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BARTOLI B.- LISBONNE P.

CEA Centre d'Etudes Nucléaires de Cadarache, 13 - Saint-Paul-lez-Durance (FR). Dept. de Recherche et Developpement Dechets

INCINERATION PLANT FOR THERMAL DESTRUCTION OF RADIOACTIVE LIQUID WASTES

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INCINERATION PLANT FOR THERMAL DESTRUCTION OF RADIOACTIVE LIQUID WASTES

B. BARTOLI - P. LISBONNE

1. INTRODUCTION

In order to destroy organic liquids contaminated by radioelements we have selected incineration.

This treatment offers the advantage of reducing the volume of wastes considerably. Therefore an incineration plant has been built within the nuclear research center of Cadarache.

Starting operations, made with inactive organic liquids, were conducted from June 1980 to March 1981.

After this experimental work, the incineration plant was approved by safety authorities for the incineration of organic liquids contaminated by radioelements.

About 200 m^3 organic liquids, differing widely in their origins and nature, have been incinerated since the month of April 1981.

2. CHARACTERISTICS AND ORIGIN OF ORGANIC LIQUIDS

2.1 THE ORGANIC LIQUIDS, we are allowed to incinerate, have to meet the following specifications :

2.1.1 radiochemical standards

- radioelements α < 37.10^6 Becquerels/m^3
- radioelements β γ < 37.10^8 Becquerels/m^3

  (Co 60 < 15.10^8 Becquerels/m^3)
- tritium < 37.10^8 Becquerels/m^3

2.1.2 Chemical and physical standards

- chlorine < 20 % weight
- phosphorus < 1 % weight
- fluorine < 50 ppm
- solid suspended matters < 5 % weight

Before incineration, we prepared a 5 m^3 batch of organic liquids that are homogenised and we check the specifications.

If chemical and physical standards are not reached, we can try to get them through additional treatments.

2.? ORIGIN OF CONTAMINED ORGANIC LIQUIDS

Most of the organic liquids we usually incinerate come from four origins and are in nature very varied.

2.2.1 <u>French nuclear research centres</u>

Inside every centre there is a radioprotection department (SPR) that collects organic liquids used for the chemical treatment of nuclear materials or for cleaning contaminated materials.

These liquids are mainly :

. solvents, such as tributyl phosphate or trilaurylamine, used for refining uranium or plutonium

. chlorinated hydrocarbons such as trichlorethylene

2.2.2 <u>A specialized department (APSN)</u>, belonging to the Health Protection and Nuclear Safety Institute (IPSN) of the Atomic Energy Commission (CEA), must gather all contaminated organic liquids generated by small manufacturers in FRANCE such as hospitals, universities, industrial research centers.

These organic wastes are mainly scintillation liquids

2.2.3 <u>Nuclear power reactors worked by the EDF</u>

They mainly generate mechanical oils.

2.2.4 <u>Industrial plants of COGEMA company</u>

They generate also :

. tributylphosphate

. chlorinated solvents

. various oils coming from mechanical equipments used for uranium or plutonium production.

3. <u>DESCRIPTION OF THE INCINERATION PLANT</u>

The standard characteristics of the incineration plant are the following :

- thermal power : 200.000 kcal per hour
- liquid flow : 20 to 50 liters per hour depending on heat of combustion
- combustion temperature : about 900°C

The main steps of incineration process are the following :

- reception and preparation of organic liquids to be burnt
- incineration
- filtration and purification of combustion gases
- removal and embedding of the incineration ashes

3.1 RECEPTION AND PREPARATION OF ORGANIC LIQUIDS

This unit has equipment designed to transfer liquid, from their various packing containers into a tank having a meshscreen of 1 mm in size.

The liquid then passes through a 300 microns cartidge filter and is poured into a 5 m^3 tank equipped with an impeller for continous homogenisation.

In this way, we obtain a homogeneous batch ready for incineration. Beforehand, we take from this batch a sample in order to check radiochemical specifications.

3.2 INCINERATION

The incinerator plant is composed of burners, horizontal combustion chamber, followed by vertical chamber for cooling gases.

The pilot burner is fed with propane fuel gas and ignites the main burner. During starting time the main burner is first fed with fuel oil, until the kiln temperature reaches 900°C.

At this moment, contaminated organic liquids are injected through the burner in place of fuel oil.

Combustion is controled by regulating the flows of organic liquids and combustion air.

The shape of the horizontal combustion chamber is cylindrical (900 mm diameter, 3000 mm lenght). It is made of special refractory bricks, a sheet of diatomite bricks, then insulating lining with mineral fibers and an external shell made of steel (6 mm in thickness). With this structure, external temperature of the shell stays lower than 50°C.

The vertical chamber for cooling gas is also cylindrical in shaped (600 mm in diameter, 4000 mm in height).

At the top of this chamber, demineralised water is injected counterflowing in order to lower the gas temperature to 650°C.

3.3 FILTRATION AND PURIFICATION OF COMBUSTION GAS

The combustion gases, successively flow through a prefiltration unit, a filtration unit and a water sprayed tower.

- The prefiltration unit is equipped with filtering bags made of PTFE ; the maximum temperature allowed is 200° C. For this purpose, air at room temperature, is sprayed into the gaseous flux just before the prefiltration unit. Solid particles are caught on the external side of the filtering bags which are cleaned by counterflow blowing air. The solid particles then fall down to the bottom of the prefiltration unit.

- Unit filtration has five absolute filters, made of fiber glass. Retention efficiency of each absolute filter is 99,9 % according to the standard AFNOR X 44.011. The working temperature must be lower than 200 °C. Coming out of the filtration unit the gases are cleansed of the dust particles, the average size being higher than 0.3 microns, but still contained acid compounds formed during the incineration. They are neutralised by sodium hydroxyde solution. The gas-liquid contact is obtained by spraying solution with a hydro-ejector. Two fans for extracting the gases are placed after the washing device and maintain the pressure inside the incinerator lower than 10 mm water column.

3.4 REMOVAL AND EMBEDDING OF THE INCINERATION ASHES

An initial device for the removal of the ashes is placed at the bottom of the vertical chamber.

Most of the ashes accumulate at the bottom of the prefiltration unit. An extraction device has been designed in order to transfer them into 100 liter containers where the ashes are kept before conditionning. The embedding of the ashes is processed into a compound matrix based on concrete and resins.

4. THE RESULTS OF EXPERIMENTS

4.1. The incineration plant works continuously five days a week. The resulting interruption, every week end, very often causes thermal stresses to the refractory materials of the kiln. In spite of this, the refractory bricks appear to be in satisfactory condition and do no present abnormal corrosion.

For maintenance, the front lining, surrounding the burner is changed every year. The incinerator has been in operation for 5800 hours. During this cumulated time about 200 m^3 of contaminated organic liquids have been burnt, and their distribution is represented as follows :

- 35 m^3 of solvents composed with 30 % TBP
- 45 m^3 of chlorinated solvents
- 90 m^3 of scintillation liquids
- 30 m^3 mechanical oils.

At the beginning, this experimental incinerator had been used as a research and development plant. We have therefore defined operating conditions to incinerate contaminated liquids of widely various compositions.

4.2 The inciniration of solvents containing TBP was the most difficult problem to solve. The chemical compounds, resulting from combustion and derived from phosphorus acid, very quickly clog PTFE bag filters. To avoid this trouble, we have selected a calcium salt which is injected directly into the combustion chamber and neutralises phosphore acid which is converted into calcium phosphate. The ashes formed this way are not sticky and are easily removed from the bags filters. Their apparent density varies from 0.3 to 0.4 g/cm^3. About 70 kg ashes are formed for every 1 m^3 TBP solvent incinerated.

4.3 The incineration of the other organic liquids does not present the same difficulties except if both chlorine and phosphorus are present.

For every 1 m^3 of organic liquids incinerated about 7 kg of ashes are generated and this represents a very interesting concentration factor. Moreover ash density varies from 0.1 to 0.3 g/cm^3.

4.4 More than 99 % of the radioactivity content, contained in the organic liquids, is concentrated into the ashes which will be embedded in compound matrix.

Chemical and physical characterisations of the ashes have been determined relative to their origin and have been used to define the embedding process.

4.5 The other wastes resulting from the incineration are the alkaline solutions used for the neutralisation of acid vapors present in the combustion gas.

The alkaline solutions have practically no radioelements and the α content is lower than 37.10^3 Bq/m^3. Therefore these liquid effluents are considered to be inactive chemical effluents.

The gases are released into the atmosphere but their contents of radioelements α β γ are continuously monitored. The average α activity remains lower than 3700 Bq per m^3 of gases. On the gas flux there is an one line analyser with an alarm value set at 10^3 Bq. If we go beyond this limit the incineration is stopped and the origin of this irregularity must be found.

5. CONCLUSION

On the basis of six years of operation the incineration plant has shown reliable operating conditions in the destruction of various organic liquids contaminated with radioelements α β γ.

The capacity of incineration ranges from 20 l/h to 50 l/h depending on the heat of combustion of organic liquids. Not only are we using this incineration to destroy organic liquids, but at the same time we are continuing research and development programs in order to improve unit operation of the process (for example gas filtration) or to obtain better knowledge concerning the lifetime of materials planed in the construction of future incinerator plants.