FRENCH EXPERIENCE ON LOW LEVEL RADWASTE INCINERATION

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ABSTRACT

The experience acquired with two models of fixed hearth incinerators processing solid waste, essentially low beta-gamma solid radwaste and contaminated solvents, in the Research Centers of the Commissariat à l'Energie Atomique, in Cadarache and Grenoble, is presented by the authors. It represents a number of years of active operation.

The Cadarache incinerator operates with a dry and wet system for off-gas treatment. A synthesis of data obtained in active operation as well as comments on some difficulties encountered in the gas purification system are presented.

The Grenoble incinerator is equipped with a dry process for off-gas purification ; the design has been refined and standardized by SGN and installed in several countries. Results from these applications are also given.

PREAMBLE

A very wide experience on radioactive waste incineration has been accumulated in France, dating back as far as 20 years ago for the oldest installation and most of the other ones being in operation since 1970/1971.

This experience is mainly acquired within the CEA Group plants, the great majority of the research centers being equipped with incineration for their combustible solid and liquid waste and the reprocessing plants being equipped or supposed to be equipped in the near future with incineration installations, while waste issued from EDF nuclear power reactors operation is compacted for the time being.

Due to the historical background, a variety of technologies are found in operation, and due to the diversity of wastes, the experience gained covers low and medium level beta-gamma waste as well as low-alpha or rich-alpha contaminated waste, and solvents and liquids as well as solids.

It is the purpose of this presentation to give information and operating results related to beta-gamma waste incineration taking as examples the incinerator in operation on the nuclear research center of Cadarache, with a depleted - air combustion principle in the first chamber, and incinerators based on CEA/CEC patents, standardized by SGN, operating with excess air, for which experience has also been accumulated out of France ; some results of these foreign plants have been included in this presentation.

INCINERATION FACILITY FOR LOW ACTIVY SOLID WASTES FROM CEN CADARACHE

Introduction

As far back as the 1960's, it appeared of interest to incinerate low activity radwaste, collected from the CEN-CADARACHE facility.

The aim sought after was :

- to reduce the volume to be stored, approximately 60 % of this volume being, in actual fact, burnable,
- to transfer these wastes into a chemically stable form, identifiable and, in general insoluble.

The first incinerator built in 1966 operated up to 1975 but, due to the simplified equipment used (limiting the permissible activity of waste) and discontinuous charging system adopted, combustion conditions obtained were far from satisfactory.

Design for defining the incinerator in service - in collaboration with the Centre d'Etude des Charbonnages de France - mainly related to the preparation of waste, the design of the furnace and equipment containment (alpha hazard).

The average composition of waste volume considered by studies is as follows :

- Polyvinyl choride - 35 %
- Polyethylene - 20 %
- Latex (gloves) - 20 %
- Wet cellulose (cotton) - 20 %
- Wood and others - 5 %

Description

The incineration facility in operation (fig. 1) is divided into 3 sub-units :

- waste preparation;
- combustion;
- treatment of solid and gaseous residues.

Waste preparation and furnace feeding

Containment of radioactive material (alpha and beta-gamma emitters) is obtained by a system of glove boxes placed side by side, separated by sliding doors, with a tight connection between these and the furnace. One hundred liter drums filled with combustible waste are introduced into the first glove-box (forming air-lock) through an opening fitted with a swinging door and an inflatable seal which ensures tightness around the drum.

A visual inspection is made in the following glove-box to avoid passing massive metallic elements through the shredder. This latter is constituted by two horizontal shafts turning in reverse direction, fitted with knives. Shredded waste falls into a hopper with a capacity of approximately 500 liters directly connected on top of the feeding screw of the furnace. The screw rotating speed is variable and controlled by an opacimetric measurement on fumes. This screw conveys shredded waste into a sloping chute where they are entrained by air scavenging to the combustion chamber. The feeding chute temperature is maintained at less than 80°C by means of an air cooled double jacket.

Combustion of wastes

The vertical design furnace is divided into two chambers by means of a ceramic grid ensuring the aerodynamic separation of their atmosphere.

The lower chamber of a 1 m^3 volume is limited at its bottom section by the combustion grid constituted by mobile hinged flaps enabling combustion air inlet and daily discharge of ashes. Its atsmosphere is reductive - Temperature is maintained between 600 and 700°C.

The upper chamber, of a 2 m^3 volume receives the reductive gases after their passage through the separation grid and additional air, injected at high speed by 4 nozzles so as to create a high turbulence (O_2 in excess in gases - 8 to 10 %).

Two variable burners, fed with propane, bring in each chamber the required heat surplus.

The depression in the chambers is maintained at a value close to - 20 mm/WG and the safety is completed by an air circulation double jacket.

Treatment of residues

a) Purifying of combustion gases

When leaving the furnace the combustion gases pass through a masoned chamber where their temperature is brought down to 150-160°C, by dilution with filtered air whose flowrate may be adjusted.

These are then filtered on two high efficiency filter stages.

A second dilution enables the gas temperature to be lowered to a value < 60°C before their admission in a neutralizer-scrubber fitted with a pH controller.

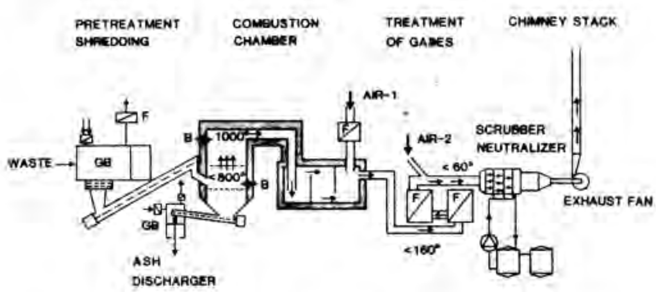
The role of the scrubber is to eliminate the acids formed during combustion before release into the atmosphere.

Two extractors, one of which in stand-by, ensure the extraction of combustion gases together with the depression inside the furnace and ducts.

b) Discharge of ashes

The ash box, of a 600 liter volume, the walls of which are constituted by a double cooling jacket, is divided into two sections by a grid fitted with mobile hinged flaps. Its lower section forming a chute is provided with an extraction screw enabling the transfer of cold ashes to the bagging glove box.

At present, ashes are stored in 100 liter drums, until a conditioning method (concrete, bitumen, thermosetting resins...) whose characteristics are under study (mechanical resistance, leaching rate...) be chosen.



SOLID-WASTE INCINERATOR AT C.E.N.- CADARACHE

GB - GLOVE BOX
B - BURNER
F - HEPA FILTER

FIG. 1

Results obtained and improvements

Started up in 1981, following inactive acceptance tests, the first campaigns with this installation have been performed with low activity beta-gamma wastes.

This probative period was intended for checking the basic safety options and for improving the process before introducing into the incinerator alpha contaminated wastes (plutonium contamination).

Results of the first campaigns

The incineration capacity ranges between 20 and 25 kg/h according to the nature of wastes.

The volume and weight reduction factors obtained on average are respectively 80 and 35.

With respect to radioactivity, analyses performed have shown that :

a) for ashes
   - in beta-gamma, the average specific activity is 5.10^{-8} Ci/g (60 % of which are due to 60 Co and 137 Cs).
   - in alpha, the average specific activity is 4.10^{-9} Ci/g (more than 80 % of which due to plutonium and americium).

b) for fly ashes collected on filters, the specific activities are respectively : $1.3.10^{-8}$ Ci/g in beta-gamma and $1.7.10^{-10}$ Ci/g in alpha.

c) for neutralizer-scrubber water, values are always lower than the limits of discharge into the center chemical effluents sewer system.

d) analyses performed on gases give non significant results upstream of the discharge stack.

Improvements envisaged

The main difficulty encountered in operation results from the heterogeneity of the nature of wastes to be treated. In spite of the mixing performed in the feeding hopper, after shredding of wastes, in practice it is difficult to obtain the constant rate of heat release desired.

As a consequence, filters clog too rapidly due to the variations in the rate of unburnt residues in the combustion gases.

Although the average value measured by opacimetry at the furnace outlet is relatively low, around 40 to 50 mg/m^3, incomplete combustion phases are revealed. In order to cope with this problem, tests, bearing on the performances and maintenance of the different types of industrial filters that may be periodically cleaned out as well as of a high temperature candle filter (CEA-SGN), will be performed in 1984.

These prefilters will be installed upstream of the high efficiency filters.

INCINERATION IN A FIXED HEARTH WITH EXCESS AIR

Introduction

Experimentation in France on radioactive waste incineration in a fixed hearth, with excess air, began in 1962. Two incinerators have been installed in 1970/1971, one at the CEA nuclear research center of Grenoble and one at the CNRS * center in Strasbourg, the latter for destruction of various liquids, solid items and animals contaminated with radioelements. Both with a capacity around 15 kg/h are still in good operating conditions.

The system, referred to as the CEA/SGN incinerator, has shown main qualities of reliability and efficiency and is now standardized.

The technique has been exported to Japan where three facilities operate on the system described below and a fourth one is under construction. The main qualities of the system are :

- an operation under constant negative pressure and with excess air giving maximum guarantees for safety.
- acceptance of a wide range of wastes, including solvents.
- easy evacuation of ashes perfectly inert and sterile.
- practically no moving mechanisms and as a result no servitude with respect to the efficiency and reliability of seals on mobile parts.
- destruction of carbon black in the fumes, element which may be disturbing and even dangerous in gas purification systems.
- a perfectly complete combustion with excellent volume and weight reduction factors.
- a hot purification of fumes and a fully dry process.
- a simple and less expensive equipment, a flexible operation which may be completely automated.

General description of the CEA/SGN standardized system (Fig. 2)

This incineration system is mainly comprised of :

- a section with metal detection, sorting, bagging, weighing and an automatic air-lock device for loading the wastes into the incinerator ; the discontinuous introduction of cardboxes filled with waste, previously weighed is automatically achieved through a programmable controller.

* Centre National de la Recherche Scientifique.

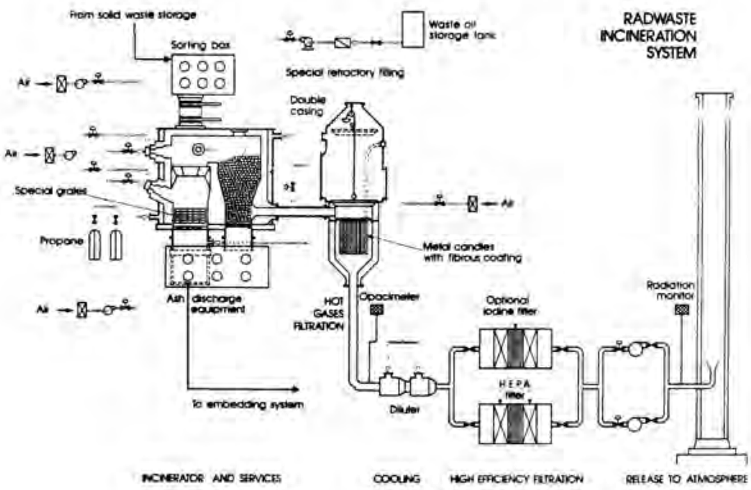


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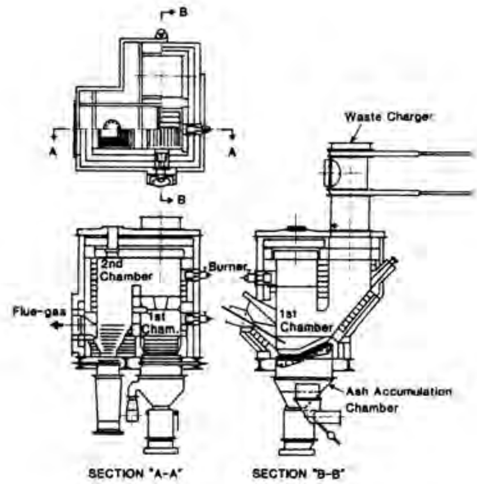
FIG 2



VIEW OF FURNACE OF INCINERATOR

FIG. 3

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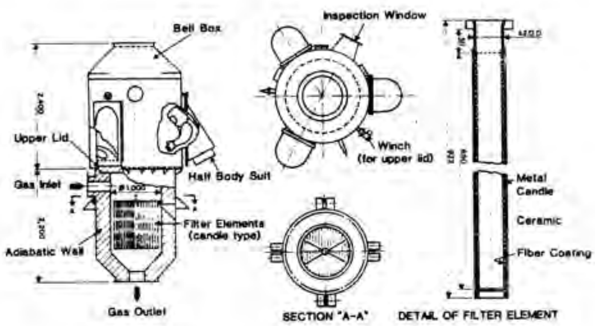

STRUCTURE OF HIGH TEMPERATURE FILTER

FIG. 4

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- the incinerator itself (Fig. 3) with :

  . its loading well,

  . its combustion chamber lined with high quality refractories,

  . its propane gas burners for possible combustion adjustment and for post-combustion,

  . its special solvent burner for contaminated solvents,

  . its special grid* and ash evacuation system,

  . its post-combustion* chamber filled with special silicon carbide pebbles.

- a high temperature regenerable filter* (Fig. 4) comprised of metallic (micro expanded metal) candles coated with mineral fiber as filtering medium. This filter can be regenerated manually with a special equipment and frogsuit arrangement. A completely automatic regeneration system is under development, using a robot comprised of :

  . an unloading (by brushing and suction) and re-coating (applying a fiber dispersion to, the inside of the candle) tool, automatically moving one from candle to the other,

  . a control station with a microprocessor,

  . an electric and pneumatic control center.

- a hot gas diluter operating by controlled admission of air at ambient temperature.

- a high efficiency filtration caisson with iodine traps on request.

- two exhaust fans, one of which in stand-by, with guide-vanes aperture depending on the furnace negative pressure.

- a discharge stack.

- regulation control and supervision equipment using a programmable controller.

- the conditioning of ashes before storage, if required, such as :

  . cementation,

  . embedding with bitumen,

  . embedding into thermosetting resins,

  . embedding or digestion in amorphous or crystalline matrices.

* patented

Experience in active operation for some CEA/SGN incinerators

CEN Grenoble incinerator

Ordered by the CEA in 1970 to CECE following a joint study, this apparatus, which has been designed for convenience purposes and which was the first of the series, has been used for several years as a pilot for development on real scale.

Its theoretical incineration capacity is 15 kg/h for wastes with a net calorific value of 5900 kcal/kg.

The following points have been examined and have led to some modifications :

- loading air-lock : addition of a package detection system,
- grids : modification of profiles and alloys,
- burners : passage from domestic fuel oil to natural gas,
- ash and silicon carbide hoppers : modification of evacuation,
- piping : air cooling of certain sections,
- control of the furnace depression : replacing of a servo-controlled high temperature valve by a guide-vane gas extractor,
- high temperature filter : durability study of metal alloys used for candles and study of the corrosion problem at high temperature,
- fumes extraction unit : increase of the number of fans.

After a shutdown between april and december 74, the facility operated with active wastes up to the end of 1977, 8 hours a day, 5 days a week.

The actual incineration capacity was on average 12 kg/h (latex, rags, paper, polyethylene, neoprene).

The beta dose rate was ranging between 0 and 10 mRem/h per package.

Ashes collected into 200 liter drums had an activity of 150 mCi/drum (corresponding to a dose rate of 15 mRem/h at one meter from the drum).

From 1978 to 1980 the facility has been used only rarely. It was completely reconditioned in 1980 and until 1983 it was subject to a serie of tests during which were burnt :

- discarded equipment	600 kg
- laboratory animals	490 kg
- polyethylene	110 kg
- oils	940 liters

At the beginning of 1984, the authorization for burning active solvents was granted by the "Safety Commission" and the first campaign currently in progress aims at destroying 15 m3 of solvents (acetone, toluene, dioxane, xylene, various organo-chlorinated products) and light oils. Taking into account the differences in terms of flash-points and viscosities between solvents and oils a convenient mixture of 50 % of each kind has been found well adapted to the special burner.

CNRS incinerator at Strasbourg

The CNRS incinerator is mainly used for treating carcases of small animals from biology laboratories where they have been contaminated by radioelements used as tracers.

It also ensures the treatment of contaminated combustible liquids.

Maximum activities admitted by safety authorities are as follows :

- animals : tracing by P32 at a rate of 2 mCi/kg
- solvents : tracing either by C14 at a rate of 0.2 mCi/kg or by tritium at a rate of 0.02 mCi/l.

The theoretical destruction capacity of the incinerator is 15 kg/h. Its operation started in 1971, and this incinerator is the second apparatus of the type.

The results of operation are as follows :

Operating : discontinuous and generally by campaigns of 9 hours per day, 3 hours for heating and six hours of actual incineration.

a) Composition of solid wastes :

- 70 % of small animals,
- 10 % of egg shells and papers,
- 20 % of various plastics.

At present, the incineration of plastics has considerably decreased, their elimination being no longer centralized in the CNRS.

b) Composition of liquid wastes :

Mainly scintillator solvents (toluene, dioxane).

Quantities incinerated :

Between 1971 and 1983, approximately 72 000 kg of solids and 13,5 m^3 of liquids.

The volume reduction obtained is approximately 20 and the ash activity around 4 mCi/kg, 86 % of initial activity is retained in the ashes.

PNC incinerator at Tokai-Mura

The incinerator was studied in France and installed on the site in 1973.

The apparatus has been subjected to various tests, it has been almost entirely disassembled and reassembled with certain modifications so as to ensure the incineration of alpha wastes from the laboratory, whereas it was initially intended for beta and gamma wastes.

Its operating with alpha started up on december 1982.

The main modifications concerned :

- the installation of a double casing on the incinerator,
- the replacing of secondary burner (initially operating with kerosene) by a propane burner.

The theoretical capacity of the incinerator is 20 kg/h.

The actual incineration of wastes only lasts 2 hours per day.

The wastes to be incinerated are delivered in 18 liter cardboard drums and represent 2 kg approximately. Six cardboxes are put together in a 208 l cardboard drum.

Ashes are evacuated under a glove box into 3 liter plastic bottles.

The dose rates checked in contact with the bottles vary from 0.01 mRem/h to 50 mRem/h.

There is no recovery of Pu from ashes, stored till a process is chosen for their immobilization.

The average composition of wastes is as follows :

- papers and rags 50 % in weight
- plastics 45 % in weight
- rubber 5 % in weight

There is neither neoprene nor PVC in the wastes, those being intended for treatment by acid digestion.

The incinerator is also used for burning oils.

The daily capacity treated is generally as follows :

- solid wastes : 20 to 30 kg (approximately 2 drums)
- oils : 6 liters

The volume reduction obtained is from 50 to 80 and the weight reduction around 20.

A radioactive concentration of gases in alphas at the stack is lower than 2×10^{-14} µCi/cm3.

This activity of 2×10^{-14} µCi/cm^3 is a prescribed threshold (average on 8 days, then on 3 months).

After high efficiency filtration, although no PVC has been burnt, a washing of gases is performed (so as to increase the decontamination factor and as a safety measure).

The annual quantities incinerated range between 100 to 150 drums of 208 liters.

The difficulties encountered have been :

- jamming of connecting rods actuating the diluter. This problem has been solved,
- corrosion at the gas washing system level.

JAERI incinerator at OARAI

This incinerator has been entirely studied and manufactured in France, it has been installed on the site in 1977.

During the first two years, it has been used for treating inactive wastes and enabled the staff to become familiar with its operation, in particular by performing several testing campaigns.

The two following years it has been used for treating wastes contaminated by beta-gamma emitters and a further important and detailed testing* campaign (Fig. 5 to 7) was started.

Since this date, the incinerator ensures the treatment of beta-gamma wastes, with a little alpha contamination. It is normally operating 3 hours per day, 2 days a week with an hourly capacity around 16 kg.

Four metric tons are treated annually which is much lower than the capacity of the apparatus.

The wastes do not contain PVC, material now prohibited in Japan for nuclear industry and the fumes are directly released without scrubbing.

The activity of wastes in alpha emitters is lower than 1 mCi per cardbox and the dose rate in contact with these cardboxes does not exceed 50 mRem/h.

The difficulties encountered have been :

- In a first time, only paper was incinerated and it is well known that paper sheets keep their shape and have a tendency to blow off with the flow of fumes.
- As a result, the post-combustion chamber has been frequently obturated at the upper level of silicon carbide. The installation of a vertical grid across the passage of fumes easily copes with this problem.
- The partial evacuation of silicon carbide has led to difficulties at the draining trap-level where aggregates were blocked. A rotating evacuating device has solved the difficulty.
- Mechanical problems with the rods actuating the diluter now solved as seen previously.

* Report IBARAKI-KEN 311-13 JAERI

OARAI INCINERATOR
COMPOSITION OF CARTON PACKAGE

COMPONENTS	WEIGHT (g)	MOISTURE (wt%)	ASH (wt%)	COMBUSTIBLE (wt%)	ULTIMATE (wt%) COMPOSITION			HEATING VALUE k.cal/kg
					C*	H*	N*	
CARTON BOX	180	7.5	12.4	80.2	36.9	5.5	0.3	3700
PAPER TOWEL	410	7.1	0.6	92.3	42.3	6.1	<0.2	3900
TISSUE PAPER	410	6.2	6.9	86.8	38.4	6.1	<0.2	3600
POLYETHYLENE	1000	<0.1	<0.1	100	84.7	12.8	0.4	10700
TOTAL	2000							
AVERAGE COMPOSITION		3.40	2.65	93.94	63.00	9.41	0.22	7220

* MOISTURE FREE BASIS

CUMULATED AMOUNT TREATED: SINCE 1977 ABOUT 25 TONS (CORRESPONDING TO 2 DAYS / WEEK ONE SHIFT)

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FIG. 5

OPERATION RESULTS OF β, γ SOLID WASTE INCINERATION

RUN-No.	RUN-1	RUN-2	RUN-3
TERM OF OPERATION	29 JULY 80 TO 10 APRIL 81	11 MAY 81 TO 31 JULY 81	11SEPT. 81 TO 26 FEB. 82
NUMBER OF OPERATION DAYS	47	53	30
WASTE CHARGING HOURS	65.5	145.3	78.1
WASTE CHARGING HOURS IN AVERAGE (HOURS / DAY)	1.4	2.7	2.6
NUMBER OF CARTON BOXES	490	1085	604
TOTAL WEIGHT (kg)	1172	2341	1364
CONTENTS	PAPER RAGS OVERALLS	PAPER RAGS	PAPER RAGS PLYWOOD FRAME OF HEPA FILTERS
SURFACE DOSE RATE IN AVERAGE (mRem/h)	0.183	0.078	0.075

ALPHA INCINERATOR BETA-GAMMA TEST

FIG. 6

	RUN N°		11	12	13	14	15	AVERAGE
H.T.F. INLET SIDE	OFF - GAS AMOUNT	ℓ	946.8	1363.7	2317.8	2230.4	3001.4	
	COLLECTED DUST AMOUNT	mg	58.3	76.9	92.6	84.4	117.4	
	LOSS ON IGNITION	mg	55.3	74.3	100.0	82.0	118.2	
	DUST CONCENTRATION	mg/Nm^3	61.6	56.4	40.0	37.9	39.1	47.0
	INCOMING DUST	g/h	32.4	29.7	21.0	19.9	20.8	24.7
	DUST CARBON PERCENTAGE	—	0.95	0.97		0.97		0.963
H.T.F. OUTLET SIDE	OFF - GAS AMOUNT	ℓ	2500.3	2517.2	2361.6	2187.3	2943.3	
	COLLECTED DUST AMOUNT	mg	0.8	0.4	0.4	0.3	0.1	0.4
	LOSS ON IGNITION		0	0	0	0	0	
	DUST CONCENTRATION	mg/Nm^3	0.32	0.16	0.17	0.14	0.03	0.164
	OUTGOING DUST	g/h	0.17	0.084	0.089	0.073	0.016	0.086
	DUST CARBON PERCENTAGE	—	0	0	0	0	0	0
COLLECTED ASH IN 1st AND 2nd CHAMBER (%)		—	0.924	0.930	0.951	0.953	0.951	0.942
H.T.F. EFFICIENCY (DUST RETENTION)		—	0.995	0.997	0.996	0.996	0.9992	0.9966
INCINERATOR + H.T.F. EFFICIENCY (DUST RETENTION)		—	0.99960	0.99980	0.99979	0.99983	0.99996	0.99980
INCINERATOR + H.T.F. DECONTAMINATION FACTOR			2.53×10^3	5.04×10^3	4.75×10^3	5.77×10^3	2.69×10^4	$0.9 \times 10^4 \sim 10^4$

EXPERIMENTAL RESULTS

FIG. 7

CONCLUSION

The incineration systems described have proved very reliable and very efficient for volume reduction and weight reduction of radioactive waste and the discharge to the stack has shown considerably lower figures than the accepted standards.

For the standardized system operating with excess air extensive studies have led to the main following performances :

- a retention over 93 % of ashes and fly ashes in the incinerator and post combustion chamber,
- an efficiency of the high temperature filter, ensuring the dry treatment of fumes, with practically no secondary residues, in excess of 99 %. The solids collected are burnt on the filter, the lifetime of which between regenerations being of several thousand hours,
- a decontamination factor of the furnace plus the high temperature filter in the order of 10^4.

Larger capacity than those presented here have been studied, up to 100 kg/h.

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