HAZARDOUS WASTE INCINERATION:

ADVANCED TECHNOLOGY TO

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The purpose of this report is to inform both public officials and the interested public regarding high temperature incineration of hazardous and industrial wastes.

This report explains why such incineration is needed, how it works, how it is regulated and the controls, safeguards and practices utilized in incinerators to protect public health and the environment.

The report is organized into the following sections:

I THE NEED

In our society, most industrial processes produce waste which the U.S. Environmental Protection Agency (EPA), acting under the Resource Conservation and Recovery Act (RCRA), has determined can be detrimental to public health or the environment if not properly managed.

Hazardous wastes are generated, for example, in the production of cosmetics, pharmaceuticals, detergents, household paint and cleaning products, light bulbs, telephones, televisions, newspapers, garden pesticides, computers, chemicals, gasoline, and even automotive safety devices such as air bags.

Companies have made considerable strides in recent years to reduce or recycle hazardous wastes from their production processes. They have been encouraged to do so by public policies and by their own economic interests in reducing their cost of waste disposal. The high cost of incineration, relative to other forms of treatment or disposal, has been an incentive to reduce the generation of incinerable wastes.

Nevertheless, more than 200 million tons of hazardous wastes are now generated annually, and large amounts of hazardous waste will continue to be generated in the future even under optimistic but realistic expectations.

Moreover, many industrial wastes which are not yet defined as hazardous should be brought under hazardous waste regulation in the future. For example, there are over 30,000 government registered pesticides that contain toxic and hazardous constituents, of which fewer than 20 are regulated now as hazardous waste when discarded. Future federal regulations should define more of these and other wastes as hazardous, as many states presently do.

In light of the risk these unregulated wastes pose, many responsible companies presently send their non-regulated industrial wastes to commercial incineration facilities for safe and proper treatment.

Another major area of need for waste treatment and disposal is the clean up of contaminated sites. The country's worst environmental sites are listed in the National Priority List under the Superfund program. The toxic materials from these sites should be properly treated and disposed. As of September 30, 2000, of the 1,228 Superfund sites, over 757 have not completed construction of remedial actions. As many as 3,000 other contaminated sites will need to be addressed under the RCRA, through the corrective action program. A top priority in this country’s environmental program must be the clean up of problem sites that pose a risk to human health and the environment.

In order to treat these wastes, destruction in high temperature incinerators has been determined by EPA, after extensive expert and public review, to be the Best Demonstrated Available Technology (BDAT) for most organic hazardous wastes. This is because incineration safely and effectively destroys the hazardous constituents in the waste, as discussed in the subsequent sections of this report.

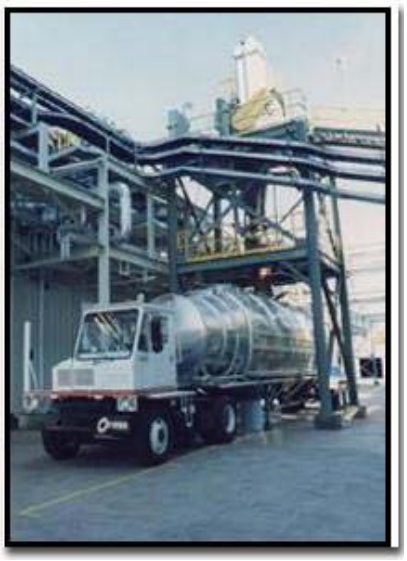
In the U.S., modern hazardous waste incineration is a widespread technology. Most hazardous waste incinerators (136 of a total of 164) are owned and operated by the factory or other facility that generates the waste, and are located on the generating site. Fewer than 30 incinerators that accept off-site generated wastes (i.e., "commercial" incinerators) serve small businesses and other generators who cannot effectively or economically incinerate their hazardous wastes on-site. Today, 95% of hazardous waste generators, including many small businesses, depend entirely on off-site facilities for management of all of their hazardous wastes.

In short, high temperature incineration will continue to play an important role in the future for the safe and effective treatment of much of the organic hazardous wastes that will continue to be generated by U.S. industry. It is also a necessary component, as noted above, of the clean up of organic wastes at thousands of existing Superfund and other remedial sites.

II HOW DOES A HAZARDOUS WASTE INCINERATOR WORK?

A typical hazardous waste incinerator, diagrammed below, consists of a rotary kiln (primary combustion chamber), an afterburner (secondary combustion chamber), connected to an air pollution control system, all of which are controlled and monitored.

Figure 1: Typical Hazardous Waste Incinerator



Rotary kilns Both solid and liquid wastes are introduced into the rotary kiln, in which the temperature is typically above 1800°F. Temperature is maintained at this level by using the heat content of the liquid wastes or by introducing supplemental fuels into the chamber, such as natural gas.

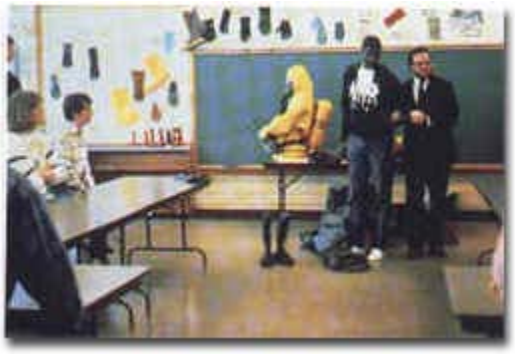
Liquid wastes generally are pumped into the kiln through nozzles, which atomize the liquids into fine droplets—as small as one microgram (one millionth of a gram)—for optimal combustion. Solid wastes may be fed into the kiln in bulk or in containers, using

either a conveyer or a gravity feed system.

The kiln slowly rotates so that the solid wastes are tumbled, to assure that they are exposed on all sides to the high temperature in the kiln, much as the rotation of a clothes dryer maximizes the exposure of the clothes to the hot air in the dryer. A large fan draws excess air (containing oxygen) into the system to increase combustion efficiency.

The flame and high temperature in the kiln cause the organic and some of the metal wastes to be converted from solids or liquids into hot gases. These hot gases pass into the afterburner. Any inorganic materials (metals, such as zinc or lead) that have not been converted into gases drop out as ash at the end of the kiln, into a container, for further management. (See "Residue Management," below).

Afterburner Atomized liquid wastes and/or supplemental fuel are injected into the afterburner, where temperatures are typically maintained at 2200°F. or higher. These atomized liquids and the hot gases entering the afterburner from the kiln are mixed with air and passed through the hot flame in the afterburner. The heat and flame break down the chemical bonds of the gaseous and atomized organic compounds into atoms. These atoms recombine with oxygen from the air in the chamber to form stable compounds primarily composed of non-hazardous chemicals such as carbon dioxide and water (i.e., steam).



Air pollution control system (APCS) The gases exiting the secondary chamber are cooled and cleaned in the APCS. The APCS removes particulates (small solid matter) and the remaining hazardous constituents—such as metals which were not destroyed by the incineration process—down to levels established as safe by the regulations and the facility's permits. These levels are already more stringent than the risk standards established by the Clean Air Act of 1990 for future controls of emissions from manufacturing processes. (Emission risks are discussed further in Section IV below.)

Controls and monitoring Operation within the key parameters of the combustion process are assured by systems of monitors and computer controls. These systems make automatic adjustments to key functions as necessary. For example, if temperatures begin to drop below desired levels, supplemental waste fuels are automatically injected. Conversely, if temperatures rise above the desired range, waste feeds are reduced.

All regulated incinerators have waste feed cut-offs (WFCOs) to assure protective operations. WFCOs automatically stop the feeding of waste into the incinerator if any of the key parameters even momentarily falls outside the narrow range of operating requirements.

There is also continuous monitoring and recording of key indicators, so that a permanent record is maintained, verifying operation of the incinerator within these parameters. Frequently, as many as twenty separate parameters are monitored and recorded.

Residue management The rotary kiln discharges an inorganic ash into a large container. The ash, and any residue from the APCS, is analyzed to assure that it does not contain any hazardous organic constituents above concentration levels specified in EPA's regulations as safe for land disposal. These concentration levels are almost always less than one part per million for any organic hazardous constituent.

This inorganic residue is further treated by mixing it with chemical stabilizers to chemically bind the constituents. The chemically stabilized inorganic residue is analyzed to assure that the metals cannot leach out of the residue above the low levels specified in EPA's rules. The facility retains the results of its analyses, and must certify that the residue meets all required treatment standards.

Finally, the stabilized and certified inorganic waste residue, which now meets all required treatment standards, is placed in a hazardous waste landfill meeting EPA's Minimum Technology Requirements (MTR). MTR landfills have two liners, with a leachate collection system between the two liners. Groundwater monitoring is also provided, outside the landfill, to supplement the protection provided by the double-liner, leachate collection and leak detection systems of the MTR landfill itself.

Conclusion Today's hazardous waste incinerators, operating under EPA and state regulations, are high-technology devices, carefully designed, controlled and maintained to assure (1) safe destruction of all hazardous organic constituents in the waste; (2) control of emissions to safe levels, generally substantially below those met by manufacturing and other industries; and (3) the proper treatment and safe disposal of any residues.

III HOW ARE HAZARDOUS WASTE INCINERATORS REGULATED?

Hazardous waste incinerators are regulated and permitted by EPA generally by state environmental regulatory agencies. The basic EPA regulations are set forth in Chapter 40 of the Code of Federal Regulations (CFR), Part 264, and are supplemented by the EPA technical and permit guidance.

Most states are "authorized" by EPA to administer these regulations, under EPA oversight. In order to be authorized, a state's regulation must be at least as stringent as the Federal regulations and they may be more stringent. Both EPA and the states enforce the regulations.

Part 264 has many provisions that apply to all hazardous waste management facilities, plus some that apply only to incinerators. The general provisions require such elements as

a worker training program, a facility inspection program, a waste analysis plan, an emergency prevention and response plan, and environmental liability insurance. The specific incineration requirements are contained in Subpart O of Part 264. The key requirements, discussed below, relate to:

Permits

Trial burns

Risk assessments

Destruction and Removal Efficiency (DRE)

Required operating parameters

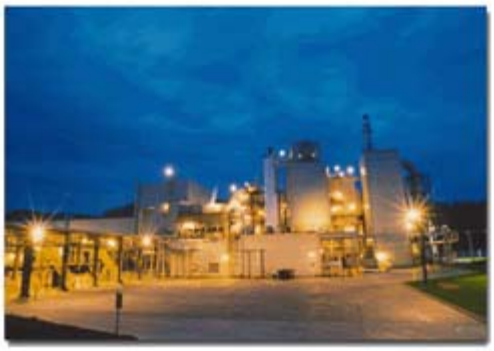
Waste feed cut-offs

Emission controls

Monitoring.

Permits All hazardous waste incinerators must obtain operating permits from EPA or an authorized state agency. To obtain a permit, as a first step the facility must submit a detailed, multi-volume permit application, providing detailed engineering and other data which specify how the incinerator is designed and how it will operate. The application must include a trial burn plan to evaluate the emissions from the process, and to demonstrate that the incinerator meets DRE. Public hearings must be held at the time of submission of the application to get the views of those near the site.

After an extensive review of the application by the regulatory agency and the public, the incinerator must conduct a trial burn (discussed further below) which demonstrates the incinerator's capability to operate within regulatory limits. The emission results from the trial burn are then evaluated in a comprehensive risk assessment study that considers both direct and indirect risks to the public. A draft permit, detailing operating and other requirements that will govern the incinerator's performance, is then issued for public review and a public hearing.



Finally, after all regulatory requirements have been met to assure protection of public health and the environment, a final operating permit is issued. The incinerator must operate at all times in accordance with its permit. This assured, in part, by extensive and

sophisticated control equipment, continuously recorded monitoring and automatic waste-feed cutoffs (discussed below). Further assurance is provided by frequent inspections by the regulatory agencies. In addition, most commercial incineration facilities maintain an open door policy that provides public access to the facility on virtually a daily basis. Community involvement and outreach is an integral part of facility operations, with many facilities conducting household hazardous waste collection days and technical seminars for their local communities.

Trial burns A trial burn is a test of an incinerator's ability to meet all applicable performance standards when burning hazardous waste under specified "worst case" conditions. The parameters demonstrated in the trial burn then become the parameters specified in the permit, which govern subsequent operations.

During a trial burn, which is conducted under direct, on-site regulatory agency supervision, measurements are taken of the waste feed characteristics and volumes; combustion temperatures; combustion gas velocity (which is a key element in determining combustion efficiency); levels of carbon monoxide (CO), hydrogen chloride (HCl), heavy metals and particulates in the stack emissions; and other important parameters, particularly the emissions of principal organic constituents (POHCs).

POHCs are difficult-to-burn compounds that are easily detected. They are selected by the regulatory agency for each waste feed tested. Successful combustion of those POHCs assures that the incinerator, in its daily operations, will properly destroy the hazardous constituents in the waste feed those POHCs represent.

Several means are used to project a worst-case performance test during the trial burn. First, POHCs are selected from constituents judged to be the most difficult to burn. Secondly, waste feeds are selected to contain maximum expected levels of ash and chlorine. These two characteristics directly relate to the capability of the APCS to achieve the particulate and hydrogen chloride (HCl) emission limits. Thirdly, the incinerator is operated during the trial burn at the projected worst-case limit of the expected range for each critical operating parameter.

As a result of these stringent test burn requirements, there is assurance that the permit will specify operating conditions that both (1) protect health and the environment and (2) were demonstrated during the trial burn, under worst-case circumstances.

Destruction and Removal Efficiency (DRE) In order to be permitted, an incinerator must also demonstrate during its trial burn a DRE of at least 99.99% ("four 9's"). In fact, most incinerators demonstrate a DRE of 99.999% ("five 9's"), ten times greater than required.

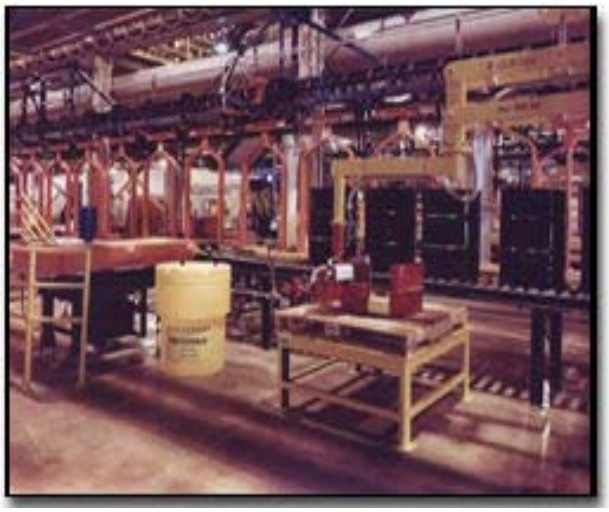
A DRE of 99.99% means that 99.99% of the POHC's - the hazardous constituents in the waste -- have been destroyed by the incineration process or removed into the ash or the air pollution residues, for further treatment and disposal. In fact, EPA reports that

"destruction and removal efficiencies reported for incinerators are almost entirely the result destruction [in the incinerator] rather than removal" into the ash or other residues.

Risk Assessment All incineration facilities are required to perform a risk assessment, to ensure that the emissions from incinerators do not pose a threat to public health and the environment. EPA sets a maximum acceptable risk level that is 10 times more protective than what is allowed for other types of environmental permits or approvals. The risk assessment must address both direct (inhalation) exposure of the general public, as well as indirect pathways. Indirect pathways are based on deposition of pollutants to local farmlands and waterways, and uptake of these pollutants in the food chain (cattle, fish, vegetables). Conservative assumptions are built into the risk assessment to ensure that the conclusions are protective of public health. (For example, it is assumed that a subsistence farmer resides at the same spot of maximum emissions impact for 30 years, while living on 100% of the beef, fish, and vegetable products obtained at that location).

The emissions modeled in the risk assessment must include metals, dioxin, and the other products of incomplete combustion (PICs). PICs are organic compounds that are formed at trace levels in the combustion process that are not totally destroyed. They are present at extremely low levels (parts per billion or less) and modeling in the risk assessment ensures that they are not present at levels that are harmful to the environment.

Required operating parameters Based on the conditions during the trial burn which demonstrated the required DRE, and the results of the risk assessment, the permit will specify acceptable wastes for incineration ("waste feeds"), waste feed rates, and at least combustion temperature, combustion gas velocity, and carbon monoxide levels in the stack gas—all determinants or indicators of the quality of the combustion process. In addition to these required operating parameters, others are typically included in incinerator permits as well.



Waste Feed Cut-offs (WFCOs) All hazardous waste incinerators must be operated with a system to cut off waste feeds automatically if key operating conditions deviate from the limits established in the permit. These include, as a minimum, carbon monoxide in the stack, combustion temperature and normally excess oxygen, combustion gas velocity, critical APCS control parameters, and others determined by the permitting agency to be necessary to ensure that the required performance standards are met.

Emissions The incinerator is required, at a minimum, to limit emissions to not more than 4 pounds per hour of hydrogen chloride (HCl) and not more than 180 milligrams of particulate matter per cubic meter. Almost invariably, the permit will include other emission limits, such as for carbon monoxide and various metals, and may specify other, more stringent limits.

A risk analysis is conducted, based on the projected emissions of metals, HCl, etc., as demonstrated during the trial burn. The resultant risk must be significantly less than the future risk levels set by the Clean Air Act for manufacturing and other emission sources. In fact, if all stationary emission sources were held to standards similar to hazardous waste incinerators, there would not be an air pollution problem today. (See also "Section IV, Safety/Environmental Protection," below.)

Monitoring There must be continuous monitoring and recording, as a minimum, of combustion temperature, waste feed rate, an indicator of combustion gas velocity, and carbon monoxide downstream of the combustion zone and prior to release to the atmosphere. These are the key parameters that determine whether the incinerator is operating properly in accordance with the regulatory requirements and the demonstrations made in the trial burn. Normally, these parameters are recorded on "strip charts", or computer data logs, which keep a continuous and permanent record of the incinerator's operation. These records are periodically reviewed by the environmental regulatory inspectors, to assure on-going compliance with the incinerator's permit. In addition, metal feed rates must be limited to acceptable limits demonstrated in the risk assessment.

The MACT Rule EPA is continually striving to improve the protectiveness of the standards applied to hazardous waste combustion. As part of this effort, EPA has promulgated new standards under the Clean Air Act that will require all hazardous waste combustion devices to install the maximum achievable control technology (MACT) for air pollution control. These new standards require that emissions of metals, particulate and dioxin be reduced to the maximum extent achievable by technology. This will result in reductions of emissions by 5 to 100 times current levels, and will make hazardous waste combustion devices the lowest emitting industrial process of any kind. The commercial incineration industry has been an outspoken supporter of these new standards.

IV SAFETY/ENVIRONMENTAL PROTECTION

Summary of Protective Measures

We have seen from the summary above of the design, operation, control monitoring and regulation of hazardous waste incinerators that numerous protective measures are provided to assure the safe and environmentally sound operation of these high temperature units, including:

A fully protective regulatory regime prior to the incineration process itself;

Design of the incineration unit itself to optimize the burning of hazardous and other industrial wastes, without compromise to accomplish other functions (such as the production of other products);

A detailed and expert regulatory (and public) review of the specific design prior to its permitting, in order to assure that it is indeed constructed in accordance with all requirements necessary to assure safe and protective operation;

A trial burn, overseen by regulatory experts, to assure that the unit and air pollution control system do in fact meet all required operating and emission standards under worst-case conditions, including 99.99% DRE;

A permit written to limit the operation of the unit to the conditions demonstrated during the trial burn, such as waste types, feed rates and metal feed rates, etc.;

Waste feed cut-offs which guarantee that waste feeds cease automatically if any of the key operating parameters are even momentarily exceeded;

Continuous monitoring and recording of key aspects of the incinerator's operation, so that a regulatory record is always available;

Periodic and unannounced regulatory inspections.

Results of Protective Measures

As a result of the design, operating and regulatory regime discussed above, today's hazardous waste incinerators are fully protective of public health and the environment, both with respect to emissions and regarding overall risk.

Emissions

Emissions from hazardous waste incinerators are the most tightly controlled and are the lowest of major manufacturing industries in the United States. For example, typical emission levels of hazardous waste incinerators are illustrated in a recent stack test of such an incinerator, in Ohio, overseen by the Ohio Environmental Protection Agency. The incinerator's annual emissions of particulates, as well as nitrogen oxide (No_X) and sulfur dioxide (SO2) – contributors to acid rain – compared to averages for other industrial facilities in the area, were:

Emission (Tons per year)

Type of Company	**Particulates**	**NOx**	**SO2**
Electric Power Plant	465	16,907	80,825
Cement Kiln	370	632	2,896
Steel Plant	310	1,643	42
Automotive manufacturer	43	124	298
HAZARDOUS WASTE INCINERATOR	6	75	ND *
College	4	32	504

ND=None detected

Similarly, with respect to dioxins and furans, hazardous waste incinerators are typically operated at temperatures in excess of 2000° F, while maintaining excess oxygen on a regular basis. Under these conditions, dioxin and furans are not readily formed. These compounds have been detected at higher levels in other combustion devices (medical and garbage incinerators), which are operated at temperatures several hundred degrees lower than hazardous waste incinerators.

Dioxin

EPA compiled information on dioxin emissions from hazardous waste incinerators, as part of their development work on the MACT rule. In addition, EPA released in 1994 a comprehensive study reassessing the risk posed by dioxin ( ). As part of this study, the EPA evaluated the known sources of dioxin and ranked them. Hazardous waste incinerators were classified as "other minor sources" of dioxin, far lower than the major sources such as diesel fuel burning, residential wood burning and utility coal combustion.

In 1998, EPA updated the inventory information of dioxin sources ( ). Hazardous waste incinerators are still viewed as minor

sources, accounting for less than 0.05% of the total dioxin emissions from all sources. For example, nationwide dioxin emissions from motor vehicle fuel consumption are 9 times higher than from hazardous waste incinerators. Nationwide dioxin emissions from residential wood burning are 13 times higher than from hazardous waste incinerators. Coal and oil combustion from electric utilities produce 15 times higher annual emissions of dioxin than hazardous waste incinerators; cement kiln plants, 19 times.

Municipal and medical waste incinerators are not as well operated and controlled as hazardous waste incinerators, and are the reason people associate dioxin emissions with incineration. Municipal and medical waste incinerators combined emit 1,964 times higher dioxin emissions than hazardous waste incinerators. After the MACT rule is effective (by 2002) hazardous waste incinerators will likely represent less than 0.0005% of the dioxin emissions from all sources.

The stack test of the Ohio hazardous waste incinerator discussed above, compared to other sources of dioxins and furans, illustrates this point:

Source	**Dioxin/Furan Emissions (parts per billion)**
Home electrostatic precipitator	1.0
Home fireplace soot	0.4
Diesel truck muffler	0.023
Automobile muffler	0.008
HAZARDOUS WASTE INCINERATOR	0.0000015

Products of incomplete combustion (PICs) are sometimes formed in the incineration process as a result of non-combustion chemical reactions. Before being emitted, however, PICs that are formed in the incinerator are destroyed in the afterburner. After considerable study, EPA has concluded that PIC emissions do not present any significant risk, provided that carbon monoxide is maintained at low levels. The required waste feed cutoff for carbon monoxide assures that this condition is continuously met.

With respect to total toxic emissions, EPA recently reported that the estimated total emissions from all hazardous waste incinerators using "reasonable worst case assumptions" (emphasis added) – was less than 0.03% of the emissions of these same chemicals from manufacturing companies (as reported in the so-called "Toxic Release Inventory").

For example, the following table shows that total annual emissions of a typical hazardous waste incinerator, in South Carolina, is far below comparable emissions from neighboring manufacturing plants.

Risks

As a result of the protective measures contained in the regulations and facility permits, and the extremely low emissions, hazardous waste incinerators do not pose any significant risk to public health or the environment.

The EPA's independent Science Advisory Board, after an extensive review, concluded that incineration is an important part of the strategy to properly manage and dispose of hazardous waste, and that the operation of hazardous waste incinerators has produced "no adverse consequences to the public health or the environment" (emphasis added).

A recent report by experts from the regulatory, academic and industrial fields states that a "properly designed and operated incineration system has received worldwide scientific acceptance as the best method for destroying and detoxifying many wastes… Today's state-of-the-art incinerator-air pollution control systems are safe, effective, and environmentally sound… [and] have emissions equal to those from several automobiles." Representatives of environmental organizations have come to similar conclusions, i.e., that hazardous waste incineration is "efficient [and] reliable."

Indeed, compared to every-day risks that the public readily accepts, the risk from a permitted hazardous waste incinerator to even the theoretical Maximum Exposed Individual (MEI) is insignificant. (The MEI is a theoretical individual located at the point of maximum emission impact from the incinerator, who is presumed to inhale the emissions continuously for 24 hours a day, 365 days per year, for 70 years.)

For example, a study undertaken by the American Society of Mechanical Engineers, in conjunction with EPA, concludes that "the risk to even the theoretical MEI who is exposed to the maximum level of incinerator pollutants continuously for 70 years is comparable or less than the risk to a person who smokes one cigarette in a lifetime, to a person crossing the street one time, or to the possibility of a person being struck by lightning" (emphasis added).

EPA states that the worst case estimates for the theoretical MEI contracting cancer from 7 years of maximum exposure to incinerator emissions is between one chance in 100,000 and one chance in 100,000,000. EPA compares this risk to the real – not theoretical worst-case – risk of one in 100 lifetime chance of death from motor vehicle accidents. By comparison, the goal of the most recent Clean Air Act Amendments is to regulate other industrial air pollution sources, by the year 2010, to a much less stringent risk level of 1 in 10,000.

V CONCLUSION

Our industrial society produces large volumes of hazardous waste, and will continue to do so in the future, even with considerable efforts to minimize waste production. Furthermore, wastes presently not regulated, which pose substantial risks if not properly managed, will become regulated in coming years. Moreover, there are substantial volumes of existing hazardous wastes that must be cleaned up at Superfund and other contaminated sites.

A wide range of governmental, scientific, academic and environmental bodies and experts have concluded that modern, regulated, high temperature hazardous waste incinerators are safe, effective, controlled and monitored means of destroying organic hazardous and industrial wastes. They have also determined that it is clearly the best available technology in the country today for the destruction of organic wastes. In fact, if all air emission sources were as well designed, controlled, operated and regulated as hazardous waste incinerators, we would not have an air pollution problem in this country today.

The Environmental Technology Council recognizes that the permitting of certain incineration facilities has caused considerable controversy, and that citizens have questions about the operation and safety of the technology in general. Citizens are well served to demand the best from this technology and the operation of incineration facilities. The operators of hazardous waste incineration facilities should be held to the highest standards of care and proof of their claims, as should the organized opponents of the technology. We trust that this report has provided useful information to understand the technology and assisted you in asking the tough questions of both sides in the debate over a facility permit.

Incineration is indeed the leading technology in this nation's transition away from land disposal and toward permanent protection of public health and the environment. In this spirit of progress, the commercial incineration industry commits to working with local communities, the states and the Federal Government to not only information but to continuously advance incineration and make the best technology even better.