United States
Environmental Protection
Agency

Hazardous Waste Engineering Research
Laboratory
Cincinnati OH 45268

Research and Development

EPA/600/S2-85/049 June 1985

EPA

Project Summary

Innovative Thermal Hazardous Waste Treatment Processes

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The full report contains discussions of 21 thermal processes identified by the U.S. Environmental Protection Agency (EPA) as innovative processes for treating or destroying hazardous organic wastes. The subject processes were identified through two national solicitations for innovative processes and several extensive literature surveys.

Information about the subject processes was provided voluntarily by the process developers. The criteria used for selection of a process for the report included the innovativeness of the process when compared with conventional existing processes and the potential contribution the process could make to the evolving field of hazardous waste management technology.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Background

The full report contains discussion of 21 thermal processes identified by the U.S. Environmental Protection Agency (EPA) as innovative processes for treating or destroying hazardous organic wastes. The subject processes were chosen through two national solicitations for innovative processes and several extensive literature surveys. The project also produced much of the information for the alternative technologies section of a 1984 EPA report on issues related to ocean incineration.

While the processes included in the full report differ widely in many respects (i.e., waste streams for which they are designed and state of development), they are similar in that they offer innovative approaches to solving problems presented by the generation of hazardous wastes. The reader is cautioned to understand that, while some of these processes have been evaluated by third parties, independent testing of these processes, especially tests under the guidance of the EPA, are the exception rather than the rule. However, all of the processes are considered at least promising. Some of the included processes might be regarded as emerging technologies. Others are in commercial operation and are already well beyond any such categorization as emerging technology.

Information provided in the full report is intended to assist in the evaluation of the processes by researchers and others interested in alternative processes for treating and disposing of hazardous wastes. The inclusion of a process should in no way be considered an endorsement of the process by the EPA. The reader is encouraged to contact the organizations for more information.

No project such as this one can include all innovative processes. A process not being included should not be interpreted as a negative evaluation of that process. It is the Agency's intention to publish other compilations such as this one periodically. Those individuals wishing to have their process included should contact the Alternative Technologies Division, Hazardous Waste Engineering Research Laboratory.

A summary of the included processes is contained in Table 1. A compilation of expressed advantages and potential limitations for the subject processes is shown in Table 2.

Table 1. *Process Summary*

Process Name	Description	Waste Streams	State of Development	Test Data Available	Cost Data Available	Contact
Wet Oxidation Processes:						
Zimpro Wet Air Oxidation	*Uses elevated temperature and pressure to oxidize organics in water*	*Aqueous streams with less than 5% organics*	*C*	*A*	*1*	*William Copa Zimpro, Inc. Military Road Rothchild, WI 54474 (715) 359-7211*
IT Catalyzed Wet Oxidation	*Uses selected catalysts and elevated temperature and pressure to oxidize organics*	*Aqueous waste stream with suspended organics*	*B*	*D*	*3*	*IT Enviroscience, Inc. 9041 Executive Park Drive Knoxville, TN 37923 (615) 690-3211*
MODAR Supercritical Fluid Oxidation	*Uses high temperatures and very high pressure to oxidize organic contaminants in water*	*Aqueous slurries or organic solutions*	*P*	*D*	*3*	*MODAR, Inc. 14 Tech Circle Natick, MA 01760 (617) 655-7741*
Methods Engineering High Temperature Wet Oxidation	*Uses long vertical underground tubular reactor to oxidize suspended organics in water*	*Liquids or sludges*	*Co*	*NA*	*3*	*Methods Engineering, Inc. P. O. Box 282 Angleton, TX 77515 (713) 331-7268*
Chemical Transportation Processes:						
Battelle Northwest Aqueous Phase Alkaline Destruction of Halogenated Organics	*Converts halogenated organics into an oil using mild alkali under pressure*	*Halogenated liquids and granular solids*	*B*	*D*	*NA*	*Battelle Pacific Northwest Laboratories P. O. Box 999 Richland, WA 99352 (509) 375-2927*
GARD Catalytic Dehalogenation of Hazardous Wastes	*Dehalogenizes compounds by replacing halogen atom with hydrogen atom*	*Liquids with high concentration of halogen compounds*	*B*	*D*	*3*	*Chamberlain National GARD Division 7501 N. Natchez Avenue Niles, IL 60648 (312) 647-9000*
Battelle Northwest Joule Heated Glass Melter	*Applies electric current directly to waste material for combustion and for creation of a glass matrix*	*Soils and other granular mineral matter*	*P*	*NA*	*NA*	*Battelle Pacific Northwest Laboratories P. O. Box 999 Richland, WA 99352 (509) 375-2927*
Molten Glass Process:						
Penberthy Electromelt Pyro Converter	*Uses a bed of molten glass to oxidize organics and to capture ash and inroganics*	*Any liquid or solid waste stream*	*C**	*NA*	*2*	*Penberthy Electromelt International, Inc. 631 South 96th Street Seattle, WA 98108 (206) 762-4244*
Fluidized Bed Incineration:						
Battelle Columbus Multisolid Fluidized Bed	*Uses a moving bed of heated inert material to incinerate wastes*	*Granular solids, sludges, slurries, liquid and gases*	*C**	*NA*	*NA*	*Battelle Memorial Institute 505 King Avenue Columbus, OH 43201 Attention: Jack Conner*
GA Technologies Circulating Bed Waste Incineration	*Uses a circulating mass of heated inert material to incinerate waste materials*	*Solids, sludges, and liquids*	*C*	*A, B*	*1*	*William Rickman GA Technologies P. O. Box 85608 San Diego, CA 92138 (619) 455-3860*
Waste-Tech Services Low Temperature Fluid Bed	*Uses granular combustion catalyst and limestone in a fluid bed*	*Liquids, sludges, slurries, or soils*	*C*	*C*	*2*	*Waste-Tech Services, Inc. P. O. Box 736 Idaho Falls, ID 83402 (208) 522-0850*

Table 1. *(continued)*

Process Name	Description	Waste Streams	State of Development	Test Data Available	Cost Data Available	Contact
Pyrolysis Processes:						
Midland Ross Pyrolytic Decomposition	Heats waste materials in the absence of oxygen to drive off volatiles for incineration or recovery	Viscous liquids, sludges, and high ash materials	C	A	NA	Midland-Ross Corporation Energy Technology Division 900 N. Westwood P. O. Box 985 Toledo, OH 43696 (419) 537-6444
Russell and Axon High Temperature Pyrolysis with Oxygen	Uses oxygen induced high temperature to pyrolyze water	Solids and liquids	C*	NA	2	Russell and Axon 319 N. Fourth Street Suite 700 St. Louis, MO 63102-2774 (314) 231-9693
Molten Salt:						
Rockwell International Molten Salt Destruction	Uses a bed of molten sodium carbonate to destroy wastes and scrub acid gases	Low ash, low water content, solid or liquid wastes	P	A	NA	Rockwell International Environmental and Energy Systems Division 8900 De Soto Avenue Canoga Park, CA 91304 (213) 700-8200
Advanced Incinerators:						
Industronics Consertherm Rotary Kiln	A modular controlled air incinerator	Liquids, sludges, or solids	C	B	1	Industronics, Inc. 489 Sullivan Avenue P. O. Box G South Windsor, CT 06074-0956 (203) 289-1551
PEDCo Technology Fast Rotary Reactor	A rapidly rotating cylinder utilizing dryer technology for waste incineration	Solids or sludges	P	C	NA	PEDCo Technology Corporation 11499 Chester Road Cincinnati, OH 45246-1000
IGT "Cyclin" Cyclone Incinerator	A cylindrical shaped combustion chamber provides for intensive mixing of fuel and air	Gases or atomized liquids	C	C	1	Institute of Gas Technology 3424 South State Street Chicago, IL 60616 (312) 567-3650
Electric Reactors:						
Thagard High Temperature Fluid Wall Reactor	Uses electrically induced radiant heat to pyrolyze organic contaminants	Granular solids	C	A	2	Thagard Research Corporation 3303 Harbor Boulevard Suite F-4 Costa Mesa, CA 92626
Huber Advanced Electric Reactor	Uses electrical heat to pyrolyze organic materials at extremely high temperatures	Finely ground solids	C	A	1	J. M. Huber Construction P. O. Box 2831 Borger, TX 79007 (806) 274-6331
Plasma Systems:						
Pyrolysis Systems Pyroplasma	Uses plasma arc device to create extremely high temperatures for waste destruction	Highly toxic liquids	P	C	2	Pyrolysis Systems, Inc. 4935 Kent Street Niagara Falls, Ontario L2H 1J6 Contact: Mr. Ian Thom

Table 1. (continued)

Process Name	Description	Waste Streams	State of Development	Test Data Available	Cost Data Available	Contact
Applied Energetics Plasma Temperature Incinerator	*Burns waste in a pressurized stream of preheated oxygen*	*Liquids and fluidized solid waste*	*P*	*C*	*2*	*Applied Energetics, Inc. P. O. Box 1177 Tullahoma, TN 37388 (615) 455-0631 Contact: Dr. John B. Dicks*

State of Development
C - Commercially available
C - Commercially available for other than hazardous wastes*
P - Pilot scale
B - Lab and bench scale
Co - Conceptual

Test Data Available
A - Sponsored by EPA or other third party
B - Company sponsored tests
C - Company sponsored pilot-scale tests
D - Company sponsored bench-scale tests
NA - Not Available

Cost Data Available
1 - Based on commercial scale operation
2 - Estimates based on pilot-scale operation
3 - Estimates based on bench-scale operation
NA - Not Available

Table 2. Summary Comments on Processes

Process	Expressed Advantages	Potential Limitations
Zimpro Wet Air Oxidation	*1. Thermally self-sustaining at relatively low organic concentrations 2. Attractive option for dilute toxic waste streams 3. Products of oxidation stay in liquid phase*	*1. Generally limited to aqueous stream containing nonhalogenated contaminants 2. Not appropriate for solids and very viscous liquids*
IT Catalyzed Wet Air Oxidation	*1. Catalysts lower oxidation temperatures 2. Catalysts increase the rate of reaction 3 More refractory compounds may be oxidized*	*1. Addition of catalysts increases costs of process 2. Process best used on a select type of waste, i.e., moderate strength aqueous wastes having high toxicity 3. Process is yet to be demonstrated at pilot scale*
MODAR Supercritical Fluid Oxidation	*1. Rapid oxidation rates and very short residence times 2. Complete oxidation of organic eliminating need for offgas processing 3. Very efficient removal of inorganic constituents*	*1. High pressures necessitate sophisticated equipment and operational techniques 2. A continuously operating unit has yet to be demonstrated*
Methods Engineering High Temperature Wet Oxidation	*1. Pressures are contained by standard tubing 2. Mild steel can be used 3. Process accommodates a wide range of concentrations and flow rates*	*1. The process is still in the conceptual stage 2. Corrosion and fouling of equipment may reduce capacities 3. Permitting of an underground reactor could present problems*
Battelle Northwest Aqueous Phase Alkaline Destruction of Halogenated Organics	*1. Energy recovery in converted oil 2. Reducing conditions minimize oxidative formation of dioxin 3. Based on standard industrial technology*	*1. Relatively low temperatures may not be sufficient for halogenated wastes 2. Potential suitable waste materials may not be many 3. Interim and supplementary products of the reaction could be more hazardous than original waste stream*

Table 2. *(continued)*

Process	Expressed Advantages	Potential Limitations
GARD Catalytic Dehalogenation of Hazardous Wastes	1. Process retains economic value of materials while rendering them harmless 2. Mild operating conditions, uncomplicated equipment 3. Easily transportable equipment	1. Process has not been demonstrated beyond a bench scale
Battelle Northwest Joule Heated Glass Melter	1. Excellent residuals incorporation into glass matrix 2. High retention of heavy metals	1. Electrical energy source may be costly 2. Secondary combustion of offgas may be required
Penberthy Electromelt Pyro Converter	1. Significant volume reductions 2. Residual product is fully stable glass 3. Based on existing glassmaking technology	1. Does not appear appropriate for soils and high ash material 2. Offgas treatment will probably be required 3. Technology is unfamiliar to hazardous waste treatment industry
Battelle Columbus Multisolid Fluidized Bed	1. Safe and economical disposal of waste materials 2. Energy recovery 3. Minimum fuel preparation	1. Temperature excursions may deteriorate the bed 2. May not be suitable for solids incineration
GA Technologies Circulating Bed Waste Incineration	1. Low temperature eliminates ash agglomerization and NO_x emissions 2. Complete combustion to minimize organic emissions 3. Minimal downstream emissions control required	1. Low temperature may limit the process to less refractory waste streams
Waste-Tech Services Low Temperature Fluid Bed	1. Can effectively handle contaminated soil	1. Effectiveness may be reduced through catalyst removal 2. Extended demonstration is needed
Midland Ross Pyrolytic Decomposition	1. Salts and metals are not liquified or vaporized 2. Reduced particulate emissions 3. Process tends to tie up leachable metals and salt in residue	1. The process appears best suited to a relatively homogeneous waste stream 2. Interim possible hazardous byproducts should be assessed
Russell and Axon High Temperature Pyrolysis with Oxygen	1. Ultra high temperatures 2. Long residence time 3. No fugitive emissions	1. Use of oxygen increases the cost substantially 2. Generally requires cocombustion with a solid material
Rockwell International Molten Salt Destruction	1. Process destroys waste materials without NO_x emissions 2. Halogens are retained in the salt bed.	1. Process is limited to low ash, low water content waste 2. Molten salt can be very corrosive
Industronics Consertherm Rotary Kiln Oxidizer	1. Rugged dependable construction 2. Capability of cofeeding liquids, sludges, and solids 3. High turndown ratios	1. Extended demonstration with hazardous wastes is needed
PEDCo Technology Fast Rotary Reactor	1. Reliability and dependability 2. High thermal efficiency 3. Handles wide variety in feed rate	1. Extended demonstration with hazardous wastes is needed
IGT "Cyclin" Cyclone Incinerator	1. Stable and energy efficient combustion 2. Small combustion volume 3. Low temperature combustion	1. Extended demonstration with hazardous wastes is needed
Thagard High Temperature Fluid Wall	1. Reduced residence times 2. Complete destruction of waste materials by virtue of high temperatures 3. Production of medium-Btu combustible gas	1. Input solids must be ground extremely finely

Table 2. (continued)

Process	Expressed Advantages	Potential Limitations
Huber Advanced Electric Reactor	1. *Process is very transportable* 2. *Extremely high treatment efficiencies* 3. *Essentially no stack or fugitive emissions*	1. *Input solids must be ground extremely finely*
Pyrolysis Systems Pyroplasma	1 *Process can handle highly toxic and refractory compounds* 2 *Scale of equipment is small* 3. *ON/OFF time cycle of only a few minutes*	1 *Limited to liquids* 2. *Demonstration of continued operation is needed*
Applied Energetics Plasma Temperature Incineration	1. *Process is contained in a very compact unit* 2. *Combustion reaction increases under these conditions*	1 *Limited primarily to liquids* 2. *Demonstration of continuous operation is needed*

As the United States continues to support the conversion of hazardous waste processes from those based on land disposal to those based on alternative technologies, the processes such as the one reviewed in the full report will become more common. This encouraging technology development should further the day when hazardous waste management and disposal is not a problem.

Summary

The processes can be placed into the following generic categories:

Wet Oxidation—processes for oxidizing suspended and dissolved organics in aqueous waste streams that are too dilute to incinerate economically, yet too toxic to treat biologically. By confining the oxidation to the aqueous medium, wet oxidation does not produce the type or quantity of emissions produced by typical incinerators. The wet oxidation process using the feature of supercritical water is especially innovative in that effective separation of inorganics from the waste stream can be realized in addition to complete oxidation of organics. Wet oxidation does not work as well on chlorinated organics as on many nonchlorinated organics. However, wet oxidation has been used in experimental work to break down chlorinated materials into less hazardous compounds. In general, it is a very promising alternative technology for a common hazardous waste stream, i.e., aqueous wastes containing nonchlorinated toxic organics.

Chemical Transformation—processes that transform the waste streams into other less toxic substances primarily through chemical reactions. These processes are important in that they are examples of technology to encourage resource recovery rather than destruction of wastes. As treatment processes become more the norm than landfills or even than incineration, chemical transformation processes will occupy a much larger segment of the waste management picture. This is especially true for those chemical processes that produce useful materials. Currently, these processes have difficulty competing with conventional disposal methods. However, as disposal costs rise, chemical processes such as the ones discussed in the full report will become increasingly attractive.

Molten Glass—processes that use a pool of molten glass as the heat transfer mechanism to destroy organics. The attractiveness of molten glass is based upon the extremely good quality of the residue from the process, i.e., essentially nonleachable glass. The combustion conditions for organics appear to be at least as good as those present in hazardous waste incinerators, and the inorganic residue and ash is incorporated into the glass. Introduction of this type of technology into the waste management industry, especially for highly toxic organic streams containing toxic metals, could prove very attractive if it can be shown through extraction tests that the residue is nonleachable and may be delisted as a hazardous waste.

Fluidized Bed Incineration—thermal processes using a very turbulent bed of inert granular material to improve the transfer of heat to the waste streams to be incinerated. Advantages of fluidized bed incinerators include their relatively compact design, their relative simplicity of operation, and their ability for combining combustion with pollution control by trapping some gases in the bed. Although fluidized beds have been used for many years in various industries, their use in hazardous waste incineration is still at a demonstration level. It is generally agreed, however, that this approach to waste incineration offers significant potential for the future.

Pyrolysis—processes that break down waste materials into less complex materials through the application of heat in the absence of oxygen. Pyroconversion units are typically custom designed to process specific types of chemicals rather than as multipurpose waste processing units. Consequently, their use as multipurpose hazardous waste treatment facilities has been very limited. However, one of the pyrolysis processes discussed in the full report would be suitable for use as a multipurpose waste processing unit. Advantages of pyrolysis processes are that there is a potential for byproduct recovery, that sludge volumes may be reduced without large amounts of supplementary fuel being used, and that air emissions are usually less for conventional incinerators.

Molten Salt—a process in which waste material is injected beneath a bed of molten sodium carbonate for incineration. The process is innovative in that the use of the molten bed requires lower temperatures for waste combustion. Also, the bed acts as a very effective scrubbing medium for acid gases.

Advanced Incinerators—processes that incorporate improvements over conventional incinerators but which maintain the essential principles of conventional incinerators. The full report contains three such systems—a liquid injection system incorporating fuel feed to promote extremely intensive mixing and two systems using rotary kilns. These systems illustrate the improvements being made in conventional incinerator designs.

Electric Reactor—processes that pyrolyze waste contaminants from particles such as soil through use of an electrically heated fluid wall reactor. These units have been used successfully in other chemical processes and are just beginning to be adopted for waste destruction. The units, especially the portable versions of the processes, appear to offer a very different and potentially valuable thermal option for hazardous waste treatment.

Plasma Systems—processes that use the extremely high temperature of plasma to destroy waste materials. The plasma systems offer a very innovative approach to destroying highly toxic chemicals. Several systems have been researched. Two of these systems are discussed in the full report.

Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Environmental Protection Agency.

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The complete report, entitled "Innovative Thermal Hazardous Waste Treatment Processes," (Order No. PB 85-192 847/AS; Cost: $14.50, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

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☆U. S. GOVERNMENT PRINTING OFFICE: 1985/559-111/20609

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