Docket 50-423

NORTHEAST UTILITIES

THE CONNECTICUT LIGHT AND POWER COMPANY
WESTERN MASSACHUSETTS ELECTRIC COMPANY
HOLYOKE WATER POWER COMPANY
NORTHEAST UTILITIES SERVICE COMPANY
NORTHEAST NUCLEAR ENERGY COMPANY

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NE-83-SAB-294

Mr. Abel Garcia
Lawrence Livermore National Laboratory
P. O. Box 808
Livermore, CA 94550

Dear Abel:

Enclosed please find the written responses to the Millstone-3 P.S.S. questions provided by Paul Amico. Should further questions arise please feel free to contact me.

Very truly yours,

John H. Bickel

Dr. J. H. Bickel
Supervisor PRA
Northeast Utilities Service Co.

cc: Mr. Paul Amico (Applied Risk Technology, Corp.)
Mr. G. Kelley (NRC)
Ms. E. Doolittle (NRC)

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QUESTION 1: Shouldn't Containment spray recirculation (CSR) always be required for success when a LOCA or LOCA-like events occurring? Wouldn't containment overpressure and loss of net positive suction head (NPSH) result from CSR failure even if LPR or HPR is available? Isn't only exemption when aux. feed is used to directly remove heat?

Response: Additional calculations were performed at NUSCO using MARCH 1.1 to address this question. It is important to note, first of all, that there is a major design difference between Millstone - 3 and the Surry plants (modelled in WASH-1400) when it comes to recirculation from the sumps. Surry has separate pumps for containment spray recirculation (CSR) and emergency coolant recirculation (ECR). The low pressure recirculation (LPRS) pumps draw suction from the sumps for ECR. Millstone-3, on the other hand, uses the four recirculation pumps for both CSR and ECR. It is therefore difficult to envision a scenario whereby ECR is successful (either high or low pressure) but CSR is not. It would entail a situation in which 3 out of 4 of the CSR pumps or associated valves had failed.

In any case, calculations were performed for two categories of accidents:

1) large LOCA with successful ECC injection and recirculation, and failure of all containment sprays;

2) small LOCA with successful ECC injection and recirculation, and failure of all containment sprays.

Figure 1 indicates that for the large LOCA, containment pressure would approach the lower tail of the containment failure probability distribution curve (5th percentile at 112 psia) around 38 hours into the accident. However, the containment sump temperature at this time, according to the calculations, is only 80°F. This is because successful ECC injection means that the large volume of the RWST water at 50°F is available for core cooling, hence depressing sump temperature. Also, the containment recirculation pump (and its associated cooler) is capable of removing sensible heat from from the sump (all decay heat is assumed to exhibit itself in the form of steam into containment, a conservative assumption).

The net effect of their 80°F sump water is that the water would not flash to steam upon containment failure and depressurization. Hence, the recirculation pumps would not cavitate and fail.

Morever, because the one recirculation pump would be throttled between core cooling and core spray, one can envision a situation in which a certain fraction of the total flow is diverted to containment spray. Figure 1 indicates that as little as 10% of the flow (388 GPM) would be capable of preventing containment pressure buildup, and still easily meet core cooling requirements.

For small LOCA, containment response is much milder as shown in Figure 2. Because the core is eventually recovered (or never uncovered in the first place) the water in the primary becomes subcooled. Eventually, the water in the primary system is cool enough so that little of it flashes to steam as it is discharged into containment. Containment pressure therefore decreases 1½ hours into the accident because of continued steam condensation on the walls. Heat is continuously removed from the sump by the recirculation coolers. (In

this analysis, no credit was taken for heat removal by the steam generators. In fact, they were modeled as heat sources).

Since the most limiting small break was chosen for analysis, the analysis performed here should bound all other variations of small LOCA's including stuck-open PORV's, pump seal LOCA's, and even bleed and feed.

Therefore, containment spray recirculation is not necessary for success, assuming that recirculation cooling has been successful.

Question 2: What is the basis for HPSI being viable for injection during large LOCAs? Usually considerations of flow capacity and pump runout eliminate HPSI from these events.

Response: In the Millstone-3 large LOCA event tree, credit is taken for injection of 3 of 3 accumulators and 2 of 4 High Pressure injection pumps to prevent core damage during the ECCS injection phase.

There is nothing other than system failure as modeled in the fault tree that would preclude the use of the Charging and/or HPSI systems following a large LOCA. There is sufficient containment spray recirculation pumps during ECCS recirculation for successful pump operation following any size LOCA. There are throttling valves in both the HPSI and Charging systems which will limit the maximum runout flow. Accumulator injection along with injection flow from 2 of 4 High Pressure pumps is sufficient ECCS injection following a large LOCA to prevent core damage. Subsequent decay heat removal via low pressure ECCS recirculation is modeled in the event tree. Also the Millstone-3 FSAR design basis large LOCA analysis takes credit for flow from one HPSI and one Charging pump.

Question 3: Please provide calculation number CN-PRA-83-022 (or a summary) for review.

Response: A summary of the calculation will be provided under separate cover at a later date.

Question 4: What is the basis for the use of secondary depressurization and Low Pressure Safety Injection (LPSI) for high pressure sequences where High Pressure Safety Injection (HPSI) is available (OA-1)?

Response: Given Unavailability of HPSI during a high pressure small or medium LOCA sequence secondary depressurization followed by low pressure injection is sufficient to prevent core degradation. The adequacy of this is shown in WCAP-9754, Inadequate Core Cooling Studies of Scenarios with Feedwater Available, using the NOTRUMP Computer Code. Attachment 1 is a copy of the September 1, 1982 Function Recovery Guideline entitled FR-C.1, Response to Inadequate Core Cooling. Secondary depressurization and LPI is discussed in this guideline.

Question 5: What is the basis for feed and bleed core cooling (OA-3, 0A-7) for accident sequences where auxiliary feedwater is unavailable? What is the break size equivalent of the PORV's? Why would bleed be required for small LOCA type event (OA-3)?

Response: The adequacy of feed and bleed cooling for decay heat removal is shown in WCAP 9744, Loss of Feedwater Induced Loss of Coolant Accident Analysis Report. Based on comparison of the Millstone 3 design with analyses in this WCAP feed and bleed core cooling utilizing both pressurizer PORV's and either one charging or one HPSI pump is sufficient for decay heat removal. The equivalent break size of both PORV's is approximately a 2 inch diameter break. Since success of feed and bleed is defined to require a 2 inch diameter equivalent break, primary system bleed could be required for small LOCA, (3/8 to 2 inch diameter equivalent break) with loss of auxiliary feedwater.

Attachment 2 is a copy of the Function Recovery Guidelines FR-H.1, Response to Loss of Secondary Heat Sink, dated September 1, 1982. The guideline discusses the steps involved in leading to the use of feed and bleed. These are: 1.) attempt to establish Auxiliary Feedwater flow (AFW); 2.) attempt to establish Main Feedwater; and finally if these are both unsuccessful 3.) initiate feed and bleed core cooling. This guideline discusses the use of Main Feedwater or Condensate Flow prior to the last resort of feed and bleed. The use of Main Feedwater, by unisolating Main Feedwater or using Condensate Flow by depressurizing steam generators was (conservatively) not needed in the event trees.

Question 6: What is the basis in the small LOCA event tree for controlled primary depressurization (OA-2) eliminating the need for recirculation? Isn't recirculation eventually needed anyway?

Response: Following a small LOCA, HPI will maintain primary system inventory and AFW will allow for decay heat removal via the Steam Generator. This will result in stabilization of the primary system. Controlled primary system cooldown and depressurization would then be performed. As discussed in Section 2.2.7.3.1 of the Millstone 3 P.S.S., controlled primary depressurization would minimize break flow and containment pressure rise. This minimizes the HPI flow required and, because of the large size of the RWST, HPI would be available for over 24 hours. This long time frame allows for long term cooling via the Residual Heat Removal System, or via AFW with continued HPI (with refilling of the RWST if desired), or via High or Low pressure recirculation. Due to the many options and long time available, these actions were not included on the event tree. Attachment 3 is a copy of the September 1, 1981 Emergency Response Guidelines, Post LOCA Cooldown and Depressurization. This guidelines discusses the steps and options available post LOCA for cooldown and depressurization.

Question 7: Reference is made to the use of the Main Condenser when Auxiliary Feedwater (AFW) is being used instead of Main Feedwater. What is the basis for this?

Response: The basis for saying that the Main Condenser could be used to supply the aux. feed pumps is as follows. The alternate supply of water to the auxiliary feedwater pumps is from the condensate storage tank. System line-up to the CST can be achieved by opening one air operated valve on the suction side of each aux. feed pump. Water removed from the CST by aux feed can be replenished by transferring water from the condenser hotwell to the CST. Each of the condensate transfer pumps can pump 200 gpm from the hotwell to the CST. Since the primary source of water for AFW is from the Demineralized Water Storage Tank, the CST would probably not be used until the DWST is depleted. The Main Condenser was (conservatively) not modeled as an alternate supply of water to the aux-feed system via the CST. However, both the DWST and the CST were included as water sources in the aux. feed system fault tree.

Question 8 & 9: For SGTR, what is the basis for HP-2 and AF-2 being sufficient to terminate the event? Also, what is the basis for using secondary depressurization (OA-4) or direct primary depressurization (OA-5) for terminating break flow?

Response: Following a SGTR the operator actions involved are to ensure adequate decay heat removal, terminate primary to secondary system inventory loss, and maintain adequate primary system inventory. Attachment 4 is a copy of the September 1, 1981 Emergency Response Guideline, E-3 Steam Generator Tube Rupture. This guidelines discusses the operator actions following a SGTR and their basis.

Question 10: Why isn't PCS (Power Conversion System) included as an event on transient trees not involving secondary failures? What causes the PCS to be unavailable? Do MSIVs isolate steam to the Feedwater pump turbines? When do the close?

Response: The PCS is conservatively not modeled in the transient event trees since it is not available for all transients. The PCS is unavailable when either main feed isolates or the MSIV's close. Feedwater isolation occurs on indications of any one of the following: a) safety injection, b) steam generator high high level, or c) Low T_{avg}. Based on the Low T_{avg} setpoints existing at the time the Millstone-3 P.S.S. was performed there is a reasonably high probability that post-trip RCS cooldown will activate the Main Feedwater Isolation logic.

Steam line isolation (MSIV closure) occurs automatically on any of the following indications: a) low steam line pressure, b) Hi-2 containment pressure, or c) high steam pressure rate.

Question 11: Why was OA-7 used as a conditional on the spurious Safety Injection Event Tree? OA-7 (Feed and Bleed Core Cooling includes HPSI unavailability, which by implication is zero.

Response: The spurious Safety Injection Event Tree only models an SI (Safety Injection) signal as the initiating event. Therefore OA-7 is necessary to address the availability of H.P.S.I. after the reactor trip generated by the SI signal. H.P.S.I. unavailability is accounted for in the quantification of the event tree, conditional on the support states.

Question 12: For the loss of a vital DC Bus event tree, the text states feed and bleed core cooling (OA-7) is unavailable, but the tree shows a decision point for this. Further the support state tables imply that support state 2 dominates, and that OA-7 can be available for support state 2.

Response: The PORV's at Millstone 3 are DC solenoid operated valves. Failure of either vital DC bus would result in the unavailability of one PORV. Since success of feed and bleed (OA-7) requires the opening of both PORV's the failure of either vital DC bus will result in the unavailability of feed and bleed core cooling. The event tree used to model this event is the loss of feedwater event tree which contains the OA-7 node. Therefore, as discussed in Section 2.2.7.18, when the event tree was quantified a failure probability of 1.0 was used for the OA-7 node. This can be readily seen by looking at the quantification of Sequence E_{18}(2)/AF-1/OA.7 on page V-10 of the Introduction and Summary.

Question 13: For A.T.W.S., what is the basis for the use of Emergency Boration (OA-8) for shutdown? Is it reasonably possible to reduce primary pressure below the shutoff head for the charging/Safety Injection pumps? What is the success criteria? This comment especially concerns OA-8', where Auxiliary Feedwater is unavailable.

Response: A response to this question will be provided under separate cover at a later date.

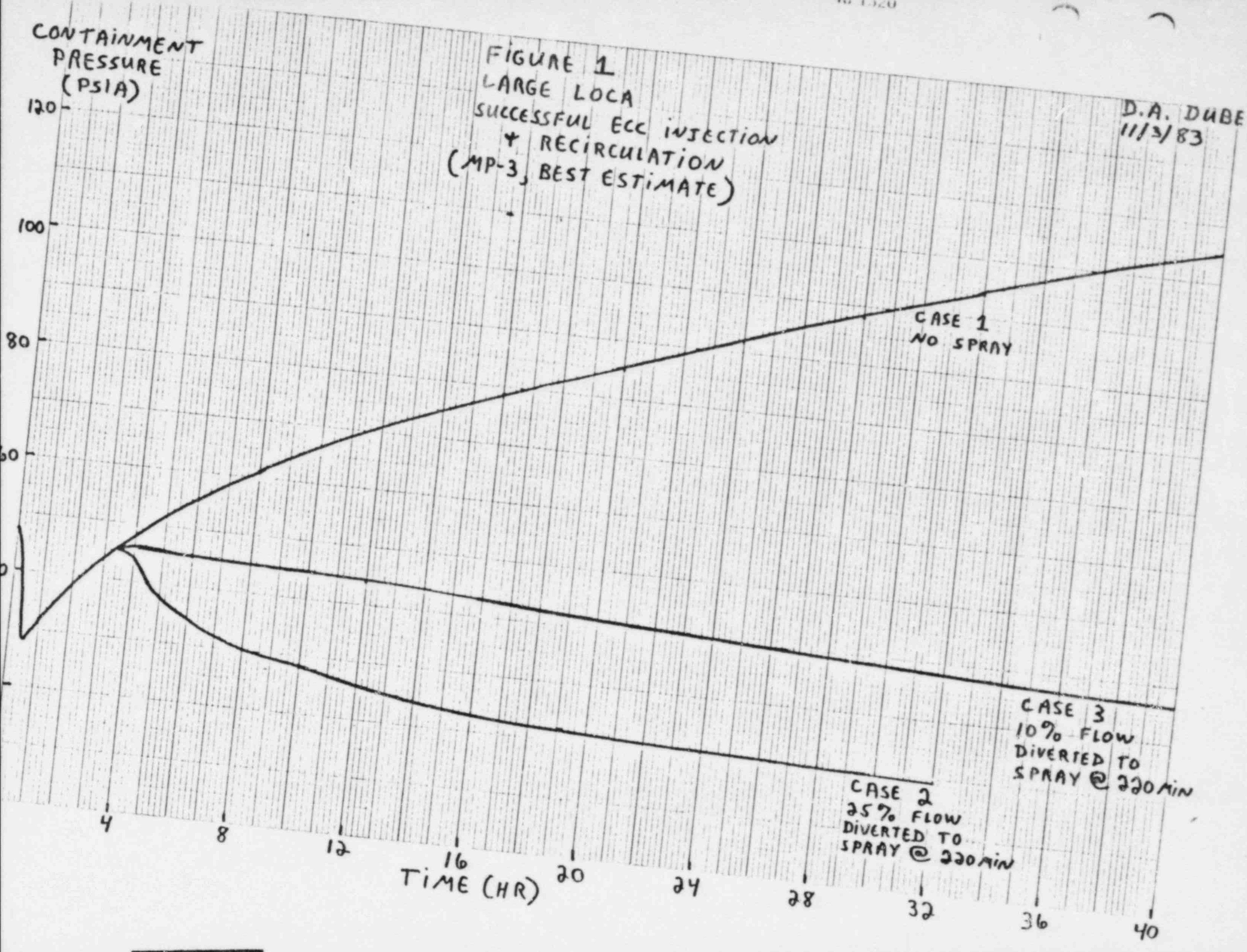
Question 14: For steamline break, does controlling HPI (OA-6) really make any difference? Why is this event included?

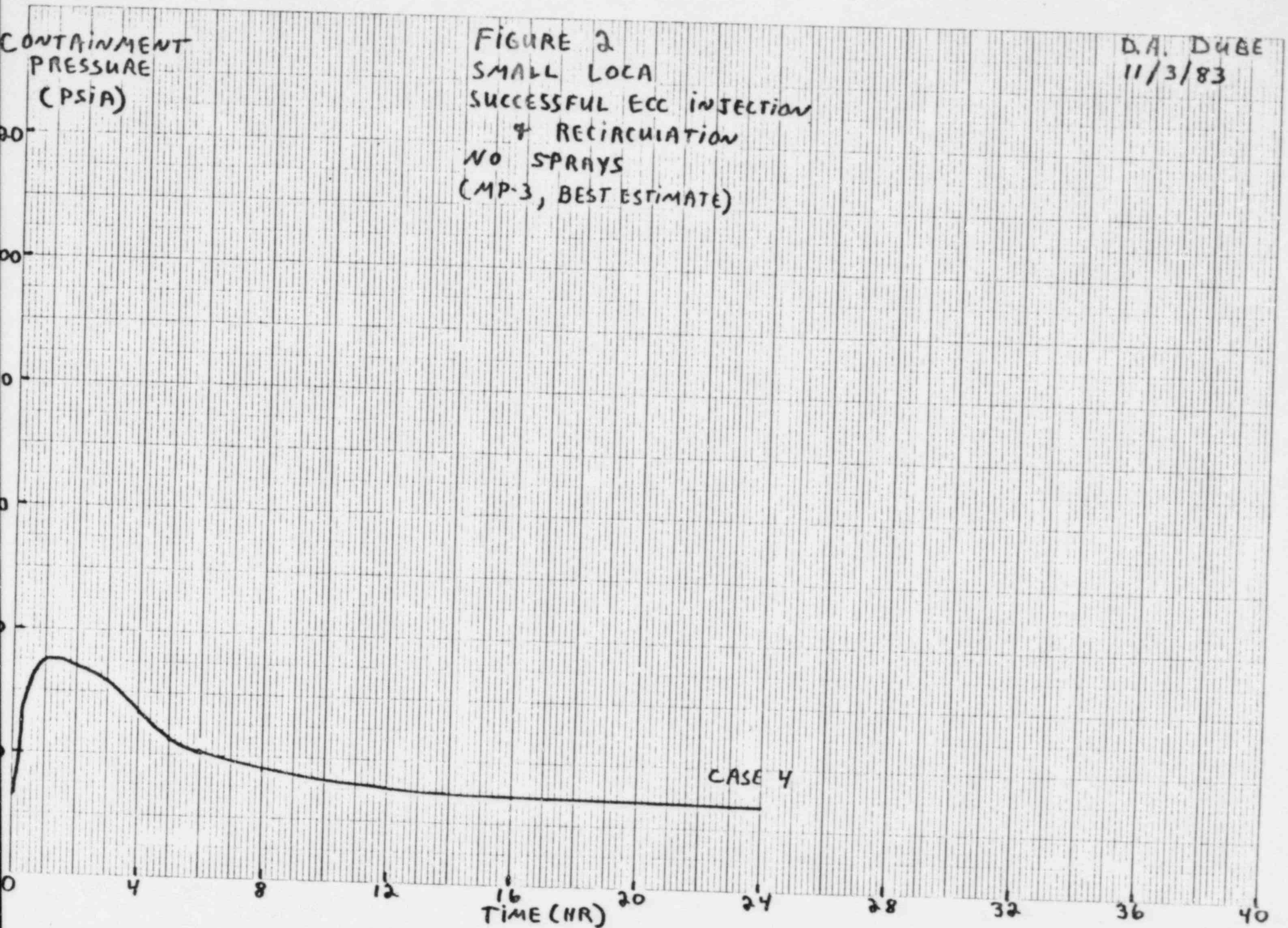
Response: OA-6 was originally included in the Steamline Branch and Spurious SI event trees to account for potential challenges to the pressurizer PORV's or safety valves if SI is not terminated in accordance with the emergency procedures. This could result in a higher probability of a consequential small LOCA. However the probability of a consequential small LOCA is already addressed in the event trees via the S2 node. Therefore this operator action doesn't affect the successful mitigation of the event but was left in the event tree anyway.

Question 15: For steamline breaks, why is failure of Main Steam Isolation assumed to fail AFWS?

Response:

Failure of Main Steam Isolation is (conservatively) assumed to fail the AFWS. The success criteria used for AFW following a steamline break (AF-2) requires three intact steam generators. Rather than requantifying AFW for different success criteria the Main Steam Isolation node was added. The success criteria for this node will ensure three intact steam generators. Failure at this node will not meet the success criteria modeled in the fault tree for AF-2 and therefore is (conservatively) assumed to fail AFW.


CONTAINMENT PRESSURE (PSIA)
FIGURE 1
LARGE LOCA
SUCCESSFUL ECC INJECTION
+ RECIRCULATION
(MP-3, BEST ESTIMATE)
D.A. DUBE
11/3/83
120
100
80
60
CASE 1
NO SPRAY
CASE 3
10% FLOW
DIVERTED TO
SPRAY @ 220 MIN
CASE 2
25% FLOW
DIVERTED TO
SPRAY @ 220 MIN
4
8
12
16
20
24
28
32
36
40
TIME (HR)


CONTAINMENT PRESSURE (PSIA)
FIGURE 2
SMALL LOCA
SUCCESSFUL ECC INJECTION
& RECIRCULATION
NO SPRAYS
(MP-3, BEST ESTIMATE)
D.A. DUBE
11/3/83
CASE 4
0
4
8
12
16
20
24
28
32
36
40
TIME (HR)

Attachment 1

Technical Bases of Secondary Depressurization/LPI
to Accommodate Failure of H.P.S.I. in the Millstone - 3
Probabilistic Safety Study