MODERNIZATION OF THE ARAK RADIOACTIVE WASTE TREATMENT PLANT

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ABSTRACT

The existing ARAK waste treatment facility at Siemens' Service Center in Karlstein, Germany, comprising an incineration plant as well as an ash compaction system, is to be upgraded in order to fulfill the new environmental protection regulations stipulated by the German Clean Air Act ("TA-Luft"). This means in particular a substantial reduction in toxic pollutant emissions.

Modification and modernization essentially comprise upgrading the flue-gas cleaning system, which to date has consisted of three dry filter stages only, and installing a new incinerator in order to increase plant throughput from 200 to 500 Mg/year. Furthermore, Siemens plans to install waste feed and ash handling systems which are partially remote-controlled.

In view of the changes recommended by the German Ministry for the Environment and Reactor Safety (BMU) with regard to the responsibility for operation of nuclear waste facilities in Germany, Siemens has sold the ARAK facility to the German Nuclear Service Company (GNS).

INTRODUCTION

Between 1984 and 1986 the Power Generation Group KWU of Siemens AG erected and put into operation a facility at Karlstein, Germany, known as ARAK (German acronym for "Abfall-Reduzierungs-Anlage- Karlstein") for volume reduction of combustible low-level radwaste arising from nuclear power plants and nuclear medicine.

The design of this facility was based on the incinerators developed at the German research centers in Karlsruhe and Jülich (i.e. a single-chamber vertical shaft incinerator and a two-chamber vertical shaft incinerator with separate pyrolysis and combustion chambers, respectively) and for a throughput of 200 Mg/year. The flue-gas cleaning system comprises three series-connected filter units (hot-gas, fabric and HEPA filters).

The containers filled with ash are compacted by means of a 15,000 kN high-efficiency compactor.

Since this facility, which had been licensed in the period between 1981 and 1983, was already no longer in compliance with the latest legal specifications in Germany governing pollutant emissions at the time when it was initially placed in service, Siemens decided in 1987 to upgrade the flue-gas cleaning system.

Added to this were the changes proposed in 1988 by the German Minister for the Environment and Reactor Safety regarding the assignment of responsibility in Germany for radwaste management, as well as the need to expand facility throughput from 200 to 500 Mg/year.

On account of this new division of responsibilities, Siemens sold the facility in 1990 to the German Nuclear Service Company (GNS; German acronym for "Gesellschaft für Nuklear-Service").

LICENSING

As explained above, extensive modifications are necessary which will be carried out jointly by Siemens and NUKEM under order from GNS. An application for a license to dismantle the radioactive components of the existing facility (incinerator and flue-gas cleaning system) has already been submitted to the appropriate authorities and the license covering erection of the new equipment will be applied for in the near future.

DESIGN CONCEPT OF UPGRADED FACILITY

The upgraded facility must comply with the most recent regulatory requirements* governing the following:(Fig. 1)

- Handling of radioactive materials
- Emission limits as specified in the German Federal Pollution Control Ordinance ("17. Bundes-Immissions-Schutz-Verordnung").

Fundamental modifications are required in the waste feed, incineration and flue-gas cleaning sections.

Design Data

Throughput	150 kg/hour 500,000 kg/year
Mode of operation	Continuous 24-hour operation, five days a week
Waste composition:	
PE, PP	approx. 30 % by wt.
PVC	approx. 5 % by wt.

* In accordance with legal specifications stipulated in Germany

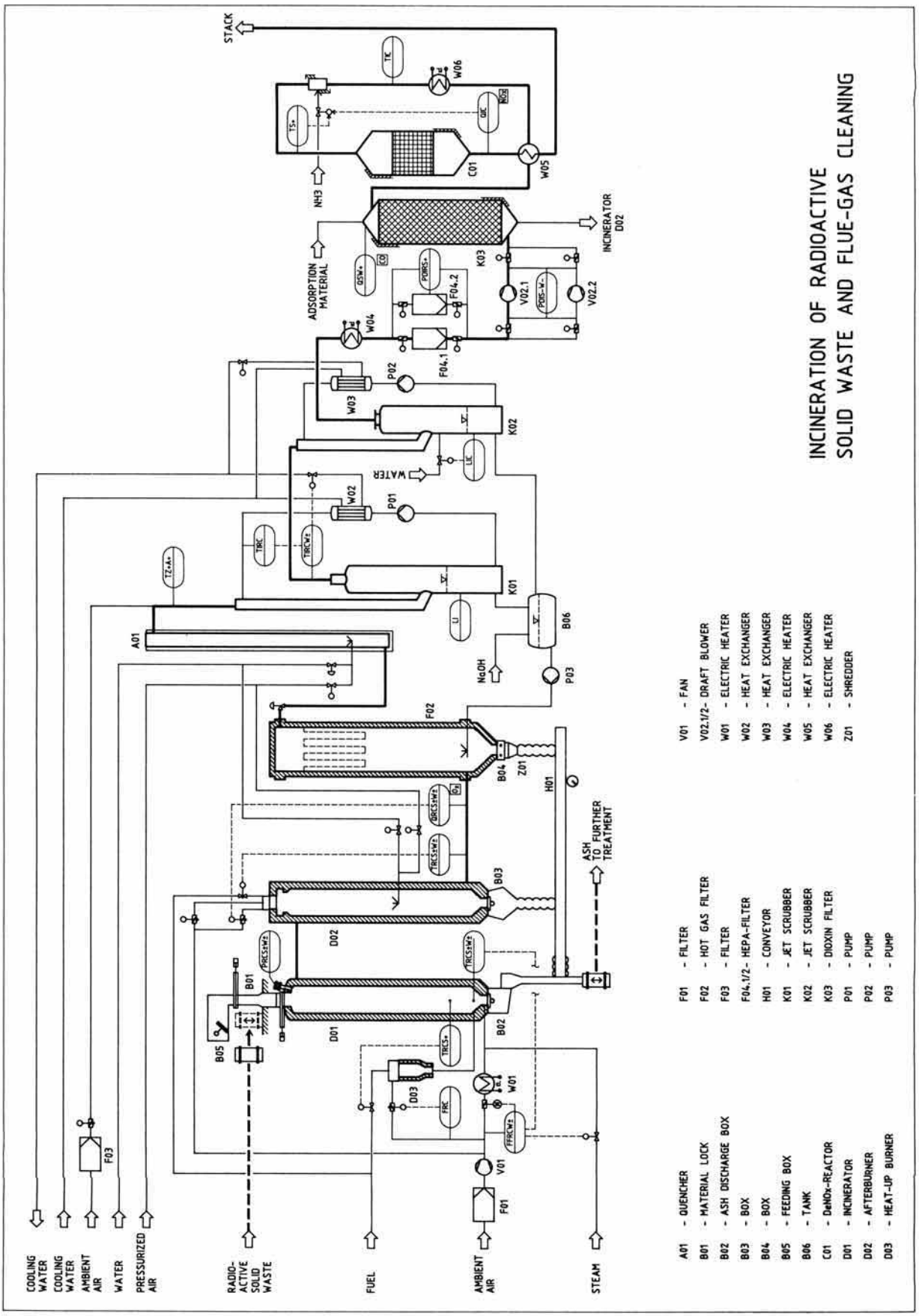

Fig. 1. Process flow sheet.

Rubber	approx. 5 % by wt.
Wood, paper, textiles	approx. 55 % by wt.
Noncombustibles	approx. 5 % by wt.
Decontamination factor DF =	1.5 E6 for nonvolatile nuclides

Waste Feeding

Radwaste arising in nuclear power plants and other nuclear facilities is delivered to ARAK in 1 m^3 containers. In order to minimize occupational exposure of personnel, these containers are automatically conveyed to and emptied into the sorting box. In this sorting box, noncombustible waste (larger than 300 mm) can be identified and removed. The radwaste, which usually has been precompacted, is then placed on a conveyor belt in batches weighing 25 to 40 kg each. The waste is fed into the incinerator through a feed hopper which separates the sorting box from the incinerator. These two sections of the facility are under different pressures. This ensures continuous air flow from the sorting box in the direction of the incinerator.

Waste feed is effected in batches at specified time intervals according to the calorific value of the waste in question.

Incineration

The incinerator is designed as a vertical shaft incinerator. Waste is fed into the unit from above. There are no internals in the combustion chamber itself.

A heat-resistant butterfly valve seals off the bottom of the incinerator. Combustion in the incinerator takes place in two zones. In the lower zone, in which the burning material is located, combustion is effected using an air-steam mixture. One-third of the total quantity of air required is heated to approximately 403 K and mixed with steam prior to introduction into the combustion chamber. The amount of steam is such that the oxygen concentration of the air-steam mixture is approximately 16 % by volume. This ensures that the temperature of the burning waste cannot exceed 1173 K, thus reliably ruling out any formation of slag and preventing clinker formation on the chamber walls.

The main air flow is introduced directly above the combustible materials. The upper zone is operated with excess air. This air flow is set to achieve a combustion temperature of between 1273 and 1323 K.

Preheating of the incinerator to its operating temperature (a minimum of 1023 K) is achieved using an auxiliary burner which is fired with fuel oil. The auxiliary burner is only in operation during startup.

Afterburning

The gaseous products from the incinerator - which still contain combustible gases and solid particles (carbon) - then flow into the afterburner chamber. The oxygen concentration in the afterburner chamber is set to a minimum of 6 % by volume. Using an auxiliary burner, the temperature in the afterburner chamber can be maintained at temperatures exceeding 1473 K. Under these conditions, and with a minimum residence time of 2 seconds, organic compounds are destroyed and the combustible constituents burnt to completion. At the bottom of the afterburner chamber the flue gas is cooled to a temperature of 1173 K by injecting water. This allows the ash, which may have become liquefied in the upper section, to deposit in solid form on the bottom of the afterburner chamber prior to being passed on to the hot-gas filter.

Hot-Gas Filtration

The flue gases, which leave the afterburner chamber at a temperature of between 1123 and 1173 K, then pass into the hot-gas filters. The thermal energy of the flue gas is utilized to evaporate the scrubbing water which is to be discharged from the facility. The quantity of scrubbing water evaporated is controlled such that the flue-gas temperature is lowered to 973 K before the gas enters the filter cartridges, thus preventing salts from melting on the filter surface. The ash, salts and any combustible solids entrained with the flue gases are removed in these filters (silicon-carbide type). The combustible materials are oxidized on the filter surface using very long residence times. The filters are cleaned on a weekly basis by reverse-pulse blowing with compressed air.

Flue-Gas Scrubbing

The flue gases contain a number of pollutants which must be retained. These include the following:

- HCl, HF, Hg
- SO_x, heavy metals
- Radionuclides
- Dioxins
- Nitrogen oxides

These substances can be removed from the flue gas by various processes.

The hot flue gas is cooled in a quencher by water injection to about 473 K. This rapid cooling process causes the temperature to drop very quickly below the range favorable for dioxin formation, thus minimizing the quantity of dioxins formed. A two-stage flue-gas scrubbing process then follows. In the first stage a jet scrubber is used and the operating parameters set to allow adsorption of HCl, HF and Hg with high removal efficiencies.

The pH of the scrubbing solution is maintained in a range of 0.5 to 1.5 through the addition of a sodium hydroxide solution. These conditions allow the removal of HCl, HF

and Hg, and the partial removal of other flue-gas constituents such as solids and alkalis.

In the second flue-gas scrubbing stage (here, too, a jet scrubber is used) SO_x, heavy metals, part of the NO_x content and the remaining HCl and HF are removed. In this second scrubbing loop the pH is maintained in a range of 8 to 9.5.

The scrubbing solutions are removed from the two jet scrubbers in batches. Appropriate chemical treatment methods are applied to remove the heavy metals and mercury in solid form. The salts NaCl, NaF and Na_2SO_4 (arising from oxidation of Na_2SO_3 in the presence of H_2O_2) are retained in the hot-gas filter as solids.

Final Stages of Flue-Gas Cleaning

The flue gas, having been cleaned of most of its chemical pollutants, then passes through HEPA filters in which radionuclides are retained with a removal efficiency of greater than 99.9 %. As this is the most important stage for removal of radionuclides, two filter units are provided. This ensures continuous operation even when the pressure differential across these filters increases. Up until now this was the final cleaning stage at such facilities.

In accordance with the new requirements regarding emission control, extensive removal of dioxins and nitrogen oxides from the flue gases must be provided for as well.

Of particular significance in this regard is the requirement that dioxin emissions be limited to 0.1 ng/Nm^3. At present, this value can only be achieved by adsorption on activated charcoal or coke.

The flue gas is admitted at an increased pressure into an adsorption bed in which the remaining HCl, SO_2, Hg, heavy metals and, in particular, dioxins are adsorbed.

The dimensions of this adsorption stage incorporate such a large safety factor that compliance with the specified emission limits is guaranteed. Spent adsorber material is discharged from the filter in batches and fed into the incinerator.

The only pollutants now remaining in the flue gas are nitrogen oxides which are reduced to nitrogen on a catalytic bed operated at a temperature of between 593 and 633 K and to which ammonia (gaseous NH_3) is added.

This method of flue-gas cleaning ensures, on the one hand, compliance with emission control requirements and, on the other hand, considerably reduces the volume of secondary waste. This very complex configuration for flue-gas cleaning involves high capital investments and operating costs, but at the same time provides a basis for acceptance of this radwaste facility by the general public.

TIME SCHEDULE

Upgrading of the ARAK facility is presently at the planning and licensing stage.

Installation of the new equipment can be expected to begin sometime in early 1992, which would allow the facility to commence operation in 1994.