INCINERATION OF LOW-LEVEL RADIOACTIVE WASTES-
FOUR YEARS OPERATIONAL EXPERIENCE AT STUDSVIK

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ABSTRACT

Nuclear power plants produce some 20-30 tonnes/year of miscellaneous low-level radioactive waste in the form of contaminated plastic, cloth, wood, paper and rubber. Similar combustible waste may also come from nuclear research establishments, fuel fabrication plants, hospitals, universities and industry.

In Sweden, since 1976, most such waste has been processed by incineration at the Studsvik research establishment. During 1981 about 300 tons of combustible low-level waste was incinerated.

In this paper we describe the incenerator system used at Studsvik, and the experience from its operation. Data on waste composition, radionuclide distribution in ashes and off-gasses, and activity emissions are also given.

INTRODUCTION

All establishments handling radioactive materials produce quantities of solid, combustible waste with low-level β/γ contamination. The high bulk of such waste can be most effectively reduced by incineration under controlled conditions, which leaves virtually the entire radioactive content in the ash residue.

A plant for the incineration of low-level radioactive wastes was built in 1976 at the Swedish state-owned nuclear and energy research establishment at Studsvik, 90 km south of Stockholm. Following a test running period, it has been used as a central treatment plant for low-level combustible waste produced at Sweden's eight operating nuclear power reactors, at a fuel fabrication plant, and at Studsvik itself. Smaller quantities of waste from hospitals, universities and industries using radioactive materials are also treated.

The incinerator at Studsvik is a special version of the Burnaway BW 400, a three-stage incinerator widely used in hospitals for burning non-radioactive waste. The ash-handling system has been modified to suit radioactive materials, and two bag-filter units for cleaning the flue-gasses before release were added in 1979.

DESCRIPTION OF THE LOW-LEVEL COMBUSTIBLE WASTE TREATMENT SYSTEM

Figure 1 shows a block diagram of the present Swedish system for the treatment of low-level combustible solid waste.

At waste generation sites low-level solid wastes are collected and packed in transparent plastic bags or cardboard boxes. Combustible waste for incineration is transported to Studsvik by truck in 30 m^3 containers. The waste is sorted at source into "combustible" and "noncombustible" the effectiveness of this separation depending on the discipline of the personnel concerned. However, when the "combustible" waste reaches Studsvik, the operators handling the transparent bags can normally see or feel if there are any large pieces of metal mixed in. If necessary, the bag contents can be further sorted at this stage. In fact, though, the incinerator is not very sensitive to pieces of metal, because there are no grates or moving parts that could be blocked by them.

The surface dose rate for the incoming bags is restricted to below 100 μSv/h (10 mrem/h)/ However, 10% of incoming bags are permitted a surface doserate of up to 1 mSv/h (100 mrem/h).

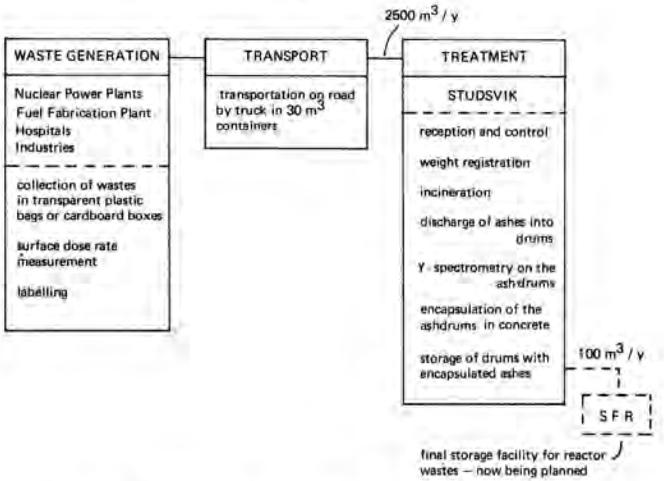

Fig. 1-Present system for the treatment of low-level combustivle solid waste in Sweden

Incinerator Plant

Figures 2 and 3 show the incinerator plant and process schematically.

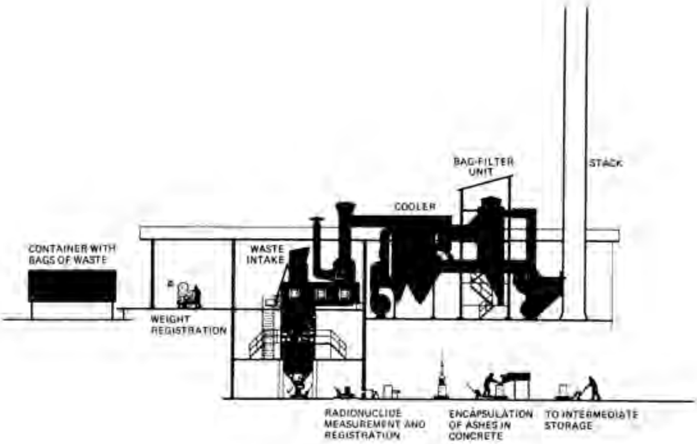

Fig. 2-Incineration plant at Studsvik, Sweden

The principal parts and systems are

- reception hall for control, registration and buffer storage of incoming waste
- feeding system for bags of solid waste
- vertical shaft primary chamber, secondary chamber and after-burning chamber
- cooler, bag filter units and a stack
- system for continuous sampling of off-gas releases
- system for emptying ashes into drums

- oil-burners, process control instrumentation

- system for activity measurement and registration of waste packages

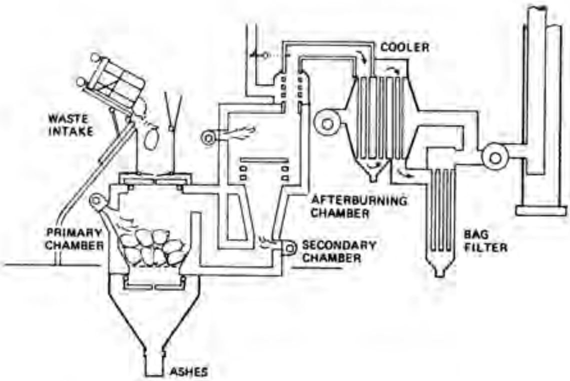

Fig. 3-Incineration process, Studsvik

Bags of waste are fed batchwise, by remote control into the top of the primary chamber, at a rate of about 120 kg every 30 minutes. Incineration is made in slight excess air at about 850°C.

The flue-gasses - about 7000 standard m^3/h at 850°C - are cooled to 600°C by direct mixing with air, then further cooled to 200°C in a gas-to-air heat-exchanger. The cooling air leaves the heat-exchanger at 400°C and is discharged to the stack. The cooled flue-gasses are then filtered in two bag filter units containing 75 bags each. The cleaned gasses released to the stack are continuously sampled

Ash is collected in a hopper at the base and allowed to cool overnight; then, after every second shift, it is emptied into 100-litre drums. These drums are then taken to an activity monitoring station, where the radionuclide content of the ashes is determined. Each drum is later placed inside a 200-litre drum and concrete is poured around it. The information on waste form, package type, radionuclide content, surface doserate, weight, etc. is registered in a data base. The 200 litre drums are transported to a building for intermediate storage on-site.

OPERATIONAL EXPERIENCES

The construction of the incinerator was completed in mid 1976, and since 1977 it has been in operation on a regular basis. The two bag-filter units for cleaning the flue-gasses before release were added in 1979. Presently the incinerator is normally operated during the day five days a week. The amounts of waste treated are shown in Fig. 4.

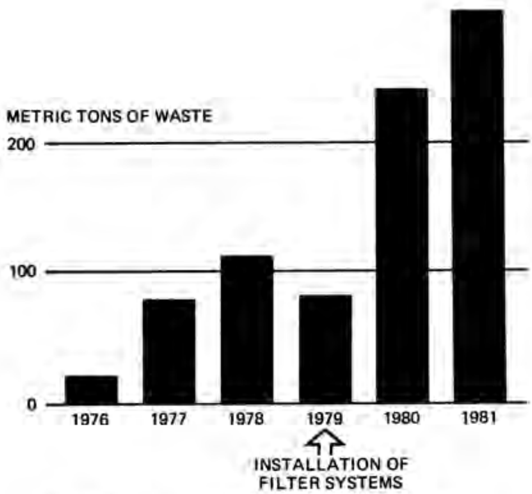

Fig. 4-Amounts of waste incinerated since the start-up of the facility

Average volume and mass reduction factors have been 50 and 6 respectively.

Waste Composition

About 80% of the waste received comes from the operating nuclear power plants and it is mainly generated during the yearly revision of the reactor units.

There are large variations in the composition of incoming "combustible" waste. The table below shows the composition, of waste from Swedish nuclear power plants.

Material	Weight (% of total)	
	mean	spread
plastic	37	32-44
cloth	26	18-42
wood	16	1-27
paper	7	2-11
rubber	5	0-9
incombustible	7	0-13

Table I - Composition of combustible waste from nuclear power plants

The bulk density of the waste is about 100 kg/m^3.

A large portion of the waste from hospitals consists of tubes with scintillaion liquids.

Activity Content of Radionuclide Distribution in The Waste

Although a surface dose rate of at least up to 100 μSv/h (10 mrem/h) is permitted for the incoming waste bags, most of the bags received have a surface dose rate well below this value.

The main radionuclides in power station waste are a mixture of corrosion products (Co-60, Zn-65, Mn-54, Co-58, Zr/Nb-95) sometimes with fission products (Cs-137, Cs-134) too. Wastes from the Studsvik research establishment and from hospitals may contain other nuclides: for example I-125, Sm-113, S-35 and Ir-192.

The table below shows the proportions of the main radionuclides currently being received from nuclear power plants.

Nuclide	% of total activity
Co-60	50-60
Zr/Nb-95	10-15
Zn-65	5-15
Cs-137/-134	5-15
Co-58	5-10

Table II - Radionuclide distribution of low-level combustible wastes from nuclear power plants.

Average concentration of Co-60 in the waste has been about 100 kBq/kg (3 μCi/kg) of waste.

Off-Gas Activity and Filter Efficiency

During each campaign the off-gasses are sampled continuously. Filters and condensate are later analyzed for particulate β/γ-activities, α-activity (TRU-wastes are however not treated in this facility), H-3 and iodine isotopes like I-125, I-131.

Present release limits set by the authorities are:

6 GBq/y unspecified β/γ-activity
5.5 TBq H-3-activity

Actual releases during 1981 have been less than 2% of these limits, the only exception being I-125 of which a high fraction of the permitted limit has been released. Waste containing I-125 is now however contolled by administrative methods, and is stored to permit its decay prior to incineration.

Special studies on the release fractions of different radionuclides have been made under contract for the Swedish National Institute of Radiation Protection.

Figure 5 shows some results from these studies.

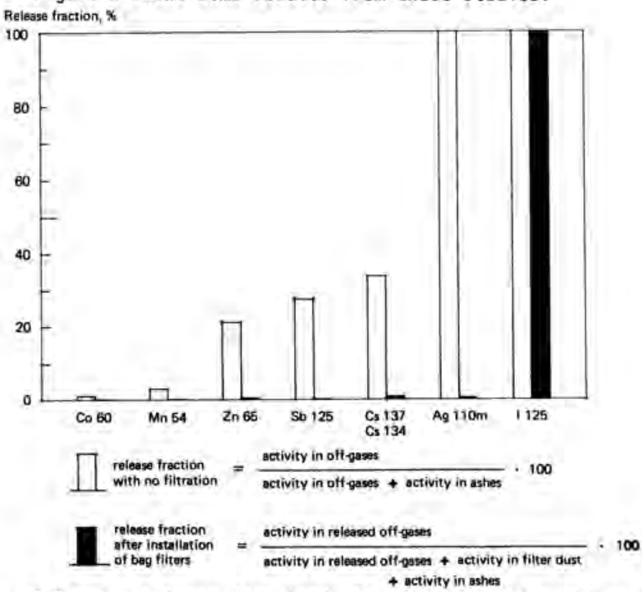

Fig. 5-Average release fractions of different radionuclides before and after installation of bag filters

As can be seen in Fig. 5 nuclides like Co-60 and Zr/Nb-95 are not volatilized, and they have a low release fraction even without filtration. The nuclides Zn-65, Sv-125, Cs-137, Sn-113 and Ag-110m have a release fraction that is a complicated function of process parameters such as incineration temperature and chemical composition of the waste. Thus, the release fractions of Zm-65, Sv-125, and Cs-137 varies from 5% up to 100% under different campaigns. The values given in Fig. 5 are average values for 1979.

A correlation can be seen between the temperature in the primary chamber and the release fraction of Cs-137.

By filtration the release fraction of most nuclides is reduced substantially, probably due to recondensation of volatilized elements on particles as the flue-gasses are cooled. The overall reduction of β/γ-emissions after the installation of bag-filters is of the order of 100 (I-125 excluded).

Doses from Operation

Only a minor part of the waste handling at the incinerator is carried out using remote control.

The average individual dose to operating personnel in 1981 was 3.1 mSv.

Operational Problems, Maintenance and Repair

No major problems which substantially influence the availability and the operation of the plant have been encountered.

After start-up of the plant in 1976, it was found that the large proportion of plastics, in the waste sometimes would give rise to a sudden pressure increase in the primary chamber a short time after feeding of a batch. This could be controlled by changes in the automatic regulation of the process.

The bag-filters are made of a PTFE (polytetrafluoroethylene) material. Initially a few filter bags of a different material were also installed for testing. These filters, however, ruptured after some time of operation.

During 1980 two service- and maintenance periods were undertaken (altogether 14 working days).

CONCLUSIONS

It can be concluded that over the past few years the incinerator at Studsvik has worked with a high availability treating solid