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THE IRIS INCINERATOR AT CEA – VALDUC
ASSESSMENT AFTER ONE YEAR OF ACTIVE WASTE INCINERATION

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ABSTRACT

In the operation of its facilities, the Valduc Research Center produces alpha contaminated solid waste. The Valduc Center has built an incineration facility to treat the most contaminated combustible waste.

The process selected for waste incineration is the IRIS process. It was developped by the CEA at the Marcoule Nuclear Research Center. The Valduc Center asked SGN to build the incineration facility.

The facility was commissioned in late 1996, and inactive waste incineration campaigns were run during more than 2,500 hours in 1997-1998. In this period, chlorinated waste incineration test runs have been performed using the phophatizing process developped by the Marcoule Research Center. Active commissioning of the facility was performed in March 1999. From then till now on, three campaigns with active waste have been carried out, the results of which are given in the paper. The Valduc incinerator is now the first industrial active application of the IRIS process.

INTRODUCTION

The operation of the facilities at the Valduc center, which belongs to CEA's Military Applications Directorate, generates various grades of waste.

Waste compatible with near surface disposal requirements is sent to Centre de Stockage de l'Aube, operated by ANDRA, the French radioactive waste management agency. The rest is processed to reduce its volume and to permit its storage in conditions that comply with the permits granted by the French Safety Authorities.

The Valduc Center asked SGN to build an incineration facility to treat the most contaminated combustible waste.

WASTE TREATED

The waste to be incinerated has the following composition by weight :

- PVC 50%
- latex and neoprene 35%
- cellulose 10%
- polyethylene 5%

The average activity of the waste is 7.5 10^8 Bq/kg (0.02 Ci/kg).

The waste is conditioned in 10 to 20 l bags set in a double containment and placed in 100 l drums.

THE INCINERATION UNIT

SGN is the Prime Contractor for the project on behalf of CEA/DAM (Valduc Center), the Owner. CEA/DCC (Marcoule Center) is the Licensor and is accordingly responsible for complimentary development tests.

The incinerator is installed in a new three-storey building with a total volume of about 5000 m^3.

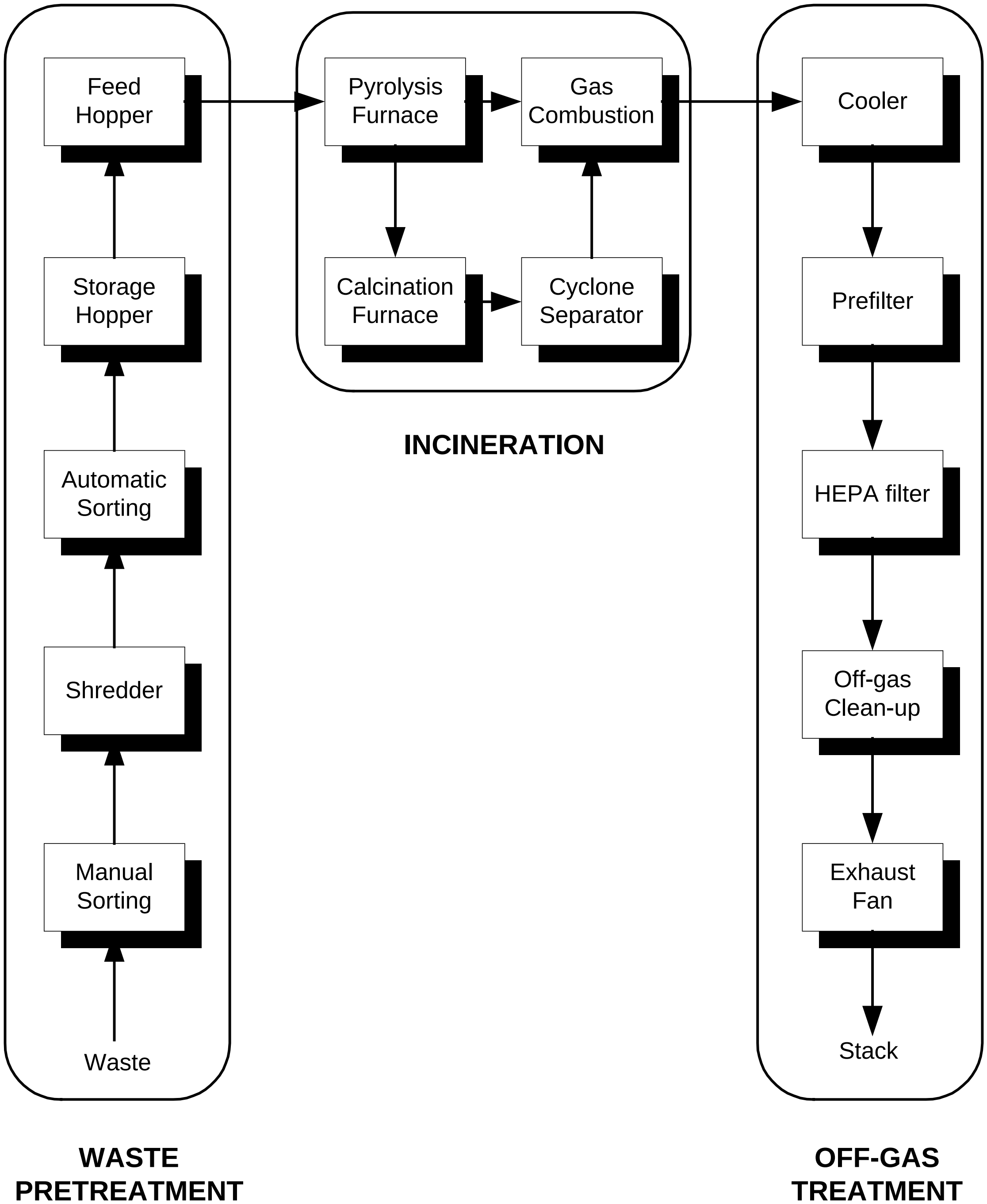
The Valduc facility, the first industrial application of the IRIS process (see below), has been designed for having the capacity to treat 26 t of contaminated waste per year.

THE IRIS PROCESS

The CEA/DCC carried out more than 5000 h of tests on its inactive pilot facility in Marcoule. The process was designed to meet the safety requirements for alpha waste. Incineration is carried out in two stages followed by off-gas postcombustion in small furnaces, enabling their installation in radioactive material containments.

The process also produces ash in a grade suitable for instance for in-line vitrification, or plutonium recovery by argentic dissolution.

The different steps of the IRIS process are shown in the diagram below



IRIS PROCESS BLOCK DIAGRAM

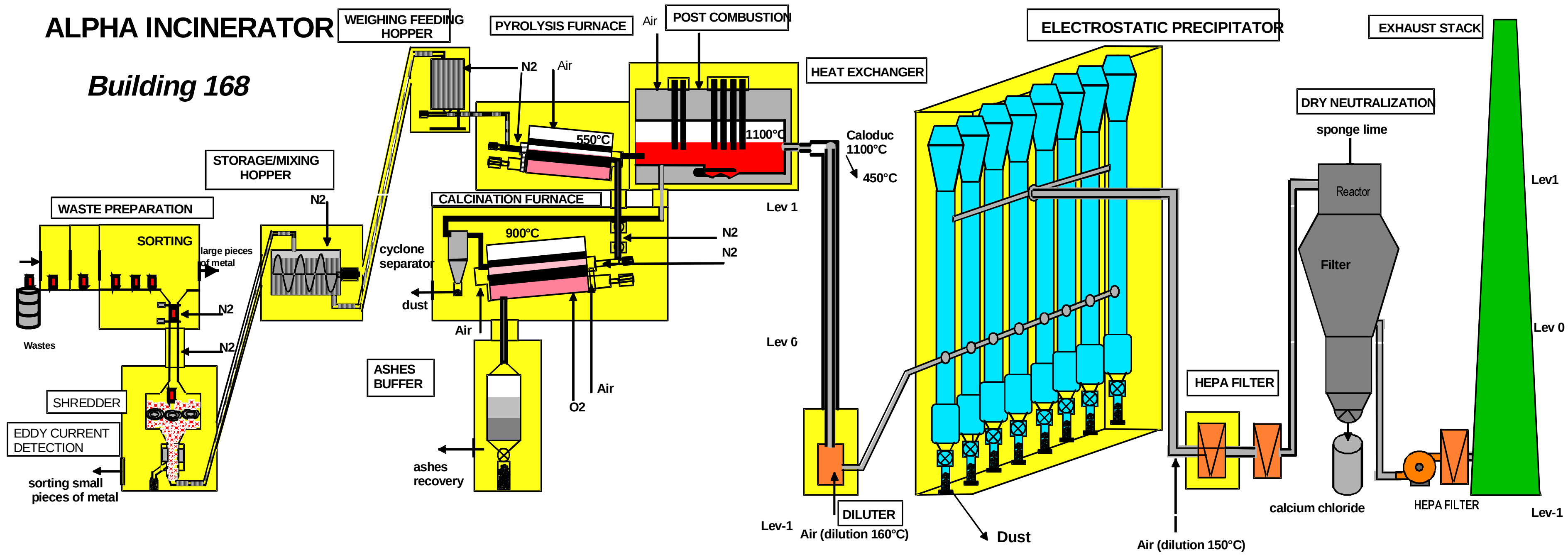


Fig. 1 : Incinerator components

Waste preparation
This part includes the following steps :

- X-ray inspection to detect large metal parts ;
- manual extraction of large metal parts if necessary ;
- waste shredding ;
- detection and automatic extraction of small metal parts ;
- buffer storage of shredded waste.

Incineration
This part includes the following steps :

- pyrolysis furnace feed at a maximum regulated rate of 7 kg/h ;
- waste pyrolysis at 550 °C in reducing atmosphere, yielding a combustible gas and a solid residue called pitch essentially consisting of carbon ;
- pitch calcination at 900 °C in oxygen-enriched atmosphere to obtain ash ;
- combustion of pyrolysis and calcination gases at 1100 °C in a post-combustion furnace.

Off-gas treatment
This part includes the following steps :

- gas cooling by passage through a pipe heat exchanger, followed by mixing with cold air ;
- gas prefiltration in an electrofilter featuring 99.8% filtration efficient ;
- HEPA filtration to meet the site release specifications ;
- chemical purification of inactive gases by dry neutralization ; performance of the process takes account of the European guidelines and applicable French legislation (see table 1).

CAPACITY AND OPERATING MODE

The facility operates five days per week with :

- waste preparation during normal working hours (8 h/day) ;
- continuous and automated waste incineration and off-gas treatment.

The facilities are placed on standby on weekends.

The facility has a maximum capacity of 7 kg/h.

For an annual 26 t of waste treated, it will produce about 1300 kg of ash and about 400 kg of dust per year. The ash and dust are conditioned in stainless steel pots and stored under a double vinyl containment in metal drums awaiting treatment or conditioning.

THE EQUIPMENT

The waste preparation equipment is built using standard machines adapted to operate in ventilated containments and modified for minimum holdup.

The pyrolysis and calcination furnaces were developed specifically for this type of application. They are rotary furnaces (see fig. 1) consisting of a metal tube surrounded by heating shells. This design accounted for maintenance operations, and all routine operations can be performed without opening the containment barrier provided by the ventilated sealed containment.

The three furnaces (pyrolysis, calcination and post combustion) are electrically heated, simplifying the auxiliary circuits while reducing the volume of off-gases.

The pyrolysis furnace is fed at a regulated rate to allow constant flue gas discharge and temperature.

Heat losses from the furnaces are removed outside the containments partly through heat pipes, which offer the advantage of requiring no energy source.

The heat exchanger used for the first gas cooling step is a water heat pipe whose two-shell evaporator surrounds the flue gas duct. The duct can easily be cleaned under containment if necessary.

The electrofilter has eight tubes in which the gas stream from the cooler is distributed. Along its centerline, each tube has a tubular stainless steel electrode raised to about 70,000 V. The geometry of the electrofilter allows cleaning by a scrapper device for zeroing of the radioactive material balance. For weekly recovery of dust, the tubes are cleared by striking.

The gases are chemically purified by a dry neutralization process operating with sponge lime at about 130°C, since liquid releases from the Valduc Center are not authorized.

WASTE ACCEPTABILITY RANGE

Inactive incineration campaigns were conducted at Valduc by varying the type of waste in order to validate the acceptance range for the different types of wastes produced at the Center. These campaigns have shown the flexibility of the process versus waste type and composition.

MASS AND ACTIVITY BALANCE

During the inactive tests in 1997/1998, 6,434 kg of waste were incinerated producing globally 310 kg of ashes.

During the two active campaigns carried out in 1999 for which we have got data (the third campaign just ended), mass and activity balance were performed and gave the following results:

	1st campaign	2nd campaign
Mass of incinerated waste (kg)	395	360
Waste activity (Ci/kg)	0.005	0.03
Mass of ashes (kg)	16	20.3
Mass of dust (kg)	0.86	0.93
MRF (waste vs ashes)	25	17
Recovered dust after cleaning (kg)	1.6	1.3 *
Pu mass in the waste (g)	33.0 ±20%	179.1 ±20%
Pu mass in the ashes (g)	28.5 ±12%	162 ±12%
Pu mass in the dust (g)	0.03 ±12%	0.7 ±12%
Recovered Pu after cleaning (g)	0.3 ±20%	3.2 ±20%*

* Only partial cleaning was performed at the end of the second campaign

The above table shows that the IRIS process allows :

- to reach an optimum Mass Reduction Ratio according to the waste which has been incinerated (very low carbon content in the ashes),
- to recover most of the plutonium in the ashes,
- to get a small quantity of low activity dust.

A very good load factor was reached for these two campaigns : more than 0.95.

During these first active waste incineration campaigns, the runs have been followed by drainage and cleaning of the facility to obtain feedback on the distribution of active material holdup in the facility.

Hence these campaigns are very useful for the criticality safety assessment the principles of which are described hereafter.

Criticality risk prevention is based on limiting the mass of active material undergoing treatment in the facility. A balance is compiled continuously by calculating the difference between the mass of active material entering the facility and the mass leaving it. These masses are evaluated by activity measurements performed on qualified equipment by measurement circuits.

Due to measurement uncertainty, the absence of holdup in the components must be checked periodically. Measurement are taken chiefly by gamma spectrometry, allowing overall or targeted measurement with a collimator, and, for the post-combustion, by passive neutron counting. The instruments used are mobile, since no continuous holdup measurement is carried out. If necessary, gamma detectors are introduced into the components to locate any holdup.

Holdup can also be visualized by endoscopy.

The balance is zeroed periodically by cleaning and drainage of the whole equipment.

The results from the first campaign holdup measurements (24 points were checked by gamma-ray measurements) did not show any particular accumulation of plutonium. The only noticeable accumulation of Pu was located at the end of the calcination furnace (about 200mg +/- 50%) and at the entrance of the cyclone separator.

Passive neutron measurements have also been performed on the post-combustion furnace. Due to the uncertainty (+/- 100%), the result (2 g of Pu) is not representative.

Endoscopic visualization has also confirmed the absence of corrosion.

OFF-GAS TREATMENT PERFORMANCES

Zinc phosphatizing results

The combustion of waste containing high proportions of chlorine and metallic oxides leads to the formation of volatile metallic chlorides. Zinc chloride in particular is a very hygroscopic product which becomes highly corrosive after absorbing moisture. To prevent the absorption of moisture, all the flue gas treatment equipment is kept at temperature by electrical tracing. This tracing is necessary in operation, and also during shutdowns. Maintenance operations must be conducted in a dry atmosphere.

The Marcoule Research Center, the Licensor, has developed a process in which phosphorus is injected into the incineration process in organic form to promote fines phosphatization reactions to the detriment of chloride formation. In fact, zinc phosphate is a much more stable compound than zinc chloride. It is not hygroscopic, not corrosive at ambient temperature, is virtually insoluble in water, can be vitrified and melted to reduce its volume. This phosphatizing process has been selected by CEA for the Valduc Research Center.

Inspections performed after the inactive incineration runs revealed the complete absence of corrosion in the equipment.

To optimally control the quantity of phosphorous injected in line with the zinc content of the waste to be incinerated, the Valduc Center proposes to conduct waste management upstream of incineration, by adjusting the feed to obtain the right ratio between the phosphorous and zinc contents.

Gaseous emissions results

During the inactive tests, INERIS (Institut National de l'Environnement Industriel et des Risques) has performed poluutants measurements in the atmospheric off gas emissions. The samples have been taken downstream the dry neutralization.

The results of these measurements are much lower than the pollutants emission limits set by the French "Arrêté" of October the 10th, 1996 which derives from the European Community Directives concerning the incineration of dangerous waste as shown in the following table.

Pollutants	French law 10/10/1996	Measured values November 1997
Total dust (mg/Nm^3)	10	0.1
Volatil Organic Total Carbon (mg/Nm^3)	10	3.5
CO (mg/Nm^3)	50	6
SO_2 (mg/Nm^3)	50	0.8
HCl (mg/Nm^3)	10	2.5
HF (mg/Nm^3)		
(Cd, Tl) (mg/Nm^3)	0.05	0.04
Hg (mg/Nm^3)	0.05	0.0002
(Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn, Se, Te) (mg/Nm^3)	0.5	0.013
(Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn, Se, Te) + Zn (mg/Nm^3)	5	0.014
Dioxins and furans (ng/Nm^3)	0.1	0.008

Table 1: comparison of measured pollutants concentration in off-gases vs French law

CONCLUSION

Inactive waste incineration campaigns in 1997/1998 and the first active campaigns carried out in 1999 allowed to validate design options taken by the CEA (as Licensor and operator) and SGN (prime contractor).

Some of these have been discussed in the paper such as :

- performance of the IRIS incineration process :
  - wide waste acceptance range,
  - important Mass Reduction Factor,
  - excellent recovery of plutonium in the ashes,
  - alpha contaminated waste adapted process ;
- criticality safety assessment principles :
  - localization of active material hold-up in the facility,
  - efficiency of the activity measurements ;
- off-gas treatment performances :
  - very low level of chemical pollutants emission (well under the French regulation limits),
  - very good results with the CEA phophatizing process inducing no corrosion on the equipment and good quality of the electrofilter dust.

The first industrial application of the IRIS process will give, in the future, more information on the operating behaviour of such a facility which, in consequence, will be very useful for any other facility to be built based on the same process.

ACKNOWLEDGMENTS

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