

LICENSING REQUIREMENTS FOR BACKFIT INCINERATORS  
AT COMMERCIAL NUCLEAR POWER PLANTS

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ABSTRACT

This paper, and the project it reports on, examines the licensing requirements for backfit incinerators at operating power plants. Analysis was made of incinerating low-level dry radioactive waste in a backfit incinerator at an existing power plant. The operation of the incinerator has been studied from viewpoints of operator safety, consequence of system failures including "worst case" scenarios, and radiological impact for normal and upset conditions. Analysis showed that releases under all normal operating or upset conditions are an extremely small fraction of the applicable limits. Nuclear Regulatory Commission review concluded that the document produced as a result of this project was useful as a design guide and of value in licensing backfit incinerators.

Introduction

Disposal of low-level radioactive waste in the United States has become a problem of increasing significance to nuclear power plant operators. Several commercial low-level waste burial sites have closed, and those remaining are experiencing more stringent regulations governing the quantities and acceptability of low-level waste. Adding to this problem is the dramatic increase in costs associated with low-level waste disposal. Utilities are responding by turning to advanced volume reduction radwaste treatment systems. One such volume reduction method that shows great promise is incineration; and, in fact, incinerator installations are planned as part of a number of new plant construction projects. However, because of recent slowdowns and schedule slippages in the construction of those plants, demonstration of the effectiveness of radwaste incineration technology in new commercial nuclear power plant applications has experienced an extended delay.

Demonstration of radwaste incineration technology on a backfit basis has also languished because installing a backfit incinerator requires a formal license amendment request to the Nuclear Regulatory Commission (NRC) in accordance with 10 CFR 50.90, Application for

Amendment of License or Construction Permit. Such an application can open a plant's operating license to full review.

Gilbert Associates, Inc., with support from the Department of Energy, prepared, on a generic basis, typical engineering design information, accident analysis data and other documentation necessary to apply to the NRC for a license to backfit a low-level radioactive waste incinerator in an operating nuclear power plant. Alternative licensing pathways were also explored in a companion document. The Department of Energy, serving in the role of a typical utility organization, submitted this generic report to the NRC for review and comment in a simulated demonstration of the licensing process. The NRC, in turn, performed an acceptance level review of the generic report and provided the Department of Energy with its comments. Gilbert Associates, Inc. is currently addressing the NRC comments. After the NRC review comments have been resolved, a final report will be published by the National Low-Level Waste Management Program.

The ultimate goal of this effort is to identify and resolve any safety issues associated with backfit incinerators so that a sufficient level of confidence in the licensability of backfit incinerators can be

instilled in nuclear utility management, and to encourage the industry to proceed with plans to install incinerators on a retrofit basis.

#### Waste Type Selection

This licensing document was limited to consideration of the incineration of low-level, dry radioactive waste. There are several reasons for this decision, as follows:

- o Dry radioactive waste material is the most likely candidate for incineration and can be handled by all incinerator systems currently on the market.
- o Most test work has been conducted using dry radioactive waste material. The data base in support of incineration of other waste forms is relatively weak by comparison.
- o Other waste forms are not common to all plant sites, so their inclusion would dilute the generic value of the licensing document.

#### Incinerator Selection

For the purpose of the licensing document, the type of incinerator used as a basis of discussion was of only secondary importance since most incinerator designs intended for this application will perform equally well. However, in order to derive realistic data for analysis of system operation and to develop conceptual system design and layout information, it was necessary to select a specific incineration technology to be used as the basis for the project.

Because of the extensive DOE-funded work that has been accomplished with controlled air incineration technology at Los Alamos National Laboratory, this process was selected for the licensing demonstration project, based on the availability of design information and test data for it.

#### Selection of Host Facility

Actual site specific information about such factors as waste quantities, waste characteristics, plant interfaces, and meteorological conditions were necessary to make the final report as useful and realistic as possible. Several plant sites were considered for this purpose, based on availability of waste quantity/characterization data and design information, favorable site conditions, and permission to use the plant site name in the report.

As a result of this analysis, Philadelphia Electric Company's Peach Bottom Nuclear Power Station was selected as the model site for the project. The plant is a two unit boiling water reactor power plant which annually produces an average of 82,000 cubic feet of dry active waste material. There is currently a project at the site to construct a two and one-half year onsite storage facility for dry active waste material and depleted ion exchange resins. The Peach Bottom site is located in south-central Pennsylvania on a narrow strip of low land adjacent to the Susquehanna River. Because the high bluffs overlooking the plant are in close proximity to the site, there is limited land available for plant expansion. The site chosen for the onsite storage facility is therefore some distance to the north of the main plant (approximately 1500 ft) and at the base of these bluffs. Incorporated into the design of this facility are provisions

for expansion which could include a radwaste volume reduction facility utilizing incinerator technology. To be consistent with these plans, the layout for the controlled air incineration process in the licensing demonstration project was restricted to the area identified for this purpose by the utility.

#### Contents of Licensing Submittal

There are no unique guidelines for preparing a licensing submittal specifically for this type of process equipment. The report has generally followed the outline used in previously prepared safety evaluation reports for other radwaste changes and addresses all items identified in NUREG-0800 (Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants), as well as those specified in 10 CFR 20.106. These include: (a) codes and standards to be followed in design and operation of the facility; (b) a description of the wastes; (c) a detailed description of the process facilities and the interfaces with existing facilities; (d) organizational structure for operation of the facility; (e) a summary of plans for eventual decontamination and decommissioning of the facility; (f) shielding design and ALARA review; (g) a discussion of both normal and accident release situations and the radiological consequences of these releases; and (h) identification of a means of complying with state and local regulations applicable to the incineration process.

#### Analysis of Radiological Impact

In order to assess the probable radiological impact of this new system on operation of the plant, the normally-generated dry active wastes, with the actual source terms being experienced at the candidate site, were "incinerated" and the radiological consequences were analyzed. In addition, a variety of possible accident conditions were analyzed, as follows:

- o Loss of scrub solution inventory
- o Loss of scrub solution and High Efficiency Particulate Air filter fire
- o Explosive loss of flue gas and ash
- o Fire in waste feed hopper
- o Fire in waste feed preparation area
- o Venting via relief valve
- o Solidified radwaste fire
- o Spill of incinerator ash in process area.

These analyses for normal operation and accident conditions demonstrated that the computed releases of activity and resultant doses to plant personnel and the general public would be significantly less than applicable limits and therefore would not result in a significant safety hazard.

The results of the analysis for each of these accident conditions are summarized in Table 1. For the worst case accident, using very conservative assumptions, the maximum individual 50-year dose commitment was calculated to be 90 mrem to the bone. Eighty-eight percent of this dose would be from the release of actinides, the likely presence of which in the dry active waste stream is minimal, making this a highly conservative assumption.

Under normal operating conditions, the maximum individual dose at the nearest residence would be less than 0.005 mrem per year. This is an insignificant percentage of the annual 150-200 mrem radiation dose

occurring naturally. It is also less than 0.02% of the 40 CFR Part 190 site boundary limit of 25 mrem per year for fuel cycle activities.

For protection of plant personnel, the facility layout includes sufficient shielding to allow safe access to areas requiring operator presence under normal operating conditions. For this purpose, required shield wall thicknesses for the various areas of the facility and the resultant radiation zones throughout the facility were calculated.

#### Nuclear Regulatory Commission Review

The NRC review was performed by the Division of Systems Integration, Office of Nuclear Reactor Regulation. Overall the review found that Gilbert Associates, Inc. did a thorough job of describing the design and attendant operation safety considerations of the subject incinerator, and in analyzing potential accidents associated with operation of such a facility. The NRC also stated that the report would be useful as a design guide and of value in licensing provided their comments were addressed. The submittal is in the appropriate format and addresses the topics of concern for licensing a backfit incinerator.

Other general conclusions of the NRC review are:

- o The subject incinerator is generally appropriate for reducing the volume of low level dry radioactive waste at nuclear power plants.
- o The described system for treating gaseous effluents, employing flue gas scrubbing (caustic spray) and filtering (with both HEPA and charcoal), is generally adequate for controlling releases to the environment.
- o The radioactive ash residue and retired caustic absorption solution can be processed safely by systems already approved for nuclear power plant use.
- o The design, including quality group classification, is consistent with NRC guidance, as expressed in Regulatory Guide 1.143.
- o Operation of the system can be in accordance with the criteria of Regulatory Guide 8.8 for occupational radiation exposure control.

Three of the areas addressed by the report were deemed sufficient for the chosen incinerator and the specified plant location, but they would require plant specific analysis for use at other sites. These areas included analysis of the contribution of the incinerator effluents to ensure compliance with the criteria of 10 CFR Part 20 and Appendix I to 10 CFR Part 50, evaluation of incinerator accidents, and compliance with the fire protection criteria of Technical Position CMEB-9.5.1.

One area not addressed in the report is the anticipated levels of contamination that will build up on the refractory lining of the incinerator vessel and the frequency of refractory replacement. This analysis will be included in the final document. Additional areas of the report needing resolution include the type of ash solidification system to be used, the radioactivity concentration of the ash prior to solidification, use of 1-in. thick charcoal filters in the

offgas treatment system, and the use of two times the average trash concentration as the design basis.

#### Conclusions

The Safety Evaluation Report prepared by Gilbert Associates, Inc. is a useful design guide for licensing submittals for backfitting low-level radioactive waste incinerators at operating nuclear power plants. NRC review concluded:

- o the subject incinerator is generally appropriate for reducing the volume of dry low-level radioactive waste
- o the described offgas treatment system is generally adequate for controlling releases to the environment
- o the radioactive ash and retired caustic absorption solutions can be safely processed by existing systems
- o the design, including quality group classification, is consistent with NRC guidance, and
- o operation of the system can be in accordance with occupational exposure criteria and without introducing or increasing safety problems.

With respect to the exploration of alternate pathways for incinerator licensing, the NRC confirmed that approval to incinerate waste at an operating reactor would require revision of the plant technical specifications and an amendment to the operating license. Before such an amendment can be issued, the public must be informed of the proposed action and given the opportunity to request a formal hearing.

TABLE I.  
Summary of Accident Analysis  
Population Exposures  
[50-Year Organ Dose Commitments (mrem)]<sup>a</sup>

Case	Total Body	Thyroid	Maximum Organ
1	3.8	0.8	90.0 (bone)
2	0.2	0.03	3.7
3	0.02	6.7	6.7
4	<10 <sup>-3</sup>	<10 <sup>-3</sup>	0.008
5	0.05	0.003	1.2
6	0.004	<10 <sup>-3</sup>	0.02
7	0.07	<10 <sup>-3</sup>	1.9
8	0.6	<10 <sup>-3</sup>	17.8

a. Doses were calculated for infants, children, teens and adults. Doses presented here are the worst case values from these categories.