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ALPHA WASTE INCINERATION PROTOTYPE INCINERATOR AND INDUSTRIAL PROJECT

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ALPHA WASTE INCINERATION

PROTOTYPE INCINERATOR AND INDUSTRIAL PROJECT

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COMMISSSARIAT A L'ENERGIE ATOMIQUE - FRANCE

ABSTRACT

To meet our requirements with respect to the processing of solid alpha wastes, a pilot cold incinerator has been used for R & D. This unit has a capacity of 5 kg/hr. The main objectives assigned to this incineration process are: a good reduction factor, controlled combustion, ash composition compatible with plutonium recovery, limited secondary solid and fluid wastes, releases within the nuclear and chemical standards, and in strict observance of the confinement and criticality safety rules.

After describing the process we will discuss the major results of the incineration test campaigns with representative solid wastes (50% PVC). We will then give a description of an industrial project with a capacity of 7 kg/hr, followed by a cost estimate.

Introduction

The manufacturing and research operations carried out at the CEA produce wastes contaminated with alpha emitters. The applicable standard for disposal from the La Manche storage site, near La Hague, is of 0,1 Ci/t. Non-disposable wastes are processed at Centers where incineration has been opted for as a solution to the management of combustible wastes which account for a large share in terms of volume.

With this process, it is possible to reduce the volume considerably, and to obtain homogeneous and stable residues. The ashes are to be recycled to recover plutonium, or stored in the future underground geological storage site which is currently being studied in France.

As far as we are concerned, the main objectives of an incineration process are the following: a good reduction factor, controlled combustion, ash composition compatible with plutonium recovery, limited secondary solid and fluid wastes, releases within the nuclear and chemical standards, and in strict observance of the confinement and criticality safety rules.

I - Process and wastes characteristics:

Wastes:

The solid, plutonium-contaminated wastes to be incinerated are generated during the "glove box" (technological wastes) operating and maintenance operations.

Their mean composition is the following:

- 50% plastic materials (chiefly PVC, polyethylene, polypropylene, resins, etc.),
- 35% of gloves made of: 50% latex, 50% neoprene,
- 15% cellulosis (paper, cotton).

On coming out of the glove boxes, the wastes are packed into bundles or in boxes under double PVC casing (maximum volume 10 l) and then stored in 100 l drums
Their average activity is rated at 20 Ci/t approx.

Process: (Figure 1)

The process chosen includes the following steps:

- opening of the drums and extraction of the wastes,
- X-ray check for absence of any large metal parts,
- sorting, if required,
- shredding,
- automatic sorting of fine metal particles,
- homogenizing and storage,
- dosage,
- pyrolysis at 500°C under inert atmosphere (CO_2 or N_2),
- burning at 800°C to 900°C under ambient air,
- conditioning and removal of the ashes,
- afterburning of pyrolysis gases at 1000°C,
- gas cooling,
- prefiltration,
- very high efficiency filtration,
- chemical cleaning of gases before discharging.

On the basis of this data we have entrusted the Marcoule Center with the development of this process. This center has already built a pilot device of a 5 kg/hr capacity to carry out tests on cold wastes.

II - Development at Marcoule: Tests and results

II.1 - Description of the pilot device (figure 2)

Processing of the solid phase

The solid refuse packaged in PVC plastic bags and boxes are crushed by a shredder with a double row of blades and closed with a metal screen (capacity 50 kg/hr). Once they have been shredded, the wastes are directed to an automatic sorter (capacity 50 to 60 kg/hr), where the metal pieces are separated (density difference) from the solid particles suspended in a gaseous flux circulating in a Z-shape tube. After shredding and sorting, the wastes are conveyed to a hopper equipped with a simple vault removal system. At the bottom of this device is a screw-type gravimetric dosage unit whose rotation speed is controlled by the weight variations of the hopper. The rate of flow ranges from 0.5 to 20 kg/hr. By gravity, these shredded wastes fall into the pyrolysis furnace. The feeding spout is cooled and blown by a stream of nitrogen or carbon dioxide. The pyrolysis furnace is a Hastelloy C 276 reactor with double co-rotating screw (stainless steel Z2 CND 17/13), heated from outside by means of electric resistors (11.6 kW). The solid product resulting from the pyrolysis at 500°C is a pitch that flows by gravity via a spout fitted with a rotating valve and down to the combustion furnace.

This combustion furnace is an Inconel 601 rotary furnace with adjustable tilting and rotation speed; it is heated from the outside to a maximum temperature of 900°C, by means of electric resistors (15 kW). An ash recovery can has been placed at the outlet from the furnace.

Processing of the gaseous phase

The pyrolysis gases leave the pyrolysis device following an axis that leads them into a tube electrically heated to 550°C; then, they reach a combustion chamber made out of refractory material and equipped with a special-type burner. This burner is supplied with propane and pyrolysis and burning gas, combustion air pre-heated to $\simeq$ 450°C and water vapor depressurized to 20 mbar. Its function is to bring promptly the facility to the right temperature, through propane combustion, and to provide the air/pyrolysis gas/propane in a quantity close to stoichiometry and pre-cracking of pyrolysis gases through water vapor. After leaving the combustion chamber, the combustion gases are directed to a refractory concrete afterburning chamber protected by a metallic casing.

This chamber is heated by super-kenthal (16.5 kW) electric resistors located in vertical shafts of silicon carbide. In the refractory brickwork, a double baffle is used to facilitate the collection of flue ashes on releasing the pressure of combustion gases (residence time greater than 1 second).

Two ash pans are provided in the lower section of the furnace for possible collection of flue ashes.

On leaving the afterburning furnace, two types of processing would be checked:

1) The fumes are cooled in a spray quench device made up of a C4 Hastelloy tube at the inlet of which have been mounted six injectors supplied with demineralised water; the spraying operation is made using compressed air. On the outside, the tube is contained within a refractory concrete cylinder with high silicon carbide cooled by a double stainless steel casing (Z2 CN 16/10), with low-pressure water circulation. The gases cooled to 200°C are caused to pass through a cyclone, and then a prefilter which is based on the continuous rotary cleaning (530 rpm) of a filtrating teflon-treated sand paper cartridge.

The gases are then filtered by H.E.P.A.[1] filters whose filtering material is a piece of sand paper (maximum using temperature 250°C).

In the pilot unit, no chemical cleaning of gases has been provided to remove acid vapours before discharging. Filtered gases are cooled to 15°C after travelling through a multitubing exchanger made out of Hastelloy B2, cooled by chilled water (0-12°C) and eventually settled in a settling unit with centrifugal vanes.

2) In the second channel, the fumes are cooled by dilution with air and then refiltered on an electrostatic filter. Electrostatic filtration consists in electrically loading the the particles, and then precipitating them under the action of an electric field.

In both cases, the cleaned gases are extracted and exhausted in a stack by means of an extractor fan.

<u>Processing Of Liquid Effluents</u>

In the first gas processing channel, the acid condensates from the condenser and from the settling cyclone flow by gravity into a storage polypropylene vessel from where they will be transferred into a stirred buffer tank by means of a pump.

Neutralizing of acid waters is achieved by sending soda using a measuring pump controlled by a pH-meter.

<u>Command - Control Station</u>:

The command-control station of the facility is equipped with a computer entering all process data from a preset sequential program. All the alarm conditions and protections are recorded, the temperature, pressure, flow rate, electric current controls are available either in automatic or in manual mode.

<u>II-2. Test Results</u>:

The purpose of the tests was to check the devices, study the operating parameters and to characterize the resulting products:

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1. HEPA: High Efficiency Particle Air

- at the end of the pyrolysis phase (solids and gases),
- ashes
- combustion gases.

The main results are outlined below.

Waste Preparation (shredding, sorting, dosage)

The tests have evidenced the good and fault-free operation of the three devices.

Pyrolysis

For a feeding rate of 5 kg/hr, the results obtained are shown in Figure 3. The weight reduction factor (rF) for a 100 sec residence time is of 6.5.

By adjusting the screw rotating speed, it is quite easy to cause the residence time to vary. Figure 4 shows that the optimum residence time lies somewhere between 4 and 5 min. The reduction factor is then in the neighborhood of 11.

Waste composition has little influence on pyrolysis efficiency. The rF factor varies between 5.2 and 7.4 (Table 1).

The first qualitative analyses of resulting gases have evidenced the following gases via GC/MS coupling: H_2, CO_2, CO, CH_4, C_2H_4, C_2H_6, C_3H_6, C_6H_6, N_2, O_2, Ar, HCl.

Further analyses should evidence the precise quantity composition.

Calcination (Figure 3)

The first tests performed by causing the tilting angle and the rotating speed to vary show that:

- the burning furnace is not large enough for 5 kg/hr, for the maximum reduction factor is only 3, while carbon concentration is too high (26.5%). Laboratory tests point to the possibility of obtaining a reduction factor in the neighborhood of 6.

- the chloride contents in the ashes is less than or equal to 1%.

Postcombustion

The analyses carried out at the end of the afterburning phase have made it possible to determine the efficiency of combustion, the mass concentration of gases in dusts, and the size distribution of these dusts.

The main results are outlined below:

- CO content	: 5 to 15 ppm
- CO_2 content	: 5 to 5.2%
- Hydrocarbons content	: 10 ppm
- Combustion efficiency	: $\frac{CO_2}{CO + CO_2}$ >= 99.95%
- Dust content	: 100 to 200 mg/Nm^3

The size analyses carried out on samples from an ANDERSEN impact separator show that for 55% of the particles (in terms of weight), the aerodynamic diameter is in the area of one micron. This result is highly important in choosing the prefilter and its performance.

Gas Cooling

Spray quenching has yielded satisfactory results although it sets a number of operating constraints to avoid condensation, especially at the start-up and stop phases.

The air dilution cooling process is currently being studied and should raise no specific problems.

Prefiltration

The tests carried out on the first device with an automatic filter cleaning rotary prefilter have evidenced operating problems such as vibrations and damages caused to some parts at 200°C. This system has now been given up in favour of electrostatic precipitators.

The efficiency measurements carried out show a cleaning efficiency better than 95%. These results are rather encouraging although several points remain to be studied, notably continuous filter cleaning. These studies are currently underway.

III - Industrial Project

Concurrently to these tests, we have studied a draft project for the implementation of a comprehensive incineration unit for solid wastes contaminated with alpha emitters.

A facility of this type includes:

- the process equipment,
- the constructions to be built,
- the various ancillary equipment and utilities required for the operation of the unit.

The project is designed for a capacity of 7 kg/hr.

Process

The solution adopted in the draft project for gas processing at the end of the afterburning process is the following:

- cooling by air/gas exchanger from 1100°C to 800°C.
This device can also be used to heat up the combustion air to 500°C.
- cooling by air dilution from 800°C to 140°C.
- prefiltration with electrostatic filters,
- final filtration with H.E.P.A. filters,
- neutralizing of acid gases in the dry channel, using limestone.

Nuclear confinement

To ensure the confinement of radioactive material, all of the process equipment from the shredder to the prefilters is from now on kept in glove boxes. These glove boxes are designed to facilitate the maintenance operations. Throughout the research phase, particular attention has been paid to the possibility of acting on devices, dismantling them and changing faulty parts.

Operating conditions

The waste preparation stage (from the shredder to the storage hopper) is operated only during the normal working hours by operators responsible for the sorting operations, waste loading, ashes recovery and current maintenance.

Outside these hours, there is no operating personnel available in the building (except for the permanent safety staff present at the center).

Therefore, the rest of the facility is designed to operate in continuous mode 96 hours a week automatically and without direct monitoring. The facility is controlled by automata and a computer recording the data and thus providing for the regulation of various parameters and taking into account the possible faults and alarm conditions. In the case of failures liable to affect safety, the facility automatically stops according to pre-set procedures.

Overall Design (Figures 5 and 6)

The building housing the incinerator includes the following rooms and units:

- incineration cells,
- control room,
- storage of drums before processing,
- storage of ash containers,
- technical premises (ventilation, power suppply station, etc.),
- offices.

Cost estimate

The financial estimate of the draft-project as it has just been outlined is given in Table 2.

The total cost is put at $M 7.6 (1$ = FF 5.70).

Note: The siting studies and the cost assessment have been carried out by USSI-Ingénierie which is responsible for this project.

CONCLUSION

The first tests on the cold pilot unit have made it possible for us to check the devices and to get a better understanding of the parameters of the selected process. The results obtained at Marcoule are indispensable for the design of a future industrial incineration unit intended to process real contaminated wastes. Operational start-up is scheduled in 1992.

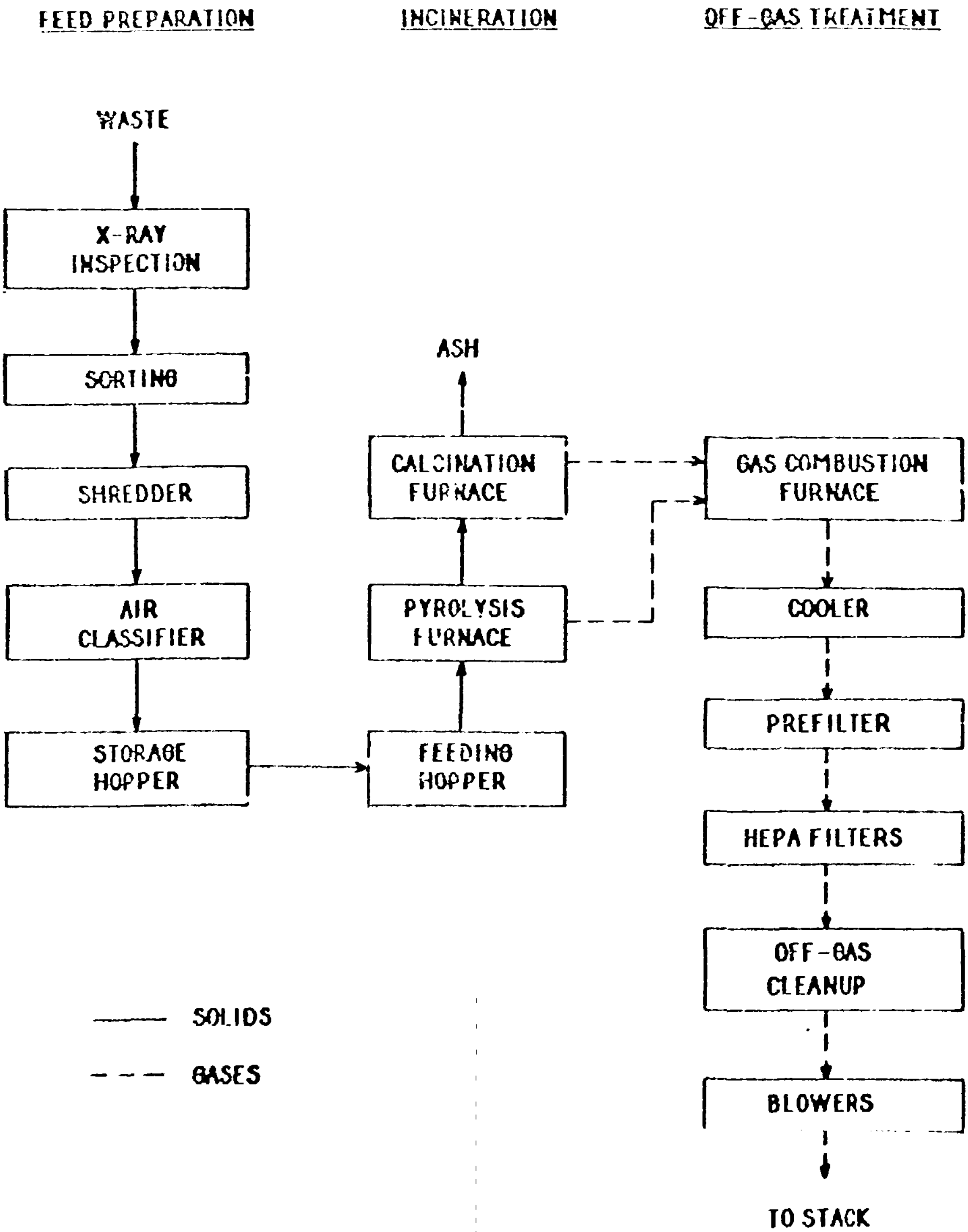
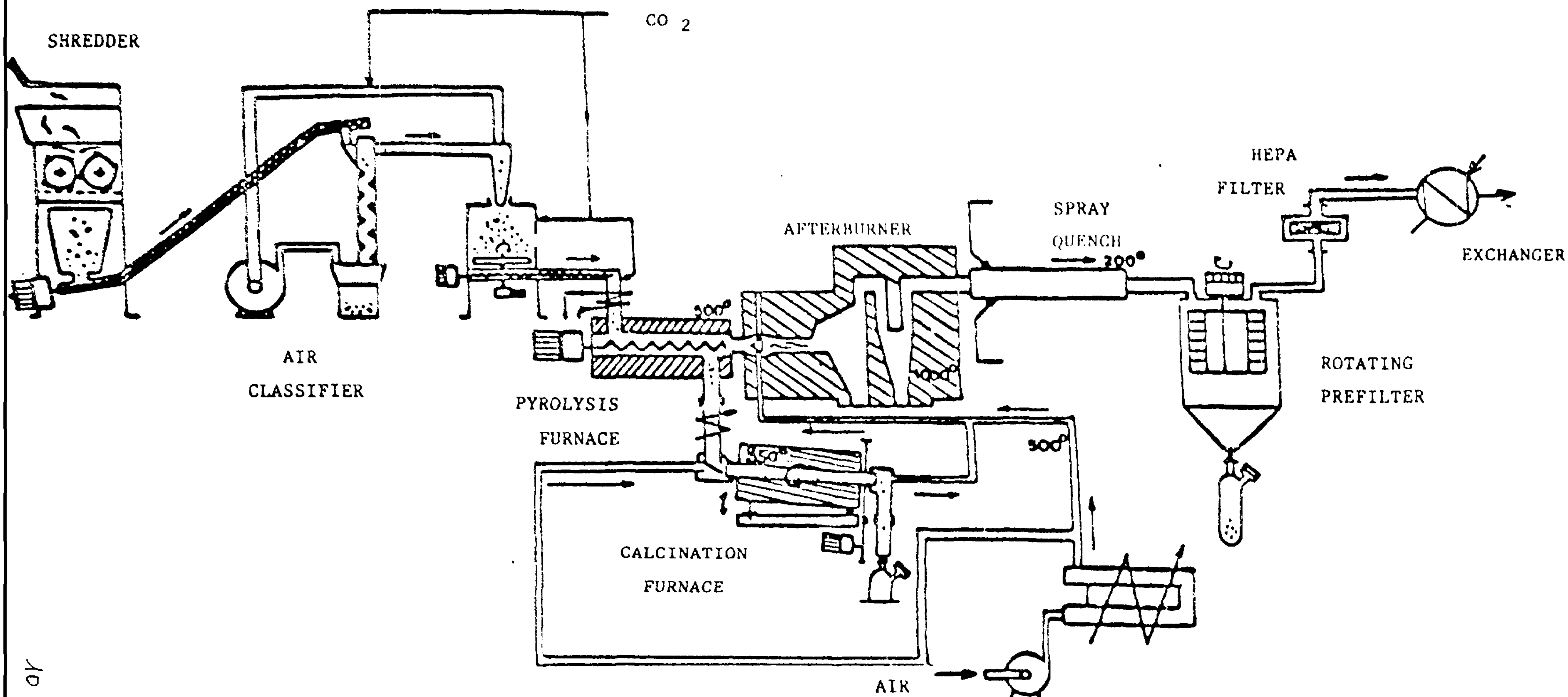
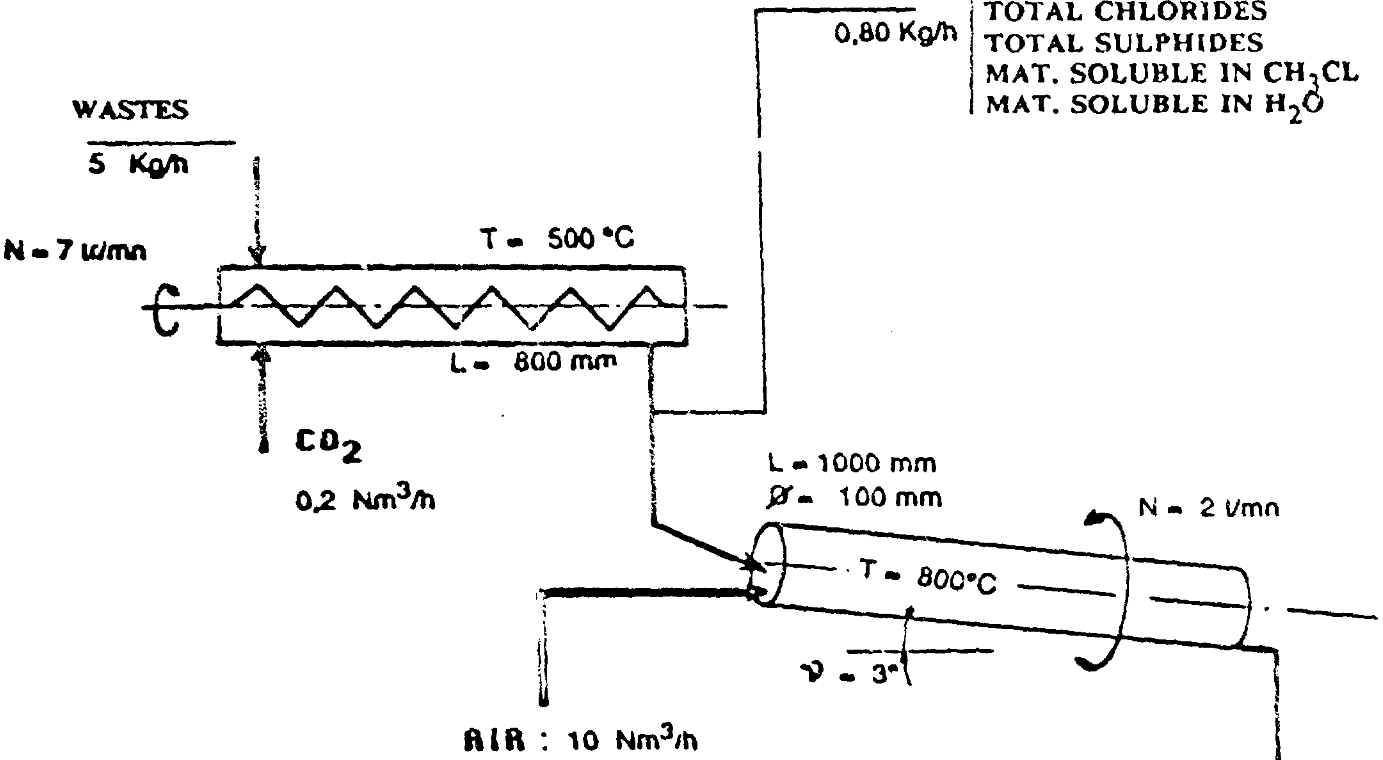


Figure 1 - PROCESS DIAGRAM

Figure 2 - SCHEMATIC DESCRIPTION OF THE PILOT INCINERATOR





Pyrolysis residue

APPARENT DENSITY	: 0,20
ACTUAL DENSITY	: 1.29
MELTING LOSS (800°C)	: 84.0 %
CARBON CONTENT	: 52.2 %
TOTAL CHLORIDES	: 4.7 %
TOTAL SULPHIDES	: 0.6 %
MAT. SOLUBLE IN CH_3CL	: 1.0 %
MAT. SOLUBLE IN H_2O	: 8.0 %

OUT OF WHICH...

Ca^{++}	: 8 %
Mg^{++}	: 0.01 %
K^{+}	: 0.3 %
Na^{+}	: 0.1 %
SO_4^{--}	: <= 0.01 %
Cl-	: 2.94 %

Ashes

APPARENT DENSITY	: 0.1 8 %
ACTUAL DENSITY	: 1.6 9 %
MELTING LOSS (800°C)	: 43.0 %
CARBON CONTENT	: 26.5 %
SOLUBLE CHLORIDES	: 0.11 %
TOTAL CHLORIDES	: 1.0 %
TOTAL SULPHIDES	: 0.9 %
MANGANESE	: 0.03 %
NICKEL	: 0.08 %
IRON	: 3.7 %
MAGNESIA	: 0.9 %
BARYUM	: 0.6 %
SODIUM	: 11.0 %
POTASSIUM	: 6.9 %
ZINC	: 2.9 %
ALUMINIUM	: 10.7 %
CALCIUM	: 2.2 %

Figure 3 - PYROLYSIS AND CALCINATION RESULTS

Figure 4 - INFLUENCE OF RESIDENCE TIME ON WEIGHT REDUCTION FACTOR

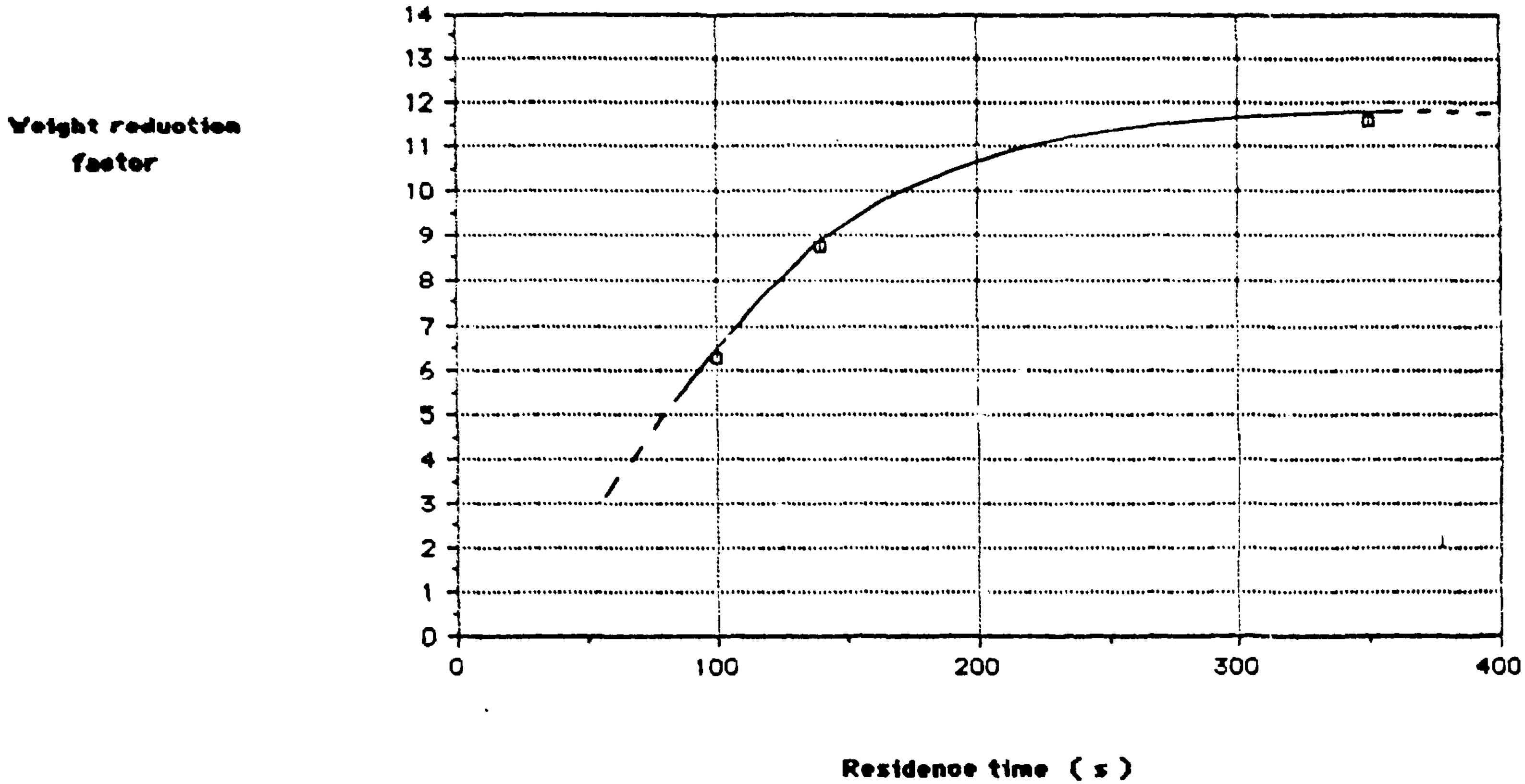


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Figure 5- INCINERATION BUILDING. FIRST FLOOR

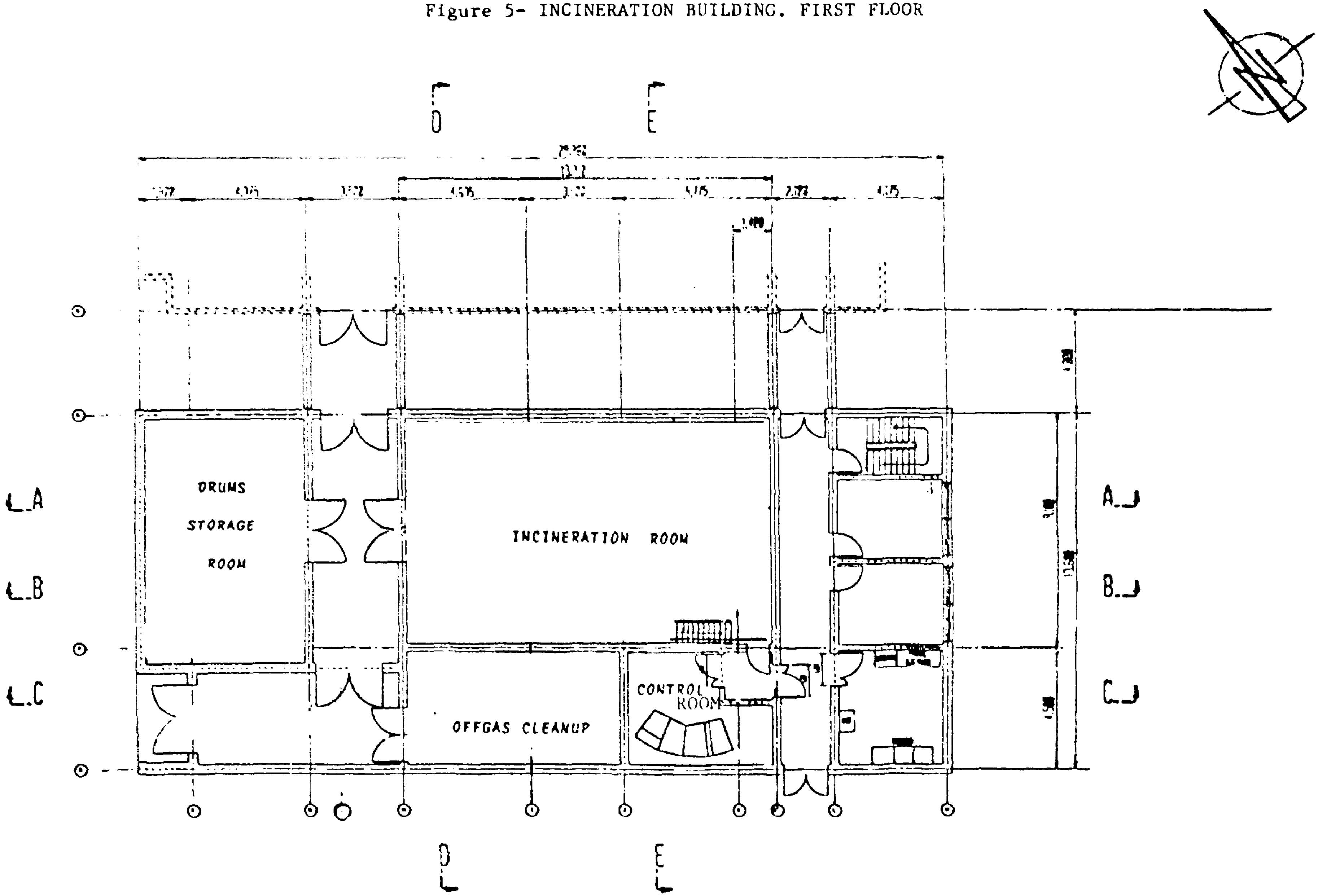

Figure 6 - INCINERATION BUILDING. BASEMENT

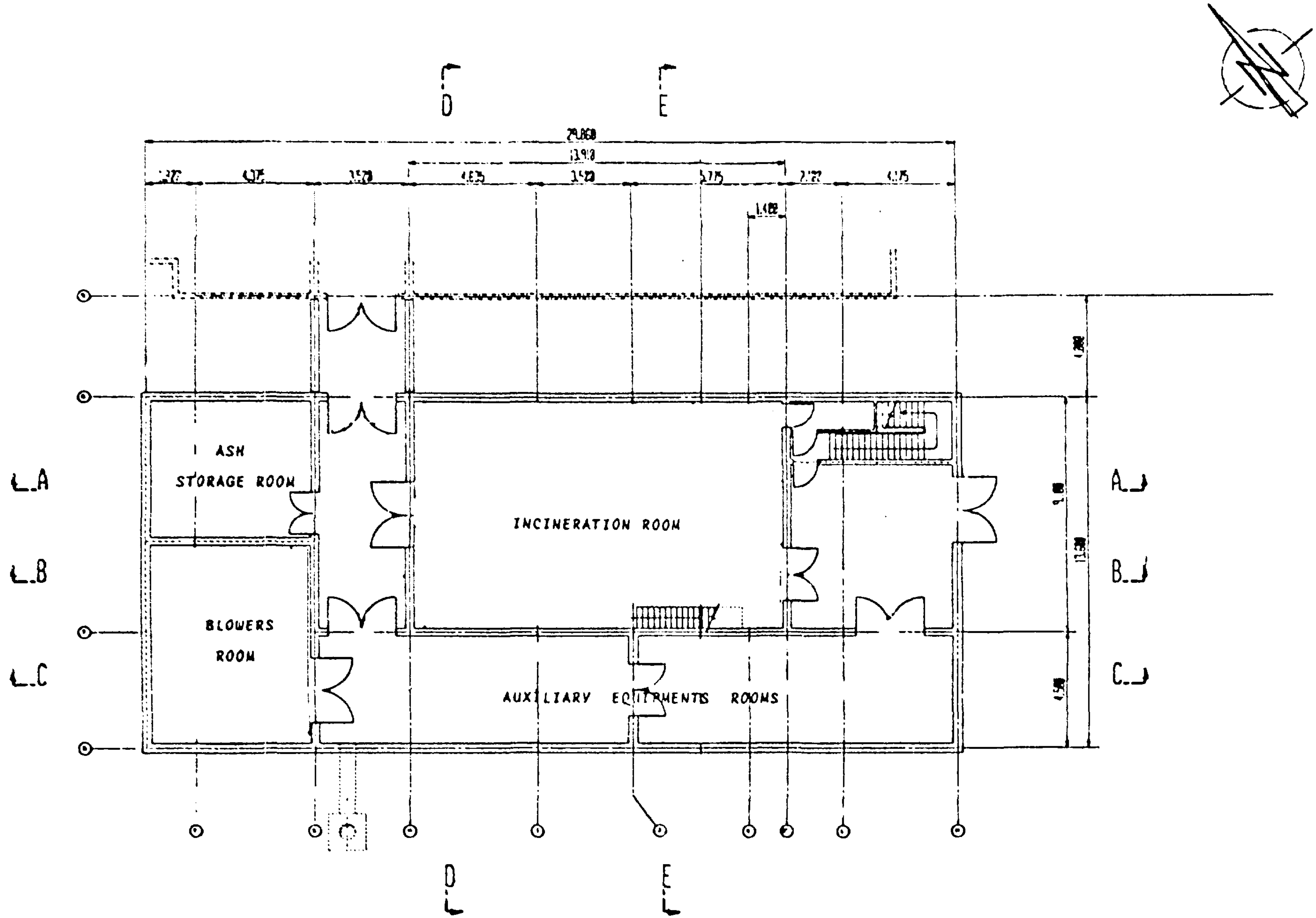

Table 1
Influence of wastes composition
on weight reduction factor
(feed rate 5 kg/h)

Composition		1	2	3	4	Type
PVC	%	75	25	50	50	50
Neoprene	%	5	25	10	10	17.5
Latex	%	10	40	20	40	17.5
Cellulose	%	10	10	5	0	15
Polyethylene	%	0	0	15	0	0
Reduction factor		7.3	5.2	7.4	7.2	6.5

Table 2
Cost estimate

	KF	K$
Process Equipments	19850	3490
Building and Utilities	16500	2895
Engineering	6920	1215
Total	43270	7600

(1dollar = 5.70 francs)