REVISION (1) TO SAFETY ANALYSIS REPORT (SAR)
FOR LOW ENRICHED FUEL OF THE RHODE ISLAND NUCLEAR SCIENCE
CENTER RESEARCH REACTOR

ACTION:

1) Replace pages 17 and 18 of the original document with new pages 17 and 18 CH-1

2) Replace Appendix C, pages 25 and 26, with new pages 25 through 30 CH-1

3) Delete Appendix D, pages 28 through 32.

LOSS OF COOLANT ANALYSIS

Beamports

There are four six-inch diameter, two eight-inch diameter aluminum beamports and one tangential through port. The beamports penetrate the pool wall liner at the mid level of the reactor core. The through port is below and off-center of the reactor core. If the pool water level reached the lowest elevation of a beamport, active fuel would remain immersed in approximately 8 inches of water.

A typical beamport is shown in figure 1-23. Four barriers to loss of coolant can be provided; not all beamports have all four barriers. The first barrier is the beamtube itself. The fixed experiment barriers (one on each end) limit any leakage area such that a beamport failure will be less than the pool makeup fill rate of the hydraulic head imposed by the pool The beamport shutter serves as another barrier, but the shutter is raised when a beamport is in use which elimates its utility. Finally the flanged cover plate serves as a fourth barrier.

At the RI Reactor, every beamport or through tube is configured with at least two of the barriers. The through tube has two of the barriers; the through tube itself and a flange at each end. There are three six-inch beamports not in use having three of the barriers; the beamtube, the shutter in closed position, and a flange installed. The three remaining beamports have a minimum of two barriers; the beamtube itself and the experimental barrier(s) described above.

Appendix A shows the calculations leading to the result that no experiment will be approved or installed with a barrier having an opening greater than the equilvalent area of a 1/2 inch diameter hole. The fixed experiment also implies that it shall be designed and installed to withstand the backpressure equivalent of the hydraulic head of the pool, or a minimum of 25.09 feet of water pressure.

Pool Make-Up Water

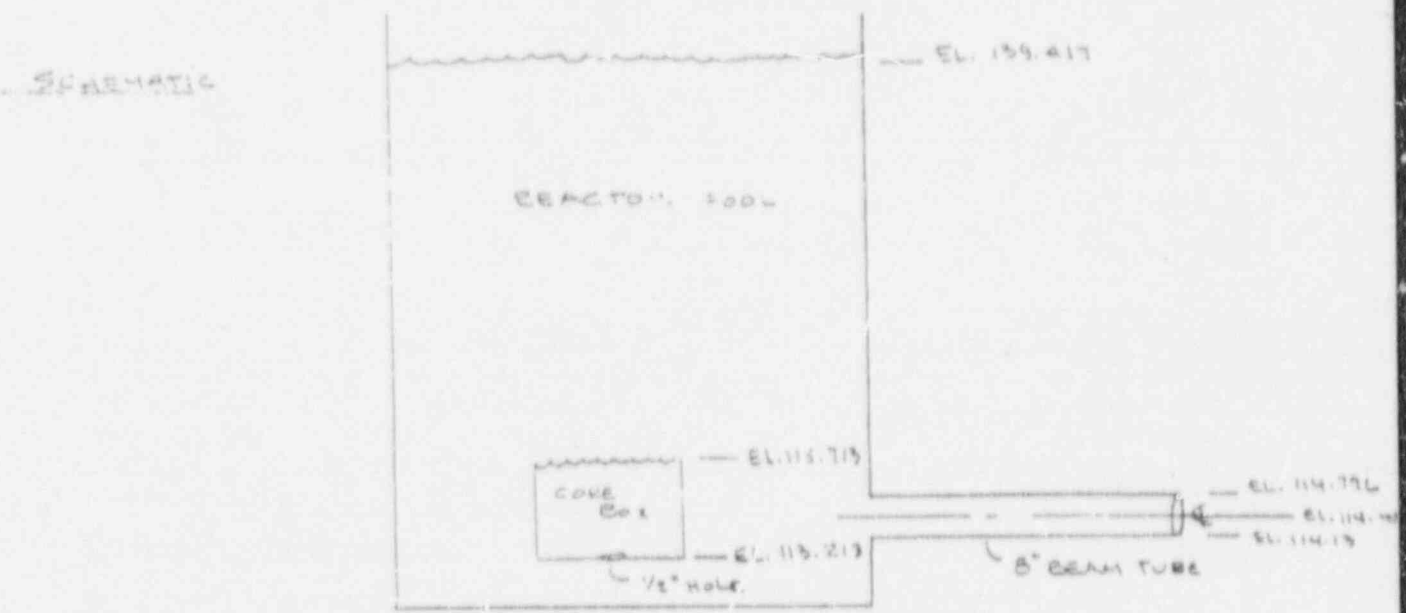
The RI Reactor has a pool fill make-up system consisting of a 2" water line from a make-up demineralizer which provides a normal flow of 20 gallons per minute. An automatic fill is initiated with a 1" drop in pool water level. A 2" drop in pool water level scrams the reactor. Manual filling of the pool is possible at 25 gallons per minute. The reliability of the water supply system has been described in Part B, Section VIII of this SAR.

LOCA Conclusions

Abnormal loss of coolant from the RI Reactor pool that could result in partial uncovering of the core can be caused by a rupture in or damage to a beamport. The maximum loss of coolant flow rate is 20 gallons per minute. The normal pool make-up system exceeds the loss of coolant flow rate. If pool make-up water is not available, the reactor core would remain completely covered for more than 35 hours subsequent to a low water level scram at which time the fission product heat would have decayed to less than 1/2 percent of the two megawatt normal operating power level (see Table 5.1). Based upon this analysis, the most severe abnormal loss of coolant event at the RI Reactor would not cause core damage.

APPENDIX C

LOSS OF COOLANT



SURFACE AREAS (FREE FLOW AREA)

Area of entire pool surface	:	150 ft^2
Area of core box	:	5.06 ft^2
Area of core (loaded)	:	.917 ft^2
Area of 1/2 diameter hole in core box	:	.00136 ft^2
Area of 8" pipe	:	.349 ft^2

APPENDIX C

Maximum Aperture Size for a Beamport Experiment

ASSUMPTIONS

(1) A postulated pool leak which could drain from a beam port and subsequently through an experiment shal[illegible] limited such that

(A) the total leakage rate is less than the minimum pool fill rate. 20 gpm

(B) the hydraulic head providing gravity flow is based upon the normal pool level less 2" for a low level scram point. The datum elevation for discharge is the centerline elevation of an 8" beam tube (El. 114.16).

COMPUTATIONAL METHOD

Discharge through an orifice[1]

$$Q = Ca\ (2gH)^{1/2}$$

where Q = flow rate, CFS
C + coefficient of discharge; .6
A = Aperture opening of a fixed beamport experiment, FPT^2
H = head (datum is el.114.16, beamport center line)

Calculations: (Minimum Aperture Size)

Assumptions: Neglecting Energy Losses

Flow Rate: 20 gallons per minute (minim m makeup flow)

Head: A 2" lever drop scram,pool water elevation 139.417-(2/12) = 139.25 and the discharge head = 139.25-114.16 = 25.09 feet

$$Q = 20\ gal/min \times 7.48\ gal/ft^3 \times 1\ min/60\ sec = .04456\ CFS$$

Solving for a

$$a = \frac{Q}{C\ (2gH)^{1/2}} = \frac{.04456}{.6\ (64.4 \times 25.09)^{1/2}} = a = \frac{.04456}{24.118} = 00184\ ft^2$$

Equivalent Diameter - .58"

(1) Handbook of Hydraulics, Ernest F. Brader, 6th Edition, McGraw-Hill Book Company, 1976

<u>Drain time for a 1/2" diameter hole with no make-up water</u>

From Reference #1

$$t = \frac{2A}{Ca\ (2g)^{1/2}} \left[(H_2)^{1/2} - (H_1)^{1/2} \right]$$

A = 150 square feet (pool surface area)

a = .00184 square feet (opening for 1/2" hole)

c = .6 (coefficient)

H2 = 25.09 (head above core box)

H1 = 1.27 (head over beamport)

$$t = \frac{2 \times 150}{.6 \times .00184 \times (64.4)^{1/2}} \left[(25.09)^{1/2} - (1.27)^{1/2} \right]$$

t = 127751 seconds = 35.49 hours

<u>Decay Heat</u>

From Table 5.1

$\frac{P}{Po}$ = .0046 (less than 1/2 percent)

P = .0046 x 2000 kw (operating power level)

P = 9.2 kw

This is less than the RI limit for natural convection (100kw) and is therefore conservative.

Discharge under Falling Head. Figure 4-5 shows a vessel filled with water to a depth h_1. The time required to lower the water surface to a depth h_2 is required. a is the area of orifice, and A, is the area of water surface for a depth y. C is the coefficient of discharge. The increment of time dt required to lower the water the infinitesimal distance dy is

$$dt = \frac{A\,dy}{Ca\sqrt{2gy}} \qquad (4\text{-}18)$$

Fig. 4-5. Discharge under falling head.

From (4-18), if A can be expressed in terms of y, by integrating between limits h_1 and h_2, the time needed to lower the water surface the distance $h_1 - h_2$ can be gotten. Placing $h_2 = 0$ gives the time of emptying the vessel. Equation (4-18) applies to horizontal or inclined orifices provided the water surface does not fall below the top of the orifice. For a cylinder or prism with vertical axis, A is constant, and Eq. (4-18), after integration, becomes

$$t = \frac{2A}{Ca\sqrt{2g}}\left(\sqrt{h_1} - \sqrt{h_2}\right) \qquad (4\text{-}19)$$

Orifice Coefficients One of the earliest experimenters on sharp-edged orifices was Hamilton Smith, Jr.[1] His values of the coefficient of discharge for round and square orifices are given in Table 4-3.

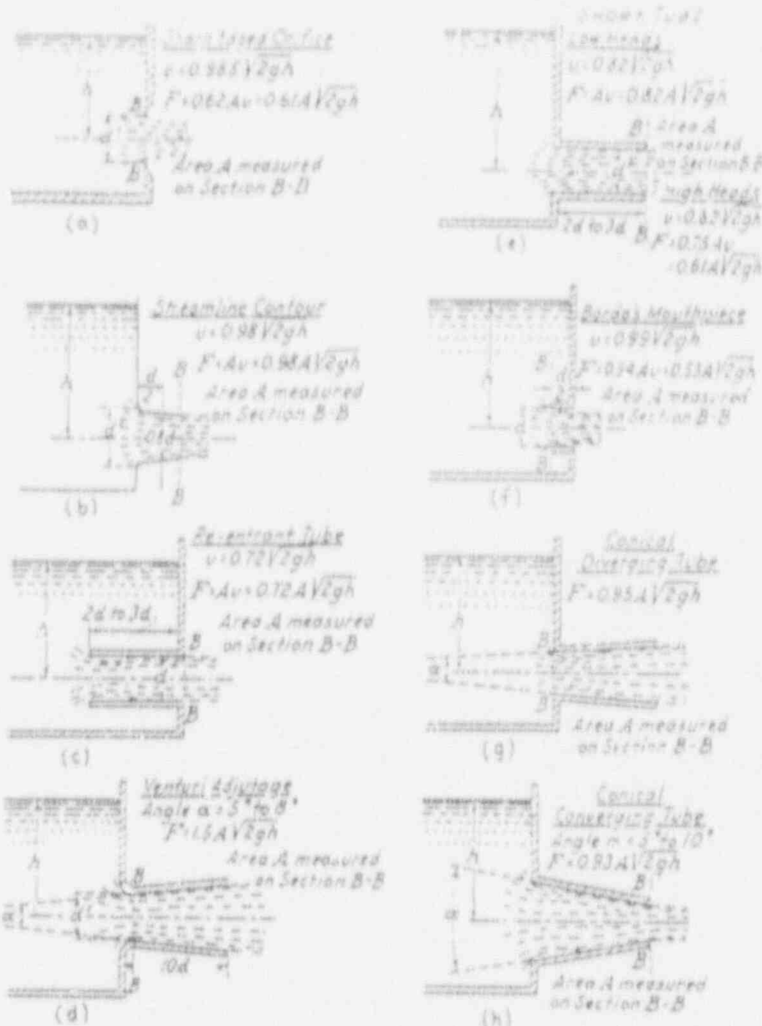


Table 4-3. Smith's Coefficients of Discharge for Circular and Square Orifices with Full Contraction

Diameter of circular orifices, feet							Head, feet	Side of square orifices, feet						
0.02	0.04	0.07	0.1	0.2	0.6	1.0		0.02	0.04	0.07	0.1	0.2	0.6	1.0
.....	0.637	0.624	0.618				0.4	.....	0.643	0.628	0.621			
0.655	0.630	0.618	0.613	0.601	0.593		0.6	0.660	0.636	0.623	0.617	0.605	0.598	
0.648	0.626	0.615	0.610	0.601	0.594	0.590	0.8	0.652	0.631	0.620	0.615	0.605	0.600	0.597
0.644	0.623	0.612	0.608	0.600	0.595	0.591	1	0.648	0.628	0.618	0.613	0.605	0.601	0.599
0.637	0.618	0.608	0.605	0.600	0.596	0.593	1.5	0.641	0.622	0.614	0.610	0.605	0.602	0.601
0.632	0.614	0.606	0.604	0.599	0.597	0.595	2	0.637	0.619	0.612	0.608	0.605	0.604	0.602
0.629	0.612	0.605	0.603	0.599	0.598	0.596	2.5	0.634	0.617	0.610	0.607	0.605	0.604	0.602
0.627	0.611	0.604	0.603	0.599	0.598	0.597	3	0.632	0.616	0.609	0.607	0.605	0.604	0.603
0.623	0.609	0.603	0.602	0.599	0.597	0.596	4	0.628	0.614	0.608	0.606	0.605	0.603	0.602
0.618	0.607	0.602	0.600	0.598	0.597	0.596	6	0.623	0.612	0.607	0.605	0.604	0.603	0.602
0.614	0.605	0.601	0.600	0.598	0.596	0.596	8	0.619	0.610	0.606	0.605	0.604	0.603	0.602
0.611	0.603	0.599	0.598	0.597	0.596	0.595	10	0.616	0.608	0.605	0.604	0.603	0.602	0.601
0.601	0.599	0.597	0.596	0.596	0.596	0.594	20	0.606	0.604	0.602	0.602	0.602	0.601	0.600
0.596	0.595	0.594	0.594	0.594	0.594	0.593	50	0.602	0.601	0.601	0.600	0.600	0.599	0.599
0.593	0.592	0.592	0.592	0.592	0.592	0.592	100	0.599	0.598	0.598	0.598	0.598	0.598	0.598

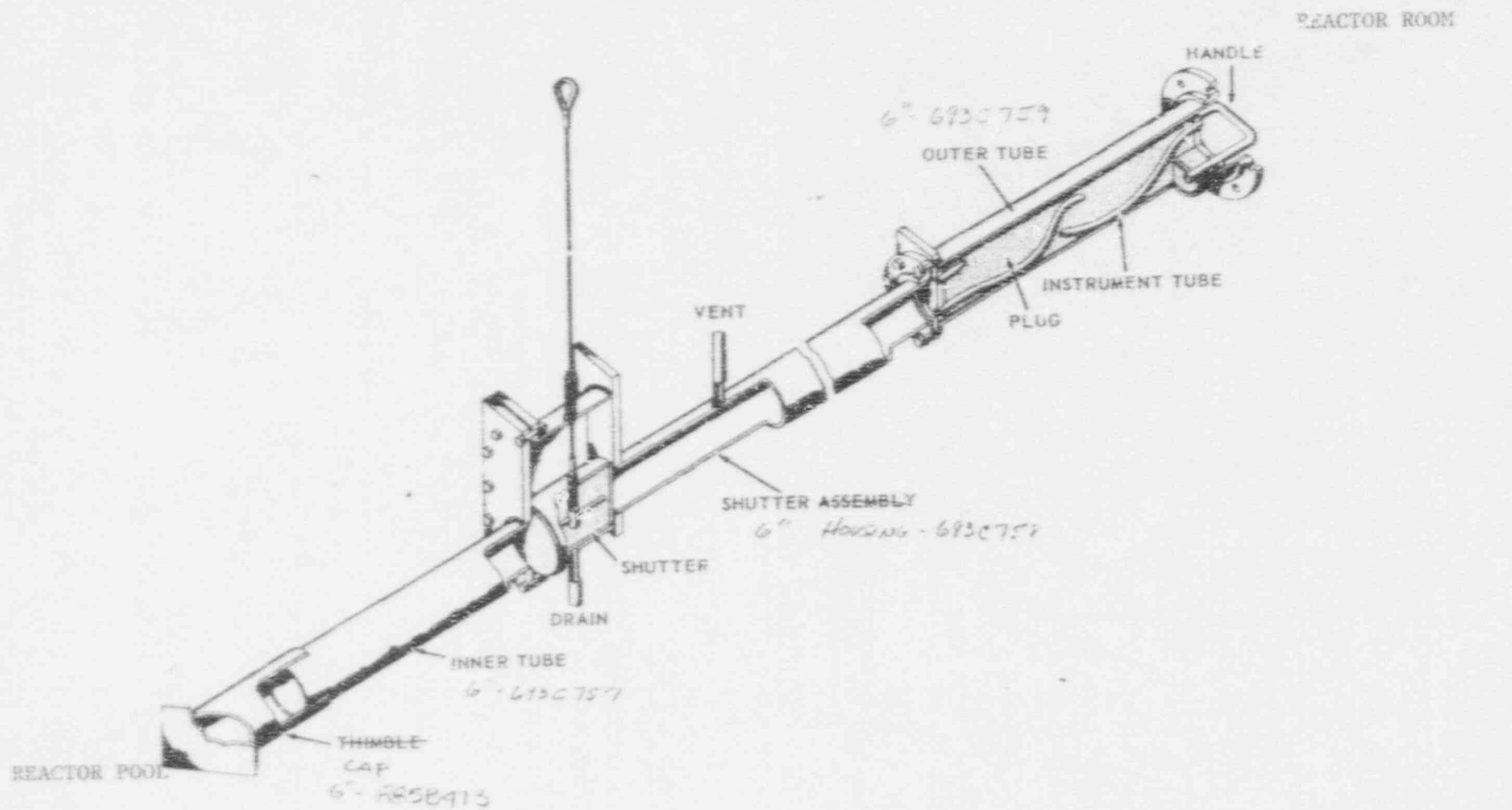


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FIGURE 1-23 BEAM PORT

Table 5.1

The Ratio, $P(t_s) / P_o$, of the Fission Product Decay Power to Reactor Operating Power as a Function of Time, t_s, After Shutdown (ANS, 1968)

Time After Shutdown, t_s (seconds)	Power Ratio $P(t_s) / P_o$	Time After Shutdown, t_s (seconds)	Power Ratio $P(t_s) / P_o$
1×10^{-1}	0.0675	6×10^{4}	0.00566
1×10^{0}	0.0625	8	0.00505
2	0.0590	1×10^{5}	0.00475
4	0.0552	2	0.00400
6	0.0533	4	0.00339
8	0.0512	6	0.00310
1×10^{1}	0.0500	8	0.00282
2	0.0450	1×10^{6}	0.00267
4	0.0396	2	0.00215
6	0.0365	4	0.00166
8	0.0346	6	0.00143
1×10^{2}	0.0331	8	0.00130
2	0.0275	1×10^{7}	0.00117
4	0.0235	2	0.00089
6	0.0211	4	0.00068
8	0.0196	6	0.00062
1×10^{3}	0.0185	8	0.00057
2	0.0157	1×10^{8}	0.000550
4	0.0128	2	0.000485
6	0.0112	4	0.000415
8	0.0105	6	0.000360
1×10^{4}	0.00965	8	0.000303
2	0.00795	1×10^{9}	0.000267
4	0.000625		