Radioactive Waste Incineration: Status Report

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ABSTRACT
Incineration is generally accepted as a method of reducing the volume of radioactive waste. In some cases, the resulting ash may have high concentrations of materials such as Plutonium or Uranium that are valuable materials for recycling. Incineration can also be effective in treating waste that contains hazardous chemicals as well as radioactive contamination. Despite these advantages, the number of operating incinerators currently in the US currently appears to be small and potentially declining.

This paper describes technical, regulatory, economic and political factors that affect the selection of incineration as a preferred method of treating radioactive waste. The history of incinerator use at commercial and DOE facilities is summarized, along with the factors that have affected each of the sectors, thus leading to the current set of active incinerator facilities.

INTRODUCTION

In the 1970's and 1980's there were a relatively large number of radioactive waste incinerators in operation in the US, with more than 50 incinerators reported to be in operation in 1976 [1]. The National Engineering Laboratories engaged in weapons research or production generally had incinerators for processing radioactive wastes and many had plans for new or expanded facilities. Commercial power plants had facilities to reduce the volume of their wastes.

Manufacturers of nuclear fuel for commercial power plants had incinerators to aid in recycling valuable uranium that might otherwise be trapped in their waste streams. A list of sample facilities from a text book in the early 1980's confirms this healthy state for incineration [2]. A listing almost 10 years later by an environmental group confirms that the facilities in operation were relatively unchanged [4].

Since that time, the technology associated with incinerators has become much more sophisticated, the design and operation of the facilities has become more complex and expensive, alternatives have been developed for treatment and disposal of the waste at competitive prices and the process of permitting for incineration facilities has become more complex, with public opinion and politics having a greater impact on decisions.

Together, these technical, regulatory, economic and political factors have served to reduce the number of incinerators in operation.

TECHNICAL FACTORS

Radioactive waste material that contains a large percentage of paper, wood, cotton cloth or other combustible material is a prime candidate for incineration. The extraneous material can be burned and the volume of the resulting ash and off-gas filter material will be reduced reliably to a small fraction of the input. Under favorable conditions, gross volume reductions of 300:1 can be experienced. After processing the resulting radioactive residue for disposal through packaging and solidification, the net reduction will be substantially less. In an example that was reviewed, a net volume reduction of 80:1

was experienced with the material having the initial 300:1 ratio [3]. For other waste streams, much more modest volume reductions have been experienced, with ratios on the order of 2:1.

Radioactive waste incinerators are complex facilities. Although the early incinerators were based largely on industrial machinery, increasing focus on worker safety and minimizing environmental emissions have resulted in more modern facilities having much more sophistication in their designs, with higher initial costs and more complex operations. For example, the initial Lawrence Livermore National Laboratory (LLNL) incinerator started operation in 1978 without sophisticated pollution control devices or off-gas filters. Its replacement was to cost $41 million in the late 1980's and was to have a staff of 50 [5].

One of the many technical challenges in incineration was described in a report on the behavior of Cesium (Cs) and Strontium (Sr) in high temperature processes. These isotopes are important because of their prevalence in wastes at DOE sites combined with their active biological pathways. The authors describe the problem:

> "Incineration, while only applicable to certain LLWs, results in large volume reductions and destruction of hazardous organic constituents. However, incineration is becoming less attractive due, in part, to the difficulty in controlling emissions of regulated hazardous metals and radionuclides that vaporize at incinerator temperatures. Once vaporized these species often nucleate or condense to form ultra fine particles ($<0.1\mu m$) that are difficult to collect at high efficiencies for even advanced particle control systems."[1]

While increasing technical sophistication available for incineration allows us to have more extensive knowledge of the behavior of the processes within the incinerator, it helps to point out their limitations. Control systems and treatment of off-gas and ash waste streams become more complex in response to the needs identified by the better understood phenomena. As a result, costs of equipment and operation are subsequently increased.

REGULATORY FACTORS

The early incinerators were installed before their emissions were covered by environmental regulations. In the current set of regulations, an incinerator must meet regulations from the Nuclear Regulatory Commission (NRC), the Environmental Protection Agency (EPA) and other federal and state regulatory bodies. In the current regulatory processes, the quantities of substance such as heavy metals that are present in waste that is incinerated can dictate the design and operation of the incinerator, rather than the radiological consequences of incinerator operation.

One of the most valued aspects of radioactive waste incinerators is the ability to dramatically reduce the volume of liquid wastes. Usually, the resulting waste form of ash and fly ash is more amenable to treatment and disposal than the volumes of liquid. Unfortunately, these liquid wastes often contain hazardous chemicals, making them potentially dangerous from both a chemical and radiological perspective. An incinerator licensed to process these "mixed wastes" must have emissions that meet both the hazardous chemical limits, as well as the radiological release criteria. These incinerators are, by their nature, expensive and difficult to design and operate.

The current regulatory environment is very open regarding the owner's intentions and facility operation criteria. The required public notices and regulatory filings provide detailed information to individuals and organizations that may have an interest in the facility. The permitting process provides the forum these individuals and groups to make their opinions heard and to affect the final outcome of an applicant's permit application.

The direct effects on incinerators from the regulatory process are the technical constraints that the regulations place on the design and operation of a new facility, and the potential delays that can occur during the regulatory process. The section on Political Factors discusses effects such as delays in the regulatory process, which are outside the direct effects.

ECONOMIC FACTORS

The technical and regulatory factors deal with the choices available to a potential incinerator operator in meeting the desired objectives and with the limits on emissions from a facility. In addition, it must make financial sense to build and operate such a facility. The Economic Factors category includes the effect of changes in the overall mission or process of the facility that includes the incinerator. If the mission of the facility changes so that the feedstock of the incinerator is significantly different in volume or composition, the owner will need to modify, replace or retire the incinerator. As a minimum, they will need to reevaluate the environmental emissions resulting from the changes in the feedstock.

For early incinerators, a significant cost factor was the value of the material recovered in the incinerated waste. A typical situation at a DOE site included:

> "Located in the PFP (Plutonium Finishing Plant) complex, the incinerator operated from 1962 through 1973. It was conceived and built as a way to salvage additional plutonium (PU) that was being buried as residual material on contaminated solid wastes in the late 1950's, a time when the per unit value of plutonium was extremely high." [7]

Use of incinerators for Uranium recovery was prevalent, with almost all US incinerators in a 1980's list having a goal of Uranium or Plutonium recovery.

In the case of waste from commercial facilities such as power plants, the cost factors are such that the smaller private operations have been driven from the market. Incineration must compete with alternative volume reduction techniques such as super compaction and with alternative solidification techniques for liquid wastes. In all cases, the cost and availability of disposal sites or the cost of storage determines the value of incineration for a given waste form.

Over time, the commercial nuclear power industry has significantly reduced the quantity of incinerable radioactive waste. Process changes in maintenance and operations focus on minimizing the amount of material that is subject to potential contamination. For example, component parts are unpacked before being taken into a contaminated area, while in earlier periods, the packing material would have been carried into the controlled plant area and would have become potentially contaminated waste that was suitable for incineration. Therefore, individual sites have reduced the amount of class A waste radioactive waste that would support the investment and staff of a single use incinerator.

Cost factors are driving the government sector, as well. The current trend is to maintain facility capability at a limited number of sites and to improve their operating efficiency. For example, some observations in an audit by the DOE Office of Inspector General were [8]:

> "A recent Department Study justified the continued operation of the TSCA Incinerator through 2006 because the potential demand for incineration, primarily from sites outside Oak Ridge, far exceeded treatment capacity. However, instead of shipping the waste to Oak Ridge for treatment, seven sites have stored about 2.5 million pounds of incinerable waste locally."

> "Even though existing treatment facilities were underutilized, the Department approved development of an additional VTD facility in Utah."

Although the alternatives available to solve the technical and regulatory issues of waste management are different at each facility, there is a universal need to demonstrate the financial effectiveness of incinerator decisions. The magnitude of the expenditures involved guarantees that funding is subject to scrutiny regardless of whether the owner is in the public or private sector.

POLITICAL FACTORS

Individuals or special interest groups that are opposed to incinerator facilities have the opportunity to participate in the licensing process. In addition, they may take action through political channels that have the potential to affect either regulatory decisions or funding, especially in the case of government owned facilities.

Three excellent examples of the mobilization of politics to halt incinerator operation or development were identified.

- Gusterson [5] describes the coalition building efforts of local groups in opposition the Lawrence Livermore National Laboratory (LLNL) development of an incinerator starting in the late 1980's. He provides the perspective of a social scientist in presenting the situation and the process that resulted in the incinerator plans being shelved in 1990. The opposition and publicity remained largely local and was effective in getting the support from a large fraction of the local population.

- The Snake River Alliance, an opposition group, presents the chronology of its activities in fighting the plan for a mixed waste incinerator at the Idaho National Engineering and Environmental Laboratory (INEEL) [9]. The initial announcement took place in 1993. Although some delays were encountered, the interveners were unsuccessful in stopping the licensing process for the incinerator. Ultimately, national political pressure caused the DOE to cancel plans for the incinerator in 2000.

- The process by which the Controlled Air Incinerator at the Los Alamos National Laboratory (LANL) succumbed to a combination of regulatory and cost factors is summarized by Reader [10], along with alternative strategies and tactics which LANL might have employed to be more successful.

These examples show that a determined opposition group can be effective in causing the delay and cancellation of an incinerator project by exerting their influence in local or national arenas.

RESULTING EFFECT ON INCINERATOR DEVELOPMENT

Government Sector

The Government sector, through the DOE sites that had their start in weapons research or production, was the largest contributor to the number of incinerators to early published lists [2] [4]. Today, most of these facilities are removed or not in operation. With the end of the Cold War, the mission of these facilities has changed and the focus of the site staffs is now largely on environmental cleanup and decommissioning. While most of the early incinerators had a purpose related to Uranium or Plutonium recovery, the current need is for volume reduction or treatment of mixed hazardous and radioactive waste.

In general, efforts to replace incinerators with new technology have not been successful due to a combination of political pressure and unfavorable cost tradeoffs. Although the incinerators at several facilities may still be in place, they do not appear to be in operation.

The Toxic Substances Control Act (TSCA) incinerator at Oak Ridge National Laboratory (ORNL) appears to be the choice for mixed waste treatment. It is reported to have significant unused capacity and is able to accept waste from other DOE sites. Cost and political factors seem likely to constrain development of additional incinerators in the face of spare capacity at TSCA.

Private Sector

While several early power plants had incinerators, all of these seem to have been retired. Currently, the incinerator owned by EnergySolutions in Tennessee is available to process waste from commercial clients. By processing waste from a large number of sites, the EnergySolutions incinerator can be operated economically, while the volume of waste from only one or two sites would not support a reasonable capacity factor.

In addition, Permafix operates a commercial facility that processes mixed waste. It appears that this incineration facility is able to maintain economic operation due to consolidation of waste from multiple customer sites for treatment.

The NRC licensing database contains references to incineration for an additional 36 facilities. These are all located at hospitals or medical laboratories. The primary purpose of these incinerators is to eliminate medical hazards from materials containing small amounts of tracers and other radioactive materials used in medicine, which are typically short lived isotopes. No trend is expected in this group.

Fabricators of nuclear fuel for commercial reactors were found in the early list of radioactive waste incinerators. These facilities continue today. Ariva, General Electric and Westinghouse have licenses that include incineration in recent years.

SUMMARY AND CONCLUSION

Incineration has had a long history of use in radioactive waste processing due to their ability to reduce the volume of the waste while destroying hazardous chemicals and biological material. However, combinations of technical, regulatory, economic and political factors have constrained the overall use of incineration.

In both the Government and Private sectors, the trend is to have a limited number of larger incineration facilities that treat wastes from a multiple sites. Each of these sector is now served by only one or two incinerators. Increased use of incineration is not likely unless there is a change in the factors involved, such as a significant increase in the cost of disposal.

Medical wastes with low levels of radioactive contamination are being treated effectively at small, local incineration facilities. No trend is expected in this group.

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