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"Experience in Decontamination and Repair of Radwaste Concentrator at Millstone Unit No. 1"

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The Northeast Nuclear Energy Company has been operating the Millstone Nuclear Generating Station Unit 1 since early 1971. The unit is a boiling-water reactor rated at 662 MWe. As with most nuclear plants built in the early 70's, Millstone Unit #1 has gone through an extensive retrofit activity with the radioactive waste treatment systems being the focus of a large portion of this activity. All three major treatment areas, liquid, gaseous and solid waste, were reworked.

In the liquid radwaste treatment system, the existing evaporator's capacity was found to be too low, (Design - 10 gpm; Actual - 6 gpm). To augment this, a second evaporator was purchased from the Ecodyne Corporation, Unitech Division. This evaporator was rated at 30 gpm and has performed at this rate consistently. Since its installation, the evaporator has served as the primary radwaste concentrator. The original 10 gpm concentrator has been used only as occasional surge capacity.

When the evaporator was purchased in late 1972, it was considered to be quite an advanced design. The space allocated for it was an expanded equipment hatch and this was an overriding constraint in the evaporator's design. The evaporator is a single pass vertical tube forced circulation unit with a non-submerged tube design (Slide I). This means that, although there is boiling in the tubes of the heater, the concentrate is pumped through the tubes. The ratio of recirculation rate-to-evaporation rate is high enough to maintain a liquid film on the tube wall. Therefore, the tubes are never boiled dry. The high liquor and vapor velocities in the tubes minimize scale build-up.

Another design feature of this evaporator are the materials of construction which were used. All major components of the evaporator in contact with the concentrates are 70/30 copper/nickel. At the time when this evaporator was designed, 304 stainless steel was the most commonly used material, with 316 stainless steel coming into use. Thus far, with almost 3 years of service, the material has given excellent service. The system has experienced severe "off-standard" operating conditions.

The evaporator did suffer a loss in capacity which ultimately necessitated opening and entering the vessel. The problem arose in December of 1977. The evaporator had been shut-down for a short period of time (approximately 2 weeks). During the restart the evaporator steam rate could not be raised above 8000 lbs/hr (15 gpm) without producing poor quality distillate. The supplier (Unitech) was contacted. At first Unitech suggested a series of disgnostic procedures to identify the problem using the control instrumentation. None of these were successful in improving operation.

In February, after a meeting between myself and their representative, we decided that the cause could only be determined by opening and inspecting the vapor body vessel. To accomplish this, the evaporator would have to be taken off line for a period of time. The only time this could be conveniently scheduled was during a three-day period at the next refueling outage, which was due in April of 1978.

This gave us between February and April to obtain any spare parts which could conceivably be needed. Also this time was used to develop a plan for decontamination, vessel entry, inspection and repair. During this period the evaporator continued to be operated, producing good quality distillate at reduced capacity. It was imperative that complete loss of capacity be avoided at that time.

It was determined that the only major spare part that would be required was a replacement mesh pad, since distillate purity was the problem. It had been concluded, from the diagnostic tests, that, if the mesh pad was not the actual cause of the problem, it was a major factor. Surges of high conductivity liquid would periodically pass through the pad, to get to the condenser. This would lead to mesh pad plugging.

The heater was not considered a problem. No high conductivity had been detected during shutdown or startup of the unit when steam pressure was below that of the concentrates. The recirculation pump was checked and there was no change in the pump motor current. A restricting orifice, which had been installed during the preoperational startup, could, if necessary, be replaced from the existing spare parts stores. The impingement plate in the vapor body could be fabricated from stocked materials, if such were required.

Unitech supplied a list of chemicals for decontaminating and de-scaling the unit, (Slide II). They also recommended that prior to use of any of these chemicals, the unit be run for between 6 and 8 hours while filled with 1000 gallons of clean water. The water was to be heated to between 160^{o} and $180^{o}F$, using the heater. It was thought this would remove a major part of the contaminants prior to using any chemical solutions. This was quite attractive from a waste handling standpoint and proved to be quite successful. The water wash alone reduced the activity in the system to an acceptable level. It saved us the necessity of either testing the chemical solutions in our solidification system or hiring a contractor to handle the decontamination process.

Entry, inspection and repair would be carried out through a flanged accessway in the top of the vessel (Slide III). This permitted removal of the mesh pad which was tack welded via support bars to the removable dished head (Slide IV). This would permit visual examination of the vessel prior to entry, which would diminish the man-rem exposure.

Readings were taken by Health Physics prior to the water wash. It was found that the concentrator read between 700 and 800 mr per hour on contact during operation (Slide V). The unit was emptied and then flushed for a half hour using the demister spray nozzles. After this, (Slide VI), the reading dropped to between 500 and 600 mr per hour on contact. The unit was then put through the warm water decon for 7 hours at a water temperature of 180°F. After this the water was discharged to storage. Readings (Slide VII) indicated that the concentrator's dose rate had dropped to between 50 and 60 mr per hour on contact. Work could proceed on the concentrator with no further chemical decontamination washes required.

Due to the concentrator location in an equipment hatch, a small shed was built to act as access control and a wind break, after hatch removal. Insulation was stripped from the vessel and the flange was unbolted. Since the bolts were tack welded to the lower flange and the bolt heads were grooved, the unbolting was quickly accomplished. A distance of several feet could be maintained between the vessel and the personnel during the unbolting operation. A crane was brought in to lift the head; the line passing through a hole made in the shed.

The head was raised sufficiently to permit a radiation count on the inside of the vessel and to take a smear sample of the mesh pad. The dose rate (Slide VIII) between the cover and the pad was 90 mr per hr. and the smear showed 180,000 d/m per 100 sq cm on the inside of the dished head. At the same time the mesh pad was examined visually (from a distance) and appeared to be badly plugged crud.

It was decided that movement of the pad might cause the crud to become airborne and respirators should be worn by personnel entering the shed. The head was to be lifted up high enough to permit the pad to clear the lower flange and then wrapped in plastic sheeting. Then the head, with the covering shed, was moved to a laydown area, disconnected from the hook and the shed replaced over the open hatch. The mesh pad was cut away from the head and crated for disposal.

The concentrator vessel was again measured and smears were taken. The reading (Slide IX) inside the flange head was 10 mr per hour on contact, the vessel walls were between 25 and 30 mr per hour, increasing as the tube bundle was approached. The tube bundle was 50 mr per hour and the tube sheet was 75 mr per hour. The smears showed that the upper vessel walls were 470,000 d/m per 100 sq.cm. To protect the maintenance personnel, respirators, full PC's and plastics were required to enter the vessel.

Upon entry, the primary cause of the problem became apparent. The liquor deflector plate had worked loose and fallen aside. This plate had been bolted rather than welded to the vessel side walls, permitting easy removal of the plate for examination and work on the tube sheet. However, after 2 plus years of pounding by the liquid stream, three bolt heads had vibrated off. One bolt head was still intact; two were found at the bottom of the vapor body. The third was located in the heater liquor box when this portion of the unit was later inspected.

It was obvious that without the deflector plate, the liquid was impinging directly into the mesh pad. Apparently, as the steam rate was increased above 8,000 lb/hr., the vapor velocity was high enough to carry droplets completely through the pad into the surface condenser.

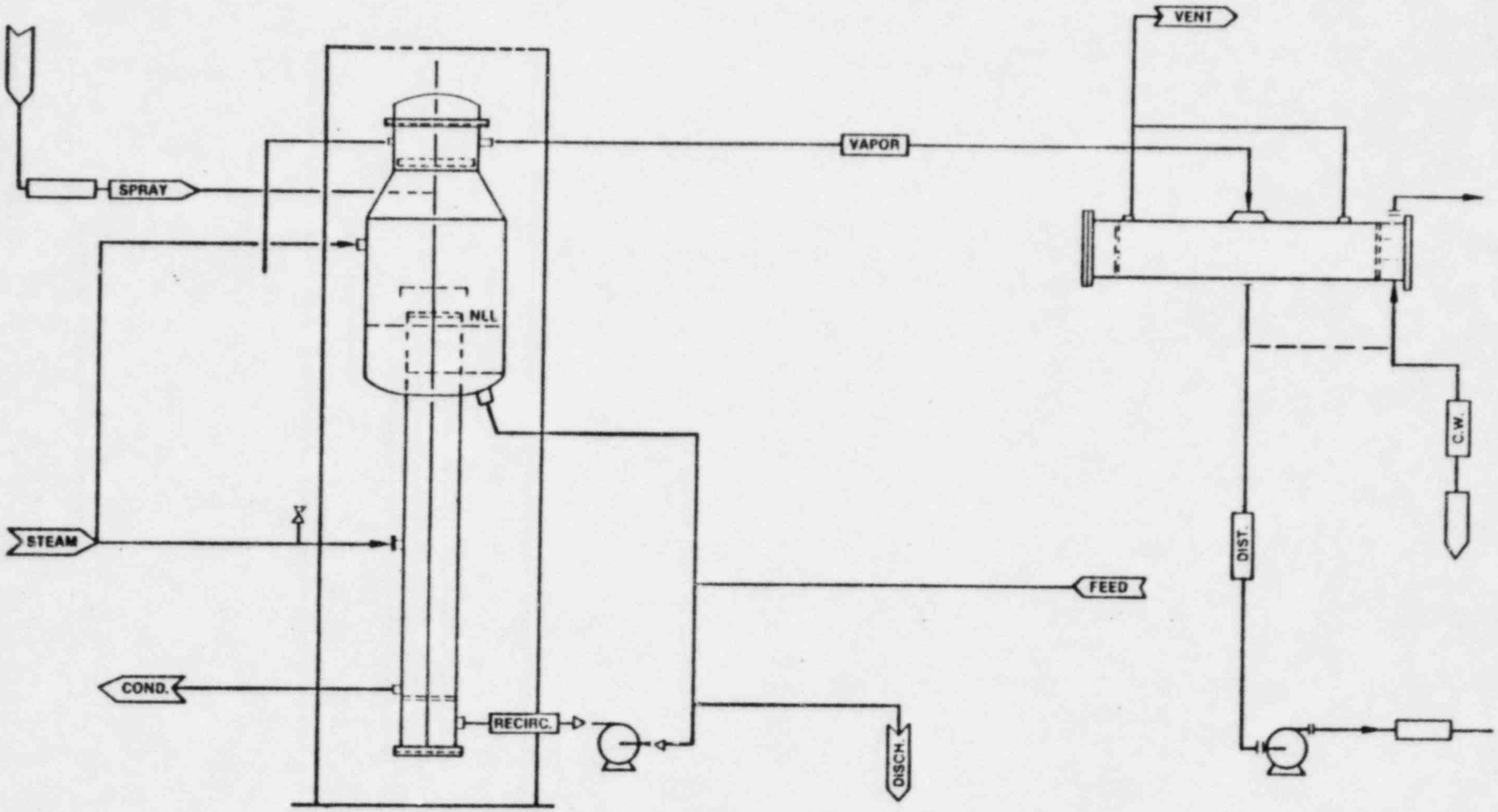
An inspection of the vessel and tube bundle was performed. The vessel and tube sheets showed no evidence of corrosion or pitting attack. The surfaces were scale free and smooth. The lower liquor box flanged head was removed and the tubes were inspected (it was at this time that the last bolt was found).

It was determined that of the 192 tubes in the heater, 25 had plugged. These plugs were a combination of calcium silicate and calcium sulfate. After attempts to drill these plugs with a tungsten carbide drill failed, it was decided that a high pressure water spray should be used. A chemical cleaning was considered but because this was such a small number of tubes, it was not felt that the large volume of chemical waste was warranted. The high pressure water jet was quite effective. It appeared to "melt" the plugs.

The final reassembly of the unit was relatively straight forward. The lower tube sheet flange was rebolted. The deflector plate was re-bolted. The bolts were drilled and pinned to prevent a repeat of the original malfunction. The new mesh pad was attached to the top head, the head was replaced and the unit was reinsulated. The entire operation took three days.

Restart was accomplished easily. The unit returned to its original 30 gpm feed rate, producing high purity distillate.

SLIDE I



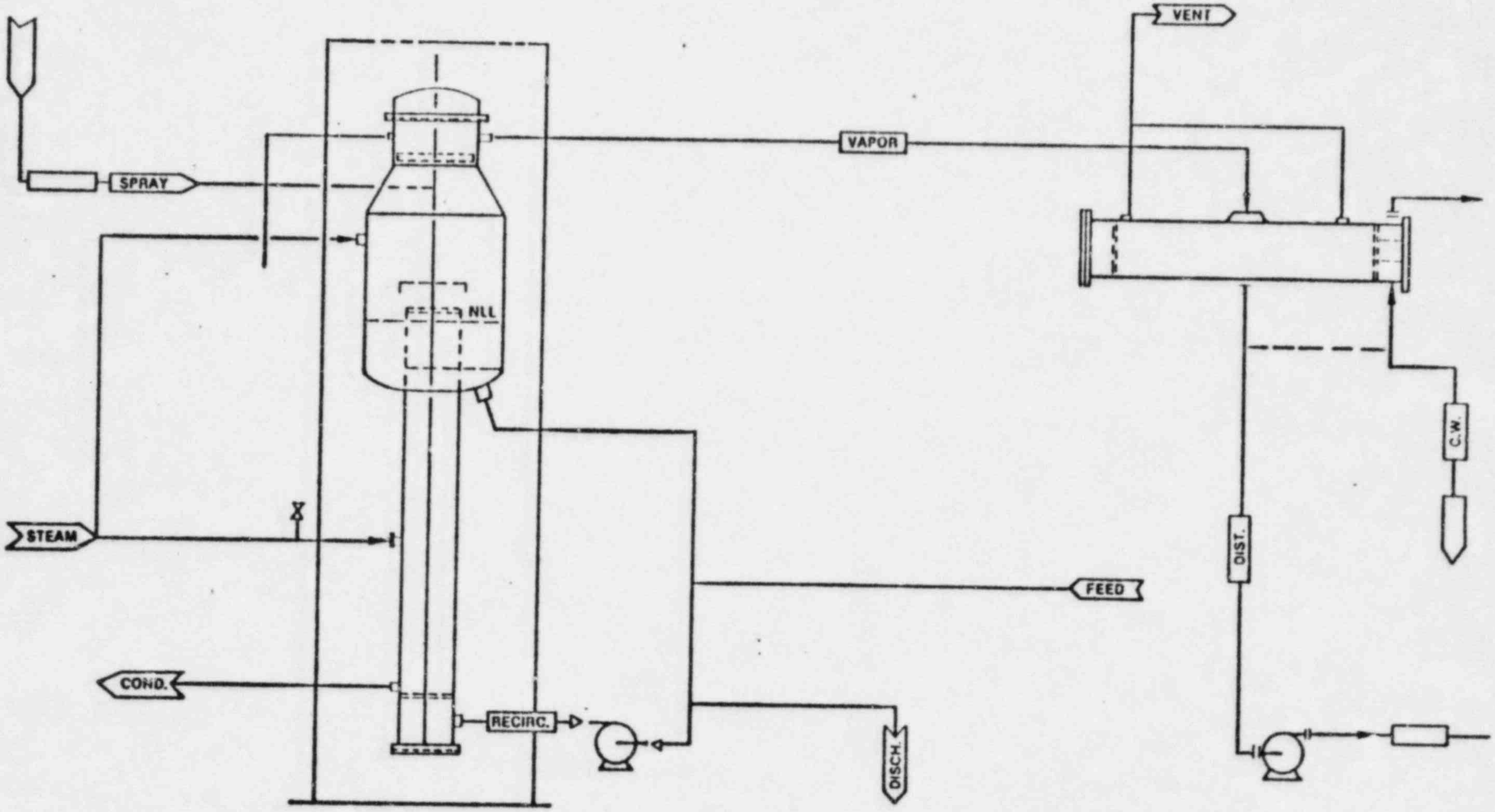
CUSTOMER -

MILLSTONE POINT COMPANY
MILLSTONE NUCLEAR STATION, UNIT #1

SUPPLIER -

ECODYNE CORP.
UNITECH DIV.

SLIDE II



CUSTOMER -

MILLSTONE POINT COMPANY
MILLSTONE NUCLEAR STATION, UNIT #1

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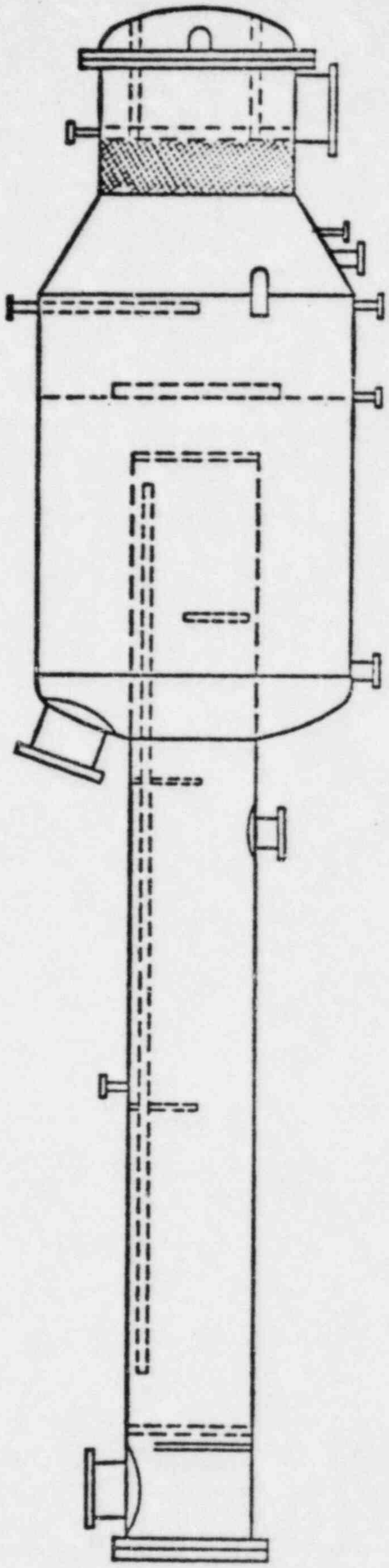
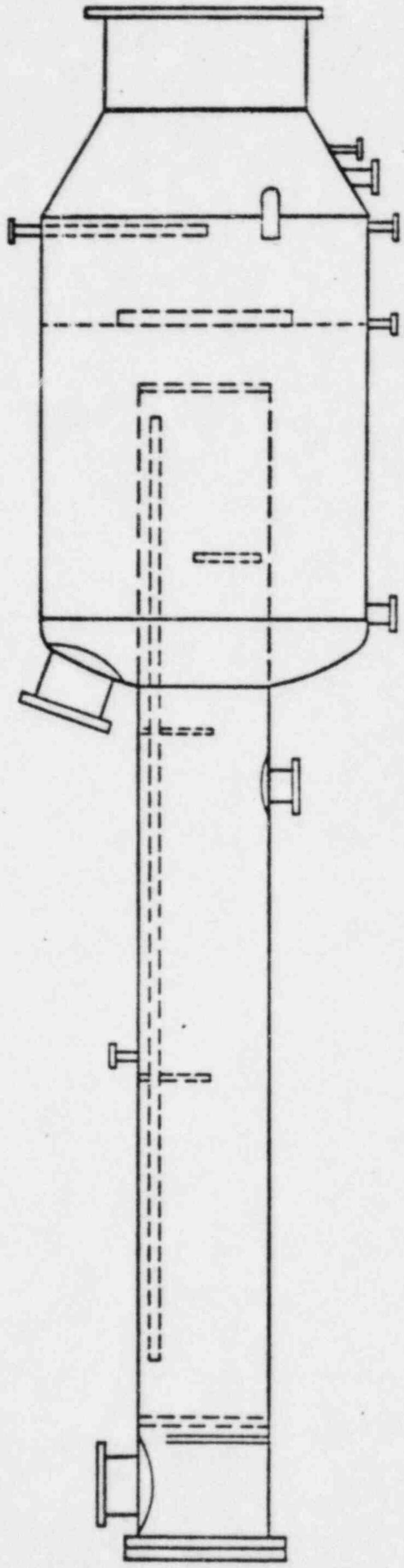
SLIDE III

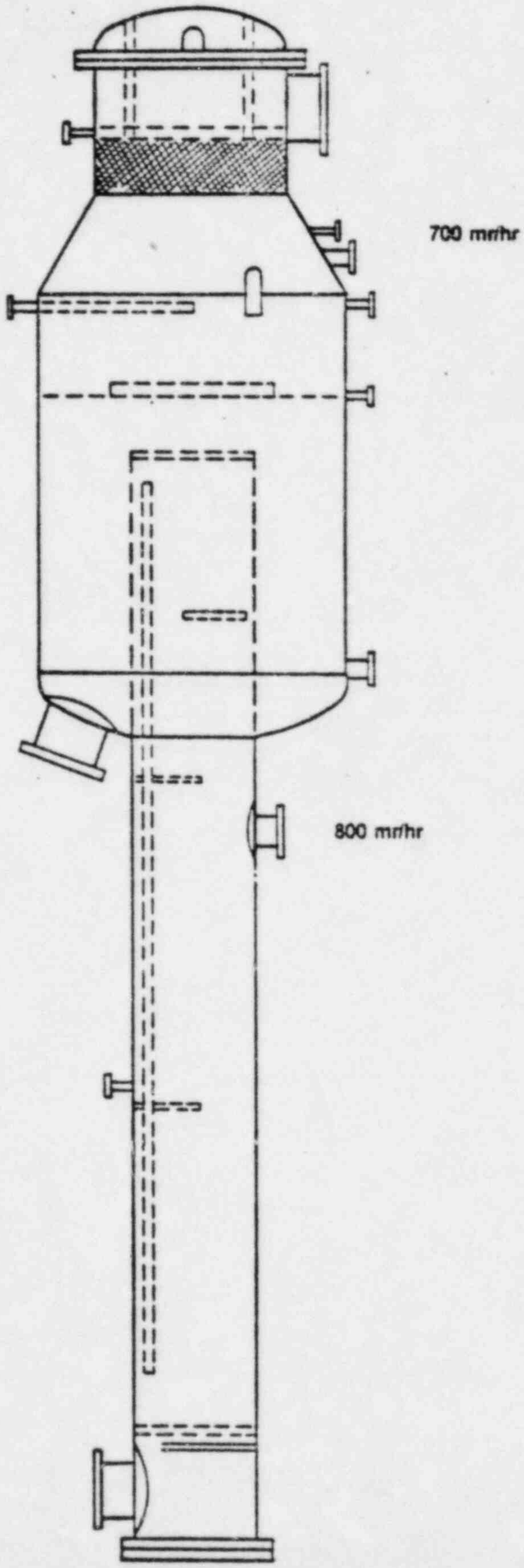


SLIDE IV

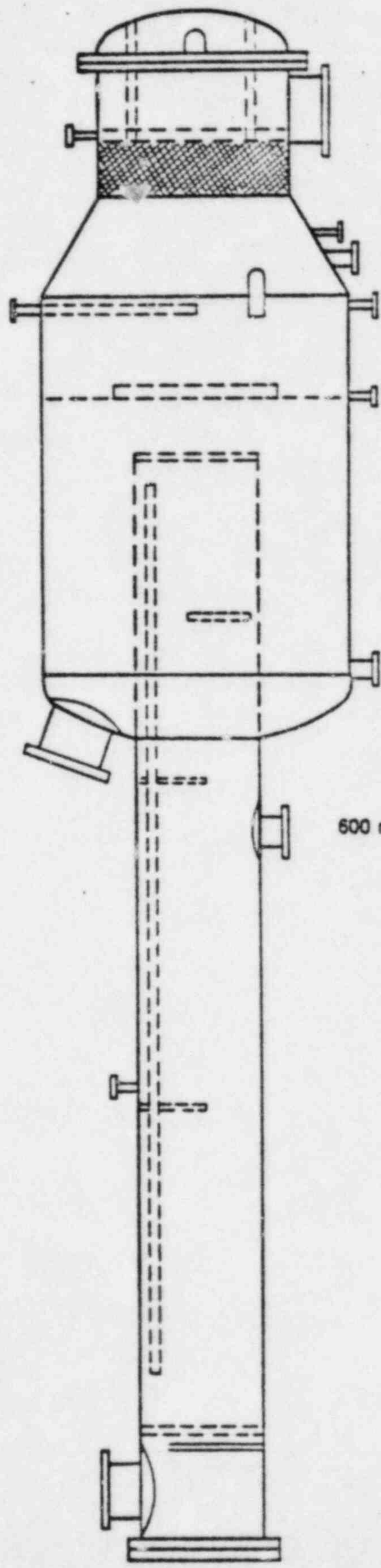


SLIDE V

OPERATION

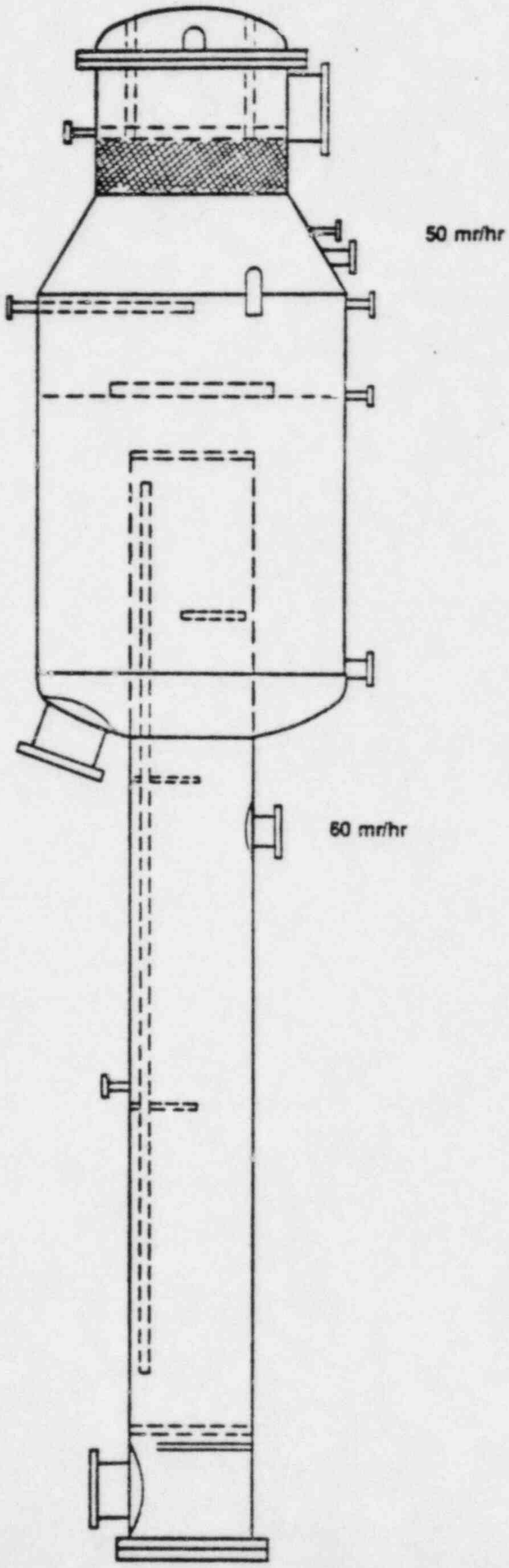


AFTER DISCHARGE FLUSH

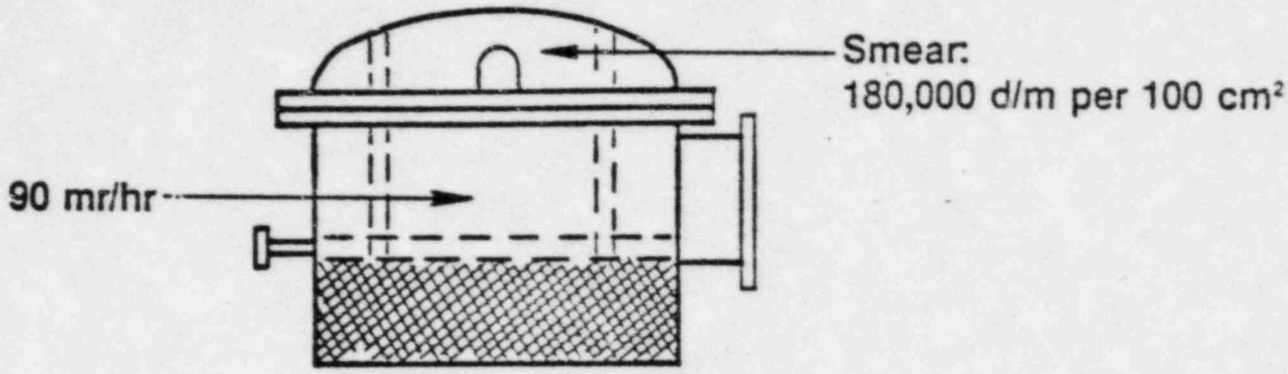


SLIDE VII

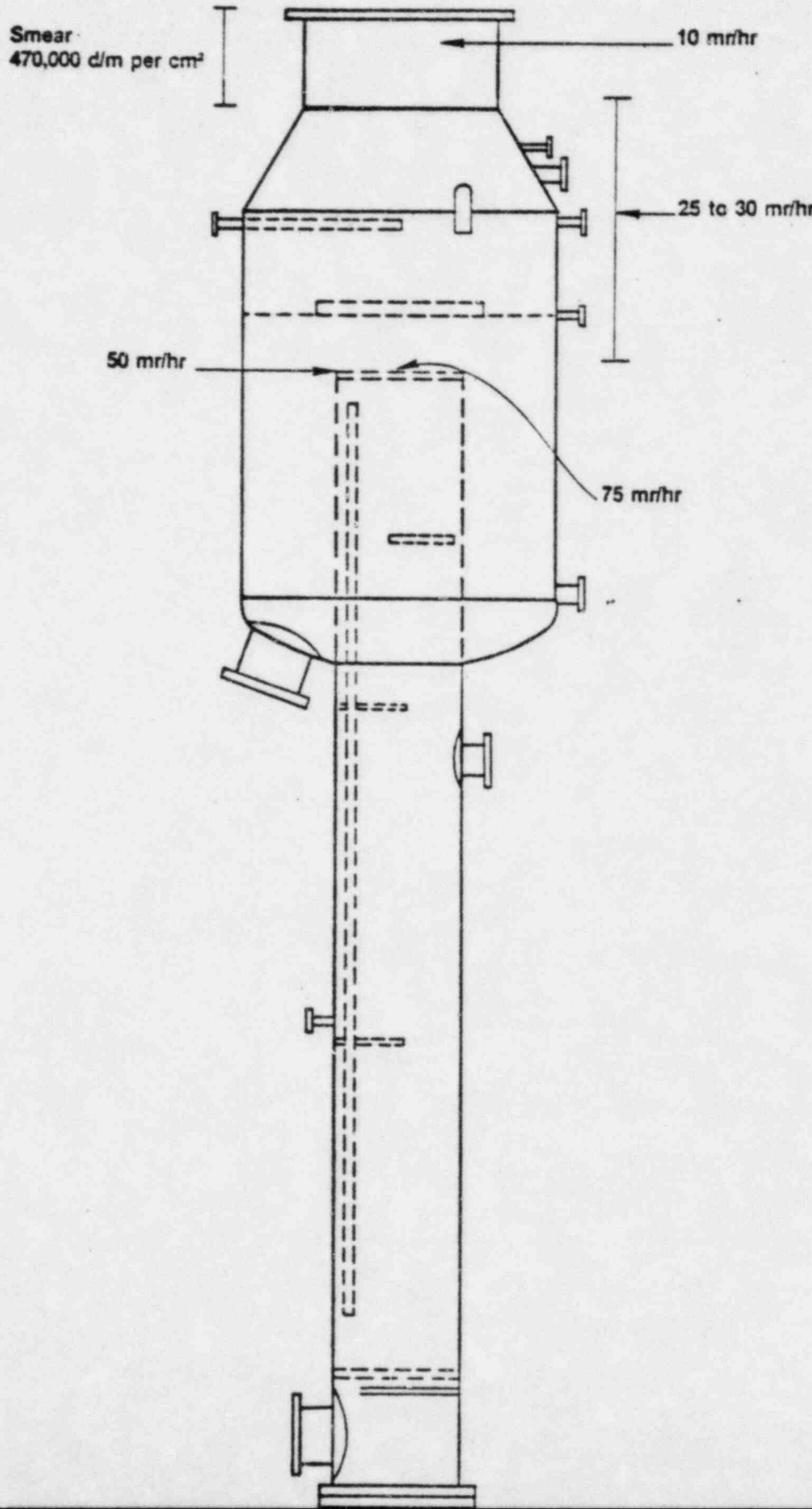
AFTER WARM WATER WASH



SLIDE VIII



SLIDE IX



SLIDE X