IP-32

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TASK CLOSE OUT DOCUMENT

Task Scope Conservative simulation of cold platform

To: M. Levenson
S. Levy
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Reason felt task is complete:

Analysis complete

Members of Committee

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Signed
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TO: Mel Lieb

FROM: Mike Kolar

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CONVECTIVE SIMULATION OF COLD SHUTDOWN FOR THREE MILE ISLAND REACTOR

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Prepared for:

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1.0 EXPERIMENTAL DESCRIPTION

A simulation of the damaged Three Mile Island nuclear reactor core was carried out in a system modeling experiment. The major apparatus associated with the experiment consisted of a plexiglass cylinder which represented the core, four circular flat heaters which represented the melted clad and fuel debris collected on the grid spacers, and a water flow network which represented the core cooling system. A schematic of the experiment is shown in Figure 1. The experiment was designed according to various parameters specified by EPRI. These are listed in Table 1.

The plexiglass cylinder is 4 feet long and has an internal diameter of 9.75 inches and a wall thickness of 1/8 inch. The four heater plates are 1/2 inch thick and 8 inches in diameter. Each is mounted in a plexiglass spacer ring such that the gap between the cylinder and the heater assembly is 1/4 inch (see Figure 2). This geometrical configuration was necessary because the largest heater elements obtainable on short notice were eight inch nominal diameter, and the closest diameter plexiglass cylinder obtainable was 9.75 inches in diameter. Since a 1/4 inch gap was specified by EPRI, a spacer ring was necessary.

The heater plate assembly consists of an electric stove top burner element. The element is packed in fine sand and surrounded by a steel shell (see Figure 3). Each element is rated at 2100 watts at 240 volts, but because of a low voltage (195 v) at night in the building's nominal 208 voltage line, the measured power to the heater plates was only 1490 watts.

The flow network representing the core cooling system is shown in Figure 1. The part of the network surrounded by the dashed line represents a constant temperature sink. Water enters the bottom of the plexiglass cylinder through a spreader plate and is dispersed into uniform flow so that a jet does not impinge on the underside of the lowest heater plate. Five thermocouple locations are indicated in Figure 4. The thermocouples were located about 1/8 inch from the heater plates.

2.0 EXPERIMENTAL PROCEDURE

The experiment was designed according to the EPRI specified parameters given in Table 1. During the construction of the apparatus, SAI staff determined from a simple heat balance on the system that the inlet temperature of 180°F was inconsistant with other parameters, namely heater plate power. It was then agreed that an inlet temperature of 100-130°F was more reasonable. Before data was about to be taken, it was also discovered that the mass flow rate had been incorrectly calculated, and that the correct value was about 17 gpm. Since the capacity of the pump in the experiment was only 10.5 gpm, it was agreed by EPRI and SAI staff that 10.5 gpm was still a representative value of the flow rate and the experiment would proceed.

To run the experiment, the secondary storage tank was first brought up to the desired temperature. This was accomplished by diverting some of the inlet flow through an auxillary heater, and adding tap water to the system, while also pumping water out from the storage tank to keep the level constant. When the system was at the approximate temperature, the bypass loop through the auxillary heater was closed. A flow loop was thus established between the simulated core and the constant temperature storage tank. When the system reached an equilibrium temperature, data was recorded as to flow rate and temperature.

Because of the unavailability of a proper size flow meter, the mass flow rate was determined by collecting the outlet flow from the vertical cylinder within a specified time and then weighing the water. The flow rates thus determined are accurate to within 5%.

3.0 RESULTS

The results of the experiment are summarized in Table 2. At both the low and high mass flow rates, there appeared to be good fluid mixing, indicated by the fact that there was no radial temperature gradient nor was there any sign of subcooled boiling. The thermocouple temperatures were recorded with a digital readout meter with a built-in reference temperature. Although the thermocouples were not previously calibrated, their accuracy is estimated at ± $2^{o}F$. The reason for this relatively large error is not due to the thermocouple itself, but is due to temperature oscillations. These oscillations are the result of bubbles from dissolved air in the water forming on the thermocouple and subsequently breaking loose.

Based on the results of this experiment, it may be concluded that, for the particular geometry and parameters defined in Table 1, no localized subcooled boiling will occur.

Table 1. Experimental Parameters

Experimental Parameters	EPRI Specified	Experiment
1. No. of Heater Plates	4	4
2. Heater Plate spacing	9"	9"
3. Flow Rate	0.3 gpm	10.5 gpm
4. Heater Power (per plate)	1.7 kw	1.49 kw
5. Annular Gap	0.25 inch	0.25 inch
6. Inlet Temp	180°	105°- 133°

Table 2. Temperature Distribution in Simulated Core

Mass Flow Rate (gal/min)	10.5	10.5	10.5	
Thermocouple No.	Temperature °F			
1	111	127	137	
2	114	127	136	
3	109	127	136	
4	109	127	136	
5	106	123	133	
Mass Flow Rate (gal/min)	0.77-0.83	0.80	0.78	0.77
Thermocouple No.	Temperature °F			
1	140	142	145	155
2	140	142	142	152
3	129	130	130	139
4	134	130	131	138
5	105	106	107	116
Heater Plate Power for all tests = 1.49 kw ± 2%				

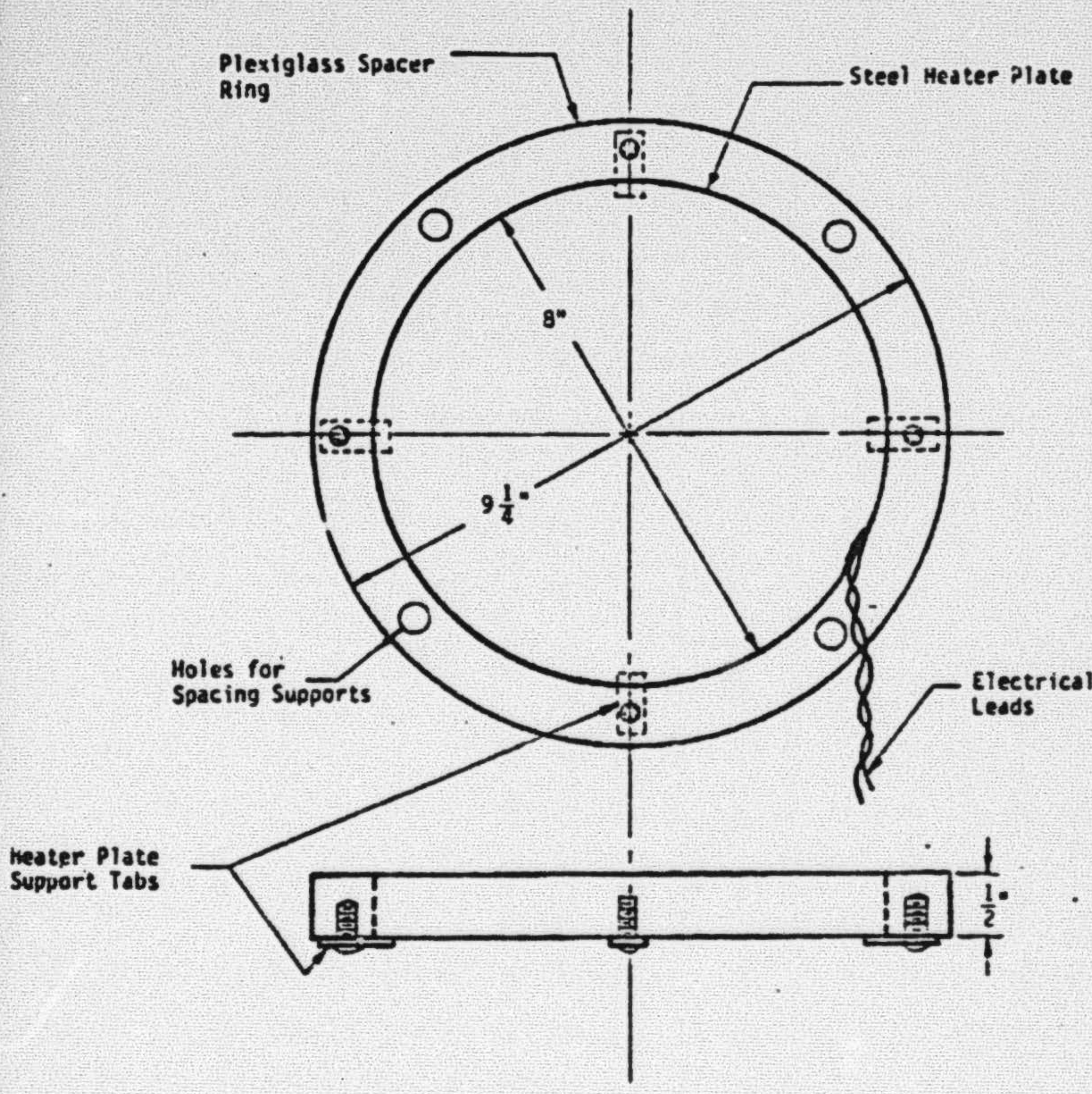

Figure 2. Heater Assembly

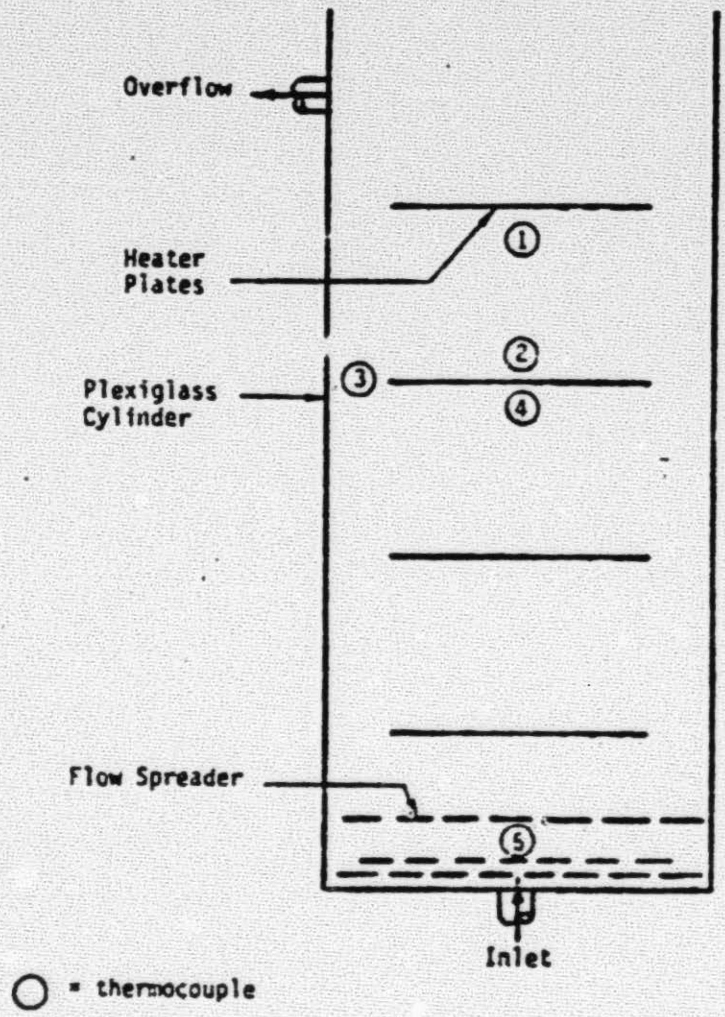

Figure 4. Location of Thermocouples