenic and reproductive effects) is more ambiguous because some scientists believe that there are no threshold doses for delayed toxicity. In practice, the concept of "no threshold" is translated into mathematical extrapolations that assume positive slope to the dose-response relationship as the dose approaches zero. The result is that one can always project a finite risk to a population after exposure to a dose of a chemical shown to have cancer-producing properties in animals. Although the scientific merits of such extrapolations have been debated, the actual magnitude of the risk generated by extrapolation should be examined from a quantitative and qualitative viewpoint.

Management of Risks

The U.S. EPA and the Canadian assessments both show that the annual cancer risks associated with the emissions of dioxins from resource recovery facilities are below one chance in one million (the EPA values of 0-19/million are divided by an expected lifespan of 72 years). (6,7,66). From the regulatory standpoint, a risk of this magnitude can be considered a "de minimis" risk (from the legal maxim 'de minimis non curat lex' or 'the law is not concerned with trifles')(20). Thus, the U.S. EPA has concluded that dioxin emissions from resource recovery facilities do not represent a risk to the public's health (6).

Colmar (17) has suggested that society disregard for the time being any small risk (about 1 in 100,000 per year or less) unless the risk carries no benefit or is easily avoided. From the ethical viewpoint, however, a projected annual risk of one in one million or, for that matter, any risk, should still be considered. Although the risk of one in one million is small and difficult to conceptualize (see examples from (20*) in References), this risk is imposed upon the community and is not accepted voluntarily on an individual basis. What this risk implies is that if one million individuals lived at the point of maximum ground level air pollution and breathed the air 24 hours a day for their entire lifespan, annually one person may die of cancer. Although 999,999 individuals are not affected, for the one unfortunate victim, the results are catastrophic. Several considerations, however, mitigate the ethical dilemmas of making decisions on events of such low probability.

Limitations of Extrapolation

It should be recognized that a finite probability of risk, 0-19/million, is obtained for dioxin emissions because the linear "no threshold" model is used for the assessment of very low doses (7). This type of extrapolation methodology will predict a finite risk for any exposure, no matter how small (1,21). Simply stated, the arithmetic for a 0.0001% risk (one in one million) can be approximated by taking the 2,3,7,8-TCDD dose that produced a 36% tumor incidence (0.01 ug/kg/day) and multiplying:

$$.0001\%/36\% \times .01 \text{ ug/kg/day}$$

to obtain a "safe" dose of .028 pg/kg/day. This value is similar to that obtained by the Canadian and the EPA authorities.

The value and precision of such extrapolation methods have been questioned. For example, Richard Peto of Oxford University had these comments (84):

"In all of this extrapolation down to low doses there is a feeling of complete unreality...I think that it's the wrong way to use animal data...These extrapolation techniques are just absurd...This desire to go to human risk (directly from animal data) is just not scientifically respectable, and it never will be."

The dangers of excessive extrapolation is also pointed out by A. Goldstein's reference to Mark Twain's comment in "Life on the Mississippi" (40a):

> "In the space of one hundred and seventy-six years the Lower Mississippi has shortened itself two hundred and forty-two miles. This is an average of a trifle over one mile and a third per year. Therefore, any calm person, who is not blind or idiotic, can see that in the Old Oolitic Silurian Period, just a million years ago next November, the Lower Mississippi River was upward of one million three hundred thousand miles long, and stuck out over the Gulf of Mexico like a fishing-rod. And by the same token any person can see that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three quarters long, and Cairo and New Orleans will have joined their streets together and be plodding comfortably along under a single mayor and mutual board of aldermen. There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact."

Acceptance of Risk

It should be emphasized that scientific investigations, no matter how extensive, cannot make guarantees or predictions of absolute (100%) safety, that is, of zero risk. To justify decisions on small risks, it is necessary to address the issue of benefits. The societal benefits of resource recovery facilities are apparent and can be balanced against the hazards of landfills and the dangers of extra transportation of wastes to distant sites. Acceptance of resource recovery facilities, on a long-term basis, depends upon community appreciation of the merits and benefits of such facilities.

Chapter 9. Non-Criteria Pollutants. B. Metals

Introduction

From a toxicologist's viewpoint, a metal is an element which, in a biological milieu, reacts by losing one more electrons to form a cation (37). The colloquial term "heavy metals" refer to metals that have densities greater than 5 grams per cubic centimeter. Analytical techniques have evolved so that many heavy metals can be detected in environmental samples at microgram or nanogram levels. Metallic substances are present in municipal refuse. When the refuse is burnt, some portion of the metals can form oxides or salts that will be emitted into the atmosphere. The amounts of metals emitted from resource recovery facilities have been estimated in a review of the literature by A.D. Little (56) and by Battelle (78). Average values from the A.D. Little report, based on a particulate emission level of 1 lb/ton of refuse, are shown in Table 9a.

The specific values represent a range of samples from different facilities. Conditions of combustion, air pollution control equipment, sources of refuse, methods of sample collection and analysis vary widely for these studies; thus, average values are estimated. In this section, the relative risks from such emissions are evaluated for the following model:

a. A 1200 ton/day facility: to estimate emission factors, the values in the table are multiplied by 1200 ton/day x 454 gm/lb x 1 day/24 hr x 1 hr/60 min x 1 min/60 sec = gm/sec

b. The source strength, gm/sec, is multiplied by a dispersion factor of 0.5 to convert the source strength number to ug/m3 of chemical at ground level. The dispersion factor of 0.5 is chosen for the estimation of annual average ground concentrations and does not apply to maximal short-term averages. This dispersion factor is an arbitrary number selected for the purposes of discussion. The actual factor would depend on wind speed, effective height of dispersion, and terrain, as described in Chapter 3.

The ground level concentrations of metals predicted for resource recovery facilities are too small to have acute toxic effects. Computer model predictions of 8 hr or 24 hr maximum ground concentration levels are, therefore, not meaningful. The impact, if any, of metals in air would be longterm contribution of metals to total body "burden". The number to evaluate should therefore be annual averages, or 3-month averages, if the metal levels in air show seasonal variations.

Basis for Comparison

It can be seen that the projected ground concentrations of most metals are quite small with most levels below 0.1 ug/m3. The potential biological significance to health of several metals can be dismissed immediately. These are: cobalt, chromium, copper, selenium and zinc. These elements are normally present in tissue at levels that would not be affected by additional intake from air at these concentrations. Moreover, these elements are considered to be essential for normal tissue functions.

The other elements, antimony, arsenic, beryllium, cadmium, lead, mercury, and nickel, are not normal constituents of cells and each metal has been associated with human toxicity at higher levels. To assess the significance of these metals in air it is necessary to develop a conceptual framework for analysis.

In discussing "safe" levels, it is important to distinguish between "safe" levels as established by experience versus "safe" levels that are desirable from a regulatory point of view. Standards based on experience are supported by evidence. On the other hand, regulatory standards for environmental exposure may reflect the application of public policy to standards.

In the table below, we have used the Threshold Limit Value divided by 30 to represent the minimal "safe" level for environmental exposures. Threshold limit values are acquired from human experience. The TLV is a time-weighted average air concentration "which is believed that nearly all workers may be repeatedly exposed to day after day without adverse effects" (2). The TLV is divided by 30 to allow for 24 hour exposures instead of a workplace exposure of 8 hours, and a factor of 10 is allowed for individual differences in susceptibility versus the healthy worker. These "safe" levels, the TLV/30, are then compared to the projected levels and the additional safety factors are then computed.

It can be seen from Table 9b that large safety factors, on the order of 1000+, are available for exposures to antimony, arsenic, beryllium, and nickel. In part, these large safety factors occur because the amounts of these metals in refuse are small and do not contribute much to air concentrations. Because the safety factors for antimony, beryllium, and nickel exceed 1000, one need not further consider their potential hazard. The metals, cadmium, lead and mercury have safety factors that are less than 1000 and are discussed below. Arsenic is also discussed because recommendations for lowering its TLV have appeared (104).

Table 9a. Emission Factors for Trace Metals.

Metal	Factor* 10-6 lb/ton	Strength+ gm/sec	Air Conc.# ug/m3
antimony	4000	0.025	0.012
arsenic	530	0.003	0.001
beryllium	13	0.00008	0.00004
cadmium	2000	0.013	0.006
cobalt	26	0.0002	0.0001
chromium	600	0.004	0.002
copper	1700	0.011	0.005
lead	180000	1.13	0.56
mercury	9600	0.060	0.030
nickel	200	0.001	0.0005
selenium	42	0.0003	0.0001
zinc	135000	0.85	0.42

* from review by A.D. Little (56)

\+ conversion based on 1200 tons/day

\# dispersion factor 5 x 10-6

Table 9b. Safety Factors for Metal Exposure Relative to TLV.

Metal	TLV* ng/m3	TLV/30+ ng/m3	Projected# ng/m3	Factor@
antimony	500000	16667	12	1389
arsenic	200000	6667	1	6667
beryllium	2000	67	.04	1675
cadmium	50000	1667	6	278
lead	150000	5000	569	9
mercury	50000	1667	30	56
nickel	100000	3333	.05	6666

* Threshold Limit Value (2), workplace standard based on 8 hour day, and healthy workers "which is believed that nearly all workers may be repeatedly exposed to day after day without adverse effects".

+ TLV divided by 30, a 3-fold factor for 24 hr exposure instead of 8 hr, and a 10-fold factor for individual differences in susceptibility relative to the healthy worker.

projected ground level air concentrations from Table 9a.

@ TLV/30 divided by projected ground level air concentrations.

Arsenic

The principal sources of arsenic in air are from the combustion of coal, from the smelting of metals, and the burning of vegetation or containers contaminated with arsenic. These sources of arsenic should be relatively insignificant for facilities that burn municipal refuse. Arsenic enters the air after combustion and therefore exists an oxide. One would expect the arsenic to be removed from the air as the oxide dust settles or is washed out by rain.

Observed arsenic concentrations in the urban air have been in the 20 ng/m3 range (37,104). Non-urban areas usually have values less than 10 ng/m3. The highest value in the U.S., reported in a 1964 survey, was a quarterly average of 1400 ng/m3 in El Paso, Texas, where a large copper smelter was located. The projected concentrations of airborne arsenic for a resource recovery facility is 1 ng/m3.

Human exposures to large amounts of arsenic in an occupational setting, or in contaminated drinking water, have been associated with the development of skin and lung cancer. The current threshold limit value for arsenic is 200,000 ng/m3. Periodically, recommendations to revise the TLV to lower levels, for example, down to 0.05 mg/m3 or even 0.005 mg/m3 (5000 ng/m3), have appeared as the longterm toxic effects of arsenic have become recognized (104). These new recommended levels are still relatively high compared to the projected concentration of 1 ng/m3 from resource recovery facilities.

It should be recognized that the principal source of human intake of arsenic is from the diet. Seafood, in particular, is rich in arsenic. An average total dietary intake of soluble (bioavailable) arsenic of 0.19 mg/day has been estimated (37,60). It would take an individual, breathing 1 ng/m3, at least 26 years to acquire the average daily dose of 0.19 mg of arsenic (190,000 ng/20 ng/day x 1 year/365 day).

Cadmium

It has been projected that resource recovery facilities may contribute 3.6 ng/m3 of cadmium to urban air (41). Here we use a figure of 6 ng/m3 for the purposes of discussion. Yearly surveys of cadmium of air in the U.S. show values ranging from 6 ng/m3 (San Francisco) to 36 ng/m3 (St. Louis), with average values for the 20 most populated cities at 10 ng/m3 and non-urban values at less than 3 ng/m3 . The highest annual value, 120 ng/m3, was measured in 1964 in El Paso, Texas, site of a smelter, as described previously (37,38). A person breathing 6 ng/m3 for 24 hr would acquire a dose of 120 ng (20 m3/day).

The principal source of cadmium is from the diet (38,60). Available data indicate that, on an average, 50,000 ng of cadmium is ingested per day in most countries, with a probable variation of 25,000 to 75,000 ng/day. An average absorption of about 6% is estimated, leading to an assimilated daily dose of 3000 ng. If we assume 40% retention of inhaled airborne cadmium, a dose of 120 ng will be 1.6% (120/3000 x .4 x 100) of the absorbed dietary dose. Cigarette smoke is a large source of cadmium intake in man. The cadmium dose from a single pack of cigarettes is approximately 2000 ng. From the viewpoint of human experience, the TLV/30 for cadmium is 1,667 ng/day.

The earliest sign of excessive cadmium exposure in man is the appearance of proteins in the urine. This sign of exposure is not accompanied, in its initial phase, by functional deficits or clinical complaints. In later stages of industrial poisonings, however, kidney function is impaired. Ingestion of large quantities of cadmium can also lead to disorders of bone metabolism.

Lead

Lead is an ubiquitous element and one that has been most thoroughly studied from the viewpoint of human health (71,90a,104). It has been estimated that resource recovery facilities may contribute 210 ng/m3 of lead into ambient air (41). We project here a level of 560 ng/m3 for the purposes of discussion. Lower levels are emitted if particulate emissions are subjected to greater control technology. For example, a 9% by weight value of total suspended particles has been used to estimate lead emissions, leading to a value of 0.17 lb/ton (1.9 lb TSP/ton refuse x 0.09) (32).

Average lead levels in different environments are: rural air, 0.1 ug/m3, suburban air, 0.5 ug/m3, urban air, 1.0 ug/m3, and areas of traffic 2.5 to 25 ug/m3. The average absorbed lead from dietary/beverage sources is estimated to be 30 ug/day (60,90a). Generally, 40% of inhaled lead is assumed to be retained. An air concentration of 0.56 ug from resource recovery facilities would be equivalent to less than 1% of the dietary dose (0.56 x .4 x 1/30 x 100).

A comprehensive survey of lead in the environment has recently been published (90a). In the U.S., vehicles manufactured after 1974 no longer use gasoline with lead additives. Thus, a primary source of lead in air has been eliminated. In Europe, leaded gasoline is still used. The significance of ambient airborne lead to blood levels of lead and adverse effects in man is still unclear. Ingestion of paint chips containing lead pigments has produced brain damage in children and this source of exposure continues to be the main problem in the control of lead toxicity.

Mercury

Elemental mercury (quicksilver) has a high vapor pressure, thus burning refuse containing elemental mercury will result in mercury emissions. The principal source of mercury in air is evaporation of mercury from mercury- containing ores, for example, from mines, and from industries that use mercury (39). The use of phenylmercuric acetate as an anti-mildew agent in paper products and paints has been curtailed, but one would expect residual phenylmercuric acetate and, perhaps, mercury from electrical appliances to be a source of mercury in the combustion products of municipal refuse.

A ground level concentration of 30 ng/m3 of mercury is projected. This number may be a high estimate of literature values (26,31,54). Reliable data for urban versus non-urban concentrations are not available but scattered analyses indicated that non- mineralized land have air concentrations of 3-9 ng/m3, mineralized land have concentrations of 7-53 ng/m3 and the air over mercury mines have 24-108 ng/m3 (39). In Northern California, mercury mines are the principal sources of mercury in air. In a survey of the offices of dentists, where mercury is used as an amalgam for fillings, average values of 25,000 ng/m3 have been obtained (11,48).

Typical levels of inorganic mercury levels in the diet have seldom been surveyed in detail or quantified (60). The allowable amounts of mercury in fish, as set by the Food and Drug Administration, is 0.5 mg/kg, and is set for the control of methylmercury, an organomercurial compound which is more toxic than elemental mercury. Methylmercury occurs in significant quantities in fish such as tuna. A typical tuna sandwich, for example, containing 3 ounces of tuna could contain up to 43 ug of mercury (3 oz x 1 lb/16 oz x 454 gm/lb x 0.5 ug/gm). The order of toxicity of mercury compounds is methylmercury greater than elemental mercury greater than inorganic mercurial salts. For resource recovery facilities, mercury would be emitted as elemental mercury in the vapor phase or as inorganic mercury salts bound to particles.

Exposure to 30 ng/m3 for 24 hr would result in a dose of 0.6 ug. From the previous discussion, it can be seen that this exposure level is small compared to a visit to a dentist's office or consumption of a tuna sandwich.

Summary

Small amounts of metals are present in refuse. When the refuse is burnt some of these metals are emitted into the air. When the exposure doses attributable to these emissions are compared to threshold doses for adverse effects, it is clear that large margins of safety exist so that metal emissions from resource recovery facilities will not endanger the public's health. For most metals, the safety factors exceed one thousand. For arsenic, cadmium, lead and mercury, it is shown here that the projected exposure doses are less than 2% of the average absorbed daily doses from other sources.

Chapter 10. Non-Criteria Pollutants. C. Other Chemicals

Introduction

In this section, we discuss the chemicals hydrogen chloride, hydrogen fluoride, and polynuclear aromatic hydrocarbons. These substances may be formed and/or emitted from resource recovery facilities.

Hydrogen Chloride

Hydrogen chloride is a gas which readily reacts with water to form hydrochloric acid. It is formed in the combustion of refuse, the principal sources of chlorine being plastics containing polyvinylchloride (PVC) and sodium chloride. The average chlorine content of municipal refuse is estimated to be 0.25% by weight (3,68). Complete conversion to hydrogen chloride gas leads to an emission factor of 5 lb/ton (0.25 x 2000 x 1/100).

Hydrogen chloride, because of its rapid water solubility in the body, is not associated with chronic or delayed toxic effects (68). The only example of chronic toxicity noted in the literature is the dissolution of enamel from the incisors of workers exposed to high concentrations of hydrogen chloride (98). Therefore, in the assessment of dose for potential adverse health effects, projected annual average ground level concentrations are not applicable. The relevant measurements are the maximal short-term excursions in ground level concentrations of hydrogen chloride. Projections of these short-term ambient air levels are very much determined by local conditions and thus cannot be generalized by use of a single dispersion factor. Here we briefly consider data on the threshold doses of hydrogen chloride for producing biological response.

The literature on hydrogen chloride in air has been thoroughly reviewed (31,68). At low concentrations of hydrogen chloride, the first effect is detection of its presence in air by olfaction. Higher concentrations lead to irritation of the mucous membranes of the eyelids and upper respiratory tract (for example, stinging sensations on the eyelids and a "scratchy" throat). Concentrations above 5-10 ppm cause subjective discomfort. In the industrial environment, the irritant properties of hydrogen chloride provide the exposed individual with good warning signs to avoid exposure to higher concentrations. The dose-response relationships are shown in the table 10a.

Table 10a. Subjective Responses to Hydrogen Chloride (68).

Response	Average (ppm)*	Range (ppm)*
none	0.40	0.06-1.80
minimal	0.70	0.07-2.17
easily noticed	4.17	1.9-8.6
strong	13.37	5.6-22.1

* 1 ppm = 1.49 mg/m3

Table 10b. Emission Factors for Polynuclear Aromatic Hydrocarbons (PAH)

Species	Emissions (10-6 lb/ton)
total PAH	500
pyrene	12.0
perylene	1.5
indeno(1,2,3cd)pyrene*	1.5
fluoranthene	10.0
coronene	1.6
benzo(a)pyrene*/benzo(e)pyrene	1.5
benzo(ghi)perylene	3.2
benzo(b)fluoranthene*	2.8
benzo(a)anthracene*	6.2

* produce tumors in animal bioassays, from (56).

Hydrogen Fluoride

Hydrogen fluoride, like hydrogen chloride, may be produced in resource recovery facilities because of combustion of refuse containing fluorine. For an uncontrolled source, the estimated output is 0.06 to 0.10 lb/ton of refuse (56,78). An alternative number to use is to consider the hydrogen fluoride emission rate as approximately 1% of the hydrogen chloride level. At these emission levels, the acidic properties of hydrogen fluoride do not reach threshold concentrations for short-term irritant effects (2,69). Thus, only the longterm contribution of emitted fluoride ion to body intake of fluorides should be considered.

In we use an uncontrolled emission factor of 0.1 lb/day and a dispersion factor of 0.5 to convert gm/sec to ug/m3, a plant processing 1200 ton/day would produce an annual ground level concentration of 0.3 ug/m3 (0.1 lb/ton x 1200 ton/day x 454 gm/lb x 1 day/24 hr x 1 hr/60 min x 1 min/60 sec x .5). At an inhaled volume of 20 m3/day and 100% retention, the daily dose is 6 ug. This dose should be compared to the average dose of 200 ug from food and a dose of 1000 ug from the drinking water (69). The 6 ug dose is 0.5% of the average daily intake. An airborne concentration of 1000 to 2500 ug/m3 is considered to be acceptable for occupational exposure (8-hr exposure per day) (2). Thus, a large safety margin, on the order of 100+, exists for possible fluoride exposure from resource recovery facilities.

The most sensitive sign in man for excessive exposure to fluorides is the mottling of dental enamel. In the early stages of exposure, this effect is manifested by specks of increased bone density in teeth which can be detected by careful dental examination. Plants are quite sensitive to the toxic effects of atmospheric fluorides. The threshold for leaf damage in plants such as citrus and pine (foliar necorsis) and for accumulation in forage of grazing animals is considered to be 0.33 to 1.3 ug/m3 (30-day average concentration) (69).

It can be stated with confidence that hydrogen fluoride gas, emitted at projected levels from resource recovery facilities, will not affect the public's health.

Polynuclear Aromatic Hydrocarbons (PAH)

Polynuclear aromatic hydrocarbons (PAH) are products of any combustion processes involving fossil fuels or compounds containing carbon and hydrogen. Generally, attention on these compounds have focused on their emissions from and formation in coke oven fumes and tars, in vehicular emissions, in cooked foods, in cigarette smoke, and in emissions from stationary sources.

A review in 1972 stated that large muncipal incinerators (50-250 tons/day) had benzo(a)pyrene emission factors of 0.44 to 26.4 x 10-6 lb/ton of refuse (74). A.D. Little (56)projected an average value of 1.5

x 10-6 lb/ton for benzo(a)pyrene/benzo(e)pyrene. The data obtained from the literature by A.D. Little is shown in Table 10b.

If we sum the emission factors for the carcinogenic PAH compounds, a total of 12 x 10-6 lb/ton is obtained. To estimate an annual ground level concentration for a 1200 ton/day plant and a dispersion factor of 0.5, an value of 38 pg/m3 is derived (12 x 10-6 lb/ton x 1200 ton/day x 454 gm/lb x 1 day/24 hr x 1 hr/60 min x 1 min/60 sec x .5). No TLV have been established specifically for PAH exposures, although indirect standards have been set in the form of benzene soluble organics for coke-oven workers (2). Thus, we do not have an established TLV for assessing the significance of exposures to 38 pg/m3.

Exposure to PAH, however, is a commonplace event. Benzo(a)pyrene is used as a standard index of PAH levels in environmental samples. In over 1000 U.S. sampling sites, Sawicki (93) found benzo(a)pyrene concentration in air was log-normally distributed with urban sites having a median winter-spring value of 6600 pg/m3. A similar distribution for non-urban sites gave a median value of 400 pg/m3. Seasonal variations occur because of the use of coal and oil for heating. Also, local industries may influence air concentrations. Daily concentrations reported in the Los Angeles area ranged from 100 pg/m3 to 10,000 pg/m3. Higher levels, approximately 7 times that of Los Angeles, were measured in Birmingham, Alabama, where industries using coal are located (74).

Another source of non-industrial airborne PAH is tobacco smoke. In a medium-sized room (40m3), three smokers can pollute the air with 2,000,000 to 4,000,000 pg of benzo(a)pyrene. Very high concentrations of benzo(a)pyrene, ranging from 28,000 to 144,000 pg/m3, have been measured in European beer halls (74). Compared to these sources of PAH, the projected level of 38 pg/m3 from resource recovery facilities is relatively small.

Ingestion of PAH is also a source of human intake. Benzo(a)pyrene is found in smoked foods; a maximal level of 25,000,000 pg/lb was measured in a charcoal- broiled T-bone steak (55). In Iceland, excessive consumption of smoked meats is associated with stomach cancer and pancreatic disorders (27,44) and it has been postulated that the effects were due to PAH or nitrosamines, but, so far, human toxicity has not been directly associated with the consumption of PAH in smoked meats in the United States.

Chapter 11. Conclusions

"All things are poisons, for there is nothing without poisonous qualities. It is only the dose which makes a thing a poison." Paracelsus (1493-1541).

"There is no such thing as absolute certainty, but there is assurance sufficient for the purposes of human life." John Stuart Mill (1806-1873).

The construction of resource recovery facilities has been proposed for a number of sites in the United States. Concern, however, has been expressed about the potential effects of pollutants emitted from such facilities on the public's health. Specifically, the lay person would want to know the answer to this question: "Will certain chemicals, emitted from such facilities, make anyone sick, either on a short-term basis or on a long-term basis?" Examples of short- term illnesses might be headaches, difficulty in breathing and respiratory infections. Examples of long-term illnesses may be liver damage or a frightening disease such as cancer.

The standard scientific approach to answering questions of this type is to estimate how much of a chemical is emitted from the facility. From this value, an estimate is made of how much of the chemical might be breathed in at ground level. The amount that is breathed in is then compared to the amount of chemical that is known to cause illness. If the dose that is breathed in is extremely small relative to the dose that is toxic, then the conclusion is made that the risk is correspondingly small.

Using this standard logical framework, the available data were analyzed and the following conclusions can be made: It can be stated, without hesitation, that projected emissions from resource recovery facilities will not produce short-term illnesses. The chances for long-term illnesses are very improbable and virtually non-existent. The reasons for these conclusions are based on the projected amounts of chemicals at ground level. These amounts are extremely small relative to the doses that are toxic. In the review of the literature, a judgment on the side of safety can be reached because:

A. For the criteria pollutants, the emitted amounts plus the background levels would not exceed the National Ambient Air Quality Standards. For nitrogen oxides, sulfur oxides, and carbon monoxide, these facts seem well-established and, in any event, these criteria pollutants will be monitored by regulatory agencies.

B. For the non-criteria pollutants, such as the metals, inorganic fluorides, and polynuclear aromatic hydrocarbons, the dosages that might be contributed from a resource recovery facility are estimated to be less than 2% of the normal average daily intake from other sources, and in most cases are substantially less than 2%. Such small contributions from a resource recovery facility to normal daily intake are not likely to produce adverse effects.

C. For dioxins, a more thorough review was conducted because these chemicals are toxic at small doses and because dioxins have been associated with emissions from resource recovery facilities. The U.S. Environmental Protection Agency and the American Society of Mechanical Engineers have both recently reviewed the issue of public health safety and dioxins and came to the conclusion that dioxin emissions from resource recovery facilities do not represent health hazards to the population in the vicinity of such facilities. Again, the reasons for this conclusion are based on the fact that the amount of dioxins that may be emitted is too small to affect human health.

In a discussion of dioxins, it should be recognized that the numbers under consideration are minute. A teaspoonful of water weighs about 5 grams. Dioxins are emitted and quantified in the picogram range (see table).

1 gram	1.0 gm
1 milligram	0.001 gm
1 microgram	0.000001 gm
1 nanogram	0.000000001 gm
1 picogram	0.000000000001 gm
1 femtogram	0.000000000000001 gm

2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) is one potent dioxin isomer which has been carefully studied. The "no observable effect level (NOEL)" of 2,3,7,8-TCDD in animals is 1 nanogram/kg body weight/day. At present, there is no evidence that exposure of man to the NOEL of 2,3,7,8-TCDD will produce toxicity. The fraction of the NOEL which is considered to be acceptable for human exposure varies for different regulatory agencies. The projected dose from resource recovery facilites can be compared to the accepted "safe" dose (see table and Chapt.7).

In the future, decisions on dioxins and public health safety will be facilitated if attention and consensus can be focused on the choice of safety factors to be applied to the NOEL.

Acceptable Dose	Fraction of NOEL
Netherlands	1 / 250
Canada	1 / 16,667
U.S.A. (E.P.A.)	1 / 38,461
projected dose	1 / 90,909

Conclusion

The purpose of a scientific review and analysis is to give an estimate of the magnitude of risk within the context of the available data. Science has its limitations in that it cannot give absolute guarantees of safety. The risks are never zero and it would be incorrect to state that any assurance of safety can be equal to 100%. It seems reasonable, however, to conclude that one can be 99.9% assured that no illnesses will result from the emissions of resource recovery facilities. Resource recovery facilities should not be viewed in an isolated context, but should be considered as an advanced form of technological alternative to land-fills. Whether small risks from such facilities are acceptable will ultimately depend on society's judgment on the benefits of resource recovery.

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Situations Involving a One-in-a-Million Risk of Death

Activity	Cause of Death
travelling 1000 miles by jet	accident
travelling 60 miles by car	accident
rock climbing for 1.5 min	accident
smoker consuming 2 cigarettes	cancer, heart disease
20 min being a man aged 60	mortality from all causes

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"The United States annually generates more than 135 million tons of municipal solid waste (MSW). Its disposal is a rapidly growing problem for many areas of the country where such traditional methods as open dumping, landfill, uncontrolled incineration, and ocean burial are too expensive or environmentally unacceptable. At the same time, MSW contains over two-thirds of the national consumption of paper and glass, over one-fifth of the aluminum, and nearly one-eight of the iron and steel. If burned, the combustible portion of MSW would be equivalent to about 1.9 percent of the Nation's annual energy use.

Resource recovery and recycling materials and energy from MSW can play significant roles in helping to solve waste generation and disposal problems. In addition, resource recovery, recycling, and reuse can contribute to the wise and efficient use of materials, to conserving materials and energy, to preserving the environment, and to improving the balance of trade by reducing our dependence on imported natural resources." J.H. Gibbons, Director of the Office of Technology Assessment, Congress of the United States (79).

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CHEMICAL & ENGINEERING

NEWS

DIOXIN

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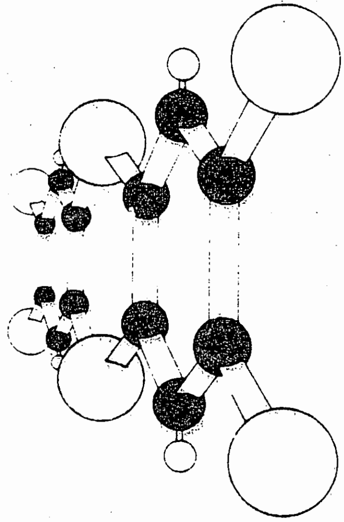
News of the Week

- **Dow Chemical will spend almost $3 million to study health effects of dioxin in the Midland area.** Page 8
- **White House announces final plan to abolish Commerce Department and set up trade department.** Page 9
- **Economic progress does not lead to adverse effects on the environment, says vice president George Bush.** Page 9
- **Monsanto soon will withdraw completely from synthetic fiber production in Europe.** Page 9



DIOXIN REPORT

2,3,7,8-Tetrachlorodibenzo-*p*-dioxin, though found in minute quantities, has made a giant impact as a potential hazard. Page 20

History

Three different types of exposure to dioxin—agent orange in Vietnam; Times Beach, Mo.; and Michigan river fish—led to the present concern over its effects on humans. Page 23

Toxicity

Studies of the contaminant have proved its toxicity to some but not all animals; its long-term effects on humans are unknown. Page 37

Origin

A by-product of commercial processes to produce chlorinated organics, dioxins are difficult to dispose of. Page 51

Litigation

Lacking a precedent, dioxin producers and the insurance industry are struggling for answers in their concern over the multiple lawsuits pending, particularly by Vietnam war veterans. Page 57

European scene

The 1976 accident in Seveso, Italy, that exposed a town to dioxin contamination was only the beginning of a continentwide scandal over disposal of the toxic wastes generated. Page 61

The dioxin phenomenon

This issue of *Chemical & Engineering News* is unique. It is devoted to one chemical: 2,3,7,8-tetrachlorodibenzo-*p*-dioxin—commonly, if imprecisely, known as dioxin. More specifically, this issue is devoted to what can best be described as the dioxin phenomenon—a brew of uncertain science, unanswered and sometimes unanswerable health questions, regulatory dilemmas, intensive press coverage, and legal maneuverings that has bubbled over to besmirch the chemical industry and leave the public confused and scared.

This phenomenon is by no means trivial to those in the chemical community, as it extends beyond dioxin itself. It involves the credibility of the chemical industry and of the entire regulatory process. It crystallizes the issue of how industrial workers and the public should be protected from any man-made chemical that may be—but possibly isn't—a health hazard and, very critically, how to do it rationally.

Dioxin, by its nature, exacerbates many of the problems. It is not a product but a trace contaminant in other products. The largest of these is 2,4,5-trichlorophenoxyacetic acid, a herbicide widely used at one time in this country and also a component of agent orange, the defoliant used by the U.S. military in Vietnam. Another complication is some sophisticated, although controversial, scientific work by Dow Chemical that indicates dioxin can be formed in minute amounts when anything containing carbon, hydrogen, oxygen, and chlorine is burned.

Another difficulty with dioxin is its peculiar toxicity. It is incredibly lethal to guinea pigs, for instance. By the way toxicologists measure such things, it is about 10 times as efficient at killing guinea pigs as nerve gas apparently is at killing humans. Dioxin is orders of magnitude less lethal to many other test animals but, under certain circumstances, it can cause cancer in mice and rats.

It is certainly fair to say that dioxin is far less toxic to humans than the public has been led to believe. No deaths have been attributed to dioxin exposure. The proven impact on those exposed to relatively high amounts through industrial accidents has been limited largely to chloracne, a serious skin lesion. There are no hard data that it causes cancer, birth defects, or reproductive difficulties in humans. But uncertainties still remain about irreversible, long-term effects—uncertainties the government is trying to resolve with a wide variety of epidemiological studies that will cost more than $100 million. The Vietnamese relate an increase in birth defects to agent orange.

The chemical industry—like it or not—is in the middle of all the uncertainties and will have to live with them. As Paul Oreffice, president of Dow said at a press conference last week, "Sometimes we have been asked questions for which there are no answers. For this we have been accused of equivocation or talking out of both sides of our mouth. When we respond unequivocally, we are accused of arrogance, or self-righteousness." He may well have a point.

The public is extraordinarily sensitive to any risks to which it is exposed involuntarily and unnecessarily. So even if the case against dioxin as a major health hazard is very thin, the chemical industry and the regulatory community are still walking on eggs on the dioxin issue. The best advice to those walking on eggs is: Don't hop. Perhaps there has been too much hopping in the past. Maybe Oreffice's announcement last week of some new scientific initiatives by Dow to address public concerns about dioxin is indicative of a more surefooted approach to resolution of the dioxin phenomenon.

Michael Heylin
Editor

DOW'S DIOXIN PROGRAM: New studies to reassure the public

Faced with increasing, unwanted notoriety, Dow Chemical last week announced it will spend nearly $3 million on new studies of the environmental and health effects of dioxin in and around its Midland, Mich., chemical production complex. For the first time, surveys either will be conducted jointly with government agencies or will be audited by independent scientific organizations.

At a press conference held at corporate headquarters in Midland, Paul F. Oreffice, Dow president and chief executive officer, said he does not expect new data to challenge the company's judgment that the low levels of dioxin likely to be encountered in the workplace or the environment pose no threat to human health.

He added, however, that the public deserves to be reassured about dioxin, and that independent corroboration of Dow's findings is the way to do it.

In a major concession to its critics, Dow is proposing a joint, cooperative soil study with federal and state government agencies. The study would examine dioxin levels in soil taken from inside Dow's Midland facility, from the town of Midland, and from several other U.S. cities to be selected jointly by the participants. To guarantee objectivity, samples would be coded and divided among the participants for independent analysis. Results would be announced jointly.

This latest move by Dow marks another step back from intransigency. The company had balked at an April request from the Environmental Protection Agency for data on the composition of the wastewater flowing out of its Midland plant on the grounds that such information would be useful to competitors and that the Clean Water Act did not require such disclosures. Early last month, however, Dow bowed to pressure and began submitting the information.

Oreffice: data from new studies are not expected to challenge Dow's judgment that low levels of dioxin pose no threat to human health

"Opening up our plant to this kind of sampling is very unusual for any industry," Oreffice commented, "and I think it should give you some idea of just how serious we are about this effort."

Dow has budgeted $250,000 for the survey, which is expected to take about six months to complete. Michigan's attorney general will coordinate the study, according to David T. Buzzelli, chairman of Dow's environmental affairs action team.

Dow also announced it will accelerate its own point-source search for dioxins inside the Midland complex. Outside auditors, to be named later, will monitor the investigation after signing a secrecy agreement covering Dow trade secrets. Results will be shared with both EPA and the Michigan Department of Natural Resources.

Dow will spend $1 million on the survey, which, Buzzelli said, will take from four months to a year to carry out.

Also, Dow will give $250,000 to the Michigan Department of Public Health to help it continue its research into the possibility of a link between dioxin and soft-tissue cancer mortality among white women in Midland County. The rate of such cancers there is higher than the national average, but the company insists that no such link exists. New research is expected to take 18 months.

Further, Dow is giving $250,000 to the University of Michigan to fund research aimed at developing technology that would reduce dioxins in Dow's effluent stream below the low part-per-quadrillion levels now detected. Interim results are expected in somewhat more than 18 months.

Dow also is spending $750,000 to expand its dioxin analysis capabilities over the next few months. The company will add scientists to the staff already studying dioxins.

Furthermore, Dow has asked an unnamed "prestigious and national scientific organization" to study the health impact of dioxins with Dow financial support. "We want an independent organization to review what's available in the literature to address the question, 'Do trace levels of dioxin in the environment pose a risk to human health?' " says James H. Saunders, Dow director of biomedical research. Dow notes that it will have absolutely no involvement—unless requested—in the scientific evaluation or ultimate judgment of the organization. □

Final plan for trade department unveiled

The White House has announced its final plan for abolishing the Department of Commerce and creating a new Department of International Trade & Industry. The final shape of the new department is quite different from that outlined earlier by Commerce Secretary Malcolm Baldrige (C&EN, May 9, page 5) and is generating a lukewarm, at best, response in Congress, particularly in the House.

The new department would inherit about 20% of Commerce's 35,000 employees, including those working in the offices of economic affairs; the international trade administration, which enforces import and export laws; and the travel and tourism administration. Also folded into the new department would be the Patent & Trademark Office and the National Telecommunications & Information Administration.

Under the proposal, the staff of the Office of the U.S. Trade Representative, which sets trade policy and handles trade negotiations, would have a clear policy-making role, reporting directly to the head of the new department, who also would serve as trade representative.

The remainder of the Commerce Department would be scattered among several government agencies. The National Oceanic & Atmospheric Administration, with about half of Commerce's staff, would become an independent agency. The National Bureau of Standards would become part of the National Science Foundation. The Minority Business Development Agency would go to the Small Business Administration, and the Economic Development Administration to the Department of Housing & Urban Development. No home has been found as yet for the Bureau of the Census. ☐

Economic progress aids environment, Bush says

Business acumen and sound environmental practices are not mutually exclusive, Vice President George Bush told officials attending a paper and forest products meeting in Washington, D.C., last week.

On the contrary, he stressed, "Economic progress produces the very funds and the technology that enable us to care for our environment with ever greater skill."

Then, deviating from his prepared address to members of the American Paper Institute and the National Forest Products Association, Bush said: "I feel that one way to show a humane interest in jobs is to have meaningful changes in the Clean Air Act."

The main thrust of his speech was to laud the economic recovery—which the Reagan Administration takes credit for—and to link that recovery to environmental improvement. "I see no reason why economic progress should have adverse effects on the environment," Bush said. In fact, "As the recovery gathers strength, this Administration will make certain that some of the fruits of that economic progress . . . continue to be devoted to protecting our rich natural heritage."

Already, Bush claimed, the Administration has moved to prevent lead poisoning by reducing the amount of lead in gasoline, and has stemmed water pollution by setting effluent standards for "19 critical industries." On the air front, Bush said he is "delighted" with the Supreme Court's decision to review the "Environmental Protection Agency's sensible 'bubble' policy for controlling new sources of air pollution."

He reiterated the points President Reagan made at William D. Ruckelshaus' swearing-in ceremony as EPA administrator. On one of those points—acid rain—Bush said the Administration is concerned enough about the problem to have "already asked for an increase of 112% in research funds for acid rain. We want to base actions on fact, not on premise." ☐

Bush: delighted at court decision

Monsanto wrapping up European fiber pullout

Within a few weeks, Monsanto likely will have withdrawn completely from the production of synthetic fibers in Europe, completing a plan first announced in March (C&EN, Mar. 14, page 7). Sales of its two acrylic fiber plants to Montefibre, the fibers arm of Italy's Montedison, are expected to be complete by the end of the month. Monsanto quit making nylon 66 fibers in Europe in 1979.

The company retains some involvement in the West European fibers scene, however. It is assuming full ownership of Polyamide Intermediates Ltd. by acquiring Montefibre's 50% stake in that firm. PIL has capacity for making 198 million lb a year each of adiponitrile and hexamethylenediamine at Seal Sands on England's east coast. The bulk of the output is being shipped to meet Monsanto's U.S. needs.

The acrylic fiber plants that Montefibre is purchasing are located at Coleraine, Northern Ireland, and at Lingen, West Germany.

Meanwhile, Montefibre, which already makes acrylic fiber in Italy, is negotiating sale of the Lingen plant to West Germany's Bayer. The deal is dependent on clearance from the West German cartel office. Bayer, Europe's second largest producer after Courtaulds, has its facility at Dormagen, near Cologne, where it can make as much as 264 million lb annually. Western Europe's overall acrylic fiber-making capability is about 2 billion lb per year. ☐

DIOXIN REPORT

A C&EN SPECIAL ISSUE

In the annals of environmental contamination, few if any chemicals have achieved the widespread notoriety of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. Under its simple if scientifically imprecise sobriquet of dioxin, it has acquired a mystique that has moved it into the forefront of hazardous substances.

Much in the news of late, it is seldom mentioned or written about without the additional notation that it is the most toxic chemical made by man. Less often is it mentioned that such a statement is based on test results on a certain species of what is a species-specific substance with widely varying toxicity. Although many health effects studies are under way, scientists have yet to find that any human death has resulted from exposure to dioxin.

Nevertheless, such exposure is the subject of numerous lawsuits. It has moved the U.S. government to buy out an entire town. It has undermined company reputations. It practically has made household names of such geographically diverse designations as Seveso, Times Beach, and Tittabawassee.

Yet dioxin lacks redeeming virtues. Although it is a contaminant of useful products, dioxin itself has no practical applications, no benefits to weigh on the scale against the risks, even if the most dire of the potential human risks have as yet only circumstantial support.

Dioxin is an intriguing substance, from its completely symmetrical structure to its widely variable toxicity. And there isn't very much of the chemical around. The concentrations that drive people and governments to action are cited in parts per million, parts per billion, even parts per quadrillion.

Because of the compound's controversial reputation, and because current events have brought dioxin prominently into the public consciousness, C&EN is devoting this issue of the magazine to an examination of the topic. A scientific and environmental concern, the dioxin problem impinges as well on the political, judicial, philosophical, and psychological spheres. In the following articles, C&EN examines such topics as the current environmental concerns, the status of toxicological and epidemiological studies, where dioxin comes from and how its generation can be controlled, available technology for disposing of existing contamination, the legal ramifications of dioxin exposure, and the current level of concern and status of regulations in Europe.

The object of current scrutiny, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin, is a colorless, crystalline solid at room temperature. It was first synthesized in 1957 by catalytic chlorination of the unsubstituted dibenzo-*p*-dioxin. That synthesis and the recognition of the compound as a contaminant in the herbicide 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) came nearly a decade after the herbicide was registered for use.

2,4,5-T is made from 2,4,5-trichlorophenol (TCP). The production of TCP is a major route for the formation of dioxin and the source of the contaminant in 2,4,5-T.

Early exposures of people to dioxin came about primarily through production or use of dioxin-contaminated herbicides. Such herbicides became widely distributed in the environment because they were effective against broadleaf weeds and undergrowth plants and less toxic to grasses, canes, and established trees. Indeed, 2,4,5-T was one of the components of the defoliants, the best known of which is agent orange, which the U.S. military began using in 1962 in Vietnam. Use of agent orange in Vietnam was halted in 1970. But the repercussions of its use still are being felt in lawsuits, brought by veterans exposed to the defoliant, which currently are being litigated.

Then came Seveso. In 1976, a reactor at a chemical plant near Seveso, Italy, making TCP for use in hexachlorophene, went out of control, spewing its contents, including an estimated several pounds of dioxin, over a densely populated area. The aftermath of that accident has been a saga of missing waste and lawsuits in Europe that are now in the courts.

Last fall, attention focused on Times Beach, Mo., when the government found what it perceived as health-threatening levels of dioxin in the environment there resulting from previous waste disposal activities. Concern intensified in succeeding months with fears that flooding, then taking place, would spread the dioxin contamination to other communities. The climax came in March, when the government announced it would buy out the town. The book on the Times Beach affair is far from closed.

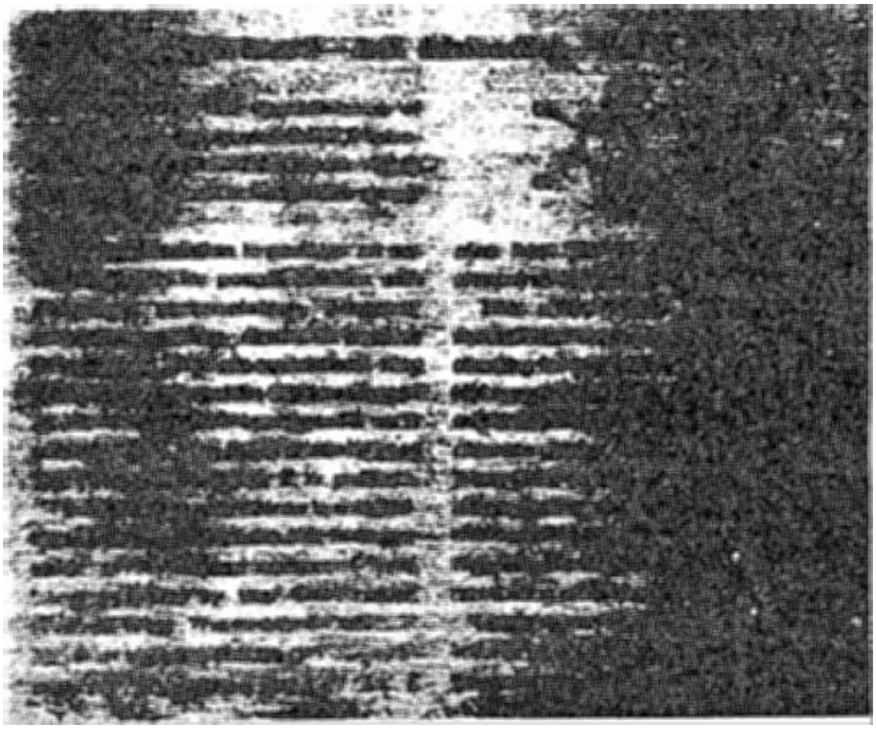
Now another episode has opened in Midland, Mich. The concentrations involved are much lower than those found in Times Beach and most of the attention is focused on dioxin contamination of fish. Unlike the Missouri episode, no one is sure where the dioxin is coming from—although theories have been put forth. In this case, the government's reaction has not been a buyout but a study.

Legal, regulatory, and other actions regarding these incidents, and others, continue. Meanwhile, scientists are continuing studies to determine the health effects of dioxin in humans. That there are nonpermanent, short-term effects is obvious. Evidence for long-term effects, such as cancer, although suggestive, is far from conclusive.

There also are unanswered, and perhaps for now unanswerable, questions about cleanup of dioxin-contaminated wastes. The relatively concentrated wastes likely will not prove to be too much of a problem. Technology for treating them is available and new methods are on the way. But the logistics that would be involved in treating acres of contaminated soil are mind-boggling, to say the least.

Another dimension to the dioxin issue is being added by the court cases now shuffling their way along the litigation route, as well as those that may yet be instituted. The potential outcomes raise major concerns among the companies involved and their insurance underwriters over the matter of liability.

Despite the ad hoc nature of the reactions to the dioxin incidents—not to mention the comic-opera aspect of the Seveso aftermath—the dioxin situation is potentially serious. Despite uncertainties, action must be taken. But as so often seems to be the case with exposures to what may be, but are yet to be proved, hazardous substances, for now there are still more questions than answers. ☐



Dioxin Issue Focuses on Three Major Controversies in U.S.

Furor developing around the question of dioxin exposure has reached a head in three historic cases—agent orange, Times Beach, and Tittabawassee River

Janice R. Long,
David J. Hanson,
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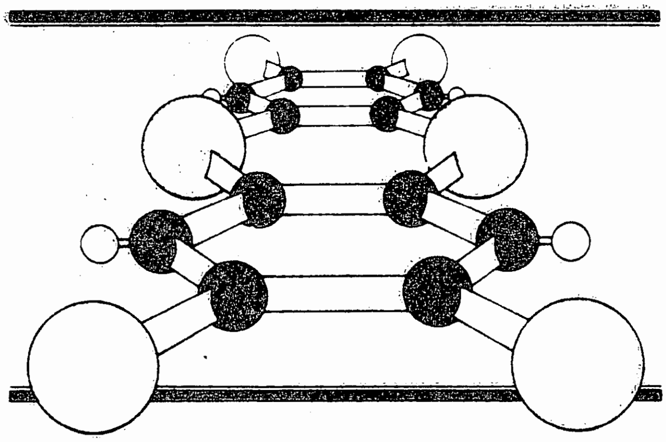


When the history of human problems with exposure to toxic chemicals is discussed in the years to come, one of the principal topics of debate will be the effects of the compound called dioxin. And, in that debate, if it focuses on the U.S., three names will be recalled—agent orange, Times Beach, and the Tittabawassee River.

More than any other incidents, these three widely differing examples of dioxin exposure point out the problems our scientific, regulatory, and legal systems have in handling the undefined hazards of potentially very dangerous substances.

Central to the entire problem is the herbicide 2,4,5-trichlorophenoxyacetic acid (2,4,5-T). Developed during World War II, it was first registered in the U.S. as a pesticide March 2, 1948, and it has been the subject of considerable study ever since.

There were some health problems associated with 2,4,5-T almost from the beginning. In 1949, an industrial accident at a Monsanto plant in Nitro, W.Va., exposed 250 workers to the compound, with a number of resulting illnesses. But it wasn't until about 1955 that the cause of the illnesses, mostly the severe skin rash called chloracne, was found. West German physician Karl Schulz, treating workers from a Boehringer Ingelheim pesticide plant in that year, identified 2,3,7,8-tetrachlorodibenzo-*p*-dioxin as the cause of the chloracne. Schulz's work was published in West Germany in 1957, and appeared in *Chemical Abstracts* in December 1958.

Still, despite this problem, 2,4,5-T was considered a good herbicide and its use spread. It was used extensively on rangeland and pastures to kill unwanted weeds, and also on rice and nursery crops. Because 2,4,5-T is quite biodegradable and works so well, it, as well as other herbicides (particularly 2,4-dichlorophenoxyacetic acid) was considered by the military in the early 1960s as the best means of defoliating large sections of forest in Vietnam to take away cover from the enemy.

Spraying began in Vietnam in January 1962, using a variety of herbicide concoctions. Only small amounts were used at first, but the amounts jumped at the end of 1965 and heavy use continued until 1969, when mounting concerns about damage to Vietnam's ecology led to a tapering off and finally a halt to the spraying of 2,4,5-T in 1970. Of the seven or so herbicide formulations used, the most significant was called agent orange, an oily liquid that was a 50-50 mixture of the *n*-butyl esters of 2,4,5-T and 2,4-D.

However, because the 2,4,5-T was contaminated with dioxin, and because during this time it was discovered that dioxin is frighteningly toxic in some animals, and because an unknown number of U.S. personnel were exposed to the herbicide while in Vietnam, an exceedingly complex problem has arisen.

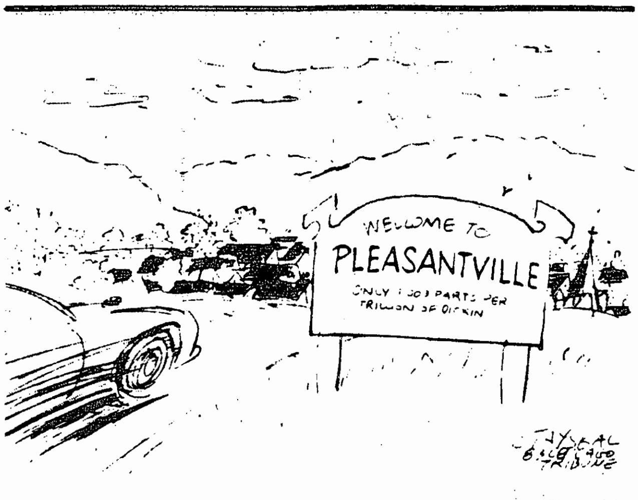
Vietnam veterans, learning from press accounts during the 1970s that dioxin was hazardous and that they might have been exposed, began to ask the Veterans Administration some tough questions. The Chicago VA office really started things moving when a case worker there asked veterans about their possible exposure to agent orange and any subsequent illnesses. She compiled a list of apparently affected veterans that found its way into the hands of a local news producer who made a documentary pointing out the possible connection.

As a result of the fears raised by this and other accounts, VA reports that as of May 1 of this year, 17,068 veterans have put in claims for disability payments because of agent orange exposure, and VA hospitals have treated 369,000 outpatients and hospitalized 9600 veterans who claim their medical problems are related to dioxin exposure. (These numbers also included a relatively small number of veterans seeking help because of radiation exposure during early atomic bomb tests.)

The problem, according to VA, is that it has essentially no evidence that the variety of complaints being described by the veterans had anything to do with exposure to agent orange or its dioxin contaminant. Consequently, VA has balked at offering compensation.

Part of VA's reason for rejecting the agent orange connection is a large amount of data compiled by the Air Force in the early 1970s on the use and fate of the herbicide and its contaminant, dioxin. This work finds, in general, that the herbicide, when sprayed on the top of a forest, quickly was destroyed by sunlight; that very little penetrated through the forest canopy to the ground; and that if it did get into the soil, the dioxin stayed there.

But the growing cries from veterans groups that their problems were caused by agent orange prompted others to act. Seeking some hard information on the potential problems from agent orange exposure, Congress passed a law at the end of 1979 that required VA to do an epidemiology study of Vietnam veterans and to compile a complete bibliography of 2,4,5-T and dioxin health studies. VA also began an agent orange registry, an effort to identify all veterans concerned about exposure to agent orange and find out what health problems they are experiencing. Veterans' records are computerized for future work.



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The biggest problem VA has had is getting the epidemiology study under way. Plans to contract out design of the study to the University of California, Los Angeles, School of Public Health were countered by a lawsuit from the National Veterans Law Center. Lewis Milford of the center says veterans did not believe VA would do an objective job in analyzing the data, because of a prejudice against blaming agent orange. Subsequently, bowing to pressure from the House Veterans Committee Subcommittee on Oversight & Investigations, as well as other Congressmen, VA transferred the whole epidemiology study to the Center for Disease Control.

Still, this did nothing for the growing number of veterans who wanted medical attention for problems they assumed were caused by the herbicide. In 1981, Congress passed the Veterans' Health Care, Training & Small Business Loan Act, which, in part, changed the rules for treatment at VA hospitals so that medical treatment for agent orange claims could be provided. Although this means most veterans who want it can get some medical attention, the question of disability compensation has not been resolved.

For veterans groups, the disability compensation issue is a top priority. According to Milford, there is enough medical evidence of a link between dioxin and cancer to allow VA to make payments. But VA claims the only confirmed medical problem is chloracne and VA has yet to grant the first disability claim for agent orange exposure.

Not that veterans haven't tried. As of May 1, 17,068 claims had been filed by persons who say they have been exposed to agent orange. Some 8400 were found to have a valid medical complaint and 1328 claims have been honored, but for reasons other than agent orange exposures. According to VA, 8617 of the claimants, when examined, had no diagnosable illness. In fact, 4102 did not even have a medical complaint, diagnosable or not.

To break this impasse, Rep. Thomas A. Daschle (D.-S.D.) has introduced legislation that would make any veterans suffering from chloracne, soft-tissue sarcoma, or the liver condition called porphyria cutanea tarda automatically eligible for compensation, whether or not any link to agent orange exposure could be made.

It is hoped that the large number of research programs now under way or starting soon will help answer all the various questions. There are at least 65 federally supported programs, expected to cost more than $100 million, in the works to study dioxin. The largest of these is the epidemiology study being done for VA by CDC. This will involve 30,000 people divided into five cohorts and will be looking for any health problems that could be associated with military service in Southeast Asia. The study is not expected to be completed until late in 1987, but other work will be finished earlier.

One of the first is the Ranch Hand study by the Air Force of about 1200 military personnel who worked spraying agent orange on South Vietnamese forests. A mortality study of these individuals has shown no evidence of a problem one way or the other, but the sample size is far too small to mean anything. More significant will be the morbidity analysis of these people that is expected this fall.

Another VA mortality study will gather data on all veterans who served in Vietnam from 1964 to 1975

Dioxin history at a glance

1872	Chlorinated dioxins first synthesized by German chemists.
1948	2,4,5-T registered as a pesticide with U.S. Department of Agriculture.
1949	First industrial accident involving dioxin at Nitro, W.Va., 2,4,5-T plant.
1957	Dioxin identified as an unavoidable contaminant in 2,4,5-T.
1962-70	2,4,5-T used in defoliants in Vietnam.
1966	U.S. Department of Agriculture and Food & Drug Administration established residue tolerances for 2,4,5-T on food products.
1970	Dioxin's teratogenicity, fetotoxicity first reported in animals. U.S. Department of Agriculture suspends uses of 2,4,5-T that might lead to greatest human exposure.
1971	Environmental Protection Agency cancels 2,4,5-T use on most food crops. Stables in eastern Missouri sprayed with dioxin-contaminated oil.
1972	FDA bans use of hexachlorophene in nonprescription soaps and deodorants.
1973	Vietnamese study links higher incidences of liver cancer, abortions, and birth defects to agent orange spraying in that country.
1976	Explosion at ICMESA chemical plant in Seveso, Italy, releases several pounds of dioxin in a densely populated area.
1978	EPA issues rebuttable presumption against registration for remaining uses of 2,4,5-T based on evidence that 2,4,5-T and dioxin cause cancer, birth defects, and fetal deaths.
1979	Environmental Protection Agency issues emergency suspension order to ban remaining 2,4,5-T uses except on rangeland and rice fields. Class action suit filed on behalf of Vietnam veterans against five U.S. chemical companies that made agent orange. Companies, in turn, file a third-party action against the U.S. government passing responsibility for alleged harm to the government for its negligent misuse of the chemicals.
1980	EPA requires advance notice of disposal of dioxin-contaminated waste.
1981	Class action suit on behalf of Vietnam veterans filed against Veterans Administration and Department of Defense. FDA advises people not to eat fish containing 50 ppt or more of dioxin.
1982	Extensive dioxin contamination found in eastern Missouri.
1983	EPA offers to buy the town of Times Beach, Mo. EPA issues proposed rule allowing disposal of dioxin-contaminated wastes only in approved landfills.

and compare their cause of death with that of veterans who were not stationed there. A twins study is also part of the VA program. About 500 pairs of twins have been found, one of which served in Vietnam and the other did not. They will be given psychological, physiological, and biochemical tests to see if any health differences can be found.

VA also is utilizing the Environmental Protection Agency's National Human Adipose Tissue Study, which has been examining human fat tissue since 1972 for the presence of about 20 chemicals, but not for dioxin. VA plans to backcheck 550 samples available from men born between 1937 and 1952 who could have served in Vietnam. VA does not expect to finish this analysis until 1985. However, under the direction of Alvin R. Young, an Air Force scientist who has been involved with agent orange studies since 1969, a small pilot study of fat tissue from exposed veterans already has been done. It casts some doubt on the ability of this kind of analysis to detect any connections between illnesses and dioxin exposure.

Then there is the chloracne task force, a major effort by VA to find veterans who have the one health problem that has been confirmed as dioxin related. But to date, about 4300 claims of skin disease have been made, and only 13 could be considered service related by VA and only one of those appeared to be truly chloracne.

Another large project that has just begun at VA is a case-controlled epidemiology study for possible occurrence of soft-tissue sarcomas. These cancers, usually very rare, have been linked to dioxin exposure by two Swedish studies and some U.S. industrial experiences. About 1000 soft-tissue sarcomas recorded at the Armed Forces Institute of Pathology involve men aged 25 to 40 who might have been in Vietnam when the spraying was done. Although the protocol still is being developed, final results are expected by the end of 1985.

These federal programs are only part of the work under way. Most were started only in the past couple of years when it was realized that huge potential problems related to dioxin exposure existed. Several states have set up their own task forces to help veterans, and there are many international investigations that are trying to find a link between the phenoxy herbicides and a variety of health problems.

Veterans with disabilities they believe were caused by exposure to dioxin in Vietnam quickly learn that unless they get compensation from VA, no other government aid will be forthcoming. There is a strong feeling among many of these veterans that the government has a responsibility not to expose its people to hazardous substances, and that, if it does so, it should be liable. But there is a long history of the courts refusing to allow veterans to sue the government for this type of injury. So, attention has been turned to the companies that manufactured the herbicides that became agent orange.

In 1979, Victor J. Yannacone Jr., representing the survivors of a helicopter pilot who served in Vietnam, sued 11 companies for their part in exposing veterans to toxic chemicals. The number of plaintiffs has since climbed to about 9000, including 5000 veterans and 4000 survivors and children of veterans. The suit insists that the companies knew of the toxicity of agent orange's components and failed to inform the government and that, therefore, the companies should be liable for injuries caused by the herbicide and the dioxin contaminant. The suit has become lengthy, complex, and costly.

The original companies named were Dow Chemical, Monsanto, Hercules, Thompson-Hayward, Uniroyal, Diamond Shamrock, Thompson Chemical, Aggrasit, Hoffman-Taft, Riverside Chemical, and Hooker Chemical (which made the 2,4,5-T precursor 2,4,5-trichlorophenol).

Most of the companies asked U.S. Federal District Court judge George Pratt for a summary dismissal of the claims that they are responsible for any injuries, under the government contractor defense. This means that the government, as the user of the herbicides, knew as much as or more than did chemical companies about the hazards and should have used this knowledge to warn those who might be exposed. They also contend, and have proved to the judge's satisfaction, that the Department of Defense had set standards for agent orange which were met by all the companies. Two companies that have not asked for a summary judgment are Monsanto and Diamond Shamrock.

For a variety of reasons, some of the companies have been released from the suit. Those remaining are Monsanto, Diamond Shamrock, Uniroyal, Thompson-Hayward, and the largest producer, Dow. The trial had been scheduled to begin June 27, but, in a procedural move, Pratt postponed the opening until completion of the discovery process, an information gathering period that attorneys say could take another year or two.

The judge's decision to go ahead with the trial means that the companies must prove they withheld no health data from the government that would have made a difference in the spraying of the herbicide. Although there are some data in the early work on 2,4,5-T on the problems from dioxin, they are scanty. Dow, which made more than 30% of the total agent orange used in Vietnam, is sure the government had all the safety data it needed.

One of the allegations raised against the companies stems from a meeting in 1965 between Dow and other agent orange makers in which the toxicity of dioxin was discussed. Dow is supposed to have told the manufacturers they would have to do something about the levels of dioxin in agent orange, or the government would take regulatory action against the use of 2,4,5-T. Shortly after that, Dow bought a license to use a process developed by West Germany's Boehringer Ingelheim that reduced levels of dioxin in 2,4,5-T to less than 1 ppm and urged the other makers to do the same. According to Dow, some did and some did not. Whether the 1-ppm level is a safe one for dioxin is one of the questions that has not been answered, though that is just what the jury may be asked to decide at this trial.

If the companies are found liable for the injuries allegedly resulting from dioxin exposure, they can be sued in state courts by veterans or their survivors for damages. In most states, the statute of limitations will have expired for taking action against the companies and special legislation will have to be passed, as it has been in New York for instance, if the veterans are still going to be able to sue over agent orange exposures.

Just how many vets actually were exposed is a question impossible to answer. The military records are not accurate enough to tell exactly where every soldier was when spraying was done in an area. And wind drift or elapsed time before troops entered a sprayed area also would determine exposure. DOD had said early in the agent orange controversy that it kept troops out of sprayed areas for up to six weeks, but many reports show that gound troops entered some sprayed areas as early as the next day. Veterans groups say they have anecdotal evidence that planes sprayed some troops directly, or that troops had loads of agent orange dumped on them when a plane was damaged by enemy fire and had to return quickly to its base.

Despite the controversy over exposure and possible health problems, VA still holds that no long-standing health problems exist from agent orange exposure. It appears, however, that this position is being eroded by the actions of other federal agencies in response to dioxin contamination, and the difference has not been lost on veterans. Although most regulatory action against 2,4,5-T and its contaminant dioxin was not begun until after 1970—after most troop exposure in Vietnam was past—concerns about health effects of dioxin from agencies such as EPA and CDC appear to be far greater than those voiced by officials at VA. Nothing makes this clearer than the dramatic actions taken to remedy the dioxin contamination problem in Times Beach, Mo.

Times Beach has a most unenviable reputation as the town too poisoned to live in. Just a few miles west of St. Louis, its fate has been sealed as the result of some poor waste disposal practices, insufficient environmental laws in the early 1970s, and political pressures for action. Because of the contamination and the federal government's decision to buy the town, Times Beach is expected to disappear.

The story traces back to the 1960s and begins with agent orange. Hoffman-Taft, one of the original defendants in the agent orange trial, made 2,4,5-T for the Department of Defense for a while, but ceased production in 1969, about the time ecological concerns led the military to halt spraying. In November of 1969, the plant in Verona, Mo., was leased to North Eastern Pharmaceutical & Chemical Co., and then later sold to Syntex Agribusiness, which let the pharmaceutical company stay to produce hexachlorophene.

According to EPA's records, wastes from the plant were being disposed of properly by shipping them to a waste facility owned by what is now Rollins Environmental Service near Baton Rouge. But in early 1971, allegedly to save money, North Eastern contracted with a firm called Independent Petrochemical to haul away its sludge bottoms. Independent, in turn, subcontracted the job to Russell Bliss, a waste oil hauler in Missouri. The records show that Bliss hauled away 18,500 gal of waste bottoms containing dioxin from the Verona plant, which he apparently stored in waste oil tanks near Frontenac, Mo., between February and October 1971.

But Bliss used some of this contaminated waste oil to spray horse arenas in May of 1971. Three stables apparently were sprayed, and the consequences were severe. Over the next few days and weeks, hundreds of animals got sick and died, including at least 65 horses. One six-year-old child, the daughter of one of the stable owners, developed an inflamed and bleeding bladder after playing in the soil of the arena, and three other children and one adult complained of skin lesions after exposure to the stables. All the symptoms disappeared after exposure was halted and have not recurred.

State of Missouri investigators, reasoning that something must have been in the oil that was sprayed, sent samples to CDC for analysis. The arena owner asked Bliss if anything dangerous had been in the oil and Bliss reportedly said there was not. In the meantime, the state had the arena's dirt hauled away and placed in a distant landfill. Some of it, however, was used as fill dirt for residential construction, in what has now become known as the Minker/Stout site.

CDC, with few clues to go on, took until 1974 to identify dioxin as the toxic compound in the oil. Scientists there, led by pathologist Renate Kimbrough, eventually determined that the oil was contaminated at about 33 ppm, a level far higher than any that occurred in Vietnam from agent orange. Crystals of trichlorophenol found during the soil analysis extraction led the investigators to the Hoffman-Taft plant in Verona, and the thinking was that 2,4,5-T production was the culprit. But it was then discovered that the hexachlorophene wastes made by North Eastern had been disposed of improperly.

By this time, Bliss had sprayed oil over many sites in eastern Missouri. EPA has reconstructed as much of the Bliss operation as possible and believes there were more than 150 sites sprayed with the waste oil, but how many are contaminated with dioxin won't be known until testing can be completed.

The search for contaminated areas did not begin immediately, however, as might have been expected. A large storage tank of wastes was found at the Verona site, heavily contaminated with dioxin. Levels of extracts were measured at 356 ppm by the CDC researchers. This became the primary concern because its potential for human health injury was seen as high. Syntex, which now owned the plant, had the wastes detoxified by ultraviolet treatment at its expense. It should be remembered that at that time there were no federal laws governing waste cleanup or proper disposal. The Resources Conservation & Recovery Act was not passed until 1976, and the abandoned waste cleanup law, superfund, didn't go into effect until 1981.

With no further reports of serious illnesses, the issue faded away after about 1975.


Trees (upper left) in this part of Vietnam were defoliated with 2,4,5-T

Then, in 1979, EPA's office in Kansas City received an anonymous telephone call that toxic wastes were buried on the James Denney farm, near Verona. The tip checked out, and a number of drums of dioxin-contaminated waste eventually were removed from the site. This got EPA investigators thinking.

It had been believed in the early 1970s that the half-life for degradation of dioxin in soil was less than a year, based on tests by the Air Force and U.S. Department of Agriculture. That was wrong. EPA found that waste leakage from the drums still had high concentrations of dioxin, when almost all of it should have decomposed after being buried for six or seven years. This prompted them, after much record searching, to go back to the stables that originally were sprayed and to the sites where the contaminated earth was dumped to measure present dioxin levels. The levels found were essentially as high as they had been in 1971. At the site where the soil had been used as a landfill, levels ranged from 10 ppb to 300 ppb. At the Shenandoah Stables, concentrations were still as high as 1750 ppb.

These tests began in spring of 1982, and the first data were released in August. The findings prompted a more exhaustive sampling of all the areas known to have been sprayed. By December, more than 300 samples had been analyzed and the results released. EPA had found dioxin levels of up to 300 ppb in the Times Beach area and contamination in about 14 other sites.

The news of extensive dioxin contamination in Missouri came at a critical time for the agency. EPA Administrator Anne Gorsuch Burford was under intense pressure from Congress for information relating to actions the agency had or had not taken under the superfund law, and that body was moving in early December towards finding Burford in contempt of Congress. The situation was complicated when the Meramec River, which flows by Times Beach, flooded just before Christmas 1982, and officials worried about the dioxin spreading to other communities. (Followup tests showed that the dioxin had not moved with the flood waters.)

The situation now began to get tense. Residents of the community demanded that the government buy their homes so they could move to a safe place. Some people began comparing the contamination problem at Times Beach to the situation at Love Canal in New York. Then, in early February, the EPA assistant administrator in charge of waste cleanup and superfund, Rita Lavelle, was fired by President Reagan, amid allegations she had used the superfund for political leverage in favor of Republican candidates.

Possibly pushed a little faster than she would have been otherwise, EPA Administrator Burford announced Feb. 22 that the federal government would buy up all the contaminated property in Times Beach, paying the residents a price reflecting property values before the dioxin contamination was found and before the flooding. Superfund would supply $33 million and the state of Missouri would supply $3.3 million more.

Subsequently, on April 5, EPA offered to buy a number of homes in the contaminated Minker/Stout site that had been built on dirt from the stables originally sprayed by Bliss. A third area, the Quail Run mobile home park, was found to be contaminated with up to 1100 ppb of dioxin in a sample dug out from beneath a paved road, with levels of 2 ppm inside two of the mobile homes. EPA has also offered to buy the trailer park. At this time, no other areas are being bought out.

The decision to move residents, either temporarily or permanently, is made by CDC and the Missouri Department of Public Health, on the basis of results from samples submitted by EPA. The belief that a level of 1 ppb is probably safe comes from a CDC estimate using a number of studies, and is discussed on page 48.

When EPA told the residents of Times Beach the government was going to buy their homes, the process was expected to take 60 to 90 days. Now, after three months, there is still a hangup. The federal government cannot take title to the property because the law forbids spending superfund money to clean up federally owned property. Missouri will not take title until all the residents have moved because they do not want to be expected to provide services, such as water, to the areas. There were, last month, about 50 families that were not moving, but a second flooding of the Meramec seems to have convinced them it was time to leave. Spokesmen for the Federal Emergency Management Administration, which has been on the site since the first flood in December and is responsible for dealing with the residents on the buyout, say it appears that all the former residents are leaving. In addition, an unofficial and unapproved agreement may have been reached that would permit the property to first be assigned to the city of St. Louis, so the cleanup could get started, then transferred to Missouri when that state's conditions are met. In the meantime, the residents are living elsewhere and have yet to receive the promised compensation.

As of this writing, there are 31 confirmed sites of dioxin contamination in eastern Missouri, all traceable to the spraying by Russell Bliss. Officials believe the final list could contain more than 100 sites. How many more people might have to be moved and how much it will cost is pure speculation, but the expenses can be expected to rise.

Midland, Mich., is another city that has become associated in the public mind with dioxin contamination.

The Midland connection first surfaced in the national news media last March when Rep. James H. Scheuer (D.-N.Y.) charged that he had evidence showing that then EPA acting administrator John Hernandez had intervened personally to allow Dow Chemical Co. to alter a draft EPA report on the sources and effect of dioxin in the Great Lakes region, suppressing all references to Dow's responsibility for dioxin contamination in and around its plant.

In fact Scheuer charged that owing to Hernandez's intervention, and by implication Dow's, all references to studies showing the adverse health effects of dioxin were removed from the report.

Testifying before Scheuer's natural resources subcommittee on March 23, Valdas Adamkus, EPA's Region V administrator, said that Dow's objections to the draft report centered on a statement that EPA concludes that Dow's Midland facility is a major, if not the only source, of dioxin contamination in the Tittabawassee and Saginaw Rivers and Saginaw Bay in Michigan. That six-line draft conclusion did not appear in the final report.

C&EN staff photo

Young: doubt cast on ability to link illness with exposure to dioxin

Ronald O. Kagel, director of environmental quality for Dow Chemical USA, who reviewed the report for EPA, says, emphatically, that he did not ask EPA to delete that six-line paragraph from the report. He says he did point out that "the whole paragraph was lifted out of a 1978 report and it appeared again almost word-for-word in a report written in 1979. At that time we could not dispute that and we didn't. But in 1981 there had already been an international dioxin conference. There had been many papers published supporting our theory that dioxin can be created by combustion. I said, 'Gee guys, that's a 1978 statement in a 1981 report and I really think you should change the word 'concludes' to 'speculates' because of the data that support our theory.' "

Kagel says that in making his comments he was "strictly trying to speak to the validity and technical accuracy of the report and specifically those portions that were taken out of Dow's work." Further, he says that many of the portions of the draft report released by Scheuer that were marked "cut" already had been deleted from the copy of the report he received. Others had markings indicating that somebody already had decided they should be cut.

At just about the time the charges of undue influence were being aired two Michigan environmental groups—the Foresight Society, headquartered in Lansing, and the Environmental Congress of Mid-Michigan, headquartered in Midland—filed a citizens petition with EPA asking for a full field investigation of central Michigan. They said an investigation was needed to determine the effect of the pollution caused by disposal and emissions into the air, land, and water of chemical substances that threatened the health of the residents and the integrity of the environment. At a press conference in Washington, D.C., Andrea K. Wilson, director of ECOMM, explained that "given the fact that soft- and connective-tissue cancers among white females in Midland County are four times the national average, the birth defect rate is now being re-evaluated, and Dow's own data indicate that soil samples taken at their Midland plant contain a range of TCDD (dioxin) from 0.3 ppb to 100 ppb, we feel that a full field investigation, including an epidemiological study, is warranted."

Hard on the heels of the petition came an announcement by EPA's Region V office (which covers the upper midwest) that a preliminary investigation had found more than 40 toxic chemicals, mostly in the low parts-per-billion range, in the effluent from Dow's Midland facility. Dioxin was found at levels of 50 parts per quadrillion in the effluent and at levels of 100 ppt in caged whole fish that were exposed to the effluent.

The search for dioxins in Midland may very well have been initiated by a false-positive test result. Dow periodically monitors its discharges for TCDD and on April 13, 1977, the lab reported a positive number—8 ppt with a detection limit of 3 ppt. "That got us concerned," Kagel explains, "because we had never seen dioxin before . . . but it triggered a number of things." The first thing that was done was an analysis of some fish that had been caught in the Tittabawassee River the year before during Dow's biennial river survey and placed in the freezer. Analysis of the fish showed dioxin levels ranging from nondetectable to 0.19 ppb, with a detection limit of 0.02 ppb. In May of 1977 the company collected more fish—mostly bottom feeders—from the river, analyzed them, and again found positives. Kagel points out that the state-of-art analytical method at that time allowed only the detection of 2,3,7,8-TCDD, plus 16 other tetra isomers.

After the second batch of fish was analyzed, Dow devised some experiments using caged fish to determine where the dioxin was coming from. The first shipment of fish ordered died before it got to Dow. The second batch of fish all had a fatal fish disease, commonly known as the "Ick." The third shipment from the East was found to be loaded with PCBs, which would have interfered at the time with the TCDD analysis. Finally, towards the end of 1977 Dow got a batch of usable trout and put them in cages where its effluent mixed with the river water under flowing conditions. Bioanalysis of the caged fish was completed in May 1978. Positives were found for most fish in the mixing zone. At the same time, Kagel says the fish research lab, which had been doing studies on the biomagnification of TCDD by trout, reported a biomagnification factor of 6600. Dow reported all of its findings to the State Department of Natural Resources in June of 1978. In July, the company met with state representatives and made a commitment to find the source of the dioxins.

The first thing Dow did, Kagel says, was to look at its own internal waste streams, where it might expect to find dioxins, and didn't find anything that could be considered significant. Then, he says, "Quite by accident two of the chemists in the lab went up to the second floor to get a control sample of dust off a bookshelf. They analyzed that dust and found it contained all the dioxins—the tetras, the heptas, the hexas, the octas. We said, 'My God, we've been looking for a waterborne source and we know that . . . the second floor has never been under water. So it's got to be from somewhere else that's airborne."

That, he explains, is when "we started looking around the division at dirt samples and seemed to find more dioxins as we got closer to our incinerator and power plants." Thus was Dow's combustion theory born.

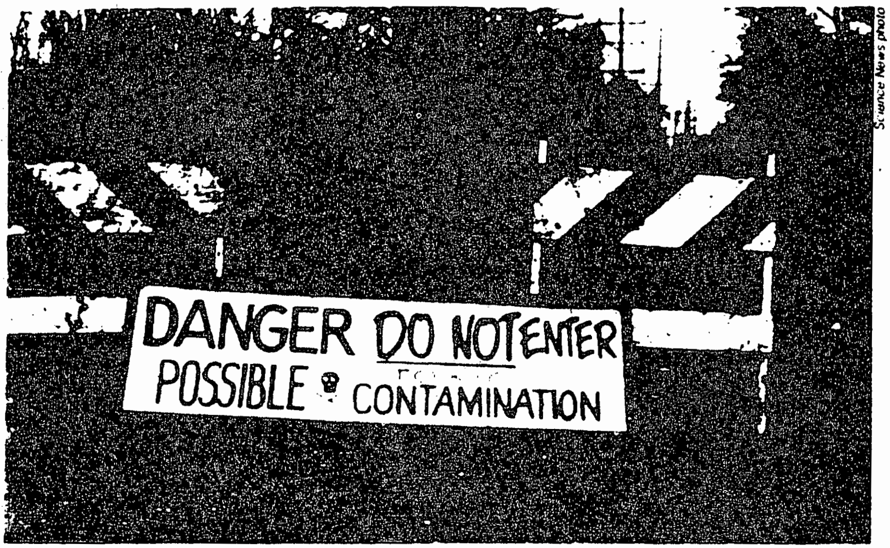
The company dispatched scientists to several cities to collect soil samples around municipal incinerators and powerhouses. In almost every case they found dioxin, although not necessarily 2,3,7,8-TCDD. They analyzed the carbon soot inside mufflers collected in Detroit and found dioxins. They also found 100 ppt of 2,3,7,8-TCDD in the soot from a fireplace, which happened to belong to Kagel.

According to Kagel, the formation of dioxins is maximized and its destruction minimized when the temperature is low, below 750 °C. At

Agent orange had far less dioxin than earlier 2,4,5-T herbicides used in Vietnam war

Code name	Herbicide	Quantity, gal	Period of use	2,3,7,8-TCDD, ppm
Orange	2,4-D; 2,4,5-T	10,646,000	1965–70	1.98
White	2,4-D; picloram	5,633,000	1965–71	—
Blue	Cacodylic acid	1,150,000	1962–71	—
Purple	2,4-D; 2,4,5-T	145,000	1962–65	32.8[a]
Pink	2,4,5-T	123,000	1962–65	65.6
Green	2,4,5-T	8,200	1962–65	65.6
TOTAL		17,705,200		

a Assumed level from one known and four probable samples of purple. Note: Pink and green levels are twice that of purple because they were full-strength 2,4,5-T. Sources: Proceedings from 2nd Continuing Education Conference on Herbicide Orange, May 1980; and Air Force OEHL technical report on toxicology, fate, and risk from agent orange and dioxin, October 1978



Science News photo

Road going through Times Beach, Mo., is blocked by sign warning of dioxin

temperatures above 1000 °C just the opposite occurs—formation is minimized and destruction maximized. Thus, municipal incinerators could be expected to produce more dioxins than industrial incinerators, which burn at 1000 °C, because the municipal facilities operate at generally lower temperatures.

Dow Chemical researchers sample Tittabawassee River for dioxin near the company's Midland, Mich., plant

While it was doing this work Dow also was perfecting its analytical techniques, Kagel says, using a mixture of three different methods during the course of study. The first separated out 2,3,7,8-TCDD plus 16 other tetra isomers; the second, 2,3,7,8-TCDD plus 11 others; and the third 2,3,7,8-TCDD plus two other isomers. Then in late 1978 a technique was developed that isolated all 22 tetra isomers.

Since 1979 Dow has done several other studies. Having, as Kagel says, "made the comment that we thought that dioxin had been around since the advent of fire" and figuring that wood was one of the earliest fuels, a study was done of residential wood-burning stoves in Minnesota, New Hampshire, Oregon, and Michigan's upper peninsula. The source of the wood for each stove was carefully documented to make sure it had never been sprayed, never treated with pentachlorophenol, Kagel says. But in each case some dioxins were found in the soot from the stoves.

As Kagel points out, one of the components of wood is lignin, a phenolic material. There is also a natural chlorine content in wood which will vary from 14 to 84 ppm. "Remember," he says, "we're talking about reactions that occur with a yield of 10^{-10}%. These are trace reactions, and 14 ppm, when you're looking at a millionth of a millionth—a ppt—is a lot of stuff. It's the same with coal, which actually has a much higher chlorine content than wood, and is nothing more than a whole mess of ring compounds of one sort or another. So the basic building blocks are there."

"This is as close as we can come," he says, "to confirming the de novo principle, that dioxin is made from carbon, hydrogen, oxygen, and chlorine. Nobody has done a definitive experiment on that that I know of. But the preponderance of evidence right now would support the fact that you can get dioxins formed at very low levels in the combustion processes from common fuels."

If that is true it would go some way towards explaining the results of a recent study which shows dioxin contamination in fish in many rivers in Michigan. The fish were collected from 19 Michigan rivers, plus Saginaw Bay and Lake Erie by DNR. Their skinless fillets were analyzed by Swiastolov Kadzmar, a graduate student working under Matthew J. Zabic, professor of entomology and assistant director of Michigan State University's pesticide research center. Thirty-four of the 62 fish analyzed had no detectable levels of dioxin. Levels of 2,3,7,8-TCDD in the other fish samples ranged from a low of 17 ppt, with a detection limit of 12 ppt, to a high of 586 ppt, with a detection limit of 81 ppt. Many of the positive samples came from fish taken from waters that had no connection with the Tittabawassee rivershed and therefore they could not have been contaminated by Dow's effluent, though the samples did come from rivers in industrialized areas.

Typically, Kagel says, dioxin is very tightly bound to fly ash, as it is to soil. To remove dioxin from fly ash one has to do exhaustive benzene or toluene soxhlet extractions for 24 hours. "It's very tightly held," he says, "so the question is how does it get off the fly ash and into the fish?" Dow has been involved with EPA's Duluth, Minn., lab in a joint study designed to answer that question. Duluth supplied some carp fingerlings, Kagel explains, "which we put into a fish tank with some municipal fly ash of which the 2,3,7,8-TCDD content was about 160 ppt. That represented about 0.48% of the total tetra isomers, all of which were present. After 30 days in the tank the fish were taken out and analyzed and 84% of what was found in the fish was 2,3,7,8-TCDD."

Kagel theorizes: "There's some weird mechanism in the fish—that was phase two of our study, to try and find out what that mechanism is—that makes them selectively accumulate 2,3,7,8-TCDD, or, the other way around, there is some mechanism whereby they break down or metabolize the other isomers. That is a preliminary experiment and we were going on to controlled experiments when all of this started and we never got back to it. . . . I sure would like to get an answer."

So would everybody else. Dow says that it has no manufacturing operation anywhere in the U.S., including Midland, that has any 2,3,7,8-TCDD associated with it. But EPA's Region V office in Chicago isn't so sure. On April 11 it asked Dow for any and all process- and waste-related information the company might have pertaining to dioxins. Dow delivered the first set of data—2000 pages worth—on May 12. The company said it took 26 employees, 13 of them working full time, to compile that information and it is still collecting data.

Among the data submitted were the results of a new soil analysis conducted by Dow, repeating the analysis done in 1978, except this time the analytical technique was isomer specific. Five soil samples collected inside the plant site showed levels of 2,3,7,8-TCDD of 0.08, 0.38, 2.04, 0.018, and 0.02 ppb. The levels in two samples from Midland were 0.0016 and 0.0072 ppb; Chicago, 0.0010 and 0.0042 ppb; Lansing, Mich., 0.0030 ppb and not detected; and Detroit, 0.0036 and 0.0021 ppb.

"There is no health hazard in Michigan because of dioxin in the dirt or in Chicago. Not at the levels we find it," Kagel says.

Midland's mayor Joseph Mann agrees. "So what if we've got 7 ppt in the soil here. Being bound the way it is how do you get to it? How do you come in contact with it? How do you assimilate it?" He points out that if the exposure were causing harm it would manifest itself somehow. But he says studies by the State Department of Public Health have shown that "the overall cancer rate in Mid-

Few regulations aim specifically at dioxin

Despite all the problems—medical, political, and social—associated with dioxin, it remains a remarkably unregulated compound. Early concerns focused on exposure to the dioxin-contaminated herbicide 2,4,5-T; only recently has dioxin itself been regulated.

In 1970 a Congressional hearing took place and the National Institute of Environmental Health Sciences announced a study that showed birth defects in animals that were exposed to 2,4,5-T containing low levels of dioxin. This prompted the U.S. Department of Agriculture to disallow most uses of the compound, permitting use only on forests, rights-of-way, open rangeland, and rice fields. In addition, a voluntary agreement by 2,4,5-T makers limited dioxin concentrations to less than 0.1 ppm.

The ball was passed to the new Environmental Protection Agency, which continued its investigations and soon moved to further limit the herbicide's use. In 1973, EPA set up the Dioxin Monitoring Program to monitor residues of dioxin in human and environmental samples. EPA attempted to cancel all uses of herbicides that were derived from 2,4,5-trichlorophenol in that year but eventually had to cancel the proceedings because the analytical methods necessary to determine low levels of dioxin were not available. The agency began a rebuttable presumption against registration process on 2,4,5-T in 1978.

Then in May 1979, on the basis of heavily criticized studies linking the spraying of forest areas with 2,4,5-T to a number of miscarriages among women in Oregon, EPA issued an emergency suspension that allowed the herbicide to be used just on rangeland and rice fields because EPA saw little risk of human exposure there.

The hearings on cancellation of 2,4,5-T have dragged on. They currently are suspended while EPA and the chemical manufacturers try to reach some kind of agreement, possibly on permitting some use of the herbicide if dioxin levels in it can be kept very low.

But other tools have passed into EPA's hands for regulating dioxin. On May 19, 1980, EPA published a rule under the Toxic Substances Control Act that requires any person intending to dispose of wastes that contain dioxin, or even of substances produced on equipment that previously was used to make 2,4,5-trichlorophenol, to notify EPA 60 days in advance of such disposal. That notification must include details on the amount being disposed of and the method to be used.

Just recently, the agency proposed a regulation for treating dioxin-contaminated waste under the Resource Conservation & Recovery Act. This would permit disposal of dioxin-contaminated waste only at facilities that are fully licensed by EPA. The agency says potential problems might arise if disposal is allowed at unpermitted landfills or in incinerators that might not be working properly. This rule, if adopted, would supersede the 60-day notification rule.

The other area in which EPA is moving forward is dioxin contamination of water. EPA presently is monitoring effluents from chemical plants to determine if dioxin is present and, if so, at what concentration. These data could be used in preparation of a water quality criteria document. This would give manufacturers an idea of what EPA thinks is a safe level for dioxin in water and probably would presage further regulation of dioxin, under either the Clean Water Act or TSCA. (Because dioxin is a priority water pollutant, some states have regulations that require no detectable levels in plant effluents.)

The only other significant action taken on dioxin is by the Food & Drug Administration. A series of recommendations (not regulations) by FDA in 1981 advised people not to eat fish with dioxin levels greater than 50 ppt, but that fish with less than 25 ppt of dioxin were okay to eat. Because these are not regulations, an FDA spokesman points out that if the levels do rise above 50 ppt, the agency cannot take any action to remove the product.

Thus, aside from the restrictions on the use of 2,4,5-T (because of its dioxin contamination) and the current 60-day notification rule for waste disposal, dioxin is not specifically regulated by the federal government.

land is low—below the national average, below the state average, and below the average for the surrounding region." He says there was a soft-tissue sarcoma in women that was higher than normal. "There was one case in the 1950s, five cases in the 1960s, and eight cases in the 1970s. This was a matter of concern to the county health department, the state health department, and certainly to us," Mann says. The State Health Department conducted a study and released its results on May 4. And according to Mann "could not ascribe any particular causes to the rate of increase. There was no commonality between the cases that could be found; although the department felt there must have been a commonality, they certainly couldn't say that it was dioxin."

The department did recommend development of a registry of persons most likely to be exposed to dioxins as evidenced by their occupations, fish consumption patterns, or location of residence. Such a cohort of people, it said, could serve as a framework for possible future epidemiologic studies.

Meanwhile, Midland's attitude to the dioxin issue is expressed in a variety of ways. Mann says that "the perception within the community is that there's nothing out of the ordinary, nothing dangerous." But he adds, "That's not the perception if you get more than 100 miles away from here and have gotten most of your information from the news media."

Then there are the retirees from and employees of Dow who come into Rep. Donald J. Albosta's (D.-Mich.) local office and who, says office manager Pat Casey, feel as if the criticism is being directed at them. "Their feelings, and I think their beliefs, are that they worked for a high-class company that spent a lot of bucks on environmental concerns and research. Dow has always had a very aggressive in-plant safety program. So the employees don't feel there is any justification for the insinuation they pick up that Dow has done something wrong."

City manager Clifford Miles thinks that one of the reasons for the very low level of concern in the city, and one he personally subscribes to, "is that the people who have done the testing, the measuring, the toxicology and epidemiology studies are all Midland people. They all live here with their families. It isn't some outsiders coming in and saying either it's safe or unsafe. It is Midland people that are doing these things and they have significant reputations not only in Midland but worldwide. Certainly no one is going to stay here if they know their family is in jeopardy," he says. Miles explains that over the years, because of Dow's environment and safety record, "people have built up a wealth of confidence in that corporation that could not be bought." And he says, "They [Dow] have done everything they can and should have done to alert the public, the media, the state and federal government."

Kagel: dioxin dust on a bookshelf

C&EN staff photos

Mann: nothing out of the ordinary

Some people aren't so confident. As Dianne Herbert, one of the leaders of ECOMM, sees it, "Dioxin is a sexy issue that has gotten the attention of the media, but it certainly isn't the only environmental or health problem in Michigan." She also thinks it's good that the attention of EPA is focused on Midland. However, she notes the city itself is fighting any investigation. "They naturally want to get the focus off," she says. "Their strategy is 'let's spread it out and say, 'Oh yes, dioxin needs to be looked at, but all over the country.' There are problems—people don't want to move to Midland; people have called and asked, 'What kind of place is it?' Maybe the problems should have been taken care of earlier on. They accumulated until they all blew up and that's too bad. I'm from Michigan and I like living here. I don't want to give up my house. I don't want to move."

Herbert says she understands the reluctance of any community to believe that there is something wrong or that the company that many of them work for has done something that is illegal or bad for their health. "The average person you talk to," she says, "will say that Dow has been good to us and I would never disagree with that. For a community this size to have its own symphony, a beautiful center for the arts—that is very unusual. But I don't think that gives them the right to do what they want with the air, and the water, and the land. The bottom line is that in this community Dow decides what is safe and what is dangerous. They make those decisions for people and I think that people should be allowed to make their own decisions."

Others are seeking further information. That was the purpose of a late May forum on dioxins organized by the Midland sections of the American Chemical Society, American Institute of Chemical Engineers, and Sigma Xi.

At the forum, which about 500 people attended, a panel of five technical experts on dioxin issues answered questions from five local citizens—none of whom worked for Dow—and the audience.

According to Susan Butts, a senior research chemist at Dow and an organizer of the forum, its impetus came from the fact that "we were aware that a lot of studies had been done on various aspects of the dioxin problem, but we hadn't really heard very much about the results of those studies. Our concern was really in trying to hear a more detailed explanation of the sitution, in terms that would be understandable not only to scientists but to the general public." In putting the panel together, she says, "We tried to be sure that we fairly represented all points of view. We did rather heavily weight it towards people with a biomedical background, because we thought most of the questions from the audience would concern human health problems. And most of them did. There were a lot of questions about the toxicity of dioxins, about the meaning of toxicity, and about how dioxins would be rated relative to other health hazards."

For her part, Butts says she never had a personal concern about her own health, but she did want to know where Midland stood in relation to other places in the U.S. that have problems with dioxin contamination. "I felt quite reassured," she says, "by what we were told by the panel members. There were some minor disagreements about interpretation of data. But, if I were going to try to summarize what the panel said, it would be that they didn't feel that there was any significant health problem in Midland. But until we know more about the situation they would like to continue monitoring health in Midland to make sure."

In fact just about everybody seems to agree that what is needed is continued monitoring and more study, preferably not just in Midland, nor even just Michigan, but nationwide. Rep. Albosta is seeking funding for just such a study. He feels that a number of questions need to be answered. Questions such as: How pervasive is dioxin? At what concentration is it present in the environment? Where is it coming from? What are safe levels? Are dioxins bioaccumulating in the environment? Is that a problem? And, finally, are national standards needed to deal with the problem?

The study as now planned would be run by the Region V office. A prototype study costing $2 million to $3 million would first be done in Michigan. That study then would be expanded to a national level at a total cost of about $12 million. According to Richard Powers of DNR's toxic chemical evaluation section, the Michigan part of the study, as tentatively planned, would consist of a study in the vicinity of Midland to determine the extent of contamination in that area. This would mean sampling soil, air emissions, and water effluents from the plant site, and river sediments. The second component of the study would be monitoring fish, including game fish and bottom-feeding carp, in 15 Michigan rivers for dioxin contamination.

As part of the national study, air and soil sampling and possibly fish monitoring would be done at other sites, perhaps in Michigan, perhaps in Region V, or perhaps somewhere else in the country. Powers says, "It doesn't make any difference to us where they're done, as long as they are done. We feel it is necessary to have comparability studies in other areas of the country: both areas that would be expected to be contaminated and others which should be relatively clean."

Protocols for the study are being developed, but actual work is pretty much on hold because everything is contingent on getting federal funding. The House Appropriations Committee has included $5 million in EPA's fiscal 1984 funding bill for nationwide dioxin studies—$1 million for R&D and $4 million for monitoring studies in Michigan and Missouri as well as other places. The Senate Appropriations Committee has not yet made a decision. EPA's new administrator, William D. Ruckelshaus, is expected to ask Congress for more money for the agency both in this and the next fiscal year and reportedly has expressed his support for a national dioxin study.

Although everybody, including Dow, supports a study, not everybody is happy about what is being planned. As Mann puts it, "First you say there's a ticking time bomb, a life-threatening situation, and then you do these studies—the results of which won't be out for two or three years. What we need is a reasonable amount of analysis in a reasonable amount of time, primarily to reassure people outside this community that it isn't as bad as had been pictured."

Along the same lines, the Midland City Council, three of whose five members, as well as Mann, work for Dow, passed a resolution expressing its support of scientific studies on exposure levels and effects of dioxin on the environment and the public health as long as they weren't limited to Michigan, but also expressing the council's feeling that $12 million was just too much.

Further study is quite probably the proper response to the levels of dioxin contamination that have been found in Michigan. And, although EPA appeared to rush into Missouri in an attempt to improve its public image when everything the agency did was being looked at with cynical eyes, hindsight may show the decision to be justifiable and prudent. Other human exposures to dioxin, such as those of soldiers in Vietnam or the people in Seveso, Italy, in 1976, involved considerably less dioxin than those of the Times Beach residents.

In Vietnam, for instance, the Air Force's Young calculates that the level of dioxin in the soil would have been 0.017 ppb, 20,000 times less than the 300 ppb found in Missouri. That assumes that agent orange, with an average dioxin concentration of 2 ppb, is sprayed at a rate of 3 gal per acre and that all the dioxin falls right to the forest floor (although studies found that only about 7% of the agent orange penetrated the forest canopy).

Similar types of exposure comparisons can be made for the residents of Seveso, leading to the conclusion that the Missouri experience may represent the largest long-term exposure to dioxins that humans have endured. If dioxin is the hazard that some believe, then the costs of moving entire towns probably are not greater than the risks of letting people continue to live there. ☐

Dioxin's Human Toxicity Is Most Difficult Problem

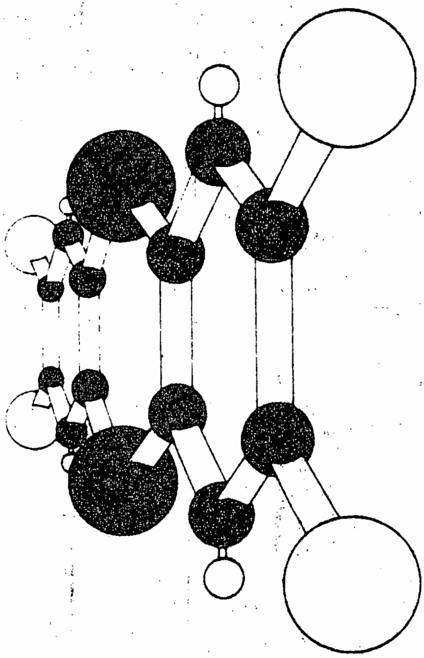
Dioxin is extremely toxic to certain animals, but scientists are only beginning to understand the nature of its toxicity and exactly what it does to humans

Rebecca L. Rawls, C&EN Washington

Of all the questions that surround dioxin, probably the most important one, and one of the most difficult to answer, is: What is its effect on human health? Although its presence in the environment still would cause problems if it were harmful only to horses or guinea pigs or some other animals, it is the possibility that dioxin may be very hazardous to people that is behind most efforts to understand how the compound behaves in the environment and to learn how to deal with it.

That dioxin is extremely toxic to certain animals, causes many different toxic effects in a wide range of animal species, and is harmful to humans when they are exposed to relatively large amounts of it are facts that are well established. But even after more than a decade of intensive study, scientists are only beginning to understand how dioxin causes its toxic effects, and the key question of whether it causes any long-term, irreversible health effects in humans remains unanswered.

The widely made claim that dioxin is one of the deadliest substances known, or that it is the deadliest man-made substance, is based on its extreme toxicity in guinea pigs. As little as 0.6 µg per kg of body weight given orally will kill half of the male guinea pigs that receive the dose. Illness occurs immediately and death within about a week. Mole for mole, this makes dioxin some 2000 times more toxic than strychnine, for example, in the mouse. Only a handful of substances are known to be more toxic than dioxin is in guinea pigs.



But dioxin is much less toxic to mice than it is to guinea pigs. In fact, one of the striking features of dioxin's toxicity in animals is that the lethal dose varies so much from one species to another. The guinea pig, the most sensitive animal yet tested, is 5000 to 10,000 times more sensitive than the hamster, the least sensitive animal yet tested. Rabbits, mice, and monkeys cluster somewhere in the middle—roughly 200 times less sensitive than guinea pigs and 30 times more sensitive than hamsters.

Dioxins are not the only compounds that show this range of sensitivities from one animal species to another. Such a pattern is characteristic of several halogenated aromatic compounds, including chlorinated dibenzofurans and chlorinated and brominated biphenyls. The fact that all of these compounds have closely related chemical structures leads some toxicologists to study them as a class and has led to promising work that is beginning to unravel how these compounds cause their toxic effects.

Dioxins and these other halogenated aromatic hydrocarbons cause many different effects simultaneously in treated animals, and the relative importance of these effects varies from species to species. Thus, dioxin appears to kill rats by causing severe liver damage, but in the guinea pig the liver lesions seem less serious and the animal appears to die from a starvationlike wasting away of the entire animal. Both the liver lesions and the wasting away occur to some degree in all of the animals that have been studied; only the relative importance of these effects varies. Similarly, all species studied lose lymphoid tissue, particularly from the thymus, and become more sensitive to infections. However, it

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usually is not the infection that kills them, and putting treated animals in a germ-free environment will not save them.

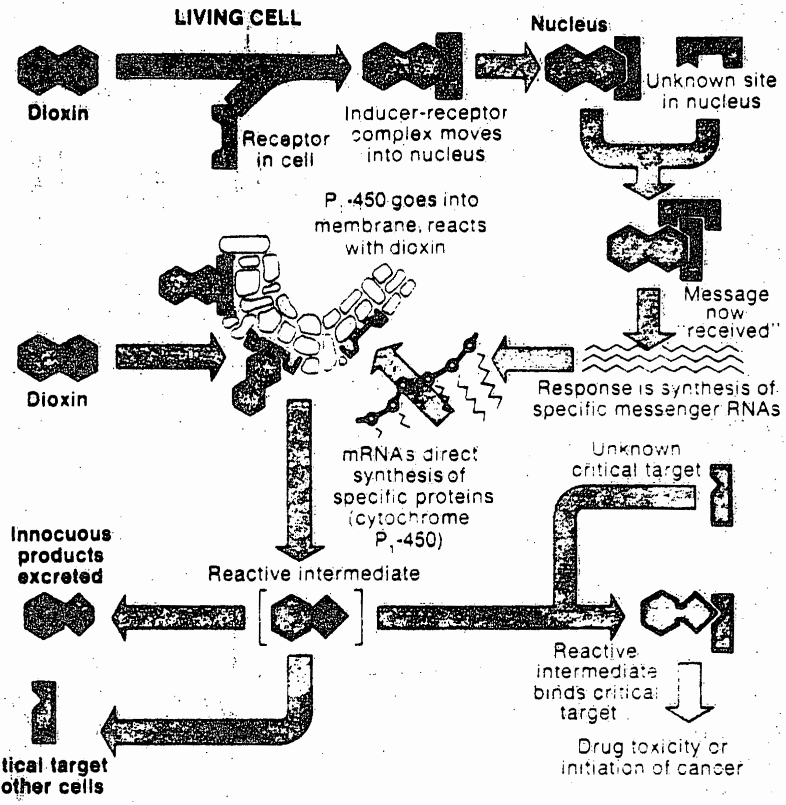
Not all effects are found in all animals. Chloracne, a skin lesion that is the most characteristic and frequently observed effect of chlorinated aromatic hydrocarbons on humans, does not occur in guinea pigs, hamsters, or some mice. Hairless mice, however, do develop a chloracnelike skin condition when exposed to dioxin, and so do rhesus monkeys and rabbits. Cattle develop skin lesions, too, but they are quite different from the kind that are seen in humans, monkeys, and rabbits.

In addition to these acute, or immediate, effects, dioxin produces at least two types of serious long-term effects in some laboratory animals—reproductive effects and cancer. As is true for nearly all long-term health effects studies, most of the work on dioxin effects has been done on rats and mice.

Because dioxin is so acutely toxic to many adult laboratory animals it is difficult to examine its teratogenic and reproductive effects. However, several studies in mice have found cleft palates and kidney abnormalities in offspring of animals fed 1 to 3 ng of dioxin per kg of body weight per day. Rat studies do not show birth defects. Instead, dioxin kills the developing fetus or embryo at levels similar to those that cause birth defects in mice.

Small-scale studies on monkeys show that dioxin is fetotoxic to these animals as well. Pathologist James P. Allen of the University of Wisconsin medical school has found that breeding female monkeys fed 1.7 ng of dioxin per kg of body weight per day for two years aborted four of seven pregnancies. In a study by Wilber P. McNulty of the Oregon Regional Primate Research Center, pregnant monkeys were given doses ranging from 9.5 to 240 ng per kg of body weight per day for three weeks during their gestation period. The two animals in the highest dose group died from their dioxin exposure. They also aborted. At the level of 48 ng per kg per day, the mothers were only slightly sick, but three of the four animals in the study aborted. At the lowest level, the mothers ap-

Researchers seek to explain dioxin's effects on cellular biology



If the exquisite sensitivity of some, but not all, animals to dioxin is a frustration to many researchers, it is a source of delight to one group: the molecular pharmacologists. It is not an accident that some cells are incredibly sensitive to dioxin, and by exploiting the differences between dioxin response in different types of cells, these scientists have a probe for examining some of the very intricate inner workings of cells.

"If morphine addiction weren't a problem, morphine would still be an interesting drug for what it can tell us about enkephalins. That's the way we feel about dioxin," explains one researcher in the field.

A consistent picture of some of dioxin's interactions with animal cells is emerging from work going on in several laboratories including those of Alan Poland and Joyce C. Knutson at the University of Wisconsin; Robert A. Neal and William Greenlee at the Chemical Industry Institute of Toxicology, Research Triangle Park, N.C.; and Daniel W. Nebert at the National Institutes of Health, Bethesda, Md. Though this work does not explain all of dioxin's toxic effects, it does begin to make some sense out of one of the more puzzling aspects of dioxin's toxicity—the great range in acute toxicities found in different animal species.

According to this picture, dioxin is only one example of a larger class of halogenated aromatic hydrocarbons. All of these materials bind to the same receptor, a soluble protein within the cytoplasm of susceptible cells. The binding site of this receptor has been quite well mapped out. Substrates need to be generally planar and pretty well fill a rectangle 10 Å long and 3 Å wide. Highly polarized groups, like chlorine atoms, need to be in at least three of the four corners and nowhere else in the molecule.

These requirements fit dioxin exactly, but other molecules like chlorinated dibenzofurans or brominated biphenyls also can be accommodated in this attachment site and induce dioxinlike toxicity in animals. The site's geometry goes a long way toward explaining why the 2,3,7,8-tetrachloro isomer of dioxin is the most toxic, since this is the one that has all four corner positions of the molecule and no others occupied by chlorine atoms.

Once bound, the dioxin-protein complex moves into the nucleus where it turns on the activity of a specific set of genes called the *Ah* (for aromatic hydrocarbon) locus. These genes, in turn, produce messenger RNAs that direct the synthesis of a family of proteins called cytochrome P-450s within the cell. Cytochrome P-450s are enzymes whose function is to react with foreign molecules like dioxin so they can be metabolized and eventually excreted from the body.

To this point, the system seems to be a beneficial one for the cell. Unfortunately, among the metabolites of dioxin as it is processed by the cytochrome P-450 system there seems to be a substance that is toxic. Inadvertently, a system that was intended to rid the body of foreign chemicals by making them easier to excrete has converted a fairly innocuous substance into a toxic one.

It now seems apparent that this whole process is controlled genetically at two points, at least. One of these is the *Ah* locus, which controls the amount and structure of the receptor protein within the cell and turns on production of the cytochrome P-450s. Experiments in mice have shown that genetically inbred strains that do not have the *Ah* locus are not susceptible to some of dioxin's toxic effects. But the *Ah* locus alone is not enough to produce toxicity, as is shown by experiments in which cytochrome activity is turned on by the presence of dioxin though there is no toxic response. Poland and Knutson have found that chloracne can be produced by dioxin in a certain strain of hairless mice even though mice generally do not show this reaction to dioxin. It is not the lack of hair itself that is responsible for chloracne in these mice, they find. Instead, some part of the genetic locus that is responsible for the hairless trait in mice is also necessary to produce the chloracne response.

It is interesting to speculate on why animals have evolved an elaborate system for dealing with foreign chemicals and why it sometimes goes awry with molecules like dioxin, making them more, rather than less, toxic to cells. One model that satisfies pharmacologists considers dioxin to be a foreign molecule that just happens to fit into a receptor and turn on a cell system originally designed to respond to an endogenous molecule and that once had some useful purpose. Such a model makes dioxin analogous to morphine, which stimulates a natural pain-killing system in place of the body's own trigger molecule—enkephalin. But to have dioxin fit a similar pattern, there would need to be a structurally related compound naturally present, at least on occasion, in the body. There also would need to be some advantage in certain circumstances to triggering the ordinarily toxic responses that the body makes to dioxin.

The body's response to dioxin, theoretically, at least, might sometimes be useful. Properly controlled, the ability to stimulate cell proliferation, for example, could lead to useful growth or repair of tissues instead of cancer. So far, however, a natural dioxinlike molecule has not been found in animal tissue.

Useful as this picture of dioxin's role in cellular biology is, it does not explain all the chemical's toxic effects. Indeed, the model purposely focuses on those effects of dioxin that vary most widely from species to species. But dioxin has other effects, like the wasting away of tissue, that appear to be common to all animal species examined. Tissue wastage is not a trivial effect of dioxin; it is probably the cause of death in the very sensitive guinea pig.

British studies in the mid-1970s showed that animals recovering from dioxin exposure had unexpectedly high numbers of cells with more than one nucleus, suggesting that perhaps cell membrane proliferation had been impaired by dioxin exposure. This work might provide a clue to the wasting effect dioxin has on animals.

Certain experiments indicate that some of dioxin's effects are brought about by such incredibly small doses of the compound that the number of molecules in the dose is too small to account for the observed effect—at least in terms of a receptor binding model. In these cases, at least, there seems to be some sort of chain reaction that magnifies the effect of a small dose of dioxin.

peared to be healthy, and their abortion rate, one in four, was about the same as that of the nontreated group, where three abortions occurred in 11 pregnancies.

Clearly, dioxin is fetotoxic to some animals and causes birth defects in others. However, its high toxicity to the mother means that the range in which it causes toxic effects on the fetus but not on the mother is very narrow. Thus, some toxicologists classify dioxin as a weak teratogen. Ironically, the fact that humans appear to be less sensitive to the acute effects of dioxin means that it could be a more potent teratogen for them than it seems to be for laboratory animals.

Several independent tests in rats or mice show that dioxin is an extremely potent carcinogen in these animals. Richard J. Kociba of Dow Chemical's Toxicology Research Laboratory found that female rats fed 10 or 100 ng of dioxin per kg of body weight developed a greatly increased number of liver tumors. At the higher dose level, both male and female rats developed increased numbers of tumors in the mouth, nose, and lungs, as well as in the liver. Nearly half the female rats in the higher exposure group developed tumors. When the data on female rats are used to calculate the potency of dioxin as a carcinogen, dioxin comes out to be about three times as potent a carcinogen as aflatoxin B_1, which is one of the most potent carcinogens known. Equally significant, however, according to Kociba, is the finding that at doses below 10 ng even the female rats showed no increased incidence of tumors in this study. He considers this evidence that there is a no-effect level for dioxin-induced cancers in the rat.

A similar study conducted for the National Cancer Institute by researchers at Illinois Institute of Technology found statistically significant increases in thyroid tumors in male rats at all doses studied and an increase in subcutaneous tissue fibronomas in male rats at the highest dose level (0.5 mg per kg of body weight per week). In female rats, the study found an increase in tumors of the liver, subcutaneous tissue, and the brain at this same dose level.

Besides these two studies there

2,3,7,8-Tetrachlorodibenzo-p-dioxin is a crystalline solid at room temperature

have been about a half-dozen others that provide some evidence that dioxin is a carcinogen in rats and mice. Although some of these other studies have methodological flaws that make them less definitive than either the Kociba or the NCI study, a panel evaluating the carcinogenic potential of dioxin for the Environmental Protection Agency in 1981 concluded that collectively these studies support the conclusions of the Kociba and NCI studies and provide strong evidence that dioxin is a potent carcinogen in animals.

Most chemical carcinogens tend to attack specific organs and produce large increases in one particular type of tumor. Dioxin produces many different tumor types in different organs, which has led some researchers to speculate that it may be a promoter, rather than an initiator, of carcinogenicity. In other words, dioxin might not actually be responsible for tumor formation, but might instead work in some way that makes the cells more receptive to tumor formation if some other activating agent is present to begin the process.

Several studies have been designed to consider this possibility. One, by Henry C. Pitot and coworkers at the University of Wisconsin, examined the effect of dioxin on rats that already had been exposed to another carcinogen, diethylnitrosamine. Animals receiving both substances had a greatly increased incidence of liver tumors compared to those that received dioxin alone, suggesting that dioxin can be a promoter of carcinogenicity. However, in a series of studies by D. L. Berry of Oak Ridge National Laboratory's biological division, dioxin neither initiated nor promoted carcinogenicity when administered along with polycyclic aromatic hydrocarbon carcinogens. Instead, it appeared to block the effect of these carcinogens in mice.

Dioxin's chemical structure suggests that it could intercalate into DNA as several carcinogen initiators are believed to do. However, experiments designed to show such interaction have, so far, given only negative results, possibly because the molecule is so highly reactive with cellular proteins that it is not actually available to react with DNA. The highest estimate of the degree of covalent bonding of dioxin to rat liver DNA in vivo is less than 1 molecule of dioxin per 10^{11} nucleotides, or four to six orders of magnitude less than what is found for most chemical carcinogens.

As is almost always the case in dioxin research, the interpretation given to these and other animal test findings depends very much on who is making the interpretation. To Dow Chemical's director of biomedical research, James H. Saunders, the animal data show that dioxin is a promoter, but not an initiator, of carcinogenicity in animals. The EPA carcinogen assessment group, on the other hand, says that since promoters generally do not produce the large increases in tumor formation when given alone that dioxin produces, dioxin should be regarded as both an initiator and a promoter of carcinogenicity.

The differences in interpretation given to the animal data on dioxin toxicity, however, pale almost to insignificance when compared with the differences that arise from examining the human data. All of the data on humans come from people who somehow have been inadvertently exposed to dioxin, always in combination with many other halogenated aromatic chemicals, and often in situations where the exposure occurred years or even decades before anyone realized that it might have important health consequences. As a result, such basic information as exactly who was exposed to dioxin at what concentration and for how long often can only be estimated.

As with animal studies, the acute effects of dioxin exposure are the easiest to establish. Most of these data come from industrial accidents in which a fairly small number of workers received a single exposure to dioxin. There have been more than 800 reported cases of this type of exposure. In addition, some 37,000 people may have been exposed to measurable amounts of dioxin when a 2,4,5-trichlorophenol-manufacturing reaction went out of control at the ICMESA chemical plant near Seveso in northern Italy. More than 500 residents of nearby towns were treated for what were presumed to be toxic effects following the accident. Thus, Seveso stands out as the single most important industrial accident in terms of the information it can provide about the human health effects of dioxin.

By far the most significant finding from the Seveso data and those of the other industrial accidents is that humans are much less sensitive to the immediate toxic effects of dioxin than are guinea pigs. So far, there has been no clear case of a human death caused by dioxin exposure, discounting voluntary abortions that were performed following the Seveso accident. There are, however, many well-documented toxic effects.

The bellwether of these acute effects is thought by many epidemiologists to be chloracne, a skin condition in which circular patches of blackheads and pale yellow cysts develop on the face and, in more severe cases, on other parts of the body.

More than 800 workers have been exposed to dioxin in industrial accidents

Date	Workers exposed	Location of accident	Remarks
1949	250	Monsanto's 2,4,5-trichlorophenol plant at Nitro, W.Va.	122 cases of chloracne being studied: so far, 32 deaths vs. 46.4 expected: no excess deaths from malignant neoplasms or circulatory disease: studies continue
1953	75	BASF's 2,4,5-trichlorophenol plant at Ludwigshafen, West Germany	55 cases of chloracne, 42 severe: 17 deaths so far vs. 11 to 25 expected (4 gastrointestinal cancers and 2 oat-cell lung cancers): most common injuries were impaired senses and liver damage: studies continue
1956	?	Rhône-Poulenc's 2,4,5-trichlorophenol plant in Grenoble, France	17 cases of chloracne, also elevated lipid and cholesterol levels in blood
1963	106	NV Philips' 2,4,5-T plant in Amsterdam, the Netherlands	44 chloracne cases (42 severe), of whom 21 also had internal damage or central nervous system disturbances: 8 deaths so far (6 possible myocardial infarctions): some symptoms of fatigue: full report planned
1964	61	Dow Chemical's 2,4,5-trichlorophenol plant at Midland, Mich.	49 cases of chloracne: deaths so far 4 vs. 7.8 expected, 3 cancer deaths vs. 1.5 expected, one a soft-tissue sarcoma: studies continue
1965–69	78	Continuing leaks in 2,4,5-trichlorophenol processing area of Spolana's 2,4,5-T plant near Prague, Czechoslovakia	78 cases of chloracne: so far 5 deaths: many of the 50 workers studied for more than 10 years have hypertension, elevated blood levels of lipid and cholesterol, prediabetes: significant amounts of severe liver and neurologic damage: studies continue
1966	?	Rhône-Poulenc's 2,4,5-trichlorophenol plant in Grenoble, France	21 chloracne cases
1968	90	Coalite & Chemical's 2,4,5-trichlorophenol plant in Derbyshire, U.K.	79 chloracne cases: so far 1 death from coronary thrombosis, cohort study planned: company refuses to divulge any more information
1976	156[a]	ICMESA's 2,4,5-trichlorophenol plant at Seveso, Italy	Workers are being studied along with exposed townspeople: more than 500 residents treated for presumed toxic symptoms: 134 confirmed chloracne cases: overall mortality rate normal so far: studies continue

[a] In addition to these ICMESA workers, some 37 000 residents of nearby towns also were exposed to dioxin in this accident. **Source:** American Medical Association study, 1983

By itself, chloracne is not considered a serious condition, although it can be disfiguring while it persists. After mild exposure it usually clears up in a few months, but for more severe cases it can last for as long as 15 years. Hundreds of cases of chloracne have been seen after industrial accidents, including 134 confirmed cases at Seveso. Most of the Seveso cases were elementary school children.

In addition to chloracne, other symptoms develop with increasing dioxin exposure. These include a general sense of fatigue or malaise, disturbances in the responses of the peripheral nervous system such as a measurable slowing down of the speed at which nerve impulses travel through the limbs, and liver toxicity including changes in many enzyme levels and in some cases enlargement of the liver. Industrial exposure data seem to indicate that these conditions generally disappear after a few years and the experience at Seveso seems largely to confirm these findings.

Of more concern at Seveso and elsewhere are the possible chronic effects, especially those that might be caused by lower-level exposures like those experienced by soldiers serving in Vietnam during the 1960s when dioxin-contaminated herbicides were used there, by workers in plants making dioxin-contaminated products and by their families, by citizens living in communities like Times Beach, Mo., with its unexpectedly high levels of dioxin in the soil, or even by the population of areas where 2,4,5-T or other dioxin-contaminated herbicides may have been used during the long period when such use was allowed in the U.S. Potentially exposed people in these categories easily number in the hundreds of thousands.

Fortunately, the evidence for chronic health effects in humans is much less substantial than for acute effects. There are, in fact, distinguished researchers who argue that no chronic human health effects of dioxin have been proved. Stated just that way, probably few epidemiologists would disagree. But there are studies that suggest long-term health problems and literally thousands of anecdotal incidents that link dioxin exposure to health problems.

Probably the most highly respected studies suggesting a link between dioxin exposure and long-term health effects are those of Swedish epidemiologist Lennart Hardell at University Hospital, Umea. Hardell's work links use of dioxin-contaminated phenoxy herbicides with an increased incidence of soft-tissue sarcomas, a rare form of cancer that affects muscle, nerve, and fat tissue. In two studies he finds a five- to sixfold increase in the incidence of this type of tumor in people who have used phenoxy herbicides compared with his control group.

Dow scientists, and others, have criticized the Hardell studies on several counts. For one thing, the determination of whether or not subjects were exposed to phenoxy herbicides was made by asking them or their relatives whether they could remember any exposure. This is not a very accurate method, and, according to Dow's Saunders, people in the exposed group more frequently were asked if they could recall herbicide use than were people in the control group. Another point that concerns epidemiologists is that the people in one study apparently were exposed to products that contained much lower levels of dioxin than those in the other study, but both groups showed the same degree of increased risk. Such data suggest that some factor other than dioxin might be responsible for the elevated cancer risk. Finally, there is a problem with the identification of the tumors as soft-tissue sarcomas. Because this is a rare cancer type, most pathologists have very little experience in identifying it. It is, to some degree, a classification that is used for tumors that don't fit into other, more clearly definable categories. Hardell relied on medical records to identify the sarcomas; he did not examine the tissues himself.

Nevertheless, the Hardell studies cause concern, and that concern is increased by early results from studies of Monsanto and Dow Chemical workers who were exposed to dioxin in separate industrial accidents in 1949 and 1964. Altogether, 182 workers from these two incidents are being monitored. By 1979, 36 of these workers had died, fewer than the 54 that would have been expected based on national mortality statistics. However, three of the people who died had soft-tissue sarcomas, and a fourth, who has died since 1979, also had soft-tissue sarcoma. For a form of cancer with a predicted incidence of less than 1% among cancer victims, finding four in such a small sample is unexpected. "It certainly raises the question as to whether there is something there," says Dow's Saunders, "but, [although] it is statistically significant, there is always that uncertainty of what would have been the luck of the draw in a sample this small."

Examination of death certificates and hospital records for Midland County, Michigan, where Dow's plant is located, also shows an elevated incidence of soft- and connective-tissue cancers among women in the period from 1960 to 1978. Exactly what this finding means is unclear, according to a report from the Michigan Department of Public Health released last month.

"It is not my judgment at this point that there is a clear link [between dioxin exposure and incidence of soft-tissue sarcomas in humans]," Saunders says. "It is a question that merits further study. We do not see sarcomas in animals [exposed to dioxin]," he points out. "What we see are carcinomas, [which are] epidermally derived tissue tumors, particularly liver cancer, as in the rat. Furthermore, when one sees cancer in rats, one sees it at a level 10 times that which produces obvious toxicity in the animal. In other words, when one produces liver cancer with dioxin in the rat, one has a very sick rat who is very sick for a long time and then develops cancer." This is very different from the humans who develop soft-tissue sarcomas, he maintains.

Other studies do not show an association between phenoxy herbicide use and increased incidence of soft-tissue sarcoma. One study that examined the relationship among people in various occupations in the state of Washington and incidence of soft-tissue sarcoma found that the occupations with the greatest number of soft-tissue sarcomas, as determined by data on death certificates, were marine engineers and bankers, groups that would not be expected to have had particularly high exposure to dioxins. Allan H. Smith and associates at the school of medicine at Wellington Hospital, New Zealand, are in the midst of a study of the incidence of soft-tissue sarcomas among herbicide applicators in New Zealand. Because New Zealand requires herbicide applicators to be registered, records of exposure to phenoxy herbicides are particularly good in that country. In a preliminary report presented in 1982, Smith had not found any instances of soft-tissue sarcomas in this group.

Dioxin's lethality compared to other poisons

Substance	Animal	Minimum lethal dose (moles per kg body weight)
Botulinum toxin A	Mouse	3.3×10^{-17}
Tetanus toxin	Mouse	1.0×10^{-15}
Diphtheria toxin	Mouse	4.2×10^{-12}
2,3,7,8-TCDD	Guinea pig	3.1×10^{-9}
Bufotoxin	Cat	5.2×10^{-7}
Curare	Mouse	7.2×10^{-7}
Strychnine	Mouse	1.5×10^{-6}
Muscarin	Cat	5.2×10^{-5}
Diisopropylfluorophosphate	Mouse	1.6×10^{-5}
Sodium cyanide	Mouse	2.0×10^{-4}

Source: EPA

The Veterans Administration is putting together a study designed to see if Vietnam veterans, who may have been exposed to dioxin through the use of agent orange in Vietnam, have an increased incidence of soft-tissue sarcomas. The study, being directed by epidemiologist Han K. Kang, will use data from the Armed Forces Institute of Pathology, which is, in effect, the U.S. center for the evaluation of soft-tissue sarcomas. The institute has on file some 8500 cases of soft-tissue sarcoma, or roughly one quarter to one third of all the cases ever reported in the U.S. The study will examine tumors reported to the institute between 1975 and 1980 to see if Vietnam veterans are overrepresented in this group. A final report of the study is expected in 1985.

One potential problem with this study is that the latency period for soft-tissue sarcomas is thought to be about 15 years. Since dioxin contamination of Vietnam occurred in the 1960s, the time period may be too short to evaluate properly what effect dioxin use in Vietnam had on development of this type of tumor. However, by 1980, reports of Hardell's findings were causing pathologists to look more closely for soft-tissue sarcomas, and the researchers chose a 1980 cutoff to remove this bias from their study.

In addition to cancer, animal studies raise concern about the possibility of fetotoxicity in humans exposed to dioxin. Several studies and many anecdotal reports of such effects in humans have appeared. By and large, however, these studies have methodological flaws that bring their findings into question.

One of the most important of these studies, at least politically, involved a group of nine women in the Alsea

Basin in Oregon who lived near forests that were sprayed seasonally with dioxin-contaminated herbicides. The women were concerned that 13 miscarriages in their group in the mid-1970s seemed to be linked chronologically with the spraying of the forests. The Environmental Protection Agency conducted two studies, one examining just these nine women and a larger one looking at miscarriage rates in that part of Oregon. Although the first study did not find a statistical relationship between the women's miscarriages and the spraying, the second study did. This study played a major role in EPA's decision in 1979 to issue an emergency suspension against many uses of the dioxin-contaminated herbicide 2,4,5-T.

However, the study did not stand up to critical evaluation. A team of University of Oregon researchers in 1979 panned the study on practically all counts. Among other things, they found that the study did not have a proper control, its data both on miscarriages and on 2,4,5-T spraying were inaccurate, there were many other factors besides 2,4,5-T spraying that varied among the three groups examined, and the variations in the levels of miscarriages reported by the study were well within expected ranges.

Poorly designed or conducted studies seem to plague the effort to find out if dioxin causes human reproductive effects. At least two Vietnamese studies, one from the early 1970s and one announced earlier this year, claim to show a substantial increase in these conditions as well as cancer following the spraying of agent orange in that country. However, western epidemiologists are uncomfortable with the lack of data on normal rates for miscarriage and birth defects in the Vietnamese population. They also question the way in which the Vietnamese data were collected.

Dioxin's lethal dose varies in different species

Animal	LD_{50} (µg per kg body weight)
Guinea pig	1
Rat (male)	22
Rat (female)	45
Monkey	<70
Rabbit	115
Mouse	114
Dog	>300
Bullfrog	>500
Hamster	5000

Source: Poland and Knutson, *Annual Review of Pharmacology & Toxicology*, 1982

Similarly, data from Seveso seem to show an increase in both the number of spontaneous abortions and in the number of birth defects in the period immediately following the ICMESA accident. However, there is so much uncertainty about what levels should be considered normal for this population that it is unlikely that the question of whether the Seveso incident caused increases in these conditions will ever be resolved. Epidemiologists who think there may be an association between dioxin exposure and these effects call the Seveso data "suggestive" of an effect; those who think that these effects probably don't occur in humans point out that the levels were well within the normal range for western countries.

There exist, in addition, several studies that do not show any increase in miscarriages or birth defects among populations that might be considered at risk because of their dioxin exposure. Studies of Dow Chemical and Monsanto chemical workers and their wives show no increase in either of these factors. So does a study released last month by the Michigan Department of Public Health that examined the rate of birth defects in Midland County, where Dow made 2,4,5-trichlorophenol until 1979.

A recently released study of the reproductive effects of dioxins on the families of Australian soldiers who fought in Vietnam during the period when agent orange was being sprayed there shows no increase in miscarriages or birth defects among these families. The study is highly praised scientifically, but there is uncertainty as to whether these Australian soldiers received very much exposure to dioxin while they were in Vietnam. Consequently, this negative finding does little to allay the fears of those who think dioxin may cause human reproductive problems.

So the overall picture that has emerged so far shows dioxin as extremely toxic and carcinogenic based on animal studies, but the picture is much less clear about human health effects. Human studies are continuing—the U.S. government is spending more than $100 million on several epidemiologic studies of the health consequences of possible dioxin exposure to veterans who served in Vietnam, and major studies also are under way in Australia, New Zealand, Finland, Sweden, the U.K.,

Dioxin has different effects in different animals

Symptom	Monkey	Guinea pig	Cow	Rat	Mouse	Rabbit	Chicken	Hamster
Abnormal cell proliferations or organ enlargement								
Gastric mucosa	++	0	+	0	0			0
Intestinal mucosa	+							++
Urinary tract	++	++	++	0	0			
Bile duct/gall bladder	++		+		++			
Lung				++				
Skin	++		a	0	0	++		
Atrophy or decreased cell proliferation								
Thymus	+	+	+	+	+		+	+
Bone marrow	+	+			+		+	
Testicle	+	+		+	+		+	
Other effects								
Liver lesions	+	0		++	+	++	+	+
Edema	+	0		0	+		++	+

Note: 0 indicates lesion not observed; + indicates lesion observed (number of pluses notes severity). a Skin lesions are observed in cattle, but they are different from the lesions seen in other species. **Source:** Poland and Knutson, *Annual Review of Pharmacology & Toxicology*, 1982 and many other countries. Most of the U.S. studies are scheduled to be completed by 1987, but already epidemiologists wonder whether uncertainties about exposure levels and questions about what other factors may have accompanied dioxin exposure will weaken the value of the studies' findings.

Not surprisingly, current assessments of the risk dioxin poses to human health vary greatly depending on which of the available data seem most important to the assessor. A reasoned argument can be made that the animal data show, in addition to severe toxic effects in certain species, that great variability can be expected from one animal species to another and that the available human data suggest that humans are among the least sensitive of animals to dioxin's effects. That interpretation is not incompatible with any of the human epidemiologic data published so far, and it may turn out to be the true picture of dioxin's hazard.

Most toxicologists, however, are much more conservative in their risk assessment. This means that, in the absence of stronger evidence to the contrary than has been seen so far for dioxin, a proven risk in animals is considered to be a potential risk in humans, and a substance that causes acute effects in humans is viewed with suspicion as a possible cause of chronic effects.

It is in this spirit of prudence that EPA views the cancer risk of dioxins in humans. "Carcinogenic responses have been induced in mice and rats at very low levels of [dioxin]," EPA's carcinogen assessment group concluded in 1981. "In addition, dioxin has been shown to be a potent cancer promoter. These results, together with the strongly suggestive evidence in epidemiologic studies, constitute substantial evidence that dioxin is likely to be a human carcinogen."

Such assumptions are only the first step in coming up with an estimate of human risk in any particular situation, however. At a site like Times Beach, Mo., explains Renate D. Kimbrough, medical officer for the center for environmental health at the Center for Disease Control, assessors also need to know how much dioxin people exposed to contaminated soil are likely to absorb. That's not well established, she says, although one study at the University of California has shown that when dioxin is on the skin, 1 to 10% will be absorbed. Dioxin binds to soil, so probably less is absorbed from there than if the dioxin were applied directly to the skin. One Seveso study found that about 1% of soil dioxin was absorbed, but the sample size was small and the results are inconclusive.

C&EN staff photo

Saunders: experimental uncertainty

Besides, Kimbrough points out, absorption may not be the only route of exposure. Some contaminated dust may float in the air and enter the lungs, and some may be eaten, especially by children.

Given all these uncertainties, CDC still came up with a level of soil contamination that it believed was low enough to pose no threat to the health of Times Beach residents. "We decided to take one increased incidence in a million as a reasonable risk," Kimbrough says, and to base their hazard assessment on studies of birth defects caused by dioxin in rhesus monkeys. Toxicologists usually allow a factor of 100 below the no-effect level in an animal study as a margin of safety when extrapolating to humans, she explains. However, in the case of the monkey study, the animals had limited, not lifetime, exposure to dioxin, so the standard safety factor was increased to 1000. The resultant calculations come up with 1 ppb as a level likely to be safe. A similar calculation based on the carcinogenicity of dioxin in rats gives about the same level, Kimbrough says.

Such values ought not to be taken as a national standard for dioxin in the soil, she cautions. CDC will be reviewing its assessment procedure with outside consultants to see if it is possible to come up with national standards for soil contamination. Even if such standards can be drawn up, there is not likely to be a single level that will be appropriate for all sites, she points out. For example, in desert areas, where very few people live, soil probably could contain higher levels of dioxin before the total health risk became equivalent to the one at Times Beach. On the other hand, data from the U.S. Department of Agriculture indicate that grazing livestock easily pick up dioxin from the soil, probably because they eat so much soil as they graze. People who eat the meat from these animals or drink their milk have an additional route of exposure to dioxin. Thus, soil levels in areas where animals graze must be lower to obtain an equivalent risk.

Is it really appropriate to base human health risk estimates on the experience of laboratory animals when limited data suggest that humans may be a good deal less susceptible to dioxin than some laboratory animals are? Kimbrough thinks it is. There is very little information on what chronic exposure levels have been in workplaces, she points out, so it is difficult to know how much weight to place on long-term studies of workers' health that seem to find no ill effects. Also, except for Seveso, there is very little information on the effects of dioxin on women or children. And even at Seveso, soil dioxin levels in areas where people were allowed to return to their homes were generally in the parts-per-billion range or lower. Animal studies show that dioxin's effects vary greatly from one species to another. In some cases the effects have even been pinned down to the presence of a particular genetic locus within a species. But the human population is genetically very diverse, so that even if many people are not susceptible to the hazards of dioxin, there may be subpopulations who face a substantial risk. □

Both Incidence, Control of Dioxin Are Highly Complex

A by-product of many industrial processes, dioxin presents big problem in waste disposal; the technology is on hand, but economic, political barriers persist

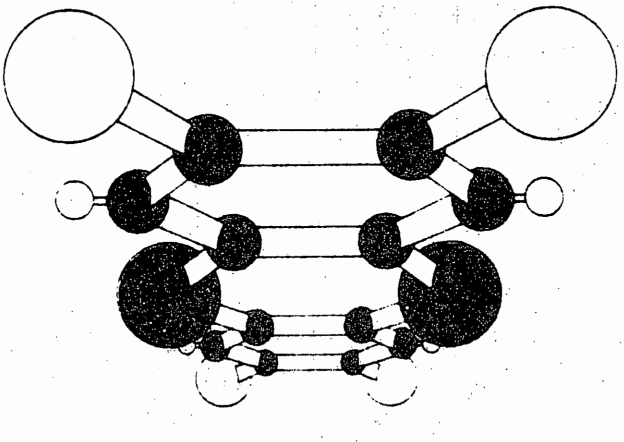
Ward Worthy
C&EN Chicago

C&EN's dioxin coverage now turns to the practical world of industry. How and where, exactly, do dioxins t[illegible]p? And how can they be controlled?

It's a complicated situation, in part because of the myriad of dioxin structures and reactions. So a short review of chemistry is in order before a look at commercial reactions and disposal methods.

On the dioxin molecular framework—consisting of two benzene rings connected by two oxygen bridges—there are eight positions where substitutions can take place. In any or all of these eight substituent positions, hydrogen atoms can be replaced by other atoms or by organic or inorganic radicals. The number of possible combinations is almost limitless.

These days, of course, when people speak of dioxins, they likely are referring to the black-sheep branch of the family, the chlorinated dioxins (CDDs), in which one to eight of the substituent positions are occupied by chlorine atoms. The arrangement allows for a total of 75 different CDDs; most but not all of them have either been synthesized or identified as by-products or contaminants in other materials.



There are 22 isomers of tetrachlorodibenzo-*p*-dioxin (TCDD) alone, all of which have been synthesized. However, the bulk of attention has gone to what is apparently the most toxic member of the group, 2,3,7,8-TCDD. This isomer is symmetrical across both horizontal and vertical axes. At room temperature, it is a colorless crystalline solid. It melts at 305 °C. Chemically, it is quite stable; for example, its thermal destruction requires temperatures of more than 700 °C. It is lipophilic, and it binds strongly to soils and other particulate matter. It is only sparingly soluble in water and most organic liquids.

Although 2,3,7,8-TCDD is the most notorious of the dioxins, it usually occurs mixed with other chlorinated dioxins. Some of these also are quite toxic.

How, then, do these compounds arise? To oversimplify the situation, a dioxin comes from a dioxin precursor. This compound must contain an ortho-substituted benzene ring, and one of the substituents must include an oxygen atom attached directly to the ring. In addition, two substituents (but not the oxygen atom itself) must be able to react with each other to form another compound. The reaction is favored by basic conditions and by temperatures in the range 180 to 400 °C. The presence of a catalyst, such as copper powder, promotes the reaction.

Although there exist a multitude of organic chemicals that qualify as dioxin precursors, perhaps the most notable of these is 2,4,5-trichlorophenol (TCP). It's notable—if for no other reason—because its geometry is such that when two TCP molecules condense, the likely result is 2,3,7,8-TCDD. According to several studies, the reaction takes place in two steps, with a diphenyl ether serving as the intermediate.

That's one way dioxins can be formed. However, it's not the only way. Actual findings don't always conform to what would be expected from that straightforward condensation reaction. Other, more complex mechanisms for forming CDDs have been discovered and still others proposed.

In fact, a case can be made—and

has been made—that many reactions can occur whenever organic and chlorine-containing materials are burned together, and that one of the things that happens is the formation of trace amounts of CDDs. There is evidence to suggest that the hypothesis is true, at least in principle, at least some of the time. Whether it's relevant to current problems of dioxin contamination is a matter of controversy, with the dispute stemming in good part from differing opinions as to what level of dioxins, if any, is acceptable in the environment.

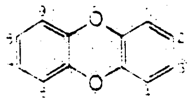
In the great majority of everyday combustion processes, the amount of dioxins produced is likely to be very small—and not much can be done about it anyway. In certain cases, however, the combustion hypothesis should be (and is being) looked at from a practical standpoint: for example, in the incineration of municipal wastes that may contain significant amounts of polyvinyl chloride or chlorophenol-preserved wood products.

Regardless of how many odd ways trace amounts of dioxins may enter the environment, and regardless of what they may mean, the fact remains that those dioxin-related incidents that have become public scandals—Seveso, agent orange, Love Canal, Times Beach—can fairly be traced back to the chemical industry. Specifically, they can be traced to producers of halogenated phenols and their derivatives.

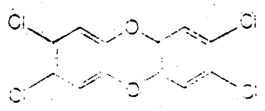
Among these chlorinated organics, o-chlorophenols deserve particular attention. One of these, TCP, practically demands especially close scrutiny. TCP is made in large quantities. It's an intermediate in the manufacture of several other widely used products, including 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and related herbicides. As noted, its structure is such that 2,3,7,8-TCDD is a likely by-product of its manufacture. TCP's the one that, directly or indirectly, has caused most of the trouble with dioxins.

2,3,7,8-TCDD is one compound in a family

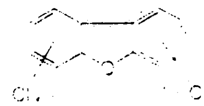
All dibenzo-*p*-dioxins have a three-ring structure consisting of two benzene rings connected by oxygen atoms:



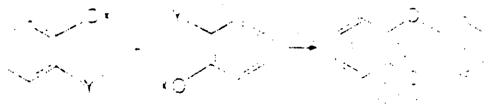
And 2,3,7,8-tetrachlorodibenzo-*p*-dioxin is one of the 75 possible chlorinated dioxins:



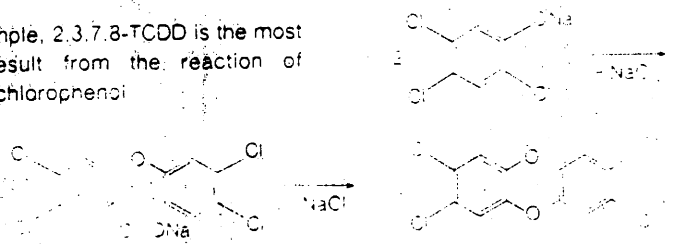
Related are chlorinated dibenzofurans:



Dioxin precursors combine to form dioxin in the general reaction:



For example, 2,3,7,8-TCDD is the most likely result from the reaction of 2,4,5-trichlorophenol



Although it's not the only possible way to do it, commercial production of TCP in the U.S. was carried out by hydrolyzing 1,2,4,5-tetrachlorobenzene, which is one of the isomers obtained by rechlorinating o-dichlorobenzene. Reaction of 1,2,4,5-tetrachlorobenzene with sodium hydroxide yields mostly the sodium salt of TCP. That salt can be used as is to make derivatives, or it can be neutralized with a mineral acid to give TCP.

Process details vary. For instance, one of several solvents (including methanol and water) can be used for the hydrolysis. Proper attention to temperature and pH control can minimize the formation of dioxins during the hydrolysis. However, trace amounts of dioxins usually are formed, along with other impurities.

As one step in the purification process, the crude salt is washed with toluene, which removes some of the high-boiling impurities, including dioxins. The organic and aqueous phases are allowed to separate and the toluene layer is sent to a still for recycling. The product can be further purified—for example, by vacuum distillation.

Current production of chlorinated phenols and related products is monitored very carefully for dioxin content. However, purity is a relative term—in the chemical industry, at least—and, in general, higher purity is reflected in higher cost for the product. So before the nature of the dioxin problem became evident, producers weren't always so careful. Consequently, there have been many confirmed instances in which commercial products—some quite widely used—have been found to contain trace levels of dioxin.

Many millions of pounds of chlorinated phenols and related compounds are made and used each year. Not surprisingly, they turn up everywhere. Pentachlorophenol (PCP), for example, is used in large tonnages to preserve wood. PCP, TCP, and related products are used as biocides for process and cooling waters in many industries and in [illegible] small-volume applications.

Even though any of these products may contain some level of dioxin contamination, there are several sources from which dioxins can enter the environment. Obviously the

products themselves are one source, and this can be a matter of concern to those who work routinely with those products. But they probably aren't the most important source, from the standpoint of imminent danger to the public. Many dilution effects are at work, so just traces of dioxins are what finally get into the environment.

Many combustion processes afford some possibility of release—or even creation—of dioxins, with the degree of hazard depending on what is being burned and the conditions under which combustion takes place. Again, concentrations typically are very low.

Accidents or mistakes in manufacturing chlorinated organics are another potential source of dioxins. They can be an extremely dangerous source of heavy local contamination, as demonstrated by the release from the TCP reactor at Seveso. In addition, there have been numerous other smaller, less-publicized—but not necessarily insignificant—accidents involving the making of TCP.

Aside from Seveso, the most famous cases of dioxin contamination of the environment have resulted from improper disposal by certain manufacturers or by their agents of products and process wastes containing relatively high concentrations of dioxins.

To return to the aforementioned production example, crude TCP can be purified by washing it with toluene (which is distilled and recycled, so that the impurities accumulate in the still bottoms). It can be further purified by vacuum distillation (again, the impurities collect in the bottoms). The dioxins and other impurities aren't destroyed in those operations. They're just moved somewhere else and, in the process, concentrated to even more dangerous levels.

These highly contaminated wastes can be rendered essentially harmless by a number of methods, including incineration. That isn't what always happened, however. Incineration is a comparatively expensive disposal option. In all too many instances it was cheaper—or so it seemed at the time—just to put the stuff in drums and bury it where it couldn't hurt anybody. That would have been fine except that the drums inevitably leaked and the dioxins (and other nasty compounds) started showing up in the water and soil around the storage site, such as at Love Canal.

Or, as happened at Times Beach, the producer simply turned his wastes over to some guy with a truck, who hauled them away, mixed the dioxins with oil, and sprayed them over the countryside.

Once at large, dioxins spread at varying rates and to varying degrees through soil, water, and air, and through living things. The ultimate fate of dioxins depends on circumstances. Although the details vary, a number of studies have shown that dioxins are degraded rather quickly by sunlight or artificial ultraviolet light. For this to happen, however, the photolytic rays must be able to reach the dioxin molecules, and hydrogen for the reaction must be available from some organic donor. In the real world, such a hydrogen donor usually is nearby—either some other component of the waste of which the dioxins are a part, for example, or even the vegetation on which the dioxins have been deposited. Thus, dioxins spread thinly in the sun will, within a few days, usually disappear or at least diminish to undetectable levels.

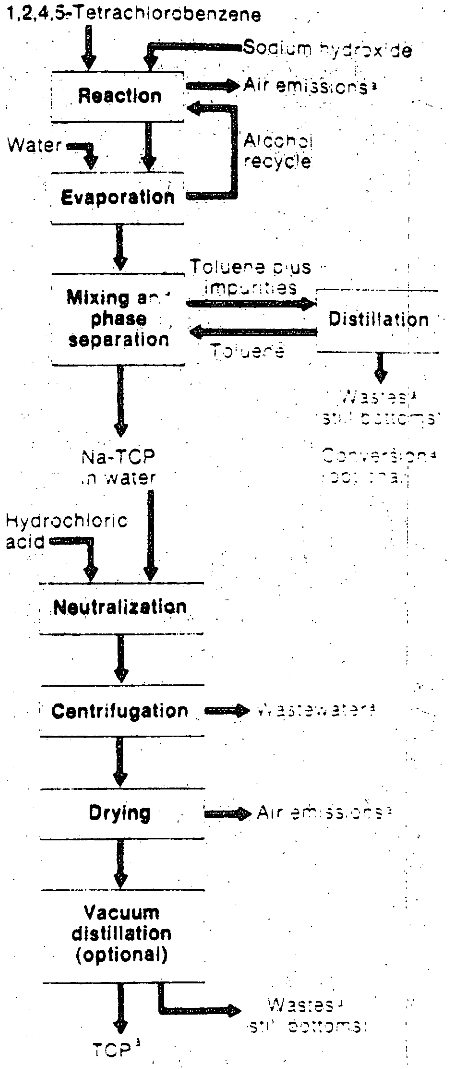
However, once dioxins penetrate the soil, they are there to stay for quite a long time, according to a number of studies. Some studies indicate that no significant degradation of dioxins occurs in the soil. Other studies suggest that some degradation does take place, but it's usually too slow to be of any comfort. In any event, places like Seveso and Times Beach demonstrate that dioxins, undisturbed, can persist in soils for many years, unless they are washed, blown, or otherwise carried away.

Since dioxins have spread rather extensively throughout the environment, what can be done about them? More to the point, perhaps, what should be done about them? Answers to the first question are fairly clear. Answers to the second question are much less clear, and subject to honest differences of opinion.

In the case of extremely low dioxin levels—a few parts per trillion or lower—the answer to both questions is probably nothing, except to stem the high-level sources, to prevent any more of the leaks, emissions, and improper disposal operations that were the original source of most of the low-level contamination.

In the case of the more highly contaminated dioxin dumps, there are a number of things that could be done, all of them quite a b[illegible]ple. Although something should be done to clean up these worst cases, there is much disagreement as to what. In the "in-between" cases, cost-benefit analyses get even trickier, and there is even less agreement.

Making 2,4,5-trichlorophenol can lead to dioxin contamination



a Potential sources of environmental dioxin contamination.
Source: Adapted from EPA, Dioxins

GC, MS useful techniques in the analysis of dioxin

How does one determine whether and to what extent something is contaminated by dioxins? The easy answer is that it's usually done with gas chromatography and mass spectrometry. But there's a lot more to it than that. Normally, dioxins are present, if at all, at levels ranging from parts per million down to the vanishing point. They coexist with many other compounds, and many of these are present in much larger amounts and capable of interfering with the analysis.

Since it's impossible to run a sack of dirt or a Coho salmon through even the most user-friendly GC/MS setup, sample preparation is an extremely important part of the process. The first step is to transfer the dioxins (and other chlorinated organics) from the sample matrix to an organic liquid, by a series of extractions. An isotopically labeled internal standard is added to help determine how much sample is lost in later steps, and to assist in quantitation.

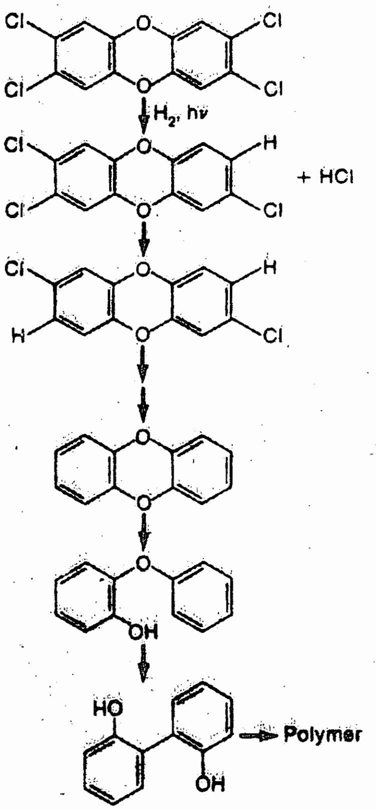
The organic extract is cleaned up with another series of washings with aqueous base and acid solutions and distilled water. Then the organic extract undergoes a sequence of preliminary liquid chromatographic separations, using a variety of columns and eluents. All the fractions from these separations are recombined and concentrated for GC/MS analysis.

Usually, the sample first goes through a GC/low-resolution MS system for preliminary screening. This can show that TCDDs, for example, are present, but it isn't sensitive enough to distinguish among the various isomers. If TCDD or other dioxins of interest are revealed by this preliminary analysis, the sample then goes to a second GC/high-resolution MS analysis. The presence and amount of specific isomers like 2,3,7,8-TCDD then can be determined from the ratios of certain key mass fragments.

With such techniques, and depending on the nature of the sample, it's possible to detect and quantify dioxins down to low parts-per-trillion levels with reasonable confidence. In the case of a "simple" sample like water, one can go even lower, down to the parts-per-quadrillion level, by taking a very large sample and concentrating the dioxins into a much smaller volume by solvent extraction. In the case of more complex samples, like soils, this approach is probably beyond the capabilities of today's analytical laboratories.

All this is terribly tedious, time-consuming, and expensive. A lot of work is going on to find simpler alternatives, especially for the preliminary screening steps.

UV light degrades dioxins to less toxic products



Source: Jurgen T. Exner, in "Detoxification of Hazardous Waste"

The basic disposal options for dioxins are the same as for other hazardous wastes: to contain them or to destroy them. Some argue that containment in a secure landfill (with all that that implies, including "impervious" liners and eternal monitoring of leachate and surrounding groundwaters) is a satisfactory means of dealing with dioxin wastes.

But security, like purity, is a relative term. Dioxins, at least some of them, aren't considered just hazardous wastes. They're considered extremely hazardous wastes. Thus there's growing sentiment not to settle for containment of dioxins, no matter how good the containment system, but to demand their outright destruction. Meanwhile, of course, much of the world's dioxin wastes is resting in dumps, some many years old, that bear little resemblance to a modern, secure landfill.

The barriers to destruction of these dioxin caches are mainly economic and political, rather than technological. Although dioxins are chemically stable, they certainly can be destroyed, with high efficiency, by the same high-temperature (1000 to 1500 °C) incineration systems used to destroy other hazardous organic wastes.

Perhaps the largest dioxin destruction operation to date involved the incineration of more than 2 million gal of agent orange left over from defoliation activities in Southeast Asia. That operation took place in 1977, in mid-Pacific Ocean, aboard the seagoing incinerator *M/T Vulcanus*, which at that time was owned by a Dutch company. Chemical Waste Management, the current owner of the ship, notes that more trial burns of dioxin wastes are set to take place soon in the Gulf of Mexico.

Mere "burning," however, isn't a satisfactory method for disposing of dioxins. If temperatures aren't high enough, there's a good possibility not only of failing to destroy all the dioxins already present, but also of actually forming new dioxins from precursor compounds contained in the wastes.

Although test data are scanty, it's reasonable to assume that some of the "advanced" incineration processes now under development, including molten salt combustion and microwave plasma destruction, might be suitable for destruction of dioxin-containing wastes.

Several chemical means of dioxin destruction also have been proposed and, to some extent, tested. These

Successful dioxin cleanup operation is complex, costly

One of the better-documented dioxin cleanup operations demonstrates that dioxin hazards can be dealt with responsibly and effectively. It also points up the tremendous complexity and expense of such an undertaking.

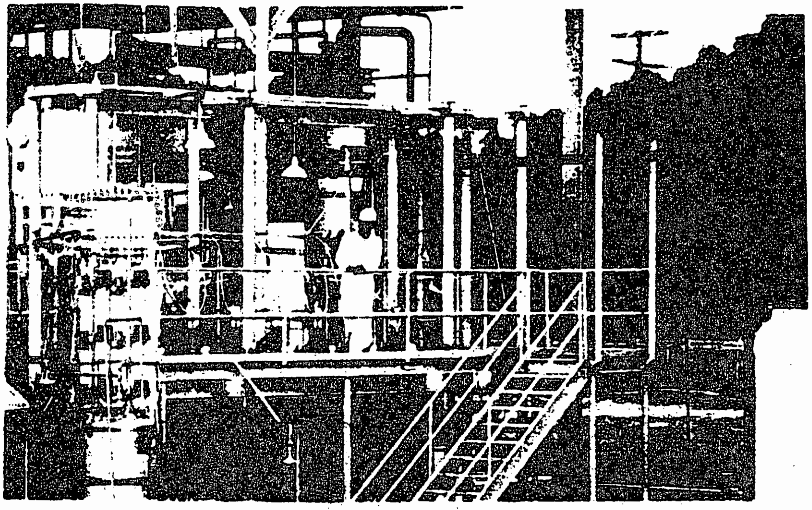
In 1969, Syntex Agribusiness bought a chemical plant at Verona, Mo., for the manufacture of animal feed additives. The previous owner had leased part of the plant and property to another firm for the manufacture of trichlorophenol and further conversion to hexachlorophene. After hexachlorophene essentially was banned in 1972, that firm went out of business and abandoned the Verona plant.

In 1974, the Syntex plant manager discovered that a steel tank on the property—never used by Syntex and presumed to be empty—actually contained about 4600 gal of dark sludge. Analysis showed the sludge to contain 356 ppm of dioxins, about 7 kg.

Although Syntex perhaps could have denied legal responsibility for the situation, the company felt that it was in its own best interests, as well as the public's, to dispose of the dioxins in a safe and acceptable manner.

The first step was to protect the tank. A concrete dike, big enough to hold all the tank's contents, was built under the tank. A building was erected over it and a fence was put around it. That was only the beginning of what would turn out to be a six-year project.

The easiest way to get rid of the dioxins would have been to incinerate them. However, there were no suitable incinerators in Missouri. Efforts to incinerate the wastes elsewhere were thwarted because Syntex was prohibited from shipping them across state lines. So Syntex started exploring the possibilities of on-site destruction.


Syntex photolysis process unit

In 1978 Syntex engaged IT Enviroscience to undertake a three-phase program: technology review to determine the best method, laboratory development and refinement of the chosen process, and finally the actual detoxification. A committee of experts was formed to provide independent evaluation and guidance. The Environmental Protection Agency also was intimately involved, along with other agencies.

Building a suitable incinerator on-site for a one-time operation would have been prohibitively expensive. IT Enviroscience came up with three other candidate processes: catalytic wet oxidation, photochemical reduction, and chemical treatment. After extensive evaluation, the photolytic method was chosen, mainly for reasons of safety, since it operated at ambient pressures. This approach required that the dioxins first be separated from the wastes by hexane extraction.

A period of refinement and scaleup followed, leading eventually to a full-size extraction and photolysis unit that included a bank of 10-kW industrial ultraviolet lamps. All this time, of course, much analytical chemistry was being conducted, along with contingency planning, industrial hygiene, legal activities, and liaison.

Finally, in May 1980, EPA approved the plan. Photolytic destruction was carried out batchwise, over a period of several weeks, with a destruction efficiency of 99.94%.

Neither Syntex nor IT Enviroscience will reveal what the total operation cost. According to a 1980 article in *Waste Age*, the installed equipment cost Syntex about $500,000. But with all of Syntex's other expenses, that was probably just the tip of the iceberg.

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include ozonolysis, chlorinolysis, catalytic wet oxidation, and various catalytic dechlorination processes. However, none have been applied full-scale. Biological methods may prove useful, especially for economical treatment of large amounts of very lightly contaminated materials. So far, however, test results have been equivocal.

In fact, aside from incineration, the only dioxin destruction method to be employed on a large (by dioxin standards) scale has been photolysis. In that operation, some 7 kg of dioxins was extracted from 4600 gal of TCP wastes and then degraded to relatively nontoxic compounds by exposure to ultraviolet light.

That case brings up the question of whether it's better to treat dioxin-contaminated materials in bulk, or to extract and concentrate the dioxins before they're destroyed. As with many other dioxin questions, the answer isn't obvious. Both approaches have been used.

Dioxins can be efficiently and fairly selectively removed from, for example, contaminated soils by repeated extractions with various organic solvents, including hexane. Supercritical fluid extraction of the dioxins also has been proposed, [illegible] it might work.

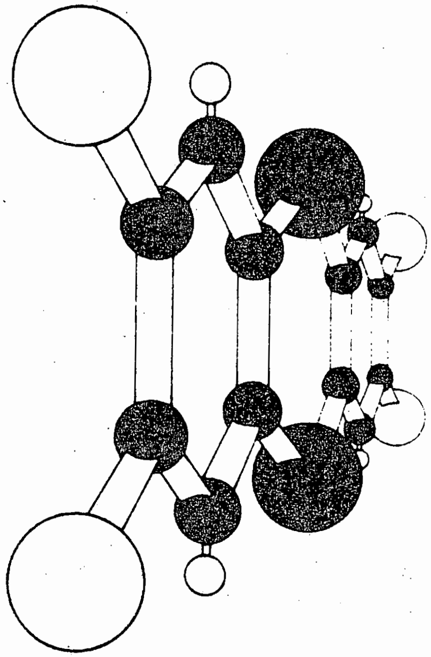
Where millions of tons of materials are contaminated by a few kilograms of dioxins, as at Seveso, it might prove easier and more economical to extract the dioxins and destroy them separately rather than to incinerate the whole mess. Either way, the logistics strain the imagination. Eventually, experience likely will provide the best solutions. □

Dioxin Liability Is Huge Problem for Companies, Courts

Lawsuits for personal injury are mounting with massive potential compensation; companies scramble for insurance, look to asbestos cases for precedents

David Webber, C&EN New York

Earlier this year, a major chemical company settled a lawsuit out of court. A farmer whose land is bisected by a utility right-of-way claimed that 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), sprayed by the utility to control vegetation under its power lines, fell onto his land as well, despite elaborate precautions by the sprayers. His family's health, he charged, had been undermined by the dioxin often found as a contaminant in the herbicide. There was, however, no visual evidence on his fields of the sort of defoliation 2,4,5-T causes. Testing detected minimal amounts of the chemical. It could have been residue from earlier sprayings. Examination of the farmer's family revealed no health problems unusual for either their age or location. On the evidence, it had all the earmarks of a case the chemical company involved would have won in court. Still, the firm elected to settle.



The chemical company in the suit is not known for its reluctance to defend itself. But cases involving dioxin elicit a different response from it and other companies associated in any way with the notorious by-product contaminant. The potential stakes are too high to worry about the relatively petty sum involved in satisfying one aggrieved farmer. Any trial involving dioxin may establish legal precedents about the compound's hazardousness to human beings. A precedent unfavorable to business could have grave financial consequences, companies believe, and their strategy has been to settle whenever possible.

But time may be running out for this policy. The lawsuits filed by Vietnam war veterans against the producers of agent orange, beginning in 1979, brought dioxin, the agent orange contaminant the veterans blame for their variety of ailments, to national attention. The discovery of large quantities of dioxin in Times Beach, Mo., last December made the chemical into a menace that might be anywhere. With public sentiment against dioxin blooming, litigation is almost sure to increase to the point where—if that point has not already been reached—the companies being sued no longer will be able to afford not to defend themselves. For claims managers advising their companies which suits to fight and which to settle on the basis of economics, it is a fretful and dangerous time.

Up to now, the dioxin issue has centered on the question of establishing the compound's hazardousness to humans. As far as most scientists are concerned, the jury is still out on that. But if research eventually proves, or if the courts, without waiting for conclusive scientific evidence, establish a presumption that the levels of dioxin to which people have been exposed are harmful, then the focus of attention is sure to shift rapidly. It will shift to compensation, and, unless Congress legislates a program to compensate victims on an exclusive basis, lawsuits—of possibly mammoth proportions—will be inevitable.

The bulk of the litigation would be made up of product liability suits by individuals or groups seeking compensation for personal injury. There also would be other types of suits. People in situations like that of the

Kloman: producers will bear bulk

residents of Times Beach, for instance, could sue for, among other things, payment for the loss of the use of their property. For companies associated with dioxin—either as producers of chemicals contaminated with it, as users of such products, or as transporters—the possibility of such suits already has been the impetus for the review and bolstering of existing insurance coverage. For the liability insurance industry, which feels comfortable only when it knows today precisely what its compensation costs will be a decade or more hence, the possibility connotes so many unpredictables that the current mood among insurers is somewhere between bewilderment and horror.

Chemical companies have to protect themselves now, if they have not already done so, against the chance of massive compensation losses. To a great extent, they have taken on that task themselves. But whether they retain self-insurance or establish a captive insurance firm, they ultimately must go into the traditional insurance market to seek reinsurance. And though wary, insurance firms are not entirely unwilling to write policies where dioxin might be involved. The insurance industry happens to be, in its own way, in a state of overcapacity. They are far more willing now than they were five years ago, when the insurance market was tight, to take risks.

But there are major problems. The biggest is the tremendous difficulty involved in predicting the potential losses dioxin suits could entail. Insurance carriers customarily set their premiums according to actuarial tables based on the rate of accidents and the size of awards in the past. In the case of dioxin, however, there is no past to refer to. The agent orange suit, a decision in which would define the nature of dioxin liability somewhat, is undoubtedly months if not years away. And even given that, the primary issue in the case at this point is whether or not—regardless of the ultimate establishment of the compound's hazardousness—the producers of the herbicide are liable at all for spraying controlled by the government. So the giant trial presumably could run its course without ever establishing precedents on dioxin liability.

Dioxin-associated firms and insurers, however, are not planning insurance strategies wholly in a vacuum. There are lessons to be gleaned, unpalatable as they might be to industry, from the ongoing asbestos litigation. The thousands of criss-crossing suits among asbestos victims, producers, users, and insurance carriers touch on a welter of issues that include most of the liability problems concerning hazardous materials. Despite the major difference that asbestos' long-term health hazard to humans has been proved and dioxin's has not, analysts cannot avoid detecting potential analogies between asbestos litigation today and dioxin litigation tomorrow.

"What ultimately happens in resolving the asbestos claims will become a precedent of sorts in resolving suits in all sorts of toxic problems," comments Rita Epstein, director of communications at the Risk Studies Foundation in New York City.

And companies can go to school on more than an implied analogy. The farmer's 2,4,5-T suit is one of more than a score of lawsuits filed in the U.S. in which dioxin is the prime issue. Of those cases, only one major one has passed through the entire trial process to a decision. For dioxin-associated companies and insurers, it is a disheartening example of what dioxin-related litigation of the future might hold in store.

Frayer: avoid legal precedents

In the case Lowe vs. Norfolk & Western Railway, 47 employees of the Norfolk & Western sued the railroad, Monsanto, and two other firms for injuries attributed to a Jan. 10, 1979, rail accident in which carbolic acid and other chemicals were spilled along the tracks outside Sturgeon, Mo. The plaintiffs, most of whom helped in the cleanup, claimed to have suffered a variety of disorders including fatigue, baldness, liver damage, brain disease and high blood pressure as a consequence of their exposure to dioxin, which Monsanto conceded could have been formed in small quantities by the chemicals involved in the spill.

Just before the trial began in March 1982, Monsanto, which owned the chemicals spilled, and the two other companies, which had built the car whose coupler yoke had ruptured, settled with the plaintiffs for a reported total of $7 million. The railroad pursued the case and lost. The jury awarded the workers more than $58 million. An appeal is under way.

The verdict was reached despite the fact that the Environmental Protection Agency detected no dioxin at the spill site, physicians found no dioxin in the plaintiffs, and the report of health disorders made by the plaintiffs' physician was refuted by a team of St. Louis University physicians.

To industry, an award of this size made without proof of dioxin's hazardousness or even proof of any exposure to the compound raises the specter of a terrifyingly resilient legal precedent. Business' hopes that the appeal will discredit the case's conclusions, however, are likely to be fulfilled, according to legal experts, because of a number of apparently questionable aspects of the trial. *American Lawyer*, for instance, in a biting article about the handling of the case by the judge and the plaintiffs' attorney, Paul Pratt, paints the entire trial as one-sided. It calls the site of the trial, Madison County in Illinois, a "plaintiff's paradise." And in his appeal brief, Norfolk & Western counsel Albert Schoenbeck wrote: "The verdicts in the case are so outrageous in light of the evidence that they display, more effectively than words can describe, the total unfairness of the trial and the complete bias and prejudice of the jury."

It is the risk of verdicts such as this, however, that has kept dioxin-associated chemical companies doing much as Monsanto did in the case: settling out of court. Dow Chemical, for instance, is or has been the subject of nearly 20 suits in which dioxin-contaminated 2,4,5-T is blamed for health disorders. Donald R. Frayer, claims manager in Dow's legal department, says the company tries to settle when the cost can be kept within a limit deemed reasonable by the company. "Frankly," he says, "we would intend to handle these things in such a way that they would not set any legal precedents."

The proliferation of dioxin-related lawsuits, however, will make that difficult. Besides the agent orange trial, there are two other major cases now in litigation that worry the chemical industry. In one, Monsanto is defending itself against former employees of its Nitro, W.Va., plant, which produced 2,4,5-T up to 1969. The plaintiffs are asking $700 million in damages for their exposure to several chemicals including dioxin. The trial could begin early next year.

In the other, Monsanto and Dow are being sued by a group of Union Electric Co. employees who claim to have been harmed as a result of exposure to dioxin while climbing utility poles. To the displeasure of the two companies, the case was filed in the same court that handled the Lowe vs. Norfolk & Western case by the same attorney, the now-notorious Pratt. For this reason, notes Dow lawyer Frayer, "It is the most disturbing case we now have."

The first major dioxin cases came at the time of an epoch in the insurance industry. Insurers are being compelled, as a result of the asbestos suits, to deal with the problem of covering "nonsudden" accidents—accidents that manifest their injuries, in the manner of asbestos, long after the occurrence of the exposure—in addition to their traditional coverage of "sudden" accidents, like car crashes, in which the occurrence and the manifestation of injuries more or less coincide.

Since many asbestos producers and users had several different liability insurers over the 30- to 40-year span between the exposure of workers to the substance and manifestation of health disorders, it has not been clear who should be liable for the victims' compensation. Three court rulings on the issue have not resolved it.

Liability insurers would like to avoid problems like this in future cases involving "nonsudden" accidents by adhering to what they call "claims-made" policies. In this type of liability insurance, the important date is not so much that of occurrence or manifestation, but when a claim is filed. If the claim is made during the period of insurance, the insurer pays. To a certain extent, this form makes insurers liable for events of the past that have not shown up yet, but insurance firms prefer it.

But insurance buyers are no fans of claims-made policies. What they want is a "tail," insurance industry parlance for coverage that, being on an occurrence basis, would indemnify them for future losses stemming from current accidents. Since most policies for large firms actually are written on a customized, "manuscript" basis, whether a particular policy tends more towards claims-made or shows signs of a tail depends on a combination of factors, including the size and type of risk and the state of the insurance market. Typically, most policies fall somewhere in between.

For chemical companies looking for protection from future dioxin suits, there is little chance of finding an independent insurance carrier willing to underwrite an "occurrence" policy providing coverage from the first dollar of a claim on. But because the insurance market is soft, carriers eager for business might take on the dioxin risk on that basis but at a higher dollar level, or "layer." This means that chemical companies cover themselves, either through self-insurance or via a captive insurance company, up to a certain amount. Once that deductible is passed, the insurance carrier's coverage would begin.

Again, the asbestos problem suggests a precedent. Users of asbestos-associated products, like manufacturers of brake linings, for example, still can buy liability insurance. The reason is that underwriters know that the average asbestos award is under $10,000. A policy therefore can be written with a deductible of about that size that mitigates the risk of the carrier and covers the insured against catastrophic losses. Once precedents are set for dioxin awards, the insurance industry presumably could respond in a similar way. At this point, however, underwriting such policies is considered risky.

"Since there are no figures, no losses to project on, it is up to each underwriter to decide," says John Gross, a senior vice president of Marsh & McLennan. "He might be willing to write it at a price—that the market would bear—or, through lack of knowledge, he might end up giving it away."

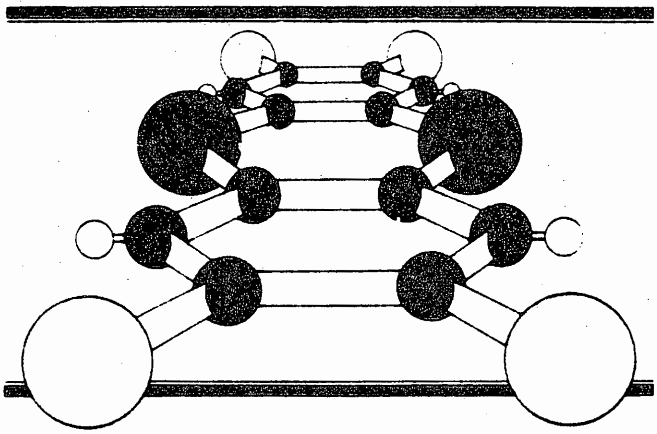
"It's a shot in the dark," remarks Risk Studies Foundation's Epstein. "The industry is in a state of flux, and everybody's scared. Still the market is soft. People will write just about anything."

"I suspect the insurance market will respond in part," says H. Felix Kloman, president of the Risk Planning Group in Darien, Conn. "The bulk of it, however, will be borne by the producers." ☐

Europe Provides Test Case of Human Exposure to Dioxin

Severe disaster of 1976 has had profound impact internationally on waste disposal standards, production of chemicals, liability laws, labor relations

Patricia L. Layman
C&EN London



If it had not been for the seriousness of the subject, it would have read like an operetta by Gilbert and Sullivan, based on Homer. In the course of what originally started out to be legitimate disposal, 41 drums of toxic wastes generated by the notorious accident at the Seveso, Italy, 2,4,5-trichlorophenol plant in 1976 went astray somewhere on an odyssey that started in Seveso, moved across Italian borders to storage in St. Quentin in France (perhaps), to disposal in exhausted salt mines at Herfa-Neurode in West Germany (perhaps), to who-knows-where.

There was talk that the material, contaminated with dioxin, had been dumped into the sea; that the Italian government has had it all along and was waiting until the furor died down to send it to the U.K. for incineration; that it has been incinerated already, at some unknown facility in Europe; that it was buried in East Germany; that it was tucked away, an inconspicuous 41 drums, in obscurity somewhere on the continent; that it was being trucked around Europe as its holders sought somewhere to dispose of it.

The wastes finally were found on May 19, in a French village between St. Quentin and Laon, about halfway between Paris and the Belgian border. They had been stored in an abandoned abattoir in Anguilcourt-le-Sart. Military personnel and police have moved the wastes to a nearby military base. The president of the French waste company involved, Spelidec, had refused to divulge the drums' whereabouts, but following seven weeks of imprisonment by the French authorities, he presumably changed his mind.

The next question is: What happens now to the 41 drums? No one wants them, but no one knows quite what to do with them. The Italian authorities refuse to permit their return.

At the same time that this tale of wandering and looking-for-a-home was being played out, a related saga was working its way into the Italian courts.

The Seveso incident occurred in July 1976. A plant operated near that town by Industrie Chemiche Meda Societa, Anonima (ICMESA), an Italian company owned by Givaudan, a Swiss subsidiary of the Swiss pharmaceutical manufacturer Hoffmann-La Roche, was making 2,4,5-trichlorophenol (TCP) for use in production of hexachlorophene. Cooling water to the reactor apparently had been turned off inadvertently at the end of the day, and the resulting rise in temperature and buildup of pressure caused a safety disk to rupture and a safety valve to open. As a result, the reactor contents were released directly to the atmosphere, contaminating a widespread area.

Now, nearly seven years after that accident, the Italian government has begun its trial of some of the people involved. Five defendants—down from an original 12—have been charged with causing, without premeditation, the dissemination of TCP and dioxin over a vast expanse of land, resulting in death of animals, destruction of vegetation, evacuation of certain inhabitants of the land, and appearance of dermatological lesions, among other charges.

The trial opened April 18 in Monza, just north of Milan, in the absence of all five defendants, and was adjourned until May 11. On May 11, a strike by lawyers forced a second postponement until June 17. The lawyers called the strike to press the government to provide more court staff to speed up proceedings.

That court action is being joined by several others. In Switzerland, for example, Hoffmann-La Roche is filing suit against the West German industrial firm Mannesmann A.G., with whom it had contracted to dispose of the dioxin waste, an estimated 2.5 tons of contaminated soil. Mannesmann, in turn, subcontracted the disposal to the French firm Spelidec—and the waste then disappeared.

The Green political party in West Germany already has pressed charges against Mannesmann and the West German representative of Hoffmann-La Roche, in an attempt to force disclosure of what happened to the wastes. And, in part prompted by a European Bureau of Consumer Unions boycott of all products made by Hoffmann-La Roche, physicians in West Germany reportedly have stopped prescribing the Swiss pharmaceutical company's drugs. The consumer union decided on its action to pressure Hoffmann-La Roche into, in turn, pressuring Mannesmann into disclosing the whereabouts of the wastes. The consumer group was thwarted in a boycott of Mannesmann because, as an industrial firm, none of its products reach the consumer directly.

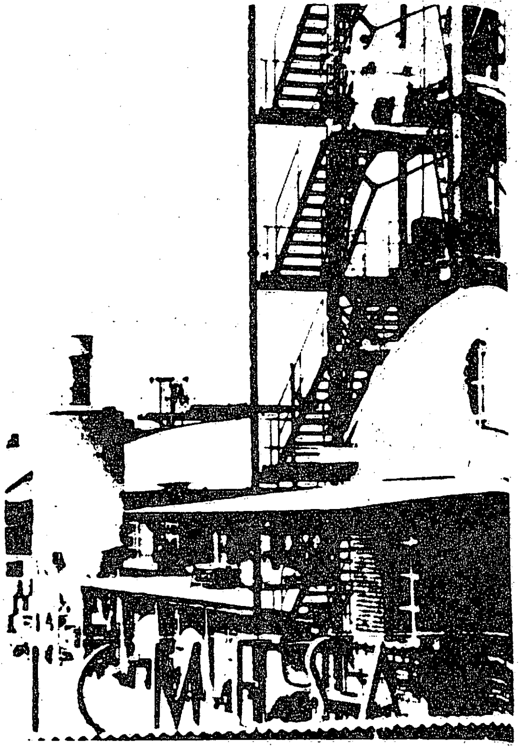
Meanwhile, the French authorities had arrested and jailed the president of Spelidec for failing to declare the contents and destination of the dioxin wastes, which his firm transported to St. Quentin—and for failing to divulge their whereabouts after that.

And during the height of the furor over the missing wastes, the archactivist environmental group Greenpeace blocked border crossings that might be used to ship the wastes, including one into a potential disposal site in East Germany.

West German protests, in fact, indirectly have caused Boehringer Ingelheim, which produces 1000 tons per year of the herbicide 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) at Hamburg, to get out of the business. Last month, it stated that it had stopped producing the herbicide, primarily because of the controversy over dioxin and dioxin disposal.

For Europe, Seveso has the same umbrella connotation of pollution as Love Canal in the U.S. There have been other industrial exposures in Europe besides the accident at the ICMESA plant. And many environmental groups and labor unions charge that 2,4,5-T herbicide spray and its dioxin contaminent have affected many times more people—industrial workers, agricultural and forestry workers, workers' families, and residents of areas that have been sprayed—than the accident at Seveso.

But Seveso has been the main horror story, and it is beginning to have an impact on the regulatory scene across Europe.



ICMESA's Seveso plant during toxic material cleanup after 1976 accident

In 1978 the European Economic Community set up a waste-control program for monitoring hazardous chemical wastes in its member countries. Implementation was set for March 1980. But there was a major loophole: The monitoring did not apply to wastes moving across national borders. That encouraged transfrontier shipping—such as was done with the Seveso wastes.

Stung by the outcry over the Seveso wastes, member states are tightening their own internal regulations, and EEC has begun to move to tighten the loophole in its waste-control program.

For example, France last month adopted measures that make a producer of toxic waste entirely responsible for all operations until its final disposal, even if subcontractors are involved. Dumping sites must report every three months any disposal of toxic waste. Subcontractors must inform the producer of the wastes about the conditions of transport, stocking, and disposal of the waste. And shippers across the French borders will have to specify the type of waste, the identity of the

UPI photos

Italian police guard one entrance to Seveso following evacuation of area transporters, and the waste's final destination.

Similarly, West Germany's interior ministry has proposed to amend the country's 1972 laws on toxic-waste transport. The legislation would require each federal state within West Germany through which the toxic waste passes to grant a special permit "only under the most restrictive conditions," with crossings only at a few predetermined border crossing points.

A new EEC proposal, adopted Jan. 17, would enable monitoring of toxic wastes down the line from producer to eventual disposal in another member state. It basically proposes that notification of transfrontier shipment must be made; that contractual commitments between the producer of the waste and the receiver in the recipient country are subject to the appropriate authorities and that they must be notified in advance, and that the shipment must be accompanied by a standard document all along its route, as well as a label indicating its nature, composition, quantity, place of origin, and security instructions.

The pace of proposals moving through EEC is usually glacially slow. But many observers believe that the Seveso controversy may speed up the timetable considerably. Some form of action obviously is needed. As one EEC official notes, the Italian authorities kept insisting, about the temporarily missing Seveso wastes, that all pertinent points of the 1978 directive had been adhered to.

"There are now doubts as to that, but no proof," the EEC official says. "For us, that is one more argument for the new directive to make illegal all aspects of this famous story. If the Jan. 17 directive had been law, unless a member state was in manifest infraction of the law, this [episode] would have been impossible."

He thinks the Seveso controversy will help push through the proposed directive in a time period shorter than the one and a half to two years normally needed for environmental issues; with further, quick implementation by the member states. "Our member states are all embarrassed by this issue," he says, "so we hope it will go through quickly."

In countries on the Continent, most of the concern over dioxin has centered on Seveso and the possibilities that the formerly missing waste might be found in one's own country. There already is dioxin-contaminated waste in various dumps throughout the Continent. Rhône-Poulenc, for example, has disposed of its 2,4,5-T wastes in landfill dumps in France.

In the U.K., attention also is focused on the Seveso wastes, but from a different perspective: the possibility that after the wastes were found, they would be sent to the U.K. for incineration. The controversy there centers on Rechem International, a chemical-waste disposal firm located in Southampton.

"If one assumes it would be a solid material, Rechem is the only company with the appropriate disposal facilities in the U.K.," agrees Arthur Coleman, managing director of Rechem. That's a hypothetical assumption, he emphasizes. Coleman echoes Giles Shaw, an official in the U.K. Department of the Environment, who said earlier this year in a statement to the House of Commons that "in principle" the dioxin would be a most unwelcome import were it sent to the U.K. "We are not interested in doing the work," says Coleman, because of the tremendous emotion generated about that possibility.

"I personally think it is sad that we have to adopt a political stance like this, but we are living in a real world," Coleman says about Rechem's position. "We have demonstrated disposal of dioxin, with independent checking of emissions. Technically, we have the capability. It comes down to individuals, emotions, and so on, in spite of anything we could say to the community. That's the real issue."

Rechem already has learned one bitter lesson about that. A number of years ago, it was ready to accept Kepone wastes from Virginia for incineration. Public outcry forced the company to abandon the plan. "It took us many years to overcome the stigma and aggravation that left us," says Coleman. "Forty-one barrels is a very insignificant commercial opportunity—it would not be worth the aggravation it would cause us. We're just not interested in the business."

That is welcome news to many of the U.K. labor unions. Most of the pressure against dioxin, or rather against the products that contain it, has come from labor unions. Chief among them are the Agricultural & Allied Workers section of the Transport & General Workers' Union; the General, Municipal & Boilermaker Workers' Union (most chemical plant workers), and the Association of Scientific, Technical & Managerial Staffs (which includes laboratory personnel).

The Agricultural & Allied Workers union, for example, passed a resolution in mid-May, says safety research officer Chris Kaufman, urging the government to bar dioxin wastes from Seveso from being imported into the U.K. "If it sneaks in, we are asking our TGU colleagues—the lorry drivers, port workers, and others—to not handle, to block it," Kaufman says.

Wouldn't it be better, in the long run, to incinerate the dioxin, ending the saga once and for all? "From our viewpoint, there are no guarantees that the incineration process is safe," says Kaufman. "Within the furnaces there are eddies and currents—it doesn't ensure that the whole consignment will go up and be safe." Besides, he adds, "Our workers are in that plant. We don't want them to be exposed to the material. We can sympathize with the Italians, but we don't want it here."

Dioxin also has become one key weapon in the unions' battle for representation on the advisory committees that recommend licensing or not licensing pesticides to the government. The present advisory committees "contain no representatives from workers, who are directly involved," chafes David Gee, safety officer of the General, Municipal & Boilermaker Workers' Union. "The Nature Conservancy is on it—the committee can protect bees, but not people."

The unions also want assessment of pesticide safety taken from the Ministry of Agriculture, Fisheries & Foods and given to the Health & Safety Executive, a sort of British version of the U.S.'s Occupational Safety & Health Administration with statutory requirements for licensing. ☐

TESTIMONY OF JAMES HILBERT, PH.D., HEAD OF RESIST

Throughout the past few years of tight budgets in government, when expensive projects in military, educational, or social spending would be proposed, we have been told that problems are not solved by simply "throwing money at them". The bill we are discussing today (A1778) is a perfect example. The idea of committing funds to sound solid waste planning and management is appealing, but this bill commits huge amounts of money to one technology (garbage incineration) only - an unproven technology with many health and environmental risks that the state DEP has shown it is not prepared to deal with. This money will be used to fund large scale incinerators for which there are no clear siting criteria and only a few outdated air quality regulations. Passage of this bill would mean that we are throwing money at the solid waste problem in hopes of a quick solution when the DEP and the counties have not done the basic homework and planning needed to provide a solid waste management plan which will protect the health and safety of the general public.

Let me detail some of the unique pollution problems of garbage incineration that your bill would be helping to spread:

DIOXINS: Dioxin emissions continue to be reported by scientists around the world each time garbage incinerators are examined. These chemicals are among the most harmful known.

The frequency of reports, and the amounts that are found, seem to be increasing all the time. Recently, for instance, Italian scientists found enough dioxins being emitted (on average) from each of 20 Italian incinerators to produce adverse doses (according to scientists in the Netherlands) for over 200 million people. This dioxin came from incinerators which averaged 8 times smaller than the proposed "reduced-size" Morris Co. plant and 26 times smaller than the proposed plant here in Newark. Scientists who have investigated incinerator particulates for toxicity have found them to have enormous toxic potential, not just because of dioxins, but because of the combined effects of dioxins and the many other chemicals (e.g. dibenzofurans, formaldehyde, polycyclic hydrocarbons and others discussed below). Despite the grave risks, the DEP has given no indication that it will ever issue standards or exposure limits for dioxins, dibenzofurans or the other chemicals I've mentioned - and don't look to the EPA, because it doesn't have them either.

HEAVY METALS: Garbage incinerators emit an unprecedented variety and amount of heavy metals. Of these, there are several metals which are extremely toxic, even at low levels. These metals (e.g. lead, cadmium, antimony, nickel, chromium, mercury and arsenic) will likely have garbage incinerators as one of their prime, if not their major source, in New Jersey. Lead is a good example. It is a kidney and heart poison in very low levels, and researchers have found that levels of lead previously thought safe can damage children's brains and impair learning ability. A Star-Ledger article on March 26 puts the enormous health risks of heavy metal pollution from garbage incinerators in perspective - and shows what little the DEP is likely to do about that problem. According to that article, a major source of lead pollution emits 5 tons per year into our air, and the DEP is not likely to ensure the public's safety from these sources. Yet according to the DEP's own published figures, a garbage incinerator as large as the proposed "reduced-size" Morris Co. facility will emit 12 tons of lead a year, and the Essex facility 40 tons per year. Can we expect the DEP to protect us from so much lead, when it can't even regulate the current emissions? Still not addressed by the DEP are cadmium and the other extremely toxic heavy metals I've listed above - no guidelines, no regulations, but a lot of risks.

PARTICULATES: As has been repeatedly pointed out, the pollutants I have mentioned are mainly found on microscopic particles which preferentially escape pollution control equipment, disperse over great distances, and are easily breathed into the lungs from which the poisons can very easily be absorbed into the body. The DEP's own figures indicate that particulate emissions are twice that of a comparable oil-fired boiler. Furthermore, a much greater fraction of the particulates emitted by a garbage incinerator are the more hazardous microparticulates. While other states are considering stringent microparticulate regulations, New Jersey's proposed guidelines neglect microparticulates altogether, and the proposed guidelines for total particulates are far less stringent than the "state-of-the-art" as proposed in California.

ACID GASES: Acid gas emissions will be substantial from garbage incinerators - over 2400 tons of sulfates and nitrogen oxides from the Newark plant alone are predicted by the DEP. The acid gas of chief concern, however, is hydrogen chloride (HCl) which, unlike the others, becomes a strong, corrosive acid immediately upon contacting moisture in the air. If you like acid rain, you'll love garbage incinerators. Federal regulations for a hazardous waste incinerator specify 99% removal of HCl. If a hazardous waste incinerator, with potentially more chlorine input than a garbage incinertor, can be expected to meet that level, why does the DEP propose a guideline that is ten times less stringent for garbage incinerators?

LANDFILLS: Incinerators are often sold as the means to eliminate landfills. They don't - up to 30% of what goes in must still be landfilled, most as incinerator ash. The DEP seems to believe that the most important factor in disposal of ash is the volume that it fills, not the hazard it presents. Incinerator ash puts all the toxic chemicals mentioned above into that smaller landfill volume. The ash is considered hazardous waste in California, and State of Massachusetts testers have also concluded it should be classified as hazardous. As of now, the DEP has no policy for it. Perhaps it will require a hazardous waste disposal facility for the ash. However, those of us who have watched the siting process of hazardous waste facilities in the state unfold know what a difficult process that is, and how little we need a major new source of hazardous waste to make the problem worse.

SITING: As of now there are no clear siting criteria for these plants - no mechanism to prevent the placing of an incinerator in an improper environment. County freeholders (as in Morris) have said that they are looking to the DEP for leadership in siting, while the DEP is contending that it is not their responsibility. Yet the plants are still being sited. In Morris County, eight potential sites were chosen, and it appears closeness to energy users was the only criterion used. Two of these sites in the Picatinny Arsenal area are located directly over a Federally-designated Sole Source Aquifer that recharges the Rockaway River. The aquifer and the river are the sources of drinking water for hundreds of thousands of people. Another example of poor siting - placing the plant in Newark so close to such a densely populated area; one in which the highest level of dioxin contamination in the country is already located.

IMPACT ON RECYCLING: Recycling is true resource recovery; the recovering of materials with more energy saving than is potentially gained by burning the materials. Furthermore, recycling makes no threat to the environment. While this bill throws money at garbage incineration, there is no comparable funding for recycling. Funds for recycling would launch a statewide program with the capability of taking care of as much solid waste as incineration. The DEP has decided the future of recycling is limited; the decision is based only on the present situation, where there is a shortage of solid data on the potential of source separation. Certainly the DEP's announced 25% "ceiling" for the amount that can be recycled is an artificial one. Are recycling and incineration compatible? The people of Akron, Ohio might say no, since they are prohibited from recycling their newspapers so they may be incinerated. Before we are locked in to incinerator technology, the State needs to thoroughly investigate and implement the maximum amount of recycling. We also need a committment of manpower and economic resources to recycling which is of the same order of magnitude as proposed for incineration. This will insure that we reduce (if not totally eliminate) the amount of health-threatening technology that must be implemented. Last year, the Assembly Energy and Natural Resources committee reported that, if a proper amount of recycling were implemented, we would need at most 4 incinerators, not 20.

In summary, I would say approval of this bill is a signal to the DEP and county governments that the Assembly considers it great to build threatening plants without regulations, controls or siting criteria. You will be telling the DEP and counties to try to put one of these monsters in every county, when in fact, far fewer - perhaps none at all - would suffice, if proper attention were given to recycling. Approval of this bill would also give a signal to everyone across this state that you consider it alright to pay only lip service to recycling. I recommend that this bill be held until legislation is passed which gives recycling the highest priority in this state and adequately funds it, and until legislation is passed which mandates issuance of siting regulations, construction regulations, design regulations, and state-of-the-art air emission regulations for garbage incinerators. In short, I would recommend that you say "We're sorry Governer Kean and we're sorry Commissioner Hughes, but we cannot give so much money to a house in such poor order. We cannot throw money at just one so-called solution that has so many health and safety questions," and hold this legislation until we first have maximum recycling, sound planning and comprehensive regulations.

SMOKE

May 11, 1984

Assemblyman McEnroe
12 Sloan Street
South Orange, New Jersey 07079

Dear Assemblyman McEnroe:

Thank you for your recent invitation to Dr. James Hilbert of SMOKE to appear before a meeting of your County Government and Regional Authorities Committee, to speak on the issue of toxic air emissions expected from garbage incinerators. Because this meeting is scheduled for a week day morning, no one of our technical experts will be able to attend. So this letter will have to serve as SMOKE's comments on the indicated topic.

First of all, the toxic air emissions expected from these incinerators are one of the main reasons why we spoke out against A-1778 at the hearing held on April 19 in Newark. You have testimony from both Dr. James Hilbert and Dr. Stephen Stoldt from that hearing addressing the serious air pollution problems that will be created from garbage incinerators.

In summary, those problems include emissions of dioxins and dibenzofurans, among the most toxic chemicals known; heavy metals in an unprecedented variety and amount, including lead, cadmium, antimony, nickel, chromium, mercury and arsenic, implicated in all kinds of health problems. These chemicals are found on microparticulates which preferentially get through air pollution control equipment, disperse for miles and are easily breathed in and absorbed into the lungs. Many other emissions, including vinyl chloride and formaldehyde, both known carcinogens, are also expected from garbage incinerators.

It has been shown that even common pollutants (e.g. carbon monoxide and hydrochloric acid), are emitted in much higher amounts from garbage incinerators than from oil or coal fired burners. (according to DEP's own figures)

Both your committee and others, including the New Jersey Department of Environmental Protection are well aware of our concerns about the lack of <u>regulations</u> which exist to protect New Jersey residents from these new sources of pollution.

A Statewide Movement Opposing Killer Environme
SMOKE Objective – an environmentally sound disposal of our municipal waste

And yet, your bill (A-1778) still speaks of committing huge amounts of money to one technology (garbage incineration) only - unproven technology with many health and environmental risks that the DEP has shown it is not going to address.

However, we would like to make it clear that even if you attempt to address concerns about toxic air emissions, we still will not support your bill. The California Air Resources Board recently proposed the strictest air emission guidelines for incinerators in the country and still concluded that these guidelines will not guarantee safety.

Therefore, as we indicated to you on April 19 and to others on numerous occasions, it is SMOKE's position that the maximum amount of recycling should be achieved, before any other decisions are made. Marwan Sadat, from the DEP, at a recent gathering of the League of Women Voters admitted that it would be possible to recycle 55% of our waste. Others indicated that this has already been achieved in Woodbury, New Jersey and that certainly more was possible.

And what about incineration? Signal-Resco, in its environmental impact statement, admitted that only 63% of the waste stream could be incinerated. And yet you're talking about releasing millions of dollars to subsidize the construction of garbage incinerators, when recycling is safer, cheaper and conserves resources?

The only way this goal will be achieved is if money is appropriated for establishment of statewide mandatory recycling, for recycling industries, and markets for recycled goods. Garbage incineration is not recycling. At least ½ of the money that is now appropriated or that would be appropriated for garbage burners, must be spent on recycling.

If we don't proceed that way we'll just be "throwing money" at a problem. We will be locked in to a polluting technology for up to 40 years.

We would also like to say that the issue of toxic air emissions is not one that should be addressed by your committee on County Government and Regional Authorities. Your committee is not equipped to address this problem. The issue of toxic air emissions is most appropriately handled by those committees in both the Senate and the Assembly whose main concern is environmental.

SMOKE urges those committees to convene to address this extremely important issue. Let's make this discussion an environmental one, not a political one. And, further, we strongly recommend that such hearings be held in the evening, not during the day. Our scientists and our members work during the day at other jobs and can not be available for daytime hearings. We are not municipal, county or state officials, or industry representatives who get paid for attending these hearings. Holding hearings on such important matters during the day shows an indifference to the voice of the community and makes investigation into this serious environmental issue totally for show and without meaning.

Thank you for giving us an opportunity to present these comments to you.

Sincerely,

(201)551 4613 Madelyn Hoffman

James M. Hilbert, Ph

Stephen H. Stott, Ph.D.

cc: Peggy McNutt, Legislative Services
all legislators

STATEMENT
DR. WILLIAM KLEPPER
MERCER COUNTY FREEHOLDER
AND
MEMBER, NJ CLEAN AIR COUNCIL
MAY 14, 1984
COUNTY GOVERNMENT AND REGIONAL AUTHORITIES
COMMITTEE HEARING - A1778

On March 19, 1984, the NJ Clean Air Council and the NJ Advisory Council on Solid Waste Management held a joint Public Hearing at Trenton State College on "The Effect of Resource Recovery Technologies on Air Quality." The councils sought testimony on the available technologies for solid waste handling and their effects on air quality. The specific questions posed are listed in the attached hearing announcement. A variety of public officials, and representatives of the private sector and the general public submitted testimony at and subsequent to the hearing. The final report and recommendations from the hearing are not yet available, but, in the hope that it might be of some assistance in your deliberations, I would like to briefly summarize some points of testimony.

The Chief of the Bureau of Engineering and Technology of the Air and Noise Quality Program, speaking on behalf of the Department of Environmental Protection, summarized the results of comparing the emissions of major contaminants from resource recovery facilities with those from existing oil-fired boilers and new coal-fired boilers, on an equivalent heat input basis: emissions of sulfur dioxide and nitrogen oxide from refuse incineration will be less than from fossel fuel combustion; particulate and onganic emission rates will be about the same; lead, carbon monoxide and hydrogen cloride emissions will be greater, but these higher emission levels will result in groundlevel concentrations "well within Federal National Ambient Air Quality Standards." Emission estimates and air quality modeling indicate that, for facilities with tall stacks and state-of-the art, comparision with groundlevel concentrations of other heavy metals indicate a negligible increased cancer risk. With regard to organic emissions, DEP expects that with state-of-the art combustion and auxiliary burners increased risk will be negligible.

O'Sullivan, pointed out that it is the goal of the air program to limit the increased cancer risk from beryllium, nickel, arsenic, cadmium and chromium to less than 1 in a million per individual. Further, NJDEP is implementing the most stringent air pollution standards for these facilities in the nation, with the possible exception of a recent California Air Resources Board proposal.

Mr. O'Sullivan submitted, both at the hearing and as a supplement, a wealth of additional testimony on the precautions being implemented by DEP to preserve air quality with resource recovery facilities, all of which is, I am sure, readily available to this Committee upon request.

Mr. James Merriam, Environmental Engineer testified for Jersey Central Power & Light Co. He indicated that, in their opinion,

> "Resource recovery can be implemented at reasonable costs while maintaining fully adequate protection to human health and the environment."

He stressed the need for a comprehensive public education process to separate emotionalism from solid waste incineration. With regard to proposed DEP air quality requirements he suggested the following adjustments:

1. Particulate Emissions - NJDEP proposed standards may be difficult to meet and the averaging period for this emission limitation should be 24 hours "to prevent unavoidable uncompliances."

2. Hydrogen Chloride - DEP should adopt a 0.05-0.1 parts per million 24-hour acceptable ambient concentration for HCl from new resource recovery facilities. An HCl scrubbing requirement should only be applied to facilities that must scrub their exhaust gases to meet a reasonable established ambient concentration.
3. Sulfer Dioxide - An Appropriate SO2 emission limitation is 0.6 lb/million BTU, not DEP's 0.32 lb/million BTU. Any SO2 emission limitation should be based on 24-hour averaging.

4. Justifying scrubbers on the basis that r. r. facilities may contribute to acid rain is erroneous.

Mr. Marrian further encouraged a scrubber bypass provision and suggested that the "public should not burdened by unreasonable waste disposal fees required to pay for emission control equipment if it is not necessary."

Assemblyman Dean Gallo emphasized the need for a public - private sector partnership to finance resource recovery plants in New Jersey, where plans for 13 plants with a total 18,000 ton daily capacity will cost over $1.5 billion in construction costs. Gallo made a strong plea for the continuation of Industrial Development Bond financing as "essential for New Jersey to implement a pollution free system of resource recovery." He urged support for exempting resource recovery facilities from any proposed State caps on IDB sales. In response to a question about attracting the private sector, in addition to IDB's, Gallo enumerated "certain things the private sector has to have before they get involved": A profit motive, length of contract, a franchise to guarantee the waste stream and the ability to take advantage of accelerated tax depreciation allowances.

W. B. Rossnagel, head of the "largest air testing company in New Jersey", testified that since N.J. already has the tightest incinerator emission level in the East, it should not be lowered further. New Jersey is the only state which counts the Wet Catch as well as the Dry Catch on incinerator tests.

In response to Question #3 (siting), he indicated that incinerators must be at least 2,000 feet, preferably 3,000 feet, from the nearest home.

Mr. Rossnagel stated that the disposal of hospital wastes alone is reason for urgency in the resource recovery process.

With regard to Question #2 under Emissions, he indicated that, "Up to 15% of municipal waste collected from the street has been proven to contain up to 15% hazardous waste." He also suggested, with regard to Question #3 under Emissions, that specifiying maximum allowable emission rates is preferable to relying on state-of-the art technology. Mr. Rossnagel urged that pilot resource recovery models be built as soon as possible.

Lewis Goldshore, Esq., appeared on behalf of East Brunswick Township urging that in view of the cost and maintenance history of mass burning incinerators, problems with residual waste and separating toxics, careful attention be given to alternatives. He stressed the need for DEP to "adopt regulations, sequencing permits, enforcement standards, performance bonds model facilities and to move forward slowly and prudently."

Michelle Hoffman, Legislative Analyst for the New Jersey State Chamber of Commerce, urged an in-depth public education program to "Provide the public with a complete and accurate picture of solid waste incineration." She also stated that the public should not be forced to pay high waste disposal fees for "unnecessary emissions control equipment."

David Marshall, member of the Montville Township Governing body, who spoke to Question #6, under Technology, with regard to the adequacy of New Jersey's approval process for resource recovery, took objection to the fact that since the State does not have clearly defined siting guidelines, the procedures are left to consultants. Montville Township has been identified as a preferred site for a resource recovery facility, despite the fact that the Central Passaic River Basin is a sole source aquifer; that 80 of the 95 acres of the site are inland wetlands and a major wildlife habitat and that nearby produce-producing farms might be affected. Mr. Marshall also drew attention to the recent report (June 1, 1983) of the New Jersey Assembly Committee on Energy and Natural Resources, which stated the lack of need for more than 3 or 4 major resource recovery facilities in the coming decade and that such hi-tech projects are not the best way to gain control over solid waste problems. The Committee suggested that low-technology, source separation and recycling are "more appropriate at least for the immediate future."

Madelyn Hoffman of SMOKE (Statewide Movement Opposing Killer Environments) testified that DEP guidelines for incinerators are inadequate, lack siting criteria, do not address dioxin emissions, formaldehyde emissions, cadmium and toxics in garbage. She urged caution in building resource recovery facilities and more effort in developing recycling programs.

Linda Stansfield, Program Consultant for Environmental Affairs for the American Lung Association of New Jersey urged that a comprehensive recycling component be made mandatory for each resource recovery facility plan. Communities could be denied access to the facility, absent a recycling component. Counties should monitor air quality for proposed sites even before construction begins. There should be 24-hour automatic monitoring for violation of permit conditions and, in the event of excessive emissions, the plant must take immediate corrective action, previously agreed upon in the permitting process, or shut down. Ms. Stansfield testified that DEP must be the primary enforcement agency and train and license all operators. It is essential that there be a proven record of air pollution control.

Mr. Albert Kent, representative of the New Jersey Chapter of the Sierra Club to the New Jersey Can and Bottle Bill Coalition, testified that a beverage container deposit law would increase recycling of beverage containers by a factor of 5 or 10 or even 20, would result in litter reduction and solid waste reduction. He urged the Councils' support of the bill.

Jennifer Nash, Director of the Delaware Valley Citizen Council for Clean Air, offered the results of a position paper developed by that body, which conditionally endorsed the development and operation of trash-to-steam incinerators. The five conditions are: The development of an environmental inpact statement for any major facility and a health survey in the area of the proposed plant to determine existing cancer respiratory health problems; the operation of already existing incinerators in compliance with the law; the support of volunteer recycling efforts and endorsement of a state-wide bottle bill by municipal governments; performance standards built into the contract whereby the municipality allows a vendor to build and operate the plant.

Threodore Pytlar, Directory of Essex County Division of Solid Waste Management addressed the hearing questions in the context of Essex County's developing project. On the "availability of different technologies." Essex had to choose a system for 2,300 tons per day of garbage. They chose recycling and a mass-burning resource recovery process that will reduce the garbage to landfills by 97%. Landfills will still receive ash, nonprocessible materials and the garbage bypassed during facility maintenance. In considering potential impact on air quality and health, in all cases, maximum concentrations (six criteria pollutants and 34 metals and onganics) were 3% or less of highest recorded concentrations for criteria pollutants. In all cases, "the worst case risk of contracting cancer or cancer deaths in each risk assessment ranged from one in a million to one in 100. To reduce any increment in vehicular emissions all trucks from outside Newark will be prohibited from using local streets to access the facility. Essex estimates their scrubber and electrostatic precipitator will increase disposal cost by about 20-25%. Mr. Pytlar also made several suggestions concerning permit conditions and penalties and submitted, for the record, copies of their RFQ, RFP, "The Integration of Energy and Material Recovery in the Essex County Solid Waste Management Plan", their Environmental Impact Statement and "Highlights of Community and Environmental Inpacts - Essex County Energy Recovery Facility."

Herbert Kaufman, Clinton Bogert Associates, testified on the disposal of solid waste by high rate composting, including the requirements and parameters that must be met. He explained that the only atmospheric emissions should be the inlet air and heat. There are at least three potential systems that compost municipal solid waste and sewage sludge. The end product contains significant quantities of plant nutrients, organic carbon and vital microorganisms necessary to convert nutrients to a form usable for plant life and is salable.

Dorothy MacArthur, Signal RESCO, Inc, described the status of their on-going resource recovery facilities. She described precautions that are taken to keep hazardous waste out of the stream. Resource recovery facilities in New Jersey "will have the most sophistcated air pollution control systems of refuse burning plants anywhere in the world," she explained "twenty five to 40 percent of the price increase projected by the State of New Jersey in implementing resource recovery to replace landfills is due to New Jersey's proposed guidelines on acid gas removal requirements."

Steve Passage addressed the point that resource recovery is being promoted for environmental reasons, because of groundwater pollution and problems caused by landfilling. He emphasized the fact that New Jersey is behind the rest of the United States and should not "go slow" and that we are not experimenting with "unproven technology." Plants to be built can meet standards set at the Federal and State level based on public health considerations. New Jersey has standards "as strict as anywhere in the world for the emission of acid gases and is considering non-criteria pollutants."

Mr. Bruce Wolf, Borough of Manville, Somerset County Solid Waste Committee and NJ Health Officers' Association, addressed the concern of the population in Manville for additional emissions on a population that has already been affected by other industrial-related disease (abestos-related), on a population with already compromised respiratory systems. He spoke to the need to control the human factor in plant operation, the public health impact of air pollution in times of atmospheric conversions and the five-year inspection and permit renewal. He feels that local health departments must be involved at the initial stages.

Ms. Audrey C. Mandel, IRATE (Independent Residents Against Toxic Environment), spoke to the need to solve safety and health problems from emissions before moving ahead. She discussed records of dioxin emissions at plants in other states; including "lesser known relatives of the dioxin family, the dibenzofurans."

Ms. Jean Carpenter, Environmental Commission and Solid Waste Advisory Council member, submitted her testimony. She urged that New Jersey use the time until energy recovery facilities can be operational to develop a "varied and broad composting capability, such that each waste management district could dispose of part or all of its food waste without the generation of leachate; and the collection of municipal refuse, for a representative segment of the population, based on a fundamental separation of food waste from the remainder." Composting methods should be refined; landfilling of leachate-generating material phased out; other sources of leachate reviewed; recovery of reusable or recyclable materials maximized; a selective, combustible fraction isolated; resistance to siting energy recovery facilities should be overcome. Time would thus be gained to better assess resource recovery facilities, she concluded.

I hope this summary will be of some benefit in the deliberations of your Committee.

N.J. CLEAN AIR COUNCIL

AND

N.J. ADVISORY COUNCIL ON SOLID WASTE MANAGEMENT

PUBLIC HEARING - RESOURCE RECOVERY

DATE: March 19, 1984 TIME: 9:00 A.M. - until the end of testimony

PLACE: Trenton State College Student Center, Room 202
Route #31, Ewing Township, N.J.

TOPIC: The effect of resource recovery technologies on air quality.

Problem Statement:

The State of New Jersey is running out of landfill space and needs alternative approaches to the problem of solid waste. Incinerators used in the past were sometimes closed because of their effect on air quality. The Clean Air Council and the Solid Waste Management Advisory Council seek information on technologies for solid waste handling and their effects on air quality.

Technology:

1. What technologies are available to deal with the problem of solid waste (incineration with resource recovery, landfill, compost, recycling)?

2. How does each of the technologies affect air quality?

3. What are the implications in siting resource recovery facilities (e.g., siting near to or distant from the points of collection)?

4. What key operating parameters need to be monitored continously and why?

5. What standards are needed for contingency plans in case of malfunction?

6. Is the State of New Jersey's approval process for resource recovery facilities adequate?

Emissions:

1. What are the costs of controlling air pollution from resource recovery operations? To what extent should costs be considered in developing control strategies?

2. Can the emission from a resource recovery facility be made reasonably safe, considering the hazardous materials which may be present in municipal and small business waste streams?

3. Should specific air contaminants be selected for testing? Should they be controlled by specifying maximum allowable emission rates or by applying state-of-the-art control technology?

4. How do emissions from resource recovery facilities compare with emissions from other sources with regard to hazards, concentrations, quantitities, et cetera?

5. What should be considered as acceptable health risks and environmental effects from emissions?

Clean Air Council

* John Carlano
Richard D. Chumney
Dr. Curtis Cummings
John P. Davidson
Albert Gessler
* John D. Grant, P.E.
Dr. Rocco Guerrieri
* Dr. William M. Klepper
William Kraemer

** Dr. Paul Lioy
Dr. Raymond Manganelli
Dr. Daniel Rossi
Louis Schindel
* Jane Tousman
* Dr. Wesley Van Pelt
Hon. Sharon A. Worrell
Irwin S. Zonis

Advisory Council on Solid Waste Management

* James Anderson
Richard D. Chumney
* Franklin B. Flower
Frank Gentempo
Frank E. Giordano

Fred Hebeler
** David R. Nalven
John Pislor
Fred Rongo
James R. Smith

* Members of Public Hearing Committee
** Council Chairman

Note: Oral testimony should be limited to 10 minutes. Length of written testimony is not limited. Please submit 20 copies of oral testimony at time of hearing.

Please be prompt in completing and mailing the Public Hearing Notice of Intention to Attend.

MAIL TO: New Jersey Clean Air Council, CN027, Trenton, NJ 08625
Attention Mrs. Helen Benedetti (609-292-6704)

PUBLIC HEARING NOTICE OF INTENTION TO TESTIFY:

____ I plan to testify at the March 19th Public Hearing of the Clean Air Council and Advisory Council on Solid Waste Management.

(NAME - PLEASE PRINT) (TELEPHONE)

(ORGANIZATION) (TITLE)

(ADDRESS)

GCA-TR-80-122-G(3)

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
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Work Assignment No. 16

STATE OF NEW JERSEY INCINERATOR STUDY
VOLUME III

TECHNICAL REVIEW AND REGULATORY ANALYSIS OF MUNICIPAL INCINERATION

Final Report

June 1983

Prepared by

Robert G. McInnes
Robert R. Hall

GCA CORPORATION
GCA/TECHNOLOGY DIVISION
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This document has not been peer and administratively reviewed within the Environmental Protection Agency and is for agency use/distribution only.

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ABSTRACT

Proper disposal of municipal solid waste is a problem confronting state, county, and municipal officials in New Jersey. The shortage of sanitary andfills has created increased interest in incineration. The purpose of this study is to provide technical background data that can be used by New Jersey to revise their incinerator emission code. Particulate, heavy metal, acid gas, and organic emissions and control methods are discussed in this report.

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FIGURES

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SECTION 1

INTRODUCTION

Proper long-term disposal of municipal solid waste is a problem confronting state, county and municipal officials in New Jersey today. The shortage of environmentally acceptable sanitary landfill sites in the state precludes the widespread use of this disposal technique as a long term disposal option. Although pilot plant studies covering composting and pyrolysis of municipal waste have been conducted, these systems have yet to gain widespread acceptance. Centralized municipal incineration is a proven solid waste disposal technology that can reduce municipal solid waste in an environmentally acceptable manner. In addition, the ability of new incinerator designs to recover energy in the form of hot water or steam makes this disposal technique economically as well as practically attractive. Based on 1970 census data, the State of New Jersey generates solid waste with the equivalent energy content of 26,483 barrels of oil per day. With the rising price of all energy sources, this untapped resource will probably be exploited in the near future.

In anticipation of the likely increase in the number of municipal incinerators, a review of the state of municipal incineration is needed. This study will provide that overview and focus on the increase in air pollution that may be produced by the increased use of centralized municipal incinerators. Specific tasks that will be included are:

- Review of pertinent facts concerning municipal waste generation rates, refuse composition and refuse quality (energy content),
- Description of current, state-of-the-art incineration techniques, both in the United States and in Europe,
- Discussion on available air pollution control methods that will miminize emissions,
- Report on actual incinerator emission rates for particulates and noxious gases, and
- Presentation of achievable emission standards.

Municipal incineration will result in the emission of several air pollutants not currently released to the atmosphere by water and land disposal techniques. This report will present the various aspects of centralized municipal incineration with special attention on how each aspect will affect air pollutant emissions and composition. Information available prior to October 1980 is included.

BACKGROUND

Municipal solid waste incineration systems have been built and operated in the United States since 1885 and have undergone considerable evolutionary change since that time. The batch-fed, dutch door type unit which does not attempt to control pollutant emissions, has been gradually replaced by the modern water walled incinerator that today recovers energy and whose air pollution is controlled by an electrostatic precipitator (ESP). Heat recovery from municipal waste itself has been practiced in the United States since 1906 when the Delancey Street plant in New York City produced electricity to light the Williamsburg Bridge. However this plant was an exception, and heat recovery from municipal refuse burning did not gain widespread acceptance in Europe until the 1960s and in this country until the 1970s. Early municipal incinerators were essentially large batch-fed refractory-lined furnaces that were used to reduce the weight and volume of the waste. Expansion chambers were used to control coarse particulate emissions, and the combustion gases were cooled before exiting the smokestack by diluting them with large quantities of ambient air.

Densely populated urban areas, with their high concentration of refuse generating sources have always been the most likely sites for municipal incinerators. Yet these areas, until the 1950s used open dumps and landfills to dispose of their solid waste. Landfilling was cheaper, required no capital expenditure, and previously unusable swamps and marshes could be reclaimed at a relatively low cost. Gradually the number of acceptable landfill sites diminished and cities, especially on the east coast of the United States, turned to centralized municipal incinerators. The cost of transporting the waste from the populace to the incinerator was kept to a minimum, and the weight and the volume of refuse that required final land disposal was substantially reduced. However, as the number of incinerators increased, so did the associated air pollution problem. Additional air pollution controls, such as spray chambers, flooded baffles and dry cyclones were added to existing incinerators to reduce pollutant emissions, but dark, dense plumes were still a trademark of municipal incineration. By 1970, municipal incinerators were emitting 1,200,000 tons per year of particulate or 5.3 percent of all particulates from point sources in the United States.[1]

In the late 1960's and early 1970's, federal and state air pollution control regulations were being adopted. One of the first source categories that was required to adopt particulate emission control was municipal incineration. Both the state of New Jersey in 1968 and the Federal Environmental Protection Agency (EPA) in 1971 promulgated particulate emission limits for municipal incinerators. New Jersey's regulations applied to all incinerators, new or existing, and the federal emission standards were applicable to only new municipal incinerators with capacities greater than fifty tons per day.[1]

When these emission standards were imposed, many municipal incinerators were closed because of the reluctance of the owners of the facilities (primarily municipal governments) to install the air pollution control equipment required to meet the new standards. In 1965, 299 incinerators with an aggregate design capacity greater than 80,000 tons per day were actually operating in the United States. By September 1979, only 64 incinerator plants ere still operational.[2] Among those plants closed were 7 in New Jersey. unicipal governments charged with disposing of solid waste chose to comply ith environmental regulations using the least costly method - landfilling the aste, rather than incinerating. Because older, more polluting incinerators closed, particulate emissions from municipal facilities in the United tes dropped to 100,000 tons per year in 1975. In New Jersey, particulate issions for 1975 totaled 237 tons per year, or 0.46 percent of all rticulates generated by point sources in the state.

he economics for municipal incineration is again changing. The cost of ing large quantities of municipal waste to often distant landfill sites is reasing, the number and availability of these sites is dwindling and public ncern about ground water contamination attributable to landfill leachate is rowing. At the same time, incinerator technology has advanced to the point ere energy can be recovered from incineration while all environmental andards are met. The increasing value of all energy supplies has now made e recovery of energy contained within the solid waste an economically viable ternative to landfilling. These factors appear to indicate that the number unicipal incinerator installations, especially those with heat recovery, l increase in the near future. New Jersey with its high population density d limited waste disposal alternatives, may especially notice this increase municipal incinerators.

SECTION 2

MUNICIPAL REFUSE COMPOSITION

A study of municipal incineration systems and their effect on air pollution must necessarily begin with an examination of the fuel for these systems, municipal solid waste. Municipal solid waste, or municipal refuse, is a self-sustaining fuel with highly variable characteristics. These characteristics are dependent on several localized variables such as geographic location, season of the year, climatic conditions, collection practices and industrial, commercial, and residential sources. For example communities in temperate areas, such as New Jersey, will have a higher percentage of yard waste in their refuse during the summer and fall months than those areas with less seasonal change, such as Texas or Arizona. Within a region, cities that are densely populated, such as Newark, may have less yard waste, regardless of the season than more suburban areas, while certain areas such as the New Jersey shore resorts will have seasonal fluctuations in both waste composition and generation rate due to seasonal increases in population. Waste characterization is unique to a specific area for these reasons. In spite of these variations, we can define a "typical" waste stream for the purpose of understanding the composition and sources of municipal refuse. Due to mass production and approximately equal distribution of consumer goods, the nonseasonal residential portion of municipal waste is similar from one region of the country to another. It is this residential waste composition that will concern us here. Industrial and commercial solid waste streams are specifically excluded. The quantity and composition of these wastes are highly individual and community collection practices concerning these wastes vary considerably. Finally, it must be realized that the amount and composition of municipal refuse itself is changing with time in all communities. This reflects local changes in the consumption of disposable items and changing attitudes toward public policies such as recycling. For these reasons, the data presented here are only average values. The design of a specific incineration facility must necessarily involve a local survey of community disposal practices, waste generation rates and waste composition in order to account for the individual nature of the waste stream.

DEFINITION OF MUNICIPAL SOLID WASTE

Municipal solid waste can be defined in several ways. First, the physical composition of the refuse can be classified as either combustible or noncombustible. Combustibles are those items of the waste that will support combustion. They include the following specific source categories: paper, plastics, leather and rubber, textiles, wood, food waste and yard waste. Combustible particulate and combustible gases result from the incineration of hese substances because of incomplete oxidation of the material. Also, these astes contain inorganic matter which adds to particulate emissions. The xact amount emitted will depend on the design and operation of the ncinerator and the installed air pollution control equipment. Minimizing the ombustible portion of particulate emissions is one area of incinerator design n which considerable advances have been made recently. New designs ensure at almost all combustibles are thoroughly oxidized before being emitted to e atmosphere.

In addition, gaseous emissions will result from the incineration of mbustibles. Some are attributable to the chemical nature of combustible terial and cannot be minimized by good incinerator design or operation. hese gases include sulfur dioxide, hydrogen chloride and hydrogen fluoride. heir emission rates are directly related to the specific composition of the aste. These gases will be more fully discussed in Section 4 of this report. her gases which incinerator design does effect include nitrogen oxides, rbon monixide, and hydrocarbons.

Noncombustibles in the waste include metal, glass and miscellaneous norganics. These materials will not support combustion and may have a gative impact on incinerator operation by absorbing heat during the ombustion process, thereby removing energy that could be used to generate team or hot water. Noncombustibles will produce inorganic particulate missions. The amount, type, and size of this particulate is dependent on efuse characteristics and plant operation. These factors will be ubsequently discussed in Sections 3 and 4 of this study.

Both combustibles and noncombustibles will contain limited amounts of the ther component. Metal cans, for example, will often have combustible paper overs. Similarly, paper and plastic will contain finely dispersed metal and ther inorganic materials. These inorganics will be released as particulate hen the combustibles are incinerated. For certain classes of inorganic articulate, specifically heavy metal emissions, the contribution of the ombustible fraction of the waste can be significant and may equal that of the noncombustible component.

Of special interest to this study are the following heavy, potentially toxic metals: arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc. The rationale for studying these specific metals and the extent of their emission will be presented in Section 4. Here, we are concerned with their sources in the refuse.

Cadmium, copper, lead, mercury and zinc are found in the combustible fraction of municipal refuse in percentages that are 10 to 100 times greater than those in coal.[3] These metals appear in the pigments for inks, stabilizers for plastics, clay fillers, whiteners, photosensitizers, and various other chemical compounds used in the production of combustible material. Although some of these heavy metals will become attached to the furnace slag and residue, substantial quantities will be emitted in the form of inorganic particulates.[4,5,6] For cadmium, chromium, mercury, lead and zinc emissions, the contribution of the combustible component of the refuse is considerable and may equal or exceed the contribution of the noncombustibles.[4] In addition, copper and zinc are normally found in significant amounts in the noncombustible fraction, with copper base components comprising 0.06 percent of the average total waste stream and zinc base metals accounting for an additional 0.14 percent of the total.[7]

Municipal refuse can also be defined by ultimate analysis. The ultimate analyses shows the relative percentage of carbon, hydrogen, nitrogen, oxygen, sulfur, chlorine, and ash in the waste. These data, which are most useful to the equipment designer concerned with calculating air requirements and furnace sizes, also indicate potential emissions. In this regard, the sulfur, chlorine and ash contents are especially informative. Sulfur and chlorine indicate the relative emission rates of sulfur dioxide and hydrogen chloride respectively, and the ash content informs us of the potential for inorganic particulate generation in the incinerator furnace.

REFUSE COMPOSITION

Table 1 presents reported data on refuse composition. For each waste category two composite ranges of values are given to indicate the wide variations that may exist in actual waste composition. This variation is clearly perceived when the yard waste category is examined. Yard waste as indicated may vary from 0 to 26 percent of total waste quantities, depending on the location of the community. This wide range of possible waste composition indicates why individual waste surveys must be undertaken before a facility is planned. If, for example, this survey demonstrates that yard wastes consititute a regular portion of the total waste stream for most of the year, then the facility might be designed to accomodate the high moisture/low Btu nature of this segment by providing for waste pretreatment (drying) or additional auxilliary fuel burners in the main combustion chamber. However, if there is a substantial difference in the seasonal generation rate of composition of this yard waste, than a waste disposal plan that calls for segregating and landfilling rather than incinerating this waste might be more appropriate and more cost-effective. A site-specific waste survey will serve to define the individual nature of the waste composition so that the waste disposal facility can accomodate this waste.

Typical municipal waste composition is also presented in Table 1. This composition was based on numerous individual waste surveys[8] and can be considered representative of a northeastern United States area such as New Jersey. In this regard it considers yard waste and averages the total quantity of this component over a year's time.

Additional waste-related parameters, such as percent moisture, heating value, and ash are presented, as are various growth rate indicators. These data, in addition to projections for each refuse component through the year 2000 were extracted from a comprehensive study of municipal incineration by the Arthur D. Litte Company.[8] These projections enable us to estimate potential changes in incinerator emissions that may be produced by changing refuse composition.

TABLE 1. MUNICIPAL REFUSE COMPOSITION (% BY WEIGHT)

Category	Composite site 1968[a] (range)	Composite site 1972[b] (range)	Typical Northeast U.S. refuse composition 1968[a]	1970[a]	1975[a]	1980[a]	1990[a]	2000[a]	2000[c]	Trend	Typical overseas refuse composition U.K.[d]	Germany[b]	Switz.[b]	Japan[e]
Glass	2.0–17.9	0.9–24.6	8.8	9.1	9.9	10.3	9.5	8.1	8.1	—	7.9	9.8	5	2.5
Metal	4.6–14.5	4.2–15.9	8.7	8.8	9.0	9.4	9.0	7.4	7.1	—	7.1	5.1	5	1.8
Paper	17.5–61.8	21.6–76.6	38.2	39.1	40.8	41.5	45.0	49.7	48.0	↗	32.5	18.7	40.50	39.4
Plastics	1.0–5.8	1.0–6.6	1.1	1.3	1.9	2.8	3.5	4.2	4.7	↗	1.0			4.5
Leather and rubber			1.5	1.5	1.5	1.5	1.5	1.6	1.3	—	-	(organic matter) 21.2	15.25	0.4
Textiles	0.4–4.8	0.2–13.4	2.0	2.0	2.1	2.1	2.5	2.8	3.1	↗	2.2			
Wood	0.3–22.4	0.0–11.5	2.7	2.5	2.2	2.0	1.6	1.3	1.6	↘	-			
Food waste	0.8–34.6	2.2–30.0	21.1	20.2	17.9	16.2	14.0	12.1	12.1	↘	19.3			38.7
Yard waste	1.6–33.3	0.0–26.0	14.1	13.8	13.2	12.9	12.2	11.8	11.9	↘				
Miscellaneous	0.2–23.6	-	1.8	1.7	1.5	1.4	1.2	1.3	2.1	—	29.9	15.2	-	12.7
% Moisture			25.9	25.2	23.4	22.1	20.5	19.3	19.9	↘				49
% Ash			21.8	22.1	22.9	23.5	22.4	19.7	20.1	—	-	30	20	
Heating value - Btu/lb			4582	4628	4719	4811	5040	5407	5207	↗	4300	4500	4700	2575
Per capita refuse quantity multiplier			1.0	1.05	1.19	1.32	1.52	1.76		↗				
Per capita refuse generation rate (lb/d)			3.3	3.5	3.9	4.4	5.0	5.8		↗				

[a] Reference 8.

[b] Reference 9.

[c] Reference 10.

[d] Reference 11.

[e] Reference 12.

Finally, the composition of municipal solid waste from four countries with standards of living similar to that in the USA is presented in Table 1. These data are presented for comparison and reinforce the conclusion that no two municipal waste streams are identical, regardless of similarities in life style.

What does this all mean to air pollution from municipal incineration? To answer this question we must first understand what types of materials are in each category, how these materials will affect pollutant emissions and what are the significance of changes in each category through the year 2000.

- Glass--the glass fraction of municipal waste primarily comprises food and beverage containers, window panes and fiberglas. Glass is virtually all (99 percent) ash and will contribute to the inorganic portion of incinerator emissions.[9] Glass will deform and become fluid[13] before other ash constituents and may cause operational problems by forming slag or clinker in the incinerator furnace. Projections show that the fraction of glass in the refuse will not change significantly over the next 20 years. This projection could change greatly if nonreturnable bottles are prohibited by state or federal regulations ("bottle-bills"), or if low-cost food grade plastic containers continue to replace glass bottles.

- Metal--metals originate in many forms, including food and beverage cans, bottle caps, wire and aluminum foils. Ferrous metals constitute from 75-85 percent of total metalic waste,[3,8] aluminum 10-20 percent, with the remainder divided primarily among copper, zinc, and lead. Metal from both combustibles and noncombustibles can be emitted from the incinerator as very fine particulate. The projections show a slight drop in the metal content of the refuse. This may vary with local conditions and depend on the extent of recycling efforts in the community.

- Paper--paper constitutes the dominant fraction of municipal solid waste. It has many sources, including corrugated cardboard, newspaper, paper packing, office paper and magazines and books. Paper has a relatively high heating value[8] and as such constitutes a major portion of the combustible fraction of the refuse. Paper has relatively little ash (6 percent), although this will vary with the specific paper being burned. In addition, certain magazines have been shown to contain over 1300 ppm of iron, over 1250 ppm of lead and over 300 ppm of zinc.[5] For speciality papers, these metal concentrations may be higher. One analysis of colored christmas wrapping paper recorded the following metals concentrations: up to 1300 ppm of iron, up to 2700 ppm of lead, up to 2700 ppm of zinc, and a copper concentration estimated as approaching 5000 ppm.[5] The principal source of these metals was the printing and processing of the paper in question. When incinerated, paper may yield coarse unburned char particles, soot, or fine metallic particulate. Paper, cardboard and other wood fiber products waste are expected to grow approximately 30-35 percent by the year 2000. This growth will decrease refuse bulk density and may adversely affect almost all refuse collection, storage and handling operations associated with refuse disposal facilities. This projected increase may also promote increased waste paper recovery.

- Plastics--the plastics content of refuse is expected to grow by from 300 to 400 percent from the year 1968 to 2000. Plastics in the form of polyvinyl chloride (PVC), polyethylene, styrene, etc. are found in packaging, plastic garbage bags, toys, housewares and non-woven synthetics. Plastics have a high heating value and this may cause hot spots in the incinerator furnace with resulting operational problems if a concentrated amount is burned at one time. Plastics can contain metals such as tin, cadmium, barium and titantium in the form of pigments and stabilizers and these metals will be released when the plastics are burned. The incineration of certain plastics, specifically PVC, will produce hydrochloric acid (HCl), which can cause severe corrosion on internal incinerator surfaces exposed to the flue gases. When released to the atmosphere HCl can be a public health problem. For these reasons HCl emissions from incineration are coming under close scrutiny. The percentage of PVC in the overall plastic components is expected in gradually increase through the year 2000. Coupled with the projected 3 to 4 fold increase in plastics waste, uncontrolled HCl emissions from municipal waste incineration are expected to increase by roughly 400 percent from 1970 to the year 2000.

- Leather and Rubber--shoes, tires, and toys are the principal sources of these items. The relative contribution of this category to the overall waste stream is low and expected to remain constant throughout the remainder of this century. Leather and rubber, like plastics, have a relatively high heating value. If improperly incinerated, they can produce gaseous hydrocarbon and organic particulate emissions. Rubber contains the highest sulfur content of any waste category, thereby contributing to sulfur dioxide emissions. Chromic acid is used in leather tanning and is a contributor to chromium emissions.

- Textiles--textiles enter the waste stream in the form of natural and synthetic woven fibers and spun-bonded synthetics. They have a heating value similar to that of paper and because of their organic base, textiles will emit hydrocarbons and organic particulate if improperly combusted. The average sulfur content of textiles is 0.2 percent[8] and this fraction will be emitted from the incinerator as sulfur dioxide. It is projected that the textile fraction of municipal solid waste will increase 40-50 percent by the year 2000, but should still remain below 3 percent.

- Wood - wood waste comes from a variety of sources, including wooden packaging, furniture and logs. Wood, when combusted, may yield ammonia, combustible particulate and trace metals from paint and other coatings, in addition to nitrogen dioxide and hydrocarbons. Because the value of wood for residential heating has increased, the amount of wood waste will probably decrease to below 2 percent of all municipal refuse by the year 2000.

- Food Waste--garbage from residential dwellings is the source of the food waste fraction of municipal refuse. The amount of food waste in the total waste stream is expected to decrease for several reasons. The advent of home food disposal units has resulted in th discharge of ground food products to the municipal wastewater lines. The increase in fast food chains also causes a reduction in household food waste quantities as less food is prepared in the home, although food waste from these chains may ultimately be processed in a municipal incinerator. Food waste can cause problem with municipal incineration. The high moisture content of this waste requires the addition of energy from other waste sources for proper combustion. Improper combustion will generate organic acids, aldehydes, ammonia and combustible particulate. The sulfur content of this waste fraction is relatively high (0.25 percent) and this will contribute to sulfur dioxide emissions.

- Yard Wastes--yard wastes are highly dependent on both geographical location and season. For a state that undergoes a considerable seasonal variation in climate, such as New Jersey, they constitute a significant fraction of the waste stream. The amount of yard waste generated depends on the season of the year. During the growing season of spring through early fall, grass, leaves, shrubs, and foliage growth will enter the waste stream. As an organic constituent, they represent a potential source of organic acids, hydrocarbons and organic particulate. Similar to food wastes, they have a relatively high moisture content, requiring the addition of heat, and a high sulfur content (0.35 percent), resulting in the release of sulfur dioxide.[14] The relative amount of yard wastes will decrease slightly by the year 2000, although this waste component is highly dependent on local conditions.

- Miscellaneous--this category includes ash, stones, and dust. Its relative percent in municipal waste is highly dependent on local practices and regulations as regards the collection of demolition and other such waste. Charging of this waste into a municipal incinerator may result in the emission of a variety of fine inorganic particulates. It is projected that the relative contribution of this category will drop by the year 2000.

Three additional refuse characteristics that will affect incinerator operation are also detailed in Table 1. The first is percent moisture of the entire waste stream. Each solid waste component has a relative moisture of level associated with it. These levels vary from 2 percent for the metal and glass fractions to over 50 percent for the food and yard waste categories. As the relative percentage of food and yard wastes in the total decrease by the year 2000, so will be projected moisture content of the entire refuse sample. Overall, this projected decrease will mean that an incinerator will have to burn less waste in the year 2000 to produce the same amount of steam it generates today, as less energy will be needed to vaporize moisture in the waste.

The percent ash in the refuse is expected to rise initially, then fall. This indicates that the potential for generating inorganic particulate emissions will similarly rise then fall, and will require that any air pollution control device installed on an incinerator is designed for an uncontrolled emission rate that may increase over time. The ash percentage figure is also important in planning residue disposal. It indicates to solid waste planners the volume of ash that must be ultimately disposed of in landfill sites.

The projected changes in the heating value of municipal solid waste will have a noticeable effect on the design and operation of municipal incinerator facilities. Table 1 indicates the estimated 1968 heating value of 4,582 British thermal units (Btu) per pound of refuse. By comparison, bituminous coal contains from 10,000 to 13,000 Btu per pound, and number 6 (residual) oil, 18000 Btu per pound. Municipal refuse therefore contains approximately one-third the heating value of coal, and represents a steady, dependable fuel supply close to urban areas. As fuel prices increase, the economics of heat recovery from municipal refuse will favor the use of this relatively untapped energy sources. As Table 1 indicates, the heating value of refuse is expected to rise 18 percent by the year 2000. This increase is attributable to the projected increases in plastics and paper, which have high heating values, and the decrease in food and yard wastes, which have lower values. This projected increase in total heating value will make heat recovery from municipal waste even more attractive than it is today.

WESTERN EUROPE

The refuse composition of Western European countries varies as much as that of refuse generated in the United States. There is less metal and glass in European refuse but more total ash. In addition, there is generally less paper and combined organics in Western European waste. The heating value of these wastes has been steadily rising over the past 20 years as the standard of living in these countries has increased. This rise in heating value combined with decreasing landfill sites and public concern over landfill leachate contamination of public water supplies has spurred interest in centralized incineration, especially in Germany and Switzerland. Municipal incinerators equipped with heat recovery are the preferred solid waste disposal method in Western Europe. By 1977, over 200 waste-to-energy plants were in operation in this area. European countries, in fact, made up 9 of the 10 top nations in municipal incineration waste disposal as measured by pounds of waste incinerated per day per capita.

JAPAN

Japanese waste is vastly different from European refuse or U.S. refuse. Japanese municipal waste has approximately twice the amount of food waste and 2 to 4 times the amout of plastics. It contains substantially less glass and metal but approximately the same amount of paper. The overall moisture content approaches 50 percent because of the large food waste fraction. Because of this composition, the heat content of the refuse is only one-half that of U.S. waste. In spite of these variations, municipal incineration is popular in Japan. By 1977, there were 85 incinerator facilities in operation, in large part because of land considerations, since the low heating content of the fuel precludes extensive thermal recovery from these incineration systems.

RATE OF MUNICIPAL SOLID WASTE GENERATION

There is considerable disagreement in the literature concerning the amount of refuse that is generated per person per day. These data are especially important to system designers who must size municipal incinerators to present and future community needs. A review of the various waste generation estimates is helpful here, as it indicates the amount of refuse that must be handled and the energy potential of this waste.

An extensive study of waste generation rates was conducted by the Federal Bureau of Solid Waste Management in 1968. This evaluation was made using a "material balance" technique in which the movement of potential refuse components into and out of state and the internal generation of potential refuse components were estimated. No measurement of actual refuse generation rates was made. Accounting for seasonal variations, this study found that an average of 6.02 pounds was generated per capita per day in New Jersey in 1968.[8] Subsequent review of these data[15] indicates that this rate may be high because of the inclusion of demolition, construction, and industrial wastes, in addition to residential, commercial/institutional, and street wastes. A residential figure of 3.2 to 3.3 pounds per day per person was cited[15] for the 1968 base year and this figure has been substantiated in several additional estimates[16,17] including EPA's fourth report to Congress on resource recovery and waste composition.[17] The waste generation rate was projected through the year 2000 using this baseline number and refuse generation multipliers estimated in the Arthur D. Little report.[8] As indicated in Table 1, residential refuse generation is projected to increase to 5.8 pounds per capita per day by the year 2000.

ULTIMATE ANALYSIS

Table 2 presents the ultimate analysis of several refuse samples. Both estimated ranges of values and actual waste analyses data are presented. These data have particular relevance to system designers who must calculate furnace size and combustion air requirements. Theoretical (or stoichiometric) air requirements are based on the complete combustion of the refuse. This calculation assumes that all carbon in the waste sample is completely oxidized to carbon dioxide and all hydrogen present is oxidized to water. Waste nitrogen may be oxidized to nitrogen dioxide or may be released as elemental nitrogen while the bound oxygen in the fuel is liberated during combustion and consumed. Sulfur is oxidized to sulfur dioxide and chlorine combines with hydrogen to form hydrogen chloride. These theoretical reactions will take place if sufficient air is supplied to the burning refuse bed. However, incomplete combustion may result from poor fuel/air mixing or insufficient air supplies. If this occurs, intermediate products of combustion will form. These include combustible particulate, carbon monoxde, hydrocarbons, aldehydes, and organic acids.

TABLE 2. MUNICIPAL SOLID WASTE ULTIMATE [illegible]

Location	Year	Reference		Carbon	Hydrogen	Nitrogen	Oxygen	Sulfur	Chlorine	Ash
Babylon, NY[a]	1970	18	(range)	15-30	2-5	0.02-0.3	15-30	-	0.1-0.5	15-27
		19								
			• Range	20-32	3.2-4.8	0.15-0.2	18-26	0.1-0.15	0.12-0.17	13-22
			• Design data	32.8	4.4	0.2	24.1	0.14	0.16	15.6
Chicago, IL[a]	1971	20		26.5	3.5	-	22.0	0.25	-	33.25
Nashville, TN[b]	1975	21		46.7	6.3	0.3	34.6	0.2	0.23	11.7
Braintree, MA[c]	1978	22		47.3	6.2	0.29	41.4	0.33	-	4.6
Orlando, FL[d]	1975	23	Orlando	39.9	6.0	1.5	41.7	0.08	0.12	10.7
Siloam Springs, ARK[d]	1975	23	Siloam Springs	47.3	7.1	0.5	35.5	0.1	0.76	5.5
(Estimate)[a]	1977	18	(RDF)[e]	21.1	3.5	-	28.1	0.1	-	16.8
Washington, D.C.[c]	1976	24		31.9	4.7	0.4	22.9	0.15	0.4	15.0
Pennsylvania[b]	1982	25	Bituminous coal	74.6	4.8	1.5	8.9	1.8	0.02-0.12	8.4
		26	Wood (Birch)	49.8	6.5	-	43.5	-	-	0.3

[a] Wet refuse.

[b] Dry refuse.

[c] May be wet or dry refuse.

[d] Combustible portion of the refuse.

[e] RDF = Refuse derived fuel.

Estimates of sulfur dioxide and hydrogen chloride emissions can be made using ultimate analysis data. These estimates will overpredict actual emissions becuase some sulfur dioxide and hydrogen chloride is absorbed in the ash and removed from the furnace as a solid. Note the wide variation in elemental analysis data in Table 2. This is consistent with the wide variations that were noted in the physical composition of the refuse in Table 1. The figures for chlorine content exhibits an especially wide range, again because of localized refuse quality. In spite of these variations, municipal solid waste can be broadly categorized as a low sulfur, high chlorine fuel. With an average sulfur content of 0.15 to 0.20 percent, refuse appears to compare favorably with the conventional fuels of coal (0.6 to 3.5 percent S) and oil (0.2 to 2.0 percent S). However, a comparison between fuels based on the common regulatory units of potential pounds of sulfur dioxide per million Btu's is more relevant owing to the comparitively low heating value of the refuse. Using this standard, municipal refuse has the potential to emit approximately 0.6 to 0.8 pounds of SO_2 per million Btu (lbs/10^6 Btu) compared to 1.0 to 5.8 lbs/10^6 Btu for coal and 0.22 to 2.8 lbs/10^6 Btu for oil. These potential SO_2 emissions can be compared to the New Jersey sulfur in fuel regulation for oil, which allows 0.3, 0.5, 1.0 or 2.0 lbs/10^6 Btu, depending on location. For new bituminous coal burning units the maximum allowable SO_2 emissions are either 0.30 or 0.60 lb/10^6 Btu. Thus, SO_2 emissions from municipal solid waste may exceed the emission rates allowable for fuel or coal, depending on the specific waste analysis and the location within the state where it is burned. The chlorine content of the solid waste, which averages 0.2 to 0.3 percent, is somewhat higher than that of coal which averages 0.14 to 0.17 percent.[26] However, a comparison between fuels based on the common regulatory units of pounds per million Btu's is more relevant owing to the comparatively low heating value of the refuse. The chlorine content of the refuse, using this standard is approximately 0.5 pounds per million Btu which is substantially higher than that of coal (0.13 pounds per million Btu).

Ultimate analysis data for refuse derived fuel, bituminous coal, and wood are also presented in Table 2. These data are provided for comparative purposes only. The use of refuse derived fuel will be more fully discussed in Section 3. Bituminous coal and wood are the principal solid fuels used in the country today.

The composition, elemental breakdown, and generation rates of municipal solid waste can vary considerably from community to community. To better understand the make-up of refuse, we can define a "typical" waste stream and generation rate, realizing that the actual waste composition in any community can differ greatly from these values. Municipal solid waste, in general, has a lower heating value than comparable solid fuels, a comparable sulfur content, and higher chlorine and ash contents. Its heterogeneous, variable nature make it somewhat more difficult to handle and burn with a constant heat release rate. These and other combustion-related parameters will be subsequently discussed.

SECTION 3

EXISTING TECHNOLOGY

As the composition of municipal waste has changed, so has the design and operation of municipal incineration facilities. Incinerators that were at one time designed for the sole purpose of reducing the weight and volume of municipal refuse have evolved into units that recover useful energy and at the same time meet strict environmental emission standards. This evolutionary process can be thought of as having progressed on two distinct paths, one for large facilities and one for small operations. The differences between these two groups involve more than equipment size. Both groups, however, do incorporate energy recovery devices, and the subsequent discussions will assume these devices are an integral part of the entire system.

Large facilities are defined here as municipal incinerators with individual furnace capacities greater than 50 tons per day (TPD). This definition is consistent with the one used for Federal New Source Performance Standard (NSPS) applicability. This source size was chosen as a cut-off because it approximately divides those facilities which typically incorporate sophisticated air pollution control and those which do not. The economies of scale inherent in large incinerators also affect the design of the refuse feed system, the furnace enclosure, the manner in which heat is recovered from the hot combustion gases, and the amount and type of resource recovery that is carried out at the installation. The extent of resource recovery at an incinerator plant will also affect the manner in which the refuse is handled before incineration. Large municipal incinerators in fact will be categorized in this report by the extent to which refuse is treated before combustion.

Small incinerators encompass all units with rated capacities of 100 to 4000 pounds per hour (1 to 50 tons/day). This size unit is often used in smaller communities to incinerate municipal refuse. Multiple units may be installed at the facility to provide operational flexibility. Until the 1970s small communities that practiced centralized incineration used simple single and multi-chamber incinerators, with little or no air pollution control. The advent of strict air pollution emission regulations forced incinerator operators to add pollution control equipment to meet emission standards. Many facilities shut down rather than install this equipment. To counter this trend, incinerator manufacturers have developed new designs that contain "built-in" emission control in the form of afterburners. These units are not being successfully marketed.

This review of large- and small-scale municipal incinerators will concentrate on only those technologies that are commercially operational. Increased municipal incineration in New Jersey in the short term can be expected to involve the use of readily available off-the-shelf technology, and it is the air quality impact of these units that must concern us. Developmental and experimental technologies, such as pyrolysis, gasification, liquefaction and biological conversion processes may find widespread acceptance in the future, but they are not generally in use now. The unit operations and environmental impacts of these technologies will not be assessed within this s

LARGE SCALE INCINERATION

Full-scale, commercially available large municipal incinerators may be categorized according to the characteristics of their solid waste feed. Mass-burn incinerators burn municipal refuse that has not been preclassified or pretreated. The solid waste is incinerated as received, and only large, bulky items such as refrigerators are separated. Refuse-derived fuel (RDF) systems, on the other hand, incinerate solid waste that has undergone extensive size reduction and classification. The RDF may be in the form of a pellet, a briquette or a fluff, and it may be burned in a semi-suspension or a full suspension combustion unit. Each of these systems has advantages in certain situations. Table 3 presents the relative advantages and disadvantages of each system. Parameters that a municipality will consider in evaluating each system for a specific application include initial cost, operating and maintenance costs, reliability, thermal efficiency, availability, and operating experience. A review of these two distinct methods of incinerating large quantities of municipal solid waste will serve to highlight their differences.

Mass Burn Incinerators

The incineration of unprepared municipal waste has been the traditional method of thermal waste reduction. Individual unit operations in the facilities have undergone considerable change in the past 80 years, yet the waste handling segment has remained essentially unchanged. Mass burn incinerators equipped with heat recovery are the preferred method of municipal waste disposal in Europe. Several hundred of these units have been constructed there in the past 20 years, in sizes ranging from 60 to 2600 TPD.[16] In the United States and Canada, more than 10 plants have been built since 1967.

Hardware--

Figure 1 presents a typical mass burn incineration plant layout. Processing begins with the arrival of refuse collection trucks at the facility. After weighing, the trucks dump the raw refuse into a receiving pit that can hold up to 7 days' supply of waste.[8] Refuse remains in the hopper until it is moved by a bridge-type loading crane and clamshell grapple to the furnace charging hopper. The loading crane and grapple are manually controlled by an operator seated in a control cab located above the crane. As time permits, this operator mixes the refuse in the pit to ensure a homogeneous mix before charging it into the furnace hopper. Any oversize, bulk items are first fed into a shredder located next to this hopper. The crane operator must keep th

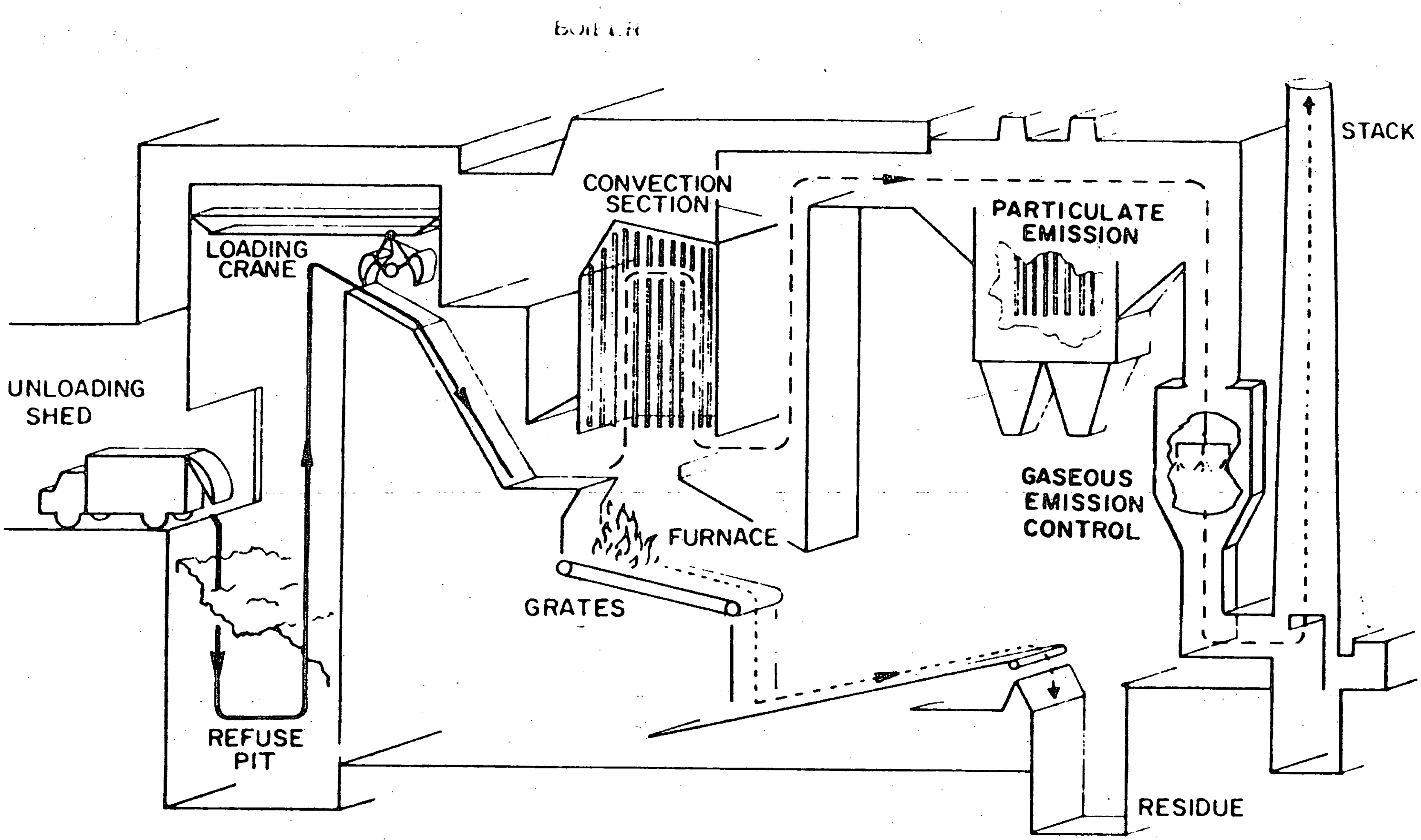

Figure 1. Typical waterwall furnace for unprocessed solids waste.[16]

furnace hopper charged at all times to ensure continuous firing and to prevent the furnace flame from backing up into the hopper. The refuse then moves by gravity onto the furnace grates. When on these grates, the refuse is dried by the flow of preheated undergrate combustion air, and by radiant heat from the burning refuse bed. Up to this point, virtually all continuous feed mass burn facilities are identical. The first major variation concerns the type of grates used in the furnace. Furnace grates are important because they must continuously convey the refuse through the furnace while promoting good combustion through adequate refuse agitation and passage of underfire air. The degree and methods of refuse agitation distinguishes one grate type from another. Agitation is important because all surfaces of the refuse must be exposed to the hot furnace temperatures to dry, ignite and completely burn the refuse. Excessive tumbling and agitation will cause entrainment of solid particles, whereas insufficient agitation will result in unburned waste. The optimum grate agitation cycle time is determined during plant start-up. The principal types of grates include traveling, reciprocating, rocking, and roller. No one grate type is significantly better than another. Because the grates are subject to a harsh environment of hot temperature and exposure to abrasives, the choice of grate type is often based on the operational record of the equipment.

The combustion process takes place in the furnace of the incinerator. Until passage of clean air legislation, furnaces were simple, refractory-lined chambers that provided for refuse combustion. However, increasingly stringent air pollution standards created the need for better air pollution controls. The waterwall furnace has virtually replaced the use of refractory-lined furnaces because waterwall units (1) are easier and cheaper to maintain, (2) are smaller and less costly to build, and (3) are more efficient in recovering the energy available in the solid waste. Waterwall furnaces are enclosed by closely spaced water-filled tubes. Water circulating through these tubes recovers heat radiated from the burning waste. Integrally constructed (attached) heat recovery boilers generate steam while reducing the temperature (and the volume) of the exhaust gases. The boilers consist of various zones or tube packages referred to as heaters, economizers, reheaters, etc., depending on the function of the particular zone. A marketable product (steam) is created while the use of smaller gas cleaning equipment is permitted because gas volume is proportional to absolute gas temperature. This energy-recovery incinerator design differs markedly from pre-1970 designs. The earliest batch-fed refractory incinerators diluted combustion gases with large quantities of ambient air to lower gas temperatures. Lower temperatures are important in order to minimize operating problems created by warping and thermal stress of metal parts. Later incinerator designs used a water-spray system that lowered gas temperatures. In both cases, the energy of the hot combustion gases was not recovered. Regardless of the equipment used to cool these gases, after cooling, the gases are passed through an air pollution control device and are then vented to the atmosphere through a stack. The principal types of municipal incinerator air pollution control devices are discussed in detail in Section 5 of this report.

Residues produced from the combustion of refuse represent approximately [illegible] percent by volume of the input waste and 25 to 35 percent of their original weight. The greatest amount of these residues come off the end of the furnace grates; the remainder comes from siftings and fly ash captured by the air pollution control equipment. In modern continuous feed incineration systems, residue is discharged continuously from the grates into a water-filled trough. This system immediately cools the residue, thereby minimizing fire hazards, while maintaining an air seal to the furnace. A slow moving drag line, submerged in the water-filled trough continuously removes the residue to a holding bin. From here, the residue is conveyed to a resource recovery operation or a sanitary landfill.

Siftings are the fine material that fall from the fuel through the grate openings during the incineration process. They consist of ash, small fragments of metal, glass, and ceramics; and unburned or partially burned organic substances. In most incinerator designs, they are conveyed directly to the common residue collection trough. Similarly, screw conveyors usually feed the fly ash captured by air pollution control devices directly to this trough. In this manner, all incinerator residue can be collected and handled by one integrated system.

Combustion--

Solid waste incineration, when carried out under the proper combination of turbulence, time, and temperature, is capable of reducing the refuse to a noncombustible residue consisting of only glass, metal, and ceramic materials present in the original charge. Unfortunately, there is no one combination of turbulence, time and temperature that will guarantee complete combustion of every municipal solid waste constituent. In practice, a combination of good design, which incorporates elevated operating temperatures and long gas residence time, and "fine-tuning" of the incinerator operation, to insure the right amount of turbulence is delivered in the best location, is used to achieve optimal incinerator operation, with a minimal amount of pollutant generation. These items will be subsequently discussed in more detail.

The incineration process may be considered to occur in several successive steps. First, the surface and internal moisture of the refuse must be removed if combustion is to take place. Most of this drying process occurs immediately after the refuse is charged into the furnace. It continues throughout the length of the furnace as the waste is tumbled and advanced by the action of the grates. Heat for refuse drying is supplied by the burning waste, and design features such as reflective furnace walls may be added to enhance the drying process. When dried, the refuse ignites and is combusted. The combustion process in an incinerator can be described by two overlapping stages--primary combustion and secondary combustion. Primary combistion refers to the physical-chemical changes that occur in the solid waste. These changes include drying, volatilization, and ignition of the refuse. Secondary combustion refers to the oxidation of gases and combustible particulate matter released by primary combustion. Both combustion stages require oxygen to complete the chemical reactions. This oxygen may be supplied beneath the furnace grates (underfire air) or above the burning refuse (overfire air). Underfire air is important to primary combustion. Insufficient underfire air will cause incomplete combustion, whereas too much air supplied beneath the grates will cause entrainment of inorganic mineral particulate. Overfire air is more concerned with the burn-out of volatile gases and combustible particulate. Overfire air will also promote turbulence of the combustion gases, which is necessary to ensure that all combustion products are exposed to sufficient oxygen so that most combustibles are oxidized. Too little overfire air will allow carbon monoxide, hydrocarbons, and unburned particulate to be emitted from the furnace, whereas excess quantities of overfire air lowers furnace temperatures and is thermally inefficient. The exact proportion of underfire to overfire air is determined by trial and error. For most municipal incinerator designs, underfire air ranges from 40 to 60 percent of total air requirements.[28]

Furnace residence times and combustion temperatures are also important to ensure complete oxidation of volatile gases and combustible particulate. Residence times are designed into an incinerator through the size of the furnace. The incinerator temperature is controlled by the rate at which refuse is supplied to the furnace. The elimination of odors requires that furnace temperatures be maintained at a minimum of 1500°F for a period of 0.5 seconds or more. This time-temperature relationship will also ensure that virtually all carbonaceous particles below 2 microns in size will be completely combusted. The exact relationship between time-temperature, turbulence, furnace oxygen content, and specific pollutant species is highly complex and not completely understood.[29] Actual incinerator temperatures will vary. The furnace temperature immediately above the burning refuse generally ranges from 2100° to 2500°F, and for short periods of time, it may reach 2800°F in localized areas,[28] if a highly concentrated batch of plastic or rubber is charged into the furnace. Older municipal incinerators without heat recovery capabilities operated with maximum design temperatures of 1500°F to 1800°F,[28] whereas modern units with energy extraction may have primary furnace design temperatures of 2000° to 2480°F. To ensure burnout of combustibles, a furnace outlet temperature of 1500°F to 1800°F is recommended.[28] Higher temperatures are advantageous for better heat recovery, yet excessive temperatures may lead to cracking of refractory and bending, warping, and misalignment of boiler tubes and should be avoided unless special designs are used. Because of variations in the composition of the waste, fluctuations in furnace temperatures of 200°F or more are not uncommon. Therefore, design temperatures should be at least 200°F higher than anticipated operating temperatures, i.e. 2200 to 2680°F in the primary chamber, 1700 to 2000°F at the furnace outlet, etc. These temperature fluctuations are caused by the varying heating characteristics of the waste and may be an operational problem if strict steam temperatures and pressures must be maintained. Crane operators are usually instructed to mix the waste in the holding pit before charging it into the furnace hopper to minimize this problem.

Refuse-Derived Fuel Installations

An alternative to mass-burn municipal incinerators is gaining in popularity in the United States. In place of straight solid waste, the incineration facilities consume refuse-derived fuel (RDF). RDF has grown in popularity as communities attempt to recycle the glass and metals in municipal waste while producing a homogeneous, combustible fuel for use in water-walled incinerators or conventional boilers designed for coal firing. Refuse-derived fuel installations shred, then classify waste into combustible and noncombustible fractions. By classifying materials before incineration, the noncombustibles can be separated into distinct fractions such as ferrous metals, aluminum and glass. These classified fractions will be relatively pure compared to mass burn incinerator residue and therefore will have a higher salvage value. The refuse-derived fuel that is produced can be incinerated by itself or combusted with another fuel. This report will only concern itself with incinerators that consume 100 percent RDF. Co-combustion facilities that derive only part of their heat input from RDF are beyond the scope of this report.

The heat recovery incineration facility that burns RDF in place of untreated refuse will have essentially all the same features (i.e., waterwall furnace, grates, residue handling, air pollution control) of a mass burn facility, except for the fuel preparation process. Actual design parameters will vary, but the unit operations are virtually identical.

A schematic of an RDF fuel preparation process is presented in Figure 2. The specific process diagrammed here is a Bureau of Mines pilot plant operation. Full-scale RDF processing plants may include some, or all, of these unit operations.

The key to resource recovery before incineration is shredding. All refuse is initially shredded to reduce the average particle size to 4 to 6 inches. This size material facilitates fractioning the refuse into various categories. Light paper and plastics are separated using an air classifier that "blows" this light fraction away from the heavier materials. Ferrous metals are segregated using a magnetic separator that preferentially draws off the iron-rich metals. A trommel, which resembles a rotating cylinder with holes throughout its length, is used to separate glass and other dense materials from the lighter fraction. The dense fraction falls through the holes in the trommel while the lighter material passes through. Aluminum and other electrically conducting metals can be sepaerated from nonconducting materials by using their electrical conductivity. The shredded nonferrous metal fraction is passed through an alternating current electromagnetic field that induces an eddy current in the aluminum. This current in turn generates a magnetic flux in the opposite direction to the initially imposed field. The resulting repulsive force sweeps the aluminum (or other conductor) off the continuous conveyor belt for collection.

Mixed glass in an RDF facility will normally be recovered during a secondary or tertiary step, after separation of light materials. Glass, stones, and other inorganics are put through a crusher to reduce the average particle size. This mixture is then placed in a froth flotation chamber filled with an aqueous solution. The glass is selectively coated with the solution and is separated by air bubbles from the ceramics, refractory brick and stone.

After all noncombustibles have been removed from the waste, the paper, plastics and organics that constitute the combustible fraction are recombined to form RDF. This fuel will have a lower ash content, a higher heating value, and a slightly higher moisture content than the unprocessed refuse. It can be

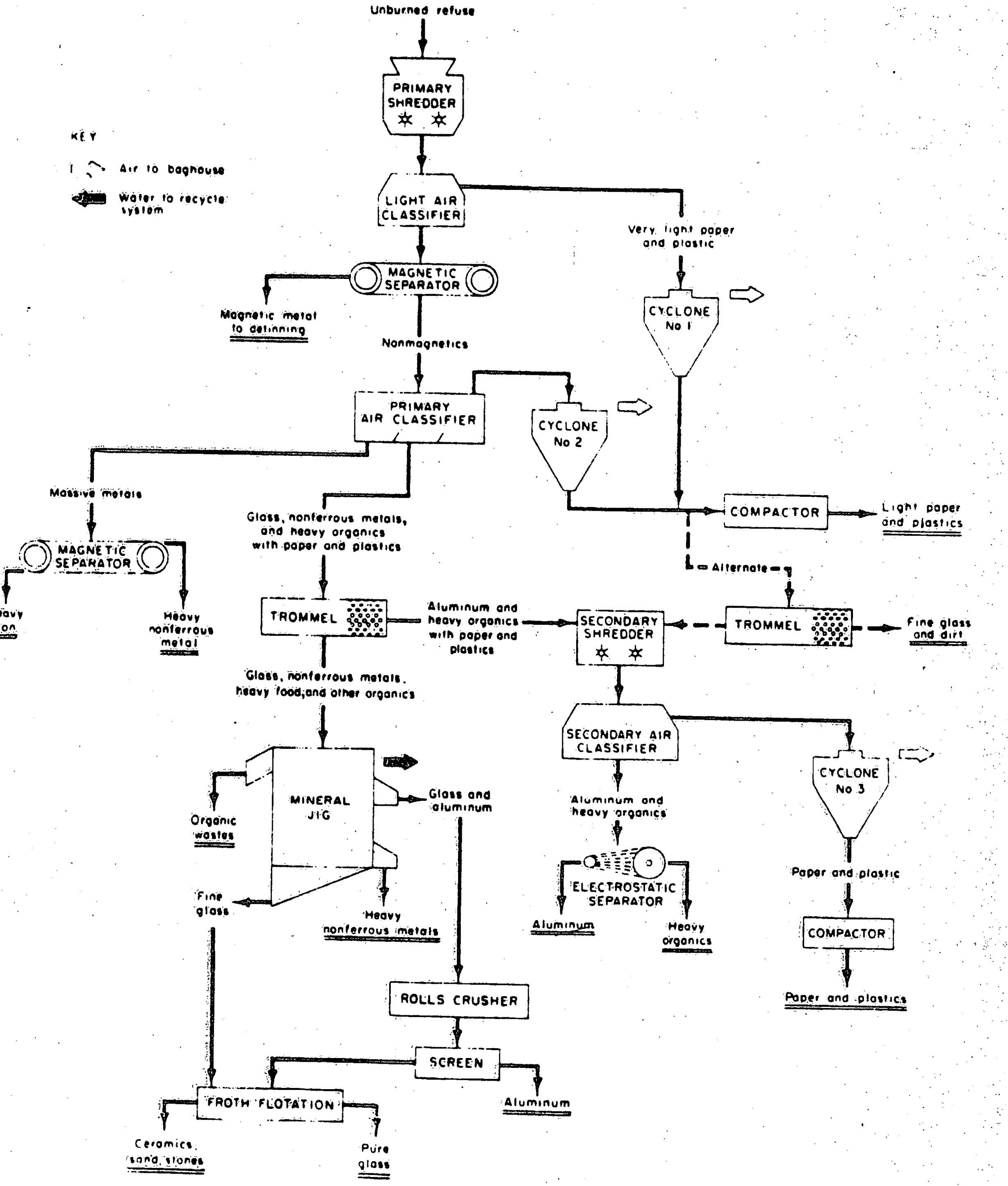

Figure 2. Refuse derived fuel (RDF) preparation process.[3]

further treated to form a fluff, a powder, or briquettes. The RDF can be incinerated on-site or transported to a distant fossil-fuel-fired facility and can be burned by itself, or as a fuel supplement to coal or oil.

Refuse-derived fuel is fed into a furnace in one of two ways. If an existing coal-fired boiler is used to burn the RDF, a spreader stoker is most commonly used. This device spreads the refuse into a traveling grate where it burns, similar to mass burn incinerators. This is considered semi-suspension incineration, and any sized RDF may be used. As an alternate, the RDF may be blown into the furnace above the grates. This method is similar to a pulverized coal feed system. Here the refuse burns in a full suspension state. Most combustion takes place while the RDF is suspended above the boiler grates. Unburned or partially burned RDF will fall onto the grates, where combustion is completed. This form of incineration requires that the RDF be in a powder or fluff form, equivalent in size to pulverized coal.

As demonstrated in Table 3, each of the large-scale incineration systems has advantages and disadvantages. The mass burn facility needs no fuel preparation equipment, but as a result must deal with operating problems associated with having a hot mixture of metal and glass in the furnace. This mixture can fuse together at elevated temperatures to form a solid deposit called clinker. Clinker can become embedded in the furnace grates and may force the incinerator to be shut down in order to remove it, and thus be a major maintenance problem. In addition, the furnace residue is partially oxidized, thereby decreasing its resale value.

RDF plants do require extensive fuel preparation equipment, which is both costly to buy and to operate. Metals, glass, and even paper and plastics can be removed from the solid waste stream for recovery and resale. The prepared fuel is compact and can be transported for incineration off-site. RDF can also be used as a supplemental fuel in existing utility boilers. This flexibility gives RDF many advantages.

The selection of mass-burn or RDF technology for a specific large-scale installation will depend on many factors: the extent of current resource recovery efforts in the community, the salvage value for segregated metal and glass fractions, and the potential use of RDF in existing local boilers. European communities appear to favor the mass-burn approach, whereas RDF production is under investigation in this country. There will probably be a mix of both technologies used for new installations in the near future.

SMALL SCALE INCINERATION

Small cities, towns, and municipalities may also choose to incinerate their solid waste. These communities are confronted with the same disposal problems that confront their larger counterparts: a steady solid waste stream that must be handled, a decreased number of acceptable sanitary landfill sites, a requirement that environmental standards must be met, and a need to offset disposal costs with revenues of recovered energy products. However, insufficient solid waste is generated in these areas to economically justify the construction of a large, mass-burn, or RDF incinerator. Their small-scale problem must be addressed in a equally small-scale manner.

TABLE 3. COMPARISON OF LARGE-SCALE INCINERATOR TECHNOLOGIES[27]

Suspension-RDF Firing	Semi-Suspension-RDF Firing	Mass Burning
	ADVANTAGES	
Lowest capital cost.	Low capital cost.	Lowest material handling cost.
Boiler may be existing.	Boiler may be existing.	Minimum preprocessing of refuse required.
		Lowest operating cost.
		Lowest cost for materials separation.
		Lowest overall cost.
	DISADVANTAGES	
Highest operating cost.	High operating cost.	Highest capital cost.
Loss of material and heat value in precombustive and combustion processes.	Loss of material and heat value in precombustive and combustion processes.	Requires specially designed control system for level steam output.
Requires auxiliary fuel for stable combustion.	Requires auxiliary fuel for stable combustion.	

Until the late 1960s, communities of this size that practiced centralized incineration did so using single chamber or multi-chamber incinerators. These units were typically large chambers that were batch fed and when ignited were left to burn. Little supervision was given to the burning refuse and vast amounts of excess oxygen were fed into each chamber to ensure complete oxidation of all combustibles. These units operated with mixed success. Consequently, large amounts of both combustible and inert particulates were discharged to the atmosphere. With close control of the burning process and constant supervision, these units could theoretically produce low emissions, but this degree of attention is not practical in a small operation. Some facilities have added wet scrubbers to minimize pollutant releases and achieve emission standards. These, too, have operated with mixed success.

To counter this emissions-related problem, the incinerator industry, in the late 1960s, introduced the controlled air incinerator. This unit is an incinerator with an afterburner or an incinerator with a primary and a secondary combustion chamber. Controlled air incinerators rely on close control of all phases of the combustion process to minimize the generation and release of pollutant emissions. Controlled air incineration can easily be integrated with heat recovery devices, enabling the owner to recover energy in the form of steam or hot water. Currently, there are over 15 manufacturers of this equipment, and at least 95 incinerators have been installed in 37 municipal operations.[31] Because these incinerators represent state-of-the-art technology for small-scale refuse incineration, they will be reviewed here. It is expected that most future municipal incinerators in the 100 to 4000 pounds per hour size range will use this technology.

Operation

A typical modern controlled air incinerator is shown in Figure 3. The unit consists of two distinct refractory-lined chambers: the first stage or primary chamber in which a reducing atmosphere is maintained and a second stage or secondary chamber where an oxidizing atmosphere is present. The pollution-limiting features of this incinerator depend on very close automatic control of conditions within these two chambers. Controls are installed on these units to automatically adjust air and fuel requirements to maintain these conditions. Waste is charged into the primary chamber where ignition takes place. Auxiliary burners may be used for start-up and they will automatically shut off when preset time and temperature conditions are reached. Inside the primary chamber, the combustion reaction is controlled by limiting the amount of air needed for complete combustion (hence the term controlled air). The oxygen that is supplied is sufficient only for partial oxidation of the waste. The fixed carbon in the refuse is oxidized and releases heat, which causes a pyrolysis reaction of the volatile fraction of the waste resulting in a dense, combustible smoke. Typically only 25 to 50 percent of theoretical air requirements are supplied to the primary chamber. This relatively small air flow requires less motor horsepower from the fans and reduces the amount of the particulates entrained in the exiting flue gases. The furnace temperature in the primary chamber is regulated by controlling the amount of air that is permitted into this chamber. A lower temperature favors the retention of volatile metals in the ash, while a higher primary chamber maximizes refuse burn out. The incinerator operator must strike a balance between these limits. The standard primary chamber temperature range is 1150°F to 1750°F.[31]

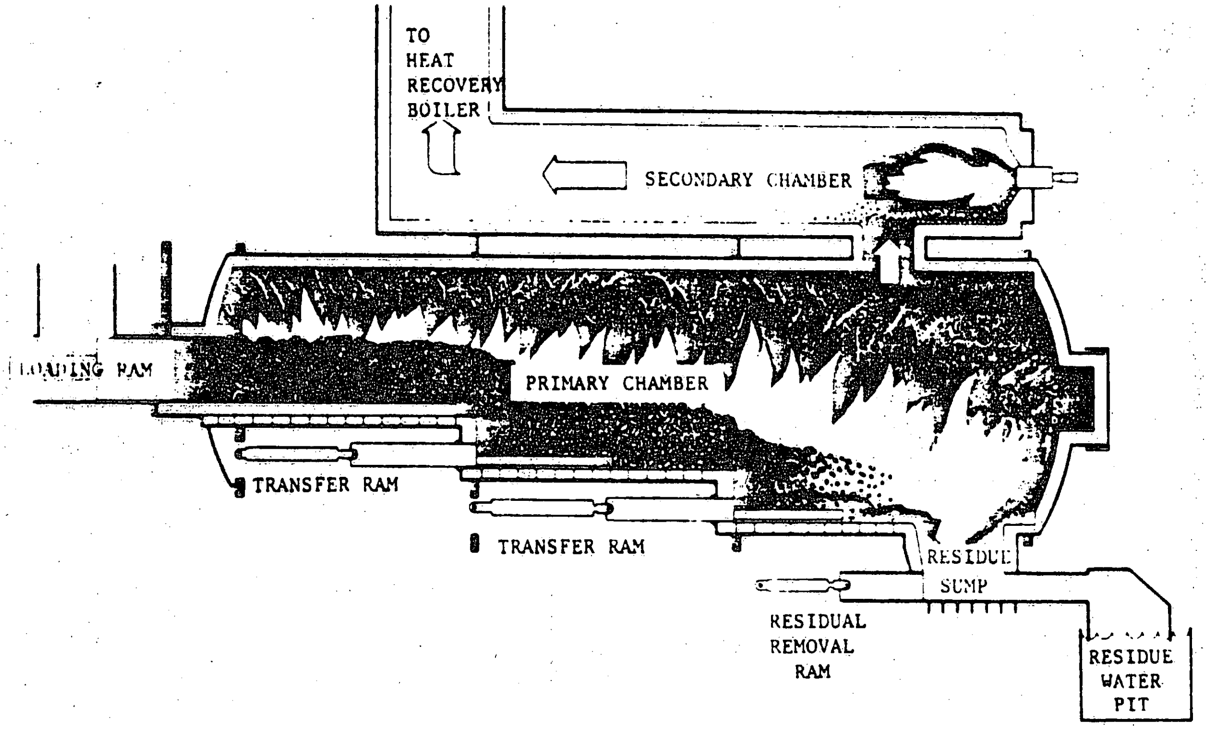

Figure 3. Controlled air incinerator.[31]

The volatile gases from the primary chamber subsequently enter the econdary chamber. Here, additional air is injected, the mixture is ignited, and the combustible gases and particulates are oxidized. If the gases are at a sufficiently high temperature, they will ignite spontaneously because the moke generated in the primary chamber is combustible. Additional fuel, pplied through an afterburner, must be used as a supplement when the gases re not rich enough to sustain combustion. The combustion temperature in this fterburner section is controlled by the amount of air injected (to lower mperatures) and the use of the afterburner (to raise temperatures). mperatures in the center of the secondary chamber are normally limited to ss than 2000°F to minimize nitrogen oxide and in the interest of equipment rability. On the lower end, temperatures of at least 1600°F are maintained o provide for complete oxidation. Temperature control is initiated by hermocouples located in each chamber. The actual controlling set points can e varied by the equipment operator and are usually maintained with a 100°F ntrol band.

Ash and other noncombustible residues that settle on the hearth of the imary chamber are periodically removed, either manually or automatically. n the manual system, the operator scoops out the ash by shovel or front end oader after the unit has been shut down and cooled. In the automatic system, he ash is pushed or forced ahead of the burning waste until it exits the hamber, generally through a drop chute into a water-sealed pit or an airlock hamber.

Energy can be recovered from controlled air incinerators by venting the ot flue gases from the secondary chamber to a heat recovery boiler. Because hese boilers are not an integral part of the total incineration system esign, as they are with large-scale systems, the heat recovery efficiency is ot as high; yet up to 72 percent of the input energy from the refuse was onverted to steam at one municipal controlled air operation.[23]

Controlled air incineration offers the additional advantage of having a odular construction. These units are constructed of integral components, one or the primary chamber, one for the secondary chamber, etc. Each component is assembled and packaged in the factory for immediate on-site installation. nly electrical, fuel, water, and gas duct connections are required at the nstallation site. When the waste volume of a community exceeds the capacity of the installed units, additional incinerators can be incorporated to meet he increased demand. This allows communities to cater their incineration ystems to actual load conditions and thus they do not rely on waste rojections or estimates.

MAINTENANCE

Because of the high operating temperatures and intermittent, cyclical peration, incinerators of all sizes are prone to operating and maintenance roblems. This situation is worsened because the pollutants generated by unicipal waste incineration are corrosive. If the internal metal surfaces hat contact the flue gases are not warmed up above acid dew point emperatures before igniting the waste, acid gas corrosion will adversely ffect incinerator performance. Incinerators designed to meet all nvironmental emission standards cannot be assured of continued compliance ith therse standards without strict operating and maintenance plans.

SECTION 4

ATMOSPHERIC EMISSION RATES AND COMPOSITIONS

TEST METHODS

All air pollutants, both particulates and gases, are defined by the test method used to measure them. Because the test method may directly affect the reported pollutant emission rate, it is important that we document the test methods used for the reported data. Standardized test procedures were adopted for the more common pollutants by the EPA in the early 1970s. These methods include:[32]

Particulates	- Method 5 (dry catch only)
Sulfur dioxide	- Method 6
Nitrogen oxide	- Method 7
Carbon monoxide	- Method 10
Beryllium	- Method 104

Most state air pollution control agencies have adopted these methods and any test conducted to demonstrate compliance with these state regulations must use these procedures. Much of the emissions test data reported in this section was collected using these standardized test methods and, as a result, one test can be directly compared with another. However certain state and county agencies have adopted slightly different test methodologies. New Jersey, for example, uses an EPA designed sampling train, but requires that any particulate collected in the impingers ("back half") of the sampling train be added to particulate collected on the filter, cyclone and associated connecting lines ("front half") of the sampling train in order to determine total particulate emissions. Since New Jersey's test method includes the back half "catch" in its determination of a source's emission rate, and the EPA Method does not, data obtained using these different methods cannot be directly compared. The emission rate obtained using the New Jersey Method will always be equal to or greater than that established by the EPA procedure since an additional amount of particulate can be captured in the back half. The amount of back half particulate collected will vary from process to process, and will depend on the species and chemical nature of the pollutants in the flue gas being sampled. It is generally impossible to quantify the difference in reported emissions that can be attributed to the difference in test methods. Emissions discussed in this report represent only the "front half" catch because data on the "back half" catch were not available. Thus, the potential differences in test methods does not affect the technical discussion in this report although it may affect any decision by New Jersey on the final standard.

The relative affects of differing test methods becomes more important when we discuss European incinerator emissions in this section. European incinerators were not tested by standard EPA Method 5 procedures. The procedures used were similar to EPA Methods (i.e., particulates were obtained using isokinetic sampling) but not identical. The effect of the variances in procedures could not be quantified. Rather than not use the wealth of information that exists on European municipal incinerator emissions, we have decided to include these data. However the reader must use these data prudently, as a precise comparison between American and European incinerator emissions cannot be made.

Similarly, there are only standard test procedures for a few of the gaseous and solid emissions species emitted from a municipal incinerator. Test methods have been adopted for SO_2 (Method 6), NO_x (Method 7), total non-methane organics (Method 25), and such heavy metals as mercury (Method 101) and beryllium (Method 104). Yet these methods have rarely been employed for municipal incinerator testing since there are no emission limits for these compounds. As a result, a variety of measurement techniques have been used. This is also true for hydrogen chloride (HCl) emissions as there is no reference method for this gaseous emission. Hydrogen chloride is typically measured using dilute sodium hydroxide to capture the gas, and mercuric nitrate to titrate and analyze it. This procedure is not universally accepted. Some researchers have reported HCl emissions obtained through the Volhard titration technique whereas others measured it potentiometrically using a Silver electrode.[33] In the absence of a standard procedure, a variety of techniques may be used. These techniques are not always reported with the emission rates, and therefore the relative accuracy of one technique versus another cannot be ascertained; nonetheless, these HCl data and data on other gaseous and solid emission species are reported here and can be used to describe facility emissions.

The incineration of municipal solid waste produces several distinct types of pollutant emissions. These can be summarized as follows: particulate (both inorganic and combustible), combustible gases (carbon monoxide, hydrocarbons), and noncombustible gases (nitrogen oxides, sulfur oxides, and hydrogen chloride). The type and amount of each of these emissions are dependent on several variables. These include:[9] refuse composition, firing system, combustion chamber design, underfire air system, overfire air system, furnace gas temperature, burning rate, incinerator operation, and operational cycle. The number of variables involved and the overlapping pollutant formation mechanisms they encompass make it difficult, if not impossible, to establish uncontrolled emission rates of pollutants such as hydrocarbons from a unit based on an examination of the hardware involved. To study incinerator emissions, we must review those factors which affect pollutant emission generation and the actual emission data on existing units. This section will present published emission data on the physical and chemical characteristics of municipal incinerator emissions. Both particulate and gaseous emissions data will be discussed. This knowledge will enable us to define the emission problem, determine the performance and evaluate the applicability of air pollution control devices, and establish which emission levels can be met with existing technology.

PARTICULATES

Airborne particulate emissions are the most obvious emission problem associated with incinerator operation. Particulates can cause localized nuisance conditions as a result of dust deposition on private property or the production of a dense, dark, aesthetically displeasing stack plume. In addition, incinerator particulates aggravate the dust and visibility problems of an entire area and can cause both acute and chronic respiratory problems if the particulate is inhaled into the deepest sections of the lungs. For these reasons, considerable research has gone into defining the causes and cures of particulate emissions.

Inorganic Particulate

Incinerator fly ash or particulate can generally be categorized as mineral or combustible. Mineral particulate is the incombustible fraction of fly ash and is mainly composed of mineral matter in the raw solid waste that is entrained by combustion air or combustion products. Oxidation of metals and the subsequent volatilization or entrainment of oxides will also contribute to this mineral fraction of total particulates. The factors that affect the amount, composition, and size distribution of mineral particulate have been identified as follows:

- Undergrate air velocity--A comprehensive study by the Public Health Service indicates that furnace particulate emissions are directly related to the underfire air rate (expressed as scfm per square foot of grate area). It is estimated[8] that the range of undergrate velocities usually encountered in incinerators will entrain particles with sizes ranging from 75 to 400 μm (micrometers). This relationship is true for both large (>50 TPD) and small (<10 TPD) incinerators, although emission rates appear to be larger (per ton of waste consumed) for large plants.

- Refuse ash content--Ash particles in the raw refuse will be entrained by the flow of combustion gases through the waste. Studies[6] indicate that approximately 10 to 15 percent of the refuse ash may be carried over with the gases. Particulate generated by this mechanism will be proportional to the refuse ash content, and this ash content will vary between cities and between seasons. Wide variations in emissions of mineral particulate can therefore be expected, depending on the amount and size distribution of the ashed residue of the waste and on undergrate velocity.

- Volatilization of metals and metallic salts--At the operating temperatures of a burning refuse bed (2000° to 2400°F) several metal salts (particularly those of the alkali metals) will vaporize or sublime. This metal will condense downstream of the incinerator furnace to form a small (<0.5 μm) particulate emission. The amount of metal that is volatized is dependent on the amount of metal in the raw refuse and the temperature in the primary chamber.

Mineral particulate generation is therefore related to the composition of e refuse and the design of the incinerator furnace. Facilities burning terial with a high ash content and/or those using relatively high undergrate ir velocities and high temperatures will generate proportionally more rticulate emissions.

anic Particulate

The combustible fraction of total incinerator particulate emissions is nerated by different mechanisms. Several distinct combustible particulate actions have been identified. These fractions and their formation chanisms include:

- Char--This is a small fraction of total particulate that results from the entrainment of paper or other carbonizable material. The high surface-to-volume ratio of this material allows it to become entrained at relatively low velocities. The rate of char emission is again dependent on refuse composition and refuse bed agitation. Agitation in a burning bed is caused by the grate system that is used to move the refuse through the furnace.

- Soot--This is the most significant source of combustible particulate. Soot is defined as fine (<2 μm) combustible particulate that is generated as a result of poor refuse/air mixing in the primary combustion chamber.[8] Although the mechanism for soot formation is complex, the amount of soot generated can be closely controlled by ensuring complete oxidation of all combustibles through proper mixing of fuel and overfire air, and sufficient temperature and residence time. Wastes with a high volatile carbon fraction (such as asphalt roofing and tires) are especially prone to the generation of soot particles.

- Liquid Aerosols--Typically identified by characteristic white smoke, this emission is formed when the pyrolysis products evolved in the furnace are cooled and condensed before mixing with hot combustion gases. Aerosols consist of fine particles (<2 μm) and can be controlled by proper combustion chamber mixing, temperature and time.[8]

n addition to these factors, several incinerator design parameters may ect total particulate generation. Data collected on incinerators structed prior to 1970 have indicated the size of the furnace, the type of nace and grate used, and the design of the combustion air supply system ll affect particulate emission formation.[8]

ncreasing the size of the furnace from 3 to over 100 tons per day (TPD) hown to result in higher emission rates, but this size effect was not ntitatively established over the more limited size range of municipal units to 300 TPD). Part of this increase was attributed to the higher burning rates, and hence the higher underfire air rates associated with large units, while the remainder was thought to be a consequence of the higher natural convection currents encountered in large units.

Continuously fed incinerators were found to have lower emission factors (pounds of emission released per ton of waste charged), than batch fed systems, and among continuous feed systems, emissions increased as the grate design changed from traveling grate to rocking grate to reciprocating grate. The emission factor of the reciprocating grate furnaces was significantly higher than those from other grate types, and this was attributed to a combination of greater stoker intensity and higher underfire air rates for these units.

Test data have also shown that underfire air, that is air supplied beneath the furnace grates, was the variable that most strongly influenced the particulate emission rate.[8] Studies conducted by a number of researchers on varying refuse compositions indicated that the particulate emission rate is (approximately) related to the square root of undergrate air rate for most incinerator sizes and types. However, there is a minimum underfire air rate that is needed to cool the grates. In addition, a reduction in the air rate will reduce the burning rate, so an economic balance is usually made between furnace burning capacity and air pollution control equipment costs.

While these studies were made on older municipal incinerators, the relationships between variables that have been derived continue to play a part in modern incinerator design today.

How these particulate generation mechanisms contribute to total particulate emissions will vary among the three incinerator classes under investigation in this study. Large mass-burn incinerators will emit each type of particulate. Because the waste to be incinerated is not altered, particulate generation must be minimized through furnace design. A design that ensures complete refuse/air mixing to provide for complete combustion is essential. Underfire and overfire air systems must provide sufficient oxygen at the right time to combust both the incoming solids and the combustible gases that are generated in the incineration process.

RDF-fired incinerators will generate substantially less mineral particulate than mass-burn units because many of the noncombustibles are removed from the waste in the fuel preparation process. The noncombustibles that do remain in the RDF are finely dispersed and are easily volatilized and will add to the total particulate burden. Combustibles from RDF-fired incinerators can be limited by the same good mixing of air and fuel that is used with mass-burn units. Because RDF is often burned in suspension, design of these incinerators often incorporates combustion techniques developed for pulverized coal boilers.

Controlled air incinerators are designed to minimize combustible particulate emissions. Because underfire air rates are extremely low, carry over of mineral particulate is not a major concern. Volatilization of metals can be minimized by incinerator design by providing a low primary chamber temperature. Combustible particulates and gases developed in the primary chamber may be a problem if the secondary chamber is not designed large enough and with sufficient afterburner capacity to ensure that all particles are exposed to a temperature of at least 1500°F and a residence time of at least 0.5 seconds. Depending on the combustible species generated, even higher temperatures may be required. The design and size of the afterburner in the secondary chamber of the controlled air unit is therefore critical.

PARTICULATE EMISSION STANDARDS

Particulate emission standards currently exist for municipal incinerators. The units that are used to define these standards are not universal, although the most widespread set of units in use is grains of particulate per dry standard cubic foot (70°F, 1 atm) of gas corrected to 12 percent CO_2 (gr/dscf at 12 percent CO_2). These units apply to stack concentrations. Particulate emissions are corrected to 12 percent CO_2 to adjust all emission tests to a common reference point and to ensure that a source will not dilute its stack gases with ambient air to reduce stack concentrations.

A municipal incinerator being built in New Jersey must be designed to meet one and possibly two emission regulations. All incinerators depending on size, must not emit more than 0.1 or 0.2 gr/dscf at 12 percent CO_2 not including the CO_2 contribution of auxiliary fuel. The particulate includes both dry and wet (front half and back half) catch, as discussed earlier. Units with waste charging capacities greater than 50 tons per day are also governed by the federal New Source Performance Standard (NSPS) for municipal incinerators. This regulation limits particulate emissions to no more than 0.08 gr/dscf at 12 percent CO_2,[32] dry catch only.

For the sake of comparison, it is worthwhile to note other particulate emission regulations currently in effect. Where necessary, regulations with units other than grains per standard cubic foot corrected to 12 percent CO_2 have been converted to this standard. The most stringent standard is that for the State of Maryland, which limits particulate emissions to 0.03 grains/dscf at 12 percent CO_2, were adopted in 1972.[34] Delaware and Nevada have emission standards that are a function of the amount of waste being charged, and these levels can fall below 0.05 grains/dscf at 12 percent CO_2 for units greater than 300 tons per day.[28] At the opposite end of the spectrum, several states, including South Carolina, Texas, and Washington, have allowable emission rates greater than 0.25 gr/dscf at 12 percent CO_2.[28] In Europe, allowable particulate emission rates vary from 0.07 gr/dscf at 12 percent CO_2 in Denmark, to 0.074 gr/dscf at 12 percent CO_2 in Germany, Switzerland and Holland, to 0.093 gr/dscf at 12 percent CO_2 in Sweden.

A comparison of installed municipal incinerators and state emission standards indicates that strict standards do not necessarily discourage the installation of municipal incinerators. Maryland and the District of Columbia, which have the most stringent particulate emission standards, each have incinerators that successfully demonstrate compliance with these standards.

PARTICULATE EMISSION RATES

Mass Burn Incinerators

A literature search and a telephone survey were undertaken to establish both uncontrolled and controlled particulate emission rates from existing municipal incinerators. The results of these investigations are reported in Tables 4 and 5. Table 4 details emission test results from 26 large, mass-burn incinerators. Fifteen of these units are located in the United States and Canada, and the additional 11 are European units. For each unit, an attempt was made to quantify emission rates at the inlet and outlet of the air pollution control device and to establish the collection efficiency of that device. Where actual emission test data were unavailable, design values were used to establish emissions. This technique was especially valuable in establishing inlet (uncontrolled) emission rates because this concentrtion is only infrequently reported. Examining the reported data, we note that the average of 20 inlet emission concentrations is 2.45 gr/dscf at 12 percent CO_2. If the atypically high value reported for the Dusseldorf incinerator is omitted, the average will be 1.89 gr/dscf at 12 percent CO_2. This latter value is perhaps a better representation of the reported data. Discounting the Dusseldorf unit, there remains an almost fivefold variation between the high and low inlet concentrations. This variable spread reemphasized the fact that there are many independent and dependent variables that contribute to particulate formation, and there is no universal uncontrolled incinerator emission rate. It is interesting to note that the inlet concentrations for North American units averaged 1.41 gf/dscf at 12 percent CO_2, whereas those for European units averaged 2.43 gr/dscf at 12 percent CO_2 (excluding Dusseldorf). The reason for this variation is unknown. Municipal solid waste composition and incinerator technology are essentially identical in the two areas. These factors would not contribute to the large difference in emissions. The variation may be produced by the test methods used, but no comparison of the European and American methods could be found in the literature. For the purpose of this report, we will assume that the average inlet concentration is 1.89 gr/dscf at 12 percent CO_2 with the knowledge that recent incinerators built in this country may have smaller emission values.

Actual, controlled municipal incinerator particulate emission levels are especially important to this study. These levels indicate realistic, achievable emissions that can and have been met with existing incinerator and emission control technology. Particulate emission concentrations measured at the outlet of air pollution control devices are reported in Tables 4 and 5. The average for 35 separate tests conducted at 26 American and European municipal incineration facilities is 0.054 gr/dscf at 12 percent CO_2. This value is substantially below the NSPS standard of 0.08 gr/dscf at 12 percent CO_2 and indicates that control technology is currently available to meet this federal standard by a wide margin. Although most facililties tested use electrostatic precipitators for particulate emission control, a standard fabric filter, a coated fabric filter, and a venturi scrubber were also used with successful results.

TABLE [illegible]. PARTICULATE EMISSION RATES: LARGE MASS BURN FACILITIES

Facility	Size (tons/day)	Control	Control efficiency actual or (design) (%)	Test results		Year of test	Comments	Reference
				Inlet (gr/dscf @ 12% CO_2) actual or (design)	Outlet (gr/dscf @ 12% CO_2) actual or (design)			
S.W. Brooklyn, NY	1000	S.C. ESP	93.3	(1.06)	0.071	1972	APC retrofit	35
S.S. Brooklyn, NY	1000	S.C. ESP	94.0	(1.03)	0.062	1973	APC retrofit	35, 36
E. Bridgewater, MA	150	F.F.			0.024	1975	Filter bag deterioration encountered	34
Saugus, MA	1200	ESP			0.049	1975		34
					0.025[a]	1980		37
					0.027[b]	1979	ESPs rebuilt	37
Framingham, MA	500	Coated F.F.	(98.5)	2.06	0.025	1980	Coated fabric filter	37
Braintree, MA	120	ESP	(93)	0.92	0.108	1971	ESP rebuilt for second test	22, 34
					0.078	1978		
Pulaski, MD	600	ESP			0.026	1975		38
					0.044	1978		
Nashville, TN	720	ESP	(98.8)	1.46	0.018	1976	Converted from scrubber	21, 34
					0.0068	1978		
Harrisburg, PA	500	ESP	96.44	1.43	0.051	1973		36, 39
					0.126	1979		
					0.114	1980		
					0.066	1981		
Ogden, UT	150	ESP			0.045	1974		34
Chicago (NW), IL	1600	ESP	96.4	1.06	0.038	1971		20
Montreal, Canada	1200	ESP	99.45	2.43	0.013	1970		
			93.5	1.24	0.08	1971		
EC Philadelphia, PA	300	ESP			0.047	1977	Converted from low energy scrubber	34
N.W. Philadelphia, PA	650	S.C.	(98.1)	(1.41)	0.048	1976	Refractory furnace	34

(continued)

TABLE 4 (continued)

Facility	Size (tons/day)	Control	Control efficiency actual or (design) (%)	Test results		Year of test	Comments	Reference
				Inlet (gr/dscf @ 12% CO_2) actual or (design)	Outlet			
Pawtucket, R.I.	200	VS(35–40)			0.078	1978		34
Werdenberg, Switzerland	120	ESP	(97.5)	(2.6)	0.065	1974		40
Baden Brugg, Switzerland	200	ESP	97.8	(3.7)	0.082	1970	Two-stage M.C. follows ESP	40
Dusseldorf, Germany	1260	ESP	(99.67)	(13.0)	0.043	1967		40
Krefeld, Germany	576	ESP	96.8	(2.3)	0.075	1976	Scrubbers follow ESP (not yet operational)	40
Paris: Issy, France	1635	ESP	(98.0)	(1.7)	0.034	1977		40
Hamburg, Germany	1180	ESP	(98.9)	(4.2)	0.046	1972	S.C. follows ESP	40
Zurich: Hagenholz, Switz.	380	ESP	98.3	(1.8)	0.031	1973	MC follows ESP	40
The Hague, Netherlands	1440	ESP	(99.6)	(2.07)	0.041	1965		40
Gothenberg, Sweden	1080	ESP			0.078	1973		40
Horsens, Denmark	120	M.C. + ESP	(96.43)	(2.63)	0.094	1977		40
Uppsala, Sweden	120	ESP	97.0	(0.9)	0.027	1972	MC precede ESP	40

[a] Unit 1.

[b] Unit 2.

Notes: S.C. = Water spray chamber; ESP = Electrostatic precipitator; F.F. = Fabric filter;
VS = Venturi scrubber (press. drop in in. H_2O); M.C. = Multiclone.

TABLE 5. PARTICULATE EMISSION RATE [illegible] RDF AND [illegible] BURN FACILITIES

Facility	Size (tons/day)	Control	Control efficiency actual or (design) (%)	Emission test results		Year	Comments	Reference
				Inlet	Outlet			
				(gr/dscf @ 12% CO_2)				
Processed Waste								
Hamilton, Ontario	300	ESP	(98.5)	(2.8) 6.71	(0.042) 0.68	Design Actual (1972)	Operational problems encountered	41
Modular Municipal Facilities								
North Little Rock, AR	58	C.A.			0.13	1978	4 units @ 14.4 TPD ea. designed to meet 0.2 gr/sec standard	31
Pahokee, FL	17	C.A.			0.065	1975	2 units	23
Orlando, FL	100	C.A.			0.084	1975	8 units	23
Siloam Springs, AR	21	C.A.			0.03	1975	2 units	23

Notes: ESP = Electrostatic precipitator
C.A. = Controlled air incinerator (afterburner in secondary chamber).

To remove the possible bias in these tests that results from including European data, the emission test methodology of which is not completely known, we must discuss American and European results separately. The American test data includes 22 sets of tests taken at 14 incineration facilities. These tests averaged 0.053 gr/dscf at 12 percent CO_2. (The Montreal facililty was not included in this tabulation due to uncertainty on the test methodology employed). Taken together with the estimated control device inlet concentration of 1.41 gr/dscf at 12 percent CO_2, this gives an average air pollution control device collection efficiency of 96.24 percent. The applicable emission standard for these incinerator tests averaged 0.076 gr/dscf at 12 percent CO_2. Thus, based on our municipal incinerator emission test data base, we can state that (a) the average unit was operating with an emission level 27 percent below the applicable standard, and (b) a minimum air pollution control device collection efficiency of 94.6 percent is required to insure that the municipal incinerator meets applicable standards.

For the European incinerators we note that 11 sets of emissions tests collected on 11 different units in six separate countries averaged 0.056 gr/dscf at 12 percent CO_2. Using this value with the estimated control device inlet concentratin of 2.43 gr/dscf at 12 percent CO_2, we can calculate an average control device collection efficiency of 97.7 percent. The applicable emission standard for these incinerator tests averaged 0.076 gr/dscf at 12 percent CO_2, coincidentally the same average applicable standard as the American tests. From these data we can also state certain conclusions: (a) the average European unit operated at an emission level 26.9 percent below the applicable standard, and (b) a minimum control device collection efficiency of 96.9 percent is required for these units to insure applicable standards are met.

Comparing American and European data, we can conclude that (a) the average reported particulate emission concentration is similar (0.053 versus 0.056 gr/dscf at 12 percent CO_2), (b) the average applicable particulate emission standard is identical (0.076 gr/dscf at 12 percent CO_2), (c) the average incinerator in both data sets is operated well below the applicable particulate emission standard, and (d) the average air pollution control device collection efficiency of the European incinerators is appreciably higher (97.7 versus 96.24 percent) than the American units, owing to the higher estimated uncontrolled particulate emission rate for the European incinerators.

This last point is significant because it indicates that higher particulate emission collection efficiencies than those currently being achieved by American incinerators are both possible, and are actually being realized in Europe. Since control device collection efficiency is a variable that is not dependent upon test methodology (if one assumes the same test procedures were used for both inlet and outlet testing), the uncertainty associated with different methodologies is removed. As the data on Table 4 indicates, European incinerator control device efficiencies commonly exceeded 98 percent and at times were in excess of 99 percent. Therefore, once the applicable emission level is known, an incinerator control system can be designed to meet this level with some "margin of safety." This is shown by the high European collection efficiencies and also by the data for the Saugus (Massachusetts) unit cited in Table 4. This unit lowered its stack emission rate by 50 percent by rebuilding its electrostatic precipitators to include additional sections. If the average European efficiency of 97.7 percent is applied to estimated uncontrolled emission rate for American incinerators of 1.41 gr/dscf at 12 percent CO_2, an average stack emission rate of 0.032 gr/dscf at 12 percent CO_2 would result. Conversely, for the same uncontrolled emission rate, the amount of pollutant emitted from a facility controlled to a level of 96.24 percent (the American average) is 63 percent higher than one controlled to a level of 97.7 percent (the European average):

$$\frac{1 - 0.9624}{1 - 0.977} = \frac{0.0376}{0.023} = 1.63$$

Technology for this increased level of particulate emission control is commercially available and currently in widespread use in Europe.

Refuse Derived Fuel Incinerators

Table 5 presents particulate emission data for one RDF-fired incinerator. Few published emission data are available for these units. Broad-based conclusions cannot therefore be drawn. The RDF facility pulverizes the waste and removes ferrous metals before feeding the fuel to two waterwall boilers. The boilers are spreader stoker design with a traveling grate similar to units designed for coal and hogged-wood fuel. The units were designed for an inlet loading of 2.8 gr/dscf at 12 percent CO_2, but test results demonstrated an actual loading of 6.71 gr/dscf at 12 percent CO_2. Operational problems involving fuel feed and combustion air supply were blamed for the high inlet loading and resulting high outlet loading of 0.68 gr/dscf at 12 percent CO_2. Using the design inlet loading of this one unit, we perceive that the RDF facility has an uncontrolled emission rate 25 to 30 percent higher than a comparable mass-burn incinerator.

Modular Incinerators

Test data on four modular municipal incinerators are also reported in Table 5. Each facility uses multiple controlled air incinerators to dispose of unprepared solid waste. Because these facilities do not have unit capacities greater than 50 tons per day, they are not governed by the NSPS emission limitation of 0.08 gr/dscf at 12 percent CO_2. State emission regulations governing facilities of this size (<50 TPD) are generally more relaxed than those controlling larger municipal incinerators, and the applicable state standard for these smaller facilities averaged 0.13 gr/dscf at 12 percent CO_2. This was some 70 percent higher than the average emission standard for large units. The average emission test valued for the modular incinerators was 0.077 gr/dscf at 12 percent CO_2, and this was [illegible] percent greater than the average for large municipal units. When one compares the average emission rate for modular incinerators with the average applicable standard, we note that actual emissions are approximately 40 percent lower than the standard, a "margin of safety" significantly greater than that for large municipal incinerators.

All four modular controlled air incinerators reported in Table 5 contained afterburners as an integral part of the incinerator. No emissions testing was conducted in the passageway before the afterburner, therefore no estimate could be made on afterburner efficiency. As no additional air pollution control device is installed on any of these incinerators, the emission rates reported in Table 5 may be defined as "uncontrolled," even though all incinerators were well below compliance levels.

The results of 32 emission tests conducted on controlled air incinerator designs was also found in the literature.[42] These data are presented in Figures 4 and 5. The units burned a variety of wastes and were identified by name or location. The 32 tests were conducted on five controlled air designs. Designs A and B were starved air units which differ mainly in the placement of the afterburner and the stack. Designs C, D and E are two chamber designs. All designs employed an integral afterburner and no other air pollution control. Each point in Figure 4 represents the average of from 2 to 4 source tests. The error bars shown represent the high and low values for a given incinerator. There appear to be no significant differences among the controlled air incinerator design in the amount of particulate matter emitted. Moreover, there is no correlation between emissions and either waste charging rate or type of waste burned. The test data which is summarized in Figure 5 reveals the following:[42]

- 97 percent of the units emitted less than 0.2 gr/dscf at 12 percent CO_2
- 75 percent tested at less than 0.1 gr/dscf at 12 percent CO_2
- 20 percent emitted less than 0.05 gr/dscf at 12 percent CO_2
- Only 6 percent tested at less than 0.03 gr/dscf at 12 percent CO_2.

This emissions information, together with the test results listed in Table 5, indicate that most controlled air units can meet a particulate emission standard of 0.1 gr/dscf at 12 percent CO_2. This is the current standard in New Jersey and 31 additional states, although the New Jersey standard is, in effect, less than 0.1 gr/dscf at 12 percent CO_2 since New Jersey test procedures require that particulate captured in both the dry and wet portions of the sampling train be counted in total particulate determinations. Should modular controlled air incinerators be required to meet a particulate standard less than 0.1 gr/dscf at 12 percent CO_2, additional air pollution control would probably be required.

ELEMENTAL BREAKDOWN

Research[30,43,44,45] has indicated that poorly controlled municipal incinerators may have been a major source of toxic trace metals in the

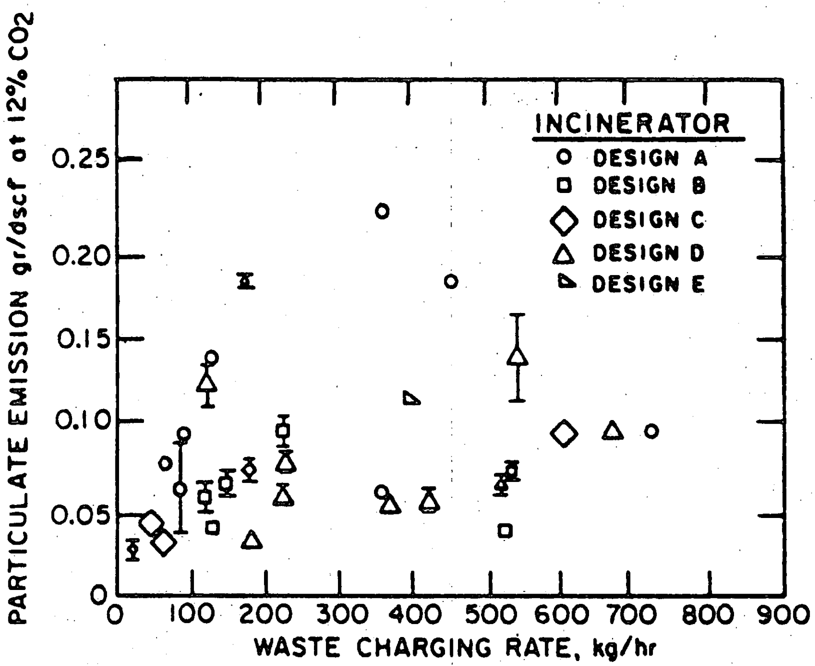

Figure 4. Particulate emissions from controlled incinerators (grains per standard cubic foot corrected to 12 percent CO_2 vs. waste charging rate in kg per hr).[42]

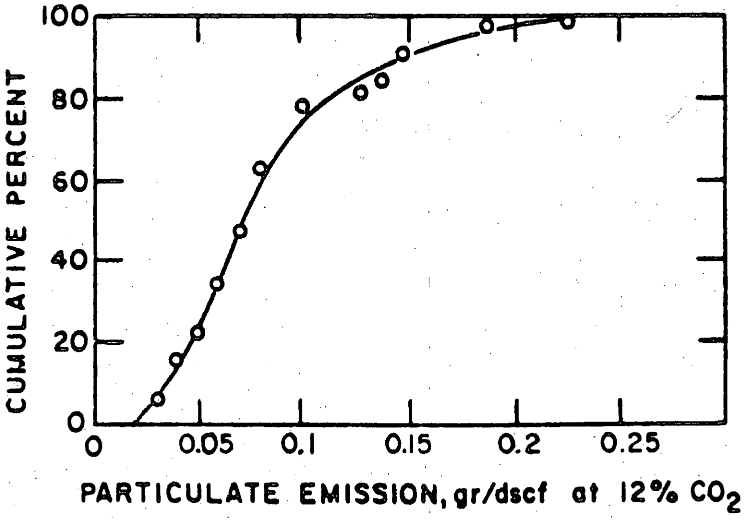

Figure 5. Cumulative percent of particulate emission measurements for controlled air incinerators that fall below specified particulate emission level.[42]

environment. These toxic metals emissions are probably caused by the volatilization and sublimation of metals in the waste feed which enter the atmosphere as fine particulate. The actual concentration of any metal can be ascertained and quantified through physical and chemical analysis of particulate captured from the flue gas.

Since few emission standards exist for toxic metal emissions and their origins and fate in the environment have only recently begun to be investigated, published data on concentrations from municipal incinerators are limited. When available, these data are reported as micrograms of metal per gram of total particulate emitted (μg/g). These data are then converted to a flue gas concentration ($\mu g/m^3$) using the total particulate emission rate for the facility.

For this study, we will investigate eight potentially toxic, heavy metals. These are: arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), and zinc (Zn). Incinerator flue gas concentrations for these elements are reported in Table 6. The total particulate emission rate for each of the incinerators studied is also reported as an emission factor. The units of measurement for this factor are pounds of total particulate emitted per ton of refuse charged. In addition, the size and control device of each incinerator is listed. Although the sample size is too small for any definitive conclusions to be made, a cursory review of the data indicates that (1) there is a wide variation (greater than an order of magnitude) in the emissions of a metal from one incinerator versus another (e.g., Zn), and (2) the metal emissions appear to vary with total particulate emissions (as expressed by the emission factor). To further investigate these apparent phenomena, we decided to normalize the metal emission rates by dividing the actual metal emission rates for each incinerator by the emission factor for that incinerator. This technique served to (1) bring metal emissions from all incinerators to a common mass-emission level of 1 pound of particulate per ton of waste charged and (2) give a better indication of actual heavy metal emissions from a well-controlled facility. These normalized heavy metal emissions rates are also presented in Table 6.

The incinerators reported in Table 6 represented both well-controlled and poorly controlled units, as measured by their emission factors. Facilities with high mass particulate emissions appear to have similarly high heavy metal emissions. By dividing emission rates by the emission factor for each incinerator, we arrive at metal emissions that would exist if each incinerator had total particulate emissions equivalent to 1 pound of particulate per ton of refuse charged. The effect of this technique, as can be seen from Table 6, is to reduce the wide variation between heavy metal emission rates.

This normalization is, at the same time, a better representation of what metallic emissions would be from a well-controlled incinerator. Using conversion factors developed by Hopper,[28] an emission factor of 1 pound of particulate per ton of refuse is approximately equal to 0.053 gr/dscf at 12 percent CO_2. Table 4 demonstrates that current incinerator technology, as measured by 22 separate tests at 14 facilities, can limit total particulate

TABLE [illegible]. PARTICULATE [illegible] [illegible] [illegible] ($\mu g/m^3$ AT 12 PERCENT CO_2)

Facility	Size (TPD)	Control device	Cd	(Cd)n	Cr	(Cr)n	Cu	(Cu)n	Pb	(Pb)n	Zn	(Zn)n	Total particulates emission factor (lb/t)	Reference
Mass Burn														
Waterbury, MA	300	STC	146	19	1,299	169	7,616	989	29,456	3,825	23,296	3,025	7.7	46
Alexandria, VA	270	SBS	708	126	316	56	1,288	230	62,468	11,155	77.280	13,800	5.6	4, 30
SWRC-Washington, DC	1,400	STC ESP	201	218	92	100	159	173	8,268	8,987	14,840	16,130	0.92	30, 47
Nicosia, IN	450	SBS	1,380	173	97	12	920	115	63,480	7,935	104,880	13,110	8	30, 47
Braintree, MA	120	ESP	911	169			861	160	29,512	5,475			5.39	22
Average			669	141	451	84	2,169	333	38,637	7,475	55,074	11,516	4.78	
Shredded Refuse														
SWRU-Hamilton, Ont.	600	ESP	2,187	188	937	81	1,093	94	3,903	767	42,174	3,633	11.61	41
Modular Incinerator														
North Little Rock, AR[a]	100	CA	123	41	1.11	0.4	62.6	21	4,280	1,413	9.071	2,994	3.03	31

[a] Composite of six filters.

Notes: (Metal)n = Normalized concentration = $\frac{\text{Actual concentration}}{\text{emission factor}} = \frac{\mu g/m^3}{\text{lb/ton}}$ = metal emissions if total particulate emissions were 1 lb/ton

ESP = Electrostatic precipitator
SBS = Spray baffle scrubber
STC = Settling chamber
MC = Multiclone
CA = Controlled air

TABLE 6b. PARTICULATE ELEMENTAL BREAKDOWN - STACK EMISSIONS IN $\mu g/m^3$ AT 12 PERCENT CO_2

Facility	Size (TPD)	Control device	As	(As)n	Hg	(Hg)n	Ni	(Ni)n	References
Mass Burn									
Waterbury, MA	300	SC	ND	ND	ND	ND	594	77	46
Alexandria, VA	270	SBS	ND	ND	ND	ND	129	23	4, 30
SWRC-Washington, DC	1,400	SC/MC ESP	33	36	ND	ND	18	20	30, 47
Nicosia, IN	450	SBS	184	23	ND	ND	73	9	30, 47
Braintree, MA	120	ESP	90	17	77	14	ND	ND	22
Average			102	25	77	14	204	32	
Shredded Refuse									
SWRC-Hamilton, Ont.	600	ESP	15.6	1	469	40	1,047	90	41
Modular Incinerator									
North Little Rock, AR[a]	100	CA	ND	ND	ND	ND	1.97	0.7	31

[a] Composite of six filters.

ND = No data available.

missions to 0.053 gr/dscf at 12 percent CO_2. Thus our normalization echnique has served to adjust the reported heavy metal emission rates to alues that would exist, were each incinerator "well controlled." Again we ust remember that there are but as few data points from which to draw onclusions. In addition, implicit in our normalization technique is the ssumption that heavy metal emissions will vary directly as total emissions. is, as we shall subsequently see, is not the case. Heavy metals are oncentrated in the smaller size fractions of the total particulate issions. The reduction of total particulates will therefore not oportionately reduce heavy metal emissions. As a result, this normalization chnique will probably underestimate somewhat heavy metal emissions from a ll-controlled incinerator. Nevertheless, this technique is useful since it erves to minimize the affect of one atypically large metal emissions number from a poorly controlled incinerator (i.e., zinc emissions from the Nicosia nit) while still presenting the relative emission concentrations of the eight etals under investigation (i.e., stack gas lead concentrations are 20 times ose of copper which in turn are 20 times greater than the concentration of ercury). This relative concentration is important in determining what ulatory options may be most useful and/or cost effective in minimizing tal incinerator heavy metal emissions.

Because no emission standards exist for heavy metals, the data reported n Table 6 are, by themselves, not meaningful. These data will be used in spersion modeling analysis to determine the effect of these emissions on mbient air quality levels. This analysis will be presented in Section 6.

Emissions for all eight heavy metals varied considerably. Although the ormalization of emissions eliminated the extremes in concentrations, riations by an order of magnitude in normalized values still exist. This henomena must be attributed to (1) varying waste composition and (2) varying erating conditions. As stated earlier, heavy metal emissions are in part ttributable to the volatilization and subsequent sublimation of the metals in e waste. Increased waste metal content and higher operating temperatures, hich increase volatilization, will increase metal emission rates.

Table 6 also presents a particulate elemental breakdown for one shredded fuse facility and one modular municipal incinerator. Again, the heavy metal ata are scanty. We have normalized heavy metal emission data for these two nits to facilitate comparisons. The shredded refuse facility was ncountering refuse feed and combustion air delivery problems when it was ested, accounting for the high emission factor. Normalized metal emission ata are similar to those for mass-burn facilities, except for lead and zinc lues, which were considerably (four to nine times) lower. As there is only ne data point for shredded refuse facilities, it is impossible to say whether ese lower metal emissions were due to shredding pretreatment in general or o the unit operations of this specific facility.

Heavy metal emissions for the controlled air unit were consistently lower an those for the mass-burn and shredded refuse facilities. The waste feed or this unit[31] was untreated and contained less food wastes, wood, paper, nd textiles than the waste consumed by the large mass-burn incinerators, but more metal, plastic and garden waste. The reason for the lower heavy metal emission rates, which for certain metals approached several orders of magnitude is probably the lower primary chamber operating temperature. Inasmuch as this was the only modular, controlled air incinerator with reported metal emission rates that could be found, it is impossible to say whether these emissions are "typical."

PARTICLE SIZE

To more accurately define municipal incinerator particulate emissions, an understanding of the particle size distribution of these emissions is required. This particle size analysis will enable us to define the types of air pollution control devices that are required to successfully limit particulate emissions and to outline the public health concerns of the incinerator emission problem.

Air pollution control technology will be reviewed in detail in Section 5 of this report. It is important to note here, however, that the overall particulate control efficiency of a device is directly related to its efficiency in limiting emissions of varying particle sizes. Incinerator particulate emissions consist of a broad range of particle sizes. Large particles can be captured by simple, relatively inexpensive control equipment. Smaller particles require the use of more sophisticated and expensive devices. An engineering evaluation of emission control device(s) which will satisfy our particulate removal requirements must be based on (1) the amount of total particulate emitted from the incinerator furnace, (2) the size distribution of these particles, and (3) the control efficiency of each device in capturing particles within each size range.

Particles smaller than 2 to 5 μm (respirable particles) have traditionally been the greatest concern, from a health effects perspective because they are deposited in the deepest part of the lungs. Volatile trace metals and organic species may be preferentially deposited on respirable particles, increasing the potential health hazard. Because of their small size, respirable particles are difficult to capture in air pollution control devices.

Particles smaller than 15 μm (inhalable particulate) also represent a potential health problem because they can be inhaled by mouth breathers. These particles are easier to capture in air pollution control devices than the respirable particles.

Particles larger than 15 to 30 μm are generally considered coarse particulates. Particles up to about 30 μm can remain suspended in the atmosphere and contribute to ambient particulate matter. Larger particles tend to settle rapidly and represent more of an aesthetic nuisance rather than a health effects problem. Emissions of coarse particulate are easily controlled.

Uncontrolled and controlled particle size data are presented in Table 7. Particle size information, similar to total particulate emissions, varies greatly among incinerators. Certain particulate formation mechanisms favor the generation of one size particle over another. Factors such as the volatilizatin and sublimation of metals and the generation of soot will tend to favor the generation of respirable particulate. Increased undergrate air velocity, on the other hand, will generate a higher proportion of coarse particulate.

An examination of uncontrolled emissions in Table 7 indicates that there is a wide data spread. Facilities, such as 50-A and 50-B, which have a high total particulate emission rate, have a relatively small percentage of these emissions in the respirable size range. For these sources, the particulate is concentrated in the larger size fractions. For most of the other reported facilities, a higher proportion of the total particulate weight is in the smaller size ranges. These facilities have correspondingly lower total emission rates. This indicates that as total furnace emissions are reduced, the relative amount of large particulate is correspondingly reduced. This is not surprising because particulate-limiting mechanisms such as low undergrate air velocities and good mixing of combustibles and overfire air would be expected to minimize large particle formation. These data also indicate that there is a relatively consistent fraction of small particles from well-designed incinerators. It appears that approximately 15 to 30 percent of all particles leaving an incinerator furnace are below 5 μm in size. This size fraction must be effectively controlled if an incinerator is to achieve the 95 to 97 percent total particulate control that is required to meet current emission standards.

The limited particle size data that could be obtained for controlled incinerator emissions is also presented in Table 7. These data are provided to demonstrate the effects of control devices on the particle size distribution. As would be expected, air pollution control removes most of the large particulate. Whereas 25 to 35 percent of uncontrolled particulate was below 10 μm, with the application of pollution controls, 70 to 75 percent are now in this size range. The vast majority of emitted particulate is in the small size fraction.

Finally, Table 7 reports controlled particle size data for one modular, controlled air incinerator. Although it is unwise to draw conclusions from one set of data, this emission information is striking. Ninety-four percent of the particles by weight emitted from this facility are smaller than 5 μm. Total particulate emissions are not extremely low (0.13 gr/dscf at 12 percent CO_2) yet the particles are virtually all within the respirable size fraction. This seems to indicate that the mechanisms for particulate formation and control in a controlled air incinerator may be vastly different than those for a large mass-burn municipal incinerator.

The analysis of particle size data for all types of municipal incineration is severely limited by the lack of test data in this area. No uncontrolled or controlled particle size information could be found for RDF-fired incinerators, and only one data set could be found for modular

TABLE 7. PARTICLE SIZE DATA

Reference	Control device	% by weight less than particle size indicated										Facility emissions (gr/scf @ 12% CO_2)	Comments
		1	5	10	15	20	30	150	250	297	590		
Uncontrolled Emissions Mass-Burn Units													
50-A			5.2	12.2	18.2	23.2	29.9	52	75	78	91	2.9	Traveling grate stocker
50-B			9.3	18.2	24.9	30.1	38.1	56	74	78	91	2.8	Rocking grate stoker
8-A		13.5[a]	17.5	23.0	25.0	27.5	30.0					1.11	Traveling grate
8-B		14.6	20.8	26.8	31.1	34.6	40.4					1.67	Reciprocating grate
8-C		23.5	31.9	38.1	42.1	45.0	50.0					0.65	Rocking grate
51		23	20	30	35	40	43						
24		21.5	23.7	34.5		43.5	49.5	76.3	81				Avg. of 5 sets of data
52		4	20	35	40	50	58					1.77	Refractory furnace
21		36	28	39.2								1.46	Nashville - heat recovery
53		34		47		53						1.43	Harrisburg - heat recovery
Controlled Emissions Mass-Burn Units													
43	SBS	28	55	70	78								
22	ESP	22[b]		77								0.235	Braintree - heat recovery
53	ESP	20											Harrisburg
Modular Incinerators													
31	CA	80	94	97	98	99	99.5					0.13	

[a] (< 2μ).

[b] (0.6μ).

Notes: SBS = Spray baffle scrubber.
ESP = Electrostatic precipitator.
CA = Controlled air.

incinerator emissions. Sufficient test data were available for only one category--uncontrolled mass-burn incinerators. As a result, broad-based conclusions cannot be made with great authority. More work is obviously needed in this area.

PARTICLE SIZE OF HEAVY METALS

One additional area of concern for particulate emissions is the particle size of emitted heavy metals. These concerns are based on public health considerations.

As stated earlier, all particulate below 2-5 μm in diameter are considered respirable and may be inhaled, to some extent, into the alveolar regions of the lungs. They may also be absorbed into the blood stream from this location. Once in the blood stream, toxic and heavy metals may be subsequently concentrated in various internal organ's and eventually build-up to levels that are potentially injurious to human health. Because of these considerations, researchers have begun to investigate the amount and deposition of heavy metal aerosols in the environment.[6,51,54] The contribution of municipal incinerators to this heavy metals aerosol concentration is also being studied.[30,43,44] Yet, there are only limited data available in this area. The existing published particle size information on heavy metals is presented in Table 8. Emission factors for each element are also listed in this table.

When Table 8 is examined, two facts stand out. The first is that the emissions of any specific heavy metal, as well as all heavy metals considered collectively, represent a small fraction of total particulate emissions. If we divide the emission factor for any heavy metal presented in Table 8, with the total particulate emission factor for the same facility, we note that the contribution of any one metal never exceeds 9 percent (zinc from facility 31), and the contribution of all heavy metals from one facility is at the most [illegible] percent (facility 31). The only other facility for which there is substantial data in Table 8, facililty 46, had a total contribution from six heavy metals equivalent to 4.25 percent of all particulate emissions. The bulk of the particulate emitted from these facilities is inorganics, such as silicon, and metals not under investigation in this study, such as aluminum and iron. Nevertheless, while heavy metal emissions may not represent a large fraction of total municipal incinerator emissions, they may be considered significant due to public health considerations.

The second fact that stands out is the particle size of the heavy metals. Given the limited data available, it appears that most of heavy metals, generally 70 to 90 percent, that are discharged from municipal incinerators are in the respirable size fraction. The exact percentage varies with each metal and is affected by the type of air pollution control that is installed at the facility. The high percentage of small metal particles contrasts greatly with the particle size data for total particles (Table 7). In this table, 20 to 30 percent of all controlled particles are less than 1 μm in diameter, indicating that heavy metal emissions are concentrated in the respirable

TABLE 8. PARTICLE SIZE OF CONTROLLED HEAVY METALS

Reference	Facility size (TPD)	Control	% by weight of metal particulate less than 2 μm	Total particulate emission factor (lb/t)	Elemental emission factor (lb/t)	Comments
Zinc						
47	270	SBS	92	5.6		Alexandria, VA
47	1500	STC/MC ESP	83	0.92		SWRC-Washington, DC
43			71	80.0	1.0	East Chicago, IL
31	58			3.03	0.28	North Little Rock, ARK (Modular)
46	300	STC		7.7	0.13	Waterbury, CT
Lead						
47	270	SBS	96	5.6		Alexandria, VA
43			88	8.0	0.38	East Chicago, IL
31	58			3.03	0.13	North Little Rock, ARK (Modular)
22				5.39	0.086	Braintree, MA
46	300	STC		7.7	0.15	Waterbury, CT
Copper						
47	270	SBS	91	5.6		Alexandria, VA
47	1500	STC/MC ESP	80	0.92		SWRC-Washington, DC
43				80.0	0.014	East Chicago, IL
31	58			3.03	0.002	North Little Rock, ARK (Modular)
46	300	STC		7.7	0.042	Waterbury, CT
Cadmium						
47	270	SBS	95	5.6		Alexandria, VA
47	1500	STC/MC ESP	83	0.92		SWRC-Washington, DC
43	225	SBS	66	80.0	0.018	East Chicago, IL
45				-	0.013	
46	300	STC		7.7	7.7×10^{-4}	Waterbury, CT

(continued)

TABLE 8 (continued)

Reference	Facility size (TPD)	Control	% by weight of metal particulate less than 2 μm	Total particulate emission factor (lb/t)	Elemental emission factor (lb/t)	Comments
Chromium						
47	270	SBS	32	5.6		Alexandria, VA
47	1500	STC/MC ESP	59	0.92		SWRC-Washington, DC
31	58	-		3.03	3.5×10^{-5}	North Little Rock, ARK (Modular)
46	300	STC		7.7	0.008	Waterbury, CT
Nickel						
31	58	-		3.03	6×10^{-5}	North Little Rock, ARK (Modular)
46	300	STC		7.7	0.003	Waterbury, CT
Arsenic						
47	270	SBS	94			Alexandria, VA
47	1500	STC/MC ESP	75			SWRC-Washington, DC
Mercury	- No data available					

Note: SBS = Spray Baffle Scrubber
STC = Spray Chamber
MC = Multiclone
ESP = Electrostatic Precipitator

particle size fraction and that these metals constitute a disproportionate share of this respirable fraction. Whether these particle size data are significant will be more fully discussed in Section 6 of this report.

GASEOUS POLLUTANTS

Combustibles

Gaseous pollutant emissions from municipal incinerators can be grouped into two major categories: combustible gases, including carbon monoxide, aldehydes, organic acids, hydrocarbons and polynuclear hydrocarbons, and noncombustible gases including nitrogen oxides, sulfur oxides and hydrogen chloride. Combustible gases are formed by the incomplete oxidation of various refuse components. For example, aldehydes, organic acids and esters are formed by the partial oxidation of heating fats and oils in the refuse, while carbon monoxide is an incomplete combustion product of the carbon contained in many municipal waste items. Combustible gases were a major incinerator emission problem in the 1950's and 1960's when domestic "back-yard" single chamber incinerators were used to burn residential refuse, and when many larger municipal incinerators were essentially batch fed, single chamber design, in which the waste was ignited and left until it burned out. Combustion control of these units was minimal, and air pollution control, if installed, usually consisted of a water spray system that had little affect on combustible pollutant emissions.

With the adoption of state and federal air pollution control regulations in the late 1960's and early 1970's, municipal incinerator designs changed. Batch fed systems gave way to continuous waste charge installations. Auxiliary fuel burners were installed in the combustion chamber to insure minimum combustion temperatures. Primary and secondary air ports were installed to provide good air/flue gas mixing as well as sufficient oxygen for complete combustion of solids and gases. While these process changes were made to bring the municipal incinerators in compliance with the applicable particulate emission standards, they had the secondary effect of controling combustible gas emissions, since they established a hot turbulent oxidizing atmosphere in which any combustibles that were generated were fully oxidized. An example of the degree of combustible emission control provided by the installation of a process modification such as a primary burner is shown by examining the hydrocarbon emission factor for a domestic single chamber incinerator with and without this burner. Without a primary burner 100 pounds of hydrocarbon are emitted per ton of refuse burned. With a burner, only 2 pounds of hydrocarbon are released per ton of refuse.[55] The specific degree of combustible pollutant production that can be attributed to changes in municipal incinerator process design is difficult to quantify since there are no incinerator emission standards for these pollutants. Stack testing of modern, continuous feed systems has not included analysis for these pollutants, and the test data reported in the literature for combustible gases was taken on older units. While these data are not indicative of levels achievable using up-to-date incinerator designs, they do indicate the extent and variation of these emissions and give historical perspective to the combustible emission problem.

Noncombustibles

Noncombustible gaseous emissions from incinerators are becoming an increasing concern. These pollutants are the products of the combustion of solid constituents of the waste, and they cannot be controlled by better equipment design or operation. As the make-up of municipal solid waste changes, so does the amount of noncombustible gases emitted from municipal incinerators.

Of all the gaseous pollutants, hydrogen chloride (HCl) presents the greatest problem. Hydrogen chloride is irritating to the eyes and respiratory system. In addition, it poses a severe corrosion threat to all exposed metal surfaces within the incineration system. The nature of the HCl problem has been widely recognized and several sources[28,34] have indicated that control measures may be necessary in the near future. Because HCl is highly soluble in water, it can be effectively controlled by water scrubbers.

The principal source of HCl in the incinerator effluent is as a product of the combustion of halogenated polymers, primarily polyvinyl chloride (PVC). Pure PVC resin burns to yield quantitatively 1180 pounds of HCl per ton of PVC.[8] Estimates of HCl emissions can therefore be made based on projected plastics content of municipal refuse and the PVC content of these plastics, although this technique may tend to underestimate actual HCl emissions since there are additional HCl sources in the waste. Nonetheless, the HCl problem is significant and growing based on refuse projections presented in Section 2.

Hydrogen fluoride (HF) is another acid gas that is produced by the incineration of municipal refuse. These emissions result from the combustion of fluorinated hydrocarbons such as polytetra fluorethylene.[8] Hydrogen fluoride exhibits many of the same properties as hydrogen chloride. It is a respiratory irritant and is potentially corrosive to exposed metal surfaces. Control measures taken to limit hydrogen chloride will effectively minimize HF emissions as well. In general HF emissions are only 1 to 2 percent those of HCl.[33]

Sulfur dioxide emissions are approximately proportional to the sulfur content of the refuse itself. When compared to other solid and liquid fuels, municipal waste does not have a high sulfur content, averaging 0.2 percent (see Section 2). This sulfur is primarily associated with paper, food wastes, and yard wastes. The sulfur content of rubber in the waste is high, and this may cause high instantaneous sulfur oxide emissions when items such as automobile tires are burned.

Substantial amounts of other sulfur-bearing compounds such as demolition plaster waste, wallboard and other inorganics may also be charged to an incinerator. However, most of the sulfate contained in these wastes will not be reduced in the furnace and will not contribute to sulfur oxide emissions.[8] It has been suggested[8] that a portion of the sulfur present in the refuse is adsorbed by alkali oxides and is fixed as a solid in the residue and fly ash. The relative extent of this flue gas cleansing mechanism, however, is unclear. Available data indicate that sulfur in the refuse is largely (~95 percent) released as sulfur dioxide.

Nitrogen oxides (NO_x) are emitted by the combustion of any fuel. They are formed at elevated temperatures (1600°F) by the reaction of atmospheric oxygen with nitrogen in the fuel and nitrogen in the air. Nitrogen oxide emissions from municipal incinerators are usually small in comparison to those released from other sources, particularly internal combustion engines. The emission factor for NO_x emissions from a municipal incinerator is on the order of 3 pounds of NO_x per ton of wasted burned.[55] Studies[8] indicate that incinerator NO_x emissions are affected by three variables. First, increases in excess air will result in increases of NO_x up to excess air levels of 300 percent, beyond which further increases in excess air cause the flame temperature and NO_x formation rate to decrease. Second, increases in underfire air rate will reduce NO_x emissions because these tend to reduce the flame intensity above the grates, and this is where most NO_x is formed. The third variable is the nitrogen content of the refuse, although a quantitative relationship has not been established between NO_x formation and fuel nitrogen content.

Several European countries have adopted standards for HCl, HF, and SO_2. These standards apply only to new or rebuilt facilities. Consequently, there has been limited practical operating experience with the controls (scrubbers) that have been installed. Table 9 presents these incinerator standards.

A literature search was conducted to obtain reported test data on municipal incinerator gaseous emissions. Because there are no emission standards for these pollutants in this country, actual test information is limited. Available data are reported in Table 10. Following the established convention, the data have been subdivided by type of incinerator used--mass burn, processed waste, and controlled air units. Most reported data covered mass-burn units. Because wet collection devices will remove some gaseous pollutants from the flue gas, units with this type of air pollution control were further segregated. The limited emission data base again makes it difficult to draw conclusions.

Stack emission test data were obtained for five European and eight American mass-burn incinerators. All of the European and four American facilities used electrostatic precipitators, while the remaining American units had wet collection devices. These wet devices were basically spray chambers, used to cool the flue gas stream as well as to provide for some particulate emission control. None of these scrubbers was designed solely to limit gaseous pollutant emissions.

Examining Table 10, we note a wide variation in emission data, especially for hydrogen chloride. While the composition and chemical make-up of the refuse incinerated at each facility was not available and a correlation between waste composition and stack emissions could not be made for each unit, it appears that variations in composition, especially variations in the

TABLE 9. EXISTING PARTICULATE AND GASEOUS EMISSION LIMITS, mg/Nm^3 [40]

Country	Particulates (mg/Nm^3)	HCl (mg/Nm^3)	HF (mg/Nm^3)	SO_2 (mg/Nm^3)
W. Germany	100(7)	100(7)	5(7)	500(7)
Switzerland	100(7)	500(7)	-	300(7)
France - 1 tonne/hr	1,000(7)	-	-	-
1-4 tonne/hr	600			
4-7 tonne/hr	250			
7-(15) tonne/hr	150			
over(15) tonne/hr	80[a]			
Great Britain	465	726		
Holland	100(7)	-	-	-
Sweden	180(10)	40(10)[b]	b	b
Denmark - small plants	180(10)	-	-	-
large plants	150(11)	1,500	-	1,500[c]
USA	180(12)	-	-	-

[a] Estimated from incomplete data. May be 150 mg/Nm^3.

[b] Total acid equivalent - Exceeding this total, 40 mg/Nm^3 for all acid gases, feasible control system.

[c] SO_2 plus SO_3.

Notes: - The conversions to volume units are:

HCl - multiply mg/Nm^3 by 0.62 to get ppm
HF - multiply mg/Nm^3 by 1.12 to get ppm
SO_2 - multiply mg/Nm^3 by 0.35 to get ppm

- To convert particulates: mg/Nm^3 to grains/scf, multiply by 0.00043

- Parentheses indicate CO_2 level to which the concentration is adjusted.

- Nm^3 = Normal cubic meter at 0°C and 760 mm Hg.

TABLE 10. UNCONTROLLED GASEOUS EMISSIONS RATES (mg/Nm^3 at 12% CO$_2$)

Facility	Size (tons/day)	Control	Concentration					Organic acids (as CH_3COOH)	Aldehydes (as HCHO)	Reference
			HCl	HF	SO_x	NO_x	CO			
<u>Mass Burn</u>										
Dusseldorf, Germany	1260	ESP	1091	9.8	551	9.8				46
Paris: Issy, France	1635	ESP	2415		228	223				40
Zurich: Hagenholz, Switz.	380	ESP	1200	15.7	314					40
Uppsala, Sweden	120	ESP	82		252					40
Copenhagen: Amager, Denmark	864	ESP	1371		429					40
Nashville, TN	720	ESP	167		100	281	178			21
"A"	1500	ESP	485							56
"B"	1600	ESP	567							56
Braintree, MA	120	ESP								22
Babylon, NY	400	SC	884	7	240	68.6	0.01	300	7.4	57, 58
Newport News	400	SC	158	-	726	310		< 3	0.5	58
SW Brooklyn, NY	1000	SC+ESP	267		123					35, 58
73rd St., NY	220	VS	433		305			< 3	12	58, 59, 60, 61
<u>Processed Waste</u>										
SWRU: Hamilton, Ontario	600	ESP	379		487			33	20.7	
<u>Controlled Combustion</u>										
North Little Rock, ARK	58	CA	394	6.5	16.0	210		3		31

Notes: ESP = Electrostatic precipitator; SC = Water spray chamber; VS = Venturi scrubber; CA = Controlled air.

plastic content of the waste, may have accounted for the differences in emissions within each control device class. Strong conclusions on the effectiveness of a control device in removing any specific pollutant should not be drawn from the data presented in Table 10. Since the data base is relatively small, the influence of waste feed composition is not explicitly known and the devices reported on, especially in the case of the scrubbers, were not designed for gaseous control. The spray chambers reported in Table 10 were installed in the late 1960's and were intended solely to lower flue gas temperatures. Should gaseous pollutant control be a prime concern, scrubbers can be designed today to achieve substantial reductions in flue gas HCl, HF and SO_2 levels.

No firm conclusions can be made regarding the differences in either NO_x or CO levels between dry control and wet control devices due to the general lack of data, and the fact that NO_x and CO emissions are directly related to incinerator operating conditions and not to relative control device efficiency.

The limited organic acid and aldehydes emission data that are available are reported in Table 10. As previously stated, these pollutants can be eliminated with good combustion control in the incinerator furnace. The one extremely high (300 ng/Nm^3) value for organic acids reported in Table 10 is therefore more a function of poor operation and low combustion efficiency of this unit rather than an indicator of control device efficiency.

Gaseous emission data could only be obtained for one processed refuse facility and one controlled combustion incinerator. Given this limited data base it is impossible to state whether gaseous emissions from these units are indicative of each process or are merely due to some phenomena of the specific unit which was tested. Nonetheless, comparisons can be made between each of these units and the mass-burn facilities.

Stack gas hydrogen chloride and hydrogen fluoride levels of both the processed waste and the controlled air incinerators are comparable to those of American mass-burn facilities, regardless of the type of emission control. The processed waste facility emits more sulfur dioxide than the average mass-burn unit, although individual mass-burn units have reported higher SO_2 emissions. Since refuse derived fuel has roughly the same sulfur content as unprepared municipal solid waste (Table 2), this is not surprising. The controlled air incinerator had a markedly lower sulfur oxide emission rate than the other incinerators. While the specific chemical breakdown of the solid waste fired into this unit was not reported, the lower rate is probably due to a proportionately lower sulfur content of the waste. The nitrogen oxide emissions of the controlled air incinerator were somewhat higher than the average mass-burn unit emissions, although individual mass-burn incinerators did report NO_x levels in excess of the controlled air value. The maximum temperature of the controlled air incinerator was in excess of 1900°F, with short-term peaks greater than 2000°F, and this contributed to the elevated NO_x emission rate.

In summation, there are extensive emission data available for only mass-burn incinerator particulate emissions. There are hundreds of these units throughout the world, and all must meet particulate emission standards. Particulate emission rates from the relatively new technologies of RDF facilities and controlled air incineration are available for only a few select facilities. This body of information is expected to grow as more of these facilities are installed and tested.

Similarly, the emission rates and particle size distribution of heavy, potentially toxic metals are limited. This data base is also expected to grow as public concerns over toxic and hazardous waste increase.

Gaseous emission data are only now being studied in depth by the Environmental Protection Agency. It has been suggested that a need exists to limit hydrogen chloride emissions from municipal incinerators in this country, but most regulatory agencies have adopted a wait-and-see attitude. Several European countries have emission standards for incinerator acid gas emissions, but there is little operating experience pollution control in this area. Should the municipal waste stream follow projections and show significant increases in its plastics content by the year 2000, municipal incinerators may become major contributors to ambient acid gas levels.

SECTION 5

AVAILABLE CONTROL TECHNOLOGY

A well-designed and operated large-scale incinerator cannot meet federal nd New Jersey particulate emission regulations without an air pollution ontrol system. Comparing the estimated uncontrolled incinerator emission te of 1.41 gr/dscf at 12 percent CO_2 from Section 4 with the Federal and w Jersey standards of 0.08 and 0.10 gr/dscf at 12 percent CO_2, spectively, it is apparent that control efficiencies greater than 92 percent n a weight basis are required. In addition, considering the particle size ta presented in Table 7, it is clear that high efficiencies for fine rticles are required. This requirement effectively eliminates the simple ir pollution control systems traditionally used on incinerators. However, hese older controls may still be valuable as first stage collectors to reduce he required efficiency of the final collector. These older systems, which nclude settling chambers, wetted baffle spray systems, cyclones, and low nergy scrubbers, will not be considered further in this report.

Electrostatic precipitators, coated fabric filters, and certain types of crubbers appear to be the only commercially available control devices that an meet the current emission standards for municipal incinerators. Newer orms of these devices, including charged droplet scrubbers and high velocity et precipitators may have advantages over more conventional devices, but have ot been commercially demonstrated for incinerator applications.

LECTROSTATIC PRECIPITATORS

Electrostatic precipitators (ESP's) have been used in utility and ndustrial steam generating boilers and many other industrial applications for ver 50 years with a relatively good performance record.[18] They have been sed to limit particulate emissions from mass-burn municipal incinerators in urope and Japan for over 15 years with excellent results.[40] They remain he preferred and virtually exclusive method for controlling incinerator missions in these areas. In the United States, the first ESPs were installed on municipal incinerators in New York City in 1969. Since that time, 18 dditional precipitators have been installed to control incinerator articulate emissions. They have met or exceeded performance guarantees in ll cases.[30] As such, ESPs have established themselves as state-of-the-art or municipal incinerator particulate control.

Figure 6 presents a cutaway of a typical electrostatic precipitator. The operation of a precipitator depends on three sequential events:

- Charging of the particles in a corona discharge.
- Migration of the charged particles in an electric field to and retention by a grounded collection electrode in the form of flat plates or a metal shell, and
- Removal of the collected particles from the collector plates by rapping to dislodge the particles, allowing them to fall into a hopper, or by flushing the collection electrode with water.

In the precipitator, a high, normally negative voltage (30,000-80,000 volts) is impressed across the charging electrode or discharge wire and the collection plates. This voltage produces a corona discharge around the wire, effectively filling the space between the wire and the collectin plates with negatively charged ions. As these ions migrate toward the grounded (relatively positive) electrode, they collide with flue gas dust particles, charging these particles negatively. These particles then migrate towards the collection plate under the influence of the electric field. At the collection plate, the particles are held by a combination of electrical, adhesive, and cohesive forces while their negative charge is gradually conducted through the layers of previously collected dust to the grounded electrode. The particles remain attached to the plates until removed by periodic rapping. The resistance to conduction is termed "dust resistivity."

The electrical properties of the particles and the moisture content and temperature of the gas stream affect precpitator operation. Particles of high resistivity lose their charge very slowly. This can cause accumulations of charge on the collected material and a considerable voltage difference between the surface of collected materials and the collector plates. Under these conditions, arcing may occur within the collected particles layer causing reentrainment of particles and poor precipitator performance. The resistivity of particles is temperature dependent, and moisture in the gas stream tends to lower resistivity (make the surface of the particles more conductive). When evaporative cooling is used to cool incinerator gases to the optimum temperature range for a precipitator (400°-600°F), the moisture added lowers particle resistivity and tends to produce stable precipitator operation. When exhaust gas cooling is achieved by air dilution or a waste heat boiler, and the incinerator emits well-burned particles, the particles may have high resistivity. Under these conditions, it may be necessary to add some moisture to the exhaust gases to achieve stable precipitator performance.

Precipitator collection efficiency is related to collection plate area, volume flow rate and particle migration velocity. The migration velocity in turn is related to the strengths of the charging and collection fields, particle diameter and gas viscosity. Assuming all variables except plate area are constant, a precipitator capable of collecting 95 percent of all particulate matter would have to be increased in plate area by about 50 percent to meet a 99 percent collection efficiency. The relative plate area for a precipitator is an approximate indication of its relative capital cost.

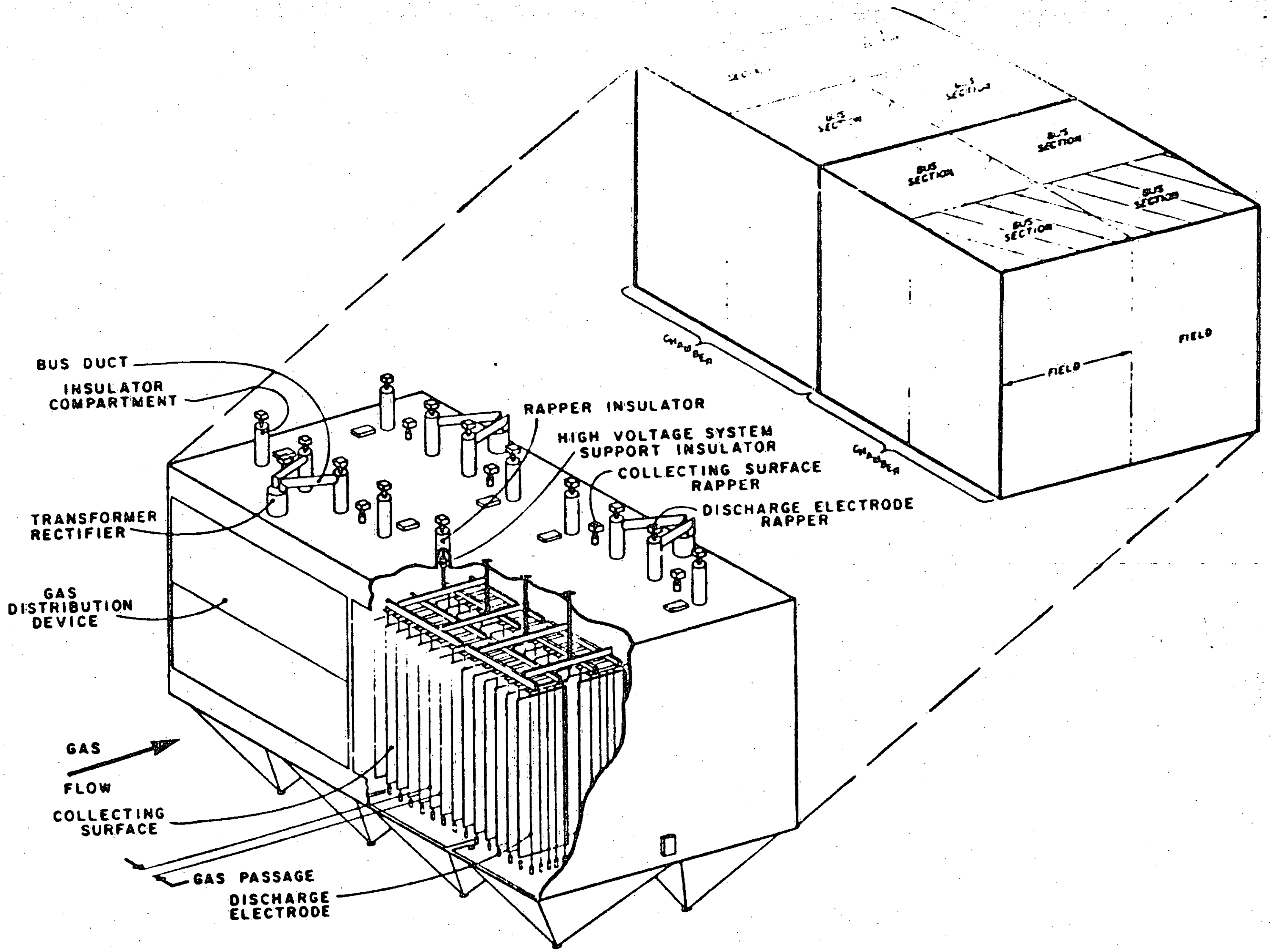

Figure 6. Typical precipitator cross section.[62]

These costs increase rapidly as control efficiency requirements approach 99 percent. Therefore, it is extremely important that an incinerator ESP not be vastly overdesigned if overall costs are to be kept to a minimum. The incineration system designer must have a good understanding of particulate formation mechanisms associated with municipal incineration and the potential effects that varying refuse compositions will have on these emissions such as the increase in inorganic paraticulate that may result with increased ash content.

Electrostatic precipitators offer two distinct advantages when applied to municipal incinerators:

- Low power requirement--ESPs offer a low resistance to flow (less than 1 in. water gauge) and this reduces fan horsepower requirements. This, in turn, lowers operating costs
- Dry collection--Captured particulate is in a dry state, which prevents water pollution and reduces corrosion to a minimum.

At the same time, ESPs exhibit certain disadvantages:

- Uniform gas and particle distribution across the inlet of the collector is necessary to obtain the design efficiency.
- There is no gaseous emission control.
- Critical temperature of operation--The optimum temperature range is 500° to 600°F. Above or below the range, incinerator particulate resistivity changes dramatically and collection efficiency decreases.
- The tendency of unburned carbon to lose its charge before it is collected may adversely affect collection efficiency. In addition, it is difficult to charge certain highly resistant inorganics.
- Corrosion of internal ESP parts by HCl, HF and other acid gases may be a problem if operating temperatures are allowed to fall below the dew point of these gases (approximately 350°F). The ESP must therefore be preheated with auxiliary fuel both prior to and subsequent to burning of any municipal waste in the incinerator to minimize this corrosion.

In spite of these disadvantages, precipitators remain the favored method of controlling municipal incinerator particulates due to their proven performance. Table 4 listed several of the installations at which ESPs have been successfully used. Precipitators, however, do not control gaseous pollutant emissions. Some gases may be neutralized and adsorbed onto particulates and in this state will be removed by the ESPs, but this cleansing mechanism is not completely understood and probably insignificant.

SCRUBBERS

Devices that contact incinerator flue gas with water have traditionally been used to clean the gases and to cool them to protect the ductwork and fan materials. These devices, including spray chambers and wetted baffle scrubbers are inadequate, however, to meet modern particulate emission control standards. As noted earlier, to meet current NSPS requirements it is necessary to use devices that can remove all particles larger than one micrometer. This can be accomplished using only the most sophisticated form of scrubbing devices, venturi scrubbers. Use of venturi scrubbers to date has shown mixed results. Municipal incinerators with venturi scrubbers in Calumet, Illinois; Louisville, Kentucky; and Sheboygan Falls, Wisconsin, have failed to meet the NSPS particulate standard, whereas a unit in Pawtucket, Rhode Island, achieved this standard only after modifications were made to the original design.[63] Nonetheless, these devices are capable of achieving a strict emission level, and thus they must be addressed.

A standard venturi scrubber schematic is presented in Figure 7. In this device, flue gases are accelerated through a restricted "throat" to velocities of 200 to 400 feet per second. Water is injected into the gas stream at this throat to promote intimate gas-liquid contact. The extremely turbulent conditions at the throat ensure that the solid particles in the gas stream impact the fine liquid droplets. The "enlarged" wet particles thus formed can then be removed in a mechanical device such as a cyclonic separator and/or wire screen demister. Water is provided to the scrubber at the rate of 5 to 10 gpm/1000 cfm. The turbulent air/water interface at the venturi throat results in gas pressure drops of up to 60 inches water gauge in municipal installations. A minimum pressure drop of 35-40 inches water gauge appears to be necessary to attain compliance with the federal NSPS municipal incinerator standard.[63] The venturi scrubber is often preceded by a quench vessel which lowers the flue gas temperature by evaporative water cooling. This lower gas temperature results in a smaller volume of flue gases that must be treated by the venturi scrubber scrubber and therefore reduces the size and cost of the scrubber.

The collection efficiency of a venturi scrubber is related to the energy required to force the flue gas across the venturi throat. This energy is supplied by fans that are normally located downstream of the scrubber. Scrubber energy requirements for a municipal incinerator installation will total 8.75-10.0 horsepower per 1000 cubic feet per minute, based on an estimated pressure drop of 35-40 inches water column.[18] This energy requirement is higher than any other incineration air pollution control device and is the main disadvantage of venturi scrubbers.

Incinerator stack gases contain water-soluble acidic gases. These gases dissolve during scrubbing and are thereby removed from the flue gas stream. Hydrochloric and hydrofluoric acid are especially soluble in water and theoretical maximum removal efficiencies greater than 97 percent have been estimated for scrubber operations.[8] Actual removal efficiencies will depend on the water flow rate, the gas temperature, and the degree of water/gas contact. The removal of acid gases from the flue gas stream has several effects. Gaseous pollutants are not emitted to the atmosphere where they

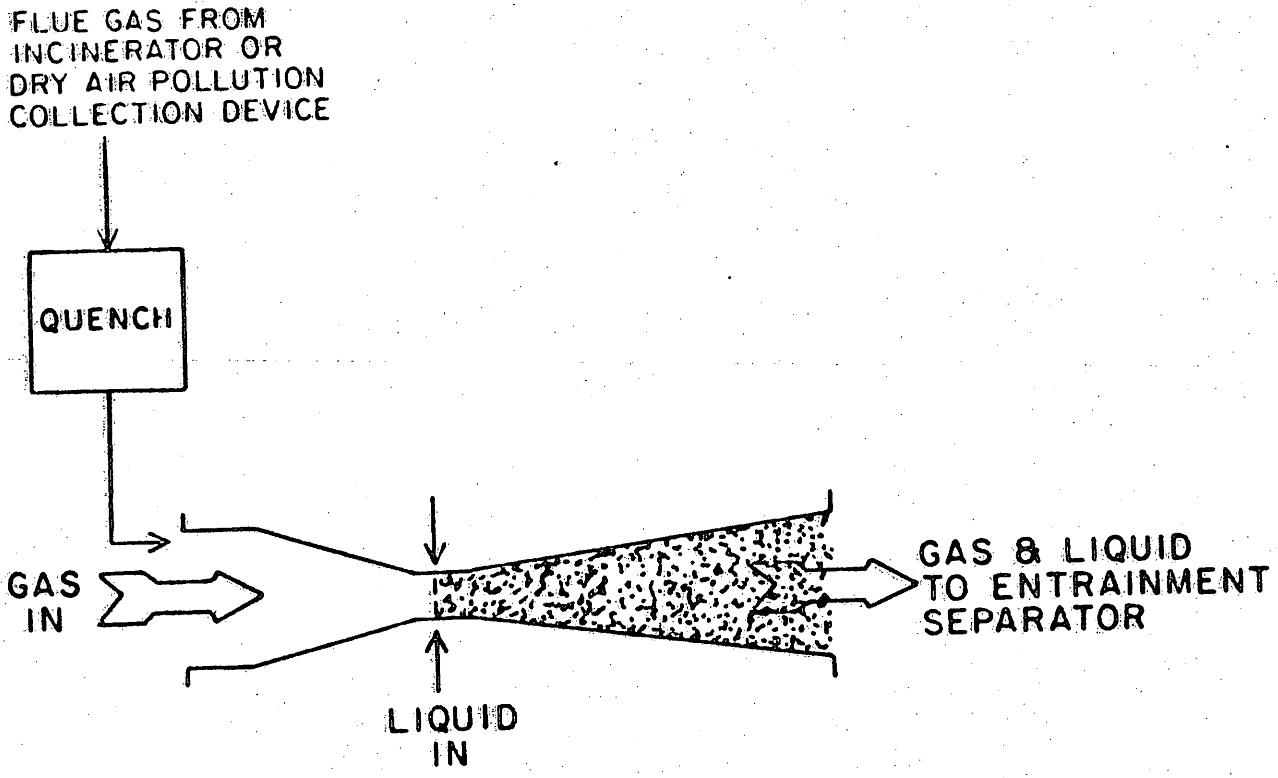

Figure 7. Typical venturi scrubber cross-section.[62]

might adversely affect public health. A water pollutant problem is created, however, that must be treated. Scrubber water, with acid gases, becomes highly acidic. If left unneutralized, this water will corrode the metallic surfaces it contacts. To counteract this, venturi throats and the ductwork immediately downstream are lined with acid resistant materials such as fiberglass, fiber reinforced plastic or refractory material such as silicon carbide. When the scrubber water is recirculated, pH control (adding alkali) must be practiced. Even with water treatment, maintenance costs and downtime may be high, both for the scrubber induced draft fans and other components in contact with the gas stream.[63] pH control is also necessary to neutralize acid gases so they are not subsequently evaporated to the air.

The use of scrubbers may potentially involve additional problems. The humidity of the stack effluent is relatively high. This leads to an almost continuous vapor plume at the top of the stack. Although this is not an air pollutant, it may have the appearance of one to plant neighbors and be a source of citizens' complaints. If this visible plume is to be eliminated, the gas can be cooled to condense out the water and then it can be reheated to obtain a dry plume with sufficient buoyancy. This process adds to the energy requirements of the system.

COATED FABRIC FILTERS

The fabric filter or baghouse, when properly designed and applied to the control of particulate matter, is considered the most efficient of all particulate control systems. Although the basic removal of particulates by filtration seems simple, because it is analogous to a household vacuum cleaner, the mechanism of removal is quite complex and involves elements of direct sieving, impingement, diffusion and electrostatic attraction. Baghouses have not been widely used in municipal incinerator applications because of the difficulty of controlling the temperature and humidity in the gas to be treated. High temperature excursions will set a baghouse on fire, and low temperatures coupled with high moisture content will "blind" the bags; i.e., encrust them with a hard, hygroscopic deposit that cannot be dislodged short of removing the bags for washing or replacement. In addition, the acid gases generated by municipal incineration will lead to quick deterioration of unprotected bag material.

A new system for municipal incinerator control has been recently developed. The dry scrubbing system uses conventional baghouses in conjunction with an adsorbing agent to control incinerator emissions. This system controls particulate emissions while it adsorbs and neutralizes acid gases. A Teller "coated" baghouse system has been in operation at the 250-ton per day Framingham Massachusetts incinerator since 1978. Here it has demonstrated compliance with a particularly low particulate emission limit. In addition, HCl emissions have been reduced to less than 30 ppm.[64] In Japan, Teller baghouses are reportedly being installed on over 53 incinerators.

A schematic of the Teller system for incinerator emission control is presented in Figure 8. Flue gases from the incinerator furnace are initially fed into a spray dryer reactor. Here the gases are sprayed with a neutralizing agent that reduces the flue gas temperature while neutralizing

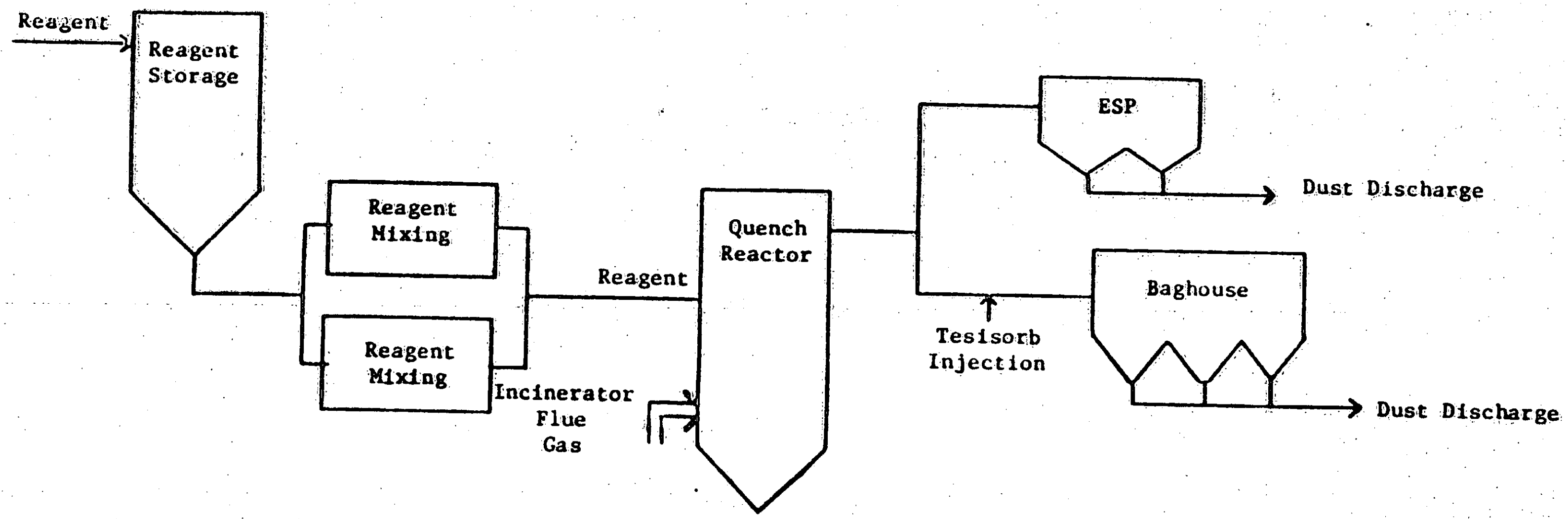

Figure 8. Typical Teller emission control system.[65]

HCl and HF by 70 to 90 percent. The reagent spray is size-temperature responsive and results in a dry particulate product at the outlet of the unit. Flue gas temperatures at the spray dryer outlet are in the order of 400°F. The spray dryer ensures that high and low temperature excursions, both of which can lead to operating problems, do not occur. In the Teller system, this spray dryer, the flue gases proceed to a venturi section where they are contacted with TESISORB A^R, a proprietary additive. TESISORB is a crystalline material that has the capability of agglomerating submicron particulate. It provides for submicron particulate capture in the dry venturi. The neutral salts created in the spray dryer, the agglomerated particulates from the dry venturi, and the supermicron particulates from the incinerator are then removed from the gas stream using either a baghouse or an electrostatic precipitator. If no precipitator is currently installed, the baghouse is preferred.

All baghouses must be intermittently cleaned to dislodge accumulated particulate, usually by manual, mechanical, or pneumatic shaking. The dislodged particulates fall into a hopper where they are removed by screw conveyor.

This cake build-up enables the baghouse to respond to changes in incinerator acid gas emissions brought about by varying refuse composition. During low acid gas emission periods, excess reagent accumulates in the cake and is available for reaction during high acid gas emission periods. In this manner, HCl and HF emissions can be reduced by greater than 98 percent. Where an electrostatic precipitator is used as the downstream collector in place of the baghouse, HCl emissions have been reduced by 90 percent in certain cases.

The basic principle of the dry scrubber system is the use of a chemically active material to form a chromotographic layer on the fabric filter bags. In doing so, this system overcomes many of the operational problems that have precluded the use of fabric filters on municipal incinerators in the past, including bag blinding and acid gas corrosion.

Baghouses have additional inherent disadvantages. Because the large number of bags, baghouses require more space than scrubbers, but perhaps comparable space compared to precipitators. Maintenance is difficult because hundreds of bags are tightly spaced in a single housing. Physically finding and replacing broken bags is a dirty, difficult job. Operating costs are generally lower than those for high efficiency scrubbers, but greater than those for electrostatic precipitators.

By addressing the temperature, humidity and acid gas corrosion problems that have precluded the use of baghouses for municipal incinerator emission control in the past, the dry scrubber appears to offer an additional control technique for incinerator emissions.

SECTION 6

RECOMMENDED ACHIEVABLE LEVELS

In this section the various elements of centralized municipal incineration will be brought together to define recommended pollutant emission levels. These levels will be established for a pollutant if they can be achieved using commercially available air pollution control technology. In addition, the possibility of minimizing incinerator emissions through selective segregation of certain pollutant forming waste materials (e.g., automobile tires, ferrous metals) has been considered and recommended since such waste separation is both feasible and enforceable. One set of emission standards has been recommended for all municipal incinerators, regardless of size so that the selection of a specific incinerator technology and/or control method will not be influenced by a variation in allowable emissions. Finally, cost considerations have not played a direct part in the recommended achievable levels. However, the levels were established on the basis of widely used technology, and this fact speaks for the economic rationale of the equipment.

PARTICULATES

The need to regulate particulate emissions is clear-cut because they have historically been the prime pollutant of concern from municipal incinerators. While one common standard will be recommended for both large (>50 TPD) and small (<50 TPD) incineration systems, it is recognized that achievement of this standard may involve a combination of different waste disposal practices, incinerator designs and air pollution control technologies. Large incineration systems can take advantage of economies of scale to select individual incineration components. Air pollution control devices for these systems can be designed to achieve the most stringent particulate emission standard now in effect. Such systems might chose to avoid the additional expense inherent in segregating particulate generating waste components, such as automobile tires, and concentrate their emission reduction efforts in a larger, more efficient, particulate control device.

Small systems, on the other hand, rely on the design and operation of the incinerator to minimize particulate emissions. Once these systems have optimized particulate control in the incinerator, they may be required to adopt additional means, such as waste segregation and/or the installation of air pollution control equipment to insure particulate emission standards that are being met. The specific combination of operating scenarios that can be used to achieve the particulate emission standard will be left to the incineration facility owner.

The units of measurement of the recommended particulate emission standard for this study will be grains of particulate per standard cubic foot of stack gases corrected to 12 percent carbon dioxide content. Particulates as used in this context will be defined as only that material which is captured in the front (dry) half of a standard EPA Method 5 sampling train. By using this measurement standard and this definition we can directly relate any proposed particulate emission standard to the data reported for previous municipal incinerator particulate emission tests and thereby support the recommended standard. However, use of only the front half of the sampling train to determine particulate emissions is contrary to the current New Jersey practice, which includes the front half particulate as well as any condensible particulate captured in the back (wet) half of the sampling train. As discussed earlier, inclusion of the back half of the sampling train in determining particulate emissions will mean that more particulates will be collected during a stack test using this method than would be captured using a standard EPA Method 5 test. As a result, the reported stack gas particulate emission concentration for an incinerator will be higher when the New Jersey particulate definition and test procedure is used than when the EPA definition and corresponding sampling technique is employed. This variance in particulate definitions and test procedures is very important in determining the compliance of a facility. An incinerator may be in compliance with the applicable emission standard when using the EPA procedures, but not in compliance when the New Jersey Method is used. Conversely, an emission standard that is predicated on New Jersey State procedures will be, in effect, somewhat stricter than one based on EPA procedures because of the inclusion of condensible particulate in the New Jersey procedure. Unfortunately all particulate emission test data that has been reported in the literature for municipal incinerators was based on EPA procedures. For the sake of consistency, the proposed standard will retain this convention.

In 1969 there were eight municipal incinerators operating in the State of New Jersey, with capacities greater than 50 tons per day.[27] Today there are none.[2] Because there are no emissions from this stationary source category at the present, any increase will add to the burden of airborne particulates in the atmosphere. The establishment of an achievable particulate emission level from incinerators must necessarily attempt to restrict this level to minimize ambient particulate increases. Based on actual test datas presented and described in Section 4, this level is 0.05 grains/dscf at 12 percent CO_2.

This emission level has been cited for several reasons. First, it is restrictive without being unattainable. More than half of the large American municipal incinerator test results reported in Table 4 were less than this 0.05 level. The average of the 22 sets of data reported in Table 4 was, at 0.053 gr/dscf at 12 percent CO_2, only slightly greater than this recommended concentration even though these units were only required to meet an emission standard that averaged 0.076 gr/dscf at 12 percent CO_2. In fact, municipal incinerators have, in certain cases, been able to demonstrate compliance with applicable emission standards as low as 0.03 gr/dscf at 12 percent, therefore the proposed 0.05 level is not unattainable by existing incineration methods.

The second rationale for this level is that it can be met by several different types of control systems. Seven of the incineration facilities in Table 4 that had particulate emission levels lower than 0.05 gr/dscf at 12 percent CO_2 employed electrostatic precipitators. Based on an uncontrolled particulate emission estimate of 1.41 gr/dscf at 12 percent CO_2 presented in Section 4, a level of 0.05 gr/dscf at 12 percent CO_2 would require 96.5 percent control. This is only marginally greater than the 96.2 percent control efficiency now being achieved for all large American mass-burn incinerators reported in Table 4, and it is significantly lower than the 97.7 percent particulate emission control efficiency being achieved by European incinerators that employ electrostatic precipitators.

Similarly, fabric filters have shown that they can ensure compliance with the 0.05 gr/dscf at 12 percent CO_2 emission standard. Again referring to Table 4, the fabric filter installations at Bridgewater and Framingham, Massachusetts, have both demonstrated compliance at levels lower than 0.03 gr/dscf at 12 percent CO_2. The Framingham unit, which utilizes a coated baghouse, provides the additional advantage of addressing the potential operating and maintenance problems associated with moisture and hydrogen chloride.

There is little published information on electrostatic precipitators ands fabric filters used with RDF systems. The one unit for which there are data, Hamilton, Ontario, is still in the process of sorting out operation problems. There is nothing to suggest, however, that these control devices would be any less effective in controlling RDF-produced emissions than they would be in minimizing mass-burn produced particulates. A municipal incinerator that is fired with RDF should be able to comply with a 0.05 gr/dscf at 12 percent CO_2 emission limitation.

The recommended emission standard of 0.05 gr/dscf at 12 percent CO_2 should also apply to small incineration systems. While only one of the four small mass-burn facilities reported in Table 5 demonstrated that it can meet this emission level, a combination of selective waste segregation and additional air pollution controls can be used to augment small, modular incinerator designs in order to lower the stack particulate emission concentration. Controlled air incinerators, of the type in use at small municipal incineration facilities, employ an afterburner to minimize particulate emissions. This afterburner is an integral part of the incinerator design and therefore cannot be considered a separate air pollution control device. Since modular incinerators have to-date demonstrated compliance with applicable emission limitations without additional air pollution control devices, none have been installed. However, the establishment of an emission limitation of 0.05 gr/dscf at 12 percent CO_2 may require that an additional control device be installed on these units to insure continued compliance with this regulation. The average particulate emission level of modular incinerators reported in Table 5 was 0.077 gr/dscf at 12 percent CO_2. To lower this level to the 0.05 gr/dscf at 12 percent CO_2 level, a minimum control device efficiency of 35 percent would be required. On the surface, attainment of this control efficiency appears simple, and readily achieved by a number of control devices. However this is not necessarily the case. As Table 8 has indicated, 80 percent of the particulate emitted by a controlled air incinerator is less than 1 micrometer. At a minimum all of the particulate in excess of 1 micrometer plus approximately 20 percent of this submicron particulate would have to be removed to achieve the recommended particulate emission level. Since particulate become increasingly more difficult and expensive to remove as the average particle size decreases, removal of this particulate from a modular incineration system exhaust may require high efficiency particulate collection devices. Nonetheless, such devices are commercially available. As an alternative, operators of these small systems may elect to remove metals before they are charged to the incinerator in order to minimize the emission of metallic particulate which, as Table 9 has shown, is of a small average particle size.

Controlled air incinerators have not yet been required to attain a particulate emission level of 0.05 gr/dscf at 12 percent CO_2. As Figure 5 has indicated, approximately 20 percent of the controlled air units tested in one survey achieved this level regardless of the stack emission level that was required. Whether controlled air units can meet this proposed regulatory standard on a regular, consistent level, without additional back end air pollution control equipment and/or selective waste separation remains to be seen. However air pollution control technology is currently available that will enable these smaller incinerators to achieve this level when burning municipal waste. Therefore, since a level of 0.05 gr/dscf at 12 percent CO_2 is achievable, and for the sake of regulatory consistency regardless of incinerator capacity, it is proposed that this level be adopted for all municipal incinerators.

HEAVY METALS

No emission limitation currently exists for heavy metal emissions from municipal incinerators. Yet these potentially toxic elements are of growing concern. A thorough discussion of the specific health affects of each of these metals is presented in Volume II of this comprehensive incinerator study. Although research in this area is limited, it is known that cadmium, chromium, copper, lead, zinc and other metals are emitted to the atmosphere from the incineration of municipal solid waste. It has also been established that nearly 80 to 90 percent of these heavy metal emissions are in the size range that could tend to adversely affect human health. These facts raise two important questions: how serious is the heavy metal emissions problem from municipal incinerators? and, should these emissions be limited? These questions must be addressed.

The seriousness of the heavy metal emissions problem can be defined by relating incinerator stack concentrations to those emission levels with possible public health effects. The average stack concentrations for the eight metals of concern are presented in Tables 11 (for large scale incinerators) and Table 12 (for small scale units). These emissions data were taken from Table 6. Both actual emissions and "normalized" emission levels are presented. The actual emissions data is an average of stack test data as reported in the literature. The normalized data was derived from the actual

TABLE 11. ESTIMATED HEAVY METAL STACK AND AMBIENT CONCENTRATONS - LARGE SCALE INCINERATORS

Compound	Average[a] actual emission ($\mu g/m^3$)	Average[a] normalized emission ($\mu g/m^3$)	DMEG[b] ($\mu g/m^3$)	Estimated increase in ambient concentrations: 1 hour Actual (ng/m^3)	1 hour Normalized (ng/m^3)	24 hour Actual (ng/m^3)	24 hour Normalized (ng/m^3)	Annual Actual (ng/m^3)	Annual Normalized (ng/m^3)	AMEG[c] (ng/m^3)
Metals										
Arsenic	102	25	2[d]	10.1	2.5	1.6	0.4	0.1	0.03	4.7
Cadmium	669	141	50[e]	66.1	13.9	10.8	2.3	0.8	0.2	120
Chromium	451	84	50[e]	44.5	8.3	7.3	1.4	0.5	0.1	120
Copper	2,169	333	200[e]	214.2	32.9	35.0	5.4	2.5	0.4	480
Mercury	77	14	50[e]	7.6	1.4	1.2	0.2	0.09	0.02	120
Nickel	204	32	15[d]	20.1	3.2	3.3	0.5	0.2	0.04	36
Lead	38,637	7,475	150[e]	3,815.4	738.2	623.0	120.5	43.8	8.5	1,500[f] (360)
Zinc	55,074	11,516	4,000[e]	5,438.6	1,137.2	888.0	185.7	62.4	13.1	9,500
Total Particulate	123,000[g]			12,146.4		1,983.3		139.4		75,000[h]
Gases										
Hydrogen chloride	354,000[i]		100,000[k]	34,957.8		5,707.9		401.2		16,666
Hydrogen fluoride	12,800[j]		5,000[k]	1,264.0		206.3		14.5		5,950
Sulfur oxides	113,000[i]		500,000[k]	11,158.9		1,822.0		128.1		80,000
Nitrogen oxides	356,000[i]			35,155.5		5,740.2		40.5		100,000

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[a] From Table 6, normalized emission = $\frac{\text{actual concentration}}{\text{emission factor}} = \frac{\mu g/m^3}{lb/ton}$ = metal emission if particulate was emitted at 1 lb/ton.

[b] Discharge multimedia environmental goals (see text).

[c] Ambient multimedia environmental goals (see text), annual average.

[d] NIOSH recommendation for worker exposure.

[e] Threshold Limit Value (TLV).

[f] Quarterly national ambient air quality standard and (annual average derived from TLV).

[g] Average of American incinerators, from Table 4.

[h] Primary national annual ambient air quality standard.

[i] Average of American, ESP controlled incinerators, from Table 11.

[j] Average of all ESP controlled incinerators, from Table 11.

[k] West German incinerator emission limitation, from Table 10.

TABLE 12. ESTIMATED HEAVY METAL [illegible] AND AMBIENT CONCENTRATIONS — SMALL SCALE INCINERATORS

Compound	Average[a] actual emission (μg/m³)	Average[a] normalized emission (μg/m³)	DMEG[b] (μg/m³)	Estimated increase in ambient concentrations: 1 hour Actual (ng/m³)	1 hour Normalized (ng/m³)	24 hour Actual (ng/m³)	24 hour Normalized (ng/m³)	Annual Actual (ng/m³)	Annual Normalized (ng/m³)	AMEG[c] (ng/m³)
Metal										
Arsenic	ND	ND	2[d]	-	-	-	-	-	-	4.7
Cadmium	123	41	50[e]	25.7	8.6	7.3	2.4	0.6	0.2	120
Chromium	1.1	0.4	50[e]	0.2	0.08	0.06	0.02	0.01	0.002	120
Copper	63	21	200[e]	13.1	4.4	3.7	1.2	0.3	0.1	430
Mercury	ND	ND	50[e]	-	-	-	-	-	-	120
Nickel	2.0	0.7	15[d]	0.4	0.1	0.1	0.04	0.01	0.004	36
Lead	4,280	1,413	150[e]	895.5	295.6	253.7	83.8	21.9	7.2	1,500[f]
Zinc	9,071	2,994	4,000[e]	1,897.8	626.4	537.8	177.5	46.4	15.3	9,500
Total Particulate	176,330[g]			36,891.8		10,453.8		901.1		75,000[h]
Gases										
HCl	394,000[i]		100,000[j]	82,432.7		23,358.3		2,013.5		16,666
HF	6,500[i]		5,000[j]	1,359.9		385.4		33.2		5,950
SO_x	16,000[i]		500,000[j]	3,347.5		948.6		81.8		80,000
NO_x	210,000[i]			43,936.2		12,449.9		1,073.2		100,000

ND = No data collected.

[a] From Table 6, normalized emission = $\frac{\text{actual concentration}}{\text{emission factor}} = \frac{\mu g/m^3}{\text{lb/ton}}$ = metal emission if particulate was emitted at 1 lb/ton.

[b] Discharge multimedia environmental goals (see text).

[c] Ambient multimedia environmental goals (see text), annual average.

[d] NIOSH recommendation for worker exposure.

[e] Threshold Limit Value (TLV).

[f] Quarterly national ambient air quality standard.

[g] Average of four incinerators from Table 5.

[h] Primary annual national ambient air quality standard.

[i] Test data for one unit from Table 11.

[j] West Germany incinerator emission limitations, from Table 11.

data by dividing the published emissions concentration for each incinerator by the total particulate emission factor for that unit. This procedure was undertaken to give a more realistic assessment of metal emissions from a well-controlled incinerator, of the type that would be required under New Jersey incinerator regulations. The intent of the normalization procedure is to correct published emission data that are above allowable standards to a level that approximates a well controlled unit (1 pound of particulate per ton of refuse charged). However, due to the particle size distribution of heavy metals, as described in Section 4, normalized estimates of these metals will probably underestimate the true metal emissions from a municipal incinerator that is capable of demonstrating compliance with the New Jersey State emissions code. Consequently, the normalized emissions estimated may be used to define the minimum heavy metals emissions rate that can be expected from a well-designed municipal incinerator. As the actual heavy metals emissions reported in Tables 11 and 12 include both well-controlled and poorly-controlled incinerators, an average of these values can be used, as a limiting case, to define the maximum heavy metals emissions rate that might be expected from a well-designed incinerator. A well-controlled incinerator should be capable of achieving lower emissions than these average levels since the reduction in total incinerator particulate emissions that would be required to meet applicable particulate emissions limitations would also result in a decrease, to some degree, in metals emission as well. Therefore by utilizing actual and normalized emission rates for metals, we can establish a realistic upper and a lower emission rate for these compounds. These heavy metals emissions will first be compared to discharge multimedia environmental goals (DMEG).

Discharge Multimedia Environmental Goals (DMEG) have been developed by EPA's Industrial Environmental Research Laboratory at Research Triangle Park, North Carolina (IERL-RTP) for over 600 potential pollutants.[66-69] DMEGs for air are used to provide perspective on potential environmental hazards, to provide direction for control technology research programs, and to prioritize emission streams for future investigation. DMEGs describe maximum concentrations believed to be safe for short term direct exposure to a discharge stream. These conservative goals are not meant to be used as emission limits. They should, however, serve as a useful screening tool to focus further more detailed investigations.

DMEGs are derived from available health effects data such as American Conference of Governmental Industrial Hygienists recommendations for Occupational Exposure [Threshold Limit Values (TLV)], NIOSH recommendations, OSHA standards, Federal environmental regulations and results of animal experiments. Most of the DMEGs for metals are based on work place standards, usually TLVs. TLVs refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. ACGHI states that TLVs are not intended for use (1) as a relative index of hazard, (2) in the evaluation and control of community air pollution, or (3) in estimating the toxic potential of continuous, uninterrupted exposure. On the other hand TLVs are widely accepted criteria that have, in some cases, been in existence for many years. They are based on the information from industrial experience, from experimental human and animal studies, and when possible, from a combination of the three. Before adoption, TLV's are subjected to expert review. Because TLVs are readily available criteria for a large number of industrial pollutants, they form a simple starting point for development of emission or ambient goals.

Typically, DMEGs are assumed to be equal to the TLV and are compared to pollutant concentrations in the stack gas. If the concentration of the pollutant in the stack gas is below the TLV, it is assumed to be acceptable. Concentrations of pollutants above the TLV require further investigation. In making this type of comparison, it is assumed that dispersion will provide adequate safety factors to account for differences between workers and sensitive sectors of the general population and between 40 hours per week exposure and continuous exposure.

A main advantage of this approach is that it is simple. It is therefore easy to apply and understandable to the general public. It can be demonstrated that this is usually a conservative approach (it may underestimate tolerable emission concentrations) that can be used to set goals without using complex source receptor models and risk assessments. Such questions as modeling techniques and accuracy, the effects of various doses on different sectors of the population and similar issues leading to considerable controversy are avoided.

The disadvantage of simplifying the very complex issue of chronic health effects is that the method may not always accurately portray the real environmental impacts. If it is used as a regulatory mechanism, it may result, in some cases, in the application of excessively stringent control or, in other cases, inadequate controls.

A comparison of DMEGs with the large incinerator heavy metals emissions presented in Table 11 indicates that these guidelines are exceeded by the actual emission rates for each of the eight metals, and by the normalized emissions for seven of the eight metals examined. An examination of the small scale incinerator data from Table 12 indicates that of the seven metals for which there is data, actual emissions exceed DMEGs in three cases (cadmium, nickel and zinc) while normalized emissions exceed DMEGs for both lead and zinc. This indicates that heavy metals emissions from municipal incinerators cannot be dismissed as being inconsequential, and must, in fact, be addressed in greater detail.

It is known that considerable dilution of the stack plume occurs because of the effects of temperature, wind speed and atmospheric stability. Because our concern with heavy metal emissions is in terms of ground level concentrations, where they may be inhaled by the general populace, and not stack concentrations, we need to quantify the amount of dilution that occurs.

Estimates of ground level pollutant concentrations produced by emissions from one or more stationary sources are commonly made in air pollution control. Typically, a mathematical dispersion model is used to relate source emission characteristics to local meteorology to predict the maximum ground level pollutant concentration. Many dispersion models exist. For this study, the CRSTER model was used because it predicts the effects of one source's emissions on ground level concentrations. Meteorological data were obtained from the Newark Airport in New Jersey for the year 1964. This year was used since it is the most recent calendar year for which comprehensive hourly meteorological data is available for all monitoring sites throughout the nation. Therefore, it has become the base year from which hourly air quality estimates are made. Finally, "representative" incinerator stack characteristics were selected for both large-scale and small-scale incinerators. These characteristics were based on actual incinerators of the type and size that may be ultimately installed in New Jersey. The Chicago northwest incinerator was used as a model for the "typical" urban, large-scale incinerator, while the modular incineration system installed in Siloam Springs, Arkansas was chosen to represent a system that may be typically installed in the more rural areas of the state.

The Chicago northwest incinerator is a 1600-ton-per-day facility that encompasses four separate waterwall furnaces. Each furnace is linked with a boiler and an economizer for the recovery of heat in the form of steam. The emissions from each furnace are controlled by electrostatic precipitators, and two identical smokestacks, each connected to a set of precipitators, is used to vent the exhaust gases to the atmosphere. Each stack is 250 feet tall, with a 15 foot exit diameter. The exhaust gas temperature is 400°F and the gas exit velocity is 12.8 feet per second. These data, together with the emissions data presented in Table 11 provided the source input characteristics required by the dispersion model. Ambient concentrations from actual facilities will vary due to differences in stack heights (150-300 ft) and other factors.

The Siloam Springs incineration system is rated at 21 tons of waste per day. The system serves a total population of approximately 8000 and consists of two 10.5 ton per day modular, controlled air incinerators. The incinerators use an automatic loading system and are connected to waste heat recovery boilers. Exhaust gases exit to the atmosphere through individual smokestacks which measure 50 feet in height by 2.2 feet in diameter. The stack gas exit velocity is 36.4 feet per second. Due to the high rate of thermal efficiency obtained by the heat recovery boilers, the stack gases have a relatively low exit temperature of 275°F. These data, together with the heavy metal emission rates presented in Table 12, were used to establish the source characteristics required by the dispersion model.

Note that representative stack conditions were selected to enable us to compare relative concentrations of each of the eight heavy metals of concern. Using stack characteristics that differ from those listed will lead to different ground level concentration predictions. Specifically, facilities with stack heights lower than those used for our "representative" examples, or those with stack gases with lower exit temperatures than those used, may cause higher ground level concentrations than predicted. Airport restrictions may require lower stack heights in some cases. Consequently, the emissions from

The proposed incinerator must be modeled with the site specific stack and exhaust gas characteristics in order to determine estimated ground level pollutant concentrations, before state approval can be granted.

Except for lead, there are no regulatory guidelines on the maximum ambient (ground level) concentrtions of the eight heavy metals under investigation. A quarterly (3-month) ambient air quality standard of 1.5 µg/m^3 (1500 ng/m^3) currently exists for lead, and this standard can be used as a basis of comparison for lead levels attributed to municipal incinerators. For the other metals, research goals, referred to as ambient multimedia environmental goals (AMEGs) do exist. These values which are annual air quality goals, are presented in Tables 12 and 13 for the heavy metals under consideration. Volume II of this three-part incineration study presents a detailed description of AMEGs.

The results of the dispersion modeling analysis of heavy metals is presented in Table 11 for large-scale incinerators, and in Table 12 for small-scale units. Predicted maximum ambient concentrations are presented for the actual and normalized emission rates for three separate averaging periods: 1 hour, 24 hour and annual average. Due to the natural hourly variations in wind speed, wind direction and atmospheric conditions which affect exhaust gas dispersion, the predicted maximum annual pollutant concentrations are always less than predicted 24-hour concentrations which, in turn, are less than predicted hourly values. The estimated maximum annual concentrations serve as the basis of comparison for the AMEGs, while the 24-hour, and hourly estimates are presented to provide additional information.

Comparing the heavy metal emission estimates for large incinerators on Table 11 with the AMEGs, we note that in all cases, except one, the predicted ambient levels are less than 5 percent of the maximum guideline values. The one exception is lead. When actual and not normalized stack emissions are used to predict ambient lead concentrations, the resulting estimate is approximately 12 percent of the AMEG which corresponds to the quarterly lead standard. Arsenic concentrations, using actual emissions, amounts to 2 percent of its AMEG, while all of the other heavy metals studied do not exceed 1 percent of the applicable AMEG. If normalized incinerator emissions are used to predict ambient metal concentrations, the estimated levels are all lower than 1 percent of the AMEG, with the exception of lead, which amounted to 2.4 percent of the annual lead AMEG.

An examination of small scale incinerator data from Table 12, shows similar results. Using actual emission data, the predicted ambient concentrations are in all cases except lead, less than 1 percent of the AMEG. The predicted ambient level for lead is 6.1 percent of the annual AMEG which is derived from the lead quarterly NAAQS. When normalized emission data are used, the results are similar Lead, at 2 percent of its AMEG, has the highest relative concentration, followed by the other metals at from 0.002 to 0.2 percent of their respective AMEGs.

In general, the predicted annual concentrations presented in Tables 11 and 12 do not appear to present a significant environmental problem. While stack emission concentrations exceed conservative regulatory guidelines for virtually all metals, these concentrations will be significantly diluted by the time they reach ground level. However these ambient metals estimates are based on a "representative" facility emissions. An incineration system which emits proportionately more metals, uses a smaller stack, has a lower stack temperature or is located in an area with atypical plume dispersion characteristics, may cause ground level metals concentrations higher than those estimated. Individual facility dispersion modeling should be conducted on every new incinerator facility to quantify the specific air pollution affects of each new incinerator. This modeling, at a minimum, should address lead emissions, since there is an ambient air quality standard for lead and because lead emissions from municipal incinerators are consistently the greatest with respect to regulatory ambient air quality guidelines. Note that the increase in annual ambient metals concentrations are similar because the higher emissions from large incinerators are offset by higher stacks.

The affect of predicted heavy metal concentrations from municipal incinerators on ambient air quality can be placed in perspective by examining existing ambient air background levels for these substances. Typical background concentrations for northern New Jersey, standard urban and rural areas and sites located near industrial emitters of the specific metal are presented in Table 13. In addition, the predicted annual average concentration for each metal, as determined for large scale incinerators, and as presented in Table 11, is also given. As the annual increase in ambient metals concentration for large scale incinerators were generally slightly greater than those for small scale units, the large scale data is used as a "worst case" for the purpose of comparison. Finally, ambient goals for each of the metals is presented in Table 12 as well.

An examination of the data presented in Table 13 indicates several facts. The concentration of arsenic is essentially the same as the ambient goal. Concentrations of the other metals range from 2 to 42 percent of the respective goals. When compared to background concentrations at other urban sites, the northern New Jersey levels are lower, at times an order of magnitude lower, than these other sites. The only exception appears to be zinc, with a New Jersey concentration which is double that of other urban sites. Rural areas have lower ambient metal concentrations across the board, when compared to urban and northern New Jersey levels. "Other" monitoring sites, those located near industrial facilities with large emissions of the metal in question, have recorded metals concentrations which may, by far, exceed the applicable ambient goal.

The addition of one "representative" large municipal incinerator to the existing northern New Jersey environment would appear at a maximum to increase the existing ambient heavy metals levels by from 2 to 13 percent, depending on the metal in question. This may be inconsequential for certain metals, such as copper or zinc, whose current ambient levels are far below the ambient goal. However, this additional source of arsenic ($\mu g/m^3$) may be of concern

TABLE 13. SUMMARY OF HEAVY METALS AMBIENT AIR QUALITY DATA

Element	Northeastern New Jersey concentrations in air (ng/m^3)	Background concentrations in air[a] (ng/m^3)			Average annual concentration[b] (ng/m^3)		Annual ambient goal (ng/m^3)
		Urban	Rural	Other[c]	Actual	Normalized	
Arsenic	5[d]	-	0.4	30	0.1	0.03	4.7
Cadmium	7[e]	50	3	500	0.8	0.2	120
Chromium	15[e]	20	2	-	0.5	0.1	120
Copper	200[e]	257	10	1-2000	2.5	0.4	480
Mercury	2.9[e]				0.09	0.02	120
Nickel	2.5[e]	25	6	-	0.2	0.04	36
Lead	1,200[e]				43.8	8.5	1,500
Zinc	480[e]	200	13	-	62.4	13.1	9,500

[a] Volume 1 of this study.

[b] Average increase in annual maximum concentration due to large incinerator.

[c] Reported air concentrations in proximity of industrial sources of trace metal.

[d] Reference 70.

[e] Reference 71.

because it would appear to increase an existing high ambient concentration (μg/m^3). Further evaluation of arsenic may be appropriate. The existing ambient monitoring data could be evaluated and, if needed, additional data could be collected. Additional investigation of an appropriate ambient goal appears to be appropriate. In addition, dispersion modelling of actual emission sources could be performed.

Snould additional control of metal emissions be required as a result of dispersion modeling analysis, then several regulatory options are available. Higher stacks and better dispersion may be feasible in some areas. A total particulate emission limitation might be set, at a more stringent level, for example, of 0.03 gr/dscf at 12 percent CO_2. By lowering the total allowable particulate emisiion rate, a reduction in heavy metals emissions would also be accomplished. As an alternative, the type of wastes accepted for incineration may be selectively restricted. For example, ferrous metals recovery might be required as a pretreatment step in order to minimize these emissions, or a prohibition on the incineration of magazines might be imposed to minimize the emission of lead and other metals contained on the paper of these publications. Imposition of these types of additional controls can only be made after an investigation into the local source(s) of the metal in question, the economic cost of such pretreatment, and the difficulty in enforcing these regulations.

ACID GASES

Gaseous emission standards do not currently exist for municipal incinerators at the Federal or state level. Several researchers[28,34] have indicated that such standrds may be needed in the future, but they have neither indicated the specific gaseous species nor the emission concentration that should be regulated. In Europe and Japan, two areas with a high population density and concurrent high polluant emission density, acid gas emissions from new municipal incinerators are controlled. These emission standards were presented in Table 9. Typical uncontrolled emission rates for these gases were presented in Table 10. Uncontrolled hydrogen chloride emissions from European incinerators, as reported in Table 10, averaged 1232 mg/Nm^3 at 12 percent CO_2, while a typical Japanese HCl emission rate, for the Yokohama municipal incinerator, was reported to be approximately 750 mg/Nm^3.[65] Both of these rates are substantially higher than HCl emissions from dry control, American units, which averaged 354 mg/m^3 at 12% CO_2. Based on the average European emission rate, the standards used in Table 9 are equivalent to gaseous control efficiencies ranging from virtually zero (in Denmark) to greater than 95 percent (in Sweden).

New Jersey does not now have a major municipal incinerator gaseous emissions problem because there are no large-scale incinerators in operation at the present time, and the few small scale units are widely dispersed. However, with the expected rise in incineration capacity, the quantities of gaseous emissions emitted to the atmosphere and the impact of these polluants on the populace will rise substantially. Large scale municipal incinerators can be expected to locate near the major population centers. In New Jersey, with its high population density, a large proportion of the population potentially may be exposed to the corrosive effects of acid gas emissions, if these emissions remain uncontrolled. In addition, the entire northeastern section of the United States is being adversely affected by acid rain. Gaseous pollutant emissions from power plants and industrial sources in the midwest are carried east by prevailing weather patterns and are deposited by rainfall in the lakes and streams of the Mid-Atlantic and New England States. This acid rainfall is believed to have affected hundreds of lakes in the Adirondack Mountains of New York State alone. To minimize the contributions of municipal incinerators to this regional problem and to protect the general population from the localized effects of gaseous pollutant emissions, the control of gaseous incinerator emissions is recommended.

The extent of gaseous emisssions on ambient pollutant levels can be quantified by an analysis similar to the one conducted for heavy metals. Gaseous pollutant data was presented for large scale incinerators on Table 11, and for small scale units on Table 12. These emission rates were first compared to a stringent acid gas emission standard, the West German standards. For both large and small incinerators, actual emissions exceeded these standards for hydrogen chloride and hydrogen fluoride, but not for sulfur oxides. A similar emission limit does not exist for nitrogen oxides. HCl and HF emissions therefore cannot be assumed to be sufficiently diluted and additional dispersion modeling analysis of these pollutants is required to quantify expected ground level concentrations. The same atmospheric dispersion model and meteorological conditions that were used to quantify heavy metal concentrations was used for the gaseous emissions analysis, and the modeling results are included in Tables 11 and 12. In addition, the ambient multimedia environmental goals for these gaseous polluants are also listed in Tables 11 and 12.

Comparing the predicted annual concentrations for the acid gases with the AMEGs, we note that none of the AMEGs is exceeded. Hydrogen chloride levels are the highest for both sizes of incinerators. Predicted HCl concentrations are 2.4 percent of the AMEG for large scale units and 12 percent of the AMEG for small scale incinerators. The predicted ambient concentrations of the other gaseous pollutants are less than 1 percent of the AMEG in every case. Thus, the worst case gaseous emission, HCl, is equivalent to the worst case heavy metal, lead, in terms of the relative impact of one facility on the ambient goal.

Emission levels that are achievable with commercially available technology include 50 ppm (80 mg/Nm^3 at 12 percent CO_2) for hydrogen chloride, 3 ppm (2.5 mg/Nm^3 at 12 percent CO_2) for hydrogen fluoride and 150 ppm (395 mg/Nm^3 at 12 percent CO_2) for sulfur oxides. No emission standard has been proposed for the combustible gaseous emissions from municipal incinerators, including carbon monoxide, hydrocarbons, organic acids and aldehydes. These substances will be minimized if an oxidizing atmosphere is maintained in the incinerator furnace and the overall combustion efficiency of the unit is high. Good combustion efficiency can generally be insured through the imposition of a strict particulate emission standard, such as the 0.05 gr/dscf at 12 percent CO_2 level recommended in this study, since combustible particulate and therefore total particulate formation is minimized when there is sufficient oxygen available for the complete combustion of all waste components. The imposition of a set of emission standards for combustibles gases would therefore be somewhat redundant. Should doubts exist on the overasll combustion efficiency and/or the combustible gaseous emission rate of a specific incineration facility, a site specific requirement for a continuous in-stack carbon monoxide or oxygen analyzer might be adopted to verify the existence (or lack thereof) of an oxidizing atmosphere.

Table 2 reports values for the sulfur content of mixed municipal refuse, ranging from 0.1 to 0.35 percent with an average of 0.15 to 0.20 percent. Therefore, municipal refuse can be considered a low sulfur fuel, when compared to most residual oil and coal.[9] Uncontrolled stack gas concentrtions of sulfur dioxide are in the range of 100-350 ppm.[9] Compared to other stationary source categories, municipal incinerators are not a major source of sulfur dioxide emissions. The achievable level cited of 150 ppm may be obtained without additional pollution control equipment, depending on the nature of the specific refuse being incinerated. In addition, the limited emission test data that are available (Table 5) indicate that five of the six incinerators tested had emission values less than this level, regardless of the type of control equipment used. Finally, some sulfur dioxide will be removed from the incinerator flue gases by the control devices installed for hydrogen chloride control. The control of sulfur dioxide emissions to the level indicated should therefore not be a major problem.

For the purpose of emission control, hydrogen chloride and hydrogen fluoride will be considered together. They have similar sources in municipal refuse and have nearly identical control characteristics (i.e., relative absorption rates). Uncontrolled emission rates for HCl and HF from all sizes of municipal incinerators range from 158 to 884 mg/Nm^3 at 12 percent CO_2 (100-550 ppm) for HCl[8,56] and 2.7 to 13.4 mg/Nm^3 at 12 percent CO_2 (3-15 ppm) for HF.[8] These concentrations are expected to increase as the refuse plastics content increases. As indicated in Table 1, the plastics category of municipal waste is projected to grow by from 50 to 70 percent between 1980 and the year 2000.

The average HCl emission rate of American units reported in Table 10 was 400 mg/Nm^3 at 12 percent CO_2, or 250 ppm. Based on this figure, a control efficiency of 80 percent would be required to achieve the recommended 50 ppm level. Should the incinerator stack gas HCl concentration increase at an annual rate proportional to the projected increase in refuse plastics content, then the average uncontrolled HCl emission rate would be approximately 425 ppm by the year 2000. A control device efficiency of 88 percent would be required to bring this level down to 50 ppm. These levels are achievable with commercially available technology. Both HCl and HF are readily absorbed in water. Theoretical studies indicate that a maximum control efficiency of nearly 100 percent for HCl and 97 percent for HF is possible using single equilibrium contact stage scrubbers.[8] Although actual scrubber performance can only approach theoretical maximum levels, these studies indicate that there are no theoretical limitations to maximum capture efficiency for HCl. This is especially important if waste content predictions for the year 2000 come true, and increasingly greater HCl control is required.

HCl and HF control technology is available. This technology has been used almost exclusively in the control of gaseous emissions from chemical waste incineration. There is no reason to believe that it cannot be used for municipal incinerator acid gas control as well. Both wet and dry systems are available. Care must be taken, however, in designing these systems. Uncontrolled emission levels are increasing; barring any change in this trend, a control device that achieves the required emission levels today may not be efficient enough tomorrow. Community waste disposal practices must be thoroughly known so that the incineration system designer can plan for expected changes in refuse composition and uncontrolled emission rates. A system can then be designed for installation today that will meet future control requirements.

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