Table 6-1 Comparison of Removal Methods

Item	Grapples: Inside C/V INCO	Grapples: Inside C/V EXTRA	Outside C/V Cask Car
Grapples			
Driving Force	Rod	Tape (SUS)	Chains
Fingers	3	3	2
Handled Item	Fuel Assembly	Fuel Pot	Fuel Assembly
Preheating	Direct Charging into Sodium	Natural Convection	Argon Gas Forced Circulation
Sodium Atmosphere	Wholly in sodium during refueling	In sodium, only during refueling in reactor vessel	Partially in sodium
Sodium Inspection	Visual	Visual	Visual
Sodium Deposition	~ 150g	~ 90g	~ 5g
Cleansor type	Alcohol with 10% water	Alcohol with 10% water	100% alcohol and 100% water
reuse	used 3 times	used 3 times	exchanged every time for use
capacity	120 ~ 130 l	130 ~ 140 l	~ 180 l
Waste Disposal	Retrieval Storage	Retrieval Storage	Drained to low activity level tank
Operation			
cover gas grappies	Argon connected to drive mechanism	Argon connected	Argon disconnected
alcohol circulation	natural with bubbling	natural with bubbling	forced circulation
drying	preheating system of the axial seal is used	cask purging system is used	cask purging system is used
Requalification	visual inspection and false operation	visual inspection and false operation	visual inspection and false operation

SODIUM REMOVAL FROM THE MECHANICAL PUMPS OF JOYO

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Abstract

Adjacent to the reactor main building a building for sodium component overhaul is prepared. This building contains a Sodium cleaning facility for the primary main pump in addition to other facilities. In this paper the sodium cleaning facility and its cleaning process is described. Further, the function of this facility is evaluated using the result of cleaning tests and experiences of actual pump cleaning.

1. Introduction

Sodium removal experience for the "Joyo" primary main pumps in the maintenance facility is presented. The contents are as follows.

(1) Description of the sodium cleaning facility.

(2) Cleaning procedure.

(3) Experiments on the cleaning effect.

(4) Sodium removal from the "Joyo" primary main pumps.

2. Sodium removal from "Joyo" mechanical pumps.

(1) Description of the sodium cleaning facility.

The sodium remaining on the components in the primary loop is removed in the maintenance building located to the west of the reactor building (Fig. 1).

The maintenance building contains a bridge crane, a large and a small cleaning cell, an alcohol tank, storage tanks, a process control room, washroom facilities for the staff and storage area for the guide tube of the control rod.

The components to be handled in this building will include main sodium pumps (Fig. 2), sodium valves and other components which have been contaminated with sodium.

The building is made of a steel frame structure approximately 17 m x 31 m and 34 m high. The entrance of the building is located on the east side and has a roll-up truck door through which a motor-driven trolley carries the components for maintenance on rails between the maintenance building and the inside of the reactor containment vessel.

The composition and the capacity of the sodium cleaning facility is shown in Table 1.

Fig. 3 shows the flow diagram of the sodium removal facility. The cells have instrumentations for the control of the cleaning process. Process control is mainly done by the control of flow rate of steam and nitrogen.

Table I Sodium cleaning facility

facility	dimensions	object	cleaning method	notice
pump cleaning cell	$1.6^{m\phi} \times 7.3^{m}$	primary main pump & its parts, etc.	steam-nitrogen & water	
highly radioactive component cleaning cell	$0.25^{m\phi} \times 7.5^{m}$	guide tube of control rod	steam-nitrogen & water, or alcohol	
sodium cleaning pan	$4^{m} \times 5^{m} \times 0.05^{m}$	disassembled parts	steam & water	steam jet cleaner

Process utilities at the site include supply of hot nitrogen gas, steam, water and compressed air. Steam and nitrogen are mixed at the separator and supplied to the cleaning cell as required under semiautomatic control.

The velocity of steam and nitrogen is slow and it is assumed that the cleaning effect is nearly equal in any parts of the component.

The hydrogen ion concentration of the waste liquids are measured in order to distinguish their radioactivity levels before they are drained to the storage tanks.

Gaseous waste generated in the cleaning vessel is blown out with nitrogen through the water-cooled condenser which controls the temperature of the waste gas. The gas goes through scrubber and filter units before it is disposed through a stack 23 m high to the atmosphere.

(2) Cleaning procedure

The primary main pump is cleaned in the pump cleaning cell with steam-nitrogen, and its parts are cleaned on the sodium cleaning pan with steam. The operation is carried out according to the following sequence.

(1) The pump is settled in the pump cleaning cell. (as shown in Fig. 4)

(2) Air in the cell is replaced by nitrogen gas. (O_2 content $<1\%$)

(3) Steam-nitrogen mixture is supplied into the cell (about 1 atm, 100°C). The steam concentration in the steam-nitrogen mixture is gradually increased (from 0% up to about 70% by volume ratio). Then, sodium reacts with steam producing sodium hydroxide.

(4) Steam-nitrogen mixture supply is stopped, and sodium hydroxide solution dripped from the pump to the bottom of the cell is drained to the waste liquid storage tank.

(5) Then, water is supplied into the cell, so that the lower part of the pump is immersed in water, and the water is drained. This operation is repeated.

(6) After the nitrogen gas in the cell is replaced by air ($O_2 > 20\%$), the pump is taken out and disassembled on the sodium cleaning pan. The parts of the pump, on which sodium still remains, are set in a cage and cleaned again in the cell.

(8) In the final process, remaining sodium on individual parts are blown away by a steam jet cleaner on the sodium cleaning pan and dried.

(3) Experiments on the cleaning effect

Prior to the cleaning of the pumps, a preliminary examination of the maintenance facility was carried to confirm the cleaning effect with a test piece. As shown in Fig. 5, the test piece had many holes on the surface (the depth and diameter were chosen as parameters).

Two test pieces of which the holes had been filled to the top with sodium in a vacuum atmosphere were set in the pump cleaning cell, one facing downward and the other upward. Two tests were done. One with steam and the other with steam and water. The depth of the holes were measured afterwards in order to determine the effects. Fig. 6 shows the cleaning effect with the test piece in 4 cases.

It shows the relation between sodium removable depth and diameter of the hole. There is a remarkable effect in the cleaning by water in all of the holes as shown in Table 2 and small differences in effects between the pieces facing downward and upward.

Table 2 Sodium removal ratio by the water (%)

diameter of the hole(mm)	0.5	0.7	1.0	1.5	2.0	2.5	3.0	4.0	5.0
downward	34	37	37	33	32	32	38	32	32
upward	24	25	37	34	35	27	44	43	41

And, the result of this experiment shows that removal of the sodium in the hole deeper than 10 mm becomes gradually difficult depending on the diameter of the hole.

(4) Sodium removal from the "Joyo" primary main pumps.

The primary pumps were taken out from loops for modification of the hydrostatic bearings in summer 1976.

Before transfered to the maintenance building, they were wrapt with vinyl sheet in which argon gas was filled for isolation from air. At that time, the primary sodium had not been activated.

Sodium deposition pattern on the pumps were as follows.

(a) At the position over the sodium surface in the loop (e.g. thermal barriers), sodium vapour deposited like dew drops.

(b) At the position dipped in sodium, sodium remained on the corner and upper side of the parts (e.g. diffuser), and in the narrow gaps and/or spaces of complicated geometory (e.g. hydrostatic bearing and bolt hole).

Sodium was removed from the pumps by the procedure mentioned above. The results were as follows.

(a) Everywhere to be seen from outside, sodium was cleaned completely by the pump cleaning cell.

(b) But, sodium in the narrow gaps or spaces of complicated geometory was not removed at all.

(c) After disassembly, the remaining sodium in there were removed completely by hand with steam jet cleaner on the sodium cleaning pan.

(d) It took 5 days to carry out all operations.

The cleaning effect are shown in Table 3.

Table 3 Pump cleaning effect

		JOYO MOCK-UP PUMP*		JOYO PUMP(A)
OPERATING TIME		12000 hr	120 hr	2500 hr
OPERATING TEMPERATURE		370°C	250~370°C	200 ~ 250°C
AMOUNT OF SODIUM REMOVED	STEAM	3.3 kg	1.2 kg	1.6 kg
	WATER	1.0 kg	1.0 kg	negligible
	BY HAND	0.5 kg	0.5 kg	negligible
	TOTAL	4.8 kg	2.7 kg	1.6 kg

* Sodium removal from the "Joyo" Mock-up pump had been done prior to the "Joyo" pumps in October 1974 and in March 1975.

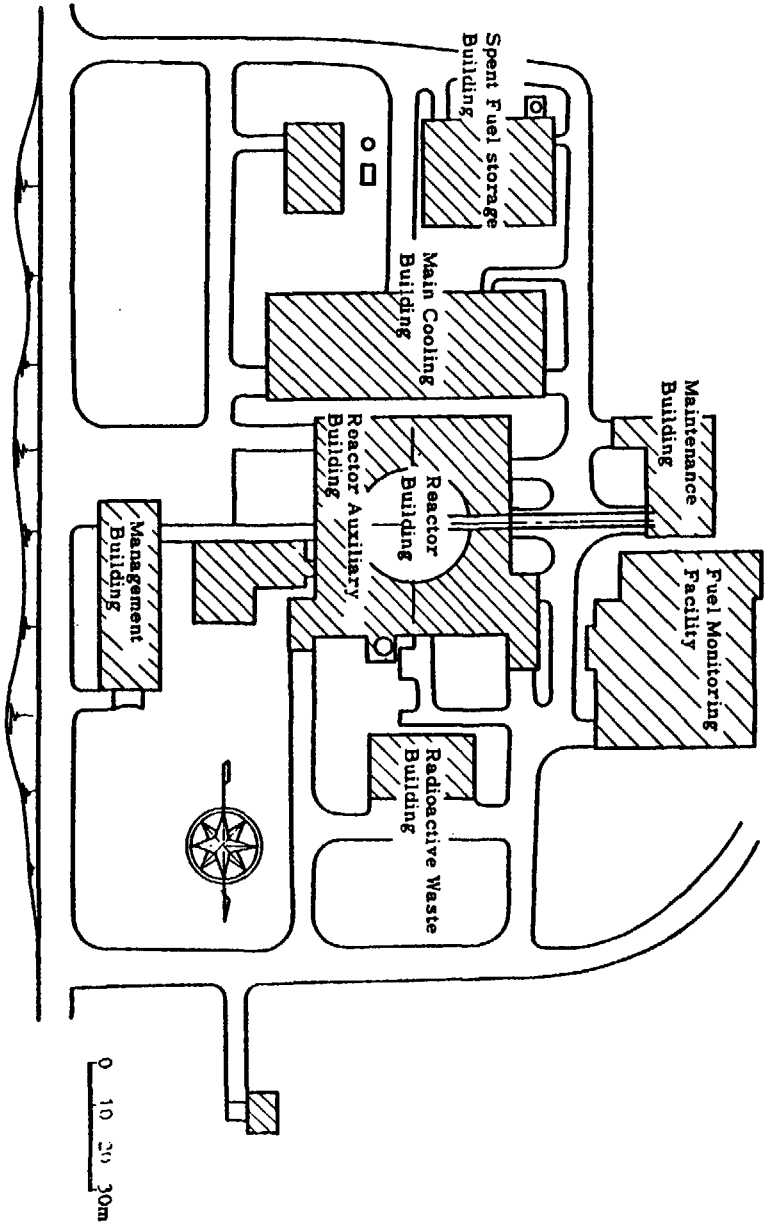


Fig. 1 JOYO Building Layout

1 Suction Nozzle
2 Discharge Nozzle
3 Impeller
4 Hydrostatic Bearing
5 Inner Casing
6 Outer Casing
7 Shaft
8 Thermal Barriers
9 Overflow Nozzle
10 Argon Gas Nozzle
11 Mechanical Seal

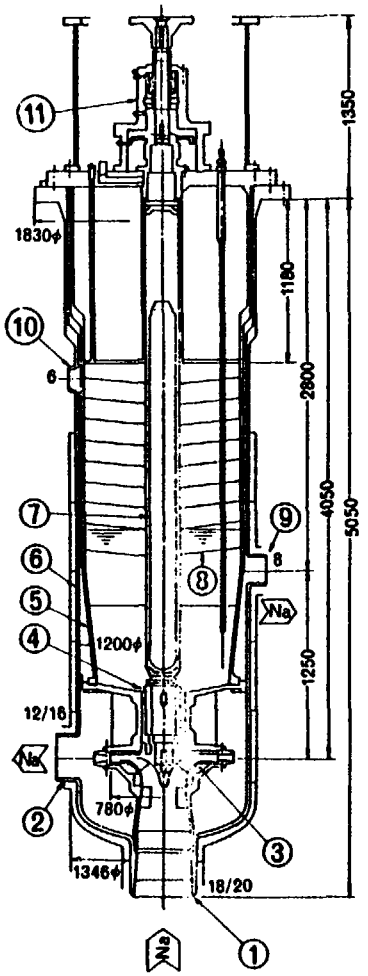


Fig. 2 Primary System Sodium Pump

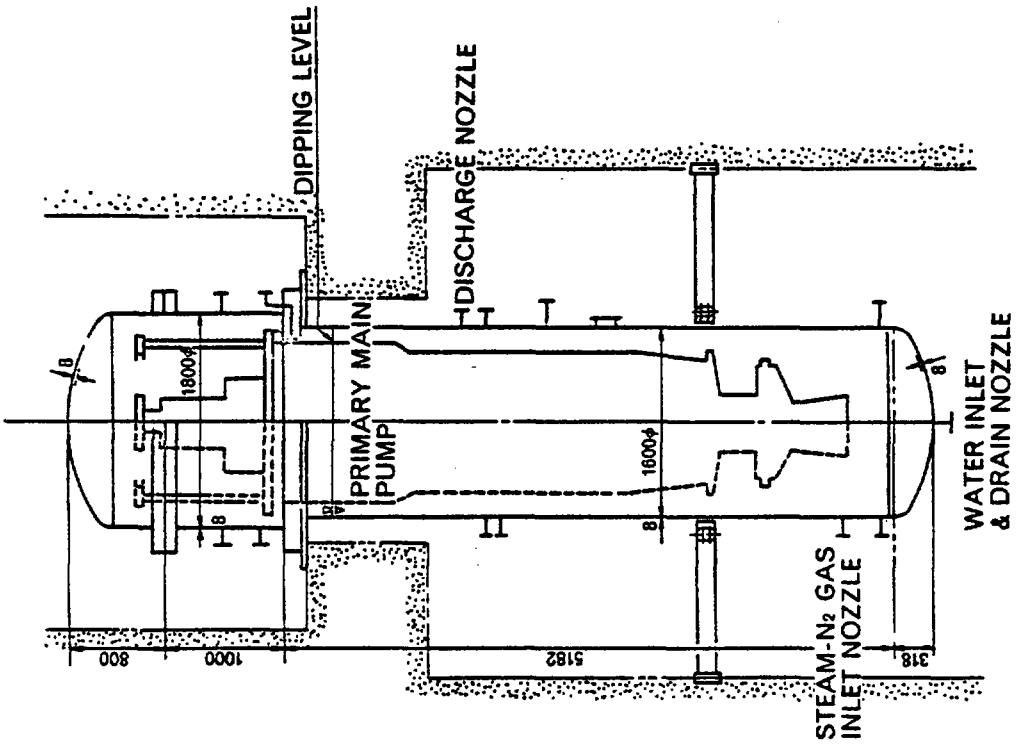


FIG. 4 PUMP CLEANING CELL

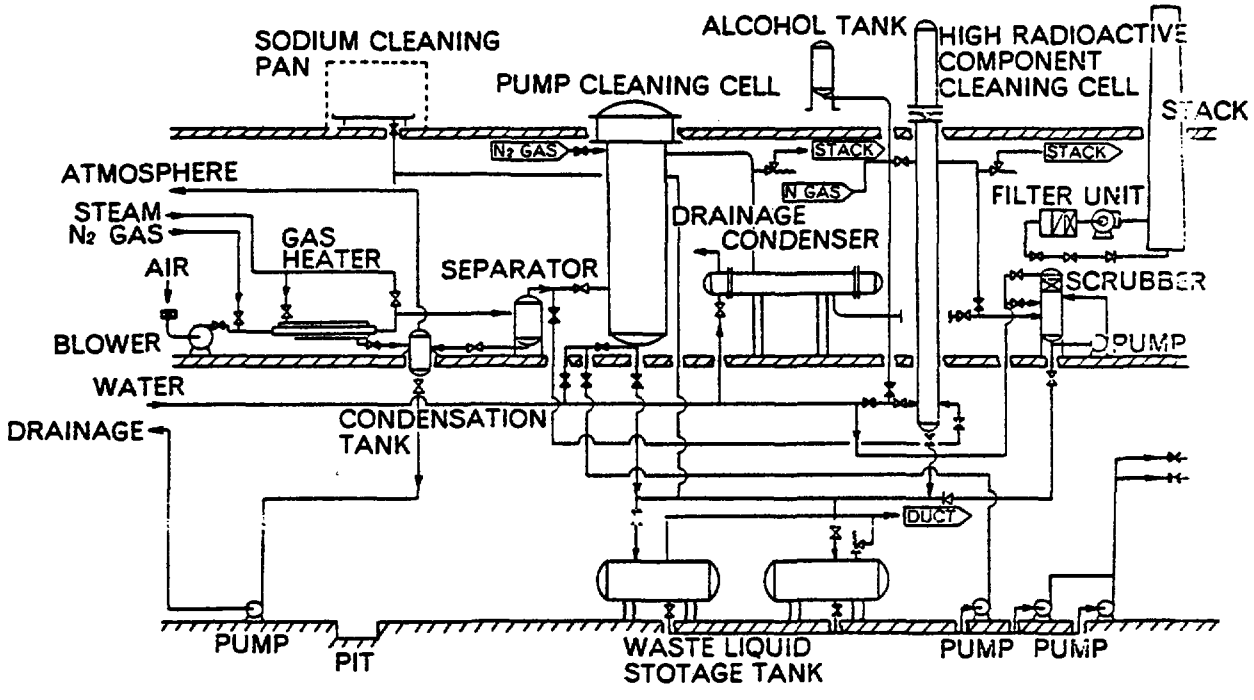
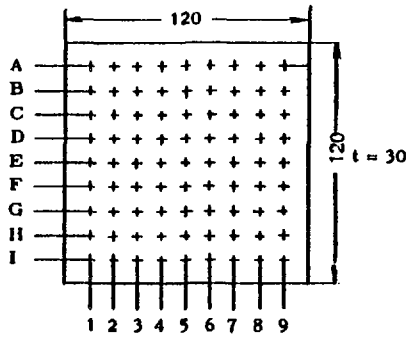


FIG. 3 FLOWSHEET OF SODIUM REMOVAL FACILITY



NAME	DIAMETER (mm ϕ)
A	5.0
B	4.0
C	3.0
D	2.5
E	2.0
F	1.5
G	1.0
H	0.7
I	0.5

NAME	DEPTH (mm)
1	27
2	24
3	21
4	18
5	15
6	12
7	9
8	6
9	3

Fig. 5 DESCRIPTION OF THE TEST PIECE

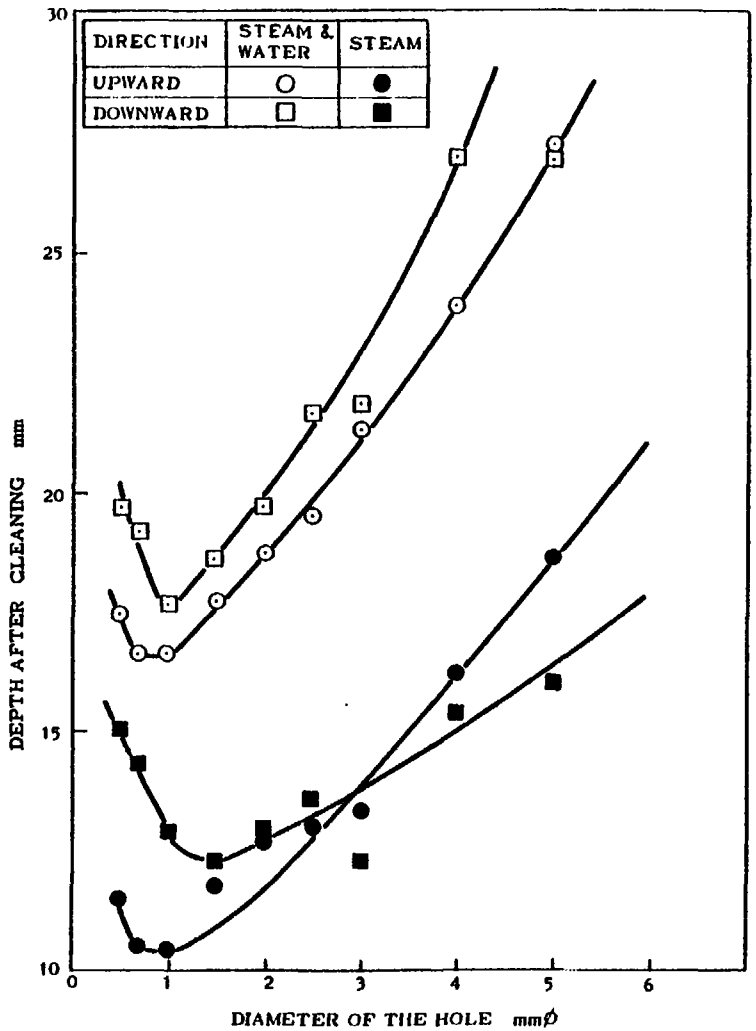


Fig. 6 THE CLEANING EFFECT (1)