SODIUM OXIDE AEROSOL FILTRATION

G. DUVERGER DE CUY
DSN/SESTR, Centre de Cadarache,
Saint-Paul-lez-Durance,
France

ABSTRACT :

In the scope of the sodium aerosol trapping research effort by the CEA/DSN, the retention capacity and yield were measured for very high efficiency fiberglass filters and several types of prefilters (cyclone agglomerator, fabric prefilters, water scrubbers).

1 - INTRODUCTION

Filtration and prefiltration studies for sodium oxide aerosols conducted by the CEA Nuclear Safety Department are based on the possibility of an active sodium fire (exclusive of the reference accident) in the Super-Phénix reactor.

The reactor zones in which such a fire hazard exists are connected to a ventilation system provided with very high efficiency filters and a total airflow capacity of 18000 cubic meters per hour.

The amount of aerosols liable to enter the ventilation system in the event of such an accident (a 61m^2 sodium fire in the reactor and fuel drum cleaning system piping gallery) was estimated by the FEUNA computer code, which calculates the thermodynamic consequences of a contained sodium fire. The calculated quantity is considerable : approximately 40-50 kg

An experimental research program was therefore undertaken with the following objectives :

- to measure the maximum aerosol quantity capable of being retained by the filters.
- to develop a prefilter system of sufficient efficiency and retention capacity to prevent clogging of the very high efficiency filters in view of the amount of aerosols released.

2 - EXPERIMENTAL PROGRAM

The efficiency and retention capacity were measured for the fiberglass very high efficiency filters currently marketed :

- SOFILTRA type 1506 (filtration area 45m^2)
- AAF "Astrocel" (filtration area 21.4m^2).

Filtration efficiency is defined in terms of the purification coefficient (i.e. the ratio of sodium inflow mass to sodium outflow mass), or in terms of filter yield (the ratio of trapped sodium mass to sodium inflow mass).

The retention capacity or clogging potential is the quantity of sodium corresponding to a 200 mm H_2O increase in the pressure drop across the filter ; this value may also be expressed in terms of the filtration surface as mass per unit area.

Prefiltration development testing was conducted on the following systems :

- cyclone agglomerators
- fabric prefilters (variable density fiberglass prefilters ; multiply prefilters ; pocket type prefilters ; stainless steel wool prefilters)
- water scrubbing prefilters (AAF "Colag" ; MONTE-SANTO "Brink" ; NEU "Aqualine").

3 - TEST FACILITY & MEASUREMENT TECHNIQUES

The test facility comprised a sodium aerosol generator and a measurement loop containing the test prefilters.

The aerosol generator was a $400 m^3$ pressure-resistant caisson in which a 300 kg sodium pool fire burned for several hours.

The measurement loop was configured as required for each test. The standard loop (cf. Figure 1) included two identical branches, each capable of a 1500 m^3/h flow rate designed for simultaneous testing of two prefilter assemblies. The aerosol flow rate was determined in order to allow full scale testing of most of the filters and prefilters commercially available.

Each branch of the loop included three series-connected chambers to accoummodate the filtration system components.

A pneumatic flow regulating system controlled a valve at the blower inlet to maintain a constant flow rate in the test loop irrespective of the increasing pressure drop resulting from filter clogging.

Measurement methods included the following :

- Filter efficiency was measured on samples coming from the ventilation duct upstream and downstream the filter ($E = \frac{q1}{q2}$, where q1 is the amount of sodium in the upstream sample, and q2 the amount of sodium in the downstream sample) or by placing a second retention filter in series after the test filter ($E = \frac{q1 + q2}{q2}$, where q1 and q2 are the amount of sodium trapped by the first and second filters, respectively).
- Filter and prefilter retention capacities were measured by determination of their respective washing solutions.
- Prefilter efficiency was measured by determination of the washing solutions for the prefilter itself and for the loop sections containing the downstream retention filter.

Sodium determination in the scrubbing water was obtained either by acidity measurements or by atomic absorption methods.

4 - RESULTS

4.1 - Very High Efficiency Filter Tests

Four retention capacity tests were conducted for the SOFILTRA 1506 and ASTROCEL 1 filters ; the measured results ranged from 3.2 to 8.1 $g.m^{-2}$, for a mean value of $6 g.m^{-2}$.

Filtration efficiency testing gave results of about 10^3 for both filters.

4.2 - Prefilter Tests

The prefilter test results are indicated in Table 1, with the following data specified for each model :

- prefilter construction
- mean sodium aerosol concentration in the test loop
- prefilter retention capacity
- prefilter efficiency.

The retention capacity was determined only in the event of prefilter clogging, and is expressed in terms of sodium mass per unit of airflow to permit subsequent comparison with tests conducted at different blower airflow rates. The clogging threshold corresponds to a pressure drop of about 200mm H_2O across the prefilter.

A very high efficiency filter was always placed downstream from the prefilter to measure the prefiltration efficiency.

NOTES

1) The prefilter operation is based on particle agglomeration in a high-flow recirculation loop (6 times higher than the prefilter inflow rate) using a cyclone blower (Figure 2).

2) The variable density filters is made of multiple fiberglass of increasing density in the direction of the airflow.

3) The bag filter used comprises 6 Nomex bags with a total area of $10m^2$. Filter cleaning is obtained by a reverse-flow compressed air blast for one second every 12 seconds, producing a sonic airflow through an air nozzle (Figure 4).

4) The COLAG prefilter consists of a perforated plate above which are placed a 200 $l.h^{-1}$ water inlet and two layers of steelwool. The perforated plated crossed by the aerosol gas flow acts as an air distributor and results in the formation of a fluoliquid suspension between the distributor plate and the second steel wool layer which recovers the entrained liquid particles (Figures 3 & 5).

5) The BRINK prefilter comprises a water spray system with a flow rate similar to the COLAG unit, in conjunction with an extensive ($5.6m^2$) fiberglass retention layer (Figures 3 & 6).

6) The AQUALINE-LS includes a water tray with a scrubbing tube flush with the water surface. The airstream sets up a water flow through the scrubbing tube, creating an intensive air + aerosol to water exchange zone. Drying is ensured by deflectors at the tube outlet and by a cyclone blower (Figures 3 & 7).

5 - CONCLUSION

This experimental determination of the retention capacity of the available very high efficiency fiberglass filters, and of the quantity of aerosols liable to be transported by the ventilation system from a possible sodium fire (excluding the reference accident) provides valuable data for specifying the prefiltration requirements of the Super-Phénix plant.

Given the filter surface area of the Super-Phénix ventilation system ($500m^2$), the maximum aerosol retention value is 3kg ($6g.m^{-2} \times 500m^2 = 3000g$).

The required prefilter efficiency (ratio of the amount of aerosols which must be trapped by the prefilter to the inlet amount) is 94 % ($\frac{50 - 3}{50} = 0.94$)

The minimum retention capacity is therefore 47kg ; for a blower airflow of $18000m^3.h^{-1}$ this corresponds to a retention capacity per unit airflow of 2.6g.

Only the cyclone agglomerator and the AQUALINE-LS prefilters meet the required performance specifications: 2.6g retention capacity per $m^3.h^{-1}$ of ventilation airflow and 94 % efficiency.

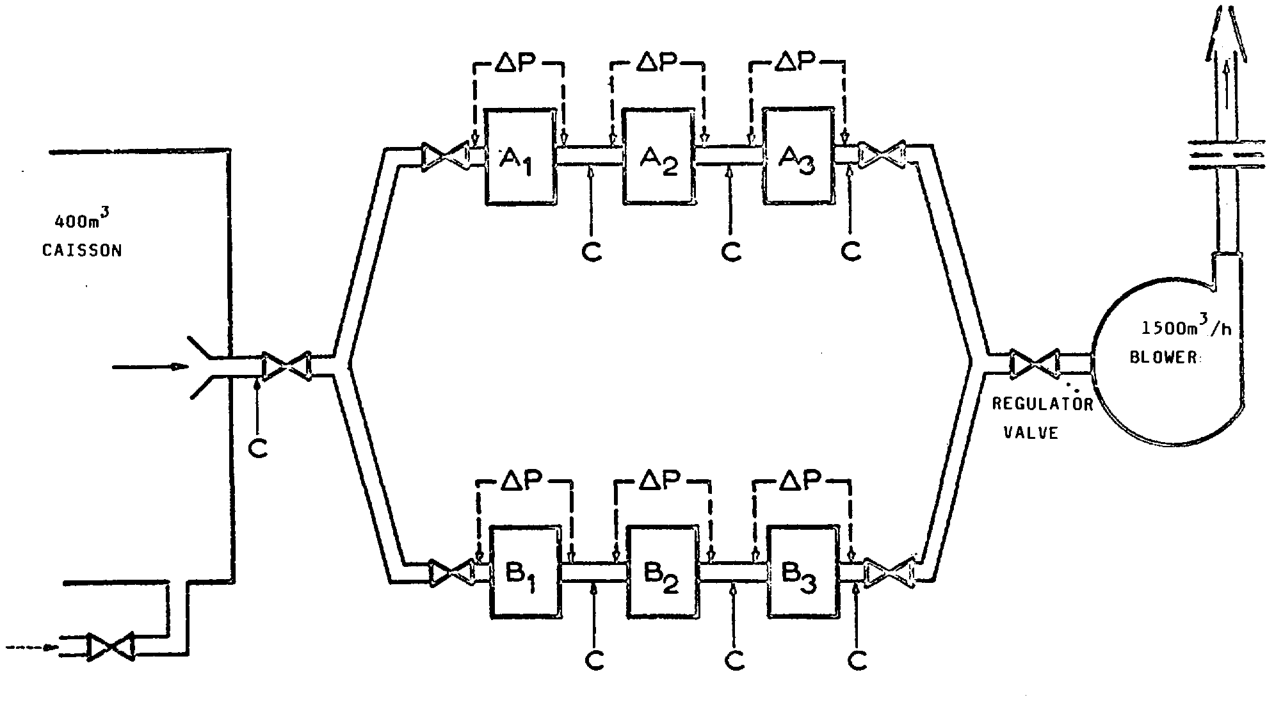
Nevertheless, the former was rejected because of its high cost, and the latter for pressure drop instability problems. The BRINK prefilter, although it was close to the required specifications, was also rejected for cost and size reasons.

Work is now in progress to improve three types of prefilters : the COLAG, the GANTOIS and the AQUALINE-R (a modified verson of the AQUALINE-LS).

TABLE 1

Prefilter Test Results

PREFILTER TYPE	MEAN AEROSOL CONCENTRATION IN TEST LOOP $g.m^{-3}$	PREFILTER RETENTION CAPACITY g per $m^3.h^{-1}$ of blower airflow	PREFILTER EFFICIENCY
Cyclone agglomerator (1)	6.3		95.4
Variable density filter "ROLL O MAT" (AAF) (2)	0.6		25.6
Variable density filter "ROLL O MAT"	3.1		37.8
Variable density filter (AAF "Roll O Mat") + high efficiency filter (AAF "Varicel")	3.8	0.74	95.8
Variable density filter (SOFILTRA "Vitglas 2") + high efficiency filter (SOFILTRA 1902-22)	1.8	0.08	85.4
Variable density filter (SOFILTRA "Vitglas 2") + bag filter (SOFILTRA 1354-07)	2.3	0.09	96.3
Self-cleaning bag filter (AIR INDUSTRIE "Sonair" (3)	0.8	0.24	76.4
2-stage multiply stainless steelwool prefilter (GANTOIS)	6.1	2.6	86
Water scrubber "COLAG" (AAF) (4)	4.7		84
Water scrubber "BRINK" (MONTE SANTO) (5)	6.6	2.4	99.85
Water scrubber "AQUALINE-LS" (NEU)(6)	3.1		95.6

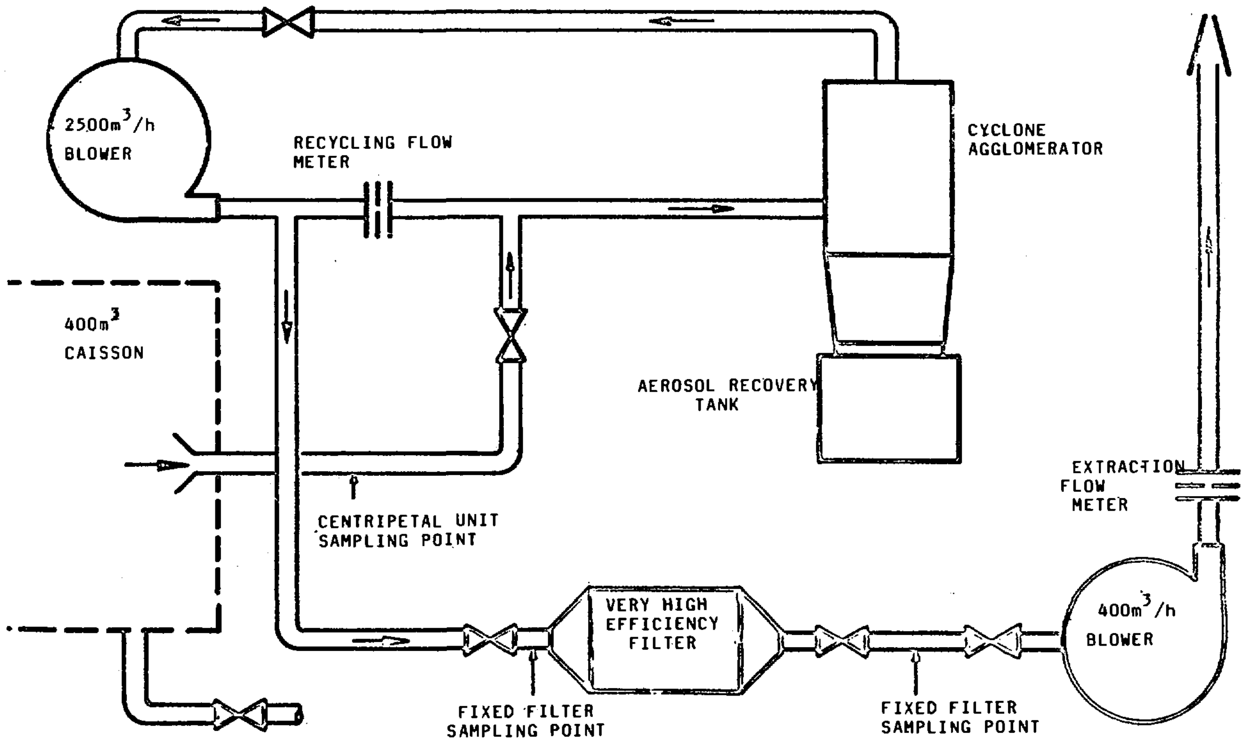


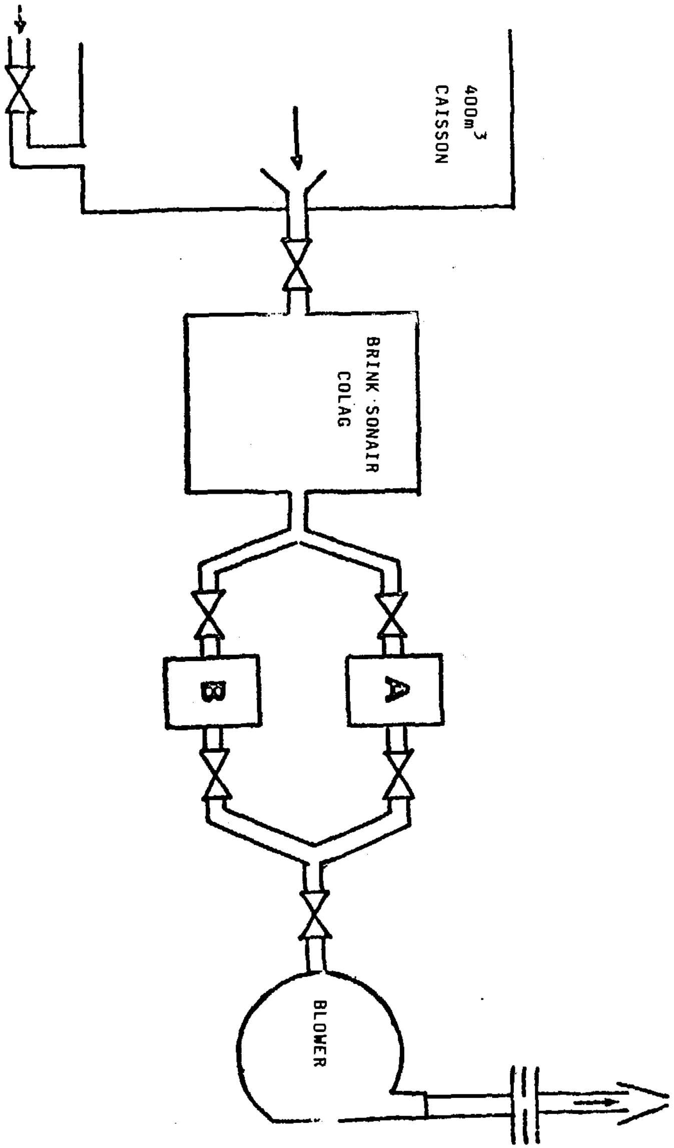
SODIUM AEROSOL FILTRATION SYSTEM
$1500 m^3/h$ LOOP

EFAS PROGRAM
FIGURE 1

SODIUM AEROSOL FILTRATION SYSTEM

FIGURE 2



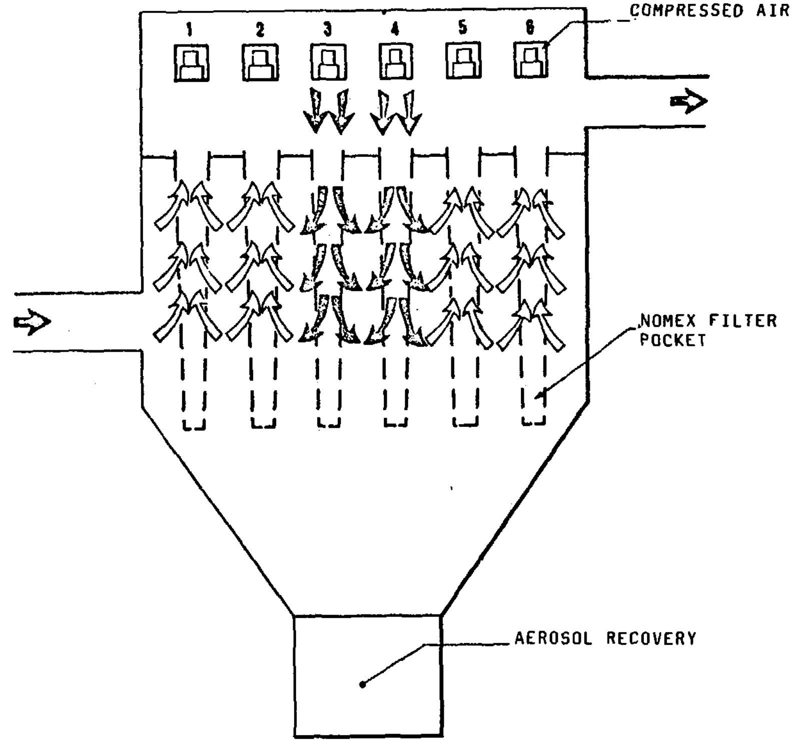


SODIUM AEROSOL FILTRATION SYSTEM

FIGURE 3

SELF-CLEANING POCKET PREFILTER (AIR INDUSTRIE "SONAIR")

FIGURE 4



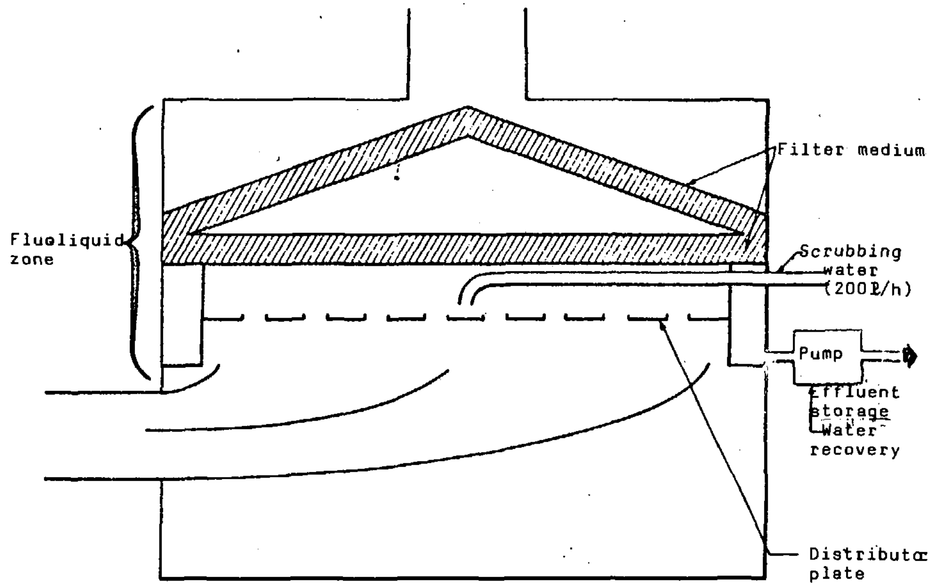
CLEANING CYCLE

Pocket No.	CYCLES			
1	F	F	F	D
2	F	F	F	F
3	D	F	F	F
4	D	D	F	F
5	F	D	D	F
6	F	F	D	D

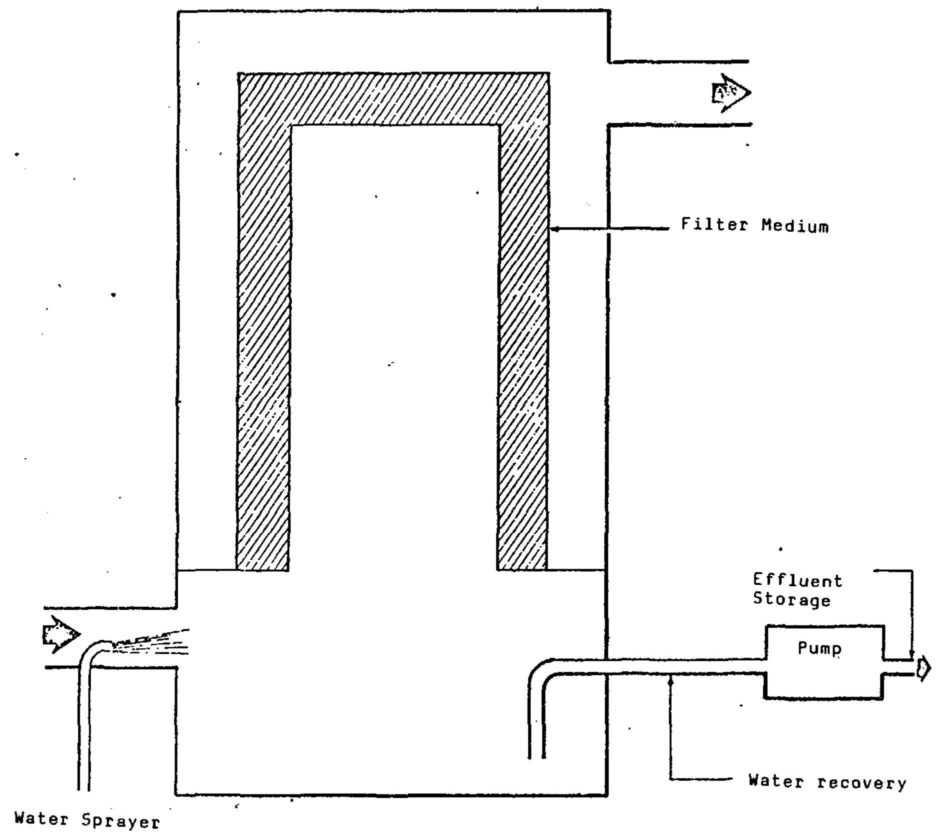
F : Filtration

D = Reverse-Flow cleaning

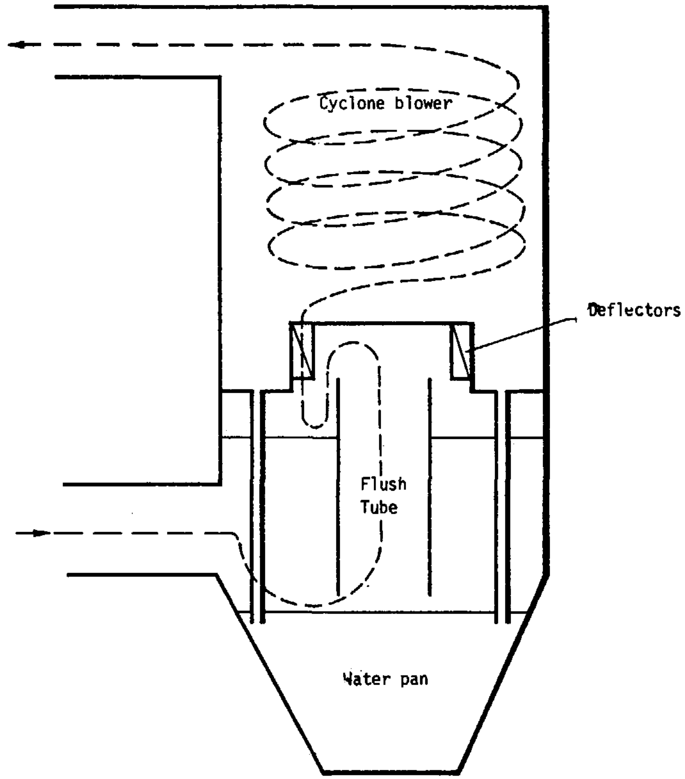
COLAG (A.A.F.) FIGURE 5



BRINK FIGURE 6



AQUALINE LS



IODINE RELEASE FROM SODIUM POOL COMBUSTION

N. SAGAWA, Y. FUKUSHIMA, N. YOKOTA
Energy Research Laboratory Hitachi Co. Ltd,
Moriyama-cho, Hitachi-shi,
Ibaraki-ken

K. AKAGANE, K. MOCHIZUKI
Power Reactor and Nuclear Fuel Development Corp.,
Akasaka, Minato-ku,
Tokyo,
Japan

ABSTRACT

Iodine release associated with sodium pool combustion was determined by heating 20 gr sodium containing sodium iodide, which was labelled with ^{131}I and dissolved in the sodium in concentration of 1 ~ 1,000 ppm, to burn on a nickel crucible in conditioned atmosphere in a closed vessel of 0.4 m^3. Oxygen concentration was changed in 5 ~ 21 % and humidity in 0 ~ 89 % by mixing nitrogen gas and air. Combustion products were trapped by a Maypack filter composed of particle filters, copper screens and activated charcoal beds and by a glass beads pack cooled by liquid argon. Iodine collected on these filter elements was determined by radio-gaschromatography.

When the sodium sample burned in the atmosphere of air at room temperature, the release fractions observed were 6 ~ 33 % for sodium and 1 ~ 20 % for iodine added in the sodium.