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March 18, 1988
Fort St. Vrain
Unit No. 1
P-88098

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Attention: Mr. Jose A. Calvo
Director, Project Directorate IV

Docket No. 50-267

SUBJECT: Core Support Floor Casing Leak; Safety Evaluation

REFERENCE: 1. PSC Letter, D. W. Warembourg to G. Kuzmycz, dated May 7, 1982 (P-82135)

Dear Mr. Calvo:

The purpose of this letter is to forward the most recent safety evaluation on the Core Support Floor (CSF) casing leak to the NRC staff for your information. The CSF casing leak and its effects on nuclear safety were discussed with NRC Region IV staff in a meeting in Arlington, Texas on March 3, 1988.

In 1982 FSV experienced a primary coolant leak through the CSF casing. Some of the helium which leaked through the CSF casing also leaked into a tube (F4T21) of the System 46 PCRV liner cooling system, pressurizing the Loop 1 System 46 surge tank. The remainder of the primary coolant leaking through the CSF casing entered the CSF vent system, designed for such a leak, and was collected by the radioactive gas waste system. Reference 1 submitted to the NRC PSC's safety evaluation of the CSF casing/liner cooling tube leak and the design change for isolating the leaking liner cooling tube.

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Since the leaking liner cooling tube was isolated in 1982, all primary coolant leaking through the CSF casing is handled by the CSF vent system and the radioactive gas waste system, as described in FSAR Sections 3.3.2.2, 5.9.2.4 and 11.1.3.4. The CSF casing leak tends to seal as PCRV pressure and core outlet temperature increase, and is normally less than 1.0 lb/hr at power levels above 30%. During startup or shutdown operations, when the CSF is leaking at its maximum rate, leak rates approaching 10 lbs/hr have been measured.

The radioactive gas waste compressors (C-6301 and C-6301S) are designed to maintain the radioactive gas waste vacuum tank (T-6301) at approximately atmospheric pressure with a total helium flow rate into the gas waste vacuum tank as high as 53 lbs/hr from the CSF leak and other sources of potentially radioactive gas. Usually there is very little flow of gas from sources other than the CSF into the gas waste vacuum tank. At design primary coolant activity concentrations, 10 CFR 20 Maximum Permissible Concentration (MPC) levels would be reached with a 14 lb/hr release of primary coolant to the radioactive gas waste system. Since actual primary coolant activity levels are only about one-sixtieth of design, much higher release rates are permitted by 10 CFR 20. Attachment 1 is a table which depicts the effects of variations in primary coolant activity concentrations and release rates on offsite doses and 10 CFR 20 limits.

PSC has recently performed a 10 CFR 50.59 safety evaluation which updates the 1982 safety evaluation enclosed in Reference 1 to reflect current leak behavior and present plant operating conditions. This recent safety evaluation (Attachment 2) evaluates a CSF internal pressure of 100 psig, instead of the 60 psig value currently identified in FSAR Sections 3.3.2.2 and 5.9.2.4. This safety evaluation also assesses the safety impact of the CSF casing leak in general. One item addressed in this recent safety evaluation centers around the possibility of "reverse pressurizing" the CSF and the effects of reverse pressurization. During normal plant operation the CSF casing is in a state of net compression, since PCRV pressure exceeds the 60 psig (or 100 psig) internal CSF pressure maintained by pressure control valve PV-6364 in the CSF vent line header. This state of compression poses no challenge to the structural integrity of the CSF casing. However, if the CSF vent line header were isolated so that CSF internal pressure equalized with PCRV pressure as the result of primary coolant leakage into the CSF, a rapid depressurization of the PCRV (such as is postulated to occur in Design Basis Accident No. 2, hypothetical rapid depressurization accident) could result in CSF internal pressures significantly in excess of PCRV pressures. The tensile stresses which the CSF casing would be subjected to in this scenario could affect the integrity of the CSF casing. The Attachment 2 safety evalution considers the potential for damage to the CSF resulting from reverse pressurization in several accidents evaluated in the FSAR. Attachment 2 concludes that plant design and procedural controls are adequate to prevent CSF deformation that could cause a safety concern. PSC concludes that the manner in which the reactor is being operated with the CSF casing leak does not constitute an unreviewed safety question. The situation was judged to be safety significant.

This potential for reverse pressurization has existed in the past, but has not been previously assessed in the FSAR or a 10 CFR 50.59 safety evaluation. The NRC staff may wish to review this particular aspect of the safety evaluation in greater detail. PSC is ready to provide further information or reference materials upon request.

If you have any questions, please contact Mr. M. H. Holmes at (303) 480-6960.

Very truly yours,

Lawrence Brey

H. L. Brey, Manager
Nuclear Licensing and Fuels

HLB:JRJ/dvd

Attachments

CORE SUPPORT FLOOR LEAK
CASE COMPARISON

	FSAR CASE	WORST CASE ACTUAL EXPERIENCE	GAS WASTE SYSTEM AT MAXIMUM CAPACITY
Helium Leak Rate	14 lbs/hr	10 lbs/hr	53 lbs/hr
Hold Up Capacity	30 hours	42 hours	7.9 hours
Circulating Primary Coolant Inventory	30,900 curies	515 curies	8163 curies
Curie Content of CSF Leak	60 curies/hr	0.7 curies/hr	60 curies/hr
Duration of Release	Continuous	During Start-up and Shutdown	During Start-up and Shutdown
Percent of 10CFR20 MPC Limit	100%	1.67%	25%
Off-site Dose	Per FSAR Table 11.1-11	1/84th of FSAR Table 11.1-11	Per FSAR Table 11.1-11

ASSUMPTIONS (ALL CASES): Two 700 cu. ft. gas waste surge tanks, capable of operating at 450 psig. FSAR short term Condition F atmospheric dilution based on elevated release (50m plant vents) with a wind speed of 5 m/sec causing down wash per FSAR Figure 14.12-1. No decay during hold-up.

Attachment 1 to P-88098

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FORT ST. VRAIN NUCLEAR GENERATING STATION

PUBLIC SERVICE COMPANY OF COLORADO

CN/TCR/SCR/PC/TR NO. ____

SAFETY EVALUATION PORC 767 MAR 2 - 1988

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CATEGORY

TYPE:

☐ CN OVERALL ☐ CN SUBMITTAL ☐ SETPOINT CHANGE REPORT ☐ TEST REQUEST
☐ TEMPORARY CONFIGURATION REPORT ☐ PROCEDURE CHANGE (FSAR) ☒ OTHER

CLASSIFICATION: ARE THE SYSTEM(S) EQUIPMENT OR STRUCTURES INVOLVED, OR DOES THE ACTIVITY AFFECT:

CLASS I	☒ YES	☐ NO	ENGINEERED SAFEGUARD	☐ YES	☒ NO
SAFE SHUTDOWN	☒ YES	☐ NO	PLANT PROTECTIVE SYSTEM	☐ YES	☒ NO
SAFETY RELATED	☒ YES	☐ NO	SECURITY SYSTEM	☐ YES	☒ NO

REMARKS ____

EVALUATION **Use Additional Sheets If Required**

1. DOES THIS ACTIVITY AFFECT STRUCTURES, SYSTEMS, COMPONENTS, EQUIPMENT, TESTS, EXPERIMENTS OR PROCEDURES DESCRIBED IN THE FSAR OR TECH SPECS? ☒ YES ☐ NO

LIST THE APPLICABLE SECTIONS REVIEWED: FSAR Sections 3.3.2.1, 3.3.2.2, 5.9.2.4, 11.1.3.4, 14.4, 14.7, 14.10, 14.11, D.1.3.4.2, D.2.2; Technical Specifications LCO 4.2.13, LCO 4.2.14, LCO 4.2.18, ELCO 8.1.1, and ELCO 8.1.5.
Fire Protection Program Plan - FP.4

2. DOES THE ACTIVITY REQUIRE THAT CHANGE(S) BE MADE TO THE FSAR OR TECH SPEC? ☒ YES ☐ NO

LIST SECTIONS TO BE CHANGED AND THE CHANGES TO BE MADE: FSAR Section 14.11 should discuss effects of rapid depressurization on the CSF when the CSF is being maintained at a pressure of 100 psig.

3. DETERMINE WHETHER OR NOT THE ACTIVITY INVOLVED IS AN UNREVIEWED SAFETY QUESTION UTILIZING THE FOLLOWING GUIDELINES:

(A) HAS THE PROBABILITY OF OCCURRENCE OR THE CONSEQUENCES OF AN ACCIDENT OR MALFUNCTION OF EQUIPMENT IMPORTANT TO SAFETY PREVIOUSLY EVALUATED IN THE FSAR BEEN INCREASED?
☐ YES ☒ NO STATE BASIS: See attached.

(B) HAS THE POSSIBILITY OF AN ACCIDENT OR MALFUNCTION OF A DIFFERENT TYPE THAN ANY EVALUATED PREVIOUSLY IN THE FSAR BEEN CREATED? ☐ YES ☒ NO STATE BASIS: See attached.

(C) HAS THE MARGIN OF SAFETY, AS DEFINED IN THE BASIS FOR ANY TECHNICAL SPECIFICATION OR IN THE FSAR BEEN REDUCED?
☐ YES ☒ NO STATE BASIS: See attached.

DOES THE ACTIVITY APPEAR TO: INVOLVE AN UNREVIEWED SAFETY QUESTION ☐ YES ☒ NO
BE SAFETY SIGNIFICANT ☒ YES ☐ NO

BY [signature] (SIGNATURE) 3-2-88 (DATE) APPROVED [signature: M. H. Holmes] (SIGNATURE) 3-2-88 (DATE)

BACKGROUND

Objectives

The objectives of this safety evaluation are to assess the safety impact of 1) controlling Core Support Floor (CSF) internal pressure at 100 psig instead of the 60 psig value currently described in FSAR Sections 5.9.2.4 and 3.3.2.2, 2) revising SSC-03, SSC-04 and SSC-05 to require establishing a CSF alternate vent path prior to restoration of forced circulation, 3) revising Emergency Procedure EP-G to require isolation of the CSF vent paths prior to controlled depressurization, and 4) primary coolant leakage through the CSF casing into the radioactive gas waste system approaching 10 lbs/hr following reactor scram with full helium inventory. The FSAR discusses a 14 lbs/hr CSF leak rate. Furthermore, the safety significance of the 14 lbs/hr value will be assessed.

Design

The configuration and principal dimensions of the FSV core support floor (CSF) are shown on Fig. 1. Within the CSF concrete are vent tubes which allow gas to be vented from the CSF to maintain the pressure within the CSF to within design allowables. FSAR Section 5.9.2.4 states the following: "Cooling water tube leaks in the core support floor have occurred and core support floor casing leaks are credible and have been detected. A network of tubes is located in the core support floor to vent any primary coolant or cooling water in-leakage to the gas waste system. The system is designed to limit the pressure buildup in the core support floor to 60 psig, during normal operation. A high-pressure alarm detects a pressure in the core support floor > 10 psig. A pressure controller limits the pressure buildup in the floor to 60 psig, during normal operation. The vent system can handle helium leakage rates up to 14 lbs/hr Although from a safety standpoint it would be allowable to vent helium at rates up to 14 lbs/hr, economic considerations make it mandatory to install a helium recovery system to recover the core support floor vent gas at a much lower flow rate. This recovery system eliminates any direct release to atmosphere."

FSAR Section 11.1.3.4 states "The maximum allowable leak rate has been determined based on continuous radioactive release from the plant at MPC levels given by 10 CFR 20. This results in an allowable leak rate of 1.0 curies/minute, which would be equivalent to 14 lbs/hr at design primary coolant activity." The preceeding paragraph, in which the FSAR states "from a safety standpoint it would be allowable to vent helium at rates up to 14 lbs/hr" is based on the assumption that the helium is at design activity levels, so that vent rates in excess of 14 lbs/hr would violate 10 CFR 20 limits.

The space inside the core support floor is vented and drained to maintain the pressure in the core support floor at a pressure below that of the water in the liner cooling tubes. The vent and drain cavities were formed during the concreting of the core support floor and are connected to tubes permanently cast in the concrete and routed through the floor, down the core support columns and to the radioactive gas waste system. (FSAR Section 3.3.2.2).

The radioactive gas waste system (FSAR Section 11.1) is designed to collect, monitor and control the release of radioactive gases in conformance with 10 CFR 20. Provision is made in this system to collect any primary coolant leaking into the core support floor (FSAR Section 11.1.2.3). The system has sufficient capacity to permit processing a continuous leak of 14 lbs/hr of primary coolant from that source in addition to the maximum gas stream from other expected sources, and in the absence of other flows, could handle as much as 53 lbs/hr In regards to this 53 lbs/hr capacity, System Description SD-63, Radioactive Gas Waste System, states the following:

"The maximum capacity of the gas waste system is achieved when both compressors are operated in parallel and the gas waste vacuum tank (T-6301) pressure is allowed to approach the set pressure (1 psig) of the tank safety valve (V-6319/V-63102). Under these conditions the compressor can pump about 53 lbs/hr of helium. Most of the time there is little, if any, flow of gas into the gas waste system. Thus, if it becomes necessary to vent primary coolant from the core support floor to the gas waste system, the compressors could handle as much as 53 lbs/hr of the vent gas. However, allowance must be made for the possible diversion of gas from the gas waste filters (F-6301 and F-6301S) to the vacuum tank (T-6301) in the event of excessive release of radioactivity to the plant ventilation system. This design flow may be as high as 80 cfm (@ 12 psia and 100 F) or the equivalent of about 39 lbs/hr of helium. During this time the compressors can handle only 53 - 39 = 14 lbs/hr of primary coolant from the core support floor vent system. This has therefore been selected as the design capacity of the gas waste system to receive core support floor vent gas."

The actual CSF vent flow is monitored and recorded in the control room by a flow recorder (FR-6375). The holdup capacity of the radioactive gas waste system is provided by two 700 cubic ft surge tanks, capable of operating at 450 psig. With a 14 lbs/hr leak, the tanks provide a total of 30 hours hold up capacity. Beyond 30 hours, the leakage would have to be vented from the plant through the reactor plant ventilation system filters. After the first tank is filled, its decayed activity would be released while the other tank is filling, and so on. However, operation of the reactor at power for significant amounts of time with a leak rate of this magnitude is not contemplated. Even if the reactor is assumed to remain at full power for 40 hours and the 14 lbs/hr primary coolant leakage during the 10 hours between 30 hours and 40 hours is vented directly from the plant the whole body gamma (WBG) dose at the exclusion area boundary would be less than 5 millirem (worst short term dilution, design primary coolant activity, 5 m/s wind speed, elevated release with downwash) (FSAR Section 11.1.3.4). At current primary coolant activity levels, which are approximately only one-sixtieth of design activity levels, the dose would be a small fraction of that value or conversely, a leak rate considerably greater could be allowed under 10 CFR 20 limitations.

The possibility of a core support floor casing leak occurring in close proximity to a liner cooling tube leak and leading to helium bypassing the vent system and leaking into the affected cooling water loop has also been considered in FSAR Section 5.9.2.4. This evaluation is based on the leakage resulting in high pressure (140 psig) in that loop and automatic isolation of all 18 subheaders in the loop. The portion of the liner cooling system between the inlet and outlet subheader block valves is designed fo PCRV reference pressure (845 psig) and a safety valve in each loop return header protects the rest of the system from over pressure by relieving water and helium to the gas waste vacuum tank, where separation occurs.

CSF Leak

Existing CSF casing leakage has been observed to be relatively high when the PCRV is pressurized at power levels below about 15% reactor power. As CSF casing temperature increases, due to increased core outlet temperatures at higher power levels, the CSF casing leakage decreases to less than 1.0 lbs/hr before completion of boilout of the steam generators (boilout takes place between approximately 11% to 22% reactor power). The Master Setpoint List identifies the permissible setpoint band of pressure controller PIC-6364 as 0-100 psig. During normal operation, when the CSF casing leak is essentially sealed, Operations sets PIC-6364 at 60 psig. During startup or shutdown conditions, when the CSF is leaking, Operations sets PIC-6364 at 95 psig. The CSF vent backpressure is increased in an effort to reduce the primary coolant leak rate.

A CSF casing to system 46 leak rate was conservatively calculated to be 1.3 lbs/hr in 1982, when primary coolant was found to be leaking through the CSF casing and into liner cooling tube F4T21. The leak rate calculations are included in the safety evaluation for CN-1496, which was transmitted to the NRC by P-82135, dated 5/7/82. The leaking tube was taken out of service and adjacent tubes are being monitored by the thermowell tube scanning system, as required.

The CSF casing leak rate into the CSF vent system has recently been calculated to reach 9.6 lbs/hr following reactor shutdown with full primary coolant inventory. This latest calculation was performed based on a 20 ACFM peak flowrate as indicated on the FR-6375 strip chart recorder following the reactor scram from 68% reactor power on 2/10/88.

Containment Considerations

FSAR Section 3.3.2.2 states the following: "The cooling pipes for the core support floor are contained within the twelve support pipe columns. Two barriers are provided against leakage of cooling water into the PCRV cavity or radioactive helium into the cooling water system. These are the core support floor liner and the cooling tube wall. Similarly, two barriers against leakage of radioactive helium out of the PCRV cavity are provided by the core support floor liner and columns, and the end caps at the bottom of the columns which are embedded in the concrete. The space inside the floor and columns is vented and drained to maintain the pressure in the core support floor at about 60 psig, during normal operation."

The CSF casing provides the reactor coolant pressure boundary. Although it has been leaking at rates up to about 10 lbs/hr when the PCRV is pressurized and the reactor is shutdown or operating at low power levels, credit is taken for this barrier. This is somewhat analogous to the PCRV primary closures which also serve as the reactor coolant pressure boundary and helium leakage is permitted. Technical Specification LCO 4.2.9 permits the total helium leakage through all primary closure seals in any penetration group to reach 400 lbs/day at a differential pressure of 10 psi. The basis for LCO 4.2.9 assesses failure of a secondary closure when its associated primary closure is leaking at the maximum permissible leak rate, and determines that an 1145 lbs/hr leak rate could result, which was considered acceptable.

If the one inch CSF vent header line were to shear when the CSF casing was leaking at its maximum rate, primary coolant leakage to atmosphere could increase. Since the geometry of the leak across the CSF casing has not been accurately defined (weld crack suspected) and the flow path from the CSF casing leak through the CSF concrete into the vent tubes is unknown, leak path flow restrictions cannot be accurately modelled. It is difficult to predict leak rates when CSF vent pressure drops to atmospheric. For accident assessment purposes, this evaluation assumes the leak rate could double, reaching 20 lbs/hr (which is unlikely if choked flow conditions exist anywhere in the leak path). This assumed leak rate is only a small fraction of the 3.4 lbs/second (12,240 lbs/hr) initial leak rate calculated for the Maximum Credible Accident (FSAR Section 14.8). The Maximum Credible Accident results in radiological doses orders of magnitude below the guidelines of 10 CFR 100, even assuming design level primary coolant circulating activity. Postulated shear of the CSF vent header, conservatively resulting in a primary coolant leak rate of 20 lbs/hr, does not prevent shutdown and cooldown of the reactor, nor would it result in an unacceptable dose at the exclusion area boundary.

Principal Safety Concerns

There are three principal safety concerns associated with the CSF casing leak and increasing the CSF internal pressure to 100 psig. First, it has been recognized that a sufficiently high CSF internal pressure could result in deformation of the CSF steel casing in the event of a rapid decrease of primary coolant pressure such as could occur during a Rapid Depressurization Blowdown Accident, Design Basis Accident No. 2 (DBA-2). The second principal concern is that excessive primary coolant leakage will reduce primary coolant density and diminish the core heat removal rate, due to lower helium mass flow rates. The high pressure feedwater system, when supplying motive power to helium circulator water turbine drives and secondary coolant to the steam generators, provides sufficient cooling to adequately remove decay heat and prevent fuel damage even when the primary coolant system is accidentally depressurized due to the hypothetical rapid depressurization (DBA-2, FSAR Section 14.11) or the maximum credible helium leak rate (MCA, FSAR Section 14.8). Following external events or accidents wherein the feedwater system is not postulated to survive (Design Basis Earthquake, Maximum Tornado, HELB, fires) and lower pressure systems (condensate, firewater) are relied on for decay heat removal, primary coolant density is more critical. The third principal safety concern is the offsite doses resulting from primary coolant leakage. These concerns are addressed in the following Safety Evaluation.

SAFETY EVALUATION

3A. Has the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the FSAR been increased?

The accidents discussed below are those which could potentially be impacted by a CSF leak or a higher CSF internal pressure.

Primary Coolant Leakage

As noted in the Background, shear of the CSF vent header line, when the CSF casing is leaking at its maximum observed rate, is assumed to result in a 20 lbs/hr initial primary coolant leak rate. This is far below the 12,240 lbs/hr initial leak rate analyzed for the Maximum Credible Accident, for which adequate core cooling can be provided (FSAR Section 14.4.3.1), and which results in acceptable doses at the exclusion area boundary (FSAR Section 14.8). Shear of the CSF vent header line results in an initial leak rate similar in magnitude to that calculated for shear of the helium sample line in FSAR Table 14.7-1 (18 lbs/hr), judged to have an insignificant impact on the primary coolant system inventory (7,370 lbs). Primary coolant leakage associated with the CSF casing leak is accomodated by plant design with consequences well below the consequences of other primary coolant leaks analyzed in the FSAR. At existing primary coolant activity levels, which are about one-sixtieth of design activity levels, the primary coolant would have to leak out of the CSF vent line at 840 lbs/hr in order to reach 10CFR20 MPC levels.

DBA-2

Increasing the CSF internal pressure from 60 psig to 100 psig, by increasing the setpoint of controller PIC-6364, gives rise to concern regarding the ability of the CSF to withstand a higher differential pressure when PCRV pressure rapidly drops to atmospheric in a hypothetical DBA-2 event. GA Technologies, Inc. has performed a substantial amount of research to address this concern, much of which is documented in the following four References:

1. Betts, W.S. "Summary of Pressurized FSV Core Support Floor Safety Study" Doc. 906970/1, July 22, 1983.

2. LEE T.T. "FSV - Structural Assessment of Core Support Floor Liner Under DBA-2" Doc. 906945/1, July 15, 1983.

3. Landoni, J. "Effect of Damaged Core Support Liner (FSV)" Doc. 906934/1, June 28, 1983.

4. Cheung, K.C. "FSV - Ass ssment of Core Support Floor Concrete Integrity Under Rapid PCRV Depressurization" Doc. 907237/1, February 1, 1984.

If CSF internal pressure were to greatly exceed the pressure of the surrounding primary coolant, resultant forces could cause excessive deformation of the CSF liner. Significant CSF liner deformation/deflection could substantially degrade reactor safety in two areas. 1) Excessive deflection of the CSF liner sidewall could significantly restrict the primary coolant flow path in the annulus between the CSF sidewall and the PCRV liner. 2) Excessive deformation of the CSF top head liner has the potential for affecting the core and could possibly cause core disarray.

Analyses were done to determine the pressure drop across the CSF liner (DP) required to cause excessive deformation of either the sidewall liner or the top head liner of the CSF. The analyses (Ref. 1 and 2) showed that excessive deformation of the sidewall liner could occur if the DP exceeded between 234 and 325 psid. Excessive deformation was defined (in Ref. 3) as that required to significantly reduce the flow path in the annulus between the sidewall of the CSF liner and the PCRV liner. The range on DP resulted from assumptions concerning the ability of the cooling tubes which are welded to the liner and embedded in the concrete to restrain the liner. The lower estimate of 234 psid conservatively assumes no restraint.

The analyses in Ref. 4 predicted that excessive deformation of the top head liner could occur if the DP exceeded 210 psid. Excessive deformation was defined as that required to cause extensive deformation of the core. The deformation of the liner resulted from the pullout of top liner anchor studs. The DP is based on the design concrete strength. Using actual concrete compressive strength in the computation, the lower bound on DP would be 250 psid.

Based on the above, it is concluded that it has been conservatively calculated that the deformation of the CSF liner will not cause a safety concern if the pressure in the CSF does not exceed the pressure in the PCRV by more than 210 psid. The pressure within the CSF is maintained at equal to or less than 100 psig. It follows that even if the PCRV pressure rapidly reduces to atmospheric conditions the DP will not exceed 100 psid. The resulting margin is 110 psid. Therefore, the consequences of DBA-2 are not affected by increasing CSF internal pressure to 100 psig.

Design Basis Earthquake/Maximum Tornado

The CSF vent header line is Class 1, seismically qualified, up to and including remote-manual isolation valve HV-1195 (PI-11-5). It could be postulated that the non-seismically qualified piping downstream of HV-1195 shears or that PV-6364 (non-seismic) fails fully open (the design failure position upon loss of pneumatic pressure) such that the 20 lbs/hr primary coolant leak rate discussed in the Background occurred given the Design Basis Earthquake (DBE). Since area radiation monitors and CSF vent flow rate monitors are not seismically qualified, and may not be available following a DBE, operators may not be readily aware of the occurrence of such a postulated leak. Emergency Procedure SSC-05, DBE/Maximum Tornado Recovery, directs the operators to initiate a firewater cooldown by 90 minutes if other modes of decay heat removal are unavailable. The effectiveness of core cooling is influenced by primary coolant density so leakage of primary coolant is a concern in a firewater cooldown following an external event.

The analysis for Safe Shutdown Cooling (SSC) following a DBE or Maximum Tornado is identical to the SSC analysis following a HELB and is described in FSAR Section 14.4.2.2. This particular analysis was performed assuming no primary coolant leakage and full PCRV helium inventory. Several analyses have been performed to ascertain the effects of primary coolant leakage on decay heat removal. The most recent such analysis evaluated the effects of primary coolant leakage on FSV's 10 CFR 50 Appendix R Fire Protection Shutdown/Cooldown Train A, which is the train having the lowest core heat removal capability (73.5 million Btu/hr open loop and 58.3 million Btu/hr closed loop). The results of these analyses are detailed in GA Report 909457 N/C and summarized in FSV Fire Protection Program Plan (FPPP) Section FP.4.3.1 In the case analyzed with the greatest amount of primary coolant leakage, 700 lbs leaked past the circulator shaft seals in the first 30 minutes following the IOFC, and there was a constant 400 lbs/day primary coolant leak rate assumed past PCRV penetration primary and secondary closure seals (Technical Specification LCO 4.2.9). The results of this analysis demonstrate adequate decay heat removal with the primary coolant leakage. Although average core temperatures increased slightly above those for the base case with no helium leakage, peak fuel temperatures were lower due to higher mass flow rates in the hottest fuel region with lower density coolant. (The higher density helium was more greatly impacted by the buoyancy or natural circulation effect in this hottest region.)

The primary coolant leakage assumed for this Fire Protection Shutdown/Cooldown Train A analysis envelopes the leakage which could be anticipated to occur following a DBE from the CSF casing leak when the CSF vent header is postulated to be sheared (20 lb/hr). The SSC configuration described in FSAR Section 14.4.2.2 has a core heat removal capacity of 82.3 million Btu/hr and is capable of decay heat removal following reactor operation at 87.5% power such that no fuel damage occurs. Since the heat removal rate of SSC exceeds that of Train A, and since the Train A helium leakage analysis envelopes postulated CSF leakage following a DBE, it is concluded that the reactor can be safely cooled down following a DBE with rupture of the CSF vent header.

PV-6364 is not seismically qualified. Should this valve fail closed at the time a DBE were postulated to occur, isolating the CSF vent path, the concern arises as to whether the isolated CSF could be damaged in the ensuing cooldown. This is the same concern discussed above with DBA-2, except in this case, the isolated CSF could potentially reach pressures above the 100 psig assessed for DBA-2 by equalizing in pressure with primary coolant pressure. FSAR Figure 14.4-9, PCRV Pressure vs time for SSC with 90 minute IOFC (attached), depicts a rapid PCRV pressure decrease immediately following restoration of forced circulation. Upon circulator startup, PCRV pressure spikes up from about 600 psia to 640 psia, then drops to about 375 psia in less than six minutes. Due to the magnitude of this drop in PCRV pressure, CSF internal pressure could exceed PCRV pressure by over 210 psi, conservatively assuming no outleakage of helium from the CSF to the primary coolant. This high differential pressure could result in damage to the CSF, as discussed for DBA-2, above. It is therefore essential that a CSF vent path exist before restoration of forced circulation cooling following a DBE or Maximum Tornado. SSC-05 is being revised to require that prior to initiation of SSC, operators open seismically qualified manual valve V-111062 (normally shut) to establish a CSF vent path which does not include remotely actuated valves that could conceivably fail closed in a DBE. This flow path through the CSF vent knockout pot drain valve (V-111062) bypasses the pressure control valve, thus eliminating any backpressure control.

As discussed in the Background, the primary coolant leak rate could increase from about 10 lbs/hr, when backpressure is controlled at 100 psig, to 20 lbs/hr, when backpressure is assumed to be atmospheric. If the gas waste compressors are not operating (and their operation cannot be assumed following a DBE since they are Class 2), then pressure would increase in the gas waste vacuum tank to the 10 psig set pressure of V-6319 and V-63102. Upon lifting, these safety valves would direct the primary coolant from the CSF to the reactor plant exhaust filters in the reactor building ventilation exhaust stack.

A safety concern exists regarding the capability to continue adequate decay heat removal in the long term with primary coolant leakage. GA Report 908862 N/C evaluates the effect of helium leakage during a delayed firewater cooldown from 105% power. Primary coolant was assumed to be released from the PCRV via the primary and secondary penetration closures and the cold reheat header leak path with initial leak rates for two different cases at Technical Specification limits. These two cases are described in detail in GA Report 908862 N/C. Case A has an initial primary coolant leak rate of over 400 lbs/day (16.7 lbs/hr). Case B has a initial primary coolant leak rate (which decays exponentially with time) of greater than 20 lbs/hr such that about 3150 lbs helium leak out in the first 200 hours. Based on the initial leak rates, equivalent orifice sizes were computed to model the penetration closure leakage. These orifices were maintained constant over the 30 day analysis period, with no credit taken for the addition of makeup helium within 30 days. 22% of the total primary coolant inventory was lost for Case A and 86% was lost for Case B at the end of 30 days. Adequate core cooling was maintained throughout the 30 day period in both cases following prior operation at 105% reactor power. The assumption of no helium makeup capability was extremely unrealistic. Even given a Design Basis Earthquake, any necessary repairs to achieve a makeup helium flow path would not be expected to exceed several days. Based on the above, it is concluded that long term SSC effectiveness would not be diminished by the primary coolant leakage which could occur if the CSF vent header were sheared during a DBE. The radiological consequences of the worst case, Case B, PCRV closure leakage are summarized in FSAR Section 14.5.1, assessed in detail in Engineering Evaluation EE-EQ-0028 Rev. A, and are many orders of magnitude below 10 CFR 100 guidelines. The radiological consequences of a 20 lbs/hr CSF initial leak rate occurring following a DBE would be less than those assessed for the Case B PCRV closure leakage.

While Technical Specification LCO 4.2.9 permits PCRV penetration closure leakage to occur, and the maximum permissible rates were utilized in the analyses, no significant amounts of closure leakage have been measured. In fact, the PCRV penetration primary and secondary closure are virtually leak tight, as demonstrated by continuous monitoring and quarterly surveillance tests per Technical Specification SR5.2.16. Some leakage of clean helium has been identified between the interspace of several steam generator penetrations and the cold reheat steam piping.

Based on the above information, the consequences of a DBE are not increased when the DBE and subsequent cooldown are evaluated with concurrent CSF leakage.

High Energy Line Break

Pneumatic operated isolation valve HV-1195 and pneumatic operated pressure control valve PV-6364, and their controls, are not environmentally qualified. Both these valves are designed to fail open upon loss of air pressure, which permits continued venting of the CSF. It is conceivable, however, that one or both of these valves could fail shut as a result of the harsh environment created by a HELB, or as a result of arbitrary single active failures which are required to be postulated following a HELB. If both valves were to fail open during a HELB, primary coolant could leak through the CSF and into the radioactive gas waste system at a rate of 20 lbs/hr, which is no different than evaluated above for the DBE. Short term and even long term SSC are not significantly effected by this small leak rate, and radiological doses resulting from this primary coolant leak are extremely low. If both valves were to fail closed, which would be highly unlikely, the CSF could not be "reverse pressurized" since SSC-04 is being revised to require V-111062 to be opened prior to restoration of forced circulation with firewater. This establishes the alternate CSF vent path. Thus, similar to a DBE or Maximum Tornado, the consequences of a HELB, as analyzed in FSAR Sections 10.3.9, 10.3.10 and 14.4.2.2, are not significantly impacted by the CSF leakage.

Fires Outside the Congested Cable Areas

The consequences of fires outside the FSV congested cable areas are assessed in the Fire Protection Program Plan, Section FP.4.3 for shutdown/cooldown with Train A and Train B. Valves HV-1195 and PV-6364 are not included in the FSV Fire Protection Shutdown/Cooldown models and could be postulated to fail either open or shut for fires outside the congested cable areas. The consequences of CSF leakage with valve failures for Train B are no different from those described above for DBE and HELB, since Train B relies on firewater cooldown following a 90 minute IOFC with identical heat removal capability to SSC (82.3 million Btu/hr). Train A relies on condensate (one small condensate pump) cooldown with an open loop heat removal capability (first 5 hours) of 73.5 million Btu/hr and a closed loop heat removal capability of 58.3 million Btu/hr.

As described under DBE/Maximum Tornado above, Train A analyses were performed assuming significant amounts of primary coolant leakage down the helium circulator shafts as well as PCRV closure leakage. While a walkdown determined that the seals could be remote-manually set for all four circulators within 5 minutes of dispatching an operator, a minimum circulator shaft leakage time of 20 minutes was conservatively assumed. This was calculated to result in 440 lb helium leakage down the circulator shafts. A second case was analyzed assuming 30 minutes leak time before the seals were set, resulting in 700 lb helium leakage. In addition to primary coolant leakage down the circulator shafts, primary coolant was assumed to leak out of PCRV penetration closures at a constant rate of 400 lbs/day. Train A was selected for this analysis since it had the highest peak fuel temperature. Leak calculations were based on the assumption that the PCRV pressure is that computed following a scram from 100% reactor power. The results of this analysis are as follows:

Time to Set Brake and Seals	Maximum Fuel Temperature
Set automatically at time zero (no leakage)	2875 degrees F
Set at 20 minutes after IOFC manually	2817 degrees F
Set at 30 minutes after IOFC manually	2782 degrees F

The maximum possible offsite doses resulting from 30 and 60 minutes of primary coolant leakage down the helium circulator shafts and 400 lbs/day initial leak rate via PCRV penetration closures are tabulated in the attached Table 1, which was submitted to the NRC in Attachment 5 of P-85460, dated 12/10/85. These doses are several orders of magnitude below 10CFR100 guidelines and are based on the conservative assumptions that initial PCRV pressures are those expected for reactor operation at 100% power and the primary coolant activity is at design levels.

For the case in which circulator shaft seals are set at 20 minutes, a total of 607 lbs helium was lost in the first 10 hours of this analysis (GA only analyzed this case for 10 hours since fuel temperatures turned by six hours), 440 lbs due to circulator leakage and 167 lbs due to PCRV closure leakage. Assuming constant 20 lbs/hr CSF leakage for 10 hours following a fire would result in 200 lb. additional leakage. This is bounded by the second case in which the circulator shafts were permitted to leak for 30 minutes since a total of 867 lbs helium leaked out in the first 10 hours of this case. Crediting operators with the ability to set circulator shaft seals in 20 minutes, previous analysis demonstrates that CSF leakage would not adversely impact the Train A cooldown following operation at 83.2% reactor power at times up to ten hours, even with 400 lb/day PCRV penetration closure leak rates. The effects of long term primary coolant leakage on this Train A condensate cooldown have not been analyzed in detail as was done for firewater cooldown (30 days). However, the only difference between the Train A condensate cooldown and the SSC cooldown with firewater, as it relates to the analyses documented in GA Report 908862 N/C (effects of primary coolant leakage on 30 day cooldown), is the lower secondary coolant flow rate available with one small condensate pump. However, the closed loop Train A secondary coolant flowpath has a higher heat removal capability (58.3 million Btu/hr) than the core decay heat generation rate (assuming prior unlimited operation at 83.2% reactor power) following 5 hours of Train A cooling when the closed loop configuration is implemented. The Train A analyses (GA Report 909457 N/C) took credit for the ability of one small condensate pump to provide 143 gpm condensate to a circulator water turbine drive with 175 psid pressure drop across the water turbine inlet nozzle. This gives identical circulator motive power capability as use of boosted firewater to supply a water turbine drive. Therefore, primary coolant mass flow rate for Train A would be identical to that analyzed in the 30 day cooldown with primary coolant leakage. Since the primary coolant flowrate of Train A is identical to that analyzed in GA Report 908862 N/C, the Train A secondary flow path has a higher heat removal capability than the core heat generation rate and since the CSF initial leak rate is nearly identical to the Case A leakage analysis and less than the Case B leakage analysis, Train A has the capability to cooldown from 83.2% power with the CSF leakage. If necessary, operators could isolate the CSF vent manually. Isolation of the CSF could only be accomplished after the large primary coolant pressure reduction associated with restoration of forced circulation has occurred. SSC-03 is being revised to assure adequate CSF venting is established before restoration of forced circulation.

The 20 lbs/hr initial CSF leak rate has radiological dose consequences less than the 60 minute circulator shaft leak with additional 400 lbs/day continuous PCRV leakage until entire primary coolant inventory is released (see Table 1, attached). This case is presented in the FPPP, and gives doses orders of magnitude below 10 CFR 100 guidelines. Therefore, the dose consequences of a fire with CSF leakage do not exceed those previously analyzed in the FPPP.

DBA-1/ACM PCRV Liner Cooldown

The permanent loss of forced circulation (LOFC) event (Design Basis Accident No.1, DBA-1) is assessed in FSAR Section 14.10 and Appendix D. This accident results from the postulated failure of all four circulators or all steam generator heat exchangers. Subsequent decay heat removal is provided by a PCRV liner cooldown. A major fire in a congested cable area which damages redundant safety circuits is postulated to result in a permanent loss of forced circulation and the subsequent PCRV liner cooldown is conducted with equipment powered by the Alternate Cooling Mode (ACM) diesel generator and switchgear. One of the first actions taken in the permanent loss of forced circulation event is depressurization of the PCRV to reduce the heat flux to the PCRV top head liner. The CSF leak would not hinder this depressurization objective.

Primary coolant activity levels following loss of forced circulation from 105% reactor power are identified in FSAR Figure 14.10-4 (attached), "Gas Borne Fission Product Activity in the PCRV During the LOFC Accident, i.e., Activity Available for Leakage." This figure is based on the assumption that 5% of the fuel kernels in the core have failed coatings before the onset of the LOFC. The increase in gas borne activity early in the LOFC event predicted in this figure is due to escape of fission products from the 5% fuel kernels assumed to have failed coatings. This assumption is extremely conservative, and not related to actual experience to date, in which less than 0.1% of the fuel kernel coatings are thought to have failed.

Adequate containment is essential to assure that accident consequences don't exceed the dose consequences of DBA-1 previously analyzed in the FSAR. FSAR Section 14.10.3.4 explains that "An arbitrarily high PCRV leak rate of 0.2% per day was used which conservatively assumed that the PCRV liner does not exist as a barrier to leakage through the PCRV, i.e., the PCRV leakage is controlled only by permeation through the concrete. The leakage driving force is assumed to be a 5 psi pressure differential caused by the final PCRV pressure following depressurization."

The time at which depressurization shall be initiated following a LOFC is prescribed by Technical Specification LCO 4.2.18. The Basis for LCO 4.2.18 states that depressurization is completed in approximately seven hours. For prior power levels above 70%, depressurization must be initiated by 2 hours following onset of the LOFC. Prior to depressurization, when full primary coolant inventory exists within the PCRV, the leak rate assumed for DBA-1 analysis purposes was (0.2%/day) (7,430 lbm) = 14.86 lbm/day. The CSF leak rate following reactor shutdown has at times reached about 10 lbs/hr, and is assumed to reach 20 lbs/hr (480 lbs/day) if PC-6364 fails open. This leak path must be isolated prior to fission product activity buildup in the PCRV if the consequences of DBA-1 are to remain within those previously analyzed in the FSAR. This requires isolation of the CSF vent lines prior to initiation of depressurization, since FSAR Figure 14.10-4 shows primary coolant activity levels increasing by 2 hours following onset of LOFC from 105% reactor power. Emergency Procedure EP-G is being revised to require isolation of the CSF vent lines prior to start of depressurization.

Isolation of the CSF vent lines raises the question as to whether the isolated CSF could increase in pressure from an initial pressure of 0 to 100 psig (depending on the position of PC-6364, which could fail open for a fire in a congested cable area) to a pressure 210 psi above PCRV pressure during the subsequent depressurization. As described under DBA-2 above, a CSF reverse pressurization of greater than 210 psid could result in damage to the CSF. Figure 2 of P-77250, dated 12/2/77 (attached), identifies anticipated PCRV pressure (as a fraction of the 617 psia initial pressure) over the course of the 7 hour depressurization. CSF internal pressure is assumed to be 100 psig when the CSF vent line isolation valves are shut immediately preceeding depressurization. It is not deemed possible that CSF pressure could exceed PCRV pressure by greater than 210 psi, at any time during the course of the 7 hour depressurization. PCRV pressure decreases from 617 psia to about 200 psia in the first 2.4 hours of the depressurization, and from 200 psia to 17 psia in the next 4.6 hours. Early in the depressurization with the CSF under external pressure and primary coolant leaking into the CSF, the CSF liner would be under compression and the liner leak would tend to close. Conversely, later in the depressurization with the CSF under internal pressure and primary coolant leaking out of the CSF, the CSF liner would be under tension and the liner leak would tend to open. Assuming helium leakage into the CSF were large enough to permit the CSF internal pressure to increase to above 227 psia within the first 2.4 hours, leakage out of the CSF and back into the PCRV cavity would occur with less resistance, and at a sufficient rate such that CSF pressure would never exceed PCRV pressure by greater than 210 psid during the PCRV depressurization.

3B. Has the possibility of an accident or malfunction of a different type than any evaluated previously in the FSAR been created?

Leakage of primary coolant through the CSF casing and into either the CSF vent system or the PCRV liner cooling system has been thoroughly evaluated in the FSAR. Deformation of the CSF liner due to excessive reverse pressurization (CSF internal pressure much greater than primary coolant pressure) has not been analyzed in the FSAR. Increasing CSF internal pressure to 100 psig by adjusting the PIC-6364 setpoint to 100 psig does not create the potential for deformation of the CSF liner for the reasons presented in the discussion of DBA-2, above. Therefore, neither the CSF casing leak nor the 100 psig CSF internal pressure creates an accident or malfunction not previously evaluated in the FSAR.

3C. Has the margin of safety, as defined in the basis for any Technical Specification or in the FSAR been reduced?

ELCO 8.1.1 and ELCO 8.1.5 are based on not exceeding the limits of 10CFR20, 10CFR50 and 40CFR190. Under normal operating conditions, as long as the CSF vent flows, combined with flow of gas from other sources, to the gas waste vacuum tank is less than 53 lbs/hr, these limits will not be exceeded. If the CSF vent flow and waste gas flow from other sources exceeded 53 lbs/hr, the safety valve on the gas waste vacuum tank (V-63102) would relieve gas to the Reactor Building ventilation system. This would be a filtered and monitored release which, given existing primary coolant activity levels, would not exceed the limits of 10CFR20, 10CFR50, or 40CFR190. In the event that the CSF vent line sheared, the radiological consequences would be less than rupturing a full gas waste surge tank, which is part of the basis for ELCO 8.1.1. A full gas waste surge tank rupturing would result in less than 0.5 rem whole body dose to a member of the public. The Maximum Credible Accident (MCA) would result in a whole body dose of less than 0.162 rem to a member of the public. The MCA initial leak rate is 12,240 lbs/hr which is much greater than the maximum leakage possible from the one inch CSF vent line.

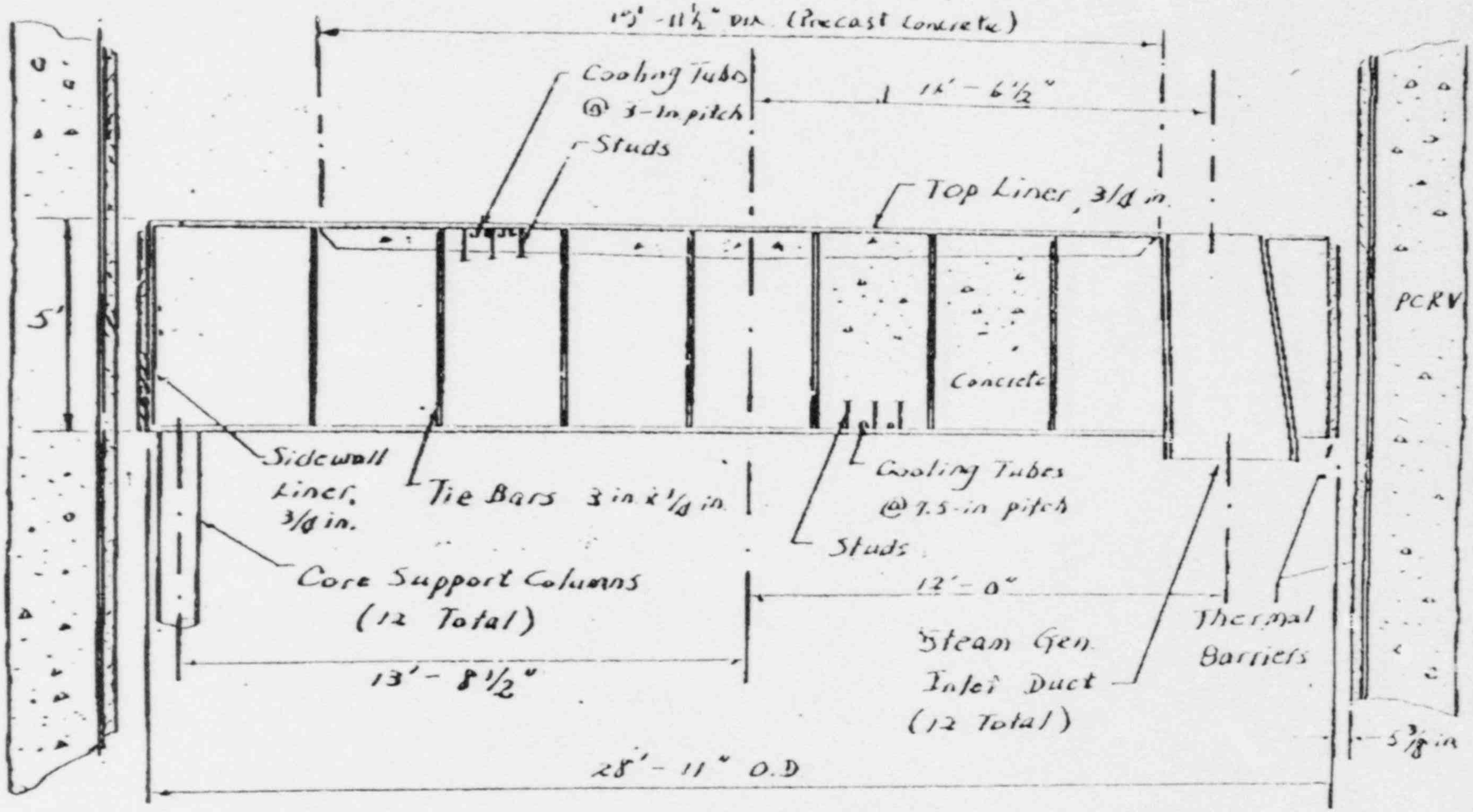


Figure 1. Configuration of CSF

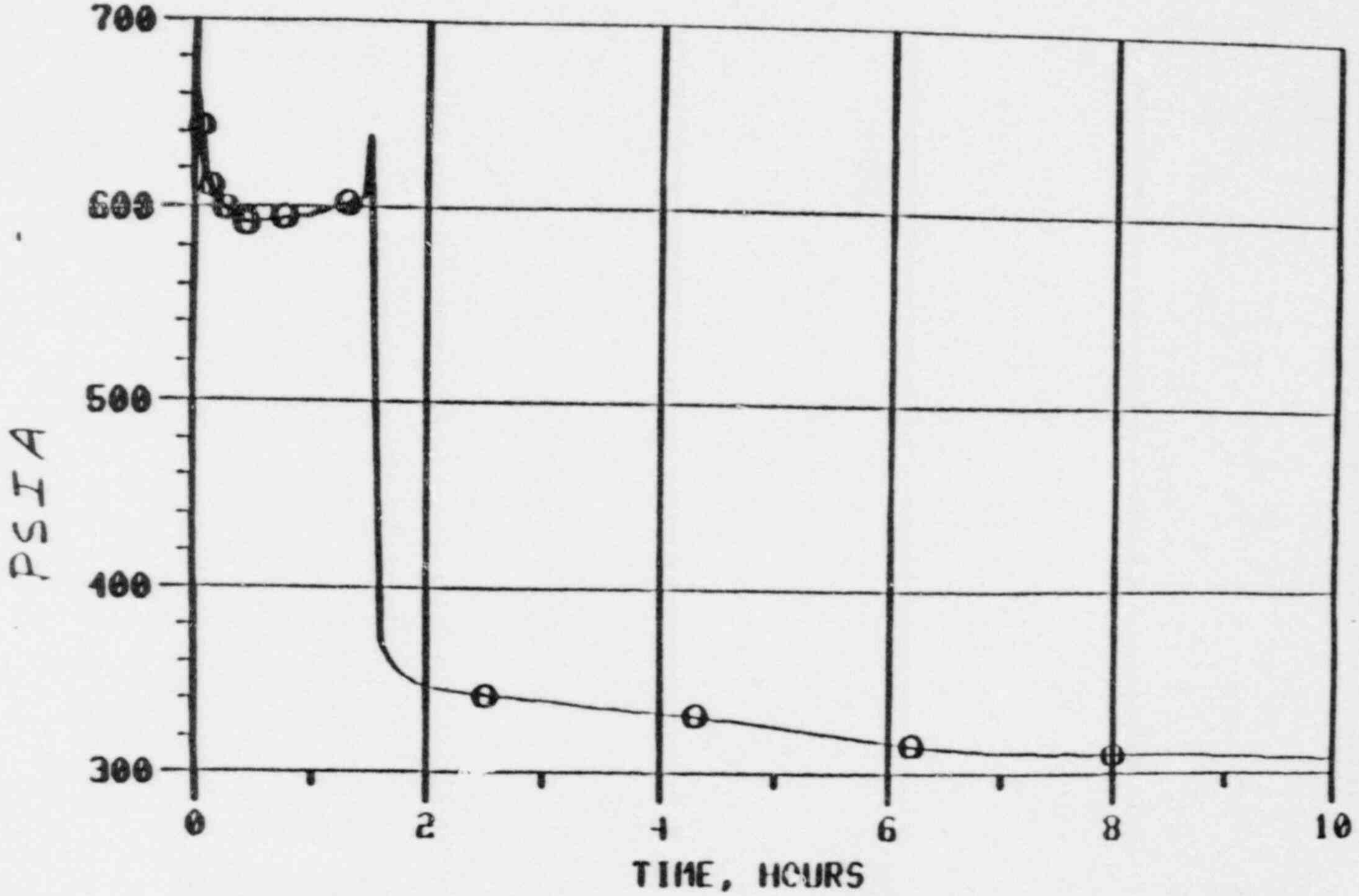


Figure 14.4-9 Safe Shutdown Cooling from 87.5% Power with Firewater to EES after 1½ HR. Delay in Restart of Forced Circulation Cooling; Primary System Pressure

Table 1

Table FP 4.3-13

SUMMARY OF OFF-SITE DOSES RESULTING FROM POSTULATED ACCIDENTS

ACCIDENT	LOCATION OF MAXIMUM DOSE	TOTAL DURATION DOSE (REM) WHOLE BODY	THYROID
Complete Loss of Forced Circulation Cooling - DBA No. 1	Low Population Zone Boundary (180 day)	3.7 E-4	3.6 E-2
Worst PCRV Penetration Failure (both closures of a steam generator penetration) - DBA No. 2	Exclusion Area Boundary (2 Hours)	2.5	17.4
"Maximum Credible Accident" (largest Potential PCRV leak rate)	Exclusion Area Boundary (2 Hours)	1.62 E-1	8.8 E-2
30 minutes to set circulator seals and 400 lbs leakage via PCRV penetration closures	Low Population Zone Boundary (30 day)	4 E-4	2.1 E-2
	Exclusion Area Boundary (2 Hours)	3.6 E-3	1.5 E-2
60 minutes to set circulator seals and 400 lbs/day leakage until entire primary coolant inventory is released	Low Population Zone Boundary (30 day)	8 E-4	5.9 E-2
	Exclusion Area Boundary (2 Hours)	5.4 E-3	2.3 E-2
10CRF100 Guidelines	Low Population Zone Boundary (Duration of Accident)	25	300
	Exclusion Area Boundary (2 Hours)	25	300

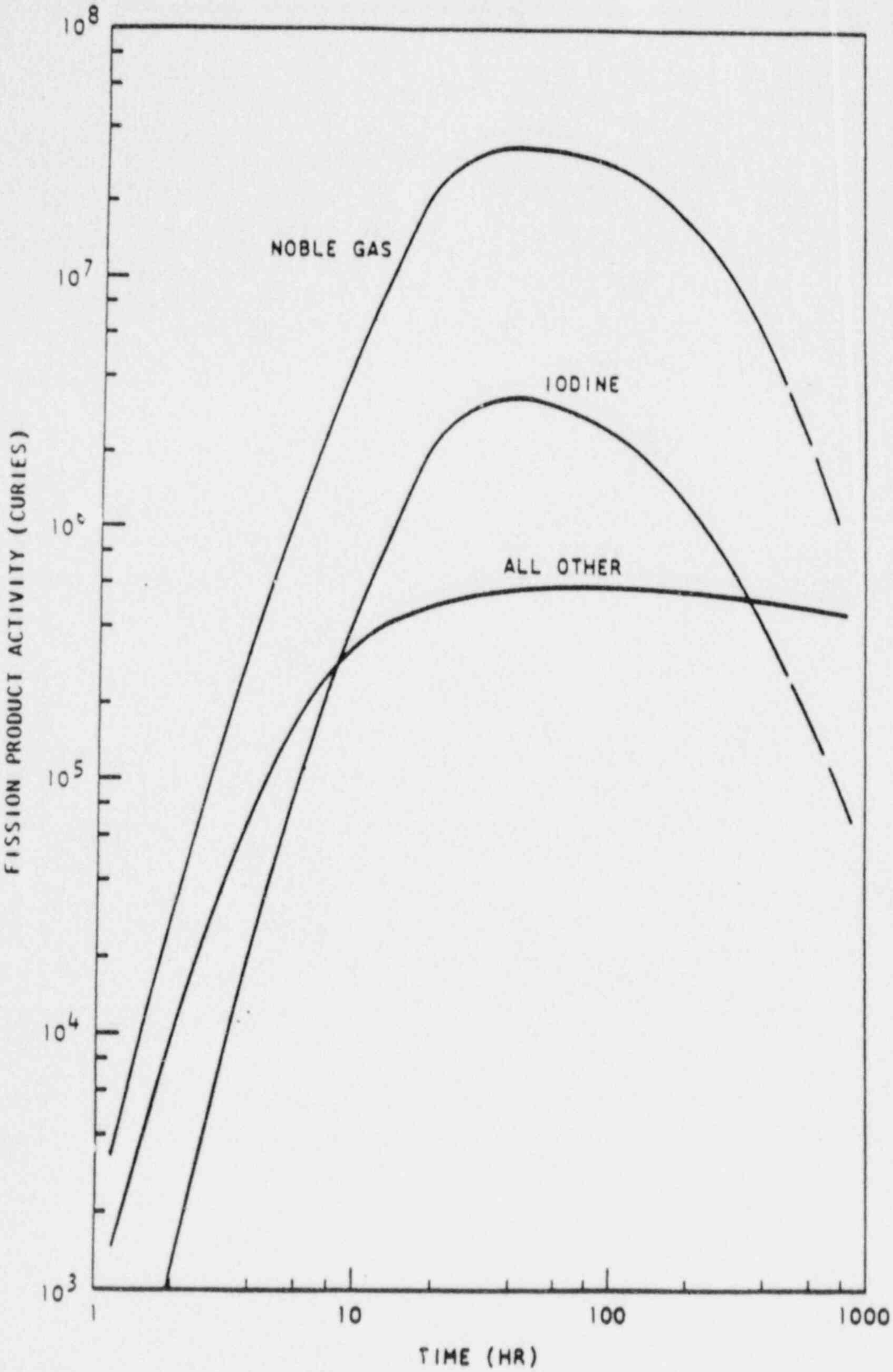
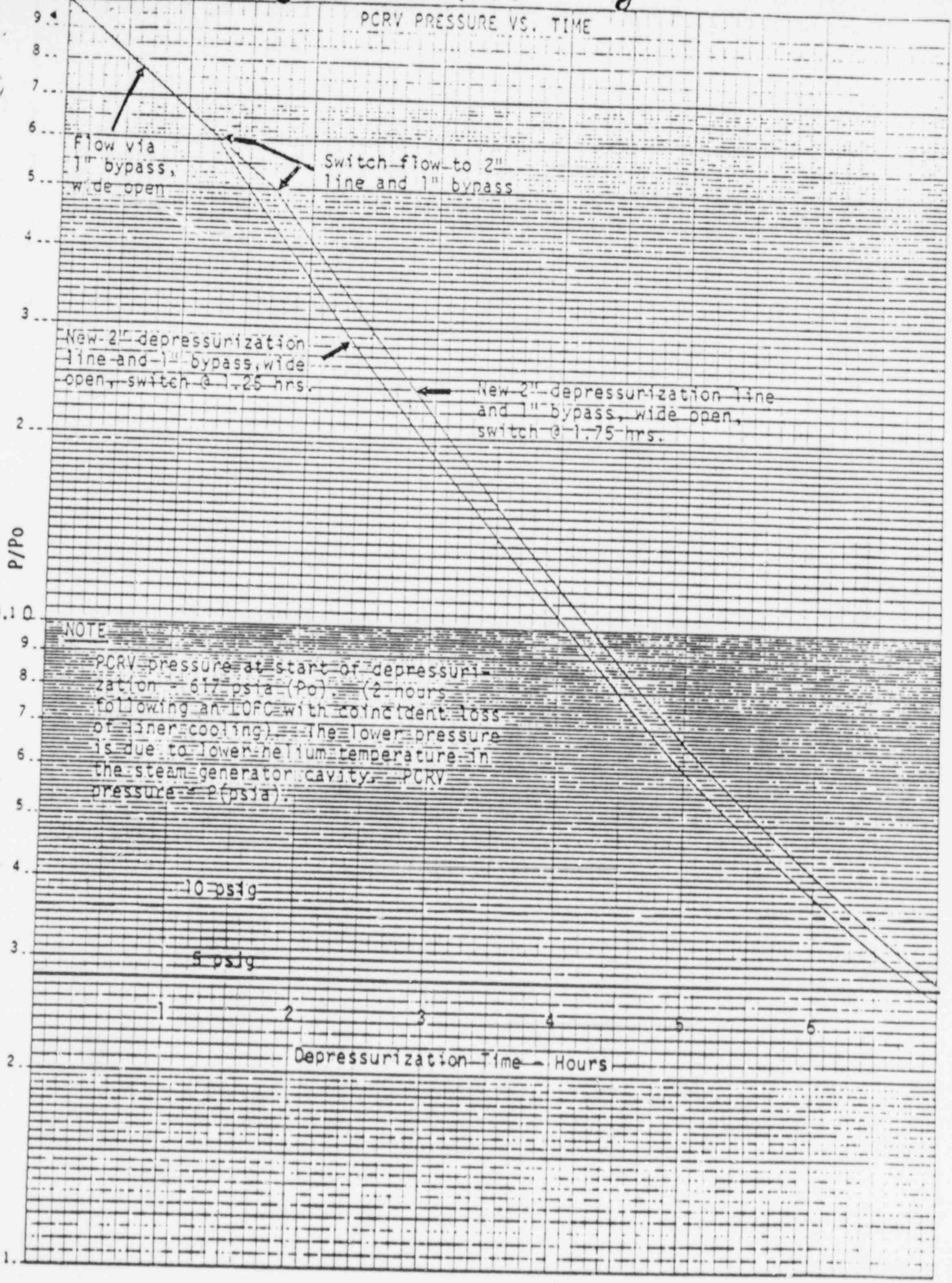


Figure 14.10–4 Gas-Borne Fission Product Activity in the PCRV During the LOFC Accident, i.e., Activity Available for Leakage

Figure 2



PCRV PRESSURE VS. TIME
Flow via 1" bypass, wide open
Switch flow to 2" line and 1" bypass
New 2" depressurization line and 1" bypass, wide open, switch @ 1.25 hrs.
New 2" depressurization line and 1" bypass, wide open, switch @ 1.75 hrs.
NOTE
PCRV pressure at start of depressurization - 617 psia (Po). (2 hours following an LOFC with coincident loss of liner cooling). The lower pressure is due to lower helium temperature in the steam generator cavity. PCRV pressure = P(psia).
10 psig
5 psig
P/Po
0.10
Depressurization Time - Hours
1
2
3
4
5
6