INCINERATION FACILITY FOR COMBUSTIBLE SOLID AND LIQUID RADIOACTIVE WASTES IN IPEN - CNEN - SÃO PAULO

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ABSTRACT

A system for incinerating the combustible solid and liquid radioactive wastes has been developed in order to achieve higher mass and volume reduction of the wastes generated at IPEN-CNEN/SP or received from other institutions. The radioactive wastes for incineration are: animal carcasses, ion-exchange resins, contaminated lubricant oils, cellulosic materials, plastics, etc.

One of the advantages of the incineration process is that the resultant ashes are highly insoluble. This fact provides an extra security against contamination risk during subsequent handling and conditioning/immobilization step.

The optimization of the process was achieved by considering the following factors: selection of better construction and insulating material, dimensions, modular design of combustion chambers to increase burning capacity in future, applicability for various types of wastes; choice of gas cleaning system. The present design features include flexibility by use of multichamber for combustion and operation with controlled air (pyrolysis) and excess air. With this it should be possible to burn material more than the present capacity of 5 kg/h.

The electric heating adopted provides additional operational safety compared to gas or oil fired furnace, resulting further in the reduction of volume of off-gases to be treated.

The off gas system utilizes dry treatment and consists of one cyclone, electrostatic precipitador, condenser, activated carbon filter followed by one HEPA filter. For exhaust, a vacuum pump of 300 m^3/h flow and 1000 mm-H_2O pressure drop was selected. The operation is designed to function with a negative pressure of about 30 mbar to avoid escape of radioactive gases. In the case of failure of exhaust, accidental release is avoided by the adequate height of the chimney which provides the required depression.

The radionuclides most frequently found in the burnable wastes of IPEN are ^{131}I and ^{99m}Tc. The activated carbon filter provides a retention efficiency of 99.9 % for gaseous ^{131}I. The solid wastes under consideration are of IAEA category 1 with exposure rate of $<$200 mR/h

The incineration facility has been installed and operational tests for the determination of, heating and cooling rate; the time required to reach the operating temperature (1000 °C) and burning capacity, have been concluded. Inactive tests using animal carcasses (rats) resulted in a burning rate of 2.2 - 2.7 kg/h.

Isokinematic sampling devices as specified by the Environmental Protection Agency - US have been installed to analyse particulate material in the off-gases

The facility is expected to be ready for semi-continuous operation in the second semester of 1986.

INTRODUCTION

Among the radwastes generated from activities in IPEN - CNEN/SP, about 80 to 90 wt % as for example, cellulosic materials, plastics, cotton, small animal, organic liquids, paper, rubber and others can be considered suitable for the incineration treatment. At. present, the procedures being implanted are: storage until radioactive decay, for the wastes containing short-lived radionuclides and compaction into 200 liters steel drums. In the first case, after decay, wastes are released to the environment as normal waste and in the second they are stored.

In order to provide a better treatment aiming at higher volume reduction factors and improving the safety of the stored wastes, a waste incineration system has been worked out since 1983. Wastes transformed into ashes are more easily and safely stored and transported. Incineration is an adequate pre-treatment for combustible wastes contaminated with long-lived radionuclides or having high radiotoxicity and for wastes requiring immobilization.

In the present work the technical and economical considerations which led to the design of the facility are described.

WASTE MANAGEMENT SCHEME

Before the start of operation of the incineration facility it is intended to implant a careful sorting of the solid and some liquid wastes.

The following criterias were adopted to select the wastes which will be incinerated:

1. Wastes contaminated with long-lived radionuclides (T 1/2 > 60 days);

2. Materials of high chemical toxicity;

3. Wastes having large volumes and susceptible to combustion;

4. Perishable wastes;

5. Wastes of such a nature that the release of which is hindered by environmental requirements.

CONCEPT OF THE FACILITY

The incineration facility consists of the following equipments (figure 1):

1. Two modular furnaces: the first is the primary waste burner and the second is a post-burner for the off-gases;

2. Off-gas treatment system: a high efficiency cyclone, an electrostatic precipitator, a gas cooler/condenser, a HEPA filter and a charcoal filter.

3. Exhaust system: a vacuum pump and a stack.

The furnaces used for primary combustion and post-burning are of mechanical modular type. This main characteristic permits an horizontal or vertical furnace installation as a simple way to increase the burning capacity.

The projected throughput for this facility with a typical waste composition is 5kg/h.

The modular type furnaces shown in figure 2 consists of:

- a cylindrical combustion chamber of 280 mm inner diameter and 1200 mm height made in refractory steel AISI 310.

- thermal isolation by special fibrous material type Fiberflex. It permits that the outside wall temperature be at 50°C (maximum).

- incinerator chamber shells in carbon steel.

- furnace body of carbon steel (AISI 1020) cylinder with 980 mm diameter and 1200 mm height.

- electric heating using silicon-carbide elements at 17 kV for operational temperature range of 900 to 1000°C. The power supply is controled by thermo-couple elements.

- two gates located in the furnace body to permit the inspection of the thermal isolation and the carbide elements.

- two primary air inlets located in the bottom of the combustion chamber below of the grate.

The furnace is loaded from the top by means of a manual batch feed system consisting of a carbon steel chamber (2 liter capacity) with double door to protect the operator from flame, thermal radiation and radioactives releases.

A cylindrical discharge pipe is located in the upper part of the post-burner furnace. This allows the gaseous effluents to enter tangentially to external secondary air in the cyclone in order to promote cyclonic motion.

The ashes are collected in as intermediate cooling chamber with double security doors to prevent release of radioactive ashes.

The operational conditions of the feeder and ash collector permit a semi-continuous process. The off-gas cleaning is executed before the liberation to the environment. For this purpose a dry off-gas system was utilized. The first stage consists of a cyclone separator. This provides an economical pre-treatment to reduce the particulate loading specially for the larger particles ($\phi eq > 10 \mu m$). The design value of the efficiency of the particulate removal is 98%.

The second stage consists of an electrostatic precipitator to remove aerosols from the off-gas. The ionization of the particles is realized by charged stainless steel needles and the collection occurs in an aluminium plate. The design value of the collection efficiency for submicron particles is 99.9%

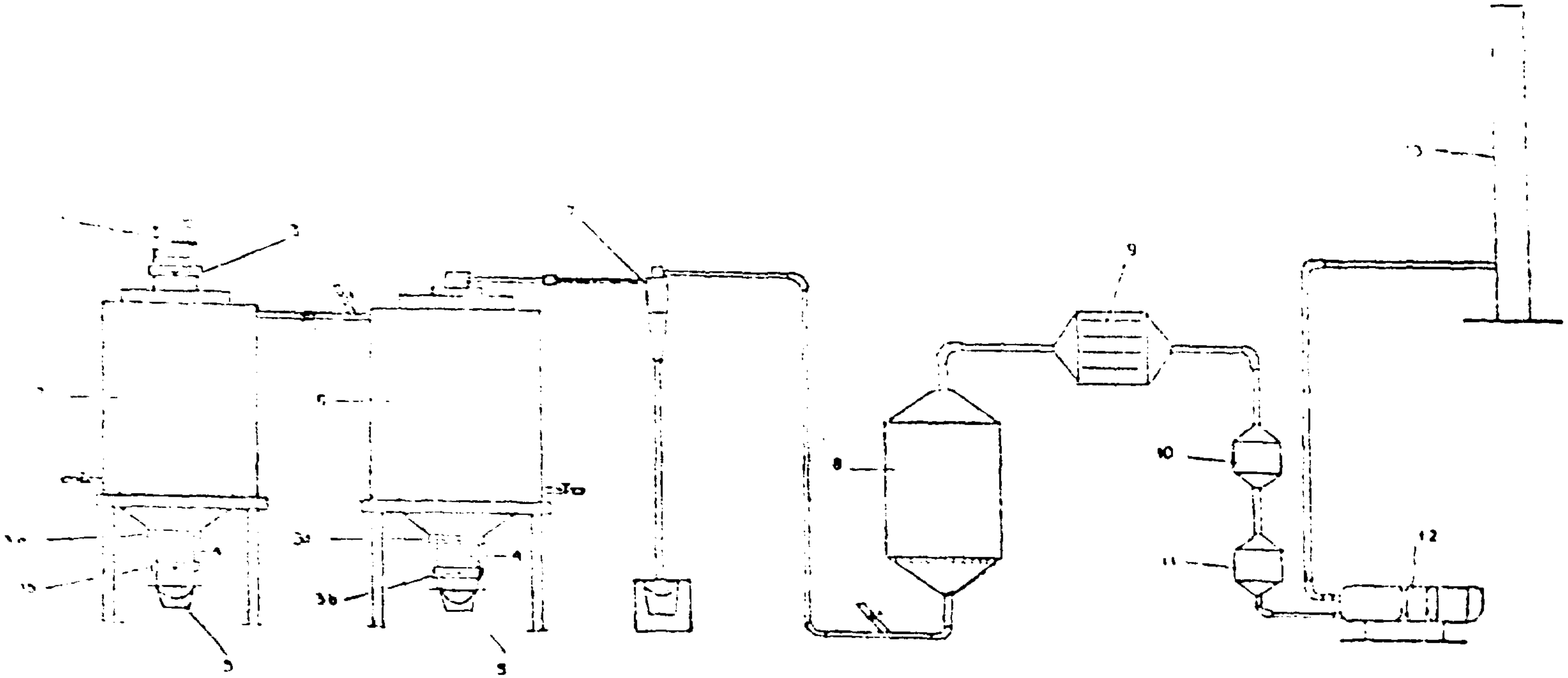
With these equipments the particulate from the off-gas are collected almost completely.

A condenser is provided to remove the moisture and eventual tritiated vapor from the off-gases. The dry off-gases are then directed to a HEPA filter (dimentions 600 x 600 x 350mm). It is used as an additional particulate collector to guarantee even higher filtration efficiency.

The volatile radionuclides, specially iodine, are removed by sorption in an activated carbon bed (600 x 600 x 350 mm) with > 99% efficiency. A secondary purpose of this bed is elimination of the odours.

The exhaust for the incineration process is executed by a vacuum pump. It creates a depression (-30 mbar), in the combustion chamber in the off-gas line and in the treatment train. The power rating of the pump is 7.5 HP and output 300 m^3/h.

The final liberation to the environment is made through a stack of 300 mm diameter and 16m height. The height of the stack was designed to guarantee enough depression in the incineration system even when there is a fault in the exhaust system.



1- Feeder
2- Incinerator furnace
3- Air-proof valve
3(a)-Air-proof valve-ashe collector
3(b)-Air-proof valve-ashe discharge
4- Intermediate cooling chamber
5- 20 L ashe drum
6- After-burning furnace
7- Cyclone separator
8- Eletrostatic precipitator
9- Condenser
10- HEPA filter
11- Active carbon bed
12- Vacuum pump
13- Stack

Figure 1 — Incineration system for the treatment of combustible wastes: solids and liquids

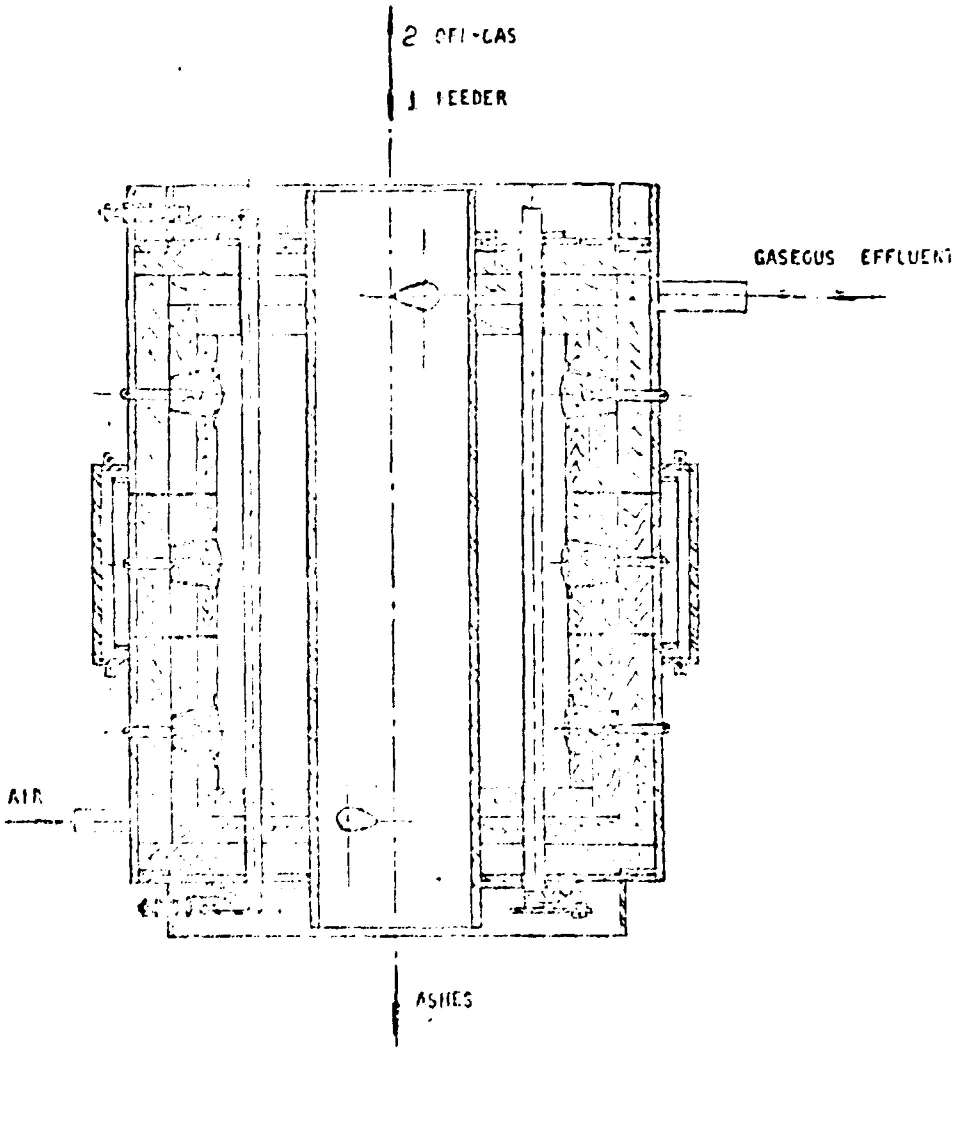


Figure 2 – Modular furnace (cross section)

COMMENTS

The design proposed for the incineration facility at IPEN-CNEN/SP for the burnable radwaste aimed to attend the following requisites: greatest safety, flexibility of the process, high combustion and off-gas, cleaning, efficiency and use of nationally available materials and equipments.

The facility was designed to minimize the off-gas generation by electrical heating which also enhances the safety.

The modular furnace coupling permits a higher flexibility insuring complete combustion or pyrolysis with higher burning capacity.

The double door system for the feeder or ashes collector guarantees operational safety conditions.

In addition to the immediate benefit of the incinerator facility i. e. a considerable reduction of the combustible wastes generated in IPEN, the most important benefit of it will be to serve as experimental incinerator for training, to design, construct and operate incinerator facilities for other nuclear installations in the country.

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