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ComEd

June 28, 1996

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

Subject: Dresden Station Units 2 and 3, Response to NRC Review of Individual Plant Examination Submittal - Internal Events
NRC Docket Nos. 50-237 and 50-249

References:
(a) M.A. Jackson Letter to Thomas E. Murley, dated January 28, 1993
(b) P.L. Piet Letter to NRR, dated October 28, 1994
(c) T.W. Simpkin Letter to NRR, dated September 1, 1995
(d) J.F. Stang Letter to D.L. Farrar, dated November 9, 1995
(e) B. Rybak Letter to NRR, dated December 15, 1995
(f) J. Stephen Perry Letter to NRR, dated March 5, 1996

Reference (d) provides the NRC Staff Evaluation Report (SER), including Technical Evaluation Reports, of the Dresden Individual Plant Examination (IPE) for internal events. The staff raised a number of concerns and stated that it "could not reach the conclusion that ComEd has met the intent of Generic Letter 88-20."

In response to similar concerns expressed by the NRC on the Zion Station IPE, ComEd defined a resolution process that would allow ComEd and the NRC to come to closure on the identified issues. In accordance with that process, ComEd developed a "modified IPE" for Zion by making changes to the base IPE. This modified IPE and additional analyses on other issues raised in the SER for Zion were submitted to the NRC in Reference (c).

In accordance with that same process, ComEd has developed a "modified Dresden IPE" to address the Staff's concerns and to allow the Staff to conclude that ComEd meets the intent of Generic Letter 88-20 for Dresden.

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Specifically, the following changes were made to the base IPE as discussed in References (e) and (f):

1. Including eight (8) new support system based initiators for each unit. Specifically, adding:

   a) A Loss of Service Water initiator;
   b) Four (4) initiators for loss of major (4 kV) AC buses;
   c) A Loss of Instrument Air initiator; and
   d) Two (2) initiators for loss of HVAC caused by 1) a loss of a 480 VAC bus or 2) loss of a 480 VAC Motor Control Center (MCC).

2. Modifying the common cause failure (CCF) factors;

3. Revising the success criteria for SBO events to explicitly account for reactor recirculation pump seal leakage and for ATWS to include the Operator Action to inhibit ADS in the ATWS Event Tree; and

4. Modifying the human error probabilities (HEPs) for significant operator actions by employing an alternative Human Reliability Analysis (HRA) methodology and revising the treatment of pre-initiator human events.

These IPE modifications were integrated with plant procedure and equipment enhancements that were implemented as a result of the base IPE as well as several refinements to the base IPE model. In summary, the modified Dresden IPE includes the following four other significant changes to the base IPE model:

- Revision of initiating event frequencies for the Loss of 125 VDC to include a water spray contribution and to reflect a recent Unit 2 hardware modification. This revision was discussed in the ComEd response to Question 13 of the Dresden IPE Request for Additional Information (RAI) in Reference (b);

- Revision of the single unit LOOP initiating event frequency to improve the use of plant-specific data;

- Model revisions to incorporate improved procedures (as recommended by the base IPE insights) for continued use of the Isolation Condenser following discharge of station batteries and for continued use of the low pressure Emergency Core Cooling System (ECCS) pumps despite loss of suppression pool cooling. These revisions were discussed in the ComEd response to Questions 13 and 34 of the RAI; and

- Revisions, including mission time changes, for standby instruments that reflect a plant-specific assessment of pre-initiator concerns involving instrument calibration.

A detailed discussion of these modifications to the base Dresden IPE is provided in Enclosure 1, including a discussion of the integrated effect on the IPE results. The modified Dresden IPE Core Damage Frequencies are 3.4E-06/yr for Unit 2 and 5.0E-06/yr for Unit 3. With respect to changes in the risk profile:

- For Unit 2, the Loss of DC Power initiator was eliminated by the hardware modification so it no longer contributes to the CDF. The Dual Unit Loss of Off-Site Power (LOOP) contribution increases by approximately a factor of 5 because of the new assumption that the reactor recirculation pump seal leakage would be significant during extended SBO events. The Single Unit LOOP contribution decreases by approximately a factor of 2 due to the initiating event frequency reduction; and

- For Unit 3, the Single and Dual Unit LOOP changes were similar to those discussed above for Unit 2. The Loss of DC Power initiator, however, is essentially the same as that reported in the ComEd response to the RAI. The hardware modification to eliminate this initiator on Unit 3 is planned for the next refueling outage.

Enclosure 2 provides a discussion of other issues raised in the Staff Evaluation Report (SER) that, upon ComEd evaluation, did not result in modifications to the IPE. Technical justification for the success criteria for HVAC and information on the Peer review performed for the modified IPE are contained in the enclosure.

For your convenience, Enclosure 3 provides revised pages to the base Dresden IPE Submittal Report (Reference (a)) that incorporate the IPE modifications discussed above.

In conclusion, ComEd believes that this submittal of the modified Dresden IPE is responsive to the comments and concerns raised in the Staff Evaluation Report and associated discussions with the NRC staff. ComEd also believes that these issues have

been resolved by this transmittal. Our expectation is that this modified Dresden IPE model will be accepted by the NRC as "meeting the intent of Generic Letter 88-20" without any special restrictions on its potential use in the full scope of PRA applications.

Sincerely,

John Hosmer

John B. Hosmer
Engineering Vice President

Enclosures: (1) Modifications Made to Dresden IPE
(2) Response to Other Issues Raised by SER
(3) Revised Pages for Base Dresden IPE Submittal Report

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ComEd

Dresden

Individual Plant Examination (IPE)

Response to NRC Staff Evaluation Report and Modified Dresden IPE

June 1996

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ENCLOSURE 1

MODIFICATIONS MADE TO DRESDEN IPE

CONTENTS

MODIFICATION 1	Additional Support System Based Initiators
MODIFICATION 2	Common Cause Factor (CCF) Revisions
MODIFICATION 3	Revised SBO and ATWS Success Criteria
MODIFICATION 4	Revised Human Error Probabilities and Treatment of Pre-Initiator Events
MODIFICATION 5	Discussion of the Final, Integrated "Modified Dresden IPE Model"

MODIFICATIONS MADE TO DRESDEN IPE

The following new modifications were made to the Dresden IPE model to create the "Modified Dresden IPE." Previous modifications had been discussed in the ComEd response to the NRC Request for Additional Information on the Dresden IPE. A discussion of these new modifications is provided below as well as in Revision 1 of the Dresden IPE Submittal Report.

MODIFICATION 1 Additional Support System Based Initiators

The NRC's Staff Evaluation Report (SER) raised concerns regarding the treatment of support system based initiators. Specifically, pages 1 and 2 of the SER state that:

> *The process used to delineate accident sequences included identification of initiating events and associated success criteria and the development of event trees. The licensee identified and evaluated initiating events that include general plant transients, loss-of-coolant accidents, interfacing systems loss-of-coolant accidents, inadvertently open relief valves, anticipated transients without scram, loss of offsite power at a single and at both units, and loss of the 125V DC from one unit. Station blackout and anticipated transients without scram were treated as consequential failures. However, the staff could not determine whether sufficient examination of failures from support systems such as instrument air, heating, ventilation, and air conditioning (HVAC), service water, and AC power was performed.*
>
> *The licensee, in their response to the staff's RAI for the treatment of support system based initiators, provided the individual events that comprise transient categories and summaries of plant trip history. These categories, however, involve events and failures primarily associated with balance-of-plant systems and not support systems. The licensee further indicated that loss of HVAC and instrument air are potential initiators since they ultimately result in a main steam isolation valve (MSIV) closure and, therefore, the licensee modeled these events as a MSIV closure initiator. This grouping, however, may be inappropriate; loss of HVAC and loss of instrument air may have more adverse impact on plant capability to cope with an accident than MSIV closure because, while closure of MSIV renders the main condenser unavailable, loss of these systems typically result in loss of many vital core cooling systems. In addition, loss of service water, and loss of AC power as support system initiators do not appear to have been addressed. Loss of these systems render all equipment which they support unavailable. The licensee has not provided sufficient*

> *evidence that a reasonable and systematic search for plant-specific support system initiators was performed. Therefore, the staff can not conclude that the licensee's rationale for screening all support-system based initiators, but one (loss of DC power) from the analysis was reasonable. Consequently, the staff can not conclude that the most likely accident sequences were analyzed.*

In the original IPE, a number of potential support system based initiators (support system failure events that would cause a scram) had been screened from further consideration because of the following judgments:

- The response of the plant to the potential initiator was judged to be similar to the response modeled for an existing initiator (such as the General Transient or single-unit Loss of Offsite Power initiators); and

- The frequency of the potential initiator was judged to be much lower than that existing initiator.

Following the screening process, the only support system based initiator that was used for the original IPE was Loss of 125 VDC (main bus). The SER indicates a concern with screening the following:

- Loss of Service Water;

- Loss of AC Power;

- Loss of Instrument Air; and

- Loss of HVAC.

In response to this concern, eight (8) new support system based initiators for each unit were added to the Modified Dresden IPE:

- One (1) new initiator is loss of Service Water.
- Four (4) of the new initiators are loss of major (4 kV) AC buses.
- One (1) new initiator is loss of Instrument Air.
- Two (2) new initiators are for loss of HVAC caused by a) a loss of a 480 VAC bus or b) loss of a 480 VAC Motor Control Center (MCC).

The selection of these new initiators and the basis for initiating event frequencies used are discussed below.

As discussed in more detail in the section "Modification 5, Discussion of the Final, Integrated 'Modified Dresden IPE Model,'" the impact of these new initiators is small. The eight (8) new initiators together contribute approximately 1% of the total core damage frequency (CDF).

> Only one sequence of the dominant 100 for the Modified Dresden IPE (i.e., Sequence #18 for Unit 2) is due to any of the new initiators; that sequence (due to the new Loss of Service Water initiator) is a variation of a previously identified sequence (Sequence #9 for Unit 2) in which the feedwater system fails in concurrence with a General Transient initiator. The quantification of these two sequences indicates that a General Transient initiator concurrent with loss of the feedwater system is more likely to occur than is the Loss of Service Water initiator in which the feedwater system is lost as a consequence of the initiator.

Based on these results, it appears that the decision to screen these eight initiators from further consideration during the original IPE was valid with respect to the stated purpose of searching for vulnerabilities. Nevertheless, now that these support system based initiators

have been added to the Modified Dresden IPE, additional low-probability sequences are available for consideration during PRA applications.

More significant, in terms of impact on the CDF totals discussed below under "Modification 5, Discussion of the Final, Integrated 'Modified Dresden IPE Model,'" are changes in other initiating event frequencies. Changes have been made for the loss of 125 VDC (main bus) and single-unit loss of offsite power (LOOP) initiators since the original IPE. These frequency changes are discussed below, as are the eight new initiators for each unit.

Loss of 125 VDC DC (Main Bus)

Each unit's 125 VDC battery bus system consists of the battery (operating in float), two battery chargers (with one in standby), and the distribution system. Each unit's battery bus provides power to its own Turbine Building Main Bus, as well as the opposite unit's Turbine Building Reserve Bus. The system operates ungrounded; two faults to ground (one on each of the positive and negative buses) are required to discharge the battery via the fault. Should an operating battery charger fail, the dedicated standby charger must be aligned manually. The batteries are designed to provide emergency and safe shutdown power for four hours without charger operation.

Loss of either the battery charger or the battery does not interrupt power to the 125 VDC buses. In addition, should the operating charger fail, the battery will provide power to the bus for several hours, providing time for the operators to align the standby charger. However, the IPE identified that loss of a 125 VDC main bus would result in reactor scram due to the loss of that unit's reactor feedwater pumps; in addition, the Isolation Condenser (IC) System at each unit and one-half of the ECCS systems are unavailable. Therefore, this event is analyzed as a support system based initiator.

NOTE: The initiating event frequency estimates are recognized as having only one significant digit for most initiators. Nevertheless, following the practice in the

original IPE, frequencies and many other input values to the PRA calculations are given to two or three digits. Although the extra digits are not significant, carrying additional digits through the calculations aids in some sensitivity studies.

The initiating event frequency of 8.70 E-4/yr used in the original IPE for the Loss of 125 VDC (main bus) initiator was based on a fault tree calculation. As discussed in ComEd response to the NRC RAI, a subsequent revision to the initiating event frequency was made to account for potential water spray sources (i.e., sources present near the Unit 3 125 VDC main bus but not present near the Unit 2 125 VDC main bus). As reported in the RAI response, the Loss of 125 VDC (main bus) frequency is now estimated as 1.56 E-3/yr for Unit 3.

Due to the importance of this event in the original IPE, a modification was performed on the Unit 2 feedwater system to eliminate the Loss of 125 VDC (main bus) initiator. Consequently, a Unit 2 Loss of 125 VDC (main bus) frequency of zero was used for the Modified Dresden IPE calculations. The Loss of 125 VDC (main bus) event will remain a support system based initiator for Unit 3 (with an estimated frequency of 1.56 E-3/yr) until completion of a similar modification now scheduled for refueling outage D3R14.

Single-Unit Loss of Offsite Power Initiator

The original IPE for Dresden Units 2 and 3 used a site-specific single-unit loss of offsite power (LOOP) frequency of 9.6 E-2/yr. A subsequent review found that this frequency estimate had been calculated on a site-year basis, including 10 years of Dresden 1 operation prior to Dresden 2 startup. The use of site-years was inconsistent with the frequencies used for other initiators and was overly conservative. Also, the subsequent review concluded that the use of Dresden Unit 1 operating experience (1960 - 1978) in the site-specific calculation for the original IPE for Dresden 2 and 3 was inappropriate due to addition of transmission lines and a second switchyard for Dresden 2 and 3.

Consequently, only the operating experience of Dresden Units 2 and 3 was used in calculating a site-specific LOOP frequency for the Modified Dresden IPE. The new single-unit LOOP frequency estimate is 5.1 E-2/yr.

Loss of Service Water

A Loss of Service Water (SW) support-system based initiator was added to the Modified Dresden IPE.

The Dresden SW system is completely shared by Units 2 and 3. It consists of five pumps, with four normally operating and one standby swing pump, which supply flow to a common unisolable header. This header then supplies three strainers, one per unit and a swing strainer, followed by another common unisolable header. This header then supplies SW cooling loads for both units. The major loads are as follows:

Turbine Building Closed Cooling Water (TBCCW) Heat Exchangers,

Reactor Building Closed Cooling Water (RBCCW) Heat Exchangers,

CCSW Keep-Fill System,

Control Room A/C,

Auxiliary Electrical Equipment Room (AEER) A/C,

Emergency Air Coolers,

Concentrator Condensers,

Generator Stator Water Coolers,

Generator Hydrogen Coolers,

MG Set Oil Coolers,

Turbine Oil Coolers, and

Steam Tunnel ("X-Area") Coolers.

The return flow from these loads is routed to one of two discharge headers (per unit), both of which then discharge to the Circulating Water system discharge header. The Service Water system may also be required to supply Standby Coolant Supply to the main condenser hotwell. Electric power to the pumps and valves is generally aligned according to the Unit being supplied. Two pumps are powered from Unit 2, two are powered from Unit 3, and the swing pump is powered from either unit

A review of several hundred reactor years of BWR experience for the original IPE indicated that a loss of all Service Water had never occurred. In addition, all ECCS systems remain available following a loss of Service Water. For these reasons, the review for the original IPE had judged that the plant response to a loss of Service Water would resemble the response to a General Transient initiator with the main condenser unavailable, and the Loss of Service Water initiator was screened from further consideration in the original IPE.

Among the loads of the TBCCW system, however, are the major pumps of the feedwater and condensate system. Because credit continues to be given for these systems in the Modified Dresden IPE, a separate Loss of Service Water support system based initiator was added.

Service water can be lost either by a combination of failures involving active components, or through rupture of a single, large passive component. Based on fault tree and rupture rate calculations, a Loss of Service Water frequency estimate of 4.48 E-3/yr was developed for the Modified Dresden IPE.

Individual AC Buses

Loss of a single AC bus as an initiating event is much less likely (and less severe) than loss of offsite power at one or both units. Nevertheless, due to the concerns expressed in

the SER, AC buses were reviewed to identify those whose loss would result in a reactor scram.

Loss of 4 kV Bus 23/33 would result in loss of two of the three circulating water pumps for the affected unit, and station procedures would require a manual scram if the bus and one of the lost circulating water pumps could not be restored immediately. Loss of Bus 23/33 was analyzed as a support system based initiator for the Modified IPE.

> Note: In this and following discussions, the first digit of the identifier for a piece of AC switchgear designates the unit served by that switchgear. The potential scrams discussed below apply only to the unit served by the switchgear that is postulated to be lost (e.g., Bus 23 serves Unit 2 and loss of Bus 23 would lead to a manual scram of Unit 2).

Loss of 4 kV Bus 21/31, 22/32, or 24/34 could cause loss of one or more condensate/booster or feedwater pumps, but would also be accompanied by loss of an M-G set for one of the affected unit's reactor recirculating water pumps. The rapid drop in reactor power due to the drop in reactor recirculation flow would mitigate the drop in feedwater/condensate flow. Based on engineering judgment, however, a low conditional probability of reactor scram exists, given loss of one of these buses, because the reactor operator may fail to cope with the feedwater/condensate transient. Therefore, loss of these buses was analyzed as support system based initiators for the Modified Dresden IPE.

> NOTE: The frequency estimate for these initiators given below is 10% of the frequency estimate for loss of the bus. This factor of 10% is based on engineering judgment.

Loss of 4 kV Bus 23-1/33-1 or 24-1/34-1 would not result in reactor scram. Loss of supported safety systems would require a unit shutdown, but a controlled shutdown rather

than a manual scram would be expected. Therefore, loss of these buses was not analyzed as support system based initiators for the Modified IPE.

Loss of 480 VAC Bus 28/38 would cause loss of power at Motor Control Center (MCC) 28-2/38-2 and, consequently, results in a loss of area cooling in the steam tunnel ("X-area"). If not promptly restored, high area temperatures would result in a Group I primary containment isolation and subsequent reactor scram. Therefore, loss of 480 VAC Bus 28/38 was analyzed as a support system based initiator for the Modified IPE. No other cases were identified where loss of a single 480 VAC bus would result in a reactor scram.

Individual AC Panel

As discussed above, loss of MCC 28-2/38-2, if not promptly restored, would result in a reactor scram. Therefore, loss of MCC 28-2/38-2 was analyzed as a support system based initiator for the Modified Dresden IPE.

Loss of Instrument Air

Instrument Air (IA) is used to maintain the outboard MSIVs in the open position. IA is also used for service water strainer, feedwater system, vent valve, and hotwell operation. Loss of IA leads to MSIV closure and loss of the path to the Main Condenser. Because extended loss of IA would make concurrent loss of service water more likely, extended loss of IA was analyzed as a support system based initiator for the Modified Dresden IPE.

Loss of HVAC

Steam Tunnel ("X-Area")

The Main Steam system was reviewed as part of the IPE. The IPE review identified a dependency of the Main Steam system on the coolers in the steam tunnel ("X-

Area"). Loss of coolers would result in high temperatures in the area of the outboard main steam isolation valves (MSIVs). High temperatures would result in a Group I isolation and loss of the Main Steam system.

No Main Steam fault trees were developed for the IPE, however, because the only plant response tree (PRT) crediting Main Steam (and Main Condenser) as a means to cool the core was the ATWS PRT. (This is a conservative approach for the other PRTs, but reasonable considering that credit is given for the highly reliable Isolation Condenser system.) The ATWS PRT quantification used actual plant transient data from the IPE baseline period to determine the Main Condenser failure probability for various cases. For this reason, no fault tree modeling of Main Steam (which could include the steam tunnel coolers) was necessary.

As mentioned in the discussion of the AC distribution system above, however, extended loss of steam tunnel ("X-area") cooling would result in a Group I isolation and reactor scram. The most likely causes for loss of X-area cooling are judged to be causes involving loss of AC power to the coolers. (Note that all of a unit's X-area coolers are powered by the same Motor Control Center.) As discussed above, two separate initiators were used in the Modified Dresden IPE to address the possibility of a scram due to loss of X-area cooling:

- Loss of 480 VAC Bus 28/38; and

- Loss of 480 VAC Motor Control Center (MCC) 28-2/38-2.

Loss of X-area cooling alone would have no impact on any fault trees and, as discussed above, the ATWS PRT accounts for loss of the main condenser already. Nevertheless, these two new initiators are warranted because of other equipment that would be lost in concurrence with loss of X-area cooling.

Electrical Switchgear Areas

At some newer plants, loss of cooling to electrical switchgear rooms is a concern. The major AC switchgear at Dresden is *not* located in separate rooms, however. Instead, the major AC switchgear is located in open areas of the ground, second and third floors of the turbine and reactor buildings. These areas are normally supplied with ventilation but do not have coolers. Most of the major DC switchgear is located in open areas of the second floor of the turbine building and third floor of the reactor building. Additionally, some of the Unit 2 DC switchgear is located in the area outside the Unit 2 battery rooms directly above the main control room and some of the Unit 3 DC switchgear is located in a battery charger room immediately below the Unit 3 battery room.

In response to an NRC recommendation to consider the effects of loss of ventilation on Station Blackout (SBO) equipment, these areas were considered. (Reference: B. M. K. Wong memorandum to C. W. Schroeder, "Dresden Station Units 2 &3, Station Blackout Responses To Safety Evaluation Report Recommendations," dated April 26, 1992, CHRON #184897.) With respect to the reactor building and turbine building, this 1992 review concluded that "Temperature in the large open areas is not expected to go higher than 120° in SBO conditions, so that no further evaluation of equipment there is required." The review also concluded that the battery room temperature would not exceed 120°F.

Furthermore, loss of ventilation to the switchgear areas of the turbine building is easily mitigated by opening normally closed doors such as the following:

- For the 4 kV switchgear in the turbine building, nearby doors to the outdoors, including the turbine building trackway doors;

- For the DC switchgear above the main control room, the door providing access from the stairwell leading to the Unit 2 turbine building area containing 4 kV switchgear; and

- For the DC switchgear in the Unit 3 battery charger room, the door providing access to the room from the Unit 3 turbine building area containing the trackway and 4 kV switchgear.

Extended loss of ventilation to the reactor building could potentially result in a controlled unit shutdown due to equipment qualification or other concerns, but the concerns would not be expected to lead to a reactor scram. Some of the major electrical switchgear in the reactor building is environmentally qualified.

The survivability review carried out during the original IPE included consideration of local heating during an interfacing system LOCA (ISLOCA). The calculated temperature for the ground floor of the reactor building was found to briefly exceed 250°F, but the survivability review did not identify a resulting failure to function (for an ISLOCA) by any of the electrical switchgear in the reactor building.

For these reasons, loss of ventilation in electrical switchgear areas was not warranted as a support system based initiator for the Modified Dresden IPE.

Battery Rooms

The IPE did not include loss of room heating or ventilation as a failure mode for station batteries.

Loss of heating for a battery room could impact the load-carrying capacity of the batteries. However, such an event would not be expected to lead to a reactor scram. Dresden Operating Abnormal (DOA) procedures 5700-01, Loss of Heating

Boilers, and DOA 5750-01, Ventilation System Failure, address problems involving the battery rooms. DOA 5700-01 specifies use of temporary heaters powered by welding receptacles to ensure that the station battery area temperatures do not go below 68°F. Because of the procedural controls, and because experience indicates that loss of room heating is mainly a concern during extended dual unit outages, loss of room heating is judged to have an insignificant impact on the probability of failure of a battery to function.

The 1992 review discussed above for the effects of loss of ventilation on SBO equipment concluded that the battery room temperature would not exceed 120°F. Dresden Station Design Basis Document DBD-DR-006, 125-V and 250-V DC System, Revision A, 12/15/92, states that 125 VDC and 250 VDC "Battery Room Temperature is to be maintained between 65°F and 120°F..." Furthermore, loss of ventilation during warm times of the year could be mitigated by opening doors and, if not during an SBO event, by using portable ventilation equipment such as fans.

For these reasons, loss of HVAC in battery areas was not warranted as a support system based initiator for the Modified Dresden IPE.

Containment Cooling Service Water (CCSW) Pump Vaults

The IPE Submittal Report includes the following note to Table 4.2.2-9 for the CCSW system:

> Delayed dependency on loss of HVAC to CCSW pumps B & C pump cubicle coolers.

The following comment was also included in Section 4.4.5.1 of the IPE Submittal Report:

> Room/area cooling for the CCSW and feed water pumps and diesel generators was assumed to fail the respective components and a survivability evaluation was therefore not required.

Therefore, as discussed in the RAI response, the B & C CCSW pump cubicle (vault) cooling was included in the fault trees for LPCI injection cooling and suppression pool cooling. The A & D CCSW pumps are in large, open areas (at a low elevation of the Turbine Building) rather than in sealed vaults. Furthermore, loss of the CCSW system would not cause a scram. For these reasons, loss of cooling in a unit's CCSW pump areas was not warranted as a support system based initiator for the Modified Dresden IPE.

Control Room and Auxiliary Electrical Equipment Room

The Main Control Room and the Auxiliary Electrical Equipment Room (AEER) are normally cooled. Dresden Operating Abnormal (DOA) 5750-01, Ventilation System Failure, addresses problems involving these rooms.

The normal cooling system for the Main Control Room uses Service Water. The safety-related Containment Cooling Service Water (CCSW) system can also be used. Except for Station Blackout (SBO) events, therefore, loss of Main Control Room ventilation is unlikely.

The 1992 review discussed above for the effects of loss of ventilation on SBO equipment concluded that opening cabinet and room doors would be necessary to maintain Main Control Room and AEER temperatures below 120°F during a Station Blackout (SBO) event. In response to that review, Dresden Operating Abnormal (DOA) 5750-01, Ventilation System Failure, specifies opening all panel doors and opening two of the security doors for the duration of the event to maintain Main Control Room and AEER temperatures below 120°F .

Because of the redundant supplies of cooling water and because of procedural controls, loss of Main Control Room or AEER ventilation, even for an SBO event, is

judged to have an insignificant impact on modeled equipment failure rates or on modeled human error probabilities (HEPs). Significantly, loss of Main Control Room ventilation is not expected to lead to Main Control Room evacuation.

For these reasons, loss of ventilation in the Main Control Room and AEER would not be expected to lead to either an automatic or manual reactor scram. Therefore, loss of ventilation in these areas was not warranted as a support system based initiator for the Modified Dresden IPE.

Reactor Feed Pumps

The reactor feedpump (RFP) motors are supplied with ventilation. This dependency is included in the feedwater system fault trees. The IPE Submittal Report includes the following note to Table 4.2.2-6 for the feedwater system:

> "Interlocked with RFPs to prevent start unless ventilation fan is running. Ventilation fans required for air cooling for RFP motors."

The following comment was also included in Section 4.4.5.1 of the IPE Submittal Report:

> "Room/area cooling for the CCSW and feed water pumps and diesel generators was assumed to fail the respective components and a survivability evaluation was therefore not required."

Because the general transient initiating event includes loss of feedwater, loss of RFP cooling is judged to be subsumed by the general transient initiating event. Therefore, loss of RFP cooling was not warranted as a support system based initiator for the Modified Dresden IPE.

HPCI Pump Room

The IPE Submittal Report includes the following note to Table 4.2.2-7 for the HPCI system:

> "There is a delayed dependency on HVAC for room cooling but it is insignificant for the HPCI mission time. A Sargent & Lundy study of April 1985 indicates HPCI can operate 152 hours without HVAC before HPCI Area high temperature (200°F) occurs. Power for HPCI area cooler is supplied by 480 V MCC 29-4."

The following comment was also included in Section 4.4.5.1 of the IPE Submittal Report:

> "Previously performed analyses were reviewed for applicability for the Core Spray/LPCI pump rooms and HPCI pump room. These analyses indicate that the equipment in these rooms will survive the environment posed by loss of room cooling."

For this reason, the HPCI fault tree does not include the HVAC dependency. Furthermore, HPCI system isolation is not considered to be an initiating event. For these reasons, loss of HPCI Pump Room cooling was not warranted as a support system based initiator for the Modified Dresden IPE.

LPCI and Core Spray Pump Rooms (Reactor Building Corner Rooms)

The following comment was also included in Section 4.4.5.1 of the IPE Submittal Report:

"Previously performed analyses were reviewed for applicability for the Core Spray/LPCI pump rooms and HPCI pump room. These analyses indicate that the equipment in these rooms will survive the environment posed by loss of room cooling."

For this reason, the LPCI and Core Spray fault trees do not include HVAC dependency except for the LPCI dependency on CCSW vault cooling discussed above. Furthermore, LPCI or Core Spray system failure due to high area temperatures is not considered to be an initiating event. For these reasons, loss of LPCI and Core Spray Pump Room was not warranted as a support system based initiator for the Modified Dresden IPE.

Emergency Diesel Generator Rooms

The following comment was included in Section 4.4.5.1 of the IPE Submittal Report:

"Room/area cooling for the CCSW and feed water pumps and diesel generators was assumed to fail the respective components and a survivability evaluation was therefore not required."

Diesel generator notes to Table 4.2.2-9 of the IPE Submittal report include the statement "Leads to loss of engine control circuitry on prolonged loss of ventilation." This dependency is included in the pertinent fault trees. Emergency diesel generator failure (e.g., during testing) is not considered to be an initiating event. Therefore, loss of emergency diesel generator room cooling was not warranted as a support system based initiator for the Modified Dresden IPE.

Isolation Condenser Makeup Pump Room

The following comment was included in Section 4.4.5.1 of the IPE Submittal Report:

"The design documentation for the Isolation Condenser makeup pumps was reviewed and the system design representative interviewed. The design of the pump and system is such that the loss of the room cooling fans is not expected to increase the temperature in the room and further survivability evaluation was therefore not required."

The pump drivers are diesel engines with an integral jacket cooling system that is inside the boundary of the diesel-driven pump, and is therefore considered as a failure mode of the pump. The diesel takes its combustion air from the pump room that receives air through louvered openings ensuring a steady flow of cool outside air into the room during pump operation. Because of this design and modeling assumption, the loss of the room cooling fans is not expected to increase the temperature in the room and further analysis was not warranted.

For the above reasons, the Isolation Condenser fault trees do not include loss of the room cooling fans. Furthermore, loss of makeup water to the Isolation Condenser would not be an initiating event. For these reasons, loss of Isolation Condenser Makeup Pump Room cooling ventilation was not warranted as a support system based initiator for the Modified Dresden IPE.

Diesel-Driven Fire Pump Areas

The two diesel-driven fire pumps are located in separate intake structures. The Unit 2/3 fire pump is located in the Unit 2/3 intake structure and the Unit 1 fire pump is located in the Unit 1 intake structure.

Loss of steam heating in the area could make a fire diesel more difficult to start in cold weather. Dresden Operating Abnormal (DOA) procedure 5700-01, Loss of Heating Boilers, specifies use of temporary heaters powered by welding receptacles

to ensure that the diesel-driven fire pump area temperatures do not go below 40°F. Outside air is used to cool the intake structures during warm months.

Failure of a diesel driven fire pump would not lead to a reactor scram. Therefore, loss of ventilation to a diesel-driven fire pump area ventilation was not warranted as a support system based initiator for the Modified Dresden IPE.

Turbine Building Closed Cooling Water (TBCCW) Pump Areas

The IPE review of the TBCCW pumps determined that they were located in a mild environment (an open area of the turbine building) and that the fluid in the system is low-temperature and low-pressure. Therefore, the loss of room/area cooling is not expected to significantly increase the temperature in the area and further analysis was not warranted.

For this reason, loss of room/area cooling was not included in the TBCCW fault tree, and loss of TBCCW pump area cooling was not warranted as a support system based initiator for the Modified IPE.

Drywell

The drywell coolers are assumed to continue operating during most transients. Therefore, a loss of drywell cooling node was not included in the transient plant response tree (PRT). Even with a loss of drywell cooling there would be little impact on the accident progression and no effect on the systems necessary to maintain the reactor in a safe, stable condition. (The main impact would be closure of Main Steam Isolation Valves but, as discussed above, credit for heat removal via the main condenser is taken only for the ATWS initiator.)

Loss of drywell cooling, by itself, is expected to result in a controlled reactor shutdown rather than a scram. For this reason, loss of drywell cooling should not be included as a support system based initiator for the Modified IPE. (Note, however, that one of the special initiating events discussed above, loss of Service Water, has loss of drywell cooling as a consequential event.)

In summary, although loss of HVAC was modeled in the fault trees for several systems, no loss of HVAC support system based initiators were found to be warranted for the Dresden Modified IPE. As discussed above, however, two of the new support system based initiators (i.e., Loss of 480 VAC Bus 28/38 and Loss of MCC 28-2/38-2) were added to the Modified IPE because they would result in a loss of steam tunnel ("X-area") cooling and subsequent reactor scram.

Frequency Estimates for Support System Based Initiators

In addition to using simplified system fault trees, the effects of water line breaks were considered.

- As discussed in detail in the ComEd response to the RAI, potential water spray sources near electrical switchgear were analyzed for their contribution to the frequency of the switchgear failure.

- For the Loss of Service Water initiator, rupture of a large service line (14" or larger) was assumed to divert sufficient flow to starve normally cooled components. Therefore, pipe rupture rates contributed to the Loss of Service Water frequency estimate.

The frequencies revised for the Modified IPE (either changes to existing initiators or additions for new initiators) are summarized in Table 1-1.

Summary

The Modified Dresden IPE included a total of nine support system based initiators for each unit as categorized below.

Loss of a Major DC Bus

One (1) initiator (previously used): Loss of 125 VDC (main bus).

Loss of a Major AC Bus (i.e., 4 kV)

Four (4) new initiators:

- Loss of Bus 21/31,
- Loss of Bus 22/32,
- Loss of Bus 23/33, and
- Loss of Bus 24/34.

Loss of Service Water

One (1) new initiator: Loss of Service Water.

Loss of Instrument Air

One (1) new initiator: Loss of Instrument Air.

Loss of HVAC

Two (2) new initiators:

- Loss of 480 VAC Bus 28/38 and
- Loss of 480 VAC MCC 28-2/38-2.

Table 1-1

New or Revised Initiating Event Frequencies for Dresden Modified IPE

Initiator	Original IPE	Modified IPE Unit 2	Modified IPE Unit 3
Loss of Offsite Power (single-unit)	9.6 E-2/yr	5.1 E-2/yr	5.1 E-2/yr
Loss of 125 VDC (main bus)	8.7 E-4/yr	0.0 (modification was completed to eliminate scram)	1.56 E-3/yr (modification to eliminate scram is pending)
Loss of Service Water	N/A	4.48 E-3/yr	4.48 E-3/yr
Loss of Instrument Air	N/A	6.95 E-3/yr	6.95 E-3/yr
Loss of Bus 21	N/A	1.76 E-4/yr	N/A
Loss of Bus 31	N/A	N/A	1.09 E-4/yr
Loss of Bus 22	N/A	1.44 E-4/yr	N/A
Loss of Bus 32	N/A	N/A	1.13 E-4/yr
Loss of Bus 23	N/A	1.62 E-3/yr	N/A
Loss of Bus 33	N/A	N/A	3.02 E-3/yr
Loss of Bus 24	N/A	3.12 E-4/yr	N/A
Loss of Bus 34	N/A	N/A	1.09 E-4/yr
Loss of Bus 28	N/A	1.24 E-3/yr	N/A
Loss of Bus 38	N/A	N/A	1.29 E-3/yr
Loss of MCC 28-2	N/A	1.27 E-3	N/A
Loss of MCC 38-2	N/A	N/A	6.88 E-4/yr

MODIFICATION 2 Common Cause Factor (CCF) Revisions

The NRC's Staff Evaluation Report (SER) raised concerns regarding the treatment of common cause factors. Specifically, page 3 of the SER states that:

> *The data used for estimating initiating event frequencies, component unavailabilities and failure probabilities are comparable with generic data. The factors used for common cause failure (CCF) quantification, however, are significantly lower than generic boiling water reactor CCF factors. Several beta factors are factors of 3-to-30 lower than typically seen for comparable components (e.g., motor-operated valves, diesel generators, and pumps). The licensee did not provide a sufficient basis for the use of these low beta factors. The licensee's response to the staff's RAI indicated that a screening of a generic (EPRI) common cause data base was performed to make it plant specific using expert opinion. However, it was not explained how this screening process was applied to ensure that CCF probabilities would not be arbitrarily underestimated and they truly represent the Dresden design, operations. Therefore, the staff has no sufficient basis to conclude that the use of low beta factors for important components (such as motor-operated valves, diesel generators, and pumps) is justified.*

"Common cause" describes multiple failures of functionally identical components due to a single, shared cause. Common cause analysis (CCA) evaluates the effects of these dependencies that may affect the ability of a system to prevent or mitigate a severe accident.

The Dresden CCA modeled common cause failures at the basic event level, employing the Multiple Greek Letter (MGL) method as defined in NUREG/CR-4780, "Procedures for Treating Common Cause Failure in Safety and Reliability Studies." The MGL method uses the parameters beta (β), gamma (γ), and delta (δ), defined as follows:

β conditional probability that the common cause of a component failure will be shared by one or more additional components

γ conditional probability that a common cause failure of two components will be shared by one or more additional components

δ conditional probability that a common cause failure of three components will be shared by one or more additional components

The MGL method allows one to continue defining parameters as far as desired. Consideration of more than three parameters generally reduces conservatism but can become unwieldy. The Dresden CCA assumed that common cause groups with greater than four components were adequately represented by the three-parameter analysis without being overly conservative.

The evaluation of Dresden failure data indicated that there had been no common cause events at the Dresden site applicable to current maintenance and operating practices. As a result, to more realistically model current experience at Dresden, a Dresden-specific evaluation of common cause failure events was performed. Dresden-specific common cause parameters were developed for components that had data available, including the following:

- Circuit Breakers
- Check Valves
- Service Water Pumps
- Diesel Generators
- Motor-operated Valves
- Relief Valves
- HPCI Room Coolers
- Fans

A generic common cause failure database was developed from EPRI NP-3967, "Classification and Analysis of Reactor Operating Experience Involving Dependent Events," supplemented with events from the September 1990 EPRI draft report, "A Database of Common Cause Events for Risk and Reliability Evaluations."

A four-member expert judgment panel reviewed data from the generic common cause failure database for applicability to ComEd plants. The Individual Plant Evaluation Partnership (IPEP) and ComEd each provided two members to the panel, one representing the Dresden IPE and one representing the Zion IPE. The members from IPEP were common cause data specialists and the members from ComEd were plant experts. One ComEd plant expert had previously

worked as an SRO and was familiar with current plant practices and procedures as well as those in practice at the time of the events in the generic common cause failure database.

The common cause failure database was reviewed for events applicable to Dresden. The expert panel came to a consensus opinion on each generic common cause event's applicability to Dresden, based upon current Dresden system configuration, and maintenance and operating practices. The detailed analysis of the common cause events is contained in the following document:

> Westinghouse Calculation Note CN-PRRA-91-118-RO, "Common Cause MGL Factors for Zion and Dresden IPEs," Westinghouse Proprietary Class 2C, 1991.

Examples (not exhaustive) of reasons for expert panel screening of events from the common cause databases discussed above as being not applicable to Dresden included the following:

- Single failure events with little to no evidence that a common cause failure existed.
- Multiple failure events due to independent causes rather than common causes.
- Events that would be prevented by procedures in place at Dresden.
- Events with significant time periods between failures.
- Event that could not have occurred at Dresden due to differences in equipment configuration or condition.
- Events with failures that would have been prevented by post-maintenance testing.
- Events that do not have a significant impact in analyses for PRA applications.
- Events involving easily recognized and recoverable failures.
- Events having failure modes that are not applicable to success criteria for Dresden.
- Events occurring prior to commercial operation, detected during startup testing, and not applicable to a mature plant.
- Events involving known common cause mechanisms addressed by specific programs in place at Dresden.

In response to the concern expressed in the SER with several beta factors being "lower than typically seen," ComEd committed in the 12/15/95 response to the SER to impose a "floor" of 1.0 E-02. Table 2-1 shows the Dresden-specific MGL parameters resulting from this revised analysis for the Modified Dresden IPE. (This is a revision of the data originally given in Table 4.4.3-1 of the original IPE.)

TABLE 2-1
MGL PARAMETERS FOR MODIFIED DRESDEN IPE

CC COMPONENT GROUP (from CC databases)	FOUR-COMPONENT SYSTEM			THREE-COMPONENT SYSTEM		TWO-COMPONENT SYSTEM
	BETA	GAMMA	DELTA	BETA	GAMMA	BETA
CB	--a--	--a--	--a--	5.6E-02	9.3E-01	5.4E-02
Containment Spray (CS) PUMP (See Note c)	--a--	--a--	--a--	--a--	--a--	5.1E-02
CV	1.0E-02	--b--	--b--	1.0E-02	--b--	1.0E-02
SW PUMP	1.0E-02	7.8E-01	5.7E-01	1.0E-02	6.0E-01	1.0E-02
DG	--a--	--a--	--a--	1.0E-02	1.6E-01	1.0E-02
HIGH-HEAD PUMP	--a--	--a--	--a--	--a--	--a--	3.2E-02
MOV	1.7E-02	5.0E-01	6.8E-01	1.4E-02	4.7E-01	1.0E-02
SLC RELIEF VALVE	1.1E-02	--b--	--b--	1.0E-02	--b--	1.0E-02
ELECTROMATIC RELIEF VALVE	2.4E-01	7.1E-01	1.0E+00	2.1E-01	7.8E-01	1.9E-01
SRV	1.1E-01	6.6E-01	2.1E-01	9.7E-02	3.5E-01	6.5E-02
HVAC CHILLER	--a--	--a--	--a--	1.0E-02	1.3E-01	1.0E-02
FAN	1.2E-02	1.0E+00	1.0E+00	1.2E-02	1.0E+00	1.2E-02
ALL	2.5E-02	7.2E-01	5.9E-01	2.3E-02	5.8E-01	1.8E-02

Notes: a. MGL values not calculated for this size system.

b. Value not calculated. The average value for all component failures ("ALL") given in this table is used as the value for these components.

c. The "CS Pump" category in the original IPE submittal referred to the Containment Spray Pump category of the databases, not Core Spray pumps. ComEd regrets any apparent misunderstanding that may have resulted from the terminology used.

An average common cause component group was quantified from a composite of all the common cause failures for all components in the database ("ALL" in Table 2-1). Use of the parameters calculated for this average common cause group was extended to components that have no history of common cause failure, but judged by the analyst to have some potential for common cause failure. The common cause contribution for the following components was calculated using the average MGL values:

- Relays, including contacts and coils
- Switches, including temperature, level, and pressure switches
- Dampers
- Explosive valves
- Solenoid-operated valves
- Diesel-driven pumps
- Strainers and filters
- Stop check valves
- Timing relays

In general, the components included in this list were judged to be less complex than the components in the database and thought to have less potential for common cause failure mechanisms. Therefore, assignment of the average common cause parameters is judged to be realistic.

The same equations discussed in Section 4.4.3 of the original IPE Submittal Report were used to calculate the MGL factors for the Modified Dresden IPE. Table 2-2 shows these revised component-specific MGL factors that were derived from the revised MGL parameters given in Tables 2-1.

TABLE 2-2
MGL FACTORS FOR MODIFIED DRESDEN IPE

COMPONENT TYPE	COMPONENTS IN SYSTEM (m)	NUMBER OF FAILED COMPONENTS (k)		
		2	3	4
PM (See Note 1)	2	1.00E-02		
(SW, LPCI, CCSW, FW, EDG	3	5.00E-03	6.00E-03	
Cooling Water, and Condensate PUMPS)	4	3.33E-03	2.60E-03	4.45E-03
PM (Core Spray PUMPS)	2	5.10E-02		
PM (SLC PUMPS)	2	3.20E-02		
CB	2	5.40E-02		
	3	2.80E-02	5.21E-02	
CV	2	1.00E-02		
	3	5.00E-03	5.80E-03	
	4	3.33E-03	2.40E-03	4.25E-03
DG	2	1.00E-02		
	3	5.00E-03	1.60E-03	
MV	2	1.00E-02		
(MOV)	3	7.00E-03	6.58E-03	
	4	5.67E-03	2.83E-03	5.78E-03
AM	2	1.00E-02		
(SLC RELIEF VALVE)	3	5.00E-03	5.80E-03	
	4	3.67E-03	2.64E-03	4.67E-03
AS	2	1.90E-01		
(SLC RELIEF VALVE)	3	1.05E-01	1.64E-01	
VALVE)	4	8.00E-02	5.68E-02	1.70E-01
AV	2	6.50E-02		
(SRV)	3	4.85E-02	3.40E-02	
	4	3.67E-02	2.42E-02	1.52E-02
RF	2	1.00E-02		
(HVAC CHILLER)	3	5.00E-03	1.30E-03	
FN	2	1.20E-02		
(FAN)	3	6.00E-03	1.20E-02	
	4	4.00E-03	4.00E-03	1.20E-02
ALL	2	1.80E-02		
	3	1.15E-02	1.33E-02	
	4	8.33E-03	6.00E-03	1.06E-02

Notes: 1. Because the analysis provided 3 and 4 pump MGL factors only for the "SW Pump" category, that category was used for systems having more than 2 pumps

MODIFICATION 3 Revised SBO and ATWS Success Criteria

The NRC's Staff Evaluation Report (SER) raised concerns regarding the treatment of specific success criteria. Specifically, pages 2 and 3 of the SER state that:

> *The licensee used realistic analyses to determine the IPE's system success criteria. Based on the licensee's responses to the staff's RAI, the staff concludes that the Dresden IPE success criteria are generally reasonable. The staff, however, believes that more technical basis is needed to support the specific success criteria: pump seal leakage would not impact the capability of the isolation condenser (IC) to cool the reactor during station blackout, HVAC is not required for any other areas except component [sic] cooling service water rooms, and that the operators will be 100 percent successful to inhibit automatic depressurization in response to anticipated transients without scram (action assumed to take place, but not modeled in the IPE).*

In response, these concerns involving reactor recirculation pump seal leakage, HVAC, and operator action to inhibit the automatic depressurization system (ADS) were reviewed. As discussed below, more conservative assumptions were adopted for the Modified Dresden IPE concerning recirculation pump seal leakage and operator action to inhibit ADS.

No changes were adopted in the modeling of HVAC for system success criteria in the Modified Dresden IPE.

> The statement that HVAC is not required for any other areas except containment cooling service water (CCSW) rooms is correct only if taken in the context of the *limited* plant areas listed in RAI question 9 (j). (If this statement were to be interpreted as literally applying to all other areas except CCSW rooms, then the statement would be incorrect and apparently would have resulted from a misinterpretation of comments in the Technical Evaluation Report prepared for the NRC.)

A discussion of the treatment of HVAC is given below in Enclosure 2, "Response to Other Issues Raised by SER." That discussion includes a repetition of information given in the original IPE Submittal Report concerning areas for which the IPE model requires HVAC, information that was not taken into account in the preparation of the SER. The discussion in Enclosure 2 also summarizes the reasons why HVAC is not required for other significant areas.

Reactor Recirculation Pump Seal Leakage

The original IPE model assumed that vessel leakage during a station blackout event, including leakage from recirculation pump seals, would be negligible and that vessel inventory loss would not impact the capability of the isolation condenser (IC) to cool the reactor. The model assumed that the Isolation Condenser would isolate upon discharge of the 125 VDC battery unless operator action was taken to defeat the system isolation. The original model assumed that operators would fail to do this. As discussed in the ComEd response to the NRC RAI on the original IPE, following procedure implementation of this action, a Human Error Probability (HEP) value was used for this action.

The seal module for a reactor recirculation pump includes both an inboard and outboard seal. Normal seal leakage rate is 0.75 gpm per pump. Failure of one of the two seals is expected to increase seal leakage rate to 1.1 gpm per pump. In the event of complete failure of both seals, the leakage rate is expected to be limited by a mechanical breakdown bushing to 60 gpm.

In the event of an SBO event, the reactor recirculation pumps would rapidly coastdown to a stop. Seal heating due to friction would be minimal during the coastdown. The hot coolant in the recirculation pump would, however, lead to gradual seal heatup, and could result in seal leakage as a result of heat damage to elastomers within the seal package. No test data for the Dresden seal module performance during an SBO is available, and the

assumption in the original IPE that seal leakage would be minimal during an SBO apparently was based on judgment.

Because no pertinent test data was identified and because of the concern expressed in the SER, a more conservative assumption on the seal leakage rate was adopted for the Modified Dresden IPE.

> The Dresden SBO coping study performed by ComEd assumed a leakage rate of 18 gpm per pump and conservatively assumed a 25 gpm leakage rate (Technical Specification Limit) for other identified sources. Based on station operating experience, however, the assumed 25 gpm leakage rate for sources other than recirculation pump seals is non-realistic. The typical leakage rate is a few gpm and is often dominated by the design seal leakage rate of 0.75 gpm per recirculation pump.

For the Modified Dresden IPE, therefore, an initial leakage rate of 18 gpm per recirculation pump is assumed, consistent with the assumption in the SBO coping study. The seal leakage rate is also assumed to decrease as the reactor pressure decreases due to cool down. An additional 3 gpm leakage rate due to other sources is also assumed, giving a total initial leakage rate of 39 gpm.

This assumed leakage rate would limit successful operation of the Isolation Condenser if makeup water were not provided to the reactor vessel. Therefore, to account for the response to the assumed leakage rate during an SBO, the SBO1 plant response tree (PRT) sequences were modified to account for seal leakage. The major sources of makeup water specified by Emergency Operating Procedures (EOPs) are:

- HPCI,
- The other unit's CRD system, if available, via the CRD cross-tie, and
- The fire protection system.

The HPCI system would likely be unavailable after discharge of the batteries, and analysis indicates that, even with successful operation of the Isolation Condenser after discharge of the batteries, core damage would occur before reactor vessel pressure could decrease sufficiently to allow injection with the fire protection system. For these reasons, the other unit's CRD system appears to be the only viable source of reactor vessel makeup water during an extended SBO event should the assumed seal leakage occur.

Provided the other unit is not also in an SBO, the other unit's CRD system would likely be available. Dresden Emergency Operating Procedure (DEOP) 0500-03, Alternate Water Injection Systems, directs operators to open the manual crosstie valves for the CRD systems and to verify that a CRD flow rate of 39-58 gpm is provided to the unit requiring vessel makeup water. Based on the seal leakage assumptions given above, this CRD flow rate would permit long-term Isolation Condenser operation.

If vessel makeup water from the opposite unit's CRD system is not available during an SBO, offsite power must be recovered in order to avoid core damage. A review of MAAP SBO runs for the original IPE and a new MAAP SBO run assuming a 39 gpm initial leakage to account for reactor recirculation pump seal degradation concluded that the 6-hour mission time for recovering offsite power remained appropriate for sequences in which the isolation condenser fails at 4 hours (estimated time of battery discharge).

The changes to the SBO PRT to include CRD makeup to permit long-term operation of the Isolation Condenser resulted in several new sequences replacing the existing success sequences given successful Isolation Condenser operation regardless of recovery of offsite power.

NOTE: Tables 4.4.1-3 and 4.4.1-4 of the original IPE Submittal Report included site-specific data for CRD pump failure rates and pump unavailability, although that data had not been used in the quantification of the original

IPE. That data was based on periods of unit operation. The addition of CRD makeup to the SBO PRT, however, required information on availability of the opposite unit's CRD system. The CRD system is very reliable and one or both pumps are normally available except during part of a unit's refueling outage. Therefore, information on CRD system unavailability during recent refueling outages was obtained for use in the Modified Dresden IPE.

In summary, several new sequences resulted from changing success criteria for the Isolation Condenser in response to concerns expressed in the SER. As discussed below in the section "Modification 5, Discussion of the Final, Integrated 'Modified Dresden IPE Model,'" the main impact of these new sequences was to increase the CDF contribution of the dual-unit LOOP initiator.

Operator Action to Inhibit ADS

The assumption in the original IPE that operator action would be 100% successful in inhibiting automatic depressurization was reviewed in response to the concern in the SER. The assumption was found to be conservative for all initiators except ATWS. The ATWS PRT was revised for the Modified Dresden IPE to include a node for this operator action, and appropriate Human Error Probability (HEP) estimates were developed.

As discussed below in the section "Modification 5, Discussion of the Final, Integrated 'Modified Dresden IPE Model,'" the main impact of including operator action to inhibit ADS for ATWS was to increase the CDF contribution of the ATWS initiator.

MODIFICATION 4 Revised Human Error Probabilities and Treatment of Pre-Initiator Events

The NRC's Staff Evaluation Report (SER) raised concerns regarding the treatment of human reliability analysis (HRA). Specifically, pages 4 and 5 of the SER state that:

> *The licensee's human reliability analysis (HRA) focused on actions needed to mitigate an accident (i.e., post-initiator human events). The submittal and the licensee's responses to the staff's RAI did not provide sufficient evidence that human events were adequately and appropriately treated. The staff has several concerns regarding the licensee's HRA:*
>
> a. *The licensee's diagnosis model does not appear to be in agreement with the HRA method/technique utilized (i.e., NUREG/CR-1278). "Diagnosis" in NUREG/CR-1278 includes the actions to "perceive, discriminate, interpret, diagnose" an event and the operators "first-level of decision making." While using symptom-based emergency operating procedures removes the need to identify the type of accident, such as a loss-of-coolant accident, their use does not remove the need for other aspects of diagnosis. It appears, however, that only "detection" was modeled and no basis was provided as to why other diagnostic tasks were excluded. Diagnosis is an important contributor to human error. In the EPRI-sponsored Operator Error Experiment program, 70 percent of the errors and near misses by the operating crew observed in simulator experiments were categorized as errors "in information processing and decision making."*
>
> b. *The licensee's method for addressing the influence of the accident progression on human performance and the dependencies between human actions does not appear to be in agreement with the HRA method/technique utilized (i.e., NUREG/CR-1278). The licensee uses combinations of (the same) three performance shaping factors (PSF) for all human actions for all accident conditions. It was not explained why these three PSF are adequate to account for the specifics of human performance under all accident conditions, nor why a particular PSF combination applies to a particular human action in a particular accident sequence. Also, explicit dependencies between separate human actions on the event trees were not provided, and there is insufficient detail to understand whether these dependencies were appropriately modeled. Therefore, the staff could not evaluate whether the licensee appropriately*

addressed the influences of different accident conditions on human performance.

c. *The licensee's consideration of time does not appear to be in agreement with the HRA method/technique utilized. The licensee appeared to have only considered a "slack time" which the licensee defined as "the amount of time available to the operator over and above that necessary to diagnose and perform the action." The staff has two major concerns:*

- *It is not apparent what the basis was for the calculation of the "slack time"; whether it was based on "real time measures" or on analysts' assumptions.*

- *The calculation of "slack time" does not appear to consider the time needed to perform an action versus the time available to perform the action.*

d. *The licensee's treatment of plant-specific performance shaping factors does not appear to be adequately justified. General conclusions appear to have been assumed regarding such items as training, communications, supervision, and procedures that resulted in reducing the human error probabilities. It is not apparent that plant-specific experience or history (e.g., detailed control room reviews, NRC or INPO training audits, NRC SALP reports or other reviews of plant operating history) was sufficiently considered and, therefore, the human error probabilities appear to be artificially derived.*

e. *The licensee did not provide a discussion in the submittal of human events associated with normal operations that may leave a system in an undetected disabled condition (pre-initiator human events). However, material provided by the licensee in response to the staff's RAI indicates that seven pre-initiator human events were quantified and included in the IPE model. Their quantification was based on the HRA method described in NUREG/CR-1278. Generic human error probabilities were obtained from appropriate NUREG/CR-1278 tables, but were not modified to reflect plant-specific factors and experience. In addition, none of these events are associated with calibration activities. The staff concludes that the IPE's treatment of pre-initiator human events is limited in scope and level of detail. In particular, the staff believes that calibration errors were dismissed from consideration without a rigorous plant-specific assessment. NUREG-1335 (Section 2.1.5) requested licensees to examine "human failures in maintenance and operations" which includes*

equipment calibration. Many IPEs/PRAs have identified restoration and calibration events as important contributing events to core damage.

The concerns (a through e) were reviewed and resulted in changes for the Modified Dresden IPE. These changes are discussed below.

Introduction

A commitment was made to the NRC to revise the Dresden and Quad Cities PRA models. A decision was made to utilize a newer technique to calculate the human error probabilities. The selected technique was the EPRI CBDTM (Cause Based Decision Tree Methodology) from EPRI TR-100259. The determination of the HEPs is very similar to those implemented for the Zion effort as addressed in the Zion Modified IPE submittal and a follow-up submittal of the Zion HRA Notebook. Complete evaluations were performed on only those actions that were deemed to be significant (see the Modified Human Reliability Analysis section below for discussion of the significant actions).

Responses to concerns a through d below, address the Human Reliability Analysis. A review of pre-initiators in response to concern e, also resulted in changes for the Modified Dresden IPE.

Concern a: Diagnosis Model

The HRA portion of the modified PRA was revised to address concerns in both detection and diagnosis. The detection and diagnosis are contained within the EPRI CBDTM (Cause Based Decision Tree Methodology) from EPRI TR-100259 which was utilized to determine the Pc (cognitive) portion of the operator action. The EPRI CBDTM considers such factors as: data availability, attention failure, data misread

and/or miscommunicated, misleading information, missed/misread procedure steps, instruction and/or logic interpretation, and deliberate violation.

Concern b: Influence of Accident Progression of Human Performance

During the revision of the HRA, the operator actions were assessed on a sequence by sequence basis to determine the appropriate HEP (Human Error Probability) considering the plant condition, any dependency on failed operator actions, stress levels and any opportunities for recovery.

Concern c: Consideration of Time

The use of "slack time" recovery has not been utilized in the revised HRA analysis. Only those recovery opportunities that have been specifically identified in the sequence by sequence evaluation of each operator action have been credited. The time consideration during these sequence by sequence evaluations first determined the feasibility of the action, and secondly assessed the feasibility of recovery given an initial error. When the time is limited, the time pressure was also taken into account by increasing the stress factor (addressed within THERP) in the evaluation of the basic HEP.

The times available for the action were determined from MAAP (Modular Accident Analysis Program) runs which established the times for the cues and the time for action completion. The time required for the detection, analysis, diagnosis, decision and action was determined by discussions with operators, operator trainers, observation of simulator runs, and by analyst's judgment.

Concern d: Treatment of Plant-Specific Shaping Factors

A review of the plant operating history and discussions with the plant training and operating personnel did not identify any deficiencies in control room design, procedure format or utilization, or operator training/experience. It was assumed that based upon the detailed control room reviews, NRC and INPO audits of training and various other initiatives, that the control room design, training, experience, etc. were at least nominal. Therefore, the nominal (mean) values for the various EPRI decision trees and THERP tables were utilized in the revised HRA analysis.

Modified Human Reliability Analysis

The modified Human Reliability Analysis modeled the current (December 1995) Dresden procedures. Two procedure changes recommended during the initial Dresden IPE have been implemented and are reflected in the revised model. The recommended procedure changes that have been implemented are:

1. During a Station Blackout, open the breakers to the Isolation Condenser isolation valves to avoid spurious closure on decreasing battery voltage; and

2. Following the loss of Suppression Pool Cooling, align one or more of the low pressure injection pumps to the Condensate Storage Tank.

Not all cases or all operator actions were re-evaluated. Only those actions which had a Risk Achievement Worth of greater than 2.5 and those actions which were added as a result of changes to the Plant Response Trees and Fault Trees (as noted above), received a complete evaluation utilizing the EPRI CBDTM technique. The remaining HEPs (with RAWs less than 2.5) were reviewed for reasonableness, including consideration of dependencies and stress factors.

The EPRI CBDTM technique provided values for one operator action, OSPC (Operator action to initiate suppression pool cooling), which appeared overly conservative. The action contains two pump starts and three valve manipulations. However, these actions are practiced during simulator exercises and multiple times during the year to keep the suppression pool cooled. Also, this action is directed to be performed early in the events (5-10 minutes), but the need does not arise until much later (5-24 hours) into the event. There are multiple indications and alarms on suppression temperature and containment pressure so there are multiple opportunities to recover the action. The CBDTM technique does not adequately treat actions which can be delayed for hours and have multiple recovery opportunities. After reviewing similar actions from other IPEs and discussions with the operators and instructors, a value of 1.0E-5 was assumed for all initiating events except for ATWS, SBO and Loss of DC. For these three initiators a value of 1.0E-4 was assumed to properly reflect the added stress and the possible shortened response times.

All of the HEPs after the re-evaluation have values above 1.0E-4, except for OSPC as discussed above. As can be seen in the summary of the HEP evaluations (Tables 4-1 and 4-2 below), some of the actions changed significantly, some increasing and some decreasing. Except for OSPC, none of the HEPs changed by more than a factor of six. Table 4-1 lists the Dresden Fault Tree HRA Results and Table 4-2 lists the Dresden Plant Response Tree HRA Results. Listed for each operator action are the node case-name, the description, the Risk Achievement Worth, the original HEP value, the revised HEP value and the percent difference in the HEP. (Note: after each set of operator action cases there is a summary line that gives the combined Risk Achievement Worth for all the cases.)

No new vulnerabilities were identified during the Human Reliability Analysis.

Table 4-1
DRESDEN FAULT TREE HRA RESULTS

NAME	DESCRIPTION	RAW	Orig. HEP	Rev. HEP	%CHG
2ACBS23-1-23-H--	Operator Fails to Energize Bus 23 From 23-1	2.796	4.6E-3	1.2E-3	-74%
2ACBS24-1-24-H--	Operator Fails to Energize Bus 24 From 24-1	13.130	4.6E-3	1.2E-3	-74%
2ACBS28-29---H--	Operator Fails to Energize Bus 28 From 29	1.172	7.9E-3		
2ACBS29------H--	Operator Fails to Energize Bus 29 From 28	1.006	7.9E-3		
2ACCB2527----H--	Operator Fails to Energize Bus 25 From 27		1.6E-3		
2ATAD22A-----H--	Master Trip Unit Not Restored After Test/Maintenance	2.330	3.7E-3		
2ATAD22B-----H--	Master Trip Unit Not Restored After Test/Maintenance	2.330	3.7E-3		
2ATAD22C-----H--	Master Trip Unit Not Restored After Test/Maintenance	2.330	3.7E-3		
2ATAD22D-----H--	Master Trip Unit Not Restored After Test/Maintenance	2.330	3.7E-3		
2CASB2330-322H--	Operator Fails to Manually Initiate High Pressure Coolant Injection After Failure to Automatically Initiate	1.000	1.0E+0		
2CSMV140225A-H--	Operator Fails to Initiate Core Spray Manually Following Failure of Automatic Initiation	1.000	1.0E+0		
2FWPM3201----H--	Operator Fails to Restart Feedwater Pump Following High Level Trip	6.977	2.5E-3	1.4E-3	-46%
2FWPMA-3201--H--	Operator Fails to Start Standby Feedwater Pump if Not Auto Started		1.6E-3	NONE	
2FWRV--------H--	Operator Fails to Prevent Feedpump Trip on High Reactor Water Level	1.000	1.0E+0		
2HISY--------H--	Operator Fails to Perform Actions for Manually Controlling High Pressure Coolant Injection in Accordance with DOP 2300-3	4.022	2.4E-3	1.3E-3	-44%
2ICMV4399-74-H--	Operator Fails to Locally Open MOV 4399 After Being Unable to Open the Valve From the Control Room		1.0E+0		
2LIMV-22A-22BH--	Operator Fails to Open Low Pressure Coolant Injection Valves	1.000	3.6E-4		
2TBPM2B3801--H--	Operator Fails to Start TBCCW Pump After the Running Pump has Failed Due to Random Fault or Loss of Support Power (Transient)	1.001	1.6E-3		
3DCBS1253A---H-- CS1	Operator Initiates Loss of Unit 3 125VDC Bus Following Loss of Unit 2 125VDC Bus		9.8E-3		
3DCBS1253A---H-- CS2	Operator Initiates Loss of Unit 3 125VDC Bus Following Loss of Unit 2 125VDC Bus		1.2E-2		
3DCBS1253A---H-- CS3	Operator Initiates Loss of Unit 3 125VDC Bus Following Loss of Unit 2 125VDC Bus		3.3E-3		
3DCBS1253A---H-- CS4	Operator Initiates Loss of Unit 3 125VDC Bus Following Loss of Unit 2 125VDC Bus		1.6E-2		
BFPPD1-G-112AH--	Failure to Restore Unit 1 Diesel Fire Pump Following Test or Maintenance	1.000	1.0E-2		
BFPPD2/3-4101H--	Failure to Restore Unit 2/3 Diesel Fire Pump Following Test or Maintenance	1.000	1.4E-2		
BSWFL3902----H--	Operator Fails to Switch Service Water Strainers Daily		5.3E-3		

Table 4-2
DRESDEN PLANT RESPONSE TREE HRA RESULTS

NAME	DESCRIPTION	RAW	Orig. HEP	Rev. HEP	%CHG
OAD-CS01	Initiate Automatic Depressurization (Transient, SLOCA, SBO, LOOP, 125VDC) - [Opt-stress, Zero-depend, Yes-recov]	23.142	1.0E-3	1.3E-3	30%
OAD-CS02	Initiate Automatic Depressurization (Transient) - [Mod-stress, Zero-depend, Yes-recov]	2.491	2.1E-3	1.6E-3	-24%
OAD-CS03	Initiate Automatic Depressurization (Transient, MLOCA, SLOCA, ISLOCA, IORV, SBO, LOOP, ATWS) - [Mod-stress, Zero-depend, No-recov]	21.338	9.8E-3	1.6E-2	63%
OAD-CS04	Initiate Automatic Depressurization (SBO) - [Opt-stress, Low-depend, Yes-recov]	1.180	1.1E-2	5.1E-2	366%
OAD-CS05	Initiate Automatic Depressurization (SBO) - [Mod-stress, Low-depend, No-recov]	1.005	5.9E-2	6.5E-2	11%
OAD-CS06	Initiate Automatic Depressurization (SBO) - [High-stress, Zero-depend, No-recov]	1.001	2.5E-2	1.6E-2	-36%
OAD-CS07	Initiate Automatic Depressurization (125VDC) - [Opt-stress, Zero-depend, No-recov]	7.171	4.9E-3	1.3E-2	165%
OAD-CS08	Initiate Automatic Depressurization (LOOP) - [Mod-stress, Low-depend, Yes-recov]	9.195	1.2E-2	5.2E-2	329%
OAD-CS09	Initiate Automatic Depressurization (LOOP) - [Opt-stress, zero-depend, Yes-recov]	14.394	1.0E-3	1.3E-3	30%
OAD-CS10	Initiate Automatic Depressurization (SBO) - [High-stress, Low-depend, No-recov]	NEW	NEW	6.5E-2	
OAD-SUM	Initiate Automatic Depressurization	72.916			
OAL-CS01	Reduce and Control Reactor Pressure Vessel Water Level (ATWS) - [Opt-stress, Zero-depend, No-recov]	1.007	4.4E-2		
OAL-CS02	Reduce and Control Reactor Pressure Vessel Water Level (ATWS) - [Opt-stress, Low-depend, No-recov]	1.019	9.2E-2		
OAL-SUM	Reduce and Control Reactor Pressure Vessel Water Level (ATWS)	1.026			
OAT-CS01	Manually Initiate Alternate Rod Insertion (ATWS) - [High-stress, Zero-depend, No-recov]	1.225	6.0E-3		
OAT-CS02	Manually Initiate Alternate Rod Insertion (ATWS) - [High-stress, Mod-depend, No-recov]	1.047	1.5E-1		
OAT-SUM	Manually Initiate Alternate Rod Insertion (ATWS)	1.272			
OCN-CS01	Initiate Containment Spray (Transient, LLOCA, MLOCA, SLOCA, IORV, SBO, LOOP, ATWS) - [High-stress, Zero-depend, Yes-recov]	1.017	3.6E-2		

Table 4-2
DRESDEN PLANT RESPONSE TREE HRA RESULTS

NAME	DESCRIPTION	RAW	Orig. HEP	Rev. HEP	%CHG
OCN-CS02	Initiate Containment Spray (MLOCA, SLOCA, ATWS) - [Opt-stress, Zero-depend, Yes-recov]	1.000	6.9E-3		
OCN-CS03	Initiate Containment Spray (125VDC) - [High-stress, Zero-depend, Yes-recov]		4.0E-2		
OCN-SUM	Initiate Containment Spray	1.018			
OCRD-CS01	Crossties Control Rod Drive flow from the other Unit for makeup (SBO, LOOP) - [Mod-stress, Zero-depend, Yes-recov]	NEW	NEW	1.4E-3	
OCRD-SUM	Crossties Control Rod Drive flow from the other Unit for makeup	NEW	NEW		
OCST-CS02	Align Low Pressure Pump Suction to the Condensate Storage Tank - [Opt-stress, Zero-depend, Yes-recov]	NEW	NEW	1.4E-3	
OCST-CS09	Align Low Pressure Pump Suction to the Condensate Storage Tank - [Mod-stress, Zero-depend, No-recov]	NEW	NEW	1.5E-2	
OCST-CS10	Align Low Pressure Pump Suction to the Condensate Storage Tank - [Mod-stress, Zero-depend, Yes-recov]	NEW	NEW	1.5E-3	
OCST-CS12	Align Low Pressure Pump Suction to the Condensate Storage Tank - [Mod-stress, Low-depend, Yes-recov]	NEW	NEW	5.1E-2	
OCST-CS18	Align Low Pressure Pump Suction to the Condensate Storage Tank - [High-stress, Zero-depend, Yes-recov]	NEW	NEW	1.9E-3	
OCST-CS20	Align Low Pressure Pump Suction to the Condensate Storage Tank - [High-stress, Low-depend, Yes-recov]	NEW	NEW	5.2E-2	
OCST-CS25	Align Low Pressure Pump Suction to the Condensate Storage Tank	NEW	NEW	1.0E+0	
OCST-SUM	Align Low Pressure Pump Suction to the Condensate Storage Tank	NEW	NEW		
OFP-CS01	Align Fire Protection to Feedwater (ISLOCA, SBO) - [Mod-stress, Zero-depend, Yes-recov]	1.001	4.4E-2		
OFP-CS02	Align Fire Protection to Feedwater (ISLOCA) - [High-stress, High-depend, Yes-recov]	1.000	1.6E-1		
OFP-CS03	Align Fire Protection to Feedwater (SBO) - [High-stress, Zero-depend, No-recov]	1.000	5.4E-1		
OFP-SUM	Align Fire Protection to Feedwater	1.001			
OFW-CS01	Restore Feedwater Injection (ISLOCA) - [Mod-stress, Zero-depend, Yes-recov]	1.007	5.3E-3		
OFW-CS02	Restore Feedwater Injection (ISLOCA) - [High-stress, Zero-depend, No-recov]		1.1E-1		
OFW-CS03	Restore Feedwater Injection (ISLOCA) - [High-stress, Low-depend, No-recov]	1.000	1.5E-1		
OFW-CS04	Restore Feedwater Injection (SBO, LOOP) - [Opt-stress, Zero-depend, Yes-recov]	1.000	1.0E+0		
OFW-CS05	Restore Feedwater Injection (SBO) - [Mod-stress, Zero-depend, Yes-recov]	1.000	1.0E+0		

Table 4-2
DRESDEN PLANT RESPONSE TREE HRA RESULTS

NAME	DESCRIPTION	RAW	Orig. HEP	Rev. HEP	%CHG
OFW-SUM	Restore Feedwater Injection	1.007			
OHX-CS01	Start Containment Cooling Service Water Pump & Close Low Pressure Coolant Injection Heat Exchanger Bypass Valve (LLOCA, MLOCA, SLOCA) - [Opt-stress, Zero-depend, No-recov]	1.862	8.8E-3		
OHX-CS02	Start Containment Cooling Service Water Pump & Close Low Pressure Coolant Injection Heat Exchanger Bypass Valve (MLOCA, SLOCA) - [Opt-stress, Zero-depend, Yes-recov]		1.8E-3		
OHX-CS03	Start Containment Cooling Service Water Pump & Close Low Pressure Coolant Injection Heat Exchanger Bypass Valve (MLOCA, SLOCA) - [Mod-stress, Zero-depend, No-recov]		1.8E-2		
OHX-CS04	Start Containment Cooling Service Water Pump & Close Low Pressure Coolant Injection Heat Exchanger Bypass Valve (MLOCA, SLOCA) - [High-stress, Zero-depend, Yes-recov]	1.158	9.2E-3		
OHX-SUM	Start Containment Cooling Service Water Pump & Close Low Pressure Coolant Injection Heat Exchanger Bypass Valve	2.021			
OI2-CS09	Open Isolation Condenser Valve Breakers (SBO) - [Mod-stress, Zero-depend, No-recov]		1.5E-1		
OI2-CS10	Open Isolation Condenser Valve Breakers (SBO) - [Mod-stress, Zero-depend, Yes-recov]	1.345	3.2E-2		
OI2-SUM	Open Isolation Condenser Valve Breakers	1.345			
OIADS-CS01	Inhibit Automatic Depressurization (ATWS) - [Mod-stress, Zero-depend, No-recov]	NEW	NEW	3.0E-3	
OIADS-SUM	Inhibit Automatic Depressurization	NEW	NEW		
OIC-CS01	Initiate Isolation Condenser		1.0E+0		
OIC-CS02	Initiate Isolation Condenser (SBO, LOOP) - [Opt-stress, Zero-depend, No-recov]	1.542	3.7E-2		
OIC-SUM	Initiate Isolation Condenser	1.542			
OIS-CS01	Isolate Low Pressure Coolant Injection Cross-tie Valves (ISLOCA) - [Mod-stress, Zero-depend, No-recov]	1.000	1.0E+0		
OIS-CS02	I Isolate Low Pressure Coolant Injection Cross-tie Valves (ISLOCA) - [Mod-stress, High-depend, No-recov]		1.0E+0		
OIS-SUM	Isolate Low Pressure Coolant Injection Cross-tie Valves	1.000			
OMU-CS01	Initiate Makeup to the Isolation Condenser (Transient, ATWS, LOOP) - [Opt-stress, Zero-depend, No-recov]	18.766	7.9E-3	1.3E-3	-83%

Table 4-2
DRESDEN PLANT RESPONSE TREE HRA RESULTS

NAME	DESCRIPTION	RAW	Orig. HEP	Rev. HEP	%CHG
OMU-CS02	Initiate Makeup to the Isolation Condenser (SBO) - Mod-stress, Zero-depend, No-recov]		1.0E-2	1.4E-2	40%
OMU-SUM	Initiate Makeup to the Isolation Condenser	18.766			
ORP-CS01	Trip Recirculation Pumps (ATWS) - [High-stress, Zero-depend, No-recov]	1.634	5.1E-2		
ORP-SUM	Trip Recirculation Pumps	1.634			
OSB-CS01	Initiate Standby Coolant Supply System (LLOCA) - [Mod-stress, Low-depend, Yes-recov]	1.318	1.7E-2		
OSB-CS02	Initiate Standby Coolant Supply System (LLOCA) - [High-stress, Low-depend, Yes-recov]	1.001	3.8E-2		
OSB-CS03	Initiate Standby Coolant Supply System		5.1E-2		
OSB-CS04	Initiate Standby Coolant Supply System (ISLOCA) - [High-stress, Zero-depend, No-recov]	1.000	3.2E-2		
OSB-SUM	Initiate Standby Coolant Supply System	1.319			
OSL1-CS01	Initiate one Standby Liquid Control Pump (ATWS) - [Opt-stress, Zero-depend, No-recov]	1.562	8.7E-3		
OSL1-CS02	Initiate one Standby Liquid Control Pump (ATWS) - [High-stress, Zero-depend, No-recov]	1.570	4.5E-2		
OSL1-SUM	Initiate one Standby Liquid Control Pump	2.132			
OSL2-CS01	Initiate two Standby Liquid Control Pumps (ATWS) - [Mod-stress, High-depend, Yes-recov]	1.235	1.1E-1		
OSL2-SUM	Initiate two Standby Liquid Control Pumps	1.235			
OSP-CS01	Initiate Suppression Pool Cooling (Transient, SLOCA, SBO, LOOP) - [Opt-stress, Zero-depend, Yes-recov]	20.385	1.6E-4	NONE	
OSP-CS02	Initiate Suppression Pool Cooling (Transient, SBO, LOOP) - [Mod-stress, Zero-depend, Yes-recov]		4.4E-4	NONE	
OSP-CS03	Initiate Suppression Pool Cooling (Transient, SLOCA, IORV, LOOP, 125VDC, ATWS) - [High-stress, Mod-depend, Yes-recov]	1.222	3.5E-2	NONE	
OSP-CS04	Initiate Suppression Pool Cooling (Transient, LLOCA, IORV, SBO, LOOP, ATWS) - [Mod-stress, Zero-depend, No-recov]	9.788	2.1E-3	1.0E-4	-95%
OSP-CS05	Initiate Suppression Pool Cooling (MLOCA, SBO, LOOP) - [High-stress, Zero-depend, No-recov]	1.041	7.5E-3	NONE	
OSP-CS06	Initiate Suppression Pool Cooling (LLOCA) - [Opt-stress, High-depend, No-recov]	1.008	5.0E-1	NONE	

Table 4-2
DRESDEN PLANT RESPONSE TREE HRA RESULTS

NAME	DESCRIPTION	RAW	Orig. HEP	Rev. HEP	%CHG
OSP-CS07	Initiate Suppression Pool Cooling (Transient, MLOCA, IORV, LLOCA, ATWS) - [Opt-stress, Zero-depend, No-recov]	197.000	6.6E-4	1.0E-5	-98%
OSP-CS08	Initiate Suppression Pool Cooling (SLOCA) - [Opt-stress, High-depend, Yes-recov]		1.1E-1	NONE	
OSP-CS09	Initiate Suppression Pool Cooling (SLOCA, SBO) - [High-stress, Zero-depend, Yes-recov]	1.010	1.6E-3	NONE	
OSP-CS10	Initiate Suppression Pool Cooling (SBO) - [Mod-stress, Mod-depend, Yes-recov]	1.002	1.1E-2	NONE	
OSP-CS11	Initiate Suppression Pool Cooling (MLOCA, SBO) - [High-stress, Mod-depend, No-recov]	1.001	1.5E-1	NONE	
OSP-CS12	Initiate Suppression Pool Cooling (125VDC, SBO) - [Mod-stress, Zero-depend, Yes-recov]		1.9E-3	NONE	
OSP-CS13	Initiate Suppression Pool Cooling (125VDC, SBO) - [High-stress, Zero-depend, Yes-recov]		5.3E-3	NONE	
OSP-CSX1	Initiate Suppression Pool Cooling (LLOCA) (conditional calculation OSP-CS07/OHX-CS1)	NEW	NEW	1.1E-03	
OSP-CSX4	Initiate Suppression Pool Cooling (MLOCA) (conditional calculation OSP-CS07/OHX-CS4)	NEW	NEW	1.1E-03	
OSP-SUM	Initiate Suppression Pool Cooling	225.457			
OSS-CS01	Restore Support Systems to Feedwater(SBO, LOOP) - [Opt-stress, Zero-depend, Yes-recov]		2.3E-3		
OSS-CS02	Restore Support Systems to Feedwater(SBO) - [Mod-stress, Zero-depend, Yes-recov]		6.1E-3		
OSS-CS03	Restore Support Systems to Feedwater(SBO) - [Mod-stress, Low-depend, Yes-recov]		1.6E-2		
OSS-CS04	Restore Support Systems to Feedwater(SBO) - [Mod-stress, Zero-depend, No-recov]		2.9E-2		
OSS-CS05	Restore Support Systems to Feedwater		1.1E-1		
OSS-SUM	Restore Support Systems to Feedwater	1.000			
OVR-CS01	Vent the Reactor Pressure Vessel (LLOCA, during containment flooding) - [Mod-stress, Zero-depend, Yes-recov]		1.0E+0		
OVR-CS02	Vent the Reactor Pressure Vessel (LLOCA, during containment flooding) - [High-stress, Zero-depend, Yes-recov]	1.000	1.0E+0		
OVR-SUM	Vent the Reactor Pressure Vessel (LLOCA, during containment flooding)	1.000			

Table 4-2
DRESDEN PLANT RESPONSE TREE HRA RESULTS

NAME	DESCRIPTION	RAW	Orig. HEP	Rev. HEP	%CHG
OVT-CS01	Initiate Containment Vent (Transient, MLOCA, SLOCA, IORV, SBO, LOOP, 125VDC, ATWS) - [Opt-stress, Zero-depend, Yes-recov]	1.300	2.5E-4		
OVT-CS02	Initiate Containment Vent (Transient, LLOCA, IORV, SBO, LOOP, 125VDC, ATWS) - [Mod-stress, Zero-depend, Yes-recov]	1.096	5.0E-4		
OVT-CS03	Initiate Containment Vent (Transient, LLOCA, MLOCA, SLOCA, IORV, SBO, LOOP, 125VDC, ATWS) - [Hi-stress, Zero-depend, Yes-recov]	1.001	1.3E-3		
OVT-SUM	Initiate Containment Vent	1.396			

(Note: after each set of operator action cases there is a summary line that gives the combined Risk Achievement Worth for all the cases.)

Concern e: Treatment of Equipment Calibration Errors

Summary of ComEd Response to Concern

The SER is correct in stating that the original IPE included seven pre-initiator basic events for which human error probability (HEP) estimates were used.

The conclusion that "calibration errors were dismissed from consideration," however, is incorrect. ComEd regrets this misunderstanding; the apparent cause of this misunderstanding is discussed later in this section. A review of the SER concern with calibration errors found that:

- The original IPE included numerous basic events for single instruments and common-cause failure of multiple instruments;

- Generic instrument failure rates listed in the original IPE submittal report (not HEPs) had been used in the fault tree quantification and (based on basic event descriptions used in fault trees) the generic failure rates had been considered to apply to out-of-calibration and other failures; and

- The mission times used for some instruments were found to have been non-conservative.

More detail on these findings during the review of the SER concern is given below. Consequently, failure probability changes for pertinent instrument basic events were adopted for the Modified Dresden IPE; these changes reflect results of a plant-specific review of calibration events over an approximate five-year period (1991 - 1995). (i.e., actual performance of plant personnel for thousands of recent calibrations was considered rather than estimating HEPs using HRA methods.)

The changes in single and common cause instrument failure probabilities resulted in significant changes in the quantification of some fault trees. Nevertheless, the impact of these changes on total CDF was small. As discussed in more detail in the section "Modification 5, Discussion of the Final, Integrated 'Modified Dresden IPE Model,'" the main impact of changes made in response to the instrument miscalibration concern was an increase in the CDF contribution of the General Transient initiator.

Background Information on SER Concern

As indicated in the SER, information on seven pre-initiator human events was provided in the ComEd response to the RAI (specifically, RAI question 41). The RAI question cited information in the original IPE Submittal Report "which indicates that some pre-initiator human error analysis was performed," and requested additional information.

For this reason, the information request in RAI question 41 (and in the related question 18 in the Quad Cities RAI) had been interpreted as dealing with details **on the use of HRA** in the ComEd IPEs. Consequently, the ComEd response had dealt only with those pre-initiator basic events included in fault trees for which HEPs were used. Most of those events involved failing to restore a system following testing.

> NOTE: In discussing the seven pre-initiator events for which HEPs were used, the SER stated: "none of these events are associated with calibration activities." In fact, four of the seven events were failure to restore ATWS MTUs following calibration testing. The HEPs applied to failure to restore the MTUs, however, not miscalibration.

Instrument basic events in fault trees for which HEPs were **not** used had been considered to be outside the scope of the RAI question due to the question's apparent concern with "human error analysis." ComEd regrets this misunderstanding.

Fault trees involving the Common Actuation, High Pressure Coolant Injection (HPCI), Low Pressure Coolant Injection (LPCI), Containment Cooling Service Water (CCSW), Isolation Condenser, and Anticipated Transient Without Scram (ATWS) systems include over 50 basic events for single instruments and over 30 basic events for common cause instrument failure. Instruments modeled can be categorized as follows:

- Pressure (including flow switches)
- Level
- Temperature
- Time Delay

For example, the HPCI fault tree (developed for the original IPE) includes the following instruments that could potentially give a false system isolation signal and thus cause a system failure:

- Reactor Pressure
- HPCI Steam Line Flow
- HPCI Area Temperature

Failure (i.e., a spurious trip at low flows) of either of the two HPCI High Steam Line Flow master trip units (MTUs) would cause system failure. An example of a basic event description shown on the fault tree is "MTU 2391-03 OUT OF CALIBRATION."

Similarly, 16 basic events for HPCI area temperature switches are shown on the fault tree. An example of a basic event description shown on the fault tree is "TS 2371C

OUT OF CALIBRATION." Because of the trip logic employed, specific combinations of two temperature switches are required to give a system isolation; therefore, the fault tree modeling of the temperature switches includes both AND and OR gates. The fault tree also includes 16 common cause basic events for temperature switches, (i.e., common cause failure of each combination of two temperature switches that could give a system isolation). An example of a common cause basic event description shown on the fault tree is "COMMON CAUSE FAILURE OF TS 2371C AND 2373C."

These HPCI high flow and temperature instruments are examples of instruments where an out-of-calibration instrument, whether due to miscalibration or instrument drift, could go undetected until the next calibration surveillance and thus represent a pre-initiator event.

The failure probabilities used for these and similar basic events for instruments were based on generic failure rates. For single instruments, values used were given in Table 4.4.1-6, Dresden Generic Failure Data, of the original IPE Submittal Report. The common cause failure rates for instruments were given in Table 4.4.1-5, Common Cause Failure Data for Dresden IPE, of the original IPE Submittal Report.

In summary, although the ComEd RAI response did not address pre-initiator events for which generic failure rates rather than HEPs were used, many such instruments were, in fact, included in the fault trees developed for the original IPE. Nevertheless, in response to the concern in the SER on this issue, a plant-specific assessment of the suitability of using generic failure rates was performed and is discussed below.

Plant-Specific Assessment of Use of Generic Failure Rates for Instruments

The fault tree quantification for the original IPE was reviewed with respect to treatment of instruments where miscalibration was judged to represent a pre-initiator concern.

In theory, the failure probability for components has a complex time dependence. The approach used in the original IPE for major items such as ECCS pumps and the Emergency Diesel Generators was to collect site-specific failure to start (probability per demand) and failure to run (probability per hour) data. This approach is reflected in the information given in Table 4.4.1-3, "Dresden-Specific Component Failure Rates," of the original IPE Submittal Report.

For many highly reliable items such as instruments, however, the approach used in the original IPE was to adopt generic failure rate data (probability per hour) and to combine these data with a mission time.

The original IPE quantification was found to have used **system** mission times for instruments to determine failure probabilities based on generic failure rates. Use of system mission times (24 hours or less) is inappropriate for "standby" instruments where miscalibration could not be detected until the next calibration surveillance. For such instruments, therefore, **mission times for the Modified Dresden IPE were increased to one-half the instrument surveillance interval.**

In response to the SER concern with pre-initiator treatment, a plant-specific review of Dresden Licensee Event Reports (LERs), Deviation Reports (DVRs), and Problem Investigation Reports (PIRs) was performed using a computer database that included the approximate period of 1991 - 1995.

The review identified no failure to restore events that warrant addition to the Modified Dresden IPE as a pre-initiator.

For the instrument types discussed above (which were included in fault trees for the original IPE and for which miscalibration is a pre-initiator concern), the review covering the approximate period of 1991 - 1995 identified one event that could have caused a miscalibration failure with respect to the IPE model. That event, involving a LPCI pressure instrument miscalibration, was due to a procedural deficiency.

Other events involving instruments occurred during that period, but the review concluded that those events were not pertinent to the pre-initiator concern. Examples included:

Misadjustment of HPCI speed controls during an outage.

This is not pertinent because it was found during startup testing and, had it occurred during on-line maintenance, would have been found during post-maintenance testing.

Non-conservative Second Level Undervoltage Relay Setpoints

Several events occurred due to management or design deficiencies, but further consideration for the Modified Dresden IPE was not warranted due to corrective actions taken and due to the very low fraction of time that the ComEd grid voltages are low enough to cause a concern.

Feed Breaker Trip Settings for MCC Feed Breakers

The LER on an MCC feed breaker trip indicated that it would only be a concern during a time of very low ComEd grid voltages. For this reason and due to the corrective actions taken, further consideration for the Modified Dresden IPE was not warranted.

Non-conservative Radiation Monitor Setpoints

Non-conservative setpoints (re-calculated every surveillance based on background radiation levels) resulted from a technician error. The error was identified during a review of the surveillance, but after the main steam line radiation monitor setpoints had been changed. This was a significant event, but was not judged pertinent to the Modified Dresden IPE because the radiation monitors are not included in the IPE model and because of the corrective actions taken in response to this event.

Other examples included events where a time delay relay or temperature switches failed to meet tolerances, but, with respect to the IPE model, the deviation from the allowed tolerance band was not judged significant.

Further plant-specific analysis was carried out by dividing the instruments into three categories:

- Temperature
- Time Delay
- Pressure (including level and flow instruments)

To estimate plant-specific miscalibration rates pertinent to the Modified Dresden IPE, 0.5 failures each were assumed for the Temperature and Time Delay categories (as a Bayesian estimate). One (1) failure, the LPCI pressure instrument miscalibration, was used for the Pressure category. These failure numbers divided by the estimated number of surveillances during the approximately 5 year period gives the following site-specific estimates for miscalibration probability due to human error:

Instrument Category	**Failures**	**Failure Probability (due to human error)**
Time Delay	0.5	1.9 E-3/demand
Temperature	0.5	2.6 E-3/demand
Pressure (including level and flow)	1	3.4 E-4/demand

Note that: (1) additional instruments (in balance of plant systems, for example) are not included in the estimated number of surveillances (based on instruments reviewed for the original IPE); and (2) the database searched for failures includes events involving other systems, including balance of plant systems. Therefore, these site-specific failure probability estimates are judged to be conservative.

Except for pressure (and flow) instruments, the increased instrument mission times adopted for the Modified Dresden IPE multiplied by the appropriate generic failure rates were found to give instrument failure probabilities that are comparable to or greater than the demand failure probability estimates given above for human error events.

Therefore, the plant-specific assessment for time delay, temperature, and level instruments concluded that the use of generic time-dependent failure

rates and instrument-specific mission times in the Modified Dresden IPE is appropriate for modeling all types of failures of these instruments, including failures due to human error such as miscalibration.

For pressure and flow instruments, however, the increased instrument mission times multiplied by the appropriate generic failure rates were found to give instrument failure probabilities that are less than the demand failure probability estimates given above for human error events. Although that failure probability is only 3.4 E-4/demand due to the thousands of pertinent surveillances estimated for a five-year period, the applicable generic failure rates are small and the mission times are relatively short. (The pertinent calibration intervals identified for the original IPE were 30 or 90 days.)

Therefore, the assessment for pressure and flow instruments concluded that a plant-specific failure probability of 3.4 E-4/demand was warranted for the Modified Dresden IPE. The assessment also concluded that this demand failure probability was appropriate for modeling all types of failures of these instruments, including failures due to human error such as miscalibration.

In summary, the plant-specific assessment of the miscalibration issue resulted in the following changes for the Modified Dresden IPE:

- Increased mission times for pertinent time delay, temperature, and level instruments; and

- Use of a plant-specific failure probability estimate for pertinent pressure and flow instruments (an estimate based on actual operating experience rather than on HEP calculations).

As discussed below in the section "Modification 5, Discussion of the Final, Integrated 'Modified Dresden IPE Model,'" the main impact of these changes appears to have been an increase in the CDF contribution of the General Transient initiator. Although these changes had a significant impact on the quantification of some fault trees, the overall impact on other initiators and on total CDF appears to be small.

MODIFICATION 5: Discussion of the Final, Integrated "Modified Dresden IPE Model"

ComEd combined the modifications described in the previous sections in a final, integrated "Modified Dresden IPE Model."

These modifications included:

- Addition of several support system based initiators;
- Revision of success criteria for single unit loss of offsite power (LOOP), dual unit loss of offsite power (DLOOP), and anticipated transient without scram (ATWS) initiators;
- Revision of common cause factors (CCFs); and
- Revision of Human Reliability Analysis (HRA).

Additionally, three other significant changes to the original IPE model were included in the final integrated model to provide as realistic a representation as possible of the current Dresden severe accident risk profile:

- Revision of initiating event frequencies for the loss of 125 VDC and single unit LOOP initiators;
- Improved procedures (as recommended by the original IPE evaluations) for continued use of the Isolation Condenser following discharge of station batteries and for continued use of the low pressure Emergency Core Cooling System (ECCS) pumps despite loss of suppression pool cooling; and

- Revisions, including mission time changes, for standby instruments that reflect a plant-specific assessment of pre-initiator concerns involving instrument calibration.

As documented in the revised pages to the Dresden IPE Submittal Report given in Enclosure 3, the Modified IPE results show a core damage frequency (CDF) of 3.4 E-06/yr for Unit 2 and 5.0 E-06/yr for Unit 3. The Modified Dresden IPE results represent the integration of the changes listed above.

Table 5-1 (attached) summarizes the modifications and other significant changes that resulted in these CDF values for the Dresden units. Tables were given in the October 1994 ComEd response to the NRC RAI showing the changes, by initiator, that resulted from changing the original IPE model to the "Enhanced Model" for both units. Similarly, Tables 5-2 and 5-3 (attached) show the changes, by initiator, resulting from the modifications made to the model subsequent to the October 1994 RAI response. Tables 5-4a and 5-4b provide the CDF contribution by initiating event and Table 5-5 provides a listing of the Top 100 sequences. The following discussion provides some insight into the contribution of each of these changes, including competing effects, on the final, integrated model.

Modifications for the Dresden "Enhanced Model"
(Results submitted to NRC in October 1994 in the ComEd Response to the RAI)

<u>Addition of Water Spray Contribution to Loss of 125 VDC Initiator</u>

Addition of water spray gave an initiating event frequency for this LDC initiator that was 1.79 times higher for Unit 3 than for Unit 2.

Improved Procedures Recommended by the Original IPE Evaluations

One procedure improvement allowed for continued use of the Isolation Condenser following discharge of station batteries. In the original IPE model, battery discharge was assumed to result in failure of the Isolation Condenser due to system isolation.

The other procedure improvement allowed for continued use of the low pressure ECCS pumps despite loss of suppression pool cooling. In the original IPE model, these pumps are assumed to fail eventually following loss of suppression pool cooling. The suppression pool is the normal suction source for these pumps, and the original IPE model assumed that loss of suppression pool cooling would lead to containment failure and loss of Net Positive Suction Head (NPSH) for the pumps. The revised procedure allows swapping the pump suction source to the Condensate Storage Tank. Consequently, loss of suppression pool cooling is still assumed to lead to containment failure, but core damage can be prevented by continued use of the low pressure ECCS pumps.

Subsequent Modifications and Other Significant Changes

Addition of Several Support System Based Initiators

New initiators added to the model are: Loss of Service Water (LOSW), Loss of Instrument Air (LOIA), Loss of 4 kV Bus 21/31 (LB21/LB31), Loss of 4 kV Bus 22/32 (LB22/LB32), Loss of 4 kV Bus 23/33 (LB23/LB33), Loss of 4 kV Bus 24/34 (LB24/LB34), Loss of 480 VAC Bus 28/38 (LB28/LB38), and Loss of Motor Control Center (MCC) 28-2/38-2 (LB282/LB382).

The Loss of Service Water initiator contributes approximately 1% of the total CDF. The contribution of the other new special initiators is insignificant. As discussed in the earlier section, "Modification 1, Additional Support System Based Initiators," the Loss of Service Water initiator contributes one sequence to the top 100 for Unit 2. That sequence

represents most of the CDF contribution of this initiator. As discussed earlier, however, that sequence is a variation of a more significant General Transient (GTR) initiator sequence that was previously identified in the original IPE.

Revised Success Criteria for LOOP and DLOOP Initiators

LOOP and DLOOP initiators can lead to Station Blackout (SBO) events. One of the modifications was the assumption of significant Recirculation Pump seal leakage during SBO events. To permit continued Isolation Condenser operation during extended SBO events, therefore, a new success criterion is that reactor vessel makeup is provided. The opposite unit's CRD system (via an existing cross-tie between the CRD systems of the two units) was added to the model as the reactor vessel makeup source for extended SBO events.

DLOOP events can lead to a dual unit SBO condition where no vessel makeup sources are available. Consequently, the new success criterion resulted in an increase in the CDF contribution of the DLOOP initiator.

LOOP events can lead to a single unit SBO condition, but for this case the unaffected unit's CRD system has a low unavailability; consequently, the new success criterion had little impact on the CDF contribution of the LOOP initiator.

Revised Success Criterion for ATWS Initiator

The new success criterion is that operator action to inhibit ADS must succeed. Addition of this criterion via a new node (OIADS) in the ATWS plant response tree (PRT) resulted in an increase in the CDF contribution of the ATWS initiator.

Revised Common Cause Factors

A floor value of 0.01 was imposed on the site-specific beta factors used in the calculation of Common Cause Factors (CCFs). This increased many of the CCFs used in the Dresden fault trees. Although this had a significant impact on some fault trees, this change had little impact on the CDF contribution of most of the initiators. An increase in the CCFs for LPCI and CCSW pumps did, however, increase the failure probability for suppression pool cooling and appears to have a small impact on the CDF contribution of the medium-break loss of coolant accident (MLOCA) initiator. This impact of CCF revisions on the MLOCA CDF appears to have been offset by the impact of the HEP changes discussed below, and the net impact of all changes was a small decrease in the MLOCA CDF.

Revised Human Reliability Analysis

As discussed in the earlier section "Modification 4, Revised Human Error Probabilities and Treatment of Pre-Initiator Events," HEP values were reviewed and revised. Significant HEP revisions included the following:

- Values for operator failure to initiate ADS (node OAD) were increased;
- Values for operator failure to swap the low pressure ECCS pump suction to the Condensate Storage Tank (node OCST) were revised;
- Values for operator failure to initiate suppression pool cooling (node OSPC) were decreased; and
- Values for operator failure to provide Isolation Condenser makeup (node OMUP) were decreased.

Tables 5-2 and 5-3 indicate the net impact of HEP revisions on the CDF contribution from various initiators.

Revised Initiating Event Frequencies

A modification recommended by the original IPE was completed on Unit 2 to eliminate the unit trip on loss of the main 125 VDC bus. Consequently, the initiating event frequency for this support system based initiator was revised to zero for Unit 2.

The site-specific single unit LOOP frequency calculation was revised, mainly because the calculation for the original IPE was found to have given a frequency in terms of site-years. Specifically, the original single unit LOOP frequency (LOOP events per site-year) was overly conservative (by approximately a factor of 2) for IPE use because the plant has two operating units. The revision reduced the frequency of this initiator; consequently, this revision contributed to a reduction in the CDF contribution of the LOOP initiator.

Although the original IPE had reported initiating event frequencies to three digits, rounded-off values had been used in the original quantification. For the new quantification, three digits were used. This contributed to the small increase in the CDF contribution for the ISLOCA initiator.

Note: It is recognized that only the first digit is significant for most of the initiating event frequencies calculated for Dresden. Three digits were reported in the original IPE for many of the initiators, but (for the ISLOCA initiator, for example) only two digits were used in the quantification. Because three digits were used often for many of the failure rates, CCFs, etc., in the quantification, three digits were also used for the initiating event frequencies input to the new quantification for the Modified Dresden IPE. This contributed to the small increase in the CDF contribution for the ISLOCA initiator.

Only two digits are being reported for the new CDF results (in Tables 5-1, 5-2, and 5-3 below), although three digits were given in the original IPE submittal report. Only one digit is judged significant for the CDF values, but use of additional digits facilitates future sensitivity calculations.

Revised Modeling of Standby Instruments, Including Mission Times

As a result of a review of instruments that could potentially be miscalibrated and represent a pre-initiator type error, the modeling of standby instruments was reviewed. The significant instruments were found to have been included in the fault trees for the original IPE, but non-conservative mission times had been used. New mission times of one-half the surveillance interval were chosen for the pertinent instruments.

A review of site-specific experience for a five-year period concluded that the existing standby instrument basic events (including common cause basic events in some systems) were appropriate. Except for certain pressure switches, the review concluded that the generic failure rates used in the original IPE, together with the corrected mission times, adequately treated pre-initiator events related to calibration issues.

For the pertinent pressure switches, a modeling change to a per demand failure was made and a site-specific failure rate was used to treat pre-initiator events related to pressure switch calibration.

These changes appeared to have little impact except for the General Transient (GTR) initiator. The revised modeling of standby instruments contributed to an increase in the CDF contribution of the GTR initiator.

Table 5-1
Core Damage Frequency (CDF) Values from Different Dresden Models

Model/ NRC Submittal Date	Unit 2 CDF	Unit 3 CDF	Significant Changes
Original IPE Model January 1993	1.85 E-05/yr	1.85 E-05/yr	N/A
"Enhanced Model" October 1994	3.67 E-06/yr	4.35 E-06/yr	• Addition of Water Spray contribution to Loss of 125 VDC initiator. • Improved procedure for continued use of Isolation Condenser following discharge of station batteries. • Improved procedure for continued use of the low pressure ECCS pumps after loss of suppression pool cooling.
Modified IPE Model June 1996	3.4 E-06/yr	5.0 E-06/yr	• Additional SBO success criterion for reactor vessel makeup (assumption of significant Recirc. Pump seal leakage). • Additional ATWS success criterion of operator inhibiting ADS. • Human Reliability Analysis revisions. • Common Cause Factor revisions. • Additional support system based initiators and revision of several initiating event frequencies. • Revised modeling of standby instruments, including mission times.

Table 5-2
Dresden Modified IPE — Results for Unit 2

Initiator	Mod. IPE CDF	RAI Response CDF	Change in CDF[1]	Main Reasons Apparent for Change
LDC	0.0	8.6E-7	-100%	Recent modification that eliminated initiator.
MLOCA	1.3E-6	1.4E-6	-4%	Net impact of HEP revisions: OAD↑, OSPC↓; CCF revisions: SPC↑.
DLOOP	8.2E-7	1.7E-7	+383%	Assumption of significant Recirc. Pump seal leakage during SBO events.
ATWS	7.7E-7	5.3E-7	+44%	OIADS node in PRT: Inhibiting ADS by operator required for success.
LOOP	2.8E-7	6.1E-7	-55%	HEP revisions: OAD↑, OMUP↓. Decrease in LOOP frequency.
GTR	1.4E-7	5.9E-8	+139%	Flow transmitter miscalibration treatment; HEP Changes: OAD↑, OMUP↓.
LOSW	3.8E-8	N/A	N/A	New special initiator.
SLOCA	9.0E-9	6.3E-9	+43%	Net Impact of HEP revisions: OAD↑, OSPC↓.
LLOCA	5.0E-9	3.7E-8	-86%	HEP revision: OSPC↓.
IORV	2.3E-9	7.9E-9	-71%	Net Impact of HEP revisions: OSPC↓, OCST↑.
ISLOCA	4.7E-10	4.4E-10	+6%	HEP revision: OAD↑. Additional digit for ISLOCA frequency.
LB23	1.8E-10	N/A	N/A	New special initiator.
LOIA	2.1E-10	N/A	N/A	New special initiator.
LB24	3.7E-10	N/A	N/A	New special initiator.
LB28	8.9E-11	N/A	N/A	New special initiator.
LB282	9.8E-11	N/A	N/A	New special initiator.
LB21	4.8E-11	N/A	N/A	New special initiator.
LB22	4.1E-11	N/A	N/A	New special initiator.
Total	**3.4E-6/yr**	**3.7E-6/yr**	**-7%**	**Elimination of LDC initiator; success criteria involving Recirc. Pump seal leakage and inhibiting ADS during an ATWS; HEP revisions; LOOP freq.**

Notes:
1. The "Change in CDF" percentages were calculated prior to rounding off the "Mod. IPE CDF" and "RAI Response CDF" values to two digits.

Table 5-3
Dresden Modified IPE — Results for Unit 3

Initiator	Mod. IPE CDF	RAI Response CDF	Change in CDF[1]	Main Reasons Apparent for Change
LDC	1.6E-6	1.6E-6	+4%	Net impact of HEP revisions: OAD↑, OCST↓.
MLOCA	1.3E-6	1.4E-6	-4%	Net impact of HEP revisions: OAD↑, OSPC↓; CCF revisions: SPC↑.
DLOOP	8.2E-7	1.7E-7	+383%	Assumption of significant Recirc. Pump seal leakage during SBO events.
ATWS	7.7E-7	5.3E-7	+44%	OIADS node in PRT: Inhibiting ADS by operator required for success.
LOOP	2.8E-7	6.1E-7	-55%	HEP revisions: OAD↑, OMUP↓. Decrease in LOOP frequency.
GTR	1.4E-7	5.9E-8	+139%	Flow transmitter miscalibration treatment; HEP Changes: OAD↑, OMUP↓.
LOSW	3.8E-8	N/A	N/A	New special initiator.
SLOCA	9.0E-9	6.3E-9	+43%	Net Impact of HEP revisions: OAD↑, OSPC↓.
LLOCA	5.0E-9	3.7E-8	-86%	HEP revision: OSPC↓.
IORV	2.3E-9	7.9E-9	-71%	Net Impact of HEP revisions: OSPC↓, OCST↑.
ISLOCA	4.7E-10	4.4E-10	+6%	HEP revision: OAD↑. Additional digit for ISLOCA frequency.
LB33	2.5E-10	N/A	N/A	New special initiator.
LOIA	2.1E-10	N/A	N/A	New special initiator.
LB34	1.8E-10	N/A	N/A	New special initiator.
LB38	9.3E-11	N/A	N/A	New special initiator.
LB382	6.1E-11	N/A	N/A	New special initiator.
LB31	4.7E-11	N/A	N/A	New special initiator.
LB32	4.4E-11	N/A	N/A	New special initiator.
Total	**5.0E-6**	**4.4E-6**	**+14%**	**Success criteria involving Recirc. Pump seal leakage and inhibiting ADS during an ATWS; HEP revisions; LOOP freq.**

1. The "Change in CDF" percentages were calculated prior to rounding off the "Mod. IPE CDF" and RAI Response CDF values to two digits.

Table 5-4a
Dresden Unit 2 - Initiating Events

NAME	DESCRIPTION	FREQUENCY	PERCENT
MLOCA	MLOCA IE	1.32E-06	39.06%
DLOOP	LOSS OF OFFSITE POWER IE	8.20E-07	24.25%
ATWS	ATWS INITIATOR	7.67E-07	22.67%
LOOP	LOSS OF OFFSITE POWER IE	2.78E-07	8.22%
GTR	GENERAL TRANSIENT IE	1.40E-07	4.14%
LOSW	LOSS OF SERVICE WATER	3.80E-08	1.12%
SLOCA	SLOCA IE	9.01E-09	0.27%
LLOCA	LLOCA IE	4.97E-09	0.15%
IORV	IORV IE	2.28E-09	0.07%
ISLOCA	INTERFACING SYSTEM LOCA IE	4.65E-10	0.01%
LB24	LOSS OF BUS 24	3.66E-10	0.01%
LOIA	LOSS OF INSTRUMENT AIR	2.14E-10	0.01%
LB23	LOSS OF BUS 23	1.82E-10	0.01%
LB282	LOSS OF MCC 28-2	9.77E-11	0.00%
LB28	LOSS OF BUS 28	8.92E-11	0.00%
LB21	LOSS OF BUS 21	4.77E-11	0.00%
LB22	LOSS OF BUS 22	4.11E-11	0.00%
	Totals:	**3.38E-06**	**100.00%**

Table 5-4b
Dresden Unit 3 Initiating Events

NAME	DESCRIPTION	FREQUENCY	PERCENT
LDC	LOSS OF DC POWER IE	1.61E-06	32.20%
MLOCA	MLOCA IE	1.32E-06	26.48%
DLOOP	LOSS OF OFFSITE POWER IE	8.20E-07	16.44%
ATWS	ATWS INITIATOR	7.67E-07	15.37%
LOOP	LOSS OF OFFSITE POWER IE	2.78E-07	5.57%
GTR	GENERAL TRANSIENT IE	1.40E-07	2.81%
LOSW	LOSS OF SERVICE WATER	3.80E-08	0.76%
SLOCA	SLOCA IE	9.01E-09	0.18%
LLOCA	LLOCA IE	4.97E-09	0.10%
IORV	IORV IE	2.28E-09	0.05%
ISLOCA	INTERFACING SYSTEM LOCA IE	4.65E-10	0.01%
LB33	LOSS OF BUS 33	2.51E-10	0.01%
LOIA	LOSS OF INSTRUMENT AIR	2.14E-10	0.00%
LB34	LOSS OF BUS 34	1.83E-10	0.00%
LB38	LOSS OF BUS 38	9.28E-11	0.00%
LB382	LOSS OF MCC 38-2	6.14E-11	0.00%
LB31	LOSS OF BUS 31	4.67E-11	0.00%
LB32	LOSS OF BUS 32	4.43E-11	0.00%
	Totals:	**4.99E-06**	**100.00%**

Table 5-5
Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
1	6.40E-07	18.93	MEABM	MLOCA	8.00E-04	MLOCA IE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
2	4.00E-07	11.82	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OCRD	1.00E+00	OPTR FAILS TO RESTORE CRD DURING DUAL-UNIT SBO
3	3.70E-07	10.95	MEABM	MLOCA	8.00E-04	MLOCA IE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
4	2.47E-07	7.3	MLCOM	MLOCA	8.00E-04	MLOCA IE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
5	1.91E-07	5.63	BLAYN	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OCRD	1.00E+00	OPTR FAILS TO RESTORE CRD DURING DUAL-UNIT SBO
				ROP2	3.22E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)
6	1.31E-07	3.89	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
7	1.07E-07	3.15	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
8	8.31E-08	2.46	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS

Table 5-5

Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
9	8.03E-08	2.38	TIABM	GTR	7.40E+00	GENERAL TRANSIENT IE
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				FW	1.52E-03	FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
10	7.49E-08	2.21	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
11	6.70E-08	1.98	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
12	4.19E-08	1.24	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
13	3.62E-08	1.07	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
14	3.43E-08	1.02	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
15	3.42E-08	1.01	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT

Table 5-5
Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
16	3.27E-08	0.97	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
17	3.24E-08	0.96	TIABM	GTR	7.40E+00	GENERAL TRANSIENT IE
				2M1	2.40E-06	LOSS OF BUS 2A-1, 24HR
				ICH2	1.00E+00	SYSTEM FAILURE
				FW	1.00E+00	SYSTEM FAILURE
				HP1	2.93E-02	HP FAILS; 2M1 FLD
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
18	3.20E-08	0.95	TIABM	LOSW	4.48E-03	LOSS OF SERVICE WATER
				SW	1.00E+00	SYSTEM FAILURE
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
19	3.11E-08	0.92	BIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				OIC	3.70E-02	OPTR FAILS TO INITIATE IC (SBO, LOOP
				RVC	2.70E-02	RVC FAILS; RELIEF VALVES CLOSING (TRANS)
20	2.94E-08	0.87	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
21	2.68E-08	0.79	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)

Table 5-5

Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
22	2.58E-08	0.76	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				OMUP	1.40E-02	OPTR FAILS TO PROVIDE M/U TO IC (SBO OR SIMILAR)
				OFW	1.00E+00	OPTR FAILS TO RESTORE FW INJ
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
23	2.29E-08	0.68	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
24	2.09E-08	0.62	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
25	2.03E-08	0.6	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
26	1.81E-08	0.54	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
27	1.63E-08	0.48	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS

Table 5-5
Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
28	1.49E-08	0.44	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				OIC	3.70E-02	OPTR FAILS TO INITIATE IC (SBO, LOOP
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OCRD	1.00E+00	OPTR FAILS TO RESTORE CRD DURING DUAL-UNIT SBO
29	1.38E-08	0.41	LIBON	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				2M1	2.40E-06	LOSS OF BUS 2A-1, 24HR
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				ICH1	1.00E+00	SYSTEM FAILURE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE
30	1.35E-08	0.4	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
31	1.32E-08	0.39	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OIC2	3.20E-02	OPTR FAILS TO PREVENT LODC FLR OF IC
32	1.19E-08	0.35	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
33	1.16E-08	0.34	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS

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Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
34	1.06E-08	0.31	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
35	1.06E-08	0.31	MLCOM	MLOCA	8.00E-04	MLOCA IE
				LP	1.39E-05	LP TRAINS A&B FAIL; ALL SUPPORTS AVAILABLE
36	1.03E-08	0.3	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
				OAT	1.50E-01	OPTR FAILS TO INITIATE ARI SYSTEM (Hi St)
37	9.46E-09	0.28	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
38	9.44E-09	0.28	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				OMUP	1.40E-02	OPTR FAILS TO PROVIDE M/U TO IC (SBO OR SIMILAR)
				ROP1	2.96E-02	FAILURE TO REC OSP TO PREVENT CM (2-4 HRS)
39	9.43E-09	0.28	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
40	9.41E-09	0.28	LLABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE

Table 5-5

Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.30E-03	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
				ROP1	1.00E+00	SYSTEM FAILURE
41	9.01E-09	0.27	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
42	8.34E-09	0.25	SEABM	SLOCA	3.00E-03	SLOCA IE
				FW	1.52E-03	FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
43	7.60E-09	0.22	MLCOM	MLOCA	8.00E-04	MLOCA IE
				OSPC	1.00E-05	OPTR FAILS TO ALIGN FOR SPC
44	7.56E-09	0.22	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
45	7.45E-09	0.22	MLCOM	MLOCA	8.00E-04	MLOCA IE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
46	7.38E-09	0.22	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
47	7.12E-09	0.21	BLAYN	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE

Table 5-5

Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				OIC	3.70E-02	OPTR FAILS TO INITIATE IC (SBO, LOOP
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OCRD	1.00E+00	OPTR FAILS TO RESTORE CRD DURING DUAL-UNIT SBO
				ROP2	3.22E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)
48	6.98E-09	0.21	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				OFW	1.00E+00	OPTR FAILS TO RESTORE FW INJ
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
49	6.76E-09	0.2	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
50	6.37E-09	0.19	LLABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.30E-03	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
				ROP1	1.00E+00	SYSTEM FAILURE
51	6.30E-09	0.19	BLAYN	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)

Table 5-5
Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
				OIC2	3.20E-02	OPTR FAILS TO PREVENT LODC FLR OF IC
				ROP2	3.22E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)
52	6.08E-09	0.18	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
53	5.95E-09	0.18	BIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				241	8.12E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				OIC	3.70E-02	OPTR FAILS TO INITIATE IC (SBO, LOOP
				RVC	2.70E-02	RVC FAILS; RELIEF VALVES CLOSING (TRANS)
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
54	5.94E-09	0.18	MEABM	MLOCA	8.00E-04	MLOCA IE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
				OHX	9.20E-03	OPTR FAILS TO ALIGN CCSW TO LPCI HX
55	5.75E-09	0.17	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
56	4.95E-09	0.15	BLABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				241	8.12E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				OMUP	1.40E-02	OPTR FAILS TO PROVIDE M/U TO IC (SBO OR SIMILAR)
				OFW	1.00E+00	OPTR FAILS TO RESTORE FW INJ
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
57	4.82E-09	0.14	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL

Table 5-5
Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
				RVO	1.10E-04	RVC FAILS; RELIEF VALVES OPENING (ATWS W/MC)
58	4.66E-09	0.14	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				MUP	2.56E-03	MUP FAILS; 28 AND 29 FLD
				OFW	1.00E+00	OPTR FAILS TO RESTORE FW INJ
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
59	4.49E-09	0.13	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
60	4.32E-09	0.13	LIBON	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				2M1	2.40E-06	LOSS OF BUS 2A-1, 24HR
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, NO SBO IN UNIT 2
				ICH1	1.00E+00	SYSTEM FAILURE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE
61	4.31E-09	0.13	TIABM	GTR	7.40E+00	GENERAL TRANSIENT IE
				2M1	2.40E-06	LOSS OF BUS 2A-1, 24HR
				2CA	3.88E-03	LOSS OF UNIT 2 CAS, HP INIT ON LLRL, LOSS 2A-1
				ICH2	1.00E+00	SYSTEM FAILURE
				FW	1.00E+00	SYSTEM FAILURE
				HP1	1.00E+00	SYSTEM FAILURE
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
62	4.29E-09	0.13	BLABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS

Table 5-5
Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
				241	8.12E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				CRD	5.60E-02	UNIT 3 CRD AVAILABLE TO UNIT 2 DURING SINGLE-UNIT SBO
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
63	3.95E-09	0.12	TIABM	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
64	3.85E-09	0.11	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	8.70E-03	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Opt)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
				OAL	9.20E-02	OPTR FAILS TO CONTROL RV LEVEL AFTER ATWS (Dep)
65	3.82E-09	0.11	TIABM	GTR	7.40E+00	GENERAL TRANSIENT IE
				AIC	1.84E-04	AIC FAILS (AUTO INITIATION OF IC)
				FW	1.52E-03	FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
66	3.82E-09	0.11	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				RPT2	5.99E-03	MANUAL RPT FAILS
67	3.81E-09	0.11	MLCOM	MLOCA	8.00E-04	MLOCA IE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
68	3.71E-09	0.11	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
69	3.68E-09	0.11	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE

Table 5-5
Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.30E-03	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
70	3.50E-09	0.1	MEBON	MLOCA	8.00E-04	MLOCA IE
				231	2.00E-04	LOSS OF BUS 23-1, GIVEN BUS 23 AVAILABLE
				241	2.35E-02	LOSS OF BUS 24-1 AFTER 23-1/BUS 24 AVAILABLE, 24HR
				LP	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE
71	3.43E-09	0.1	MEABM	MLOCA	8.00E-04	MLOCA IE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				OHX	9.20E-03	OPTR FAILS TO ALIGN CCSW TO LPCI HX
72	3.31E-09	0.1	TLBON	GTR	7.40E+00	GENERAL TRANSIENT IE
				2M1	2.40E-06	LOSS OF BUS 2A-1, 24HR
				241	1.99E-04	LOSS OF BUS 24-1, GIVEN BUS 24 AVAILABLE
				ICH2	1.00E+00	SYSTEM FAILURE
				FW	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE
73	3.24E-09	0.1	LLABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				OAD	1.30E-03	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
				ROP1	1.00E+00	SYSTEM FAILURE
74	3.22E-09	0.1	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DG3	1.38E-01	LOSS OF DG3, 6 HRS
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
75	3.14E-09	0.09	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE

Table 5-5

Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
76	3.13E-09	0.09	BIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				RVC	2.70E-02	RVC FAILS; RELIEF VALVES CLOSING (TRANS)
77	3.08E-09	0.09	TIABM	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
78	2.89E-09	0.09	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				SLC	1.04E-02	SLC FAILS; 2/2 PUMPS; ALL SUPPORTS AVAILABLE
79	2.88E-09	0.09	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DG3	1.38E-01	LOSS OF DG3, 6 HRS
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
80	2.83E-09	0.08	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
				OAT	1.50E-01	OPTR FAILS TO INITIATE ARI SYSTEM (Hi St)
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
81	2.81E-09	0.08	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE

Table 5-5
Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
82	2.80E-09	0.08	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				OIC	3.70E-02	OPTR FAILS TO INITIATE IC (SBO, LOOP
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
83	2.78E-09	0.08	TLABM	GTR	7.40E+00	GENERAL TRANSIENT IE
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				FW	1.52E-03	FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE
				OAD	1.30E-03	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
84	2.72E-09	0.08	BLAYN	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				OMUP	1.40E-02	OPTR FAILS TO PROVIDE M/U TO IC (SBO OR SIMILAR)
				ROP1	2.96E-02	FAILURE TO REC OSP TO PREVENT CM (2-4 HRS)
				ROP2	2.23E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-4 HRS)
85	2.57E-09	0.08	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				OIC	3.70E-02	OPTR FAILS TO INITIATE IC (SBO, LOOP
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
86	2.55E-09	0.08	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE

Table 5-5
Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
				ROP1	2.96E-02	FAILURE TO REC OSP TO PREVENT CM (2-4 HRS)
87	2.55E-09	0.08	LLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.30E-03	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
				ROP1	1.00E+00	SYSTEM FAILURE
88	2.53E-09	0.07	BLABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				241	8.12E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OIC2	3.20E-02	OPTR FAILS TO PREVENT LODC FLR OF IC
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
89	2.25E-09	0.07	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				SLC	1.04E-02	SLC FAILS; 2/2 PUMPS; ALL SUPPORTS AVAILABLE
90	2.10E-09	0.06	MLCOM	MLOCA	8.00E-04	MLOCA IE
				241	1.99E-04	LOSS OF BUS 24-1, GIVEN BUS 24 AVAILABLE
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
				CS	1.41E-02	CS FAILS; 1 PUMP; 24-1, 29, OR 2R1 FLD
91	2.08E-09	0.06	MLCOM	MLOCA	8.00E-04	MLOCA IE
				231	2.00E-04	LOSS OF BUS 23-1, GIVEN BUS 23 AVAILABLE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				CS	1.42E-02	CS FAILS; 1 PUMP; 23-1, 28, OR 2M1 FLD
92	2.05E-09	0.06	BLAYN	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				241	8.12E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)

Table 5-5
Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
				CRD	5.60E-02	UNIT 3 CRD AVAILABLE TO UNIT 2 DURING SINGLE-UNIT SBO
				ROP2	3.22E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)
93	2.00E-09	0.06	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
94	1.96E-09	0.06	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				SLC	2.96E-04	SLC FAILS; 1/2 PUMPS; ALL SUPPORTS AVAILABLE
95	1.93E-09	0.06	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	8.70E-03	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Opt)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
96	1.92E-09	0.06	MEBON	MLOCA	8.00E-04	MLOCA IE
				28	1.18E-04	LOSS OF BUS 28, GIVEN BUS 23-1 AVAILABLE
				29	2.18E-02	LOSS OF BUS 29 AFTER 28, 24HR
				LV	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE
				SPC	1.00E+00	SYSTEM FAILURE
97	1.90E-09	0.06	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
98	1.83E-09	0.05	TLABM	GTR	7.40E+00	GENERAL TRANSIENT IE
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
				FW	1.52E-03	FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE
				OAD	1.30E-03	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
99	1.81E-09	0.05	BLABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE

Table 5-5

Dresden Unit 2 Dominant Accident Sequences

Seq. No.	Frequency	Percent	Damage State	Node	Value	MDR Description
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				241	8.12E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				OMUP	1.40E-02	OPTR FAILS TO PROVIDE M/U TO IC (SBO OR SIMILAR)
				ROP1	2.96E-02	FAILURE TO REC OSP TO PREVENT CM (2-4 HRS)
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
100	1.79E-09	0.05	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]

ENCLOSURE 2

RESPONSE TO OTHER ISSUES RAISED BY SER

CONTENTS

ISSUE 1 Success Criteria for HVAC

ISSUE 2 Peer Review

RESPONSE TO OTHER ISSUES RAISED BY SER

ISSUE 1: Success Criteria for HVAC

The NRC's Staff Evaluation Report raised some concerns related to system success criteria involving HVAC for areas. Specifically, it contains the following statement:

> *The licensee used realistic analyses to determine the IPE's system success criteria. Based on the licensee's response to the staff's RAI, the staff concludes that the Dresden IPE success criteria are generally reasonable. The staff, however, believes that more technical basis is needed to support the specific success criteria: ...HVAC is not required for any other areas except component [sic] cooling service water rooms...*

Introduction

The statement that HVAC is not required for any other areas except containment cooling service water (CCSW) rooms is correct only if taken in the context of the *limited* plant areas listed in RAI question 9 (j). (If this statement were interpreted as literally applying to all other areas except CCSW rooms, then the statement would be incorrect and apparently would have resulted from a misinterpretation of comments in the Technical Evaluation Report prepared by Science and Engineering Associates, Inc. for the NRC.)

The RAI response cited in the Staff Evaluation Report included the following section concerning success criteria for HVAC:

QUESTION 9 (j)

(j) Explain how the submittal modeled the requirements for cooling of electrical switchgear rooms, battery rooms, CCSW rooms, and the control room.

RESPONSE TO QUESTION 9 (j)

Page 4-6 of the IPE Submittal Report stated the following concerning heating, ventilation, and air conditioning (HVAC) system modeling:

> "The HVAC systems are independent systems each with its own power supply connections and cooling system connections. If HVAC is found to be important to specific equipment, it is modeled in the system model and is detailed in the system notebook for that system."

The results of the review of the dependence of front-line and support system dependence on HVAC are summarized in Tables 4.2.2-6 through 4.2.2-9 in the Dependency Matrices section of the IPE Submittal Report. Dependency of the emergency diesel generators and CCSW on HVAC is shown in Table 4.2.2-9.

The emergency diesel generators were found to be dependent on HVAC because prolonged loss of ventilation would lead to loss of engine control circuitry. Consequently, diesel generator room ventilation was included in the loss of emergency diesel generator fault trees.

CCSW pumps B and C for Dresden 2 & 3 were found to be dependent on HVAC because they are located in vaults for flood protection and (as shown in Fig. 4.2.1.3-2 of the IPE Submittal Report) have associated vault coolers. Consequently, vault cooling was included in the fault trees for LPCI injection cooling and suppression pool cooling.

Table 4.2.2-9 indicates no dependence of the AC, DC, Instrument, ESS, or RPS busses on HVAC. Fault trees for those busses include events involving electrical switchgear, battery busses, and selected control room equipment (e.g., RPS switches and contactors). Consequently, cooling is not modeled for those busses.

This ComEd response dealt mainly with the rooms listed in RAI question 9 (j). Because question 9 (j) indicated a concern with the dependence of the electrical power distribution systems on HVAC, the response also discussed the emergency diesel generator rooms and stated that room ventilation was included in fault trees for loss of emergency diesel generators. Ventilation is also included in the fault trees for loss of feedwater pumps. The feedwater pump dependence on HVAC was stated in the IPE Submittal Report. The feedwater pumps were outside the scope of question 9 (j), however, and were not included in the RAI response.

Section 2.2.4 of the Technical Evaluation Report states the following:

> The Submittal provides tables that delineate system dependencies, and each figure has an accompanying table of notes. [IPE submittal, Tables 4.2.2-1 through 4.2.2-9]
>
> Important asymmetries in train-level system dependencies are indicated. The following types of dependencies were considered: shared component, instrumentation and control, isolation, motive power, direct equipment cooling, area HVAC, operator actions, and environmental and phenomenological effects.
>
> We found the dependency tables and accompanying notes to be useful in our review of the IPE.

Section 2.2.2 of the Technical Evaluation Report includes the following statement in a list of comments on systems/sequences success criteria:

> HVAC was modeled as required for the containment cooling service water (CCSW) pumps B and C. HVAC was assumed to not be required for other areas, specifically the electrical switchgear rooms, battery rooms, CCSW rooms, and the control room. The basis for not requiring HVAC for the other areas was not further clarified.

This paragraph in the Technical Evaluation Report was clearly an attempt to summarize the response to RAI question 9 (j). The last sentence appears to reflect the fact that question 9 (j) did not include a request for additional information on the bases for excluding HVAC from fault trees.

In summary, RAI question 9 (j), the ComEd response, and the Technical Evaluation Report's comments on this HVAC issue apply to limited areas and systems. For that reason, the statement in the Staff Evaluation Report that "HVAC is not required for any other areas except component [sic] cooling service water rooms," is correct only if applied to the limited areas listed in RAI question 9 (j). *Nevertheless, the Staff Evaluation Report indicates a desire, not expressed in the RAI, for additional information on the basis for not including a dependency on HVAC for other important systems. In response, additional information related to this issue follows.*

A discussion is given below for each of the areas mentioned in RAI question 9(j). The discussion includes a repetition of some information on loss of HVAC that was given in the Dresden IPE Submittal Report and other correspondence with the NRC. Other cases for which HVAC dependency was considered during the equipment survivability review of the original IPE, and, in some cases, modeled in fault trees, are also discussed below. The equipment survivability review is summarized in Section 4.4.5 of the IPE Submittal Report. (Note that consideration of loss of HVAC as a support system based initiator, including repetition of much of the information given below, is also discussed in Enclosure 1, "Modifications Made to Dresden IPE," of this submittal.)

Discussion of Specific Areas

1.1 Electrical Switchgear Areas

At some newer plants, loss of cooling to electrical switchgear rooms is a concern. The major AC switchgear at Dresden is *not* located in separate rooms, however. Instead, the major AC switchgear is located in open areas of the ground, second and third floors of the turbine and reactor buildings. These areas are normally supplied with ventilation but do not have coolers. Most of the major DC switchgear is located in open areas of the second floor of the turbine building and third floor of the reactor building. Additionally, some of the Unit 2 DC switchgear is located in the area outside the Unit 2 battery rooms directly above the main control room and some of the Unit 3 DC switchgear is located in a battery charger room immediately below the Unit 3 battery room.

In response to an NRC recommendation to consider the effects of loss of ventilation on Station Blackout (SBO) equipment, these areas were

considered. (Reference: B. M. K. Wong memorandum to C. W. Schroeder, "Dresden Station Units 2 &3, Station Blackout Responses To Safety Evaluation Report Recommendations," dated April 26, 1992, CHRON #184897.) With respect to the reactor building and turbine building, this 1992 review concluded that "Temperature in the large open areas is not expected to go higher than 120° in SBO conditions, so that no further evaluation of equipment there is required." The review also concluded that the battery room temperature would not exceed 120°F.

Furthermore, loss of ventilation to the switchgear areas of the turbine building is easily mitigated by opening normally closed doors such as the following:

- For the 4 kV switchgear in the turbine building, nearby doors to the outdoors, including the turbine building trackway doors,

- For the DC switchgear above the main control room, the door providing access from the stairwell leading to the Unit 2 turbine building area containing 4 kV switchgear, and

- For the DC switchgear in the Unit 3 battery charger room, the door providing access to the room from the Unit 3 turbine building area containing the trackway and 4 kV switchgear.

Loss of ventilation to the Unit 2 and 3 battery rooms is discussed in more detail in Section 1.2 below.

Extended loss of ventilation to the reactor building could potentially result in a controlled unit shutdown due to equipment qualification or other concerns, but the concerns would not be expected to lead to a reactor

scram. Some of the major electrical switchgear in the reactor building is environmentally qualified.

The survivability review carried out during the original IPE included consideration of local heating during an interfacing system LOCA (ISLOCA). The calculated temperature for the ground floor of the reactor building was found to briefly exceed 250°F, but the survivability review did not identify a resulting failure to function (for an ISLOCA) by any of the electrical switchgear in the reactor building.

For these reasons, loss of ventilation in electrical switchgear areas was not warranted as a support system based initiator for the Modified Dresden IPE, and additional loss of ventilation basic events (beyond existing basic events for the emergency diesel generators) are not warranted for electric power system fault trees.

1.2 Battery Rooms

The IPE did not include loss of room heating or ventilation as a failure mode for station batteries.

Loss of heating for a battery room could impact the load-carrying capacity of the batteries, but such an event would not be expected to lead to a reactor scram. Dresden Operating Abnormal (DOA) procedures 5700-01, Loss of Heating Boilers, and DOA 5750-01, Ventilation System Failure, address problems involving the battery rooms. DOA 5700-01 specifies use of temporary heaters powered by welding receptacles to ensure that the station battery area temperatures do not go below 68°F. Because of the procedural controls, and because experience indicates that loss of room heating is mainly a concern during extended dual unit outages, loss

of room heating is judged to have an insignificant impact on the probability of failure of a battery to function.

The 1992 review discussed above for the effects of loss of ventilation on SBO equipment concluded that the battery room temperature would not exceed 120°F. Dresden Station Design Basis Document DBD-DR-006, 125-V and 250-V DC System, Revision A, 12/15/92, states that 125 VDC and 250 VDC "Battery Room Temperature is to be maintained between 65°F and 120°F..." Furthermore, loss of ventilation during warm times of the year could be mitigated by opening doors and, if not during an SBO event, by using portable ventilation equipment such as fans.

For these reasons, loss of HVAC in battery areas was not warranted as a support system based initiator for the Modified Dresden IPE, and loss of HVAC was not warranted as a basic event in DC power system fault trees.

1.3 Containment Cooling Service Water (CCSW) Pump Vaults

The IPE Submittal Report includes the following note to Table 4.2.2-9 for the CCSW system:

> Delayed dependency on loss of HVAC to CCSW pumps B & C pump cubicle coolers.

The following comment was also included in Section 4.4.5.1 of the IPE Submittal Report:

> Room/area cooling for the CCSW and feed water pumps and diesel generators was assumed to fail the respective components and a survivability evaluation was therefore not required.

Therefore, as discussed in the RAI response, the B & C CCSW pump cubicle (vault) cooling was included in the fault trees for LPCI injection cooling and suppression pool cooling. The A & D CCSW pumps are in large, open areas (at a low elevation of the Turbine Building) rather than in sealed vaults. For this reason, including ventilation in the fault tree modeling of the A & D CCSW pumps was not warranted. Furthermore, loss of the CCSW system is not an initiating event. For these reasons, loss of cooling in a unit's CCSW pump areas was not warranted as a support system based initiator for the Modified Dresden IPE.

1.4 Control Room and Auxiliary Electrical Equipment Room

The Main Control Room and the Auxiliary Electrical Equipment Room (AEER) are normally cooled. Dresden Operating Abnormal (DOA) 5750-01, Ventilation System Failure, addresses problems involving these rooms.

The normal cooling system for the Main Control Room uses Service Water. The safety-related Containment Cooling Service Water (CCSW) system can also be used. Except for Station Blackout (SBO) events, therefore, loss of Main Control Room ventilation is unlikely.

The 1992 review discussed above for the effects of loss of ventilation on SBO equipment concluded that opening cabinet and room doors would be necessary to maintain Main Control Room and AEER temperatures below 120°F during a Station Blackout (SBO) event. In response to that review, Dresden Operating Abnormal (DOA) 5750-01, Ventilation System Failure, specifies opening all panel doors and opening two of the security doors for the duration of the event to maintain Main Control Room and AEER temperatures below 120°F .

Because of the redundant supplies of cooling water and because of procedural controls, loss of Main Control Room or AEER ventilation, even for an SBO event, is judged to have an insignificant impact on modeled equipment failure rates or on modeled human error probabilities (HEPs). Significantly, loss of Main Control Room ventilation is not expected to lead to Main Control Room evacuation.

For these reasons, loss of ventilation in the Main Control Room and AEER would not be expected to lead to either an automatic or manual reactor scram. Therefore, loss of ventilation in these areas was not warranted as a support system based initiator for the Modified Dresden IPE. Furthermore, neither modification of HEPs (due to temperature concerns) nor addition of HVAC basic events to relevant fault trees (e.g., Common Actuation System) was warranted.

1.5 Reactor Feedwater Pumps

The reactor feedwater pump (RFP) motors are supplied with ventilation. **This dependency is included in the feedwater system fault trees.** The IPE Submittal Report includes the following note to Table 4.2.2-6 for the feedwater system:

> Interlocked with RFPs to prevent start unless ventilation fan is running. Ventilation fans required for air cooling for RFP motors.

The following comment was also included in Section 4.4.5.1 of the IPE Submittal Report:

> Room/area cooling for the CCSW and feed water pumps and diesel generators was assumed to fail the respective components and a survivability evaluation was therefore not required.

Because the general transient initiating event includes loss of feedwater, loss of RFP cooling is judged to be subsumed by the general transient initiating event. Therefore, loss of RFP ventilation was not warranted as a support system based initiator.

1.6 HPCI Pump Room

The IPE Submittal Report includes the following note to Table 4.2.2-7 for the HPCI system:

> There is a delayed dependency on HVAC for room cooling but it is insignificant for the HPCI mission time. A Sargent & Lundy study of April 1985 indicates HPCI can operate 152 hours without HVAC before HPCI Area high temperature (200°F) occurs. Power for HPCI area cooler is supplied by 480 V MCC 29-4.

The following comment was also included in Section 4.4.5.1 of the IPE Submittal Report:

> Previously performed analyses were reviewed for applicability for the Core Spray/LPCI pump rooms and HPCI pump room. These analyses indicate that the equipment in these rooms will survive the environment posed by loss of room cooling.

For this reason, the HPCI fault tree does not include the HVAC dependency.

1.7 LPCI and Core Spray Pump Rooms

The following comment was included in Section 4.4.5.1 of the IPE Submittal Report:

> Previously performed analyses were reviewed for applicability for the Core Spray/LPCI pump rooms and HPCI pump room. These analyses indicate that the equipment in these rooms will survive the environment posed by loss of room cooling.

For this reason, the LPCI and Core Spray fault trees do not include HVAC dependency except for the LPCI dependency on CCSW vault cooling discussed above.

1.8 Emergency Diesel Generator Rooms

The following comment was included in Section 4.4.5.1 of the IPE Submittal Report:

> Room/area cooling for the CCSW and feed water pumps and diesel generators was assumed to fail the respective components and a survivability evaluation was therefore not required.

Diesel generator notes to Table 4.2.2-9 of the IPE Submittal report include the statement "Leads to loss of engine control circuitry on prolonged loss of ventilation." **This dependency is included in the pertinent fault trees.** Emergency diesel generator failure is not considered to be an initiating event, however, so loss of emergency diesel generator room cooling areas was not warranted as a support system based initiator for the Modified Dresden IPE.

1.9 Steam Tunnel ("X-Area")

The Main Steam system was reviewed as part of the IPE. The IPE review identified a dependency of the Main Steam system on coolers in the steam tunnel ("X-Area"). Loss of coolers would result in high temperatures in the area of the outboard main steam isolation valves (MSIVs). High temperatures would result in a Group I isolation and loss of the Main Steam system.

No Main Steam fault trees were developed for the IPE, however, because the only plant response tree (PRT) crediting Main Steam (and Main Condenser) as a means to cool the core was the ATWS PRT. (This is a conservative approach for the other PRTs, but reasonable considering that credit is given for the highly reliable Isolation Condenser system.) The ATWS PRT quantification used actual plant transient data from the IPE baseline period to determine the Main Condenser failure probability for various cases. For this reason, no fault tree modeling of Main Steam (which could include the steam tunnel coolers) was warranted.

Note, however, that as discussed in Enclosure 1, two new support system based initiators were added to the Modified Dresden IPE due to consideration of loss of X-area cooling.

1.10 Isolation Condenser Makeup Pump Room

The following comment was included in Section 4.4.5.1 of the IPE Submittal Report:

> The design documentation for the Isolation Condenser makeup pumps was reviewed and the system design representative interviewed. The design of the pump and system is such that the loss of the room cooling fans is not expected to increase the temperature in the room and further survivability evaluation was therefore not required.

The pump drivers are diesel engines with an integral jacket cooling system which is inside the boundary of the diesel-driven pump, and is therefore considered as a failure mode of the pump. The diesel takes its combustion air from the pump room which receives air through louvered openings ensuring a steady flow of cool outside air into the room during pump operation. Because of this design and modeling assumption, the

loss of the room cooling fans is not expected to increase the temperature in the room and further analysis was not warranted.

For the above reasons, the Isolation Condenser fault trees do not include loss of the room cooling fans. Furthermore, loss of makeup water to the Isolation Condenser would not be an initiating event. For these reasons, loss of Isolation Condenser Makeup Pump Room cooling fans was not warranted as a support system based initiator for the Modified Dresden IPE.

1.11 Diesel-Driven Fire Pump Areas

The diesel-driven fire pumps are located in the intake structures. Loss of steam heating in the area could make a fire diesel more difficult to start in cold weather. Dresden Operating Abnormal (DOA) procedure 5700-01, Loss of Heating Boilers, specifies use of temporary heaters powered by welding receptacles to ensure that the diesel-driven fire pump area temperatures do not go below 40°F.

Outside air is used to cool the Unit 2/3 intake structure during warm months because of the heat load from the service and circulating water pump motors. Because outside air is admitted through large, open windows, cooling of the Unit 2/3 diesel-driven fire pump area is not judged a concern.

The Unit 1 diesel-driven fire pump and day tank are located in a separate, large room in the basement of the Unit 1 intake structure. A small ventilation fan normally runs, but loss of the ventilation fan is judged to have an insignificant impact on the fire diesel. The normal heat loads from equipment, such as circulating water pump motors, in other rooms of

the Unit 1 intake structure are relatively low because Unit 1 is shutdown. Also, as discussed above for diesel-driven isolation makeup pumps, the running engine would draw air into the room.

Because of the above reasons, loss of room heating or ventilation is judged to have an insignificant impact on the failure-to-start or failure-to-run probabilities of the diesel-driven fire pumps. Consequently, loss of HVAC was not included in the fire protection system fault tree. Furthermore, failure of a diesel-driven fire pump would not lead to a reactor scram. Therefore, loss of ventilation to a diesel-driven fire pump area was not warranted as a support system based initiator for the Modified Dresden IPE.

1.12 Turbine Building Closed Cooling Water (TBCCW) Pump Areas

The IPE review of the TBCCW pumps determined that they were located in a mild environment (an open area of the turbine building) and that the fluid in the system is low-temperature and low-pressure. Therefore, the loss of room/area cooling is not expected to significantly increase the temperature in the area and further analysis was not warranted.

For this reason, loss of room/area cooling was not included in the TBCCW fault tree, and loss of TBCCW pump area cooling areas was not warranted as a support system based initiator for the Modified Dresden IPE.

1.13 Drywell

Even with a loss of drywell cooling there would be little impact on the accident progression and no effect on the systems necessary to maintain

the reactor in a safe, stable condition. RAI question 29 dealt with this issue, and the response was as follows:

QUESTION 29

29. No node exists in the PRTs to address drywell coolers. How were these coolers addressed in the IPE?

RESPONSE TO QUESTION 29

The drywell coolers were not modelled in the Dresden IPE. It was determined that the heat removal capability of the drywell coolers was small, the drywell coolers would easily trip on most events and that significant operator actions would be required to return the coolers to service. Therefore, it was decided that to model the drywell coolers would not be worthwhile.

Loss of drywell cooling could lead to closing of the inboard MSIVs, but as discussed above for the steam tunnel, the only credit taken for the ability to cool the core via the Main Steam system and Main Condenser is in the ATWS PRT. Because the failure probabilities for the Main Condenser used in the ATWS PRT are based on actual plant transient data for the IPE baseline period, these failure probabilities are judged to subsume a contribution from loss of drywell cooling.

Loss of drywell cooling, by itself, would probably lead to a controlled reactor shutdown rather than a scram. For this reason, loss of drywell cooling was not warranted as a support system based initiator for the Modified Dresden IPE.

Summary

The SER's statement that HVAC is not required for any other areas except containment cooling service water (CCSW) rooms is correct only if taken in the context of the *limited* plant areas listed in RAI question 9 (j). The original IPE Submittal Report and the ComEd response to RAI question 9 (j) gave two additional areas for which HVAC is required. Specifically, the equipment/areas

discussed above for which loss of ventilation was included in fault trees developed for the original IPE are as follows:

- CCSW pump cubicle (vault) containing a unit's B & C CCSW pumps,
- Reactor feedwater pumps, and
- Emergency diesel generator rooms.

The detailed discussion above also includes the basis for not requiring fault tree modeling of loss of HVAC for the following areas:

- Area containing a unit's A & D CCSW pumps,
- Electrical switchgear areas,
- Battery rooms,
- Main control room and auxiliary electrical equipment room,
- HPCI pump room,
- LPCI and Core Spray pump rooms,
- Steam tunnel,
- Isolation condenser makeup pump room,
- Diesel-driven fire pump areas,
- TBCCW pump area, and
- Drywell.

Consideration of these areas found no cases that warranted addition of loss of HVAC to any of the fault trees used for the Modified Dresden IPE.

ISSUE 2: Peer Review

ComEd committed to obtain a peer review of the Modified Dresden IPE.

RESPONSE 9:

During the Dresden IPE modification process, ComEd has employed two "peers" to review the changes being made to the Dresden IPE model.

Mr. Robert C. Bertucio

Mr. Robert C. Bertucio of NUS was employed to perform a peer review of: 1) modifications of success criteria; and 2) the final Modified Dresden IPE quantification and key results.

Mr. Bertucio, whose detailed resume is available upon request, has more than twenty years experience in the field of probabilistic safety analysis and risk assessment. His experience includes involvement in numerous utility, industry, and government programs associated with Individual Plant Examinations. His previous experience in PRA developmental programs such as IREP, IDCOR, and NUREG-1150 provide him with understanding and insight of the current capabilities of PRA technology and expected risk characteristics of reactor facilities. His utility IPE involvement includes significant work on the Point Beach, Surry, North Anna, Palo Verde, Brunswick, and Indian Point 3 IPEs. He previously performed a peer review of the Modified Zion IPE.

During his review of the Modified Dresden IPE, Mr. Bertucio asked a number of questions related to initiating events, initiating event frequencies, success criteria, and the dominant core damage sequences. These questions were answered to his satisfaction and required no

changes to the Modified Dresden IPE. More detailed documentation of his review and acceptance of the final modifications is available upon request.

Dr. Gareth W. Parry

An industry recognized HRA expert, Dr. Gareth W. Parry, also of NUS, had previously been retained to train ComEd analysts in an alternative HRA methodology to support the Modified Zion IPE. Dr. Parry was retained to oversee the ComEd application of that methodology to Dresden, and to perform a detailed peer review of its use and of the results.

The alternative HRA used the EPRI Cause Based Decision Tree methodology to estimate the cognitive failure probability (P_C) of each modeled human interaction. This methodology was authored by Dr. Parry and published after the initial ComEd IPE (for Zion) had been submitted. The execution failure probabilities (P_e) were estimated using an evaluation process recommended by Dr. Parry based on THERP data.

Dr. Parry reviewed the modeling and calculations of the operator actions as well as the plant response trees for identification of operator action mode dependencies and calculation of conditional failure probabilities.

Dr. Parry's major comments, recommendations, and corrections (not only those changes that resulted in human error probability increases, but also many changes that resulted in decreases) were incorporated into the revised HRA as they were identified.

ENCLOSURE 3

REVISED PAGES

FOR

BASE DRESDEN IPE SUBMITTAL REPORT

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DRESDEN NUCLEAR POWER STATION
UNITS 2 AND 3

INDIVIDUAL PLANT EXAMINATION
SUBMITTAL REPORT

VOLUME 1

REVISION 1

JUNE 1996

Submitted By

COMMONWEALTH EDISON COMPANY

MAIN SUMMARY REPORT

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EXECUTIVE SUMMARY OF THE DRESDEN INDIVIDUAL PLANT EXAMINATION

OVERVIEW

The Dresden Individual Plant Examination (IPE) conducted by Commonwealth Edison and the Individual Plant Evaluation Partnership (IPEP) demonstrates that no severe accident issue requiring remedial action exists. The IPE results are well within the safety goals established by the Nuclear Regulatory Commission (NRC). The IPE concludes that Dresden Station functions well within accepted safety limits due to safety margins incorporated in the original design and to the effectiveness of the emergency procedures.

The following paragraphs present more detailed information on the features and results of the IPE.

FEATURES OF THE DRESDEN IPE

The Dresden IPE is a Probabilistic Risk Assessment (PRA) study which has been integrated with an Accident Management Program. During each step of the study, there was a systematic search for insights to identify plant characteristics that are good "as-is," as well as to identify potential enhancements for improving plant safety relative to severe accidents and, in the future, for developing a Severe Accident Management Program. The study employed realistic, best-estimate analyses and realistic treatment of operator actions.

The Dresden IPE incorporated a number of significant innovative features such as the following:

- The development of plant response trees (PRTs). These improvements on traditional event trees, which trace a sequence of events and subsequent actions, permitted an evaluation of the total plant response to a severe accident. Because this methodology considers the total plant response, the interface between the core damage analysis and the containment analysis is fully integrated.

- The full integration of the Dresden Emergency Operating Procedures (DEOPs) and the abnormal operating procedures. The accident progression reflected a realistic operator response and its impact on the accident consequences. Alternative recovery strategies, already included in the DEOPs, were considered as well as the total capabilities of the plant, rather than just the capabilities of the dedicated safety systems.

- The development of realistic success criteria for systems and operators based on many transient calculations which utilized the MAAP computer code. These computer analyses defined the minimum system functional requirements and the time windows for successful operator action.

- Experiments were conducted using Dresden-specific geometries to investigate lower vessel head cooling.

- The introduction of a Success with Accident Management (SAM) endstate to track and collect sequences that would progress to core damage well after the traditional 24 hour evaluation time of PRAs. In traditional PRAs, these sequences would be grouped with all of the other "success" sequences which are in a safe, stable state before 24 hours. However, Commonwealth Edison did not want to lose information to be gained from these sequences in regard to the development of an Accident Management program.

The Modified IPE for Dresden Station, as presented in this report, models the baseline response of the station to a wide range of initiating events based on, for the most part, the plant design, equipment reliability and availability, and operating practices that were existing at the beginning of 1991. The main exceptions to this statement are the hardened containment vent installation, the diesel-driven IC makeup pump installation, the procedure enhancement related to alignment of low pressure coolant injection or core spray to the condensate storage tank, and the DC modification to eliminate loss of DC as an initiator. Also, the revised Human Reliability Analysis was based on emergency response procedures in place as of December 1995. Other changes in plant design or operation since January 1991 which may affect the risk profile will be evaluated as part of the periodic review and update of the Dresden PRA -the "living PRA" process.

DRESDEN IPE RESULTS

Two basic measures of severe accident risks were employed for these studies:

- The frequency of damage to the reactor core in any given year (or core damage frequency, referred to as CDF). CDF is expressed as "chances" of core damage per year of reactor operation.

- The large, early release frequency (referred to as LERF) as defined in the NEI-sponsored PSA Applications Guide (EPRI TR-105396) published in August 1995. ***Large*** means that the event results in "the rapid, unscrubbed release of airborne aerosol fission products to the environment." ***Early*** means that the event occurs "before the effective implementation of the off-site emergency response and protective actions."

The IPE study produced the following statistics which provide a better appreciation of the high level of safety provided by the station design and operating practices:

- The CDF for Unit 2 is 3.4×10^{-6} per year or once in 300,000 years of operation.

- The CDF for Unit 3 is 5.0×10^{-6} per year or once in 200,000 years of operation.

The only significant difference between the Unit 2 and 3 results is a modification to eliminate the "loss of 125 VDC" special initiator. That modification has been

implemented on Unit 2, but is scheduled for the next refueling outage for Unit 3. For that reason, the detailed results for the Modified IPE are currently applicable to Unit 2 and will also be applicable to Unit 3 upon completion of the modification.

- The LERF for both units is 1.6×10^{-7} per year or once in 6,000,000 years of operation.

The following summarizes important results of the Modified Dresden IPE analysis:

- Of the total CDF, 98% is due to five initiating events.
  - The Medium Loss of Coolant Accident initiator contributes 39%.
  - The Dual Unit Loss of Offsite Power initiator contributes 24%.
  - The Anticipated Transient Without Scram initiator contributes 23%.
  - The Single Unit Loss of Offsite Power initiator contributes 8%.
  - The General Transient initiator contributes 4%.
- Fifteen accident sequences have individual contributions to the total CDF exceeding 1%.
  - Two sequences initiated by a Medium Loss of Coolant Accident in which high pressure coolant injection (HPCI) fails and in which operators fail to initiate the automatic depressurization system (ADS) contribute 30% of the total CDF.
  - Two sequences initiated by a Dual Unit Loss of Offsite Power event in which all emergency diesel generators fail and in which offsite power is not recovered in time to prevent core damage contribute 17% of the total CDF.
  - A sequence initiated by a Medium Loss of Coolant Accident in which suppression pool cooling (SPC) fails contributes 7% of the total CDF.
  - The contribution of each of the remaining sequences varies between 1% and 4% of the total CDF.
- Containment failure or venting within 24 hours is associated with 41% of the total CDF.

NEW EXPERIMENTAL STUDIES

An experimental study was commissioned as part of the IPE to provide new insights to the response of the Dresden reactor and containment under severe accident conditions. The experimental program dealt with the potential for external cooling of the reactor vessel by water accumulated in containment. During an accident, water injected into the Dresden containment, either from the accident condition or from the drywell sprays, could eventually accumulate in the containment and fill the reactor pedestal volume directly underneath the vessel. If the water can make direct contact with the vessel wall, substantial heat removal would result through the vessel, the core would remain in the vessel, and the accident progression would be terminated. Two experiments were

performed: the first considered the Dresden plant geometry, complete with simulated lower RPV head and support skirt, and, the second considered the same configuration with vent holes introduced into the support skirt. The first experiment showed that accumulation of steam in the skirt inhibited contact between water and the vessel, leading to relatively poor heat transfer. In the second experiment, the introduction of vent holes in the skirt allowed for good contact and heat transfer.

ENHANCEMENTS

The Commonwealth Edison IPE/AM program has identified over 210 Dresden-related insights. IPE insights deal with plant procedures, hardware, training, information, and test/maintenance. Accident management insights address issues involving Accident Management strategies, organization, training, computational tools, and information systems. Most insights are fairly minor in significance. However, ComEd implemented the recommendations of two of the IPE insights, as discussed below.

A review of the IPE results against NUMARC Severe Accident Issue Closure Guidelines (NUMARC 91-04, January 1992), indicated the need to investigate improvements to reduce one class of sequences--sequences involving loss of containment heat removal causing a subsequent loss of coolant inventory makeup. These improvements are called for on the basis of the fraction of total core damage frequency represented by these sequences. It was determined that the greatest improvement in plant risk could be realized by implementing IPE insights recommending a procedure enhancement related to alignment of low pressure coolant injection (LPCI) or core spray (CS) pump suction to the condensate storage tank (CST) when suppression pool cooling cannot be established. This enhancement would allow injection to the reactor vessel to be maintained when it would otherwise be lost due to insufficient net positive suction head for the low pressure emergency core cooling system (ECCS) pumps as the suppression pool water is heated. Intermittent operation of LPCI or CS to control level in the reactor pressure vessel based upon the volume of water available in the CST would provide core cooling well beyond 24 hours. ComEd implemented this procedure modification. This procedure change was to bring Dresden into agreement with the NUMARC guidelines addressing the most likely accident class.

In accordance with the recommendations provided by the NUMARC Closure Guidelines, accident management guidance will be developed for one other class of sequences: those involving a loss of all onsite AC power (station blackout (SBO) sequences). IPE insights related to these sequences recommended a procedure change which would maintain the operation of the isolation condenser during extended SBO sequences. The frequency of the SBO class of sequences fell just below the cutoff of the Closure Guidelines for requiring action. However, since these sequences can potentially lead to significant fission product releases, ComEd implemented a procedure change that further reduces the frequency of these sequences.

CONCLUSIONS

The IPE took several major steps toward injecting more realism into the evaluation for severe accidents at Dresden Station. These included the following:

- Integration of Level 1 and Level 2 analyses using plant response trees
- Use of best-estimate success criteria
- Implementation of the control room operator DEOPs into the accident evaluation

The realistic modeling employed shows that Dresden Station is a very good plant with reliable systems. The DEOPs are effective in responding to severe accidents, and they contribute to Dresden Station's low core damage frequency. Dresden Station was found to have no serious weaknesses or vulnerabilities.

The NUMARC Closure Guidelines, when applied to the original IPE, indicated the need to address the class of accident sequences in which suppression pool cooling failures ultimately lead to the inability to supply coolant to the vessel. A procedure change was implemented to enhance the ability to maintain the reactor water vessel inventory.

Although not required for compliance of the original IPE to the NUMARC Guidelines, a procedure modification was also implemented to reduce the contribution to CDF by station blackout sequences. This procedure change will allow the isolation condenser to continue to operate under extended station blackout conditions.

The Commonwealth Edison engineering staff has been intimately involved in the IPE process and has acted as both originator of IPE analyses and reviewer of all IPE analyses. As a result of the Integrated IPE/AM Program, the CECo PRA staff has developed a unique understanding of the behavior of the plant under accident conditions and of the total plant capabilities to respond to accidents.

The principal purpose of the Dresden IPE was to develop an understanding of the response of the plant to severe accidents. It accomplished this purpose. A second purpose of the Dresden IPE was to serve as the basis for an Accident Management program. The insights developed during performance of the Dresden IPE will form the basis for future development and implementation of the Dresden Accident Management program. The final results of the study support the idea that the best improvement for plant safety is a good Accident Management program.

1.0 SUMMARY OF THE DRESDEN IPE

This section provides a summary of the Dresden Individual Plant Examination (IPE); all of the information presented in this section can be found in greater detail in subsequent sections of this document.

1.1 Philosophy and Conformance with GL 88-20

The Dresden IPE has been performed to identify and resolve severe accident issues germane to Dresden Station. To assure that this purpose was accomplished, CECo performed a full-scope Level II Probabilistic Risk Assessment (PRA), into which Accident Management (AM) considerations were fully integrated.

Commonwealth Edison Company (CECo) conducted the Dresden Level II PRA to be in full compliance with the requirements of NRC Generic Letter 88-20 and its Supplement 1. CECo's approach to the IPE has been to perform realistic evaluations of Dresden Station's capability with emphasis on the prevention of severe accidents and on the need to effectively respond to accident sequence progression in the event of a severe accident. CECo's evaluations were carried out in a manner that supported senior management decision-making processes, relative to potential enhancement of plant design and/or operation, aimed at reduction of risk from severe accidents.

Integrated throughout the IPE was the development of insights and information that either suggested plant improvements, or which evolved into the framework of an accident management program for Dresden Station. In performing the IPE, standard PRA systems analysis practices such as those outlined in the PRA Procedures Guide (NUREG/CR-2300) were used. The Dresden IPE employs the large event tree/support state method. An innovative approach to integrating the traditional systems analysis and containment analysis portions of the PRA was used that involves the development of combined, fully integrated, event trees referred to as Plant Response Trees (PRTs). The methods employed were presented to the NRC during a series of technical exchange meetings which took place during 1991.

The focus of the investigation was on realistic assessment of the plant response to potential accident sequences, so that insights feeding CECo's accident management program represented CECo's best understanding of the plant response. The Dresden IPE specifically models the Dresden Emergency Operating Procedures (EOPs), which are based on the generic Boiling Water Reactor Owners Group (BWROG) symptom-based guidance. The success criteria used to determine whether or not plant systems achieve their intended safety function was realistically determined for each important type of accident sequence rather than relying on the Dresden FSAR (Final Safety Analysis Report) success criteria.

These success criteria considered both equipment capability and timing of the accident progression. Well-known, detailed approaches for common cause failure and human error that supported the conduct of realistic studies were adopted for the Dresden IPE. Special attention was also given to the treatment of dual-unit site issues.

1.2 Project Organization

Commonwealth Edison Company engaged the Individual Plant Evaluation Partnership (IPEP) to support the analysis efforts on the Dresden IPE and the IPE's for CECo's other nuclear generating stations. The IPEP companies are Westinghouse, Fauske and Associates, Inc. and TENERA. CECo created an organization for the performance of these projects which effectively utilizes its personnel resources and provides CECo with complete control and involvement in the analysis of each plant. The CECo personnel assigned to conduct the IPE program collectively have extensive experience in plant operations and systems engineering, as well as PRA experience. Many of the methods used in the Dresden IPE were originated by CECo. IPEP personnel performed the basic modeling and analysis, while CECo personnel performed success criteria analysis using MAAP and conducted detailed reviews of the models, assumptions, and results.

Interactions between CECo personnel and the IPEP analysts were conducted on a continual basis and intensively at each intermediate step to resolve CECo comments and incorporate plant-specific knowledge. Figure 1.2-1 shows the overall organizational structure for the CECo IPE program. Insights developed during the performance of the PRA were evaluated by a "Tiger Team" of experienced IPEP and CECo personnel. Key insights and key results from each stage of the study were also reviewed by an IPEP Senior Management Support Team (SMST). The SMST consisted of a senior manager from each IPEP company who was not involved in the day-to-day conduct of the IPE. In addition, CECo senior management actively reviewed all results and insights as well as the IPE program team's recommendation to decide which of the insights and/or recommendations to pursue. As noted in the initial CECo response to the Nuclear Regulatory Commission (NRC) on Generic Letter 88-20, no separate "independent review" of the base Dresden IPE was performed. It is CECo's view that the quality of the study is assured by the employment of knowledgeable, experienced analysts both at IPEP and at CECo, as well as the many levels of review within the CECo program. The changes made in the generation of the modified Dresden IPE received an independent, peer review.

1.3 Methodology

This section summarizes the overall PRA methodology used for the Dresden IPE/AM Program.

1.3.1 Overall Model

The IPE was conducted using standard analysis practices, such as those outlined in NUREG/CR-2300, "PRA Procedures Guide - A Guide to the Performance of Probabilistic Risk Assessments for Nuclear Power Plants" and NUREG/CR-2815, "Probabilistic Safety Analysis Procedures Guide." However, innovative techniques were developed for several areas of the analysis. The traditional systems analysis and containment analysis portions of the PRA were fully integrated by plant response trees that depict the combinations of interactions that can impact the plant behavior from the initiating event to an end state characterized by retention of fission products within the containment boundary or release to the environment. The MAAP computer code was utilized to characterize success criteria, timing and containment response.

The models developed in the original IPE represent with minor exception the as-built, as-operated Dresden Station, as of a data cut-off date in January 1991. The exceptions were modifications then in progress; those modifications have since been completed. The Modified IPE models two procedure enhancements that were analyzed as part of the original IPE and have since been implemented. The Modified IPE also reflects completion of a modification on Unit 2 to eliminate the most significant special initiator. The modification is scheduled for Unit 3 but is not yet complete. For that reason, the core damage frequency contribution for that special initiator is still included in a summary for Unit 3, but the detailed discussions in the Modified IPE (such as the dominant sequence listing for Unit 2) reflect completion of the modification. Care has been taken to ensure that only formal procedures, which the operators are trained to use, have been credited.

The key tasks in the overall IPE model are described below:

- Plant familiarization was accomplished by the analysts through a review of the Dresden Updated Final Safety Analysis Report (UFSAR), design drawings, design descriptions, training materials, normal and emergency procedures, technical specifications, test procedures, location and layout drawings, and plant walkdowns.

- Plant specific information was collected from a variety of logs, reports, and operator interviews for the period from January 1, 1984 to December 31, 1990 to examine plant specific component failure, testing and maintenance data, as well as initiating events which have led to reactor trips. Generic data from IEEE-500, NUREG-2815, Revision 1, and other sources were used to supplement the plant specific information. For common cause failure, the Multiple Greek Letter (MGL) method was used to generate failure probabilities.

- The accident initiators were identified from the collection and analysis of plant trip data. This was supplemented by the use of other industry sources, such as NUREG/CR-3862, where Dresden plant specific data was insufficient due to low or non-existent frequency of occurrences. Some of the loss of coolant accident initiating event information was derived from WASH-1400. Special initiators for Dresden Station were identified through analyses of selected systems, such as DC power. Loss of offsite power and plant centered losses were derived from generic data in NUREG-1032, NSAC-147 and NSAC-166 which are applicable to the dual unit Dresden Station.

- Internal flooding was treated as a special initiator. Separate analyses were performed to determine whether there are areas in Dresden Station that are susceptible to flooding or spray from pipe breaks and whether there is sensitive equipment in those areas that could cause plant shutdown or result in a failed safety system.

- A detailed analysis of the various front-line safety systems and supporting systems was conducted for each of the identified initiators and for the interactions between the two Dresden units.

- Plant Response Trees (PRTs) and support system event trees were used to develop the Dresden accident sequence model. A plant response tree was developed for each

initiator; a support system event tree model was developed for each major class of initiating events. The support system event tree model was developed as a dual unit model, where appropriate, because the two Dresden units share important support systems. The MAAP computer code was used to develop realistic accident sequence models, including success criteria and operator actions, so that the accident sequences represent the best estimate plant response.

- The Dresden systems represented in the PRTs were modeled with fault trees. The development of the fault trees was done starting from the success criteria for the system specified in the PRTs. The relationship between the two units was carefully examined and, where appropriate, modeled. The systems modeled include safety systems, support systems, containment systems and miscellaneous systems, as dictated by the PRTs.

- Extensive phenomenological evaluations were made to study accident progression and the possible containment failure mechanisms. These evaluations serve as the primary means by which phenomenological issues were addressed. A combination of these evaluations and MAAP analyses were used to assess the importance of the phenomenological issues and the significance of uncertainty. For some issues, Dresden specific experiments were developed and performed to support the phenomenological evaluations.

- Source terms were developed by analyzing the dominant accident sequences that led to containment failure, using the MAAP code. Source terms were binned into release categories based on type, timing, and magnitude of release.

1.3.2 Initiating Events

The Dresden-specific initiating events considered in the IPE are as follows:

- Large Loss of Coolant Accident (LOCA)
- Medium Loss of Coolant Accident (LOCA)
- Small Loss of Coolant Accident (LOCA)
- Interfacing Systems LOCA (ISLOCA)
- Inadvertent Opening of a (Main Steam) Relief Valve (IORV)
- Anticipated Transients
- Single Unit Loss of Offsite Power (LOSP)
- Dual Unit LOSP (DLOSP)
- Loss of the 125VDC (main bus) from one Unit (LODC)
- Loss of Service Water (LOSW)
- Loss of Instrument Air (LOIA)
- Loss of 4 kV Bus 21/31 (LB21/LB31)
- Loss of 4 kV Bus 22/32 (LB22/LB32)
- Loss of 4 kV Bus 23/33 (LB23/LB33)
- Loss of 4 kV Bus 24/34 (LB24/LB34)
- Loss of Steam Tunnel Cooling due to Loss of 480 VAC Bus 28/38 (LB28/LB38)
- Loss of Steam Tunnel Cooling due to Loss of 480 VAC MCC 28-2/38-2 (LB282/LB382)

In addition, two events were treated as consequential failures in the accident sequence analysis and thus, no frequencies were calculated:

- Loss of all AC Power (Station Blackout (SBO))
- Anticipated Transient Without Scram (ATWS)

The LOCA frequencies were taken from WASH-1400 for this analysis. The interfacing system LOCA frequency was determined by a Dresden specific calculation considering all likely flow paths. The frequency of an inadvertent opening of a relief valve was determined from plant-specific and industry data on such events.

Fault trees were developed for both frontline, containment, miscellaneous and support systems. Their analysis is conditional on both the initiating event (and its effects), and the availability of support systems that impact system operation.

As part of the Modified IPE, the opposite unit's control rod drive (CRD) hydraulic system was included in the modeling of station blackout (SBO) events. If reactor vessel makeup is required during an extended single-unit SBO event, a CRD cross-tie can be used for high-pressure injection via the cross-tie. Instead of a detailed frontline system analysis of the opposite unit's CRD system, recent experience with CRD system unavailability was employed.

1.3.4 Support System Modeling

The "support state methodology" was used to model the key support systems and their impact on the safety systems that are required to respond to the modeled initiating events. The concept of a support state model allowed the major support systems to be modeled outside of the accident sequence plant response trees. Dresden Station contains two units which share major support systems. Shared systems were modeled to ensure that the influence on both units is captured.

A support system is defined as a system that is depended upon for the successful operation of frontline systems, safety systems, miscellaneous systems or other support systems. The support systems were identified by reviewing the Dresden Station Updated Final Safety Analysis Report (UFSAR), system descriptions, and piping and instrumentation diagrams.

The second step in the development of the support state model was a review of the system dependency matrices. The dependency matrices were developed to identify the interrelationships among the various systems modeled in the IPE and focus the investigation on key dependencies between initiating events, support systems, and frontline systems for major system components. The dependencies considered in the development of these matrices considered partial dependence as well as complete dependence.

The third step in developing the support state model was to identify the key support systems. The key support systems are those systems which interact with the other frontline and support systems. The criteria for identifying key support systems include whether the system supports multiple frontline systems and whether the frontline systems would not function without the support system (further discussion of the selection of key support systems is provided in Section 4). Based on the review of system descriptions and the system dependency matrices, the following key support systems were selected for modeling in the support system event trees:

- Electrical Power - DC
- Electrical Power - AC
- Common Actuation System - CAS
- Service Water - SW
- Turbine Building Closed Cooling Water - TBCCW

The AC and DC electric power systems provide the motive or control power for a majority of the safety-related pumps and valves. The CAS provides the actuation signals for the safety systems on an ECCS signal. The SW system provides the ultimate heat sink for the cooling of major heat loads and the TBCCW system provides the cooling for the feed and condensate system pumps and other turbine building auxiliaries.

component approach permitted resources to be focused on the most important failures and unavailabilities. Failure and unavailability data for non-key components was obtained from generic data sources.

The failure and component unavailability data collected for the Dresden IPE spanned the period of January 1, 1984 through 1990. The most recent 7 year period (i.e., 1984 through 1990) gives failure rate and unavailability results that come the closest to the current true state of unreliability of the key components. Plant-specific data was collected from the operating records of both units and was combined to form one data base. No significant differences between the components of Unit 2 and Unit 3 were identified; therefore, no basis was found for pursuing the hypothesis that the unreliability of Unit 2 components could be different from the unreliability of Unit 3 components.

Failure rates were calculated as point-estimate values. An hourly failure rate is defined as the number of failures that occur during a particular period of component operation divided by the operating hours of the component. This type of point estimate was used to calculate the failure rates of pumps and diesel generators failing to run. The demand failure rate is the number of failures during a particular period of time divided by the number of component demands that occurred during the same period. This type of point estimate was used to calculate the failure rates of components failing to start, and motor-operated valves failing to open or close.

The boundaries of each component were also considered in the screening of failures and maintenance events. For example, circuit breakers and handswitches were included within the boundaries of pumps, and failures of the subcomponents were counted as failures of the pump.

NUREG/CR-2815 was the primary source of generic failure rate data. NUREG/CR-2815 was the first source consulted and was used except in cases where it did not provide data for the particular failure mode needed or where some other source was determined to provide more relevant data. NUREG/CR-4550 was the primary source of generic maintenance unavailability data. Generic data were obtained from other industry sources for use in this task, including IEEE Std. 500-1984 and WASH-1400.

For the Modified IPE, "pre-initiator" type failures of standby instruments were re-considered and plant-specific data was reviewed. For most instruments, generic failure rates (together with appropriate standby mission times) were judged to appropriately represent failures, including out-of-calibration failure due to personnel errors. Nevertheless, the review resulted in use of a plant-specific demand failure probability to represent calibration errors for pertinent pressure and flow instruments. The plant-specific demand failure probability estimate for pressure and flow instruments was based on recent plant experience (i.e., a period of approximately 5 years, through the end of 1995).

Testing was found to affect the unavailability of only a few systems analyzed (Isolation Condenser and Anticipated Transient Without Scram systems). These unavailabilities were calculated from the test frequencies and their average durations based on Dresden-specific experience and documentation.

1.4.2 Success Criteria

For the Dresden IPE/AM project, a large number of plant specific analyses were performed to define the 'success criteria' for the Dresden model. These analyses were performed using computer codes and hand calculations.

COMPACT was used for the reactor building analysis and MAAP was used to predict containment and RCS responses for the equipment survivability evaluations.

1.4.3 Human Reliability Analysis

The original Human Reliability Analysis (HRA) for the Dresden IPE utilized the Technique for Human Error Rate Prediction (THERP). The revised HRA implemented a newer alterative technique, the EPRI CBDTM (Cause Based Decision Tree Methodology) from EPRI TR-100259. The methodology estimates the cognitive (Pc) part of the HEPs by evaluating a series of decision trees that evaluate failure mechanisms such as: data availability, failure of attention, data misread/miscommunicated, information misleading, procedure step missed/misread, misinterpreting instructions, misinterpreting logic, and deliberate violation.

Estimation of the execution (Pe) portion of the HEPs was based on THERP data. Various tables in Chapter 20 of the THERP manual were utilized, as appropriate, in determining the HEPs. The approach was essentially to review each procedure to identify the critical sub-tasks (i.e., those essential to completion of the task(s)) and to determine whether any potential recoveries (such as verification of flow or valve position, alternative steps accomplishing the same action, revisitation of the step due to a procedure "loop', etc.) were present in the procedure and would be read in accordance with the procedure format.

The operator actions within each of the Plant Response Trees were analyzed on a sequence-by-sequence basis to identify the conditions of stress, dependency, and availability of recovery opportunities. This sequence by sequence evaluation generated multiple cases for each of the operator actions.

For the Modified IPE, significant operator actions were re-evaluated. Only those actions which had a Risk Achievement Worth of greater than 2.5 and those actions which were added as a result of changes to the Plant Response Trees and Fault Trees received a complete evaluation utilizing the EPRI CBDTM technique. The remaining HEPs were reviewed for reasonableness of values and for the selection of the appropriate value for each branch of the PRTs.

All of the HEPs after the re-evaluation have values above 1.0E-4, except for OSPC (Operator action to initiate Suppression Pool Cooling), as discussed in Section 4.4.2. Some of the actions changed significantly, some increasing and some decreasing. Except for OSPC, none of the HEPs changed by more than a factor of six.

1.4.4 Common Cause Analysis

"Common cause" describes multiple failures of functionally identical components due to a single, shared cause. Common cause analysis (CCA) evaluates the effects of these dependencies that may affect the ability of a system to prevent or mitigate a severe accident.

The Dresden CCA modeled common cause failures at the basic event level, employing the Multiple Greek Letter (MGL) method as defined in NUREG/CR-4780, "Procedures for Treating Common Cause Failure in Safety and Reliability Studies."

The evaluation of Dresden failure data indicated that there had been no common cause events at the Dresden site applicable to current maintenance and operating practices. As a result, to more realistically model current experience at Dresden, a Dresden-specific evaluation of common cause failure events was performed. Dresden-specific common cause parameters were developed for components that had data available, including the following:

- Circuit Breakers
- Check Valves
- Service Water Pumps
- Diesel Generators
- Motor-operated Valves
- Relief Valves
- HPCI Room Coolers
- Fans

A generic common cause failure database was developed from EPRI NP-3967, "Classification and Analysis of Reactor Operating Experience Involving Dependent Events", supplemented with events from the September 1990 EPRI draft report, "A Database of Common Cause Events for Risk and Reliability Evaluations".

A four-member expert judgement panel reviewed data from the generic common cause failure database for applicability to CECo plants. The expert panel came to a consensus opinion on each generic common cause event's applicability to Dresden, based upon current Dresden system configuration, and maintenance and operating practices. Events involving known common cause mechanisms addressed by specific programs in place at Dresden were discarded from the database as were common cause events that occurred due to specific system configurations not present at Dresden. Events involving common cause mechanisms that have been addressed in general by maintenance or operating practices at Dresden were assigned a lesser probability of occurrence based on judgement of the panel.

For the Modified IPE, a "floor" of 0.01 was imposed on beta values.

Flooding events such as pipe, valve, and tank breaks or ruptures are sufficiently infrequent to be unimportant as trip initiators alone. Only if the same flooding event also degrades safe shutdown capability will the potential for core damage become significant.

The information gathered was used to analyze the flooding zones with the potential to result in equipment failures that could lead to core damage. Many zones were found to have drainage adequate to mitigate the effects of any flooding that could affect the zone. The potential for flood propagation to other zones and the potential for water spray to result in equipment failure was investigated. Shielding and distance from potential spray sources was also considered in the evaluation, as well as the qualification of equipment for operation in adverse environments. All of the flooding zones except for the Unit 2 and 3 Turbine Building Condensate Pump Rooms were eliminated from consideration during the qualitative analysis. The frequency for flooding occurring in the Condensate Pump rooms is approximately 1.2E-02 per year. This event would be similar to a loss of feedwater transient which is already considered in the evaluation of transient events. This contribution to the transient initiator is probabilistically insignificant in comparison with the transient initiator frequency.

Although electrical switchgear was not identified as being threatened by flooding, water spray from nearby pressurized piping is possible should a pipe leak occur. An electrical bus or motor control center was conservatively assumed to fail if sprayed by a pipe leak. Potential water spray of electrical switchgear was included in estimating initiating event frequencies for the pertinent special (support system based) initiators.

1.4.6 Equipment Survivability

As part of the Dresden IPE, equipment important for prevention of core damage and/or containment failure was evaluated for survivability during the range of accident conditions postulated in the IPE. To accomplish this task, the Dresden equipment survivability study was divided into three phases:

Phase I: Support State and Fault Tree Assumptions
Phase II: IPE Conditions
Phase III: Accident Management/Core Damage Conditions.

For Phase I of the study, the assumptions regarding support equipment in the support state and fault tree models were reviewed. Analyses were then completed, as necessary, to verify the assumptions. All support state and fault tree assumptions were confirmed by this analysis.

Phase II of the study involved a review of all Plant Response Trees (PRTs) for a determination of the components (including instrumentation) important in achieving 'successful' end states. The limiting conditions, with respect to the PRTs, were then identified for each piece of equipment and a survivability evaluation was completed. The results of the phase II investigation show that all components that are modeled in the PRTs would be available for the appropriate accident sequences.

Phase III of the study will consider the equipment identified for accident management purposes. This will include the equipment needed for post-24 hour accident management to maintain the plant in a safe, stable state (i.e, a SAM endstate); the equipment needed for containment accident management following a core damage event; and any other equipment which is identified for the overall CECo accident management program. The

and sequences. Then, an innovative aspect of the Dresden IPE/AM program is reported: the frequency of occurrence of so-called Accident Management (AM) sequence endstates.

In the Dresden IPE/AM Program, two types of AM sequences have been defined. "Success with Accident Management" or "SAM" endstates have been defined for sequences with no core damage within 24 hours, but requiring accident management actions after 24 hours to assure continued long-term core cooling. "Containment success with Accident Management" or "CAM" endstates have been defined for sequences with core damage and no containment failure within 24 hours, but requiring accident management actions after 24 hours to assure continued long-term containment integrity. The method used for classifying sequences in the Dresden IPE/AM project is shown in Table 1.5-1.

1.5.1 Summary of Results

The core damage frequency for Dresden Station is 3.4E-06/yr. Of this total, the frequency of core damage and containment success is 2.0E-06/yr. The remainder of the core damage frequency would result in fission product releases due to venting the containment or containment failure (or both), that exceed normal containment leakage.

The core damage frequency (CDF) and the initiating event frequency are shown in Table 1.5.1-1 by initiating event. As can be seen from this table, the top two initiators contribute 63% to the total CDF, the top three initiators contribute 86%, the top four initiators contribute 94%, and 98% of the CDF comes from five initiating events with one single initiator contributing 39% to each of these percentages. The other initiating events contribute about 2% of the total core damage frequency.

The core damage frequency by "plant damage state" is shown in Table 1.5.1-2 for plant damage states within the upper 95% of the total CDF. As can be seen from this table, a large number of the plant damage states involve the failure of operator action (OAD) to initiate the automatic depressurization system (ADS) function. In fact, 44% of the top 95% contribution to the CDF involve plant damage states with a loss of the OAD function. This is primarily attributed to significantly increasing the OAD failure probability after re-evaluating the Dresden IPE Model HEPs.

The plant damage states shown in Table 1.5.1-2 also provide an indication of the capability of the plant to contain radioactive fission products within the plant boundaries. For core damage sequences, 61% of the CDF is represented by sequences in which the containment is intact and not vented. These sequence plant damage states are represented by the letters B, M, or G in the fourth position. The vented-and-failed states (representing controlled releases through one of the vent paths prior to containment failure) compose 10% of the CDF and are those states having L, O, or P in the fourth position of the endstate designator. These two sequence groups combined represent 71% of the CDF.

Containment failures are represented by plant damage states in which the containment fails after having been previously vented or in which the containment fails directly due to high pressure. Sequences represented by "O" are vented-and-failed sequences contributing 10% to the CDF. Late high temperature/pressure containment failures ("X" or "Y") contribute 6%. Rapid containment failures compose 22% of the CDF and are represented by N, Q, R, S, T, U, or V endstate designators in the fourth position.

Table 1.5.1-3 identifies the key contributors, both hardware failures and operator errors for each of the unsuccessful events in the top 7 sequences. These 7 sequences contribute approximately 62% to the CDF. Sequences #8 and above have a CDF contribution of less than 2.5% per sequence and a frequency of less than 1E-07 per year.

The core damage frequency of 3.4E-06 per year for Dresden is dominated (19% of CDF) by sequence #1, medium LOCA with early core damage (0-2 hours), due to HPI failure and operator failure to depressurize; injection into the failed vessel by LP pumps and SPC prevents containment failure. The Dresden IPE analyzes 17 initiating events. The medium LOCA initiator contributes 39% of the CDF, the dual-unit loss of offsite power contributes 24% of the CDF, the anticipated transient without scram initiator contributes 23% of the CDF, the single-unit loss of offsite power initiator contributes 8% of the CDF, and the general transient initiator contributes 4% of the CDF. These top five initiators contribute 98% of the total CDF. The remaining 8 initiators contribute less than 3% of the total CDF and the last 4 initiators contribute less than 0.01% of the total CDF. The top 15 sequences have individual contributions greater than 1% of the CDF and sequence #16 and above have individual contributions less than 1% of the CDF. The CDF distribution becomes flat at sequence #16 and above.

These results show a significant contribution to CDF from support systems, specifically AC power. Also, there is a significant contribution to CDF from failure of the high pressure injection system (HPI), failure of suppression pool cooling, and failure of the operator action to initiate the automatic depressurization system (ADS). There is a minor contribution from operator actions such as failure to inhibit the automatic depressurization system (OIADS), failure to makeup to the isolation condenser, failure to initiate the standby liquid control system (OSL1, OSL2), and failure to initiate the reactor protection trip system.

The majority of sequences (about 53%) involve early core damage (0-2 hours). All of the early core melt sequences with early containment over-pressure failure are initiated by ATWS. About one-third of the core damage sequences (32%) involve late core damage. The remaining one-sixth of the sequences (15%) involve intermediate core damage.

Overall, containment integrity is maintained in about 61% of the core damage sequences, while containment failure before vessel failure or shortly after vessel failure occurs in about 39% of the core damage sequences.

TABLE 1.5.1-1
CORE DAMAGE FREQUENCY BY INITIATING EVENT

INITIATING EVENT	INITIATING EVENT FREQUENCY (/YR)	CORE DAMAGE FREQUENCY (/YR)	PERCENT CONTRIBUTION
Medium LOCA[1]	8.00E-04	1.3E-06	39
Dual Unit LOSP[2]	1.63E-02	8.2E-07	24
ATWS[3]	2.28E-04	7.7E-07	23
Single Unit LOSP[2]	5.10E-02	2.8E-07	8
General Transient	7.40E-00	1.4E-07	4
Loss of Service Water	4.48E-03	3.8E-08	1
Small LOCA[1]	3.00E-03	9.0E-09	0.3
Large LOCA[1]	3.00E-04	5.0E-09	0.2
IORV[4]	7.14E-02	2.3E-09	0.1
ISLOCA[5]	1.14E-07	4.7E-10	0.01
Loss of Bus 24	3.12E-04	3.7E-10	0.01
Loss of Instrument Air	6.95E-03	2.1E-10	0.01
Loss of Bus 23	1.62E-03	1.8E-10	0.01
Loss of Bus 28-2	1.27E-03	9.8E-11	<0.01
Loss of Bus 28	1.24E-03	8.9E-11	<0.01
Loss of Bus 21	1.76E-04	4.8E-11	<0.01
Loss of Bus 22	1.44E-04	4.1E-11	<0.01
TOTAL		3.4E-06	100

1. LOCA = Loss of Coolant Accident
2. LOSP = Loss of Offsite Power
3. ATWS = Anticipated Transient Without Scram
4. IORV = Inadvertent Open Relief Valve
5. ISLOCA = Interfacing System LOCA

TABLE 1.5.1-2
CORE DAMAGE FREQUENCY BY PLANT DAMAGE STATE

STATE	DESCRIPTION	FREQUENCY	PERCENT CONTRIB
MEAB	Medium LOCA with early core damage (0-2 hours), due to HPI failure and operator failure to depressurize; injection into the failed vessel by LP pumps and SPC prevents containment failure	1.0E-06/yr	30
TEEQ	ATWS with wetwell over-pressure failure prior to early core damage (0-2 hours) due to failure to trip recirc pumps or failure to inject SLC	6.0E-07/yr	18
BLAB	Station Blackout with late core damage (6-24 hours), due to operator failure to keep IC online; injection into the failed vessel by LP pumps and SPC prevent containment failure	5.1E-07/yr	15
MLCO	Medium LOCA with late core damage (6-24 hours) due to LPI failure; SPC fails, containment fails	2.9E-07/yr	9
LIAB	Loss of Offsite Power (single or dual unit) with core damage at 2-6 hours, loss of HPI, operator fails to depressurize and recover offsite power; SPC prevents containment failure	2.6E-07/yr	8
BLAY	Station Blackout with late core damage (6-24 hours), due to operator failure to recover offsite power and keep IC online	2.1E-07/yr	6
TIAB	General Transient with core damage at 2-6 hours, due to failure to makeup to IC, loss of HPI, failure to depressurize; SPC prevents containment failure	1.7E-07/yr	5
TEER	ATWS with drywell failure by over-pressure prior to early core damage (0-2 hours) due to failure to trip recirc pumps or failure to inject SLC	1.6E-07/yr	5
	TOTAL	3.2E-06/yr	95% of total CDF

1.5.2 AM Endstates

SAM Endstates - The SAM endstates occur with a cumulative frequency of 1.5E-06. The top 48 accident sequences with a SAM endstate represent 80% of the total SAM frequency, these 48 SAM sequences are presented in Table 1.5.2-1.

Based on a review of the dominant sequences with a SAM endstate, a set of possible accident management strategies to bring the plant to a long term safe, stable state can be developed. Since a relatively long time is available for accident management activities for the SAM endstates, the possible accident management activities include both repair of unavailable equipment and the implementation of alternate methods of achieving a safe, stable state. The information developed from the review of the SAM sequences represents input to the Accident Management Program for Dresden Station, for sequences which otherwise would progress to core damage at a time beyond 24 hours after the initiating event.

TABLE 1.5.1-3
KEY CONTRIBUTORS TO DOMINANT ACCIDENT SEQUENCES

SEQUENCE	EVENT	NODE	DESCRIPTION OF KEY CONTRIBUTORS
1	MLOCA	OAD	Operator failure misreading reactor vessel water level or omission of step in depressurization procedure.
		HP2	Failure of HPCI pump to start or run.
2	DLOOP	DGB	Failure of DG 2/3 to start or run, or maintenance.
		DG2	Common cause failure to start or run of DG2.
		DG3	Common cause failure to start or run of DG3.
		SBO	Station blackout occurs in Unit 2 and Unit 3.
		ROP1	Failure to recover offsite power within 4 hours to prevent core damage.
3	MLOCA	HP1	Failure of HPCI pump to start or run, or maintenance unavailability.
		OAD	Operator failure misreading reactor vessel water level or omission of step in depressurization procedure.
4	MLOCA	SPC	Common cause failure of suppression pool cooling due to plugging or common cause MOV failures.
5	DLOOP	DGB	Failure of DG 2/3 to start or run, or maintenance
		DG2	Common cause failure to start or run of DG2.
		DG3	Common cause failure to start or run of DG3.
		SBO	Station blackout occurs in Unit 2 and Unit 3.
		ROP1	Failure to recover offsite power within 4 hours to prevent core damage.
		ROP2	Failure to recover offsite power within 6 hours (given offsite power was not recovered by 4 hours) to prevent containment failure.
6	ATWS	RCFM	Control rod mechanical failure.
		OIADS	Operator failure to inhibit automatic depressurization system.
7	ATWS	MC	Main condenser unavailable.
		RCFM	Control rod mechanical failure.
		AT	ATWS system actuation of recirc pump trip fails.

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TABLE 1.5.2-1
KEY CONTRIBUTORS TO "SAM" ACCIDENT SEQUENCES

SAM Seq. No.	INITIATING EVENT	SEQUENCE FREQUENCY	DESCRIPTION OF FAILED PRT NODE
1	GTR	9.710E-08	2M1, ICH2, FW, LP, SPC
2	LOOP	8.246E-08	DGB, ICH1, ROP1, LP, SPC
3	LOOP	7.921E-08	DGB, 24, MUP, ROP1, LP, SPC
4	ATWS	6.518E-08	MC, ICH2
5	LOOP	5.577E-08	DGB, MUP, ROP1, LP, SPC
6	ATWS	5.084E-08	FWA, MC, ICH2
7	ATWS	4.842E-08	RCFM, OSL1, OSL2
8	LOOP	4.497E-08	ICH1, ROP1, SPC
9	LOOP	4.295E-08	DGB, 24, ICH1, ROP1, LP, SPC
10	ATWS	4.289E-08	MC, MUP
11	IORV	3.406E-08	FW, SPC
12	ATWS	3.346E-08	FWA, MC, MUP
13	LOOP	3.041E-08	MUP, ROP1, SPC
14	ATWS	3.007E-08	MC, RCFM, ICH2
15	LOOP	2.836E-08	DGB, OMUP, ROP1, LP, SPC
16	LOOP	2.754E-08	23, 24, MUP, ROP1, SPC
17	ATWS	2.345E-08	FWA, MC, RCFM, ICH2
18	ATWS	2.181E-08	MC, OMUP
19	DLOOP	2.176E-08	DGB, ICH1, ROP1, LP, SPC
20	DLOOP	2.092E-08	DGB, 24, MUP, ROP1, LP, SPC
21	ATWS	1.979E-08	MC, RCFM, MUP
22	ATWS	1.899E-08	FWA, ICH2
23	ATWS	1.701E-08	FWA, MC, OMUP
24	ATWS	1.563E-08	RCFM, SLC
25	LOOP	1.546E-08	OMUP, ROP1, SPC
26	ATWS	1.543E-08	FWA, MC, RCFM, MUP
27	LOOP	1.523E-08	DGB, DG2, ICH1, ROP1, LP, SPC
28	LOOP	1.493E-08	23, 24, ICH1, ROP1, SPC
29	LOOP	1.477E-08	DGB, 24, OMUP, ROP1, LP, SPC
30	DLOOP	1.472E-08	DGB, MUP, ROP1, LP, SPC
31	LOOP	1.463E-08	DGB, DG2, 24, MUP, ROP1, LP, SPC
32	GTR	1.327E-08	ICH2, FW, SPC
33	ATWS	1.250E-08	FWA, MUP
34	DLOOP	1.218E-08	ICH1, ROP1, SPC
35	DLOOP	1.135E-08	DGB, 24, ICH1, ROP1, LP, SPC

TABLE 1.5.2-1 (Continued)
KEY CONTRIBUTORS TO "SAM" ACCIDENT SEQUENCES

SAM Seq. No.	INITIATING EVENT	SEQUENCE FREQUENCY	DESCRIPTION OF FAILED PRT NODE
36	LOOP	1.030E-08	DGB, DG2, MUP, ROP1, LP, SPC
37	ATWS	1.006E-08	MC, RCFM, OMUP
38	ATWS	9.094E-09	FWA, RCFM, ICH2
39	GTR	8.734E-09	MUP, FW, SPC
40	DLOOP	8.237E-09	MUP, ROP1, SPC
41	LOOP	7.935E-09	DGB, DG2, 24, ICH1, ROP1, LP, SPC
42	ATWS	7.847E-09	FWA, MC, RCFM, OMUP
43	DLOOP	7.483E-09	DGB, OMUP, ROP1, LP, SPC
44	DLOOP	7.465E-09	23, 24, MUP, ROP1, SPC
45	LOOP	7.140E-09	DG2, ICH1, ROP1, SPC
46	DLOOP	6.500E-09	DG2, DG3, SBO?, ICH1, ROP1, LP, SPC
47	DLOOP	6.405E-09	DG2, DG3, 23, SBO?, MUP, ROP1, LP, SPC
48	ATWS	6.355E-09	FWA, OMUP

CAM Endstates - These sequences have end state designators with "AB" as the third and fourth characters. Within the top 100 core damage sequences, there are 50 sequences in this category.[1]

These sequences were investigated to determine whether the containment was pressurizing, heating up, or whether conditions were stable. The type "AB" sequences in which SPC and injection to the core debris bed continue, potentially result in containment failure also, but at a much later time. These sequences have a significant potential for avoiding containment failure through use of containment sprays to periodically cool the containment atmosphere, in conjunction with suppression pool cooling, which is functional throughout these sequences. If SPC fails at some time after 24 hours, several alternate sources of water to the core debris remain: the condensate storage tank, Standby Coolant Supply, and cross-connect to the unaffected unit's LPCI system. Repair of the affected unit's LPCI and CCSW systems can also return SPC and LPCI capability.

Ten of the CAM sequences are Station Blackout (SBO) sequences (SBO in Units 2 and 3) in which offsite power is not recovered in time to prevent core melt, but is recovered in time to supply containment systems and to reduce containment failure likelihood. Likewise, SPC and injection to the core debris bed need to be maintained and used in conjunction with containment sprays to prevent containment failure.

1.5.3 Evaluation of Large Early Release Frequency (LERF)

The large, early release frequency (referred to as LERF) as defined in the NEI-sponsored PSA Applications Guide (EPRI TR-105396) published in August 1995. ***Large*** means that the event results in "the rapid, unscrubbed release of airborne aerosol fission products to the environment." ***Early*** means that the event occurs "before the effective implementation of the off-site emergency response and protective actions." The PSA Applications Guide also includes a general guideline that an early release "Occurs Before or Within 4 Hours of Vessel Breach."

The Modified IPE gives a LERF of 1.6E-7/yr, less than 5% of the total CDF value. This LERF value corresponds to approximately once in 6,000,000 years.

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[1] The analysis of "CO" type sequences indicates that containment structural failure due to high temperature would occur at about 27-28 hours into the event. Although potentially CAM sequences, the "CO" sequences are considered in this study to be containment failure sequences. (See Table 4.5.5-3 for the source term analysis results.)

1.6 IPE Evaluations

1.6.1 IPE Insight Development

In the broadest sense, insights are those observations regarding the station configuration or practices which may affect the risk profile of the plant. Insights can suggest changes to enhance the capability of the plant and the plant operators to respond to an initiating event to either prevent core damage or to mitigate the consequences of core damage. Insights can also include those "good features" which have been identified during the IPE process. The IPE insights described in this section address the capability of the existing plant (January 1991) to respond to an initiating event. IPE insights are distinguished from Accident Management Insights which deal with enhancements to the capability of the plant emergency response organization to respond to a core damage accident situation, given that it has occurred.

In order to focus the IPE analysts on the identification of IPE insights, it was necessary to develop structured guidance. The development of the guidance began with the definition of the aspects of the plant which can impact the severe accident risk profile including: plant design features, testing and maintenance activities, the EOPs and DGAs, training, and plant status information. These broad features were then correlated to the IPE work products to define the types of IPE insights which could be obtained from each task of the IPE analyses. This detailed correlation of possible plant features versus IPE work products was used to define a set of questions for each IPE task which would focus and stimulate the IPE analysts to identify insights as the tasks were being performed. Therefore, at each step of the risk assessment, analysts were systematically required to answer questions to stimulate the identification of insights. In addition to changes to Dresden Station to improve the accident risk profile, the IPE insights also include good features of Dresden Station which contribute to its present risk profile.

The IPE insights identified in the current study are, in many cases, significantly different from those identified in previous PRA studies. The primary difference is in completeness of the search for insights and the comprehensive coverage of all of the aspects of the IPE. The Dresden IPE insight development methodology prescribes the identification of insights by each analyst as the work is ongoing, instead of the process employed in previous PRA studies, which was backward looking from the IPE results.

Another aspect of the IPE insights identified during this study is the overall approach of using best estimate analyses for the accident progression and mapping the plant procedures to the accident progression to determine those operator actions which can impact the accident progression. This has resulted in a comprehensive review of the plant procedures for their impact on the progression of accidents, including core damage accidents. As a result of this review, a significant number of insights were developed relating to enhancements to the procedures, primarily to improve clarity and the likelihood that appropriate operator actions will be taken in response to plant parameters.

IPE Insight Evaluation

For each of the over 130 IPE insights developed during the IPE, a process of evaluation was followed. The first step of the process was a distillation of the insights by a "Tiger Team", composed of individuals from CECo and the IPE Partnership. The first step of the distillation consisted of verifying the technical accuracy of each of the insights. The Tiger Team then grouped all of the insights related to the same subject together for further evaluation. Groupings were performed for the following subject areas:

- 125VDC Power
- Containment Flooding
- ISLOCA
- NRC Strategies
- Loss of Offsite Power
- Plant Procedures
- Containment Performance

At that point the insights within a group were evaluated for their effect on the risk profile of the plant. The insights with the greatest impact on the risk profile were identified. Of particular interest are those insights which provide a major benefit to risk reduction and can be implemented with minor impact to plant hardware or procedures.

A further grouping of insights was performed to facilitate the disposition of plant enhancements by CECo management. This grouping consisted of the following types of enhancements: Generic Procedure Enhancements (11% of insights), Plant Specific Procedure Enhancements (42%), Hardware Enhancements (27%), Training (6%), Information (11%) and Test & Maintenance (3%).

All of the insight evaluation information was then presented to the Senior Edison Management Review Team (SEMRT) for final evaluation and disposition. As part of their evaluation process, the SEMRT utilized the NUMARC Severe Accident Closure Guidelines (NUMARC 91-04).

1.6.2 Evaluation Against NUMARC Severe Accident Issue Closure Guidelines

The results of the Dresden IPE have been evaluated against the NUMARC (now NEI) Severe Accident Closure Guidelines. The guidelines were used to assess the proposed enhancements developed via insights related to severe accidents.

The first step in using the Severe Accident Closure Guidelines was to group the core damage sequences; the groupings used were those of Table B-1 of that document.

The grouping was carried out for all core damage sequences down to the quantification frequency cutoff of 1E-12 for a given sequence. The following groups contain some contribution to the total core damage frequency:

IA Accident sequences involving loss of coolant inventory makeup in which the reactor pressure remains high.

IB Accident sequences involving a loss of all AC power and loss of coolant inventory makeup (i.e., station blackout).

ID Accident sequences involving a loss of coolant inventory makeup in which reactor pressure has been successfully reduced.

II Accident sequences involving loss of containment heat removal leading to containment failure and subsequent loss of coolant inventory makeup.

IIIB Accident sequences initiated or resulting in small or medium LOCAs for which the reactor cannot be depressurized and inadequate coolant inventory makeup is available.

IIIC Accident sequences initiated or resulting in medium or large LOCAs for which the reactor cannot be depressurized and inadequate coolant inventory makeup is available.

IV Accident sequences involving an ATWS leading to containment failure due to high pressure and subsequent loss of inventory makeup.

V Unisolated LOCA outside containment leading to loss of effective coolant inventory makeup.

The sequence numbers of the top 100 sequences included in each group are listed in Table 1.6.2-1 with the resulting mean group core damage frequency and percent contribution to the total core damage frequency. The group core damage frequency and contribution is based upon all sequences.

The core damage frequency and percent contribution to the total core damage frequency for each group were then evaluated against Tables 1 and 2 of the Severe Accident Closure Guidelines. Table 2 was used for the containment bypass sequences (group V only), and Table 1 was used for all other groups. The comparison shows that the IB, IIIB, and IV groupings are of interest with respect to the Severe Accident Closure Guidelines.

The IIIB group CDF falls into the Table 1 category range of mean CDF 1E-5/yr to 1E-6/yr that suggests the licensee ensure that Severe Accident Management Guidance (SAMG) is in place with emphasis on prevention/mitigation of core damage or vessel failure, and containment failure.

The IB, IIIB, IV groups fall into the Table 1 category range of 20% to 50% of total CDF that suggests the licensee:

1. Find a cost effective treatment in EOPs or other plant procedure or minor hardware change with emphasis on prevention of core damage.

TABLE 1.6.2-1
NUMARC SEVERE ACCIDENT CLOSURE GUIDELINES
SEQUENCE GROUPING INFORMATION

SEQUENCE GROUP	SEQUENCE NUMBERS[1]	CORE DAMAGE FREQUENCY	TOTAL GROUP % CONTRIBUTION TO TOTAL CDF
IA	9, 10, 11, 17, 18, 25, 26, 32, 34, 40, 44, 49, 50, 61, 63, 65, 69, 73, 74, 75, 77, 79, 81, 82, 83, 85, 87, 93, 98, 100	4.3E-07	12.7%
IB	2, 5, 19, 22, 28, 31, 38, 47, 48, 51, 53, 56, 58, 62, 76, 84, 86, 88, 92, 99	7.4E-07	21.9%
ID	29, 60, 72	2.1E-08	0.6%
II	None in top 100 sequences		
IIIB	1, 3, 42, 54, 71	1.0E-06	30.4%
IIIC	4, 35, 43, 45, 67, 70, 90, 91, 96	2.9E-07	8.5%
IV	6, 7, 8, 12, 13, 14, 15, 16, 20, 21, 23, 24, 27, 30, 33, 36, 37, 39, 41, 46, 52, 55, 57, 59, 64, 66, 68, 78, 80, 89, 94, 95, 97	7.3E-07	21.7%
V	None in top 100 sequences		

[1] Refers to the sequence position in the ranking of core damage sequences in descending magnitude of core damage frequency.

2. If unable to satisfy above response, ensure SAMG is in place with emphasis on prevention/mitigation of core damage or vessel failure, and containment failure.

These suggested actions were again considered for potential plant enhancements. The addition of the SBO Diesel Generators should significantly reduce the contribution of sequence group IB. It is anticipated that the core damage and containment release frequency contribution within sequence groups IIIB and IV will be reduced by the implementation of Severe Accident Management Guidelines (SAMGs).

1.6.3 Conclusions of IPE Enhancement Evaluations

The utilization of the NUMARC Severe Accident Issue Closure Guidelines in the original IPE submittal identified the need for the implementation of one or more plant enhancements at Dresden station related to sequences in which suppression pool cooling has failed. A procedure enhancement related to alignment of LPCI or Core Spray pump suction to the condensate storage tank when suppression pool cooling cannot be established has been implemented. As a result, no group II events now appear in the top 100 sequences. A procedure enhancement to maintain the function of the Isolation Condenser during long-term SBO events resulted in a reduction of the group 1B sequences.

Because all of the groups have a core damage frequency of less than or equal to 1E-6, a vigorous pursuit of further enhancements is not warranted at this time. It is anticipated, however, that the core damage and containment release frequency contribution within many of these sequence groups will be reduced by the implementation of SAMGs issued by the BWROG.

A number of individual AM insights for Dresden Station were identified by the IPE analysts and evaluated by the Dresden Tiger Team. The distribution of insights over the elements of the AM framework was concentrated in accident management strategies and information, as expected:

Organization	1%
AM Guidance	39%
AM Tools	19%
AM Training	1%
AM Information	40%

A series of experiments performed as part of the Dresden IPE/AM program verified that submerging the bottom portion of the reactor vessel can prevent vessel failure after relocation of the damaged core to the lower head, given that the RPV support skirt is modified to allow the egress of steam. This would eliminate the subsequent postulated containment challenges related to ex-vessel phenomena such as direct containment heating, ex-vessel steam explosions, and core-concrete interactions. AM insights have identified the need for providing alternate means of achieving containment sprays to control fission product release fractions, especially under station blackout conditions. Finally the IPE analyses have indicated the importance of being able to monitor and understand the progression of the core damage accident. As a result of these insights and work performed by NUMARC, the BWR Owners Group developed Severe Accident Guidelines (SAG) and recommended changes to the EPGs for the emergency response organizations. To perform these functions and training in the use of these AM tools, implementation of Severe Accident Management (SAM) will be achieved within the constraints of existing personnel and plant hardware consistent with the NEI formal industry position on SAM.

1.8 Conclusions

The Dresden IPE/AM project is believed to be one of the most comprehensive PRAs ever undertaken. It has provided a new level of understanding of the plant and its behavior under a variety of potential accidents.

The realistic modeling employed in the Dresden IPE shows that Dresden Station design is very good. The Dresden EOPs are effective in responding to severe accidents, and they contribute to Dresden Station's low core damage frequency. Dresden Station was found to have no serious weaknesses or vulnerabilities.

The core damage frequency was calculated to be 3.4E-06/yr.

Of the total core damage frequency, 99% is spread over six initiating events; the top contributor to core damage frequency is Medium LOCA at 39% followed by Dual Unit Loss of Offsite Power at 24%, Anticipated Transient Without Scram at 23%, Single Unit Loss of Offsite Power at 8%, General Transient at 4%, and Loss of Service Water at 1%. The other initiating events contribute about 0.5% of the total core damage frequency.

A review of the results using Fussell-Vesely importance measures indicates that the most significant hardware contributors are the emergency diesel generators and the most significant operator contributor is the operator action to initiate the automatic depressurization system (ADS). The hardware enhancement with the greatest potential for reducing core damage frequency is completing the installation of the station blackout diesel generators.

The utilization of the NUMARC Severe Accident Issue Closure Guidelines in the original IPE submittal identified the need for the implementation of one or more plant enhancements at Dresden station related to sequences in which suppression pool cooling has failed. A procedure enhancement related to alignment of LPCI or Core Spray pump suction to the condensate storage tank when suppression pool cooling cannot be established was implemented in early 1994. As a result, no group II event appears in the top 100 sequences of the Modified IPE.

A procedure enhancement to maintain the function of the Isolation Condenser during long-term SBO events was implemented in late 1993 and resulted in a reduction of the contribution of group IB sequences. One significant enhancement, installation of the station blackout diesel generators, is nearing completion and will further reduce the contribution of the group IB sequences. Because all of the NUMARC sequence groups have a core damage frequency of less than or equal to 1E-6/yr, a vigorous pursuit of further enhancements is not warranted at this time.

The use of realistic analyses, in conjunction with modeling the EOPs, has shown that some accident sequences do not achieve core damage until well after 24 hours. Rather than assuming that these sequences were successes, as has been done in past PRAs, these sequences were separately identified and were categorized as resulting in the success with accident management (SAM) endstate. The SAM sequences have a predicted frequency of occurrence of 1.5E-06/yr. It was found that simple actions for each of these sequences could restore the plant to a long-term safe, stable state.

The frequency of uncontrolled release caused by high pressure and/or high temperature containment failure was calculated to be 9.7E-07/yr (29% of the total CDF). This frequency consists almost entirely of ATWS and station blackout events where venting would be unavailable or ineffective. Source terms in these sequences are much larger than those due to other types of accident sequences. A notable portion of the total core damage frequency is due to sequences in which the containment is vented during the event and, though vented, fails later due to high temperature (3.3E-07/yr; 10% of the total CDF). In yet other sequences, LPCI injection or drywell sprays are used in combination

with suppression pool cooling to prevent containment failure and limit source terms to containment leakage (2.1E-06/yr; 61% of the total CDF). The interfacing systems LOCA sequence frequency of 4.7E-10/yr at Dresden makes ISLOCA a negligible contributor to source term and plant risk. For an inerted containment, the likelihood of plant operation with a failure to isolate is extremely remote.

The Dresden IPE demonstrated that MAAP is a very useful tool for plant analysis. It was found to be of value for system success criteria and for event timing, as well as for calculation of fission product releases.

The ComEd PRA staff has been intimately involved in the IPE process and has acted as both originator of IPE analyses and reviewer of all IPE analyses. In addition, the ComEd PRA staff performed all of the analyses required for the Modified IPE. As a result of the Integrated IPE/AM Program, the ComEd PRA staff has developed a unique understanding of the behavior of the plant under accident conditions and of the total plant capabilities to respond to accidents.

As an indication of the value of the IPE model, a proposed plant modification, the installation of station blackout diesel generators at the station, was evaluated as part of the original IPE to estimate its impact on plant core damage frequency. That evaluation found that this modification would reduce the core damage frequency given by the original IPE model only minimally compared to the benefit gained from an Isolation Condenser procedure enhancement identified during the IPE. That procedure enhancement was subsequently implemented in 1993. This evaluation process demonstrates the value of the IPE as an input to the plant management process.

The principal purpose of the Dresden IPE was to develop an understanding of the response of the plant to severe accidents. It accomplished this purpose. A second purpose of the Dresden IPE was to serve as the basis for an Accident Management program. The insights developed during performance of the Dresden IPE will be reviewed and dispositioned during the Dresden-specific implementation of the BWR Owners Group generic SAM guidance. This effort will form the basis for future development and implementation of the Dresden Accident Management program. The final results of the study support the idea that the best improvement for plant safety is a good Accident Management program.

Although accident management considerations were not required at this time, an extensive accident management evaluation program was conducted to fully integrate the IPE/AM effort.

Finally, the results of the IPE have been carefully reviewed to identify areas where plant improvements could be effectively made with emphasis on core damage prevention.

2.3 Information Assembly

A tremendous amount of information was needed to perform the detailed Dresden IPE/AM study. The project team reviewed and assembled information from plant specific sources, relevant plant studies, and generic sources. Plant walkdowns were an important part of the data collection effort. Information was assembled to familiarize the analysts with the plant, determine and quantify the important initiating events, determine the component and system failure rates, perform various supporting analyses (e.g., common cause failure), conduct the evaluation of internally initiated flooding events, and develop plant layout insights. Table 2-1 provides a list of the important information sources reviewed. Complete lists of individual references are documented in the project notebooks.

The Dresden team for the original IPE/AM study used only the latest revision of drawings, design documents such as the FSAR, and plant procedures that were available as of January 1991. Differences between these documents and systems and layout were noted and resolved or included in the models as appropriate, if found. Thus, the PRA models for the original IPE reflect the Dresden as-built condition as it existed in January 1991[1]. The Modified IPE took into account several major changes that had resulted from the original IPE, specifically two procedure enhancements and a modification. Additionally, selected human reliability analyses were revised as part of the Modified IPE. For the procedure enhancements and revised human reliability analyses, plant procedures that were available as of December, 1995, were used.

Detailed system notebooks were developed for 26 major systems and miscellaneous systems that were expected to have an influence on the IPE/AM results. In addition, notebooks were developed for the major elements of the IPE/AM analyses (e.g., initiating events, internal flooding, etc.). Again, the plant information sources identified in Table 2-1 were used to develop system descriptions and models. Both plant specific and generic sources were used to define component availabilities, initiating events and initiating event frequency, important accident sequences, potentially important modeling features, common cause failure rates, and human reliability data. Subsequent sections of this report provide more detailed discussions of the specific use of the information collected.

While no other Dresden specific PRA studies were directly consulted for use in the IPE/AM, information from plants similar to Dresden has been collected and incorporated

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[1] Two modifications to the plant, imminent in January 1991, were included in the "baseline" Dresden model: the installation of the hardened containment vent and the installation of diesel-driven isolation condenser makeup pumps.

where appropriately justified. NSAC 151, a report on other plant PRA's, was also reviewed for applicability.

Plant walkdowns were conducted by members of the IPE/AM team who were responsible for the evaluation of specific plant systems, or areas of special interest, e.g., internal flooding. The walkdown teams were led by CECo personnel who were knowledgeable about the plant and its detailed arrangement.

The walkdowns had a number of objectives in addition to the familiarization of the analysts with the plant systems and layout. Checklists were developed to collect information needed for the IPE analysis and the assessment of potential AM recovery actions. The scope of these checklists included:

- Assess room environment (cooling, barriers, open area, etc.),
- Assess diligence of maintenance (cleanliness, leaks, equipment condition, stored special equipment, etc.),
- Identify local controls & indications available,
- Establish ability to use local controls (posted instructions, lighting at controls, etc.),
- Identify potential room hazards,
- Identify control room alarms / indications for system or component,
- Identify flooding information (critical equipment, source of flooding, room drainage, etc.).

Figures 2-1 through 2-8 in Volume 2 (behind tab for Plant Layout) show the general areas of the plant. The systems and plant environment of most concern are contained primarily in the Reactor Building; however, several other buildings or areas are important because of the key equipment located in them. The areas or buildings of importance to the Dresden IPE are:

- Reactor Building
- Turbine Building
- Crib House
- Control Room
- Outside Grounds

2.4 General Methodology

The Dresden IPE/AM program, as previously mentioned, consisted of 14 major task areas encompassing a full scope Level II PRA and an Accident Management analysis. These analyses used standard PRA methodology and were focused on performing a realistic assessment of plant response to postulated severe accidents.

The plant systems and operator actions were modeled in detail including explicit modeling of all key components. The MAAP code was used to develop realistic success criteria as well as the plant response to each important accident sequence. Accident Management assessment methodology was integrated into the steps of the PRA evaluation to develop detailed insights concerning system faults and potential recovery actions. The key tasks are discussed below.

Plant Familiarization

Plant familiarization was accomplished through a combination of a comprehensive document review and plant walkdowns. The document review included: the plant FSAR, design drawings, design descriptions, training materials, normal and emergency operating procedures, technical specifications, test procedures, location and layout drawings. Walkdowns were used to develop an appreciation for the potential environmental impact on equipment that is difficult to discern from drawings. In addition, design descriptions and drawings were checked for accuracy and completeness during the walkdown process.

Plant Information and Data Analysis

Plant specific information was collected from a variety of logs, reports, and operator interviews for the period from January 1, 1984 through December 31, 1990 to examine plant specific component failure, testing, and maintenance data as well as initiating events that have led to reactor trips. In a few instances, generic data from IEEE-500, NUREG/CR-2815 Revision 1, or other sources, were used to supplement plant specific information when sufficient plant data was not available. For common cause failure data, the Multiple Greek Letter (MGL) method was used to generate failure probabilities.

Accident Initiators

The selection of accident initiating events for Dresden was made from the collection and analysis of plant trip data. Additionally, the plant specific data evaluation was supplemented with industry data from NUREG/CR-3862 and from WASH-1400.

Dresden trip data was collected from scram reports, deviation reports, LERs and plant operating logs to identify actual trip events, power level at which the trip occurred, the failure which caused the trip, and the safety equipment that operated in response to the event.

The Dresden accident initiating events included large LOCA, medium LOCA, small LOCA, interfacing systems LOCA (ISLOCA), loss of offsite power, transients and special (support

system based) initiators. Most transient initiators were evaluated together since they all leave the plant in a state where the reactor protection system (RPS) is challenged and demand is made of safety systems to provide the reactor with a reliable source of cooling and makeup injection. These transients include such events as reactor trips, turbine trips, loss of main feedwater, etc. Special initiators included loss of 125VDC (main bus) in one unit, loss of service water, loss of instrument air, loss of 4 kV buses 21, 22, 23, 24, 31, 32, 33, and 34, loss of steam tunnel cooling due to loss of 480 VAC buses 28 and 38, and loss of steam tunnel cooling due to loss of 480 VAC motor control centers 28-2 and 38-2.

Several methods were employed to determine initiating event frequencies for the relevant initiators. For those events having sufficient plant specific data, each event was categorized as identified above and the frequency determined by the number of events in the category. For events where there were insufficient plant specific data, such as LOCAs, the initiating event frequency was developed from generic data or similar plants. In the cases of small, medium, and large break LOCAs, the initiating event frequencies were taken from WASH-1400. Loss of offsite power was determined from a detailed study of the CECo grid reliability and plant experience.

Internal flooding was treated as a special initiator. A separate analysis was performed to determine if areas in Dresden are susceptible to flooding, and if there is sensitive equipment in those areas that could cause a plant shutdown or result in one or more failed safety systems. If such areas and equipment were identified, the contribution to core melt was evaluated from flooding those areas. The event trees from the other internal event initiators were used to quantify the contribution of flooding to core melt frequency.

Intersystem Dependence

A detailed analysis of dependence of the various frontline safety systems and supporting systems was conducted for each of the identified initiators, and for the interactions between the two Dresden units. Dependency matrices were developed for the dependence of a) frontline and support systems upon the initiating events, b) frontline systems upon support systems, c) frontline systems upon other frontline systems, d) support systems upon other support systems, and e) systems in one unit upon the systems or initiators in the other unit.

Information obtained from the accident initiating event analysis, system description documents and other sources, and plant walkdowns was used to construct the dependency matrices.

Event Tree Modeling

Plant response event trees (PRTs) and support state event trees were used to develop a Dresden accident sequence model. A plant response tree was developed for each initiator. A support state model was developed for each major class of initiating events: Transients (including LOCAs and most Special Initiators), Loss of Offsite Power, and the Loss of 125 VDC (main bus) Special Initiator.

Support systems were modeled in a separate support system event tree. The support system model was a dual unit model since the two Dresden units share important support systems. The frontline system trees were connected directly to the support system event trees by the computer code, QT, for the quantification process.

The plant response tree is a relatively unique and innovative modeling approach used by CECo for all IPE models. This tree combines the events of core damage prevention with those of accident progression through accident mitigation or containment failure and fission product release. The trees were developed by evaluating the accident initiator to

TABLE 2-1
DRESDEN IPE/AM INFORMATION SOURCES

SOURCE	PURPOSE[1]
Plant Specific	
System Descriptions	SN, DM
Updated FSAR	SN, DM
Units 2&3 General Arrangement Plan	SN, IF
Fluid System Drawings	SN, FT
Piping & Instrumentation Drawings	SN, FT
Station Electrical Drawings	SN, FT, SS
Station Structural Drawings	SN, ES
Technical Specifications	SN, FT, Q
Abnormal Operating Procedures	SN, FT, PRT
Emergency Operating Procedures	PRT, SN
Periodic Test Procedures	FT, Q
Maintenance Procedures	FT, Q
Licensee Event Reports (LERs)	Q, IE
Deviation Reports (DVRs)/Problem Identification Forms (PIFs)	IE, Q
Plant Operating History	IE, Q
Maintenance Records	Q
Scram Reports	IE, Q
Inoperable Equipment Log	Q
Dresden Operating Procedures (DOP)	SN, FT
IPE/AM System/Containment/Flooding Evaluation Walkdowns	SN, FT, DM, IF
Emergency Plan	ST
Plant Pump Head Curves for Key Pumps	ST, SC
HVAC Calculations	ES
DBA and LOCA Calculations	ST
Vendor Data/Specifications for Safety Grade Components	SN, SC
Fire Protection Studies	ID, PRT, IF
Tech Staff Surveillance Procedures	SN
Station Blackout Coping Study	SC

[1] Acronyms are defined at the end of this table.

analysts were organized so that independent review of each system model was conducted by selected members of the contractor team before its submittal to CECo. The CECo IPE/AM organization, described in Section 3.1 above, performed detailed technical reviews of the submitted models. Models were assigned to individuals or several of the PRA staff according to the expertise required. The reviews examined the quantification of the models as well as their accuracy and completeness. Comments and guidance were provided in meetings with contractor analysts to insure that appropriate modeling changes were made. This process was repeated until the CECo PRA staff was satisfied with the quality of the models.

At important milestones in the study, products and results were reviewed with the SMST and the CECo program manager. These additional reviews were conducted to insure that the approach taken, the products developed, and the results obtained were reasonable and acceptable.

A final review of the IPE/AM study was conducted by CECo senior management. Decisions concerning IPE and/or AM recommendations were made as part of the CECo management review.

As described in CECo's Project Plan, and as submitted in the earlier CECo response to Generic Letter 88-20, no separate "independent review" of the base Dresden IPE was performed. It is CECo's view that the quality of the study is assured by the employment of knowledgeable, experienced analysts both at IPEP and at CECo; as well as the many levels of review within the CECo program. The changes made in the generation of the modified Dresden IPE received an independent, peer review.

In addition to reviews of the IPE/AM studies conducted for accuracy and completeness, reviews were organized to develop realistic insights for possible plant improvements or accident management strategies. Program personnel participated in review of the models, results, and products as well as relevant material from other programs to identify and suggest insights. A group of senior level engineers, designated the "Tiger Team" and familiar with all aspects of plant design, operations, licensing environment, and severe accident issues, met regularly to review and distill insights into meaningful accident management strategies and/or plant improvements. The insights were further reviewed by the contractor Senior Management Support Team for further refinement, and a final review was made by CECo senior management of the recommendations as well as all other insights not selected for further consideration. The "Tiger Team" is intended to review the insights from all future CECo IPE/AM studies. CECo participants on the team are Mr. Harding, Mr. Raney, Mr. Knoespel, and Mr. Christensen for the BWR plants. The mix of CECo personnel who are intimately familiar with the plant and senior engineers with broad outside experience proved especially valuable in discerning the value of suggested insights and formulating broad strategies.

4.0 ANALYSES

4.1 Accident Sequence Delineation

This section describes the three key elements in defining the accident sequences. These three elements are the initiating events, the support system modeling, and the plant response tree modeling.

4.1.1 Initiating Events

CECo has identified the initiating events relevant to the Dresden IPE. These initiating events include the following:

- LOCAs involving the loss of coolant from the primary system due to pipe breaks, safety/relief valve failures and interfacing system piping ruptures.
- Transient events including reactor trips, turbine trips, loss of main feedwater, and loss of the condenser.
- Special (support system based) initiators.
- Other initiators including loss of offsite power (LOSP), loss of all AC power, and anticipated transient without scram (ATWS).

Transient events were identified through BWR operating experience. The following steps were taken to create a database of transient initiating events and make them specifically applicable to Dresden:

- Data from NUREG/CR-3862 was used to supplement historical data for categories which had no occurrence from 1/1/84 through 12/31/90.
- The Dresden trip history was reviewed to identify events that have occurred at this plant. To assure that the data reflected current Dresden configuration and operating practices, the time frame investigated was 1/1/84 through 12/31/90.
- The Dresden design and abnormal operating procedures were reviewed to determine whether plant conditions were considered that may result in the addition or deletion of accident initiators.
- The results of plant systems analyses were utilized to identify potential initiating events.

The Dresden initiating event frequencies are listed in Table 4.1.1-1. A summary of the method to develop each initiating event frequency is provided in the following paragraphs.

Large, Medium and Small LOCA frequencies were taken from WASH-1400 for this analysis.

The interfacing system LOCA frequency analysis was determined by a Dresden specific calculation considering all likely flowpaths. The frequency of high-energy line breaks (steamline-feedline ruptures) was calculated based upon methodology originally presented in WASH-1400 and further developed in the "Boiling Water Reactor Individual Plant Evaluation Methodology" by Delian Corporation.

The anticipated transient frequency is the sum of anticipated transient frequencies for Dresden. The NUREG/CR-3862 ("Development of Transient Initiating Events Frequencies for Use in Probabilistic Risk Assessments," May 1985) anticipated transient categories relevant to Dresden are grouped as one initiating event, with the exception of LOSP and loss of 125VDC power at one unit which were considered as special initiators. Although the transient events begin as significantly different initiators, these transient events break down to the same basic components, namely, removal of decay heat from the core and containment heat removal.

The original IPE included one special (support system based) initiator, loss of 125VDC (main bus). As a consequence of insights from the original IPE, a modification was performed on Unit 2 (and is planned for Unit 3) to eliminate this special initiator. Consequently, for the Modified IPE, the frequency of this initiator has been set to zero for Unit 2. The frequency for loss of 125VDC (main bus) for Unit 3 was determined by fault tree analysis techniques, with an additional water spray contribution based of leakage rate estimates for nearby piping. Loss of 125VDC in one unit affects both units due to the cross-connected design. Loss of the unit's own 125VDC power was selected as the power source lost because it provides the worst plant response, causing a plant trip and rendering some systems and subsystems inoperable.

The Modified IPE also added the following special initiators:

- Loss of 4 kV buses 21, 22, 23, 24, 31, 32, 33, and 34. The frequency of loss of these buses was determined by adding a water spray contribution to the failure frequency based on a fault tree analysis.

- Loss of service water. The frequency of this special initiator was determined by adding a contribution from rupture rate estimates (for large service water system piping) to the failure frequency based on a fault tree analysis.

- Loss of steam tunnel cooling due to loss of 480 VAC buses 28 or 38 or due to loss of motor control centers (MCCs) 28-2 or 38-2. The frequency of loss of these buses or MCCs was determined by adding a water spray contribution to the failure frequency based on a fault tree analysis.

- Loss of instrument air. The frequency of this special initiator was based on the instrument air system failure rate calculated as part of the original IPE.

The frequencies for single unit LOSP and dual unit LOSP were calculated separately. The methodology and site specific values developed in NUREG-1032 for grid related losses, weather related losses, and extreme weather related losses were used to

calculate the LOSP frequencies. The values for Plant Centered Loss (PCL) were calculated from generic data presented in NSAC-147 (Nuclear Safety Analysis Center, "Losses of Off-site Power at U.S. Nuclear Power Plants All Years Through 1989," March 1990) and NSAC-166 ("Losses of Off-site Power at U.S. Nuclear Power Plants All Years Through 1990," March 1991) for LOSP at dual unit sites. The generic PCL frequency for dual unit sites was used in the Dresden analysis. Three single-unit LOSP events have been experienced at the Dresden site. Plant-specific data were therefore used in the calculation of a single-unit LOSP at Dresden.

4.1.2 Support System Modeling

The support state methodology was used to model the key support systems and their impact on the safety systems that are required to respond to the initiating events modeled. The concept of a support state model allowed the major support systems to be modeled outside of the accident sequence event tree structures. Dresden contains two units which share major support systems. Shared systems were modeled to ensure

TABLE 4.1.1-1
SUMMARY OF DRESDEN INITIATING EVENT FREQUENCIES

FREQUENCY (/Y) Unit 2	FREQUENCY (/Y) Unit 3	INITIATING EVENT
3.0E-04	3.0E-04	Large Loss of Coolant Accident (LOCA)
8.0E-04	8.0E-04	Medium Loss of Coolant Accident (LOCA)
3.0E-03	3.0E-03	Small Loss of Coolant Accident (LOCA)
1.1E-07	1.1E-07	Interfacing Systems LOCA (ISLOCA)
7.1E-02	7.1E-02	Inadvertent Open Relief Valve (IORV)
7.4E-00*	7.4E-00*	Anticipated Transients
5.1E-02*	5.1E-02*	Single Unit LOSP (LOSP)
1.6E-02*	1.6E-02*	Dual Unit LOSP (DLOSP)
(1)	(1)	Loss of all AC Power (Station Blackout)
2.28E-04 (2)	2.28E-04 (2)	Anticipated Transient Without Scram (ATWS)
0*	1.56E-03*	Loss of 125VDC Main Bus (LODC)
4.48E-03*	4.48E-03*	Loss of Service Water
6.95E-03*	6.95E-03*	Loss of Instrument Air
1.76E-04*	1.09E-04*	Loss of 4 kV Bus 21/31
1.44E-04*	1.13E-04*	Loss of 4 kV Bus 22/32
1.62E-03*	3.02E-03*	Loss of 4 kV Bus 23/33
3.12E-04*	1.09E-04*	Loss of 4 kV Bus 24/34
1.24E-03*	1.29E-03*	Loss of 480 VAC Bus 28/38
1.27E-03*	6.88E-04*	Loss of 480 VAC MCC 28-2/38-2

(1) This event is treated as a consequential failure in the accident sequence analysis and thus, no frequency was calculated.

(2) This event is a consequential failure, but the likelihood of a transient occurring (7.4/yr) and the likelihood of failure to scram (3E-05) were combined manually and input to the ATWS PRT quantification (2.28E-04).

* Plant-specific calculation.

TABLE 4.1.3-4
SUMMARY OF NODAL DESCRIPTIONS

NODE	DESCRIPTION
ADS	AUTOMATIC DEPRESSURIZATION SYSTEM
AIC	AUTO INITIATION OF ISOLATION CONDENSER
ARI	AUXILIARY ROD INSERTION
AT	AUTOMATIC ATWS SYSTEM INITIATION
CI	CONTAINMENT ISOLATION
CNTS	HARDWARE FOR CONTAINMENT SPRAYS
CRD	CONTROL ROD DRIVE HYDRAULIC FLOW FROM OPPOSITE UNIT
CS	CORE SPRAY
CS1	CORE SPRAY SUCCEEDS FOR 4 HRS (ISLOCA)
CS2	CORE SPRAY SUCCEEDS FOR 1 HR (ISLOCA)
FP	DIESEL FIRE PUMP STARTS AND RUNS
FW	FEEDWATER (WITH CONDENSATE)
FWA	FEED/COND FOLLOWING ATWS (% OF IEs THAT ARE LOFW)
HP1	AUTO INITIATION/OPERATION OF HPCI (SINGLE START)
HP2	AUTO INITIATION/OPERATION OF HPCI (MULTIPLE STARTS)
ICG	HARDWARE TO ALIGN CCSW TO LPCI HX
ICH	PROPER OPERATION OF IC HARDWARE
ICH1	PROPER OPERATION OF IC HARDWARE (EARLY)
ICH2	PROPER OPERATION OF IC HARDWARE (LATE)
LP	LPCI PUMPS
LPV	LPCI PUMPS/INJ VALVES (ISLOCA)
LPC	HARDWARE TO ALIGN CCSW TO LPCI HX
LPXT	LPCI TRAIN CROSS-TIE (ISLOCA)
LV	LPCI INJECTION VALVES
LVD	HARDWARE FOR 10IN DRYWELL VENT
LVW	HARDWARE FOR 10IN WETWELL VENT
MC	AVAILABILITY OF MAIN CONDENSER AFTER ATWS
MUP	ADDITION OF SHELL SIDE MAKEUP
OAD	OPERATOR ACTION TO INITIATE ADS
OIADS	OPERATOR ACTION TO INIHIBIT ADS (ATWS)
OAT	OPERATOR ACTION TO INITIATE ARI SYSTEM
OVNT	OPERATOR ACTION TO VENT CONTAINMENT
OAL	OPERATOR ACTION TO CONTROL RV LEVEL AFTER ATWS
OAVR	OPERATOR ACTION TO VENT RX VESSEL FOR CONT FLDG
OBN	OPERATOR ACTION TO RETAIN INJECTED BORON
OCNTS	OPERATOR ACTION TO INITIATE CONTAINMENT SPRAYS
OCRD	OPERATOR ACTION TO OPEN CRD CROSS-TIE TO OPPOSITE UNIT
OFW	OPERATOR ACTION TO RESTORE FW INJ
OFP	OPERATOR ACTION TO CONNECT FP TO FW
OHX	OPERATOR ACTION TO ALIGN CCSW TO LPCI HX
OIC	OPERATOR ACTION TO INITIATE IC
OIC2	OPERATOR ACTION TO PREVENT LODC FLR OF IC
OIS	OPERATOR ACTION TO ISOLATE ISLOCA (VLVS, PMPS, FLO)
OMUP	OPERATOR ACTION TO PROVIDE MAKEUP TO IC
ORE	OPERATOR ACTION TO RESTORE EQUIP AFTER RECOVERY OF OSP
ORP	OPERATOR ACTION TO INITIATE RPT
OSBCS	OPERATOR ACTION TO INITIATE STANDBY COOLANT SUPPLY
OSL1	OPERATOR ACTION TO INITIATE SLC (1/2 PUMP)
OSL2	OPERATOR ACTION TO INITIATE SLC (2/2 PUMPS)
OSF	OPERATOR ACTION TO RESTORE SUPPORT SYSTEMS TO FW
OSS	OPERATOR ACTION TO RECOVER SW/TBCCW
OSPC	OPERATOR ACTION TO ALIGN FOR SUP POOL CLG

- Function: Reactor Pressure Control

  The MAAP code was used to define the pressure relief requirements for the specific cases in which the isolation condenser was not initiated rapidly enough to prevent RPV pressure from exceeding the lowest relief valve setpoint. The results of these code runs show that a single relief or safety valve is adequate to maintain pressure less than 1375 psig in all events except Anticipated Transient Without Scram events.

- Function: RPV Inventory Control

  RPV Inventory Control was separated into High and Low Pressure Categories. The means of high pressure inventory control include HPCI, FW and the Isolation Condenser. For the Modified IPE, the opposite unit's CRD hydraulic system was added as a means of high pressure inventory control during SBO events. Sources of low pressure inventory include FW, FP, LPCI, and CS. Low pressure sources can only be used with adequate methods of depressurization or following vessel failure.

  The MAAP code was used for the LOCA events to determine the minimum requirements of the ECCS to maintain core cooling. Various ECCS configurations were modeled for each break category to determine the minimum number of ECCS pumps and/or systems needed to maintain core cooling. Actual ECCS pump flow curves were used in order to attain realistic success criteria for ECCS injection.

  The ECCS requirements as determined for these events were typically considered as the success criteria for the other initiating events.

- Function: RPV Depressurization

  The MAAP code was used to determine the minimum number of valves required to depressurize the reactor vessel and allow low pressure injection in time to preclude core damage. Various entry conditions were analyzed with the result being the same in all cases; a single valve opened at the top of active fuel will allow low pressure injection in time to prevent core damage.

- Function: Containment Pressure/Temperature Control

  For accident sequences in which decay heat is being deposited in the containment, the MAAP code was used to evaluate the ability of plant systems to control containment temperature and pressure and to evaluate system initiation timing required for successful event mitigation. In addition to addressing containment failure, sequences were evaluated, using the MAAP code, to ensure that adequate NPSH was maintained to the low pressure pumps to prevent pump failure.

TABLE 4.1.4-1
DRESDEN PRT SUCCESS CRITERIA

ACCIDENT INITIATOR	REACTIVITY CONTROL	REACTOR PRESSURE CONTROL	RPV INVENTORY CONTROL		RPV DEPRESSURIZATION	CONTAINMENT PRESS/TEMP CONTROL	PRT ENDSTATE
			HIGH PRESSURE	LOW PRESSURE			
LARGE LOCA	NONE REQ'D	NONE REQ'D	NONE REQ'D	1 LPCI and LV -OR- 1 CS	INITIATING EVENT	SPC[1]	SUCCESS
	NONE REQ'D	NONE REQ'D	NONE REQ'D	1 LPCI and LV	INITIATING EVENT	SPC[2]	SUCCESS
	NONE REQ'D	NONE REQ'D	NONE REQ'D	1 LPCI and LV -OR- 1 CS	INITIATING EVENT	SBCS[3]	SUCCESS
MEDIUM LOCA	RC	NONE REQ'D	HP1	1 LPCI and LV -OR- 1 CS	HP2[6]	SPC[1]	SUCCESS
	RC	NONE REQ'D	FAILED	1 LPCI and LV -OR- 1 CS	ADS[5] (1 valve)	SPC[1]	SUCCESS

TABLE 4.1.4-1 (Continued)
DRESDEN PRT SUCCESS CRITERIA

ACCIDENT INITIATOR	REACTIVITY CONTROL	REACTOR PRESSURE CONTROL	RPV INVENTORY CONTROL		RPV DEPRESSURIZATION	CONTAINMENT PRESS/TEMP CONTROL	PRT ENDSTATE
			HIGH PRESSURE	LOW PRESSURE			
SMALL LOCA	RC	RVO/RVC (1 Relief/Safety Vlv)	1 FW	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D[13]	SUCCESS
	RC	RVO/RVC (1 Relief/Safety Vlv)	HP1 and HP2	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D[14]	SUCCESS
	RC	RVO/RVC (1 Relief/Safety Vlv)	FAILED	1 LPCI and LV -OR- 1 CS	ADS[5] (1 valve)	SPC[1] (1LP/CCSW Pump)	SUCCESS
INTERFACING SYSTEM LOCA	RC	NONE REQ'D	NONE REQ'D	LPV and 1 FW and SBCS[3]	INITIATING EVENT	NONE REQ'D[13]	SUCCESS
	RC	NONE REQ'D	NONE REQ'D	LPV or CS1 -AND- 1 FW or FP[7]	INITIATING EVENT	NONE REQ'D[13]	SUCCESS
	RC	NONE REQ'D	NONE REQ'D	CS2 -AND- 1FW or FP[7] (Following LPXT Success)	INITIATING EVENT	NONE REQ'D[13]	SUCCESS

TABLE 4.1.4-1 (Continued)
DRESDEN PRT SUCCESS CRITERIA

ACCIDENT INITIATOR	REACTIVITY CONTROL	REACTOR PRESSURE CONTROL	RPV INVENTORY CONTROL		RPV DEPRESSURIZATION	CONTAINMENT PRESS/TEMP CONTROL	PRT ENDSTATE
			HIGH PRESSURE	LOW PRESSURE			
INADVERTENT OPEN RELIEF VALVE	RC	NONE REQ'D	NONE REQ'D	1 FW	NONE REQ'D	NONE REQ'D[13]	SUCCESS
	RC	NONE REQ'D	NONE REQ'D	1 LPCI and LV -OR- 1 CS	INITIATING EVENT	SPC[1] or OCST and CST	SUCCESS
TRANSIENT	RC	RVO/RVC (1 Relief/Safety Vlv)	IC[8]	NONE REQ'D[15]	NONE REQ'D[15]	IC[8]	SUCCESS
	RC	RVO/RVC (1 Relief/Safety Vlv)	1 FW	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D[13]	SUCCESS
	RC	RVO/RVC (1 Relief/Safety Vlv)	HP1 and HP2[6]	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D[14]	SUCCESS
	RC	RVO/RVC (1 Relief/Safety Vlv)	FAILED	1 LPCI and LV -OR- 1 CS	ADS[5] (1 valve)	SPC[1] or OCST and CST	SUCCESS

TABLE 4.1.4-1 (Continued)
DRESDEN PRT SUCCESS CRITERIA

ACCIDENT INITIATOR	REACTIVITY CONTROL	REACTOR PRESSURE CONTROL	RPV INVENTORY CONTROL		RPV DEPRESSURIZATION	CONTAINMENT PRESS/TEMP CONTROL	PRT ENDSTATE
			HIGH PRESSURE	LOW PRESSURE			
LOSS OF OFFSITE POWER	RC	OIC and ICH1 -OR- RVO/RVC (1 Relief/Safety Vlv)	IC[8]	NONE REQ'D[15]	NONE REQ'D[15]	IC[8]	SUCCESS
	RC	OIC and ICH1 -OR- RVO/RVC (1 Relief/Safety Vlv)	HP1 and HP2[6]	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D[14]	SUCCESS
	RC	RVO/RVC (1 Relief/Safety Vlv)	FAILED	1 LPCI and LV -OR- 1 CS	ADS[5] (1 valve)	SPC[1] or OCST and CST	SUCCESS
	RC	RVO/RVC (1 Relief/Safety Vlv)	HP1 and 1 FW[12]	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D[13]	SUCCESS

TABLE 4.1.4-1 (Continued)
DRESDEN PRT SUCCESS CRITERIA

ACCIDENT INITIATOR	REACTIVITY CONTROL	REACTOR PRESSURE CONTROL	RPV INVENTORY CONTROL		RPV DEPRESSURIZATION	CONTAINMENT PRESS/TEMP CONTROL	PRT ENDSTATE
			HIGH PRESSURE	LOW PRESSURE			
STATION BLACKOUT	RC	RVO/RVC (1 Relief/Safety Vlv)	IC[8] and ROP1 -OR- IC[8] and OIC2 and CRD and OCRD	NONE REQ'D[15]	NONE REQ'D[15]	IC[8]	SUCCESS
	RC	RVO/RVC (1 Relief/Safety Vlv)	ROP1 and 1 FW[12]	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D[13]	SUCCESS
	RC	RVO/RVC (1 Relief/Safety Vlv)	FAILED	ROP1 -AND- 1 LPCI and LV -OR- 1 CS	ADS[5] (1 valve)	SPC[1] or OCST and CST	SUCCESS
	RC	RVO/RVC (1 Relief/Safety Vlv)	FAILED	FP[7] and ROP1A -AND- 1 LPCI and LV -OR- 1 CS	ADS[5] (1 valve)	SPC[1] or OCST and CST	SUCCESS

TABLE 4.1.4-1 (Continued)
DRESDEN PRT SUCCESS CRITERIA

ACCIDENT INITIATOR	REACTIVITY CONTROL	REACTOR PRESSURE CONTROL	RPV INVENTORY CONTROL		RPV DEPRESSURIZATION	CONTAINMENT PRESS/TEMP CONTROL	PRT ENDSTATE
			HIGH PRESSURE	LOW PRESSURE			
ATWS with MAIN CONDENSER	ARI[11] (elect. failures)	RVO (4 Relief/Safety Vlv)	1 FW	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D[13]	SUCCESS
	RPT1 or RPT2[9] -AND- SLC[10] (mech. failures)	RVO (4 Relief/Safety Vlv)	1 FW	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D[13]	SUCCESS
	RPT1 or RPT2[9] -AND- OAL (mech. failures)	RVO (4 Relief/Safety Vlv)	1 FW	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D[13]	SAM
	ARI[11] (elect. failures)	RVO (4 Relief/Safety Vlv)	IC[8]	NONE REQ'D[15]	NONE REQ'D[15]	IC[8]	SUCCESS
	ARI[11] (elect. failures)	RVO (4 Relief/Safety Vlv)	HP2[6]	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D[14]	SUCCESS
	ARI[11] (elect. failures)	RVO (4 Relief/Safety Vlv)	FAILED	1 LPCI and LV -OR- 1 CS	ADS[5] (1 valve)	SPC[1] or OCST and CST	SUCCESS
	RPT1 or RPT2[9] -AND- SLC[10] (mech. failures)	RVO (4 Relief/Safety Vlv)	HP1 -AND- IC[8]	NONE REQ'D[15]	NONE REQ'D[15]	IC[8]	SUCCESS

TABLE 4.1.4-1 (Continued)
DRESDEN PRT SUCCESS CRITERIA

ACCIDENT INITIATOR	REACTIVITY CONTROL	REACTOR PRESSURE CONTROL	RPV INVENTORY CONTROL		RPV DEPRESSURIZATION	CONTAINMENT PRESS/TEMP CONTROL	PRT ENDSTATE
			HIGH PRESSURE	LOW PRESSURE			
	RPT1 or RPT2[9] -AND- SLC[10] (mech. failures)	RVO (4 Relief/Safety Vlv)	HP1 -AND- HP2[6]	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D	SAM
	RPT1 or RPT2[9] -AND- SLC[10] (mech. failures)	RVO (4 Relief/Safety Vlv)	NONE REQ'D	1 LPCI and LV -OR- 1 CS	ADS[5] (1 valve)	SPC[1] or OCST and CST	SUCCESS

TABLE 4.1.4-1 (Continued)
DRESDEN PRT SUCCESS CRITERIA

ACCIDENT INITIATOR	REACTIVITY CONTROL	REACTOR PRESSURE CONTROL	RPV INVENTORY CONTROL		RPV DEPRESSURIZATION	CONTAINMENT PRESS/TEMP CONTROL	PRT ENDSTATE
			HIGH PRESSURE	LOW PRESSURE			
ATWS w/o MAIN CONDENSER	RPT1 -AND- ARI[11] (elect. or mech.)	RVO (9 Relief/Safety Vlv)	IC[8]	NONE REQ'D[15]	NONE REQ'D[15]	IC[8]	SUCCESS
	RPT1 -AND- ARI[11] (elect. or mech.)	RVO (9 Relief/Safety Vlv)	HP2[6]	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D[14]	SUCCESS
	RPT1 -AND- ARI[11] (elect. or mech.)	RVO (9 Relief/Safety Vlv)	FAILED	1 LPCI and LV -OR- 1 CS	ADS[5] (1 valve)	SPC[1] or OCST and CST	SUCCESS
	RPT1 -AND- SLC[10] (mech. failures)	RVO (9 Relief/Safety Vlv)	HP1 and IC[8]	NONE REQ'D[15]	NONE REQ'D[15]	IC[8]	SUCCESS
	RPT1 -AND- SLC[10] (mech. failures)	RVO (9 Relief/Safety Vlv)	HP1 and HP2[6]	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D	SAM
	RPT1 -AND- SLC[10] (mech. failures)	RVO (9 Relief/Safety Vlv)	FAILED	1 LPCI and LV -OR- 1 CS	ADS[5] (1 valve)	SPC[1] or OCST and CST	SUCCESS

TABLE 4.1.4-1 (Continued)
DRESDEN PRT SUCCESS CRITERIA

ACCIDENT INITIATOR	REACTIVITY CONTROL	REACTOR PRESSURE CONTROL	RPV INVENTORY CONTROL		RPV DEPRESSURIZATION	CONTAINMENT PRESS/TEMP CONTROL	PRT ENDSTATE
			HIGH PRESSURE	LOW PRESSURE			
LOSS OF 125VDC	RC	RVO/RVC (1 Relief/Safety Vlv)	HP1 and HP2[6]	NONE REQ'D[15]	NONE REQ'D[15]	NONE REQ'D[14]	SUCCESS
	RC	RVO/RVC (1 Relief/Safety Vlv)	FAILED	1 LPCI and LV -OR- 1 CS	ADS[5]	SPC[1] or OCST and CST	SUCCESS

Notes:

1. Operator action also required to establish Suppression Pool Cooling - 1 LP & 1 CCSW pump reqd.
2. Operator action also required to establish Injection Cooling - 1 LP & 1 CCSW pump reqd.
3. Operator action also required to initiate Standby Coolant Supply.
4. Operator action also required to initiate reactor vessel venting for containment flooding.
5. Operator action also required to initiate automatic depressurization.
6. Operators take manual control of HPCI.
7. Operator action also required to install FP/FW system cross-connects.
8. All nodes that support IC operation, including initiation of makeup (MUP), are included in the IC designator. IC operation only prevents the loss of existing RPV inventory.
9. Operator action also required to trip recirculating pumps.
10. Operator action also required to start SLC pump(s) and to inhibit ADS.
11. Operator action also required to initiate Alternate Rod Insertion.
12. Operator action also required to restore support systems to FW (including offsite power).
13. Containment status (success/failure) does not affect the success of the core.
14. Containment pressure/temperature control not required during first 24 hours.
15. Depressurization and low pressure inventory control is not required if high pressure injection is available.

TABLE 4.1.4-1 (Continued)
DRESDEN PRT SUCCESS CRITERIA

ACRONYM	DEFINITION	ACRONYM	DEFINITION
ADS	Depressurization using at least 1 valve of the Automatic Depressurization system	LPXT	LPCI train crosstie isolation
ARI	Alternate Rod Insertion	LV	LPCI injection valves
ATWS	Anticipated Transient Without Scram	MUP	Hardware associated with isolation condenser makeup
CCSW	Containment Cooling Service Water system	OAL	Manual control of RPV level by operator during an ATWS
CRD	Injection using opposite unit's CRD hydraulic system.	OCRD	Manual action to open cross-tie between the CRD hydraulic systems of Units 2 and 3
CS	Injection using Core Spray system	OCST	Realign the LPCI and/or CS pump suctions to the Condensate Storage Tank
CS1	Injection using Core Spray system for four hours	OIC	Manual initiation of Isolation Condenser
CS2	Injection using Core Spray system for one hour	OIC2	Manual action to open supply breakers to IC motor-operated-valves.
CST	Use of the Condensate Storage Tank for a source of cold water injection following the failure of Suppression Pool cooling	RC	Reactor trip (176 of 177 rods to or beyond 02 position)
FP	Injection using Fire Protection/Feedwater system cross-connect	ROP1	Recovery of offsite power to in-plant 4KV buses in time to prevent core damage
FW	Injection using Feedwater system	RPT1	Recirculating pump trip due to automatic signal
HP1	Injection with HPCI Pump (auto-start)	RPT2	Recirculating pump trip due to manual initiation
HP2	Injection with HPCI Pump (manual control following trip)	RVO/RVC	Relief or safety valve cycles as required to maintain reactor pressure ≤ 1375 psig

TABLE 4.1.4-1 (Continued)
DRESDEN PRT SUCCESS CRITERIA

ACRONYM	DEFINITION	ACRONYM	DEFINITION
IC	Successful operation of the Isolation Condenser including makeup	SAM	Accident Management Required After 24 Hours for success
ICH1	Isolation Condenser hardware operation	SBCS	Valves open and allow Service Water to flow into the hotwell
LOCA	Loss of Coolant Accident	SLC	Injection of borated water using the Standby Liquid Control pumps
LPCI	Low Pressure Injection using LPCI pumps	SPC	Containment heat removal by circulating water through the LPCI heat exchanger and back to the suppression pool (LP/CCSW)
LPV	Low pressure injection using LPCI pumps and opening of injection valve. This is equivalent to LPCI and LV.	SUCCESS	Successful Termination of Accident Prior to Core Damage

A locked open manual valve, 2(3)-1101-1, located on the inside of the containment, allows isolation of the system from the reactor for system maintenance. Outside the containment, locked open Manual Valve 2(3)-1101-23 provides for system isolation and maintenance. Two check valves are located in series, near the drywell penetration. Check Valve 2(3)-1101-15 is located inside the drywell and 2(3)-1101-16 is outside the drywell.

Heat Tracing

The SLC system piping from the storage tank to the injection pumps is insulated and heat traced. This ensures the solution does not fall below its chemical saturation temperature and that the resultant precipitate does not solidify and clog the pumps and lines. Power for the heat tracing is supplied by 480VAC on MCC 28-1 (38-1) and MCC 29-1 (39-1).

A simplified diagram of the Unit 2 SLC system is shown in Figure 4.2.1.13-1. There are no significant differences between Units 2 and 3.

4.2.1.14 Torus/Drywell Vent (TDV) System

The Torus/Drywell Vent is designed to provide primary containment pressure control in emergency operating conditions. The Torus/Drywell Vent includes the Standby Gas Treatment (SBGT) system and the new Augmented Primary Containment Vent (APCV) system. The APVC system is a 10-inch hardened vent which connects the normal 18-inch vent path with the station exhaust stack via the large Ventilation Exhaust Duct that is located outdoors, above the roof of the Radwaste Building. The 10-inch hardened vent pipe bypasses small ventilation ducting which could potentially rupture during severe accident venting.

The preferred method for containment pressure control by venting is to vent from the torus or drywell through the SBGT system. If the SBGT flow capacity is not sufficient to control and maintain drywell pressure below the primary containment pressure limit or if the SBGT system fails, then venting is performed via the APCV system. (The primary containment pressure limit is 60 psig torus bottom pressure for all primary containment water levels between 15 and 93 feet.)

The Torus/Drywell Vent is included in the IPE analysis because both emergency procedures and normal operating procedures control primary containment pressure through venting of the torus or drywell. The intent of the Torus/Drywell Vent is to protect primary containment from overpressurization and potential breach, thus preventing an uncontrolled release.

Figure 4.2.1.14-1 shows the vent path from the torus or drywell. The path is of interest since emergency procedures (DEOP 200-1 and DEOP 500-4) and normal operating procedures (DOP 1600-1) require venting of the torus or drywell to control primary containment pressure. If torus water level is below 30 feet, venting occurs through the

torus two-inch vent valve, AO2(3)-1601-61. If torus level is above 30 feet, the vent line is covered with water. The drywell is then vented through the drywell two-inch vent valve, AO2(3)-1601-62. In both cases the air flow passes through AO2(3)-1601-63 to the SBGT system. If the SBGT flow capacity is not sufficient to control and maintain

Step 3.1

Calculate basic event probabilities - Utilizing the component failure rates, test and maintenance unavailabilities and other basic event data, the basic event probabilities defined in the fault tree were quantified using the equations provided in the technical guidelines.

Step 3.2

Calculate human error probabilities - The human errors considered in the development of the fault trees and the human error probabilities used in the quantification of the fault trees were developed using the EPRI Cause Based Decision Tree Methodology.

For the Modified IPE, "pre-initiator" type failures of standby instruments were re-considered and plant-specific data was reviewed. For most instruments, generic failure rates (together with appropriate standby mission times) were judged to appropriately represent failures, including out-of-calibration failure due to personnel errors. Nevertheless, the review resulted in use of a plant-specific demand failure probability to represent calibration errors for pertinent pressure and flow instruments.

Step 3.3

Calculate common cause failure probabilities - Once a fault tree for a system was developed, which includes random hardware failures, test outages, maintenance outages and human errors, the important common cause component groups were identified for inclusion in the fault trees. The common cause attributes that were used for the identification of common cause failures are:

- Component Type
- Component Use/Function (system isolation, flow modulation, etc.)
- Component initial conditions (i.e., normally closed, initially running, etc.)
- Component failure mode

For each common cause component group identified, common cause events were added to the fault tree at the component level. Once all important common cause failures were identified, the Multiple Greek Letter method was used to calculate the common cause failure probability.

With the common cause failure probabilities input into the fault tree, the fault tree was quantified to determine the total system failure probability and to obtain the dominant contributors (cutsets) for the system.

STEP 4 Document Process

The entire process of fault tree development including key assumptions, boundary conditions, and other important information was documented in the fault tree section of the system notebook. The quantification of the fault tree was also documented in the

system notebook in the quantification section (including the computer code used and its input and output). The dominant contributors to system failure were identified and documented in the system notebook. The key insights were also documented in the system notebook.

Containment Venting

The Torus/Drywell Vent is designated to provide primary containment pressure control in order to prevent failure at the containment pressure boundary and uncontrolled releases of radioactive fission products to the environment. The Torus/Drywell Vent contains 18″ vent pipes from both the drywell and torus gas spaces. Flow can be diverted from the 18″ lines through a 2″ vent valve to limit the discharge rate. Once extracted from containment, the vent flow can be directed through the Standby Gas Treatment (SBGT) System located in the turbine building at the 534′ -0″ elevation or the Augmented Primary Containment Vent (APCV) system. The APCV or "hardened vent" provides an alternative 10-inch nominal diameter flow path connecting the 18-inch vent line (normally used for the reactor building exhaust system) to the Ventilation Exhaust Duct discharging directly into the main chimney.

The flow diagram for various containment vent paths is illustrated in Figures 4.3-6 through 4.3.-6b.The EOPs instruct the operator to vent the primary containment if the primary containment pressure cannot be maintained below the Primary Containment Pressure Limit. According to this limit, venting must occur if the primary containment water level exceeds 93 feet or the torus bottom pressure exceeds 60 psig. If the torus water level is below 30 feet, the torus vent line is uncovered and the operator is instructed to vent the wetwell through the 2″ vent line to the SBGT system inlet. The 2″ drywell vent line leading to the SBGT system can be used if the torus water level exceeds 30 feet or if the wetwell 2″ vent line cannot be otherwise used.

The SBGT system consists of a demister, an electric heater, an activated carbon iodine absorber, rough and high efficiency prefilters, a high efficiency afterfilter and a fan. The gas enters the demister which removes moisture and then is heated to lower the gas relative humidity. The gas is then filtered and passed through the activated charcoal bed which is capable of removing 100 grams of iodine. The gas stream is then filtered once again and blown out through the chimney.

If the SBGT flow is not sufficient to control or maintain drywell pressure below the primary containment pressure limit or if the SBGT system fails, then the use of the 18″ line is recommended. The selection of whether to vent from the drywell or the wetwell is dependent on the torus water level with the torus vent line being the preferred vent path. If the 18″ line is used, the inlet valve to the SBGT system is closed and all flow is directed to the reactor building exhaust system and out of the reactor building through the APCV system.

4.3.1.3 Containment Data

The Modular Accident Analysis Program (MAAP) [1] is used in the Dresden IPE to provide an integrated approach to the modeling of plant and containment thermal hydraulic response and fission product behavior during severe core damage accidents. MAAP requires plant specific input data, which is compiled into a MAAP parameter file. The Dresden MAAP parameter file provides a complete, realistic description of Dresden for a MAAP simulation, and its data remains identical for all accident sequences.

4.4 Supporting Analysis

The following sections describe several analyses that support the quantification of the fault trees and the plant response trees. These supporting analyses include the generation of plant specific and the compilation of generic component data, the generation of human error probabilities, the generation of plant specific common cause failure probabilities, the identification of any internal flooding initiating events, and the identification of any equipment that may not survive the expected accident conditions. These analyses were completely documented in separate Dresden IPE/AM project notebooks.

4.4.1 Data Analysis

The purpose of the data analysis task was to collect data and obtain reasonable estimates of the failure rates and unavailabilities of basic components significant to the IPE. Random failure rates (including failure probabilities per demand), unavailabilities due to maintenance and testing, and common cause failure rates are the basic quantities that were evaluated extensively in the data analysis task. Testing was found to affect the unavailability of only a few systems analyzed (the Isolation Condenser and the Anticipated Transient Without Scram systems). These unavailabilities were calculated from the test frequencies and their average durations based on Dresden-specific experience.

At the onset of the data collection task, important key components were identified as likely to dominate or have an important impact on core damage frequencies, based on knowledge of previous PRAs. The list of key components for the Dresden IPE defined the scope of the major phase of the plant-specific data collection effort. The key component approach permitted resources to be focused on the most important failures and unavailabilities and enabled investigations to be made in greater depth when needed. Failure and unavailability data for key components for which plant-specific data was not available was obtained from generic data sources. Table 4.4.1-1 is a list of key components and failure modes. This list was used during the process of collecting plant-specific data.

Comparisons were made between key component failure data and generic failure data, and comparisons were also made between key component failure rates and failure rates and maintenance unavailabilities provided in the Dresden Nuclear Power Station Individual Plant Evaluation Methodology (IPEM) initiating event and component data. Generally, the Dresden IPE data was comparable to both generic and the Dresden IPEM.

The failure and component unavailability data collected for the original Dresden IPE spanned the period of January 1, 1984 through December 31, 1990. This period included seven years of plant operating experience. In general, the use of the seven years, particularly the most recent seven years, as the basis for data analysis is believed to be optimal. Seven years is a sufficient period of time for the calculation of most failure rates. More significantly, the most recent 7 year period (i.e., 1984 through 1990) should produce failure rate and unavailability results that come closest, in most cases, to the current true state of unreliability of the key components. January 1, 1984, was selected as the start

TABLE 4.4.1-1
SUMMARY OF KEY COMPONENTS AND FAILURE/UNAVAILABILITY MODES

KEY COMPONENT	SYSTEM CODE[1]		FAILURE AND UNAVAILABILITY MODE[2]
Electrical Components			
Diesel Generators	DG	(66)	FTS, FTR, Unavailable due to Maintenance
Diesel Generator Output Breakers	DG	(66)	FTO, FTC, Spurious Opening, Unavailable due to Maintenance
4KV Breakers	AC	(67)	FTO, FTC, Spurious Opening, Unavailable due to Maintenance
Batteries (125/250VDC)	DC	(83)	FTF, Unavailable due to Maintenance
Battery Chargers (125/250VDC)	DC	(83)	FTF, Unavailable due to Maintenance
Inverters	DC	(81, 82)	FTF
Mechanical Components			
Valves			FTO, FTC, Unavailable due to Maintenance
Motor Operated	All		
Air Operated	All		
Dampers	SG		
Pumps			FTR, FTS, Unavailable due to Maintenance
Containment Cooling Service Water	CC	(15)	
Control Rod Drive (CRD) Hydraulic[3]	CR	(03)	
Core Spray	CS	(14)	
DG Cooling Water Pump	DG	(66)	
Feedwater and Condensate	FW	(32, 33, 34)	
Fire Protection	FP	(41)	
High Pressure Coolant Injection	HI	(23)	
Low Pressure Coolant Injection	LI	(15)	
RBCCW	RB	(37)	
Service Water	SW	(39)	
Standby Liquid Control	SL	(11)	
TBCCW	TB	(38)	
Miscellaneous			FTF
Containment Vent	CV	(16)	
Isolation Condenser	IC	(13)	
Low Pressure Coolant Injection/Containment Cooling Service Water Heat Exchanger	LI	(15)	
Standby Gas Treatment Fans	GT	(75)	
TBCCW Heat Exchanger	TB	(38)	

Notes:
1. System Codes Represent
   - The Code used in the database
   - The Dresden Plant System Code
2. Fails to Open (FTO), Fails to Close (FTC), Fails to Start (FTS), Fails to Run (FTR), Fails to Function (FTF).
3. The failure mode modeled for the Modified IPE is unavailability of the opposite unit's CRD hydraulic system.

date because the data examined prior to 1984 was less specific. December 31, 1990, was selected as the end date because the required records had been consolidated up through this date during the data collection process.

Additional data was gathered for the Modified IPE. The unavailability of the opposite unit's CRD hydraulic system was based on recent refueling outage experience and engineering judgment. Plant-specific data on "pre-initiator" type failures involving calibration of pertinent instruments was gathered from records of recent events available in a computer database covering approximately a five-year period through the end of 1995. For most instrument types, no "pre-initiator" type failures were identified. The review for the Modified IPE concluded that use of generic failure rates and appropriate mission times was appropriate for most standby instruments. An exception was pressure instruments. The review for the Modified IPE concluded that a demand failure probability, based on plant-specific data, should be used for pertinent standby pressure instruments to adequately account for calibration failures due to personnel error.

Plant-specific data was collected from the operating records of both units and was combined to form one data base. The advantage of this approach is that the length of record available for plant-specific failure rate estimation is double what the record would be if the units were treated separately. The dual-unit data base results in better average (point estimate) failure rates for the key components. Another reason for the combined data base was that no significant differences between the components of Unit 2 and Unit 3 were identified. Therefore, no basis was found for pursuing the hypothesis that the unreliability of Unit 2 components could be different from the unreliability of Unit 3 components. For key components which lacked enough operating experience during the 7-year period to provide a usable estimate of failure, generic data was used.

In accordance with the CECo Guidelines, failure rates were calculated as point-estimate values. One type of point estimate failure rate (hourly failure rate) is simply the number of failures that occur during a particular period of component operation divided by the operating hours of the component. This type of point estimate was used to calculate failure to run of components such as pumps and diesel generators. Another type of point-estimate failure rate is the number of failures during a particular period of time divided by the number of component demands that occurred during the same period. This type of point estimate was used to calculate the failure rates of components failing to start, and motor-operated valves failing to open or close.

Criteria was established for the plant-specific analysis. The purpose of the criteria was to distinguish failures from non-failures, and to screen out maintenance events that would not contribute to maintenance unavailability. The type of maintenance unavailability desired was the unavailability that would be applicable during times when components could be required to operate for all modes of plant operation. Failures that occurred during cold shutdown were not arbitrarily screened out for two reasons. First, to get statistically significant records for components which are normally operating only during cold shutdown, cold shutdown periods must be included. Second, equipment failures are assumed to occur randomly in time. They are assumed to occur no more or no less

frequently during plant operation than during plant shutdown. Therefore, the failure data base considered failures during all modes of operation and shutdown.

The boundaries of each component were also considered in the screening of failures and maintenance events. A table of component boundaries in the CECo guidelines indicated which subcomponents to include with the main component. For example, circuit breakers and handswitches were included within the boundaries of pumps, and failures of the subcomponents were counted as failures of the pump.

The sources of plant-specific data are presented in annotated form in Table 4.4.1-2.

NUREG/CR-2815 was the primary source of generic failure rate data. NUREG/CR-2815 was the first source consulted and was used except in cases where it did not provide data for the particular failure mode needed or where some other source was determined to provide more relevant data. NUREG/CR-4550 was the primary source of generic maintenance unavailability data. The following sources of generic data were also used in the data analysis task:

- IEEE Std. 500-1984, "IEEE Guide to Collection and Presentation of Reliability Data for Nuclear Power Generating Stations," IEEE Power Engineering Society, March 21, 1984.

- NUREG/CR-2728, "Interim Reliability Evaluation Program Procedures Guide," January 1983.

The plant-specific failure rates and maintenance/test unavailabilities are given in Tables 4.4.1-3 and 4.4.1-4 respectively. Table 4.4.1-5 contains the plant-specific common cause failure rates and probabilities. A discussion of the common cause analysis is presented in Section 4.4.3 of this report.

The generic failure rates and unavailabilities are presented in Table 4.4.1-6.

4.4.2 Human Reliability Analysis

The human reliability analysis (HRA) for the Dresden probabilistic risk assessment (PRA) provides human error probabilities (HEPs) for use in quantifying the fault trees and plant response trees (PRTs) which comprise the model.

The original HRA was performed in two phases. The first phase of the analysis used the THERP (Technique for Human Error Rate Prediction) method to determine the HEPs for operator actions in the PRA model. The second phase consisted of verifying assumptions made during phase one through the use of simulator exercises and interviews with Dresden operations and training personnel. The significant operator actions were re-evaluated utilizing a newer alternate technique. The selected technique was the EPRI CBDTM (Cause Based Decision Tree Methodology) from EPRI TR-100259.

4.4.2.1 Description of the HRA Methodology

The fault tree and PRT (plant response tree) analysts identified operator actions during the development of the trees representing the Dresden PRA model. These operator actions were then analyzed and quantified by human reliability analysts. The process was an iterative one, to ensure that the assumptions made by the PRT analysts and the HRA analysts were consistent.

The HEPs within each of the Plant Response Trees were analyzed on a sequence-by-sequence basis to identify the conditions of stress, dependency, and availability of

recovery opportunities. This sequence by sequence evaluation generated multiple cases for each of the operator actions.

Only one case is considered for operator actions modeled in the fault trees since the various conditions under which the action may occur can not be predetermined.

4.4.2.1.1 Dresden Characteristics and Assumptions Important to the HRA

Shift Manning

Shift manning as well as the role of each member of the shift during accident conditions was discussed with members of the Dresden Operations Department. This information was used to determine the applicable opportunities for error recovery and to determine the level of dependency between members of the crew. Error recovery and dependency are further discussed below.

Applicable Procedures

The procedures which are used during the course of an accident or transient at Dresden include the Generating Station Emergency Plan (GSEP), the Dresden Emergency Operating Procedures (DEOPs), annunciator procedures, abnormal procedures, and operating procedures.

It should be noted that the DEOPs are in a flow-chart format, and provide very general guidance for the operators to follow based upon plant symptoms. This is consistent with the emergency operating procedures at other BWRs. Systems to be used to fulfill a desired function are specified. The Dresden DEOPs do not provide step-by-step, proceduralized actions necessary to accomplish the desired action. Therefore, line up of systems directed by the DEOPs is accomplished from memory by the operators, without initial reliance on procedures. Since many of the DEOP actions are simple (i.e., start pump, open valve), these activities are considered well within the skill of the craft.

Use of the abnormal and operating procedures during DEOP execution is discouraged; it is considered that the DEOP actions are well practiced and use of these procedures would tend to slow down implementation of the required function. However, the operators are expected to consult the procedures to verify proper system line up as time permits (for example, when the accident has reached a stable condition). This represents a recovery opportunity which is dependent upon enough time being available, and is included in the model as a possible recovery.

The operators are trained to perform most actions directed in the DEOPs from memory. Job Performance Measures are used to accomplish this training. For this reason, the Job Performance Measures were used to determine the subtasks for actions which are performed from memory.

Command and Control

During an accident situation, each member of the shift staff has a definite role to perform. As of June 1996, the shift staffing consists of:

one Shift Manager (SRO)
two Unit Supervisors (SRO - at least one STA qualified)
one Field Supervisor (SRO)
four Nuclear Station Operators (NSO - RO) - two on each unit
one High Voltage Operator
six Equipment Attendants

The normal control room complement consists of the two Unit Supervisors and the four Nuclear Station Operators.

During an event, the Unit Supervisor on the affected unit will direct all unit control room and in-plant activities. The STA qualified Unit Supervisor will function as an STA. The Shift Manager will enter the control room and perform an overview of plant conditions and activities. The Shift Manager is responsible for the coordination of the GSEP and, ultimately, has overall responsibility of the plant. The NSO on the affected unit will initially operate the control rods and nearby equipment (I.e., feedwater, recirculation control, etc.). The extra NSO will assist on the ECCS panels or BOP panels, wherever needed. One of the unaffected unit's NSO may assist if the need arises. The remaining NSO will maintain control of the unaffected unit and provide control of the unaffected unit's equipment that may be needed to support the affected unit.

If the Unit Supervisor of the affected unit was the only STA qualified supervisor on shift, then the Unit Supervisor on the unaffected unit will assume the Unit Supervisor role on the affected unit to permit the STA qualified Unit Supervisor to assume the responsibilities of the STA.

If both units are affected, then the Field Supervisor (SRO) would be called into the control room to assist with the other unit.

During Emergency Operating Procedure use, the Unit Supervisor is the designated procedure reader and is responsible for ensuring actions required by the Emergency Operating Procedures are properly implemented. This action verification was considered a possible recovery.

Control Room Human Factors

The Dresden control room appears to be well designed from a human factors standpoint. The main control board layout is based upon functional groupings. Color coding is used to separate trains and systems. Mimic buses are used to aid the operator in the selection

of pumps, valves, electrical power sources, and breakers. This greatly facilitates establishing flow paths or providing electrical power.

Indicator lights are provided adjacent to the control switches for pumps, valves, breakers, and other components. A "green board" concept is employed, such that the indicator lights are green for normal or expected conditions and red to indicate deviation from the norms.

4.4.2.1.2 General Approach

The analysis of a given operator action requires knowledge of the detection, diagnosis, decision, and action execution steps associated with the accomplishment of the action. Additionally, performance shaping factors, recovery, and dependency must be incorporated. To properly address these factors, it is necessary to consider the operator action in the context of the accident sequence.

Determination of Human Error Probabilities

Each human interaction can be divided into a cognitive phase and an execution phase, namely.

$$HEP = Pc + Pe$$

where

Pc = the probability of failure to initiate the correct response
Pe = the probability of failure to execute the response correctly.

Each part (Pc & Pe) utilizes a common approach: a search for error modes that could result in the error, and a search for potential recovery.

Estimation of Pc

The methodology used to estimate Pc is explained in detail in EPRI TR-100259. The methodology assesses Pc by evaluating a series of decision trees that evaluate failure mechanisms such as: data availability, failure of attention, data misread/miscommunicated, information misleading, procedure step missed/misread, misinterpreting instructions, misinterpreting logic, and deliberate violation.

Use of the EPRI decision trees requires an understanding of the quality of information, procedures, training, and similar attributes. The time variable enters the analysis through application of "recovery factors" such as extra crew, STA review, staffing of the Technical Support Center and shift change. Specific allowable values for recovery factors are provided in EPRI TR-100259.

Estimation of Pe

The action execution portion of a given operator action encompasses those steps which must be accomplished to complete the desired action. The steps required to accomplish each operator action were determined based upon what the operator must do to meet the specific success criteria utilized in the PRA.

It should be noted that a procedure may specify more than just the minimum required steps to meet the PRA success criteria. For the purposes of determining human error probabilities, only the steps in the procedure which were important to accomplishing the function based upon the success criteria were considered. Verification steps were considered as a potential for error recovery.

For DEOP actions which do not explicitly provide direction to the operator, it is assumed that the operator is acting from memory. In this case, it is not the operating procedure steps which are important, but those steps which the operator recalls. Therefore, it is assumed that the operator will respond to the requirements of the DEOPs based upon how they have practiced the evolutions during training. For this reason, the Job Performance Measures (JPM) were utilized instead of the operating procedures for these types of actions.

Action execution errors in the Dresden HRA are of two types: Omission errors and commission errors. The omission errors involve missing procedure steps or, in the case of operating from memory, the failure to recall non-written instructions. Commission errors include selection of the wrong switch, control, or gage, as well as improper operation of controls given that the correct one has been selected. The nominal HEPs for errors of omission and commission were taken from the appropriate table in NUREG/CR-1278 Chapter 20.

Determination of Cases

In general, a different case of a given operator action is evaluated to account for differences in stress level, differences in available recovery factors, or differences pertaining to the success or failure of preceding operator actions (dependency).

Stress

One of the major performance shaping factors in the analysis is stress. Factors such as lighting, noise levels, control board ergonomics, and administrative controls at Dresden are considered nominal.

The factors considered when determining the stress level include the time available to perform the action, the amount of activity during that time, and the availability of systems and components. In general, greater workload, more equipment failures and shorter time frames for performing an action were considered to result in higher stress.

The stress levels employed in the analysis were taken from NUREG/CR-1278, Table 20-16. Stress levels were taken to be either optimal, moderate, or high. When optimal stress applied, the nominal HEPs from the appropriate NUREG/CR-1278 table were used for each identified error opportunity. If stress was considered to be moderate, the nominal HEPs were multiplied by a factor of 2; if stress was high, the nominal HEPs were multiplied by 5.

Recovery

When errors are made in diagnosing or performing an action, there is the possibility that the error will be detected in time to recover the error and continue with the accident mitigation. Some of the recovery opportunities credited in this analysis include the following:

- a procedure step directing the operator to verify that the system is performing its intended function
- a second alarm at another location in the control room that a different crew member may acknowledge
- an alarm that would indicate that the action had not been performed correctly, assuming that there would still be sufficient time to accomplish the action

The non-recovery probabilities associated with these recovery opportunities are taken from the appropriate table in NUREG/CR-1278 Chapter 20.

Additional recovery opportunities are addressed within the CBDTM, which credits the review of the event progression by a person or persons who had not been intimately involved with mitigation of the event up to that point. Recoveries of this type include the STA and Shift Manager becoming available to focus on the event in progress, manning of the Technical Support Center, arrival of off-duty personnel to assist in accident mitigation and recovery, and/or arrival of a relieving crew. It was deemed that these recoveries, as identified in EPRI TR-100259, document were appropriate for both the cognitive and execution portion of the HEPs.

Dependence between Operator Actions

Since the same crew must detect, diagnose, decide, and act upon all actions which take place in the scenario, it is reasonable to expect that operator actions are not necessarily independent events. If an operator action within a PRT sequence was preceded by an earlier failed operator action, this was evaluated and any impact on the calculated human error probability (HEP) for the latter event was determined. The method for adjusting the HEP was to assign a dependency of the second event upon the first.

The methodology used in assessing dependencies is discussed below.

There are two places where dependency must be considered. The first is when the crew must perform more than one operator action in a given event sequence. The second involves the dependency among the subtasks which comprise any single operator action.

When a given event sequence involved more than one operator action, the dependency of each operator action in a plant response tree (PRT) upon the previous operator action was considered.

Within a given operator action, the subtasks may also be interdependent. Dependency between subtasks of an operator action was determined and the HEPs modified accordingly.

In assessing dependencies, the five categories presented in NUREG/CR-1278 were utilized: Complete, high, moderate, low, and zero dependency. The formula for the conditional probability of failure on task "n," given failure of previous task "n-1" for each level of dependence, are presented in Table 20-17 of NUREG/CR-1278. These were utilized to appropriately modify the HEP for any given operator action or subtask.

Quantification

For the Modified IPE, signficant operator actions were re-evaluated. Only those actions which had a Risk Achievement Worth (using the original IPE model) of greater than 2.5 and those actions which were added as a result of changes to the Plant Response Trees and Fault Trees, received a complete evaluation utilizing the EPRI CBDTM. The remaining HEPs were reviewed for reasonableness of values and for the selection of the appropriate value for each branch of the PRTs.

The EPRI CBDTM technique provided values for one operator action, OSPC (Operator action to initiate Suppression Pool Cooling), which appeared overly conservative. The action contains two pump starts and three valve manipulations. However these actions are practiced during simulator exercises and multiple times during the year to keep the suppression pool cooled. Also, this action is directed to be performed early in the events (5-10 minutes), but the need does not arise until much later (5-24 hours) into the event. There are multiple indications and alarms on suppression temperature and containment pressure so there are multiple opportunities to recover the action. The CBDTM technique does not adequately treat actions which can be delayed for hours and have multiple recovery opportunities. After reviewing similar actions from other IPEs, discussions with the operators and instructors, and discussions with the developer of the CBDTM technique, a value of 1.0E-5 was assumed for all initiating events except for ATWS, SBO and Loss of DC. For these three initiators a value of 1.0E-4 was assumed to properly reflect the added stress and the possible shortened response times.

4.4.2.2 HRA Results

All of the HEPs after the re-evaluation have values above 1.0E-4, except for OSPC as discussed above. As can be seen in the summary of the HEP evaluations (Tables 4.4.2-1 and 4.4.2-2 below), some of the actions changed significantly, some increasing and

some decreasing. Except for OSPC, none of the HEPs changed by more than a factor of six. Table 4.4.2-1 is a Summary of Dresden Fault Tree Operator Actions and Table 4.4.2-2 is a Summary of PRT Operator Action Cases. Listed for each operator action are the node case-name, the description, the Risk Achievement Worth, the original HEP value, the revised HEP value and the percent difference in the HEP. (Note: After each set of operator action cases there is a summary line that gives the combined Risk Achievement Worth for all the cases.)

The results are presented in Tables 4.4.2-1 and 4.4.2-2. Note that more than one case was identified for many of the operator actions; as discussed above, this was to account for differences in stress, dependency, and recovery on a sequence-by-sequence basis.

4.4.2.3 Time Considerations

During the Human Reliability Analysis, time available versus time required was evaluated to first determine the feasibility of the action, and secondly by assessing the feasibility of recovery given an initial operator error.

The times available for the action were determined from MAAP (Modular Accident Analysis Program) runs which established the times for the cues and the time for action completion. The time required for the detection, analysis, diagnosis, decision and action was determined by discussions with operators, operator trainers, observation of simulator runs, and by analyst's judgment.

The modeled operator actions, the performance times (Pt) and the available times (At) for the action are addressed below.

1. **OAD** Initiate Automatic Depressurization

   This action is required for all initiating events except for Inadvertent Open Relief Valve and Large LOCA to depressurize the RPV to permit injection by the low pressure injections systems. Depressurization is required prior to the RPV (Reactor Pressure Vessel) level reaching the "top of active fuel."

   Pt < 1 minute
   At ~ 5 minutes for a Medium and Interfacing System LOCA without any high pressure injection
   > 30 minutes during other initiators (LOOP, SLOCA, Tran, LOIA, LOSW, Loss of AC buses, ATWS) without any high pressure injection
   > 60 minutes for a medium LOCA with HPCI or Feedwater success
   > 4 hours during other initiators (LOOP, SLOCA, Tran, LOIA, LOSW, Loss of AC buses, ATWS) with HPCI, Isolation Condenser, or Feedwater success.

Table 4.4.2-1
SUMMARY OF DRESDEN FAULT TREE OPERATOR ACTIONS

NAME	DESCRIPTION	RAW	Orig. HEP	Rev. HEP	%CHG
2ACBS23-1-23-H--	Operator Fails to Energize Bus 23 From 23-1	2.796	4.6E-3	1.2E-3	-74%
2ACBS24-1-24-H--	Operator Fails to Energize Bus 24 From 24-1	13.130	4.6E-3	1.2E-3	-74%
2ACBS28-29---H--	Operator Fails to Energize Bus 28 From 29	1.172	7.9E-3		
2ACBS29-----H--	Operator Fails to Energize Bus 29 From 28	1.006	7.9E-3		
2ACCB2527---H--	Operator Fails to Energize Bus 25 From 27		1.6E-3		
2ATAD22A----H--	Master Trip Unit Not Restored After Test/Maintenance	2.330	3.7E-3		
2ATAD22B----H--	Master Trip Unit Not Restored After Test/Maintenance	2.330	3.7E-3		
2ATAD22C----H--	Master Trip Unit Not Restored After Test/Maintenance	2.330	3.7E-3		
2ATAD22D----H--	Master Trip Unit Not Restored After Test/Maintenance	2.330	3.7E-3		
2CASB2330-322H--	Operator Fails to Manually Initiate High Pressure Coolant Injection After Failure to Automatically Initiate	1.000	1.0E+0		
2CSMV140225A-H--	Operator Fails to Initiate Core Spray Manually Following Failure of Automatic Initiation	1.000	1.0E+0		
2FWPM3201---H--	Operator Fails to Restart Feedwater Pump Following High Level Trip	6.977	2.5E-3	1.4E-3	-46%
2FWPMA-3201--H--	Operator Fails to Start Standby Feedwater Pump if Not Auto Started		1.6E-3	NONE	
2FWRV-----H--	Operator Fails to Prevent Feedpump Trip on High Reactor Water Level	1.000	1.0E+0		
2HISY-----H--	Operator Fails to Perform Actions for Manually Controlling High Pressure Coolant Injection in Accordance with DOP 2300-3	4.022	2.4E-3	1.3E-3	-44%
2ICMV4399-74-H--	Operator Fails to Locally Open MOV 4399 After Being Unable to Open the Valve From the Control Room		1.0E+0		
2LIMV-22A-22BH--	Operator Fails to Open Low Pressure Coolant Injection Valves	1.000	3.6E-4		
2TBPM2B3801--H--	Operator Fails to Start TBCCW Pump After the Running Pump has Failed Due to Random Fault or Loss of Support Power (Transient)	1.001	1.6E-3		
3DCBS1253A---H-- CS1	Operator Initiates Loss of Unit 3 125VDC Bus Following Loss of Unit 2 125VDC Bus		9.8E-3		
3DCBS1253A---H-- CS2	Operator Initiates Loss of Unit 3 125VDC Bus Following Loss of Unit 2 125VDC Bus		1.2E-2		
3DCBS1253A---H-- CS3	Operator Initiates Loss of Unit 3 125VDC Bus Following Loss of Unit 2 125VDC Bus		3.3E-3		
3DCBS1253A---H-- CS4	Operator Initiates Loss of Unit 3 125VDC Bus Following Loss of Unit 2 125VDC Bus		1.6E-2		
BFPPD1-G-112AH--	Failure to Restore Unit 1 Diesel Fire Pump Following Test or Maintenance	1.000	1.0E-2		
BFPPD2/3-4101H--	Failure to Restore Unit 2/3 Diesel Fire Pump Following Test or Maintenance	1.000	1.4E-2		
BSWFL3902---H--	Operator Fails to Switch Service Water Strainers Daily		5.3E-3		

Table 4.4.2-2
SUMMARY OF PRT OPERATOR CASES

NAME	DESCRIPTION	RAW	Orig. HEP	Rev. HEP	%CHG
OAD-CS01	Initiate Automatic Depressurization (Transient, SLOCA, SBO, LOOP, 125VDC) - [Opt-stress, Zero-depend, Yes-recov]	23.142	1.0E-3	1.3E-3	30%
OAD-CS02	Initiate Automatic Depressurization (Transient) - [Mod-stress, Zero-depend, Yes-recov]	2.491	2.1E-3	1.6E-3	-24%
OAD-CS03	Initiate Automatic Depressurization (Transient, MLOCA, SLOCA, ISLOCA, IORV, SBO, LOOP, ATWS) - [Mod-stress, Zero-depend, No-recov]	21.338	9.8E-3	1.6E-2	63%
OAD-CS04	Initiate Automatic Depressurization (SBO) - [Opt-stress, Low-depend, Yes-recov]	1.180	1.1E-2	5.1E-2	366%
OAD-CS05	Initiate Automatic Depressurization (SBO) - [Mod-stress, Low-depend, No-recov]	1.005	5.9E-2	6.5E-2	11%
OAD-CS06	Initiate Automatic Depressurization (SBO) - [High-stress, Zero-depend, No-recov]	1.001	2.5E-2	1.6E-2	-36%
OAD-CS07	Initiate Automatic Depressurization (125VDC) - [Opt-stress, Zero-depend, No-recov]	7.171	4.9E-3	1.3E-2	165%
OAD-CS08	Initiate Automatic Depressurization (LOOP) - [Mod-stress, Low-depend, Yes-recov]	9.195	1.2E-2	5.2E-2	329%
OAD-CS09	Initiate Automatic Depressurization (LOOP) - [Opt-stress, zero-depend, Yes-recov]	14.394	1.0E-3	1.3E-3	30%
OAD-CS10	Initiate Automatic Depressurization (SBO) - [High-stress, Low-depend, No-recov]	NEW	NEW	6.5E-2	
OAD-SUM	Initiate Automatic Depressurization	72.916			
OAL-CS01	Reduce and Control Reactor Pressure Vessel Water Level (ATWS) - [Opt-stress, Zero-depend, No-recov]	1.007	4.4E-2		
OAL-CS02	Reduce and Control Reactor Pressure Vessel Water Level (ATWS) - [Opt-stress, Low-depend, No-recov]	1.019	9.2E-2		
OAL-SUM	Reduce and Control Reactor Pressure Vessel Water Level (ATWS)	1.026			
OAT-CS01	Manually Initiate Alternate Rod Insertion (ATWS) - [High-stress, Zero-depend, No-recov]	1.225	6.0E-3		
OAT-CS02	Manually Initiate Alternate Rod Insertion (ATWS) - [High-stress, Mod-depend, No-recov]	1.047	1.5E-1		
OAT-SUM	Manually Initiate Alternate Rod Insertion (ATWS)	1.272			
OCN-CS01	Initiate Containment Spray (Transient, LLOCA, MLOCA, SLOCA, IORV, SBO, LOOP, ATWS) - [High-stress, Zero-depend, Yes-recov]	1.017	3.6E-2		
OCN-CS02	Initiate Containment Spray (MLOCA, SLOCA, ATWS) - [Opt-stress, Zero-depend, Yes-recov]	1.000	6.9E-3		
OCN-CS03	Initiate Containment Spray (125VDC) - [High-stress, Zero-depend, Yes-recov]		4.0E-2		
OCN-SUM	Initiate Containment Spray	1.018			
OCRD-CS01	Crossties Control Rod Drive flow from the other Unit for makeup (SBO, LOOP) - [Mod-stress, Zero-depend, Yes-recov]	NEW	NEW	1.4E-3	
OCRD-SUM	Crossties Control Rod Drive flow from the other Unit for makeup	NEW	NEW		

Table 4.4.2-2
SUMMARY OF PRT OPERATOR CASES

NAME	DESCRIPTION	RAW	Orig. HEP	Rev. HEP	%CHG
OCST-CS02	Align Low Pressure Pump Suction to the Condensate Storage Tank - [Opt-stress, Zero-depend, Yes-recov]	NEW	NEW	1.4E-3	
OCST-CS09	Align Low Pressure Pump Suction to the Condensate Storage Tank - [Mod-stress, Zero-depend, No-recov]	NEW	NEW	1.5E-2	
OCST-CS10	Align Low Pressure Pump Suction to the Condensate Storage Tank - [Mod-stress, Zero-depend, Yes-recov]	NEW	NEW	1.5E-3	
OCST-CS12	Align Low Pressure Pump Suction to the Condensate Storage Tank - [Mod-stress, Low-depend, Yes-recov]	NEW	NEW	5.1E-2	
OCST-CS18	Align Low Pressure Pump Suction to the Condensate Storage Tank - [High-stress, Zero-depend, Yes-recov]	NEW	NEW	1.9E-3	
OCST-CS20	Align Low Pressure Pump Suction to the Condensate Storage Tank - [High-stress, Low-depend, Yes-recov]	NEW	NEW	5.2E-2	
OCST-CS25	Align Low Pressure Pump Suction to the Condensate Storage Tank	NEW	NEW	1.0E+0	
OCST-SUM	Align Low Pressure Pump Suction to the Condensate Storage Tank	NEW	NEW		
OFP-CS01	Align Fire Protection to Feedwater (ISLOCA, SBO) - [Mod-stress, Zero-depend, Yes-recov]	1.001	4.4E-2		
OFP-CS02	Align Fire Protection to Feedwater (ISLOCA) - [High-stress, High-depend, Yes-recov]	1.000	1.6E-1		
OFP-CS03	Align Fire Protection to Feedwater (SBO) - [High-stress, Zero-depend, No-recov]	1.000	5.4E-1		
OFP-SUM	Align Fire Protection to Feedwater	1.001			
OFW-CS01	Restore Feedwater Injection (ISLOCA) - [Mod-stress, Zero-depend, Yes-recov]	1.007	5.3E-3		
OFW-CS02	Restore Feedwater Injection (ISLOCA) - [High-stress, Zero-depend, No-recov]		1.1E-1		
OFW-CS03	Restore Feedwater Injection (ISLOCA) - [High-stress, Low-depend, No-recov]	1.000	1.5E-1		
OFW-CS04	Restore Feedwater Injection (SBO, LOOP) - [Opt-stress, Zero-depend, Yes-recov]	1.000	1.0E+0		
OFW-CS05	Restore Feedwater Injection (SBO) - [Mod-stress, Zero-depend, Yes-recov]	1.000	1.0E+0		
OFW-SUM	Restore Feedwater Injection	1.007			
OHX-CS01	Start Containment Cooling Service Water Pump & Close Low Pressure Coolant Injection Heat Exchanger Bypass Valve (LLOCA, MLOCA, SLOCA) - [Opt-stress, Zero-depend, No-recov]	1.862	8.8E-3		
OHX-CS02	Start Containment Cooling Service Water Pump & Close Low Pressure Coolant Injection Heat Exchanger Bypass Valve (MLOCA, SLOCA) - [Opt-stress, Zero-depend, Yes-recov]		1.8E-3		

Table 4.4.2-2
SUMMARY OF PRT OPERATOR CASES

NAME	DESCRIPTION	RAW	Orig. HEP	Rev. HEP	%CHG
OHX-CS03	Start Containment Cooling Service Water Pump & Close Low Pressure Coolant Injection Heat Exchanger Bypass Valve (MLOCA, SLOCA) - [Mod-stress, Zero-depend, No-recov]		1.8E-2		
OHX-CS04	Start Containment Cooling Service Water Pump & Close Low Pressure Coolant Injection Heat Exchanger Bypass Valve (MLOCA, SLOCA) - [High-stress, Zero-depend, Yes-recov]	1.158	9.2E-3		
OHX-SUM	Start Containment Cooling Service Water Pump & Close Low Pressure Coolant Injection Heat Exchanger Bypass Valve	2.021			
OI2-CS09	Open Isolation Condenser Valve Breakers (SBO) - [Mod-stress, Zero-depend, No-recov]		1.5E-1		
OI2-CS10	Open Isolation Condenser Valve Breakers (SBO) - [Mod-stress, Zero-depend, Yes-recov]	1.345	3.2E-2		
OI2-SUM	Open Isolation Condenser Valve Breakers	1.345			
OIADS-CS01	Inhibit Automatic Depressurization (ATWS) - [Mod-stress, Zero-depend, No-recov]	NEW	NEW	3.0E-3	
OIADS-SUM	Inhibit Automatic Depressurization	NEW	NEW		
OIC-CS01	Initiate Isolation Condenser		1.0E+0		
OIC-CS02	Initiate Isolation Condenser (SBO, LOOP) - [Opt-stress, Zero-depend, No-recov]	1.542	3.7E-2		
OIC-SUM	Initiate Isolation Condenser	1.542			
OIS-CS01	Isolate Low Pressure Coolant Injection Cross-tie Valves (ISLOCA) - [Mod-stress, Zero-depend, No-recov]	1.000	1.0E+0		
OIS-CS02	I Isolate Low Pressure Coolant Injection Cross-tie Valves (ISLOCA) - [Mod-stress, High-depend, No-recov]		1.0E+0		
OIS-SUM	Isolate Low Pressure Coolant Injection Cross-tie Valves	1.000			
OMU-CS01	Initiate Makeup to the Isolation Condenser (Transient, ATWS, LOOP) - [Opt-stress, Zero-depend, No-recov]	18.766	7.9E-3	1.3E-3	-83%
OMU-CS02	Initiate Makeup to the Isolation Condenser (SBO) - Mod-stress, Zero-depend, No-recov]		1.0E-2	1.4E-2	40%
OMU-SUM	Initiate Makeup to the Isolation Condenser	18.766			
ORP-CS01	Trip Recirculation Pumps (ATWS) - [High-stress, Zero-depend, No-recov]	1.634	5.1E-2		
ORP-SUM	Trip Recirculation Pumps	1.634			
OSB-CS01	Initiate Standby Coolant Supply System (LLOCA) - [Mod-stress, Low-depend, Yes-recov]	1.318	1.7E-2		
OSB-CS02	Initiate Standby Coolant Supply System (LLOCA) - [High-stress, Low-depend, Yes-recov]	1.001	3.8E-2		
OSB-CS03	Initiate Standby Coolant Supply System		5.1E-2		
OSB-CS04	Initiate Standby Coolant Supply System (ISLOCA) - [High-stress, Zero-depend, No-recov]	1.000	3.2E-2		

Table 4.4.2-2
SUMMARY OF PRT OPERATOR CASES

NAME	DESCRIPTION	RAW	Orig. HEP	Rev. HEP	%CHG
OSB-SUM	Initiate Standby Coolant Supply System	1.319			
OSL1-CS01	Initiate one Standby Liquid Control Pump (ATWS) - [Opt-stress, Zero-depend, No-recov]	1.562	8.7E-3		
OSL1-CS02	Initiate one Standby Liquid Control Pump (ATWS) - [High-stress, Zero-depend, No-recov]	1.570	4.5E-2		
OSL1-SUM	Initiate one Standby Liquid Control Pump	2.132			
OSL2-CS01	Initiate two Standby Liquid Control Pumps (ATWS) - [Mod-stress, High-depend, Yes-recov]	1.235	1.1E-1		
OSL2-SUM	Initiate two Standby Liquid Control Pumps	1.235			
OSP-CS01	Initiate Suppression Pool Cooling (Transient, SLOCA, SBO, LOOP) - [Opt-stress, Zero-depend, Yes-recov]	20.385	1.6E-4	NONE	
OSP-CS02	Initiate Suppression Pool Cooling (Transient, SBO, LOOP) - [Mod-stress, Zero-depend, Yes-recov]		4.4E-4	NONE	
OSP-CS03	Initiate Suppression Pool Cooling (Transient, SLOCA, IORV, LOOP, 125VDC, ATWS) - [High-stress, Mod-depend, Yes-recov]	1.222	3.5E-2	NONE	
OSP-CS04	Initiate Suppression Pool Cooling (Transient, LLOCA, IORV, SBO, LOOP, ATWS) - [Mod-stress, Zero-depend, No-recov]	9.788	2.1E-3	1.0E-4	-95%
OSP-CS05	Initiate Suppression Pool Cooling (MLOCA, SBO, LOOP) - [High-stress, Zero-depend, No-recov]	1.041	7.5E-3	NONE	
OSP-CS06	Initiate Suppression Pool Cooling (LLOCA) - [Opt-stress, High-depend, No-recov]	1.008	5.0E-1	NONE	
OSP-CS07	Initiate Suppression Pool Cooling (Transient, MLOCA, IORV, LLOCA, ATWS) - [Opt-stress, Zero-depend, No-recov]	197.000	6.6E-4	1.0E-5	-98%
OSP-CS08	Initiate Suppression Pool Cooling (SLOCA) - [Opt-stress, High-depend, Yes-recov]		1.1E-1	NONE	
OSP-CS09	Initiate Suppression Pool Cooling (SLOCA, SBO) - [High-stress, Zero-depend, Yes-recov]	1.010	1.6E-3	NONE	
OSP-CS10	Initiate Suppression Pool Cooling (SBO) - [Mod-stress, Mod-depend, Yes-recov]	1.002	1.1E-2	NONE	
OSP-CS11	Initiate Suppression Pool Cooling (MLOCA, SBO) - [High-stress, Mod-depend, No-recov]	1.001	1.5E-1	NONE	
OSP-CS12	Initiate Suppression Pool Cooling (125VDC, SBO) - [Mod-stress, Zero-depend, Yes-recov]		1.9E-3	NONE	
OSP-CS13	Initiate Suppression Pool Cooling (125VDC, SBO) - [High-stress, Zero-depend, Yes-recov]		5.3E-3	NONE	
OSP-CSX1	Initiate Suppression Pool Cooling (LLOCA) (conditional calculation OSP-CS07/OHX-CS1)	NEW	NEW	1.1E-03	
OSP-CSX4	Initiate Suppression Pool Cooling (MLOCA) (conditional calculation OSP-CS07/OHX-CS4)	NEW	NEW	1.1E-03	

Table 4.4.2-2
SUMMARY OF PRT OPERATOR CASES

NAME	DESCRIPTION	RAW	Orig. HEP	Rev. HEP	%CHG
OSP-SUM	Initiate Suppression Pool Cooling	225.457			
OSS-CS01	Restore Support Systems to Feedwater(SBO, LOOP) - [Opt-stress, Zero-depend, Yes-recov]		2.3E-3		
OSS-CS02	Restore Support Systems to Feedwater(SBO) - [Mod-stress, Zero-depend, Yes-recov]		6.1E-3		
OSS-CS03	Restore Support Systems to Feedwater(SBO) - [Mod-stress, Low-depend, Yes-recov]		1.6E-2		
OSS-CS04	Restore Support Systems to Feedwater(SBO) - [Mod-stress, Zero-depend, No-recov]		2.9E-2		
OSS-CS05	Restore Support Systems to Feedwater		1.1E-1		
OSS-SUM	Restore Support Systems to Feedwater	1.000			
OVR-CS01	Vent the Reactor Pressure Vessel (LLOCA, during containment flooding) - [Mod-stress, Zero-depend, Yes-recov]		1.0E+0		
OVR-CS02	Vent the Reactor Pressure Vessel (LLOCA, during containment flooding) - [High-stress, Zero-depend, Yes-recov]	1.000	1.0E+0		
OVR-SUM	Vent the Reactor Pressure Vessel (LLOCA, during containment flooding)	1.000			
OVT-CS01	Initiate Containment Vent (Transient, MLOCA, SLOCA, IORV, SBO, LOOP, 125VDC, ATWS) - [Opt-stress, Zero-depend, Yes-recov]	1.300	2.5E-4		
OVT-CS02	Initiate Containment Vent (Transient, LLOCA, IORV, SBO, LOOP, 125VDC, ATWS) - [Mod-stress, Zero-depend, Yes-recov]	1.096	5.0E-4		
OVT-CS03	Initiate Containment Vent (Transient, LLOCA, MLOCA, SLOCA, IORV, SBO, LOOP, 125VDC, ATWS) - [Hi-stress, Zero-depend, Yes-recov]	1.001	1.3E-3		
OVT-SUM	Initiate Containment Vent	1.396			

2. **OAL** Reduce and Control Reactor Pressure Vessel Water Level (ATWS)

This action is required during an ATWS to lower reactor power to reduce the heat input to the Suppression Pool. This action is only required if Feedwater is available. The only other high pressure injection system is High Pressure Coolant Injection which does not have the flow capacity to maintain the normal RPV level. If the main condenser is not available the action is not credited.

Pt ~ 2 minutes
At ~ 10 minutes if the main condenser is available (insufficient if the main condenser is not available)

3. **OAT** Manually Initiate Alternate Rod Insertion (ATWS)

This is an immediate action after noting the Control Rods have not successfully scrammed. This action is only credited if the main condenser is available -- if the condenser is unavailable, there is insufficient time to trip the ARI system to prevent over-pressurization of the Primary system.

Pt < 1 minute (about 1 minute into the event)
At ~ 10 minutes if the main condenser is available (insufficient if the main condenser is not available)

4. **OCNTS** Initiate Containment Spray

This action is modeled in all initiators except for Interfacing System LOCA, the action is only required to prevent Containment venting in those cases where the Containment cannot be cooled. The sprays also provide scrubbing of the Containment atmosphere for source term considerations. The cue to start the spray happens at the initiator with the Small, Medium and Large LOCAs. The condition for starting sprays for the other initiators usually does not occur until the RPV fails. If the sprays were started earlier they could provide an alternate path for removing Containment heat and prevent the loss of the low pressure ECCS pumps on NPSH (Net Positive Suction Head).

Pt ~ 2 minutes
At > 4 hours if high pressure systems were unsuccessful - to protect ECCS pumps NPSH
> 6 hours if HPCI were successful - to protect ECCS pumps NPSH
> 20 hours to avoid Containment venting.

5. **OCRD** Crossties Control Rod Drive flow from the other Unit for makeup

This action is credited only in the single unit black-out (SBO) sequences. This provides the necessary volume of makeup water to the RPV to compensate to any Primary system leakage -- principally from the failure of the Recirculation Pump Seals. This makeup plus the successful operation of the Isolation Condenser will avoid core damage. Two side by side manual valves in the plant need to be opened for success.

Pt ~ 5 minutes (at about 30 minutes into the event)
At ~ 2-3 hours

6. **OCST** Align Low Pressure Pump Suction to the Condensate Storage Tank

An alternate path of providing low temperature water for the low pressure ECCS pumps when Suppression Pool cooling or other means of avoiding the loss of the ECCS pumps due to NPSH. The action is not credited in the LOCA events. A local operator closes a single valve and opens 2 others.

Pt ~20 minutes
At > 4 hours if high pressure systems were unsuccessful - to protect ECCS pumps NPSH
> 6 hours if HPCI were successful - to protect ECCS pumps NPSH

7. **OFP** Align Fire Protection to Feedwater

OFP is modeled in the Interfacing System LOCA and SBO. The action requires a local operator to use multiple firehoses to connect the Fire Protection system to the Feedwater system. The action requires the successful operation of High Pressure Coolant Injection and/or the Isolation Condenser during an SBO and requires successful injection by Core Spray during an Interfacing System LOCA.

Pt ~ 30 minutes
At > 4 hours if HPCI or IC successful during an SBO
> 1 hour if CS operates ~ 1 hour during an ISLOCA

8. **OFW** Restore Feedwater Injection

This action is only modeled in the LOOP and SBO events. Due to the time required to fill and vent the Condensate system after a complete system shutdown, this action is deemed to have a failure probability of 1.0.

9. OHX Start Containment Cooling Service Water Pump & Close Low Pressure Coolant Injection Heat Exchanger Bypass Valve

OHX is utilized in the Small, Medium and Large LOCA sequences, it credits Containment heat removal using the RPV injection path. The path is only effective in the Small and Medium cases after failure of the RPV which will provide a sufficient opening to allow near full injection flow capability. This action is required prior to Containment venting.

Pt ~ 5 minutes (start ~ 5 minutes into the event)
At > 20 hours (to avoid Containment venting)

10. OI2 Open Isolation Condenser Valve Breakers

The Isolation Condenser Isolation Valves will receive an isolation signal upon the depletion of the 125V DC batteries during station black-out (SBO) events. The operators are directed to locally open the breakers to the valves prior to receiving the isolation signal. This action will permit the Isolation Condenser to continue to control the RPV pressure.

Pt ~ 15 minutes (at about 3 hours into the event)
At ~ 4 hours

11. OIADS Inhibit Automatic Depressurization

During ATWS sequences the Automatic Depressurization function is inhibited to prevent any injected boron from being flushed from the core region by operation of the low pressure ECCS pumps.

Pt < 1 minute
At ~ 2 minutes after the simultaneous high Containment pressure (>2 psig) and low-low reactor pressure vessel level (< -59 inches).

12. OIC Initiate Isolation Condenser

During LOOP and SBO events, the operators are credited with starting the Isolation Condenser in sufficient time to prevent the relief valves and safety valves from being challenged. The action will avoid the failure of the valves to reclose after opening to control pressure. The operator response on the simulator has indicated that the operators are able to avoid the relief and safety valves opening.

Pt < 1 minute (starting about 1 minute into the event)
At sufficient according to simulator and plant experience

13. OIS Isolate Low Pressure Coolant Injection Cross-tie Valves

This action is only utilized in the Interfacing System LOCA events. The LOCA is assumed to take place in the LPCI system and without the operators successfully isolating the LPCI cross-tie valves both trains of LPCI are assumed to fail. Since, OIS is not well practiced and there is limited procedural guidance, this action is assumed to fail with a probability of 1.0.

14. OMU Initiate Makeup to the Isolation Condenser

The Isolation Condenser is not credited during the Small, Medium, Large and Interfacing System LOCAs. The Isolation Condenser contains at least a 20 minute supply of water. The action is required to permit the continued operation of the Isolation Condenser. Normally, the action to start the pump and open the shell-side makeup valve can be performed from the control room. During station black-out conditions, the makeup valve must be opened locally.

Pt ~ 2 minutes for all but SBO events
~15 minutes for SBO events
At ~ 20 minutes at the minimum shell side water level
~ 1 hour at the normal shell side water level

15. ORP Trip Recirculation Pumps

During ATWS sequences, this action reduces the reactor power to limit the heat input into the Suppression Pool. ORP is only credited if the main condenser is available -- if the condenser is unavailable, there is insufficient time to trip the ARI system to prevent over-pressurization of the Primary system.

Pt ~ 1 minute (about 1 minute into the event)
At ~ 10 minutes if the main condenser is available (insufficient if the main condenser is not available)

16. OSB Initiate Standby Coolant Supply System

The action to initiate Standby Coolant Supply (SBCS) is only credited in the Large and Interfacing System LOCAs. The action involves opening two motor-operated valves to supply raw service water to the condenser. The Condensate and Feedwater system then utilize this water to inject into the reactor vessel. The cue to initiate SBCS is given in the DEOPs, when it is determined that the RPV level cannot be maintained above the "top of active fuel" or that RPV level cannot be determined. During a Large LOCA, the action can flood the Containment to the "top of active fuel" region within 4 - 5 hours. It will also provide additional NPSH margin for the low pressure ECCS pumps. During Interfacing LOCA events, this system provides an alternate means of providing water to the RPV.

Pt ~ 2 minutes
At insufficient time to prevent core damage for Large LOCA without other ECCS pumps injecting
~ 5 minutes for Interfacing System LOCA with no other injection.
> 1 hour if a Low pressure ECCS pump can inject water initially.

17. OSL1 Initiate one Standby Liquid Control Pump

The action during ATWS events, to initiate standby liquid control (inject boron) assuming only one injection pump is available. The operators are required to start initiating the injection prior to the Suppression Pool reaching 110 degrees. OSL1 is not credited if the Reactor Recirculation Pumps do not trip. Additional time would be available if the Feedwater flow is terminated or controlled to lower the RPV level to the "top of active fuel" (TAF).

Pt < 1 minute (about 1 minute into the event)
At < 1 minute if main condenser is unavailable and Recirc pump trip failed
1.3 minutes if main condenser is unavailable and Recirc pump trip is successful
4.2 minutes if main condenser is available and Recirc pump trip is successful

18. OSL2 Initiate two Standby Liquid Control Pumps

The action during ATWS events, to initiate standby liquid control (inject boron) assuming two injection pumps are available. The operators are required to start initiating the injection with both pumps prior to the Suppression Pool reaching 110 degrees, however if two pumps are utilized additional time is available without

exceeding the heat capacity limit of the Suppression Pool. If the Feedwater flow is terminated or controlled to lower the RPV level to the TAF, then the reactor power is reduced and the heat input into the Suppression Pool is also reduced. If the main condenser is available, the Reactor Recirculation Pumps were tripped and the RPV level were lowered to the TAF, then the reactor power would be reduced to the point that no heat is being added to the Suppression Pool

Pt < 1 minute (about 1 minute into the event)
At ~ 5 minutes if main condenser is unavailable and Recirc pump trip failed
> 5 minutes if main condenser is unavailable and Recirc pump trip is successful
~ 10 minutes if main condenser is available and Recirc pump trip is successful

19. OSP Initiate Suppression Pool Cooling

This action is modeled in all initiators except for Interfacing System LOCA, the action is required to avoid Containment venting and to prevent the loss of the low pressure ECCS pumps due to NPSH. The NPSH is not of concern during Large and Medium LOCAs, therefore Containment venting is the limiting case. The cue to initiate Suppression Pool cooling happens early in the event (about 5 minutes), but the action can be delayed for hours.

Pt ~ 5 minutes (start ~ 5 minutes into the event)
At > 4 hours if high pressure systems were unsuccessful - to protect ECCS pumps NPSH
> 6 hours if HPCI were successful -- to protect ECCS pumps NPSH
> 20 hours to avoid Containment venting.

20. OSS Restore Support Systems to Feedwater

This action is only modeled in the LOOP and SBO events. This action restarts the Service Water and Turbine Building Closed Cooling Water systems. This action is required to be completed prior to the restart of the Feedwater and Condensate System. This action is effectively not credited, since it is only required for the success of OFW, and as discussed in the OFW section, OFW is deemed to have a failure probability of 1.0.

21. OVR Vent the Reactor Pressure Vessel (LLOCA, during Containment flooding)

OVR is only modeled in the Large LOCA events and is only utilized to vent the reactor vessel to permit flooding of the core during Containment flooding. As

mentioned in the discussion of OSB, Containment flooding is cannot prevent core damage, therefore this action is given a failure probability of 1.0

22. OVT Initiate Containment Vent

The Containment is required to be vented to avoid Containment over-pressure failure. The need for venting can be essentially be controlled by the use of Containment heat removal. This action requires the use of jumpers and lifted leads to bypass the Containment Isolation signals. Containment pressurization is slowly developing and can be anticipated with all preparations made before-hand. The cue to start venting is the Containment pressure at about 60 psig and the Containment failure is anticipated to occur at about 138 psig.

Pt ~ 30 minutes (at more than 20 hours into the event)
At > 24 hours

23. 2ACBS23-1-23-H-- Operator Fails to Energize Bus 23 From 23-1

This action is only needed during LOOP events when the only source of power for 4KV Bus 23 is from the DG Bus 23-1. The only loads on Bus 23 modeled in the PRA are the Containment Cooling Service Water Pumps. These pumps are only needed to cool the Containment. The times involved are the same as those addressed in OHX and OSPC discussions above.

24. 2ACBS24-1-24-H-- Operator Fails to Energize Bus 24 From 24-1

This action is only needed during LOOP events when the only source of power for 4KV Bus 24 is from the DG Bus 24-1. The only loads on Bus 24 modeled in the PRA are the Containment Cooling Service Water Pumps. These pumps are only needed to cool the Containment. The times involved are the same as those addressed in OHX and OSPC discussions above.

25. 2ACBS28-29---H-- Operator Fails to Energize Bus 28 From 29

This is a recovery action that cross-ties the 480VAC Buses 28 and 29. The action is only required if Bus 28 cannot be supplied power from the DG Bus 23-1. Bus 28 supplies the following loads: SBLC pump 2A, Div I Core Spray and LPCI valves, DG2/3 cooling water pump and normal supply for the Instrument Bus. Any time considerations would be driven by the need for both SBLC pumps.

26. **2ACBS29------H--** Operator Fails to Energize Bus 29 From 28

This is a recovery action that cross-ties the 480VAC Buses 28 and 29. The action is only required if Bus 29 cannot be supplied power from the DG Bus 24-1. Bus 29 supplies the following loads: SBLC pump 2B, Div II Core Spray and LPCI valves, DG2 cooling water pump, Isolation Condenser shell side makeup valve from the Clean Demineralized Water system and normal supply for the Essential Service Bus.

27. **2ACCB2527----H--** Operator Fails to Energize Bus 25 From 27

This is a recovery action that supplies the 480VAC Bus 25 from Bus 27 which is an alternate supply. The action is only required if Bus 25 cannot be supplied power from the Bus 24. Bus 25 acts as an alternate supply for the Essential Service Bus.

28. **2ATAD22A-----H--** Master Trip Unit Not Restored After Test/Maintenance

This is a pre-initiator action - no time considerations are involved.

29. **2ATAD22B-----H--** Master Trip Unit Not Restored After Test/Maintenance

This is a pre-initiator action -- no time considerations are involved.

30. **2ATAD22C-----H--** Master Trip Unit Not Restored After Test/Maintenance

This is a pre-initiator action -- no time considerations are involved.

31. **2ATAD22D-----H--** Master Trip Unit Not Restored After Test/Maintenance

This is a pre-initiator action -- no time considerations are involved.

32. **2CASB2330-322H--** Operator Fails to Manually Initiate HPCI After Failure to Automatically Initiate

This action is a backup to the automatic action to start the High Pressure Coolant Injection system, it is used for sensitivity analysis. At present this action carries a failure probability of 1.0.

33. **2CSMV140225A-H--** Operator Fails to Initiate Core Spray Manually Following Failure of Automatic Initiation

This action is a backup to the automatic action to start the Core Spray system, it is used for sensitivity analysis. At present this action carries a failure probability of 1.0.

34. **2FWPM3201----H--** Operator Fails to Restart RFP Following High Level Trip

This action is modeled in the Feedwater Fault-tree. It is assumed that the Feedwater pumps will trip on high level during all transient events. This action will restore Feedwater as a makeup source to the RPV. This action is required to avoid the need to depressurize the reactor. See discussion of OADS above.

Pt ~ 2 minutes
At > 30 minutes during LOOP, SLOCA, Tran, ATWS initiators without any high pressure injection
> 60 minutes for a medium LOCA with HPCI success
> 4 hours during LOOP, SLOCA, Tran, ATWS initiators with HPCI or Isolation Condenser success.

35. **2FWPMA-3201--H--** Operator Fails to Start Standby RFP if Not Auto Started

This action is no longer being credited in the PRA model. It will be deleted in the future.

36. **2FWRV--------H--** Operator Fails to Prevent Feedpump Trip on High Reactor Water Level

This action models the operators' capability to intervene in sufficient time during events other than Medium, Large, and Interfacing System LOCAs to prevent the trip of the Feedwater pumps. At present this action carries a failure probability of 1.0.

37. **2HISY--------H--** Operator Fails to Perform Actions for Manually Controlling HPCI in Accordance with DOP 2300-3

This action models the operator action to manually throttle the High Pressure Coolant Injection system. This action prevents the system from continuously tripping and restarting on RPV level. The system will function without the intervention, however the cycling of the system can be reduced if the operator takes control.

Usually this action is accomplished shortly after the system initiates (within 2-3 minutes).

38. **2ICMV4399-74-H--** Operator Fails to Locally Open MOV 4399 After Being Unable to Open the Valve From the Control Room

This operator action locally opens the Isolation Condenser shell side motor-operated valve, assuming that it does not open from the Control Room. During SBO sequences this action is modeled in the OMUP operator action, for other events this action recovers localized failures. At present this action carries a failure probability of 1.0.

39. **2LIMV-22A-22BH--** Operator Fails to Open LPCI Injection Valves

This action is a backup to the automatic action to start the open the LPCI injection valve(s). At present this action carries a failure probability of 1.0.

40. **2TBPM2B3801--H--** Operator Fails to Start TBCCW Pump After the Running Pump has Failed Due to Random Fault or Loss of Support Power (Transient)

This action is a backup to the automatic action to start the standby Turbine Building Closed Cooling Water pump. At present this action carries a failure probability of 1.0.

41. **3DCBS1253A---H-- CS1** Operator Initiates Loss of Unit 3 125VDC Bus Following Loss of Unit 2 125VDC Bus

This is a commission error that could un-intentionally fail the other 125VDC Bus.

42. **3DCBS1253A---H-- CS2** Operator Initiates Loss of Unit 3 125VDC Bus Following Loss of Unit 2 125VDC Bus

This is a commission error that could un-intentionally fail the other 125VDC Bus.

43. **3DCBS1253A---H-- CS3** Operator Initiates Loss of Unit 3 125VDC Bus Following Loss of Unit 2 125VDC Bus

This is a commission error that could un-intentionally fail the other 125VDC Bus.

44. **3DCBS1253A---H-- CS4**Operator Initiates Loss of Unit 3 125VDC Bus Following Loss of Unit 2 125VDC Bus

This is a commission error that could un-intentionally fail the other 125VDC Bus.

45. **BFPPD1-G-112AH--** Failure to Restore Unit 1 Diesel Fire Pump Following Test or Maintenance

This is a pre-initiator action -- no time considerations are involved.

46. **BFPPD2/3-4101H--** Failure to Restore Unit 2/3 Diesel Fire Pump Following Test or Maintenance

This is a pre-initiator action -- no time considerations are involved.

47. **BSWFL3902----H--** Operator Fails to Switch Service Water Strainers Daily

This is a daily routine that should be maintained during an event to avoid the gradual loss of Service Water due to a high differential pressure across the strainers. The only time constraint is to perform the action once every 24 hours.

4.4.3 Common Cause Analysis

"Common cause" describes multiple failures of functionally identical components due to a single, shared cause. Common cause analysis (CCA) evaluates the effects of these dependencies that may affect the ability of a system to prevent or mitigate a severe accident.

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SRO and was familiar with current plant practices and procedures as well as those in practice at the time of the events in the generic common cause failure database.

The common cause failure database was reviewed for events applicable to Dresden. The expert panel came to a consensus opinion on each generic common cause event's applicability to Dresden, based upon current Dresden system configuration, and maintenance and operating practices. Events involving known common cause mechanisms addressed by specific programs in place at Dresden were discarded from the database as were common cause events that occurred due to specific system configurations not present at Dresden. Events involving common cause mechanisms that have been addressed in general by maintenance or operating practices at Dresden were assigned a lesser probability of occurrence based on judgement of the panel. Furthermore, as part of the Modified IPE, a "floor" of 0.01 was imposed on beta values. Table 4.4.3-1 shows the Dresden-specific MGL parameters resulting from this analysis.

An average common cause component group was quantified from a composite of all the common cause failures for all components in the database (ALL in Table 4.4.3-1). Use of the parameters calculated for this average common cause group was extended to components that have no history of common cause failure, but were judged by the analyst to have some potential for common cause failure. The common cause contribution for the following components was calculated using the average MGL values:

- Relays, including contacts and coils
- Switches, including temperature, level, and pressure switches
- Dampers
- Explosive valves
- Solenoid-operated valves
- Diesel-driven pumps
- Strainers and filters
- Check valves
- Timing relays

In general, the components included in this list were judged to be less complex than the components in the database and thought to have less potential for common cause failure mechanisms. Therefore, assignment of the average common cause parameters is judged to be realistic.

TABLE 4.4.3-1
MGL PARAMETERS FOR MODIFIED DRESDEN IPE

CC COMPONENT GROUP (from CC databases)	FOUR-COMPONENT SYSTEM			THREE-COMPONENT SYSTEM		TWO-COMPONENT SYSTEM
	BETA	GAMMA	DELTA	BETA	GAMMA	BETA
CB	--a--	--a--	--a--	5.6E-02	9.3E-01	5.4E-02
Containment Spray (CS) PUMP	--a--	--a--	--a--	--a--	--a--	5.1E-02
CV	1.0E-02	--b--	--b--	1.0E-02	--b--	1.0E-02
SW PUMP	1.0E-02	7.8E-01	5.7E-01	1.0E-02	6.0E-01	1.0E-02
DG	--a--	--a--	--a--	1.0E-02	1.6E-01	1.0E-02
HIGH-HEAD PUMP	--a--	--a--	--a--	--a--	--a--	3.2E-02
MOV	1.7E-02	5.0E-01	6.8E-01	1.4E-02	4.7E-01	1.0E-02
SLC RELIEF VALVE	1.1E-02	--b--	--b--	1.0E-02	--b--	1.0E-02
ELECTROMATIC RELIEF VALVE	2.4E-01	7.1E-01	1.0E+00	2.1E-01	7.8E-01	1.9E-01
SRV	1.1E-01	6.6E-01	2.1E-01	9.7E-02	3.5E-01	6.5E-02
HVAC CHILLER	--a--	--a--	--a--	1.0E-02	1.3E-01	1.0E-02
FAN	1.2E-02	1.0E+00	1.0E+00	1.2E-02	1.0E+00	1.2E-02
ALL	2.5E-02	7.2E-01	5.9E-01	2.3E-02	5.8E-01	1.8E-02

Notes:

a. MGL values not calculated for this size system.

b. Value not calculated. The average value for all component failures ("ALL") given in this table is used as the value for these components.

TABLE 4.4.3-3
MGL FACTORS FOR MODIFIED DRESDEN IPE

COMPONENT TYPE	COMPONENTS IN SYSTEM (m)	NUMBER OF FAILED COMPONENTS (k)		
		2	3	4
PM (See Note 1)	2	1.00E-02		
(SW, LPCI, CCSW, FW, EDG	3	5.00E-03	6.00E-03	
Cooling Water, and Condensate PUMPS)	4	3.33E-03	2.60E-03	4.45E-03
PM (Core Spray PUMPS - See Note 2)	2	5.10E-02		
PM (SLC PUMPS - See Note 3)	2	3.20E-02		
CB	2	5.40E-02		
	3	2.80E-02	5.21E-02	
CV	2	1.00E-02		
	3	5.00E-03	5.80E-03	
	4	3.33E-03	2.40E-03	4.25E-03
DG	2	1.00E-02		
	3	5.00E-03	1.60E-03	
MV	2	1.00E-02		
(MOV)	3	7.00E-03	6.58E-03	
	4	5.67E-03	2.83E-03	5.78E-03
AM	2	1.00E-02		
(SLC RELIEF VALVE)	3	5.00E-03	5.80E-03	
	4	3.67E-03	2.64E-03	4.67E-03
AS	2	1.90E-01		
(ELECTRO-MATIC RELIEF	3	1.05E-01	1.64E-01	
VALVE)	4	8.00E-02	5.68E-02	1.70E-01
AV	2	6.50E-02		
(SRV)	3	4.85E-02	3.40E-02	
	4	3.67E-02	2.42E-02	1.52E-02
RF	2	1.00E-02		
(HVAC CHILLER)	3	5.00E-03	1.30E-03	
FN	2	1.20E-02		
(FAN)	3	6.00E-03	1.20E-02	
	4	4.00E-03	4.00E-03	1.20E-02
ALL	2	1.80E-02		
	3	1.15E-02	1.33E-02	
	4	8.33E-03	6.00E-03	1.06E-02

Notes:

1. Because the analysis provided 3 and 4 pump MGL factors only for the "SW pump" category, that category was used for systems having more than 2 pumps.

TABLE 4.4.3-3 (Continued)
MGL FACTORS FOR DRESDEN

2. For the Modified IPE, the containment spray pump category from the common cause databases was used for the Dresden core spray pumps.

3. For the Modified IPE, the high-head pump category from the common cause databases was used for the Dresden standby liquid control pumps.

4.4.4.1 Information Collection

Much information needed for the analysis was taken from the Safe Shutdown Report (SSR) prepared in response to the requirements of 10CFR Part 50, Appendix R. The fire zones developed for the SSR were generally found to be acceptable for use as flooding zones. The list of equipment necessary for safe shutdown developed for the SSR was used for the internal flooding analysis as well.

Additional information necessary to the analysis was collected during plant walkdowns. This included investigation of the potential flooding and spraying sources, the equipment that would be affected by these sources, the potential for flooding propagation between areas, and flood mitigation features in the various areas. The walkdowns encompassed those areas judged to be of possible significance in terms of core damage potential in a flooding zone screening process.

4.4.4.2 Screening Process

Core damage results from the combination of an initiating event and failure of systems or components necessary to the safe shutdown of the plant. The safe shutdown systems are sufficiently reliable to reduce the core damage frequency to within acceptable levels for trip initiators on the order of several per year. Flooding events such as pipe, valve, and tank breaks or ruptures are sufficiently infrequent to be unimportant as trip initiators alone. Only if the same flooding event also degrades safe shutdown capability will the potential for core damage become significant.

The flooding zones judged to be of possible significance were, therefore, those containing both safe shutdown equipment and equipment whose failure would result in a reactor trip. These zones were investigated during the plant walkdowns. Other flooding zones were eliminated from further analysis as possible contributors to core damage.

4.4.4.3 Qualitative Analysis

The information gathered as described in Section 4.4.4.1 was used to analyze the flooding zones with the potential for core damage. The potential for flooding to result in equipment failure was investigated. Many zones were found to have drainage adequate to mitigate the effects of any flooding that could affect the zone. The potential for flood propagation to other zones was investigated. The potential for water spray to result in equipment failure was investigated. Shielding and distance from potential spray sources was considered. Qualification of equipment for operation in adverse environments was considered.

Although electrical switchgear was not identified as being threatened by flooding, water spray from nearby pressurized piping is possible should a pipe leak occur. An electrical bus or motor control center was conservatively assumed to fail if sprayed by a pipe leak. Potential water spray of electrical switchgear was included in estimating initiating event frequencies for the pertinent support system based initiators.

4.4.4.4 Results

All of the flooding zones except for the Unit 2 and 3 Turbine Building Condensate Pump Rooms were eliminated from consideration during the qualitative analysis. The frequency for flooding occurring in the Condensate Pump rooms is approximately 1.2E-02 per year. This event would be similar to a loss of feedwater transient which is already considered in the evaluation of transient events. This contribution to the transient initiator is probabilistically insignificant in comparison with the transient initiator frequency.

Water spray was found to be a contributor to the initiating event frequencies for support system based initiators involving the following electrical switchgear:

Unit 3 125 VDC Main Bus;

480 VAC Buses 28 and 38;

480 VAC Motor Control Centers 28-2 and 38-2; and

4 kV Buses 21, 22, 23, 24, 32, and 33.

4.4.5 Equipment Survivability

As part of the Dresden IPE, equipment important for prevention of core damage and/or containment failure was evaluated for survivability during the range of accident conditions postulated in the IPE. To accomplish this task, the Dresden equipment survivability study was divided into three phases:

Phase I: Support State and Fault Tree Assumptions
Phase II: IPE Conditions
Phase III: Accident Management/Core Damage Conditions.

For Phase I of the study, the assumptions regarding support equipment in the support state and fault tree models were reviewed. Analyses were then completed, as necessary, to verify the assumptions.

Phase II of the study involved a review of all Plant Response Trees (PRTs) for a determination of the equipment (including instrumentation) important in achieving 'successful' end states. The limiting conditions, with respect to the PRTs, were then identified for each piece of equipment and a survivability evaluation was completed. Only equipment with a potential of experiencing a harsh environment as a result of the event were evaluated.

Phase III of the study will consider the equipment identified for accident management purposes. This will include the equipment needed for post-24 hour accident management to maintain the plant in a safe, stable state (see also SAM discussion in 4.1.3.4); the equipment needed for containment accident management following a core damage event; and any other equipment which is identified for the overall CECo accident management program.

4.4.5.1 Phase I - Support State and Fault Tree Assumptions

Equipment Identification

For Phase I, the support state and fault tree models were reviewed to determine those assumptions which impact equipment survivability. The results of the review indicated that assumptions regarding support equipment for the LPCI pumps, Isolation Condenser Makeup pumps, HPCI pumps, CCSW pumps, FW pumps, TBCCW pumps, CS pumps and diesel generators affected the survivability of these components. The support equipment considered included room coolers, oil coolers and seal coolers.

Assumptions

The support state and fault tree models made the following assumptions regarding equipment survivability:

4.5 Sequence and Source Term Quantification

Accident sequence quantification for the Dresden IPE began with the support system event trees, which were loaded into the QT code system using CADET, the event tree editor. Fault trees were developed to address each node of the support system event trees consistent with the operating states defined for each support system. The support system fault trees were quantified using the GRAFTER code system.

Typically, the support system event trees are evaluated to determine which paths have similar impact on the frontline systems. This impact analysis results in a smaller set of support states (combinations of support system event tree paths) for which the accident sequence event trees are quantified. Therefore, each plant response tree is quantified for each significant support state and the results are combined with the initiating event probability. For the Dresden IPE study, support state grouping through frontline system impact analysis is not necessary since computer codes that can analyze the models completely in a timely manner are readily available. Unique support system event trees are developed in the Support State Model notebook for the following events:

1. transient events and LOCAs,
2. loss of offsite power at Unit 2, and
3. loss of offsite power at both units.

The plant response trees were developed and loaded into the QT code system using CADET. Analysis was then performed to provide failure probabilities for the nodes of each plant response tree. Fault trees consistent with the system success criteria were developed using the GRAFTER code system for a majority of the nodes. These fault trees were quantified for the case with all supporting equipment available and for various degraded cases representing loss of specific support equipment. Fault tree results are presented in Section 4.5.2. The operator action nodal failure probabilities were determined using the THERP methodology. Also, hand calculations were used, in several cases, to determine failure probabilities for nodes which were not system or human error related.

Some nodes were determined to be dependent upon other nodes which preceded them on the plant response trees. In order to account for these dependencies, and ensure a correct quantification of the accident sequence, conditional failure probabilities were calculated and used in place of the fault tree quantification results as appropriate.

Sequence quantification was then performed on the entire plant model with a calculational cutoff of 1.0E-12. This quantification was done by appending each PRT to each support system event tree path. Therefore, PRT sequences include the support system model nodes. Each plant response tree was quantified with its associated initiating event frequency for each path of its associated support system event tree. The QT code multiplied each accident sequence and placed the resulting probability in the designated damage state bin. If the multiplicative probability for a specific sequence dropped below the calculational cutoff during quantification, quantification of that path was halted and the

probability was placed in the "residual" bin which was reported as a plant damage state. Plant response tree quantification results are presented in Section 4.5.3.

The support system event tree used in the quantification of each plant response tree is shown in Table 4.5-1.

4.5.1 Support System States and Probabilities

Typically, the support system event trees are grouped according to impact on the frontline systems and quantified. For the Dresden IPE study, support state grouping through frontline system impact analysis is not necessary since computer codes that can analyze the models completely in a timely manner are readily available. Tables 4.5.1-1 through 3 list the most frequent support system combinations which were identified and their probabilities, according to initiating event.

4.5.2 Unavailability of Systems and Plant Functions

Table 4.5.2-1 (located in Volume 2) provides a listing of failure probabilities for systems and plant functions used in the Dresden IPE. The unavailabilities are grouped by system and function. Within each group unavailabilities are delineated by success criteria and initiating event as appropriate. Each listing provides a description of the success criteria and the failure probability which resulted from fault tree analysis or hand calculation.

4.5.3 Accident Sequence Frequencies

Table 4.5.3-1 (located at the end of this subsection) individually lists the top 100 accident sequences for the Modified IPE model quantification. These account for more than 95.7% of the total core damage frequency. For each of these sequences the following information is provided:

- Accident sequence frequency
- Percentage contribution to total core damage frequency
- Plant damage state (bin)
- Initiating event name and frequency
- Failed support state event tree nodes, probabilities, and descriptions
- Failed plant response tree nodes, probabilities, and descriptions

The total plant damage state frequency is 3.381E-06 for the Modified IPE model quantification.

As an example of dominant sequence generation, sequence #10 is described in detail. Sequence #10 is a loss of offsite power in Unit 2; the initiating event frequency is 5.1E-02/yr. To follow the accident progression, it is necessary to address the availability of the support systems in the support system event tree (SSET) for a loss of offsite power. Example sequence #10 lists the node successes and failures. The values assigned each node are from Table 4.5.2-1; "success" means that the quantification code assigns a value of one minus the node failure probability. The probabilistic value associated with each SSET node is described below:

TABLE 4.5-1
CORRELATION BETWEEN SUPPORT SYSTEM EVENT TREES AND PRTs

SUPPORT SYSTEM EVENT TREE	PLANT RESPONSE TREE
Transient and Loss of Coolant Accidents (LOCA)	Small LOCA (SLOCA) Medium LOCA (MLOCA) Large LOCA (LLOCA) Interfacing Systems LOCA (ISLOCA) Transient Anticipated Transient Without Scram (ATWS) Inadvertently Open Relief Valve (IORV) Loss of Instrument Air (LOIA) Loss of Service Water (LOSW) Loss of Bus 21 (LB21) Loss of Bus 22 (LB22) Loss of Bus 23 (LB23) Loss of Bus 24 (LB24) Loss of Bus 28 (LB28) Loss of Bus 28-2 (LB282)
Single Unit Loss of Offsite Power (LOOP)	Loss of Offsite Power (LOOP) Station Blackout (SBO)
Dual Unit Loss of Offsite Power (DLOOP)	Loss of Offsite Power (LOOP) Station Blackout (SBO)

TABLE 4.5.1-1
TRANSIENT, LOCA, LOSW, LOIA, LB21, LB22, LB23, LB24, LB28, LB28-2
SUPPORT MODEL QUANTIFICATION RESULTS

NUMBER[1]	FREQUENCY[2]	PERCENT[3]	EVENT[4]	VALUE[5]	DESCRIPTION[6]
1.	7.394E+000	99.91%	GTR	7.400E+000	GENERAL TRANSIENT IE
2.	1.451E-003	0.02%	GTR	7.400E+000	GENERAL TRANSIENT IE
			241	1.990E-004	LOSS OF BUS 24-1, GIVEN BUS 24 AVAILABLE
3.	1.425E-003	0.02%	GTR	7.400E+000	GENERAL TRANSIENT IE
			231	2.000E-004	LOSS OF BUS 23-1, GIVEN BUS 23 AVAILABLE
4.	8.535E-004	0.01%	GTR	7.400E+000	GENERAL TRANSIENT IE
			28	1.180E-004	LOSS OF BUS 28, GIVEN BUS 23-1 AVAILABLE
5.	8.356E-004	0.01%	GTR	7.400E+000	GENERAL TRANSIENT IE
			2CA	1.130E-004	LOSS OF UNIT 2 CAS, HP INIT ON LLRL, ALL DC AVAIL
6.	6.976E-004	0.01%	GTR	7.400E+000	GENERAL TRANSIENT IE
			23	1.130E-004	LOSS OF BUS 23, 24HR
7.	5.290E-004	0.01%	GTR	7.400E+000	GENERAL TRANSIENT IE
			24	1.130E-004	LOSS OF BUS 24, 24HR
8.	3.016E-004	0.00%	GTR	7.400E+000	GENERAL TRANSIENT IE
			24	1.130E-004	LOSS OF BUS 24, 24HR
			DG2	3.650E-001	LOSS OF DG2, 24 HRS
9.	1.359E-004	0.00%	GTR	7.400E+000	GENERAL TRANSIENT IE
			23	1.130E-004	LOSS OF BUS 23, 24HR
			DGB	1.650E-001	LOSS OF DG2/3, 24 HRS
10.	3.477E-005	0.00%	GTR	7.400E+000	GENERAL TRANSIENT IE
			231	2.000E-004	LOSS OF BUS 23-1, GIVEN BUS 23 AVAILABLE
			241	2.350E-002	LOSS OF BUS 24-1 AFTER 23-1/BUS 24 AVAILABLE, 24HR
11.	2.473E-005	0.00%	GTR	7.400E+000	GENERAL TRANSIENT IE
			2R1	3.360E-006	LOSS OF BUS 2B, 24HR

TABLE 4.5.1-1 (Continued)
TRANSIENT, LOCA, LOSW, LOIA, LB21, LB22, LB23, LB24, LB28, LB28-2
SUPPORT MODEL QUANTIFICATION RESULTS

NUMBER[1]	FREQUENCY[2]	PERCENT[3]	EVENT[4]	VALUE[5]	DESCRIPTION[6]
12.	2.322E-005	0.00%	GTR	7.400E+000	GENERAL TRANSIENT IE
			29	3.140E-006	LOSS OF BUS 29, GIVEN BUS 24-1, BUS 28 AVAILABLE
13.	2.248E-005	0.00%	GTR	7.400E+000	GENERAL TRANSIENT IE
			2TB	3.040E-006	LOSS OF UNIT 2 TBCCW, 24HR
14.	2.046E-005	0.00%	GTR	7.400E+000	GENERAL TRANSIENT IE
			241	1.990E-004	LOSS OF BUS 24-1, GIVEN BUS 24 AVAILABLE
			29	1.390E-002	LOSS OF BUS 29, GIVEN BUS 28 AVAILABLE
15.	2.008E-005	0.00%	GTR	7.400E+000	GENERAL TRANSIENT IE
			231	2.000E-004	LOSS OF BUS 23-1, GIVEN BUS 23 AVAILABLE
			28	1.390E-002	LOSS OF BUS 28, GIVEN BUS 29 AVAILABLE
16.	1.902E-005	0.00%	GTR	7.400E+000	GENERAL TRANSIENT IE
			28	1.180E-004	LOSS OF BUS 28, GIVEN BUS 23-1 AVAILABLE
			29	2.180E-002	LOSS OF BUS 29 AFTER 28, 24HR
17.	1.767E-005	0.00%	GTR	7.400E+000	GENERAL TRANSIENT IE
			2M1	2.400E-006	LOSS OF BUS 2A-1, 24HR

Notes:

1. "Number" refers to support state model sequence.
2. "Frequency" is the frequency per year that this initiator/support combination is expected to occur.
3. "Percent" is the percent of off-normal conditions for the subject initiators that would involve this state.
4. "Event" is the model top event label.
5. "Value" is frequency (for initiators) or probability (for failures) that the event would occur.
6. "Description" defines the event label.

TABLE 4.5.1-2
LOOP SUPPORT MODEL QUANTIFICATION RESULTS

NUMBER[1]	FREQUENCY[2]	PERCENT[3]	EVENT[4]	VALUE[5]	DESCRIPTION[6]
1.	3.953E-002	77.51%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
2.	6.277E-003	12.31%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			DG2	1.380E-001	LOSS OF DG2, 6 HRS
3.	4.013E-003	7.87%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			DGB	9.500E-002	LOSS OF DG2/3, 6 HRS
4.	7.413E-004	1.45%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			DGB	9.500E-002	LOSS OF DG2/3, 6 HRS
			DG2	1.570E-001	LOSS OF DG2 AFTER DG2/3, 6 HRS
5.	1.217E-004	0.24%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			24	3.090E-003	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
6.	1.185E-004	0.23%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			23	3.090E-003	LOSS OF BUS 23/23-1 AVAILABLE, 24HR
7.	5.656E-005	0.11%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			DGB	9.500E-002	LOSS OF DG2/3, 6 HRS
			28	1.390E-002	LOSS OF BUS 28, GIVEN BUS 29 AVAILABLE
8.	5.047E-005	0.10%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			DG2	1.380E-001	LOSS OF DG2, 6 HRS
			241	8.120E-003	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
9.	1.932E-005	0.04%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			DG2	1.380E-001	LOSS OF DG2, 6 HRS
			24	3.090E-003	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
10.	1.882E-005	0.04%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			DG2	1.380E-001	LOSS OF DG2, 6 HRS
			23	3.090E-003	LOSS OF BUS 23/23-1 AVAILABLE, 24HR
11.	1.227E-005	0.02%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			DGB	9.500E-002	LOSS OF DG2/3, 6 HRS
			24	3.090E-003	LOSS OF BUS 24/24-1 AVAILABLE, 24HR

TABLE 4.5.1-2 (Continued)
LOOP SUPPORT MODEL QUANTIFICATION RESULTS

NUMBER[1]	FREQUENCY[2]	PERCENT[3]	EVENT[4]	VALUE[5]	DESCRIPTION[6]
12.	1.045E-005	0.02%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			DGB	9.500E-002	LOSS OF DG2/3, 6 HRS
			DG2	1.570E-001	LOSS OF DG2 AFTER DG2/3, 6 HRS
			28	1.390E-002	LOSS OF BUS 28, GIVEN BUS 29 AVAILABLE
13.	6.090E-006	0.01%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			DGB	9.500E-002	LOSS OF DG2/3, 6 HRS
			DG2	1.570E-001	LOSS OF DG2 AFTER DG2/3, 6 HRS
			241	8.120E-003	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
			SBO?	1.000E+000	SBO OCCURS IN UNIT 2
14.	4.468E-006	0.01%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			2CA	1.130E-004	LOSS OF UNIT 2 CAS, HP INIT ON LLRL, ALL DC AVAIL
15.	4.267E-006	0.01%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			23	3.090E-003	LOSS OF BUS 23/23-1 AVAILABLE, 24HR
			24	3.520E-002	LOSS OF BUS 24 AFTER 23/ 24-1 AVAILABLE, 24HR
16.	2.412E-006	0.00%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			2TB	6.100E-005	LOOP, LOSS OF UNIT 2 TBCCW, 24HR
17.	2.267E-006	0.00%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			DGB	9.500E-002	LOSS OF DG2/3, 6 HRS
			DG2	1.570E-001	LOSS OF DG2 AFTER DG2/3, 6 HRS
			24	3.090E-003	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
63.	1.523E-008	0.00%	LOOP	5.100E-002	LOSS OF OFFSITE POWER IE
			2M1	2.400E-006	LOSS OF BUS 2A-1, 24HR
			DG2	1.380E-001	LOSS OF DG2, 6 HRS

Note:

1. "Number" refers to support state model sequence.
2. "Frequency" is the frequency per year that this initiator/support combination is expected to occur.
3. "Percent" is the percent of off-normal conditions for the subject initiators that would involve this state.
4. "Event" is the model top event label.
5. "Value" is frequency (for initiators) or probability (for failures) that the event would occur.
6. "Description" defines the event label.

TABLE 4.5.1-3
DUAL UNIT LOOP SUPPORT MODEL QUANTIFICATION RESULTS

NUMBER[1]	FREQUENCY[2]	PERCENT[3]	EVENT[4]	VALUE[5]	DESCRIPTION[6]
1.	1.071E-002	65.68%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
2.	1.700E-003	10.43%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			DG3	1.380E-001	LOSS OF DG3, 6 HRS
3.	1.657E-003	10.16%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			DG2	1.380E-001	LOSS OF DG2, 6 HRS
4.	1.059E-003	6.50%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			DGB	9.500E-002	LOSS OF DG2/3, 6 HRS
5.	3.191E-004	1.96%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			DG2	1.380E-001	LOSS OF DG2, 6 HRS
			DG3	1.600E-001	LOSS OF DG3 AFTER DG2, 6 HRS
			SBO?	1.000E+000	SBO IN UNIT 3, NO SBO IN UNIT 2
6.	2.026E-004	1.24%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			DGB	9.500E-002	LOSS OF DG2/3, 6 HRS
			DG2	1.570E-001	LOSS OF DG2 AFTER DG2/3, 6 HRS
7.	2.001E-004	1.23%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			DGB	9.500E-002	LOSS OF DG2/3, 6 HRS
			DG3	1.600E-001	LOSS OF DG3 AFTER DG2/3, 6 HRS
8.	1.509E-004	0.93%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			38	1.390E-002	LOSS OF BUS 38, GIVEN BUS 39 AVAILABLE
9.	3.318E-005	0.20%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			34	3.090E-003	LOSS OF BUS 34/34-1 AVAILABLE, 24HR
10.	3.307E-005	0.20%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			24	3.090E-003	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
11.	3.210E-005	0.20%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			23	3.090E-003	LOSS OF BUS 23/23-1 AVAILABLE, 24HR

TABLE 4.5.1-3 (Continued)
DUAL UNIT LOOP SUPPORT MODEL QUANTIFICATION RESULTS

NUMBER[1]	FREQUENCY[2]	PERCENT[3]	EVENT[4]	VALUE[5]	DESCRIPTION[6]
12.	3.160E-005	0.19%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			DGB	9.500E-002	LOSS OF DG2/3, 6 HRS
			DG2	1.570E-001	LOSS OF DG2 AFTER DG2/3, 6 HRS
			DG3	1.300E-001	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
			SBO?	1.000E+000	SBO IN UNIT 3, SBO IN UNIT 2
26.	3.241E-006	0.02%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			DGB	9.500E-002	LOSS OF DG2/3, 6 HRS
			24	3.090E-003	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
32.	1.666E-006	0.01%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			DGB	9.500E-002	LOSS OF DG2/3, 6 HRS
			DG2	1.570E-001	LOSS OF DG2 AFTER DG2/3, 6 HRS
			241	8.120E-003	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
			SBO?	1.000E+000	SBO IN UNIT 2, NO SBO IN UNIT 3
36.	1.156E-006	0.01%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			23	3.090E-003	LOSS OF BUS 23/23-1 AVAILABLE, 24HR
			24	3.520E-002	LOSS OF BUS 24 AFTER 23/ 24-1 AVAILABLE, 24HR
37.	9.922E-007	0.01%	DLOOP	1.630E-002	LOSS OF OFFSITE POWER IE
			DG2	1.380E-001	LOSS OF DG2, 6 HRS
			DG3	1.600E-001	LOSS OF DG3 AFTER DG2, 6 HRS
			23	3.090E-003	LOSS OF BUS 23/23-1 AVAILABLE, 24HR
			SBO?	1.000E+000	SBO IN UNIT 3, NO SBO IN UNIT 2

Note:

1. "Number" refers to support state model sequence.
2. "Frequency" is the frequency per year that this initiator/support combination is expected to occur.
3. "Percent" is the percent of off-normal conditions for the subject initiators that would involve this state.
4. "Event" is the model top event label.
5. "Value" is frequency (for initiators) or probability (for failures) that the event would occur.
6. "Description" defines the event label.

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TABLE 4.5.2-1

UNAVAILABILITY OF SYSTEMS AND PLANT FUNCTIONS (IN VOLUME 2)

NODE	VALUE	EXPLANATION
LOOP	5.10E-02	LOSS OF OFFSITE POWER EVENT
2M1	1.00E+00	Success of Unit 2 Main 125VDC Bus
2R1	1.00E+00	Success of Unit 2 Reserve 125VDC Bus
DGB	9.05E-01	DG 2/3 Starts and Runs (success)
DG2	8.62E-01	DG 2 Starts and Runs (success)
231	1.00E+00	Success of Unit 2 Bus 23-1
241	1.00E+00	Success of Unit 2 Bus 24-1
28	1.00E+00	Success of Unit 2 Bus 28
29	1.00E+00	Success of Unit 2 Bus 29
23	9.97E-01	Success of Unit 2 Bus 23
24	9.97E-01	Success of Unit 2 Bus 24
25	1.00E+00	Success of Unit 2 Bus 25
26	1.00E+00	Success of Unit 2 Bus 26
27	1.00E+00	Success of Unit 2 Bus 27
SW	1.00E+00	Success Service Water (Shared by Both Units)
2TB	1.00E+00	Success of Unit 2 TBCCW
2CA	1.00E+00	Success of Unit 2 Common Actuation
2R2	1.00E+00	Success of Unit 2 Reactor Building 250VDC Bus
SBO	1.00E+00	Station Blackout Does NOT Occur

Accident Sequence #10 continues with the loss of offsite power (LOOP) PRT. The probabilistic value associated with each PRT node is described below:

NODE	VALUE	EXPLANATION
RC	1.00E+00	Success of Reactivity Control
OIC	9.63E-01	Operator Initiates Isolation Condenser
ICH1	9.96E-01	Proper Operation of Isolation Condenser Hardware - Early
RVO	1.00E+00	Relief Valves/Safety Valves Open (This node is not required in this scenario; therefore, the plant response tree does not branch at the RVO node.)
RVC	1.00E+00	Relief Valves/Safety Valves Close (This node is not required in this scenario; therefore, the plant response tree does not branch at the RVC node.)
AIC	1.00E+00	Automatic Initiation of Isolation Condenser (This node is not required in this scenario; therefore, the plant response tree does not branch at the AIC node.)

NODE	VALUE	EXPLANATION
ICH2	1.00E+00	Operation of Isolation Condenser Hardware - Late (This node is not required in this scenario; therefore, the plant response tree does not branch at the ICH2 node.)
OMUP	1.30E-03	Operator Fails to Provide Makeup to the Isolation Condenser
MUP	1.00E+00	Addition of Shell Side Makeup to the Isolation Condenser (This node is not required in this scenario; therefore, the plant response tree does not branch at the MUP node.)
HP1	2.93E-02	Failure of Automatic Initiation/Operation of the HPCI System - Single Start
OAD	5.20E-02	Operator Fails to Initiate Automatic Depressurization System (ADS)
ADS	1.00E+00	Automatic Depressurization System (This node is not required in this scenario; therefore, the plant response tree does not branch at the ADS node.)
HP2	1.00E+00	Automatic Initiation/Operation of the HPCI System - Multiple Starts (This node is not required in this scenario; therefore, the plant response tree does not branch at the HP2 node.)
ROP1	1.00E+00	Failure to Recover Offsite Power - Early (No credit was taken for recovering offsite power if an onsite source of AC power was available.)
LP	1.00E+00	Success of Both LPCI Trains (The probability of success equals one minus the probability of failure of train A minus the probability of failure of train B minus the probability of failure of both trains. This calculation is discussed in detail in Section 5.2.)
LV	9.97E-01	Success of LPCI Injection Valve
CS	1.00E+00	Core Spray (This node is not required in this scenario; therefore, the plant response tree does not branch at the CS node.)
OSPC	1.00E+00	Operator Aligns for Suppression Pool Cooling

NODE	VALUE	EXPLANATION
SPC	1.00E+00	Success of Hardware Required for Suppression Pool Cooling
OCNTS	1.00E+00	Operator Action to Initiate Containment Sprays (This node is not required in this scenario; therefore, the plant response tree does not branch at the OCNTS node.)
CNTS	1.00E+00	Hardware Required for Containment Sprays (This node is not required in this scenario; therefore, the plant response tree does not branch at the CNTS node.)
OVNT	1.00E+00	Operator Action to Vent the Containment (This node is not required in this scenario; therefore, the plant response tree does not branch at the OVNT node.)
SVW	1.00E+00	Hardware Required for the Small Torus Vent (This node is not required in this scenario; therefore, the plant response tree does not branch at the SVW node.)
SVD	1.00E+00	Hardware Required for the Small Drywell Vent (This node is not required in this scenario; therefore, the plant response tree does not branch at the SVD node.)
LVW	1.00E+00	Hardware Required for the Large Torus Vent (This node is not required in this scenario; therefore, the plant response tree does not branch at the LVW node.)
LVD	1.00E+00	Hardware Required for the Large Drywell Vent (This node is not required in this scenario; therefore, the plant response tree does not branch at the LVD node.)
WW/DW	1.00E+00	Location of Containment Failure (This node is not required in this scenario; therefore, the plant response tree does not branch at the WW/DW node.)

The quantification code, QT, multiplies all of the probabilistic values associated with sequence #10 together to yield the sequence frequency. The product of the column of probabilistic values above including the initiating event frequency is 7.487E-08.

A quantification was also performed in which the SAM endstate was set to a damage state. The total plant damage state frequency for this run is 4.869E-06 and indicates the need for accident management which allows these SAMs to be success states.

TABLE 4.5.3-1
DOMINANT ACCIDENT SEQUENCES FOR MODIFIED IPE MODEL QUANTIFICATION

Number	Frequency	Percent	Damage State	Event	Value	Description
1	6.40E-07	18.9	MEABM	MLOCA	8.00E-04	MLOCA IE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
2	4.00E-07	11.8	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OCRD	1.00E+00	OPTR FAILS TO RESTORE CRD DURING DUAL-UNIT SBO
3	3.70E-07	11	MEABM	MLOCA	8.00E-04	MLOCA IE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
4	2.47E-07	7.3	MLCOM	MLOCA	8.00E-04	MLOCA IE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
5	1.91E-07	5.63	BLAYN	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OCRD	1.00E+00	OPTR FAILS TO RESTORE CRD DURING DUAL-UNIT SBO
				ROP2	3.22E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)
6	1.31E-07	3.89	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
7	1.07E-07	3.15	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
8	8.31E-08	2.46	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
9	8.03E-08	2.38	TIABM	GTR	7.40E+00	GENERAL TRANSIENT IE
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				FW	1.52E-03	FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
10	7.49E-08	2.21	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
11	6.70E-08	1.98	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE

TABLE 4.5.3-1 (Continued)
DOMINANT ACCIDENT SEQUENCES FOR MODIFIED IPE MODEL QUANTIFICATION

Number	Frequency	Percent	Damage State	Event	Value	Description
12	4.19E-08	1.24	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
13	3.62E-08	1.07	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
14	3.43E-08	1.02	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
15	3.42E-08	1.01	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
16	3.27E-08	0.97	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
17	3.24E-08	0.96	TIABM	GTR	7.40E+00	GENERAL TRANSIENT IE
				2M1	2.40E-06	LOSS OF BUS 2A-1, 24HR
				ICH2	1.00E+00	SYSTEM FAILURE
				FW	1.00E+00	SYSTEM FAILURE
				HP1	2.93E-02	HP FAILS; 2M1 FLD
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
18	3.20E-08	0.95	TIABM	LOSW	4.48E-03	LOSS OF SERVICE WATER
				SW	1.00E+00	SYSTEM FAILURE
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
19	3.11E-08	0.92	BIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				OIC	3.70E-02	OPTR FAILS TO INITIATE IC (SBO, LOOP
				RVC	2.70E-02	RVC FAILS; RELIEF VALVES CLOSING (TRANS)
20	2.94E-08	0.87	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)

TABLE 4.5.3-1 (Continued)
DOMINANT ACCIDENT SEQUENCES FOR MODIFIED IPE MODEL QUANTIFICATION

Number	Frequency	Percent	Damage State	Event	Value	Description
21	2.68E-08	0.79	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
22	2.58E-08	0.76	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				OMUP	1.40E-02	OPTR FAILS TO PROVIDE M/U TO IC (SBO OR SIMILAR)
				OFW	1.00E+00	OPTR FAILS TO RESTORE FW INJ
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
23	2.29E-08	0.68	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
24	2.09E-08	0.62	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
25	2.03E-08	0.6	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
26	1.81E-08	0.54	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
27	1.63E-08	0.48	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
28	1.49E-08	0.44	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				OIC	3.70E-02	OPTR FAILS TO INITIATE IC (SBO, LOOP
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OCRD	1.00E+00	OPTR FAILS TO RESTORE CRD DURING DUAL-UNIT SBO

TABLE 4.5.3-1 (Continued)
DOMINANT ACCIDENT SEQUENCES FOR MODIFIED IPE MODEL QUANTIFICATION

Number	Frequency	Percent	Damage State	Event	Value	Description
29	1.38E-08	0.41	LIBON	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				2M1	2.40E-06	LOSS OF BUS 2A-1, 24HR
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				ICH1	1.00E+00	SYSTEM FAILURE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE
30	1.35E-08	0.4	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
31	1.32E-08	0.39	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OIC2	3.20E-02	OPTR FAILS TO PREVENT LODC FLR OF IC
32	1.19E-08	0.35	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
33	1.16E-08	0.34	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
34	1.06E-08	0.31	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
35	1.06E-08	0.31	MLCOM	MLOCA	8.00E-04	MLOCA IE
				LP	1.39E-05	LP TRAINS A&B FAIL; ALL SUPPORTS AVAILABLE
36	1.03E-08	0.3	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
				OAT	1.50E-01	OPTR FAILS TO INITIATE ARI SYSTEM (Hi St)
37	9.46E-09	0.28	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)

TABLE 4.5.3-1 (Continued)
DOMINANT ACCIDENT SEQUENCES FOR MODIFIED IPE MODEL QUANTIFICATION

Number	Frequency	Percent	Damage State	Event	Value	Description
38	9.44E-09	0.28	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				OMUP	1.40E-02	OPTR FAILS TO PROVIDE M/U TO IC (SBO OR SIMILAR)
				ROP1	2.96E-02	FAILURE TO REC OSP TO PREVENT CM (2-4 HRS)
39	9.43E-09	0.28	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
40	9.41E-09	0.28	LLABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.30E-03	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
				ROP1	1.00E+00	SYSTEM FAILURE
41	9.01E-09	0.27	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
42	8.34E-09	0.25	SEABM	SLOCA	3.00E-03	SLOCA IE
				FW	1.52E-03	FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
43	7.60E-09	0.22	MLCOM	MLOCA	8.00E-04	MLOCA IE
				OSPC	1.00E-05	OPTR FAILS TO ALIGN FOR SPC
44	7.56E-09	0.22	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
45	7.45E-09	0.22	MLCOM	MLOCA	8.00E-04	MLOCA IE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
46	7.38E-09	0.22	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)

TABLE 4.5.3-1 (Continued)
DOMINANT ACCIDENT SEQUENCES FOR MODIFIED IPE MODEL QUANTIFICATION

Number	Frequency	Percent	Damage State	Event	Value	Description
47	7.12E-09	0.21	BLAYN	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				OIC	3.70E-02	OPTR FAILS TO INITIATE IC (SBO, LOOP
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OCRD	1.00E+00	OPTR FAILS TO RESTORE CRD DURING DUAL-UNIT SBO
				ROP2	3.22E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)
48	6.98E-09	0.21	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				OFW	1.00E+00	OPTR FAILS TO RESTORE FW INJ
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
49	6.76E-09	0.2	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
50	6.37E-09	0.19	LLABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.30E-03	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
				ROP1	1.00E+00	SYSTEM FAILURE
51	6.30E-09	0.19	BLAYN	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OIC2	3.20E-02	OPTR FAILS TO PREVENT LODC FLR OF IC
				ROP2	3.22E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)
52	6.08E-09	0.18	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
53	5.95E-09	0.18	BIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				241	8.12E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				OIC	3.70E-02	OPTR FAILS TO INITIATE IC (SBO, LOOP
				RVC	2.70E-02	RVC FAILS; RELIEF VALVES CLOSING (TRANS)
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]

TABLE 4.5.3-1 (Continued)
DOMINANT ACCIDENT SEQUENCES FOR MODIFIED IPE MODEL QUANTIFICATION

Number	Frequency	Percent	Damage State	Event	Value	Description
54	5.94E-09	0.18	MEABM	MLOCA	8.00E-04	MLOCA IE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
				OHX	9.20E-03	OPTR FAILS TO ALIGN CCSW TO LPCI HX
55	5.75E-09	0.17	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
56	4.95E-09	0.15	BLABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				241	8.12E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				OMUP	1.40E-02	OPTR FAILS TO PROVIDE M/U TO IC (SBO OR SIMILAR)
				OFW	1.00E+00	OPTR FAILS TO RESTORE FW INJ
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
57	4.82E-09	0.14	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RVO	1.10E-04	RVC FAILS; RELIEF VALVES OPENING (ATWS W/MC)
58	4.66E-09	0.14	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				MUP	2.56E-03	MUP FAILS; 28 AND 29 FLD
				OFW	1.00E+00	OPTR FAILS TO RESTORE FW INJ
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
59	4.49E-09	0.13	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
60	4.32E-09	0.13	LIBON	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				2M1	2.40E-06	LOSS OF BUS 2A-1, 24HR
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, NO SBO IN UNIT 2
				ICH1	1.00E+00	SYSTEM FAILURE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE

TABLE 4.5.3-1 (Continued)
DOMINANT ACCIDENT SEQUENCES FOR MODIFIED IPE MODEL QUANTIFICATION

Number	Frequency	Percent	Damage State	Event	Value	Description
61	4.31E-09	0.13	TIABM	GTR	7.40E+00	GENERAL TRANSIENT IE
				2M1	2.40E-06	LOSS OF BUS 2A-1, 24HR
				2CA	3.88E-03	LOSS OF UNIT 2 CAS, HP INIT ON LLRL, LOSS 2A-1
				ICH2	1.00E+00	SYSTEM FAILURE
				FW	1.00E+00	SYSTEM FAILURE
				HP1	1.00E+00	SYSTEM FAILURE
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
62	4.29E-09	0.13	BLABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				241	8.12E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				CRD	5.60E-02	UNIT 3 CRD AVAILABLE TO UNIT 2 DURING SINGLE-UNIT SBO
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
63	3.95E-09	0.12	TIABM	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
64	3.85E-09	0.11	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	8.70E-03	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Opt)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
				OAL	9.20E-02	OPTR FAILS TO CONTROL RV LEVEL AFTER ATWS (Dep)
65	3.82E-09	0.11	TIABM	GTR	7.40E+00	GENERAL TRANSIENT IE
				AIC	1.84E-04	AIC FAILS (AUTO INITIATION OF IC)
				FW	1.52E-03	FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	6.50E-02	OPTR FAILS TO INITIATE ADS
66	3.82E-09	0.11	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				RPT2	5.99E-03	MANUAL RPT FAILS
67	3.81E-09	0.11	MLCOM	MLOCA	8.00E-04	MLOCA IE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
68	3.71E-09	0.11	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
69	3.68E-09	0.11	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.30E-03	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE

TABLE 4.5.3-1 (Continued)
DOMINANT ACCIDENT SEQUENCES FOR MODIFIED IPE MODEL QUANTIFICATION

Number	Frequency	Percent	Damage State	Event	Value	Description
70	3.50E-09	0.1	MEBON	MLOCA	8.00E-04	MLOCA IE
				231	2.00E-04	LOSS OF BUS 23-1, GIVEN BUS 23 AVAILABLE
				241	2.35E-02	LOSS OF BUS 24-1 AFTER 23-1/BUS 24 AVAILABLE, 24HR
				LP	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE
71	3.43E-09	0.1	MEABM	MLOCA	8.00E-04	MLOCA IE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				OHX	9.20E-03	OPTR FAILS TO ALIGN CCSW TO LPCI HX
72	3.31E-09	0.1	TLBON	GTR	7.40E+00	GENERAL TRANSIENT IE
				2M1	2.40E-06	LOSS OF BUS 2A-1, 24HR
				241	1.99E-04	LOSS OF BUS 24-1, GIVEN BUS 24 AVAILABLE
				ICH2	1.00E+00	SYSTEM FAILURE
				FW	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE
73	3.24E-09	0.1	LLABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				OAD	1.30E-03	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
				ROP1	1.00E+00	SYSTEM FAILURE
74	3.22E-09	0.1	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DG3	1.38E-01	LOSS OF DG3, 6 HRS
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
75	3.14E-09	0.09	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
76	3.13E-09	0.09	BIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				RVC	2.70E-02	RVC FAILS; RELIEF VALVES CLOSING (TRANS)
77	3.08E-09	0.09	TIABM	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS

TABLE 4.5.3-1 (Continued)
DOMINANT ACCIDENT SEQUENCES FOR MODIFIED IPE MODEL QUANTIFICATION

Number	Frequency	Percent	Damage State	Event	Value	Description
78	2.89E-09	0.09	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				SLC	1.04E-02	SLC FAILS; 2/2 PUMPS; ALL SUPPORTS AVAILABLE
79	2.88E-09	0.09	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DG3	1.38E-01	LOSS OF DG3, 6 HRS
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
80	2.83E-09	0.08	TEERF	ATWS	2.28E-04	ATWS INITIATOR
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
				OAT	1.50E-01	OPTR FAILS TO INITIATE ARI SYSTEM (Hi St)
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
81	2.81E-09	0.08	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
82	2.80E-09	0.08	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				OIC	3.70E-02	OPTR FAILS TO INITIATE IC (SBO, LOOP
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
83	2.78E-09	0.08	TLABM	GTR	7.40E+00	GENERAL TRANSIENT IE
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				FW	1.52E-03	FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE
				OAD	1.30E-03	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
84	2.72E-09	0.08	BLAYN	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				OMUP	1.40E-02	OPTR FAILS TO PROVIDE M/U TO IC (SBO OR SIMILAR)
				ROP1	2.96E-02	FAILURE TO REC OSP TO PREVENT CM (2-4 HRS)
				ROP2	2.23E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-4 HRS)
85	2.57E-09	0.08	LIABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				OIC	3.70E-02	OPTR FAILS TO INITIATE IC (SBO, LOOP
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE

TABLE 4.5.3-1 (Continued)
DOMINANT ACCIDENT SEQUENCES FOR MODIFIED IPE MODEL QUANTIFICATION

Number	Frequency	Percent	Damage State	Event	Value	Description
86	2.55E-09	0.08	BLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				ROP1	2.96E-02	FAILURE TO REC OSP TO PREVENT CM (2-4 HRS)
87	2.55E-09	0.08	LLABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.30E-03	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
				ROP1	1.00E+00	SYSTEM FAILURE
88	2.53E-09	0.07	BLABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				241	8.12E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OIC2	3.20E-02	OPTR FAILS TO PREVENT LODC FLR OF IC
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
89	2.25E-09	0.07	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				SLC	1.04E-02	SLC FAILS; 2/2 PUMPS; ALL SUPPORTS AVAILABLE
90	2.10E-09	0.06	MLCOM	MLOCA	8.00E-04	MLOCA IE
				241	1.99E-04	LOSS OF BUS 24-1, GIVEN BUS 24 AVAILABLE
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
				CS	1.41E-02	CS FAILS; 1 PUMP; 24-1, 29, OR 2R1 FLD
91	2.08E-09	0.06	MLCOM	MLOCA	8.00E-04	MLOCA IE
				231	2.00E-04	LOSS OF BUS 23-1, GIVEN BUS 23 AVAILABLE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				CS	1.42E-02	CS FAILS; 1 PUMP; 23-1, 28, OR 2M1 FLD
92	2.05E-09	0.06	BLAYN	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				241	8.12E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				CRD	5.60E-02	UNIT 3 CRD AVAILABLE TO UNIT 2 DURING SINGLE-UNIT SBO
				ROP2	3.22E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)
93	2.00E-09	0.06	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	5.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]

TABLE 4.5.3-1 (Continued)
DOMINANT ACCIDENT SEQUENCES FOR MODIFIED IPE MODEL QUANTIFICATION

Number	Frequency	Percent	Damage State	Event	Value	Description
94	1.96E-09	0.06	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				SLC	2.96E-04	SLC FAILS; 1/2 PUMPS; ALL SUPPORTS AVAILABLE
95	1.93E-09	0.06	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	8.70E-03	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Opt)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
96	1.92E-09	0.06	MEBON	MLOCA	8.00E-04	MLOCA IE
				28	1.18E-04	LOSS OF BUS 28, GIVEN BUS 23-1 AVAILABLE
				29	2.18E-02	LOSS OF BUS 29 AFTER 28, 24HR
				LV	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE
				SPC	1.00E+00	SYSTEM FAILURE
97	1.90E-09	0.06	TEEQF	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
98	1.83E-09	0.05	TLABM	GTR	7.40E+00	GENERAL TRANSIENT IE
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
				FW	1.52E-03	FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE
				OAD	1.30E-03	OPTR FAILS TO INITIATE ADS
				HP2	5.22E-02	HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START
99	1.81E-09	0.05	BLABM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				241	8.12E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				OMUP	1.40E-02	OPTR FAILS TO PROVIDE M/U TO IC (SBO OR SIMILAR)
				ROP1	2.96E-02	FAILURE TO REC OSP TO PREVENT CM (2-4 HRS)
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
100	1.79E-09	0.05	LIABM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]

Notes:

1. "Number" refers to accident sequence ranking in the top 100 sequences.
2. "Frequency" is the frequency per year that this sequence is expected to occur.
3. "Percent" is the percent of total core damage represented by this single sequence.
4. "Damage St" is the plant damage state to which this sequence belongs. The fifth character presents the release associated with this type of sequence and is manually assigned at the end of the analysis in presentations of dominant sequences.
5. "Event" is the list of PRT and support system event tree top events which have failed in this sequence.
6. "Value" is frequency (for initiators) or probability (for failures) associated with each event.
7. "Description" defines the "Event" label.

4.5.4 Accident Sequence Sensitivity Analysis

The following Dresden IPE Model "parameters" were evaluated in the sensitivity analysis studies. The purpose of conducting these sensitivity analyses was to evaluate assumptions or data which if varied could have a significant impact on the analysis results, and thereby address model uncertainty.

Human Error Probabilities

Several operator actions are significant in the IPE results. These operator actions (OA) are listed below:

OMUP (all events): Operator Action to supply makeup to shell side of the IC
OSPC (all events): Operator Action to establish suppression pool cooling
OAD (all events): Operator Action to depressurize the reactor vessel

The human error probabilities (HEPs) for these operator actions were varied (increased or decreased by an order of magnitude) one at a time to determine the sensitivity of the overall IPE model results to these values. Each operator action has several probabilities due to sequence timing and/or dependencies of other operator actions. If the probability is greater than 0.1, that specific case was not varied because its value is determined primarily by dependencies on other actions.

The results of these sensitivities are summarized in Table 4.5.4-1. Included in the table are the different sets of values used for the operator action probabilities. Beside each set of values is the respective calculated core damage frequency.

Recovery of Offsite Power

The base IPE model was quantified taking no credit for recovery of offsite power during those events in which some onsite source of AC power was available. This sensitivity analysis was performed to determine the impact of this assumption. The results of this sensitivity analysis are provided in Table 4.5.4-1.

Conclusions

From the results of the sensitivity analysis presented in Table 4.5.4-1, several conclusions can be drawn. Increasing the human error probabilities for the significant operator actions by an order of magnitude does result in some substantial changes in the core damage frequency. The model is sensitive to changes in the human error probability for the operator actions to: a) provide makeup to the IC, b) establish suppression pool cooling, and c) depressurize the reactor pressure vessel. Increasing the value of OMUP by one order of magnitude changed the core damage frequency from 3.381E-06 to 5.057E-06, an increase of about 49.6%. Increasing OSPC by an order of magnitude changed the core damage frequency from 3.381E-6 to 3.523E-6, an increase of approximately 4.2%. Increasing OAD by an order of magnitude changed the core damage frequency from 3.381E-6 to 1.740E-5, an increase of about 414.6%. Although some of these changes appear significant

TABLE 4.5.4-1
SENSITIVITY ANALYSIS RESULTS

	BASE IPE MODEL		SENSITIVITY CASES	
PRT Node	Value	Core Damage Frequency	Value	Core Damage Frequency
OMUP				
OMU-CS1	1.30E-03	3.381E-06	1.30E-02	5.057E-06
OMU-CS2	1.40E-02		1.40E-01	
OMU-CS1	1.30E-03	3.381E-06	1.30E-04	3.214E-06
OMU-CS2	1.40E-02		1.40E-03	
OSPC				
OSP-CS1	1.60E-04	3.381E-06	1.60E-03	3.523E-06
OSP-CS3	3.50E-02		3.50E-01	
OSP-CS4	1.00E-04		1.00E-03	
OSP-CS7	1.00E-05		1.00E-04	
OSP-CS9	1.60E-03		1.60E-02	
OSP-CS10	1.10E-02		1.10E-01	
OSP-CS11	1.50E-01		1.50E-01	
OSP-CSX1	1.14E-03		1.14E-02	
OSP-CSX4	1.09E-03		1.09E-02	
OSP-CS1	1.60E-04	3.381E-06	1.60E-05	3.367E-06
OSP-CS3	3.50E-02		3.50E-03	
OSP-CS4	1.00E-04		1.00E-05	
OSP-CS7	1.00E-05		1.00E-06	
OSP-CS9	1.60E-03		1.60E-04	
OSP-CS10	1.10E-02		1.10E-03	
OSP-CS11	1.50E-01		1.50E-01	
OSP-CSX1	1.14E-03		1.14E-04	
OSP-CSX4	1.09E-03		1.09E-04	

TABLE 4.5.4-1 (Continued)
SENSITIVITY ANALYSIS RESULTS

	BASE IPE MODEL		SENSITIVITY CASES	
PRT Node	Value	Core Damage Frequency	Value	Core Damage Frequency
OAD				
OAD-CS1	1.30E-03	3.381E-06	1.30E-02	1.740E-05
OAD-CS2	1.60E-03		1.60E-02	
OAD-CS3	1.60E-02		1.60E-01	
OAD-CS4	5.10E-02		5.10E-01	
OAD-CS5	6.50E-02		6.50E-01	
OAD-CS6	1.60E-02		1.60E-01	
OAD-CS7	1.30E-02		1.30E-01	
OAD-CS8	5.20E-02		5.20E-01	
OAD-CS9	1.30E-03		1.30E-02	
OAD-CS10	6.50E-02		6.50E-01	
OAD-CS1	1.30E-03	3.381E-06	1.30E-04	1.979E-06
OAD-CS2	1.60E-03		1.60E-04	
OAD-CS3	1.60E-02		1.60E-03	
OAD-CS4	5.10E-02		5.10E-03	
OAD-CS5	6.50E-02		6.50E-03	
OAD-CS6	1.60E-02		1.60E-03	
OAD-CS7	1.30E-02		1.30E-03	
OAD-CS8	5.20E-02		5.20E-03	
OAD-CS9	1.30E-03		1.30E-04	
OAD-CS10	6.50E-02		6.50E-03	

initially, all of the core damage frequencies associated with the sensitivities are within the range of core damage frequencies reported in previous BWR probabilistic risk assessments. However, the increases in the core damage frequencies highlight the importance of maintaining good procedures and effective training.

Decreasing human error probabilities by an order of magnitude did not result in any significant decrease in plant risk for operator actions OMUP and OSPC. For each of the sensitivity analyses in which the human error for OMUP and OSPC was reduced by an order of magnitude, the core damage frequency was not less than 3.2E-06, virtually unchanged from the base IPE model quantification. However, the sensitivity analyses in which the human error for OAD was reduced by an order of magnitude, the core damage frequence was 1.979E-06 which is a notable reduction of 41.47% from the base IPE model quantification.

The conclusion from these analyses is that improvements in procedures or training associated with these operator actions (OMUP, OSPC, and OAD), without accompanying improvements in the hardware, would not result in any significant reduction in plant risk.

4.5.5 Source Term Analysis

Any sequence of events that causes core damage may result in a release of radioactivity to the environment in excess of design-basis limits. Such radioactivity releases are possible whether or not the containment building remains intact, because no structure is perfectly leak-tight. The amount of radioactivity that may be released from the containment building if core damage occurs is sequence-dependent and strongly influenced by the size and complexity of the flow paths out of the this building. Relatively large and unrestrictive flow paths from the containment building are expected to exist if the automatic containment isolation function is impaired, or a containment structural component fails due to high pressure and temperature, or piping attached directly to the reactor vessel fails in an unisolable manner. Relatively small and restrictive flow paths from the containment building are expected to exist if the containment integrity is maintained because a plant's technical specifications allow only an extremely small amount of containment leakage. Thus, much smaller amounts of radioactivity would be released to surrounding buildings and the environment if containment integrity was maintained during a core-damage sequence than if containment was breached.

The large amounts of radioactivity that are associated with a severe accident occur because radioactive isotopes that are the by-product of the fission process accumulate in the fuel pellets. During core damage, the fuel pellets would overheat, chemically react with other reactor materials, and possibly melt and move outside of the original core geometry. As the fuel pellets dissociated, the highly radioactive fission products would be released from the fuel. Typical fission product isotopes include the Noble gases Xenon (Xe) and Krypton (Kr), as well as Cesium (Cs), Iodine (I), Tellurium (Te), Strontium

(Sr). Cesium and Iodine predominantly react to form the relatively low boiling-point (or volatile) compound Cesium-Iodide (CsI). Tellurium and Strontium typically oxidize and form relatively higher boiling-point (or non-volatile) compounds (e.g., SrO, TeO_2). The amounts of radioactivity released from containment as these various isotopes constitute the so-called source term for an accident sequence.

The purpose of a source term analysis is to quantitatively estimate the masses of the various fission products that are released from the containment structure for the PRT end-states (or sequences) that result in core damage. Performing actual source term calculations for each sequence is an impossibility, however, given the large number of sequences defined by the PRTs. Thus, the scope of the source term analysis was limited to a consideration of the 100 highest-frequency sequences. The number of fission product release calculations performed was further reduced by binning the 100 highest-frequency sequences according to each unique combination of their 3rd and 4th PDS designator letters. Since these two PDS designator letters describe functional failures, accident progression, and fission product release path after core damage in great detail, differences between the containment behavior and fission product releases for sequences within a bin should be enveloped by the precision of the analysis for these sequence characteristics. The bins identified in this manner and the PDS's corresponding to each bin are listed in Table 4.5.5-1. Source term characteristics are estimated for each bin by selecting a representative sequence from each bin and simulating these sequences using the MAAP code. The sequences chosen to support the source term analysis are listed in Table 4.5.5-2.

4.5.5.1 Sequence Source Terms

Key results of the MAAP analysis for each sequence listed in Table 4.5.5-2 are summarized in Table 4.5.5-3. A capsule summary of each sequence is presented below. The following characteristics are common to all of the analyses reported.

- Normal containment leakage is modeled by a hole size equivalent to one-half of the leakage rate allowed by the plant technical specifications.

- The sequences are analyzed for 48 hours to assure that containment behavior and fission product transport behavior are well-developed and that identification of potential accident management insights is not limited by the 24-hour mission time. Thus, the equipment status at 24 hours is assumed to apply through the end of the calculation. Also, fission product releases are reported after 48 hours of elapsed sequence time.

- No credit is taken for the possibility that fission product aerosols could accrete in the containment failure site and eventually plug the failure.

- No credit is taken for fission product retention in the reactor building.

TABLE 4.5.5-1
BINNING OF PLANT DAMAGE STATES

CO - MLCO,

AB - BIAB, BLAB, LIAB, LLAB, MEAB, SEAB, TIAB, TLAB

EQ - TEEQ

BO - LIBO, MEBO, TLBO

AY - BLAY

ER - TEER

TABLE 4.5.5-2
ANALYZED SEQUENCE SELECTION TABLE

Bin	PDS	Analyzed Sequence (No. From Dominant Accident Sequence List)
AB	BLAB[1]	2
AY	BLAY	5
BO	DIBO[2]	--
CO	DLCO[3]	--
EQ	TEEQ[4]	7
ER	TEER[5]	20

Notes:

1. The highest frequency sequence in the AB bin is Sequence 1 from the MEAB PDS. However, MAAP calculations from this sequence do not predict core damage. Therefore, the second highest frequency sequence in the AB bin (Sequence 2 from the BLAB PDS) was used to provide estimates of source term characteristics for this bin.

2. The highest frquency sequence in the BO bin is Sequence 29 from the LIBO PDS. However, existing MAAP calculation results for PDS DIBO (above) were available from the original submittal report and were used to represent the BO source term bin results.

3. The highest frquency sequence in the CO bin is Sequence 4 from the MLCO PDS. However, existing MAAP calculation results for PDS DLCO (above) were available from the original submittal report and were used to represent the CO source term bin results.

4. The highest frquency sequence in the EQ bin is Sequence 6. However, existing MAAP calculation results for Sequence 7 were available from the original submittal report and were used to represent the EQ source term bin results.

5. The highest frquency sequence in the ER bin is Sequence 13. However, existing MAAP calculation results for Sequence 20 were available from the original submittal report and were used to represent the EQ source term bin results.

TABLE 4.5.5-3
DRESDEN NUCLEAR STATION
CONTAINMENT AND SOURCE TERM ANALYSIS DOMINANT SEQUENCES

SEQUENCE TYPE	CO	AB	AY	BO	EQ	ER
Sequence No.	--	2	5	--	7	20
Sequence Frequency (BIN)	1.5E-05	4.0E-07	1.9E-07	3.5E-07	1.3E-07	3.6E-08
Sequence Designator	DLCO	BLAB	BLAY	DIBO	TEEQ	TEER
MAAP Run Database ID No.	D920510	D920811	D920810	D920512	D920903	D920902
CORE/CONTAINMENT RESPONSE						
Time of Core Uncovery (hr)	11.4	6.14	6.15	11.3	1.3	1.3
Time of Core Relocation (hr)	13.1	7.52	7.52	12.8	2.2	2.1
Time of Vessel Failure (hr)	16.2	10.1	10.1	14.3	4.1	3.9
Time of Containment Failure (hr)	27.5	39.0	16.1	24.0	1.2	1.06
Time of Venting (hr)	16.5	--	--	17.7	--	--
Maximum Drywell Pressure (psig)	57.1	64.2	58.6	55.2	114.3	95.1
Maximum Drywell Temperature (°F)	668.	718.	1021.	806.	846.	716.
Fraction of Clad Reacted in Vessel	0.1067	0.1097	0.1123	0.0446	0.1063	0.0983
ENVIRONMENTAL RELEASE @ 48 Hr.						
Noble Release (%)	99.9	50.4	80.0	99.8	99.9	99.8
Volatile FP Release (%)	5.9	2.15	14.5	24.3	13.0	66.2
Non-Volatile FP Release (%)	0.16	2E-07	0.046	0.18	0.023	1.05
Tellurium-based FP Release (%)	32.3	1E-05	34.6	31.2	0.48	20.6

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Sequence - DLCO

Sequence Description

This accident scenario is initiated by a loss of the main 125 VDC bus and associated reserve 125 VDC bus. The 125 VDC loss causes a reactor and turbine trip with the main condenser isolated from the reactor. For this accident scenario, the following equipment, systems, and operating instructions were assumed available:

RC - Reactivity Control: Control rods insert and scram the reactor.

RVO, RVC - Relief Valves Open, Relief Valves Close: All relief valves open and close as dictated by the reactor vessel pressure.

HP1 - Automatic initiation of HPCI and operation in the level control mode: HPCI is assumed to be unused after reactor vessel pressure decreases below its turbine's low inlet pressure setpoint that causes automatic isolation.

OAD, ADS - Operator action to initiate ADS: Proper operation of the ADS system in response to an actuation demand. The operator is assumed to actuate ADS when HPCI isolates to maintain the reactor vessel pressure low enough that the available LPCI pumps can inject.

LP, LV - Automatic operation of one train of LPCI: Automatic opening of the LPCI injection valve after the LPCI pump has started and reactor pressure has decreased below 350 psig.

OVNT, SVW - Operator action to initiate containment venting: Containment venting through the two-inch wetwell vent. The operators are assumed to initiate wetwell venting through the SBGT system per the EOPs.

In addition, the following characteristics of this scenario are noteworthy.

- The Feedwater, Isolation Condenser and CRD Hydraulic systems are assumed unavailable.
- Only three of the seven drywell coolers are operable as a result of the initiator.
- Containment is successfully isolated.

Sequence Quantification

The pre-core damage phase of this sequence includes HPCI isolation at 5.6 hr with immediate operator initiation of ADS. LPCI then injects and maintains core cooling until there is insufficient NPSH at 8.1 hr due to suppression pool heat-up. Loss of LPCI results in a sustained uncovered core state starting at 11.4 hr.

Since recovery of vessel injection does not occur during this sequence, the vessel inventory boils off and the core overheats. The core damage phase of this sequence is

characterized by core debris relocation within the original core geometry at 13.1 hr, continuing core degradation, and eventual reactor vessel failure at 16.2 hr. At that time, about 11% of the core Zircaloy inventory has oxidized.

The release of core debris, steam, and water to the pedestal results in an increased energy load on containment, and increases the rates of change of pressure and gas temperature. The increased drywell gas density also is assumed to fail the drywell coolers by causing the fan motors to overheat. The operator initiates containment venting by opening the small wetwell vent for the first time when Torus Bottom Pressure exceeds 60 psig at 16.5 hr. The operator is assumed to close this vent when Torus Bottom Pressure decreases below 50 psig, and then to cycle the vent as needed thereafter. Since there is no containment heat removal, drywell gas temperature continues to increase and heats the drywell shell sufficiently that drywell failure is predicted to occur at 27.5 hr.

Fission products are released from the containment building via both the wetwell vent and the drywell failure location. At 48 hours after the sequence begins, the following fission product mass fractions are calculated to be released from the containment:

• Noble Gases	99.9 %
• Volatile Fission Products (Represented by CsI and RbI)	5.9 %
• Non-Volatile Fission Products (Represented by SrO)	0.16 %
• Tellurium-based Fission Products (Represented by Te_2 and TeO_2)	32.0 %

Sequence 2 - BLAB

Sequence Description

This accident scenario is initiated by a loss of off-site power and is followed by a failure of the diesel generators. The unit's loss of off-site power causes a reactor and turbine trip. For this accident scenario, the following equipment, systems, and operating instructions were assumed available:

RC - Reactivity Control: Control rods insert and scram the reactor.

OIC, ICH1 - Operator initiates Isolation Condenser: Proper operation of the IC equipment. The operator is assumed to initiate the isolation condenser before any relief valve opens. The isolation condenser is assumed to operate until battery power is exhausted at 4 hours after the start of the sequence.

OMUP, MUP - Operator initiates Isolation Condenser make-up: Proper operation of the IC make-up equipment. The operator is assumed to initiate make-up to the shell-side of the isolation condenser.

ROP2 - Operator action to restore offsite power (assumed to occur 6 hours after initiating event).

product mass fractions are calculated to be released from the containment:

- Noble Gases 50.4 %
- Volatile Fission Products (Represented by CsI and RbI) 2.15 %
- Non-Volatile Fission Products (Represented by SrO) 2E-7 %
- Tellurium-based Fission Products (Represented by Te_2 and TeO_2) 1E-5 %

Sequence 5 - BLAY

Sequence Description

This accident scenario is initiated by a loss of off-site power and is followed by a failure of the diesel generators. The unit's loss of off-site power causes a reactor and turbine trip. For this accident scenario, the following equipment, systems, and operating instructions were assumed available:

OIC, ICH1 - Operator initiates Isolation Condenser: Proper operation of the IC equipment. The operator is assumed to initiate the isolation condenser before any relief valve opens. The isolation condenser is assumed to operate until battery power is exhausted at 4 hours after the start of the sequence.

OMUP, MUP - Operator initiates Isolation Condenser make-up: Proper operation of the IC make-up equipment. The operator is assumed to initiate make-up to the shell-side of the isolation condenser.

In addition, the following characteristics of this scenario are noteworthy.

- No reactor vessel injection is available.
- No containment heat removal is available.
- Containment is successfully isolated.

Sequence Quantification

The pre-core damage phase of this sequence includes IC loss of heat removal capability at 4 hr when the battery power is depleted. Following the loss of IC heat removal, reactor vessel pressure increases to the relief valve setpoint. Intermittent operation of the relief valves increases the suppression pool water temperature but no suppression pool cooling can be initiated. Similarly, no systems are available to inject into the vessel. Thus, a sustained uncovered core state starts at 6.15 hr.

Since recovery of vessel injection does not occur during this sequence, the vessel inventory boils off and the core overheats. The core damage phase of this sequence is characterized by core debris relocation within the original core geometry at 7.52 hr, continuing core degradation, and eventual reactor vessel failure at 10.1 hr. At that time, about 11% of the core Zircaloy inventory has oxidized.

When the reactor vessel fails, the release of core debris, steam, and water to the pedestal results in an increased energy load on containment, and increases the rates of change of pressure and gas temperature. No containment heat removal is available, so the debris in containment heats up sufficiently to erode the concrete floor. The core debris and fission products remaining in the vessel, and the core debris in containment both radiatively heat the containment gas, while concrete erosion releases hot gases to the containment atmosphere. The containment pressure and drywell gas temperature increase until drywell shell failure is predicted at 16.1 hr.

Fission products are released from the containment building via the drywell failure. At 48 hours after the sequence begins, the following fission product mass fractions are calculated to be released from the containment:

• Noble Gases	80.0 %
• Volatile Fission Products (Represented by CsI and RbI)	14.5 %
• Non-Volatile Fission Products (Represented by SrO)	0.05 %
• Tellurium-based Fission Products (Represented by Te_2 and TeO_2)	34.6 %

Sequence - DIBO

Sequence Description

This accident scenario is initiated by a loss of one main 125 VDC bus and one reserve 125 VDC bus. The unit's loss of DC causes a reactor and turbine trip with the main condenser isolated from the reactor. For this accident scenario, the following equipment, systems, and operating instructions were assumed available:

RC - Reactivity Control: Control rods insert and scram the reactor.

RVO, RVC - Relief Valves Open, Relief Valves Close: All relief valves open and close as dictated by the reactor vessel pressure.

HP1 - Automatic initiation of HPCI and operation in the level control mode: HPCI is assumed to be unused after reactor vessel pressure decreases below its turbine's low inlet pressure setpoint that causes automatic isolation.

OAD, ADS - Operator action to initiate ADS: Proper operation of the ADS system in response to an actuation demand. The operator is assumed to actuate ADS when HPCI isolates to maintain the reactor vessel pressure low enough that the available LPCI pumps can inject.

OVNT, SVW - Operator action to initiate containment venting: Containment venting through the two-inch wetwell vent. The operators are assumed to initiate wetwell venting through the SBGT system per the EOPs.

In addition, the following characteristics of this scenario are noteworthy:

- The Feedwater, Isolation Condenser and CRD Hydraulic systems are assumed unavailable.
- Only three of the seven drywell coolers are operable as a result of the initiator.
- Containment is successfully isolated.

Sequence Quantification

The pre-core damage phase of this sequence includes HPCI isolation at 5.6 hr. The operator initiates ADS when the downcomer water level falls below the Top of Active Fuel at 11.3 hr. Since low pressure injection is unavailable, an uncovered core state is sustained from 11.3 hr.

Since recovery of vessel injection does not occur during this sequence, the vessel inventory boils off and the core overheats. The core damage phase of this sequence is characterized by core debris relocation within the original core geometry at 12.8 hr, continuing core degradation, and eventual reactor vessel failure at 14.3 hr. At that time, about 4% of the core Zircaloy inventory has oxidized.

The release of core debris, steam, and water to the pedestal results in an increased energy load on containment, and increases the rates of change of pressure and gas temperature. The increased drywell gas density also is assumed to fail the drywell coolers by causing the fan motors to overheat. The operator initiates containment venting by opening the small wetwell vent for the first time when Torus Bottom Pressure exceeds 60 psig at 17.7 hr. The operator is assumed to close this vent when Torus Bottom Pressure decreases below 50 psig, and then to cycle the vent as needed thereafter. Since there is no containment heat removal, drywell gas temperature continues to increase and heats the drywell shell sufficiently that drywell failure is predicted to occur at 24.0 hr.

Fission products are released from the containment building via both the wetwell vent and the drywell failure location. At 48 hours after the sequence begins, the following fission product mass fractions are calculated to be released from the containment:

- Noble Gases 99.8 %
- Volatile Fission Products (Represented by CsI and RbI) 24.3 %
- Non-Volatile Fission Products (Represented by SrO) 0.18 %
- Tellurium-based Fission Products (Represented by Te_2 and TeO_2) 31.2 %

Sequence 7 - TEEQ

Sequence Description

This accident scenario is initiated by a turbine trip with the main condenser isolated, and a failure of the control rods to insert. For this accident scenario, the following equipment, systems, and operating instructions were assumed available:

Sequence 20 - TEER

Sequence Description

This accident scenario is initiated by a turbine trip with the main condenser isolated, and a failure of the control rods to insert. For this accident scenario, the following equipment, systems, and operating instructions were assumed available:

FWA - Feedwater available: Reactor vessel level is controlled automatically using the feed pumps for as long as hotwell inventory is available.

In addition, the following characteristics of this scenario are noteworthy.

- The main condenser hotwell inventory is initially 76,000 gallons, with a 900 gpm make-up flow.
- The reactor power level will exceed the vessel relief capacity with the main condenser isolated, resulting in over-pressurization of the reactor vessel. As a result, a large hole is assumed to open in the main steam piping at 1 minute into the sequence.
- The CRD Hydraulic systems is assumed unavailable.
- HPCI, LPCI, and the isolation condenser are available and assumed to operate automatically. No operator actions regarding use of these systems is credited.
- Drywell coolers are operable.
- Containment is successfully isolated.
- Containment failure occurs in the drywell.

Sequence Quantification

The pre-core damage phase of this sequence includes a predicted average ATWS power level of about 25% full power. Maintaining normal water level with this power level depletes the hotwell inventory in about 22 minutes, at which time the feed pump trips. The high core power associated with ATWS causes a rapid drywell and suppression pool heat-up. The HPCI pump trips at 23 minutes as a result of high suppression pool water temperature. Vessel pressure decreases below the LPCI shut-off head at about 28 minutes, so LPCI injection starts. The rapid containment heat-up leads to a large drywell failure at 1.06 hr. The LPCI pumps trip on low NPSH about eight minutes later. Since vessel injection is unavailable at this point and core power is significantly greater than decay power levels, a sustained uncovered core state starts at 1.3 hr.

Since recovery of vessel injection does not occur during this sequence, the vessel inventory boils off and the core overheats. The core damage phase of this sequence is characterized by core debris relocation within the original core geometry at 2.1 hr, continuing core degradation, and eventual reactor vessel failure at 3.9 hr. At that time, about 10% of the core Zircaloy inventory has oxidized.

Fission products are released from the containment building via both the wetwell vent and the normal drywell leakage location. At 48 hours after the sequence begins, the following fission product mass fractions are calculated to be released from the containment:

- Noble Gases 99.8 %
- Volatile Fission Products (Represented by CsI and RbI) 66.2 %
- Non-Volatile Fission Products (Represented by SrO) 1.05 %
- Tellurium-based Fission Products (Represented by Te_2 and TeO_2 20.6 %

4.5.6 Source Term Sensitivity Analyses

Due to the complexity of a nuclear plant, the models developed to perform a Level 2 analysis contain simplified representations of operator actions, plant and equipment behavior, and severe accident phenomena. These simplifications, while necessary, all introduce uncertainty into the base-line characterization of a plant. To describe the uncertainty associated with the source term calculations, a number of additional MAAP calculations are performed. These sensitivity calculations are based on the MAAP runs described in Section 4.5.5, but each differs from its base case by having one key sequence attribute changed in a bounding way. For example, the DLCO sequence described above did not include the benefit of vessel injection from a CRD hydraulic system pump. Since such pumps are normally on and injecting into the vessel, one variation on the DLCO sequence could be to include CRD hydraulic system injection into the vessel. In this way, a set of such source term sensitivity analyses can identify those plant and/or sequence attributes that have the largest effect on the likelihood or timing

screening criteria, any sequence that dropped below the core damage frequency criteria because the frequency was reduced by more than an order of magnitude by credit taken for human recovery actions not in the Dresden EOPs were identified. Additionally, sequences which have been designated as "SAM" and respective insights of major importance are also reported.

These screening criteria are consistent with those recommended in NUREG-1335, Section 2.1.6

4.6.2 Summary of Results

This section provides a discussion and explanation of the Dresden IPE accident sequence results previously tabulated in Section 4.5.3. The core damage frequency (CDF) and the initiating event frequency are shown in Table 4.6.2-1 by initiating event. As can be seen from this table, the top two initiators contribute 63% to the total CDF, the top three initiators contribute 86%, the top four initiators contribute 94%, and 98% of the CDF comes from five initiating events with one single initiator contributing 39% to each of these percentages. The other initiating events contribute less than 2% of the total core damage frequency.

The top contributor to core damage frequency is Medium LOCA at 39% followed by Dual Unit Loss of Offsite Power at 24%, Anticipated Transient Without Scram at 23%, Single Unit Loss of Offsite Power at 8%, and General Transient at 4%.

The remaining discussion in this section is based upon the screening criteria presented in Section 4.6.1.

- Screening criterion A required that "any sequence that contributes 1E-07 or more per reactor year to core damage" be identified. The first 7 sequences previously shown in Table 4.5.3.1 fall into this criteria.

- Screening criterion B required that "all sequences within the upper 95 percent of the total core damage frequency" be identified but not to exceed a total of 100 sequences. The first 100 sequences previously shown in Table 4.5.3.1 add up to 96% of the total CDF (note that the top 88 sequences add up to 95% of the total CDF).

- Screening criterion C required that "all sequences within the upper 95 percent of the total containment failure probability" be identified. 50 of the 100 sequences contribute to containment failure. The total containment failure[1] frequency in the top 50 sequences is 1.25E-06 (note that the highest frequency 44 sequences have a total frequency of 1.24E-06 which is 95% of the total containment failure frequency).

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[1] "Containment failure" here means failures due to high pressure and/or high temperature. Releases can occur due to venting the containment, as well, while the containment remains intact. The analysis of the "CO" type sequences indicates containment structural failure at about 27 hours; this is beyond the normally considered 24 hours but is considered containment failure in this analysis.

TABLE 4.6.2-1
CORE DAMAGE FREQUENCY BY INITIATING EVENT

INITIATING EVENT	INITIATING EVENT FREQUENCY (/YR)	CORE DAMAGE FREQUENCY (/YR)	PERCENT CONTRIBUTION
Medium LOCA[1]	8.00E-04	1.3E-06	39
Dual Unit LOSP[2]	1.63E-02	8.2E-07	24
ATWS[3]	2.28E-04	7.7E-07	23
Single Unit LOSP[2]	5.10E-02	2.8E-07	8
General Transient	7.40E-00	1.4E-07	4
Loss of Service Water	4.48E-03	3.8E-08	1
Small LOCA[1]	3.00E-03	9.0E-09	0.3
Large LOCA[1]	3.00E-04	5.0E-09	0.2
IORV[4]	7.14E-02	2.3E-09	0.1
ISLOCA[5]	1.14E-07	4.7E-10	0.01
Loss of Bus 24	3.12E-04	3.7E-10	0.01
Loss of Instrument Air	6.95E-03	2.1E-10	0.01
Loss of Bus 23	1.62E-03	1.8E-10	0.01
Loss of Bus 28-2	1.27E-03	9.8E-11	<0.01
Loss of Bus 28	1.24E-03	8.9E-11	<0.01
Loss of Bus 21	1.76E-04	4.8E-11	<0.01
Loss of Bus 22	1.44E-04	4.1E-11	<0.01
TOTAL		3.4E-06	100

1. LOCA = Loss of Coolant Accident
2. LOSP = Loss of Offsite Power
3. ATWS = Anticipated Transient Without Scram
4. IORV = Inadvertent Open Relief Valve
5. ISLOCA = Interfacing System LOCA

The sequences in the top 100 that lead to containment failure are identified by the letter "O," "Q," "R," or "Y" as the fourth character in the five-character endstate designator. The sequences with an "O" as the fourth character in the endstate designator are "semi-controlled" releases in which the containment is vented and later fails; there are twelve such sequences with a total frequency of 3.1E-07. The sequences with a "Q" are containment high pressure failure ("uncontrolled releases") in the wetwell; there are twenty-one such sequences with a total frequency of 5.8E-07. The sequences with a "R" are containment high pressure failure ("uncontrolled releases") in the drywell; there are twelve such sequences with a total frequency of 1.5E-07. There are five "Y" sequences (high temperature/pressure failure) with a total frequency of 2.1E-07 that adds to the "uncontrolled releases". These 50 sequences, therefore, contribute a total of 96% of the total containment failure frequency.

- Screening criterion D required that "sequences that contribute to a containment bypass frequency in excess of 1E-08 per reactor year" be identified. There are no interfacing system LOCA sequences which cause a containment bypass greater than 1E-08 per year.

- Screening criterion E required that any sequences deemed to be of interest be identified. There are no sequences of interest that fall under this criteria.

The top 100 accident sequences are listed in Table 4.6.2-2. The top 90 of these meet one or more than one screening criteria. Sequences #1 through #7 meet screening criterion A. Sequences #1 through #88 meet screening criterion B. There are 44 sequences which meet screening criterion C. Sequences #1 through #3 satisfy screening criteria A and B only. Sequences #4 through #7 satisfy screening criteria A, B, and C. Of the remaining 81 sequences, there are 55 sequences that satisfy criterion B only and 26 sequences which satisfy both criteria B and C. There are no containment bypass (interfacing systems LOCA) sequences above 1E-08 or within the top 100 sequences.

The 50 containment failure sequences out of the dominant top 100 CDF sequences are summarized in Table 4.6.2-3. Four (4) of these 50 sequences contribute 95% of the total containment failure probability and thus meet screening criterion C. The remaining sequences that provide the additional containment failure contribution fall outside the screening criteria of reporting no more than the upper 95% percent of the total containment failure sequences. Of the 44 sequences, 4 sequences have frequencies that are greater than 1E-07, 16 sequences have frequencies that are between 1E-08 and 1E-07, and 24 sequences have frequencies that are between 1E-09 and 1E-08.

Containment isolation failures were not included in the accident sequence modeling. During normal operation, the containment is normally isolated and kept inerted with nitrogen and at a slightly positive pressure. Therefore, containment isolation failures were not modeled.

There were no accident sequences that dropped below the core damage frequency criteria because the frequency had been reduced by more than an order of magnitude by credit taken for human recovery actions not defined in the Dresden EOPs.

TABLE 4.6.2-2
SEQUENCES MEETING MORE THAN 1 SCREENING CRITERIA

SEQUENCE NUMBER	SCREENING CRITERIA A - >1E-07 CDF	B - 95% CDF	C - 95% CFP	D - >1E-08 Bypass
1-3	Yes	Yes		
4-7	Yes	Yes	Yes	
8		Yes	Yes	
9-11		Yes		
12-16		Yes	Yes	
17-19		Yes		
20-21		Yes	Yes	
22		Yes		
23-24		Yes	Yes	
25-26		Yes		
27		Yes	Yes	
28		Yes		
29-30		Yes	Yes	
31-32		Yes		
33		Yes	Yes	
34		Yes		
35-37		Yes	Yes	
38		Yes		
39		Yes	Yes	
40		Yes		
41		Yes	Yes	
42		Yes		
43		Yes	Yes	
44		Yes		
45-47		Yes	Yes	
48-50		Yes		
51-52		Yes	Yes	
53-54		Yes		
55		Yes	Yes	
56		Yes		
57		Yes	Yes	
58		Yes		
59-60		Yes	Yes	
61-63		Yes		
64		Yes	Yes	
65		Yes		
66-68		Yes	Yes	
69		Yes		
70		Yes	Yes	
71		Yes		
72		Yes	Yes	
73-77		Yes		
78		Yes	Yes	
79		Yes		
80		Yes	Yes	
81-83		Yes		
84		Yes	Yes	
85-88		Yes		
89-90			Yes	
93		Yes		
94-97		Yes	Yes	
91-100				

TABLE 4.6.2-3
CONTAINMENT FAILURE SEQUENCES[1]

Number (1)	Frequency (2)	Percent (3)	Damage State - Containment Failure (Release) Type (4)	Event (5)	Value (6)	Description (7)
4	2.47E-07	7.3	MLCOM - Semi-Controlled	MLOCA	8.00E-04	MLOCA IE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
5	1.91E-07	5.63	BLAYN - Uncontrolled	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OCRD	1.00E+00	OPTR FAILS TO RESTORE CRD DURING DUAL-UNIT SBO
				ROP2	3.22E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)
6	1.31E-07	3.89	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
7	1.07E-07	3.15	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
8	8.31E-08	2.46	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
12	4.19E-08	1.24	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
13	3.62E-08	1.07	TEERF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
14	3.43E-08	1.02	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
15	3.42E-08	1.01	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
16	3.27E-08	0.97	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL

[1] Notes located at the end of the table.

TABLE 4.6.2-3 (Continued)
CONTAINMENT FAILURE SEQUENCES

Number (1)	Frequency (2)	Percent (3)	Damage State - Containment Failure (Release) Type (4)	Event (5)	Value (6)	Description (7)
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
20	2.94E-08	0.87	TEERF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
21	2.68E-08	0.79	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
23	2.29E-08	0.68	TEERF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
24	2.09E-08	0.62	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
27	1.63E-08	0.48	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
29	1.38E-08	0.41	LIBON - Semi-Controlled	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				2M1	2.40E-06	LOSS OF BUS 2A-1, 24HR
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				ICH1	1.00E+00	SYSTEM FAILURE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE
30	1.35E-08	0.4	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
33	1.16E-08	0.34	TEERF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
35	1.06E-08	0.31	MLCOM - Semi-Controlled	MLOCA	8.00E-04	MLOCA IE
				LP	1.39E-05	LP TRAINS A&B FAIL; ALL SUPPORTS AVAILABLE
36	1.03E-08	0.3	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR

TABLE 4.6.2-3 (Continued)
CONTAINMENT FAILURE SEQUENCES

Number (1)	Frequency (2)	Percent (3)	Damage State - Containment Failure (Release) Type (4)	Event (5)	Value (6)	Description (7)
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
				OAT	1.50E-01	OPTR FAILS TO INITIATE ARI SYSTEM (Hi St)
37	9.46E-09	0.28	TEERF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
39	9.43E-09	0.28	TEERF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
41	9.01E-09	0.27	TEERF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
43	7.60E-09	0.22	MLCOM - Semi-Controlled	MLOCA	8.00E-04	MLOCA IE
				OSPC	1.00E-05	OPTR FAILS TO ALIGN FOR SPC
45	7.45E-09	0.22	MLCOM - Semi-Controlled	MLOCA	8.00E-04	MLOCA IE
				HP1	2.93E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
46	7.38E-09	0.22	TEERF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
47	7.12E-09	0.21	BLAYN - Uncontrolled	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				OIC	3.70E-02	OPTR FAILS TO INITIATE IC (SBO, LOOP
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OCRD	1.00E+00	OPTR FAILS TO RESTORE CRD DURING DUAL-UNIT SBO
				ROP2	3.22E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)
51	6.30E-09	0.19	BLAYN - Uncontrolled	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)

TABLE 4.6.2-3 (Continued)
CONTAINMENT FAILURE SEQUENCES

Number (1)	Frequency (2)	Percent (3)	Damage State - Containment Failure (Release) Type (4)	Event (5)	Value (6)	Description (7)
				OIC2	3.20E-02	OPTR FAILS TO PREVENT LODC FLR OF IC
				ROP2	3.22E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)
52	6.08E-09	0.18	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
55	5.75E-09	0.17	TEERF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
57	4.82E-09	0.14	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RVO	1.10E-04	RVC FAILS; RELIEF VALVES OPENING (ATWS W/MC)
59	4.49E-09	0.13	TEERF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
60	4.32E-09	0.13	LIBON - Semi-Controlled	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				2M1	2.40E-06	LOSS OF BUS 2A-1, 24HR
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, NO SBO IN UNIT 2
				ICH1	1.00E+00	SYSTEM FAILURE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE
64	3.85E-09	0.11	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	8.70E-03	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Opt)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
				OAL	9.20E-02	OPTR FAILS TO CONTROL RV LEVEL AFTER ATWS (Dep)
66	3.82E-09	0.11	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				RPT2	5.99E-03	MANUAL RPT FAILS
67	3.81E-09	0.11	MLCOM - Semi-Controlled	MLOCA	8.00E-04	MLOCA IE
				OAD	1.60E-02	OPTR FAILS TO INITIATE ADS
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
68	3.71E-09	0.11	TEERF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				RPT1	5.99E-03	AUTO RPT FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
70	3.50E-09	0.1	MEBON - Semi-Controlled	MLOCA	8.00E-04	MLOCA IE

TABLE 4.6.2-3 (Continued)
CONTAINMENT FAILURE SEQUENCES

Number (1)	Frequency (2)	Percent (3)	Damage State - Containment Failure (Release) Type (4)	Event (5)	Value (6)	Description (7)
				231	2.00E-04	LOSS OF BUS 23-1, GIVEN BUS 23 AVAILABLE
				241	2.35E-02	LOSS OF BUS 24-1 AFTER 23-1/BUS 24 AVAILABLE, 24HR
				LP	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE
72	3.31E-09	0.1	TLBON - Semi-Controlled	GTR	7.40E+00	GENERAL TRANSIENT IE
				2M1	2.40E-06	LOSS OF BUS 2A-1, 24HR
				241	1.99E-04	LOSS OF BUS 24-1, GIVEN BUS 24 AVAILABLE
				ICH2	1.00E+00	SYSTEM FAILURE
				FW	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE
78	2.89E-09	0.09	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				SLC	1.04E-02	SLC FAILS; 2/2 PUMPS; ALL SUPPORTS AVAILABLE
80	2.83E-09	0.08	TEERF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				ORP	5.10E-02	OPTR FAILS TO INITIATE RPT
				OAT	1.50E-01	OPTR FAILS TO INITIATE ARI SYSTEM (Hi St)
				WW/DW	2.16E-01	FRAC OF CONT FLRS IN DW (VS. WW)
84	2.72E-09	0.08	BLAYN - Uncontrolled	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.30E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				OMUP	1.40E-02	OPTR FAILS TO PROVIDE M/U TO IC (SBO OR SIMILAR)
				ROP1	2.96E-02	FAILURE TO REC OSP TO PREVENT CM (2-4 HRS)
				ROP2	2.23E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-4 HRS)
89	2.25E-09	0.07	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	4.50E-02	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Hi Str)
				SLC	1.04E-02	SLC FAILS; 2/2 PUMPS; ALL SUPPORTS AVAILABLE
90	2.10E-09	0.06	MLCOM - Semi-Controlled	MLOCA	8.00E-04	MLOCA IE
				241	1.99E-04	LOSS OF BUS 24-1, GIVEN BUS 24 AVAILABLE
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
				CS	1.41E-02	CS FAILS; 1 PUMP; 24-1, 29, OR 2R1 FLD
91	2.08E-09	0.06	MLCOM - Semi-Controlled	MLOCA	8.00E-04	MLOCA IE
				231	2.00E-04	LOSS OF BUS 23-1, GIVEN BUS 23 AVAILABLE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				CS	1.42E-02	CS FAILS; 1 PUMP; 23-1, 28, OR 2M1 FLD
92	2.05E-09	0.06	BLAYN - Uncontrolled	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				241	8.12E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE

TABLE 4.6.2-3 (Continued)
CONTAINMENT FAILURE SEQUENCES

Number (1)	Frequency (2)	Percent (3)	Damage State - Containment Failure (Release) Type (4)	Event (5)	Value (6)	Description (7)
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				CRD	5.60E-02	UNIT 3 CRD AVAILABLE TO UNIT 2 DURING SINGLE-UNIT SBO
				ROP2	3.22E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)
94	1.96E-09	0.06	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				SLC	2.96E-04	SLC FAILS; 1/2 PUMPS; ALL SUPPORTS AVAILABLE
95	1.93E-09	0.06	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	8.70E-03	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Opt)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
96	1.92E-09	0.06	MEBON - Semi-Controlled	MLOCA	8.00E-04	MLOCA IE
				28	1.18E-04	LOSS OF BUS 28, GIVEN BUS 23-1 AVAILABLE
				29	2.18E-02	LOSS OF BUS 29 AFTER 28, 24HR
				LV	1.00E+00	SYSTEM FAILURE
				CS	1.00E+00	SYSTEM FAILURE
				SPC	1.00E+00	SYSTEM FAILURE
97	1.90E-09	0.06	TEEQF - Uncontrolled	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				AT	1.50E-02	ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE
				OIADS	3.00E-03	OPTR FAILS TO INHIBIT ADS

Notes:

1. "Number" refers to accident sequence ranking in the top 100 core damage sequences.
2. "Frequency" is the frequency per year that this sequence is expected to occur.
3. "Percent" is the percent of total core damage represented by this single sequence.
4. "Damage St" is the plant damage state to which this sequence belongs. The fifth character indicates the associated release and is manually assigned at the end of the analysis in presentations of dominant sequences. "Containment failure (Release) type" denotes whether the containment failure mode leads to an uncontrolled release (as a containment failure with no venting) or a semi-controlled release (as a vented condition followed by a high temperature failure).
5. "Event" is the list of PRT and support system event tree top events which have failed in this sequence.
6. "Value" is frequency (for initiators) or probability (for failures) associated with each event.
7. "Description" defines the "Event" label.

The core damage frequency by "plant damage state" is shown in Table 4.6.2-4 for plant damage states within the upper 95% of the total CDF. As can be seen from this table, a large number of the plant damage states involve the failure of operator action to initiate the automatic depressurization system (ADS) function. In fact, 44% of the top 95% contribution to the CDF involve plant damage states with a loss of the OAD function. This is primarily attributed to significantly increasing the OAD failure probability after re-evaluating the Dresden IPE Model HEPs.

Table 4.6.2-5 identifies the key contributors, both hardware failures and operator errors for each of the unsuccessful events in the top 7 sequences identified by screening criteria A. These 7 sequences contribute approximately 62% to the CDF. Sequences #8 and above have a CDF contribution of less than 2.5% per sequence and a frequency of less than 1E-07.

Conclusions From Accident Sequence Quantification

The core damage frequency of 3.4E-06 for Dresden is dominated (19% of CDF) by sequence #1, medium LOCA with early core damage (0-2 hours), due to HPI failure and operator failure to depressurize; containment failure is prevented by injection into the failed vessel by LP pumps and SPC. The Dresden IPE analyzes 17 initiating events. The medium LOCA initiator contributes 39% of the CDF, the dual-unit loss of offsite power contributes 24% of the CDF, the anticipated transient without scram initiator contributes 23% of the CDF, the single-unit loss of offsite power initiator contributes 8% of the CDF, and the general transient initiator contributes 4% of the CDF. These top five initiators contribute 98% of the total CDF. The top 15 sequences have individual contributions greater than 1% of the CDF.

These results show a significant contribution to CDF from support systems, specifically AC power. Also, there is a significant contribution to CDF from failure of the high pressure injection system (HPI), failure of suppression pool cooling hardware (SPC), and failure of operator action to initiate the automatic depressurization system (ADS). There is a minor contribution from operator actions such as failure to inhibit automatic depressurization system (OIADS), makeup to the isolation condenser (OMUP), failure to initiate standby liquid control system (OSL1, OSL2), and failure to initiate the recirc pump trip (ORP).

The majority of sequences (about 53%) involve early CDF (0-2 hours). All of the early core melt sequences with early containment over-pressure failure are initiated by ATWS.

About one-third of the core damage sequences (32%) involve late core damage.

The remaining one-sixth of the sequences (15%) involve intermediate core damage.

Summary of Screening Criteria:

1. sequences with core damage frequency greater than 1E-07
2. sequences in upper 95% of total core damage frequency
3. sequences within upper 95% of total containment failure probability
4. sequences with containment bypass frequency greater than 1E-08

TABLE 4.6.2-4
CORE DAMAGE FREQUENCY BY PLANT DAMAGE STATE

STATE	DESCRIPTION	FREQUENCY	PERCENT CONTRIB
MEAB	Medium LOCA with early core damage (0-2 hours), due to HPI failure and operator failure to depressurize; injection into the failed vessel by LP pumps and SPC prevents containment failure	1.0E-06/yr	30
TEEQ	ATWS with wetwell over-pressure failure prior to early core damage (0-2 hours) due to failure to trip recirc pumps or failure to inject SLC	6.0E-07/yr	18
BLABM	Station Blackout with late core damage (6-24 hours), due to operator failure to keep IC online; injection into the failed vessel by LP pumps and SPC prevent containment failure	5.1E-07/yr	15
MLCO	Medium LOCA with late core damage (6-24 hours) due to LPI failure; SPC faills, containment fails	2.9E-07/yr	9
LIAB	Loss of Offsite Power (single or dual unit) with core damage at 2-6 hours, loss of HPI, operator fails to depressurize and recover offsite power; SPC prevents containment failure	2.6E-07/yr	8
BLAY	Station Blackout with late core damage (6-24 hours), due to operator failure to recover offsite power and keep IC online	2.1E-07/yr	6
TIAB	General Transient with core damage at 2-6 hours, due to failure to makeup to IC, loss of HPI, failure to depressurize; SPC prevents containment failure	1.7E-07/yr	5
TEER	ATWS with drywell failure by over-pressure prior to early core damage (0-2 hours) due to failure to trip recirc pumps or failure to inject SLC	1.6E-07/yr	5
	TOTAL	3.2E-06/yr	95% of total CDF

TABLE 4.6.2-5
KEY CONTRIBUTORS TO DOMINANT ACCIDENT SEQUENCES

SEQUENCE	EVENT	NODE	DESCRIPTION OF KEY CONTRIBUTORS
1	MLOCA	OAD	Operator failure misreading reactor vessel water level or omission of step in depressurization procedure.
		HP2	Failure of HPCI pump to start or run.
2	DLOOP	DGB	Failure of DG 2/3 to start or run, or maintenance.
		DG2	Common cause failure to start or run of DG2.
		DG3	Common cause failure to start or run of DG3.
		SBO	Station blackout occurs in Unit 2 and Unit 3.
		ROP1	Failure to recover offsite power within 4 hours to prevent core damage.
3	MLOCA	HP1	Failure of HPCI pump to start or run, or maintenance unavailability.
		OAD	Operator failure misreading reactor vessel water level or omission of step in depressurization procedure.
4	MLOCA	SPC	Common cause failure of suppression pool cooling due to plugging or common cause MOV failures.
5	DLOOP	DGB	Failure of DG 2/3 to start or run, or maintenance
		DG2	Common cause failure to start or run of DG2.
		DG3	Common cause failure to start or run of DG3.
		SBO	Station blackout occurs in Unit 2 and Unit 3.
		ROP1	Failure to recover offsite power within 4 hours to prevent core damage.
		ROP2	Failure to recover offsite power within 6 hours (given offsite power was not recovered by 4 hours) to prevent containment failure.
6	ATWS	RCFM	Control rod mechanical failure.
		OIADS	Operator failure to inhibit automatic depressurization system.
7	ATWS	MC	Main condenser unavailable.
		RCFM	Control rod mechanical failure.
		AT	ATWS system actuation of recirc pump trip fails.

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4.6.3 Unique Features

During the performance of the Dresden IPE, a number of good features were identified as insights by the IPE analysts. Such features are those aspects of plant design or operation which may contribute to reducing initiating event frequency, or to enhancing the capability of the station to withstand challenges to the fission product barriers. Section 4.7.1 provides a summary of the insight process. This section highlights those features which are believed to be "unique" or important from the standpoint of preventing core damage accidents or mitigating the consequences of such accidents.

As noted earlier in Section 2.3, the IPE model reflects the Dresden as-built condition as it existed in December 1990, with two exceptions: the hardened containment vent installation and the diesel-driven IC makeup pump installation were both included in the plant model because both modifications were imminent at the start of this analysis. Both of these modifications have been completed. Other changes in plant design or operation since that time which may affect the beneficial aspects of the "unique" features will be evaluated as part of the periodic review and update of the Dresden PRA - the "Living PRA" process.

Table 4.6.3-1 summarizes those aspects of Dresden which are considered to be "unique" features. A brief description of each "unique" feature is provided in the following paragraphs.

Shared Service Water System: The Service Water (SW) System at Dresden is shared between Units 2 and 3. This sharing significantly reduces the probability of a loss of SW leading to initiation of an accident condition.

During an accident on one unit, the SW System can provide the heat removal needs of both units with as few as 2 out of 5 SW pumps if the unaffected unit is brought to hot shutdown and non-essential heat loads shed from the SW System. As a result, the frequency for loss of SW capability was found to be very low.

Isolation Condenser: Dresden is equipped with an isolation condenser (IC) system for closed loop cooling of the reactor after a reactor trip. This system is passive, requiring only one valve to be opened for it to operate. This makes the system very reliable during normal shutdown operations as well as during loss of AC power conditions. The IC alone is capable of dissipating the entire decay heat load (after 5 minutes), without loss of RPV inventory under most conditions, and has enough shell-side water to operate for 20 minutes before makeup is required. Makeup to the IC can be provided by multiple sources which also provides high reliability of the IC makeup for long term continued operation.

Low Pressure Coolant Injection Cross-Connect Capability: The discharge flow of the LPCI pumps from one unit at Dresden can be directed to the discharge header of the other unit as needed. This provides an alternate water source as well as motive and cooling capacity. This would mitigate the effects of a loss of suppression pool cooling

in which the affected units LPCI pumps fail due to a loss of NPSH. The cross-connect of the two units LPCI systems requires the opening of two locked-closed manual valves and four normally shut air-operated valves.

Control Rod Drive Cross-Connect Capability: Additionally, Dresden is equipped with a cross-tie between the control rod drive (CRD) systems of Units 2 and 3. This cross-tie was a modification installed in response to 10 CFR 50 Appendix R and allows use of the IC for extended periods during single-unit station blackout (SBO) events when one or both of the opposite unit's CRD pumps are available and/or running. This CRD cross-connect capability requires the opening of two side-by-side manual valves and will provide the RPV makeup flow required under the conservative assumption of significant leakage due to reactor recirculation pump seal failure.

Shared Condensate Storage Tanks: The two condensate storage tanks at Dresden are normally split. However, in an emergency, condensate may be drawn from either or both tanks. This lineup requires the repositioning of several manual, locked closed valves. The normal use of the CST is makeup to the hotwell through the condensate transfer pumps and as the CRD and HPCI suctions. In an emergency, LPCI may be lined up to take a suction from the CST.

TABLE 4.6.3-1

UNIQUE FEATURES OF DRESDEN STATION

UNIQUE FEATURE	CONTRIBUTION TO RISK PROFILE
Shared Service Water System	• Reduced frequency of Loss of SW Initiating Event • Reduced frequency of core damage
Isolation Condenser	• Reduced frequency of core damage
Low Pressure Coolant Injection Cross-connect Capability	• Reduced frequency of core damage
Control Rod Drive Cross-Connect Capability	• Reduced frequency of core damage during single unit SBO events
Shared Condensate Storage Tanks	• Reduced frequency of core damage

4.6.4 Decay Heat Removal Evaluation

This section provides an evaluation of the decay heat removal critical safety function at Dresden based upon the results from the IPE as required by Generic Letter 88-20. The purpose of the evaluation is to identify potential decay heat removal vulnerabilities for events initiated from power operation and to examine whether or not risks attributed to the loss of decay heat removal can be lowered in a cost-effective manner.

Decay heat removal during the first 24 hours following a plant trip is accomplished by the following key systems at Dresden.

- During transient-type events, decay heat is removed via the Isolation Condenser (IC). If the IC fails, bleed and feed operations are needed. The bleed and feed operation requires a high pressure injection system (either FW or HPCI), the relief valves or the main condenser, and the associated operator actions. These coolant makeup sources do not depend on cooling of the suppression pool. If FW or HPCI fails, then the reactor is manually depressurized and the low pressure systems in conjunction with SPC are used. After the recirculation loop temperature is below 350°F the shutdown cooling system can also be used.

- During medium or large LOCA events (excluding ISLOCA) and inadvertent open relief valve (IORV) events, decay heat is removed directly by the low pressure systems and SPC. This includes the low pressure coolant injection (LPCI) pumps with the containment cooling service water (CCSW) system, the core spray (CS) pumps and the associated operator actions.

Given that successful decay heat removal depends upon the above systems and operations, the following is a discussion of these systems and their respective features. The discussion includes: the decay heat removal functional failures that contribute to the core damage frequency (CDF); enhancements proposed to reduce the decay heat failure contribution to the CDF; and requantification results showing the reduction in CDF achieved if the proposed enhancement is implemented.

- The IC is a passive system requiring only one valve to open for operation. This makes the IC very reliable during normal shutdown operations as well as during loss of AC power conditions. The IC can remove all the reactor decay heat produced within minutes after reactor shutdown and has enough shell-side water to operate for 20 minutes before makeup is required. Makeup to the IC can be provided by multiple sources which also provides high reliability of the IC makeup for long term continued operation. The IC can take the reactor to cold shutdown.

- Because the IC is a closed loop system, no reactor pressure vessel (RPV) makeup is required for extended use of the IC due to the low RPV leakage rate during normal shutdown operations. During extended station blackout conditions, however, cooling would be lost to the reactor recirculation pump seals, and increased seal leakage is possible. Therefore, for the Modified IPE, a new IC

success criterion was added that RPV makeup must be provided; this new criterion is based on a conservative assumption that seal leakage would be large enough to require RPV makeup to allow extended IC operation.

- The failure probability of IC (Automatic Initiation) was calculated to be a very low value with all supports available. The IC system is designed to operate without reliance on AC Power. However, the IC is unavailable on loss of 125VDC power at either unit. During a long-term station blackout in which 125VDC will ultimately be lost due to battery depletion, the ICs can be kept in service even without DC power, if appropriate operator actions are taken.

- If the MSIVs remain open, the reactor pressure will increase until the turbine-bypass valves open and steam is relieved to the main condenser. Reactor water level is maintained by either FW or HPCI. If the bypass valves or the main condenser is unavailable, then the relief valves will automatically open and relieve steam directly to the suppression pool. During those transient events which do not result in loss of either turbine bypass to the main condenser or feedwater, decay heat can be removed by the condenser. However, the main condenser was not included in the model as a heat sink because many events result in its unavailability. The relief valves and HPCI can function in the feed and bleed mode even with a station blackout provided that DC power is available. However, after recovery of onsite AC power SPC with the low pressure systems would be required to prevent suppression pool overheating and loss of net positive suction head (NPSH) to the low pressure pumps.

- If the high pressure injection systems fail, the reactor vessel may be depressurized to allow the low pressure injection systems to inject. This is accomplished using the relief valves of the Automatic Depressurization System (ADS). Manual depressurization (OAD) is not initiated until the low pressure systems are started and recirculating through their respective minimum flow lines.

- The low pressure injection systems, LPCI and CS, can inject when reactor pressure is less than 350 psig. LPCI consists of four pumps, each capable of providing full injection flow. CS consists of two pumps, each capable of providing full injection flow. These pumps provide a highly redundant means of supplying makeup to the reactor vessel from diverse sources through redundant and diverse injection points.

- If the decay heat is directed to the suppression pool through either the relief valves or the break (except for interfacing system LOCAs), the suppression pool must be cooled to maintain a minimum net positive suction head (NPSH) for the low pressure pumps. The heat is removed by SPC, using the LPCI pumps, heat exchangers, and the CCSW system. If heat is not removed by SPC, external sources of water can be used to obviate the dependence on NPSH from the suppression pool.

The IPE Model was revised to include the use of the CST as a source of water to the LPCI/CS pumps. This revision was an insight which could significantly reduce the CDF contributions due to loss of suppression pool cooling.

In the top 100 core damage sequences of the modified IPE, about 7.9% of the CDF involves failures of long term decay heat removal using SPC resulting in long term core damage (6-24 hours). About 7.7% of the CDF is a result of SPC equipment failures while about 0.2% is due to operator failure to initiate SPC (OSPC).

It is felt that the evaluation of decay heat removal performed during this IPE provides adequate understanding of this vital function and Dresden's means for dealing with decay heat removal during accident conditions to resolve this generic issue.

4.6.5 Evaluation of AM Endstates

SAM Endstates - The dominant Plant Response Tree sequences with SAM damage states from the IPE analysis have been reviewed and are shown in Table 4.6.5-1. Table 4.6.5-1 (located at the end of this subsection) individually lists the top 48 SAM sequences and provides the following information:

- Sequence number (if the SAM damage states were combined with core damage states in a new top 100 damage sequence listing)
- Accident sequence frequency
- Percentage contribution to total core damage frequency
- Plant damage state (bin)
- Initiating event name and frequency
- Failed support state event tree nodes, probabilities, and descriptions
- Failed plant response tree nodes, probabilities, and descriptions

The core damage frequency for these 48 SAM sequences is 1.2E-06. This is 36% of the base core damage frequency of 3.4E-06. The total SAM damage state frequency (all SAM sequences) is 1.5E-06, or 44% of the base core damage frequency of 3.4E-06.

TABLE 4.6.5-1
DOMINANT ACCIDENT SEQUENCES WITH SAM DAMAGE STATES

Number (1)	Frequency (2)	Percent (3)	Damage State (4)	Event (5)	Value (6)	Description (7)
8	9.71E-08	1.99	SAM	GTR	7.40E+00	GENERAL TRANSIENT IE
				2M1	2.40E-06	LOSS OF BUS 2A-1, 24HR
				ICH2	1.00E+00	SYSTEM FAILURE
				FW	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	5.87E-03	SPC FAILS; 24, 28, 29, 2R1 AVAILABLE
10	8.25E-08	1.69	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	5.87E-03	SPC FAILS; 24, 28, 29, 2R1 AVAILABLE
12	7.92E-08	1.63	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				24	3.09E-03	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
				MUP	6.98E-03	MUP FAILS; 25 FLD
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	1.00E+00	SYSTEM FAILURE
15	6.52E-08	1.34	SAM	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
16	5.58E-08	1.15	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	5.87E-03	SPC FAILS; 24, 28, 29, 2R1 AVAILABLE
17	5.08E-08	1.04	SAM	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
18	4.84E-08	0.99	SAM	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OSL1	8.70E-03	OPTR FAILS TO INITIATE SLC (1/2 PUMP) (Opt)
				OSL2	1.10E-01	OPTR FAILS TO INITIATE SLC (2/2 PUMPS) (Potential Rec)
19	4.50E-08	0.92	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
20	4.30E-08	0.88	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				24	3.09E-03	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	1.00E+00	SYSTEM FAILURE
21	4.29E-08	0.88	SAM	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
26	3.41E-08	0.7	SAM	IORV	7.14E-02	IORV IE
				FW	1.52E-03	FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
27	3.35E-08	0.69	SAM	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
32	3.04E-08	0.62	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
33	3.01E-08	0.62	SAM	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS

TABLE 4.6.5-1 (Continued)
DOMINANT ACCIDENT SEQUENCES WITH SAM DAMAGE STATES

Number (1)	Frequency (2)	Percent (3)	Damage State (4)	Event (5)	Value (6)	Description (7)
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
35	2.84E-08	0.58	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	5.87E-03	SPC FAILS; 24, 28, 29, 2R1 AVAILABLE
36	2.75E-08	0.57	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				23	3.09E-03	LOSS OF BUS 23/23-1 AVAILABLE, 24HR
				24	3.52E-02	LOSS OF BUS 24 AFTER 23/ 24-1 AVAILABLE, 24HR
				MUP	6.98E-03	MUP FAILS; 25 FLD
				ROP1	1.00E+00	SYSTEM FAILURE
				SPC	1.00E+00	SYSTEM FAILURE
39	2.35E-08	0.48	SAM	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
41	2.18E-08	0.45	SAM	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
42	2.18E-08	0.45	SAM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	5.87E-03	SPC FAILS; 24, 28, 29, 2R1 AVAILABLE
43	2.09E-08	0.43	SAM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				24	3.09E-03	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
				MUP	6.98E-03	MUP FAILS; 25 FLD
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	1.00E+00	SYSTEM FAILURE
46	1.98E-08	0.41	SAM	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
47	1.90E-08	0.39	SAM	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
49	1.70E-08	0.35	SAM	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
51	1.56E-08	0.32	SAM	ATWS	2.28E-04	ATWS INITIATOR
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				SLC	2.96E-04	SLC FAILS; 1/2 PUMPS; ALL SUPPORTS AVAILABLE
52	1.55E-08	0.32	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				ROP1	1.00E+00	SYSTEM FAILURE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
53	1.54E-08	0.32	SAM	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
54	1.52E-08	0.31	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE

TABLE 4.6.5-1 (Continued)
DOMINANT ACCIDENT SEQUENCES WITH SAM DAMAGE STATES

Number (1)	Frequency (2)	Percent (3)	Damage State (4)	Event (5)	Value (6)	Description (7)
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	5.87E-03	SPC FAILS; 24, 28, 29, 2R1 AVAILABLE
56	1.49E-08	0.31	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				23	3.09E-03	LOSS OF BUS 23/23-1 AVAILABLE, 24HR
				24	3.52E-02	LOSS OF BUS 24 AFTER 23/ 24-1 AVAILABLE, 24HR
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				SPC	1.00E+00	SYSTEM FAILURE
57	1.48E-08	0.3	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				24	3.09E-03	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	1.00E+00	SYSTEM FAILURE
58	1.47E-08	0.3	SAM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	5.87E-03	SPC FAILS; 24, 28, 29, 2R1 AVAILABLE
59	1.46E-08	0.3	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				24	3.09E-03	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
				MUP	6.98E-03	MUP FAILS; 25 FLD
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	1.00E+00	SYSTEM FAILURE
62	1.33E-08	0.27	SAM	GTR	7.40E+00	GENERAL TRANSIENT IE
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				FW	1.52E-03	FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
64	1.25E-08	0.26	SAM	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
65	1.22E-08	0.25	SAM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
68	1.14E-08	0.23	SAM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				24	3.09E-03	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	1.00E+00	SYSTEM FAILURE
71	1.03E-08	0.21	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	5.87E-03	SPC FAILS; 24, 28, 29, 2R1 AVAILABLE
73	1.01E-08	0.21	SAM	ATWS	2.28E-04	ATWS INITIATOR
				MC	1.37E-01	MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
78	9.09E-09	0.19	SAM	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				ICH2	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
80	8.73E-09	0.18	SAM	GTR	7.40E+00	GENERAL TRANSIENT IE

TABLE 4.6.5-1 (Continued)
DOMINANT ACCIDENT SEQUENCES WITH SAM DAMAGE STATES

Number (1)	Frequency (2)	Percent (3)	Damage State (4)	Event (5)	Value (6)	Description (7)
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
				FW	1.52E-03	FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
82	8.24E-09	0.17	SAM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				MUP	2.56E-03	MUP FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
83	7.94E-09	0.16	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.57E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				24	3.09E-03	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	1.00E+00	SYSTEM FAILURE
84	7.85E-09	0.16	SAM	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				MC	7.28E-01	MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS
				RCFM	3.33E-01	FRAC OF RPS FAILURES THAT ARE MECHANICAL
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
87	7.48E-09	0.15	SAM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	5.87E-03	SPC FAILS; 24, 28, 29, 2R1 AVAILABLE
88	7.47E-09	0.15	SAM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				23	3.09E-03	LOSS OF BUS 23/23-1 AVAILABLE, 24HR
				24	3.52E-02	LOSS OF BUS 24 AFTER 23/ 24-1 AVAILABLE, 24HR
				MUP	6.98E-03	MUP FAILS; 25 FLD
				ROP1	1.00E+00	SYSTEM FAILURE
				SPC	1.00E+00	SYSTEM FAILURE
91	7.14E-09	0.15	SAM	LOOP	5.10E-02	LOSS OF OFFSITE POWER IE
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				SPC	3.25E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
95	6.58E-09	0.14	SAM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				DG3	1.60E-01	LOSS OF DG3 AFTER DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, NO SBO IN UNIT 2
				ICH1	3.87E-03	IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
				SPC	5.89E-03	SPC FAILS; 23, 28, 29, 2M1 AVAILABLE
96	6.41E-09	0.13	SAM	DLOOP	1.63E-02	LOSS OF OFFSITE POWER IE
				DG2	1.38E-01	LOSS OF DG2, 6 HRS
				DG3	1.60E-01	LOSS OF DG3 AFTER DG2, 6 HRS
				23	3.09E-03	LOSS OF BUS 23/23-1 AVAILABLE, 24HR
				SBO?	1.00E+00	SBO IN UNIT 3, NO SBO IN UNIT 2
				MUP	6.98E-03	MUP FAILS; 25 FLD
				ROP1	1.00E+00	SYSTEM FAILURE
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
				SPC	1.00E+00	SYSTEM FAILURE
98	6.36E-09	0.13	SAM	ATWS	2.28E-04	ATWS INITIATOR
				FWA	1.28E-01	FW FAILS (% OF IEs THAT ARE LOFW)
				OMUP	1.30E-03	OPTR FAILS TO PROVIDE M/U TO IC

Notes:

1. **"Number" refers to accident sequence ranking in the top 100 sequences.**

TABLE 4.6.5-1 (Continued)
DOMINANT ACCIDENT SEQUENCES WITH SAM DAMAGE STATES

2. "Frequency" is the frequency per year that this sequence is expected to occur.

3. "Percent" is the percent of total core damage represented by this single sequence.

4. "Damage State" is the plant damage state to which this sequence belongs. The fifth character presents the release associated with this type of sequence and is manually assigned at the end of the analysis in presentations of dominant sequences.

5. "Event" is the list of PRT and support system event tree top events which have failed in this sequence.

6. "Value" is frequency (for initiators) or probability (for failures) associated with each event.

7. "Description" defines the "Event" label.

CAM Endstates - These sequences have end state designators with "AB" as the third and fourth characters. Within the top 100 core damage sequences, there are 50 sequences in this category.[1]

These sequences were investigated to determine whether the containment was pressurizing, heating up, or whether conditions were stable. The type "AB" sequences in which SPC and injection to the core debris bed continue, potentially result in containment failure also, but at a much later time. These sequences have a significant potential for avoiding containment failure through use of containment sprays to periodically cool the containment atmosphere, in conjunction with suppression pool cooling, which is functional throughout these sequences. If SPC fails at some time after 24 hours, several alternate sources of water to the core debris remain: the condensate storage tank, Standby Coolant Supply, and cross-connect to the unaffected unit's LPCI system. Repair of the affected unit's LPCI and CCSW systems can also return SPC and LPCI capability.

Ten of the CAM sequences are Station Blackout (SBO) sequences (SBO in Units 2 and 3) in which offsite power is not recovered in time to prevent core melt, but is recovered in time to supply containment systems and to reduce containment failure likelihood. Likewise, SPC and injection to the core debris bed need to be maintained and used in conjunction with containment sprays to prevent containment failure.

4.6.6 Evaluation of Large Early Release Frequency (LERF)

The large, early release frequency (referred to as LERF) is defined in the NEI-sponsored PSA Applications Guide (EPRI TR-105396) published in August 1995. ***Large*** means that the event results in "the rapid, unscrubbed release of airborne aerosol fission products to the environment." ***Early*** means that the event occurs "before the effective implementation of the off-site emergency response and protective actions." The PSA Applications Guide also includes a general guideline that an early release "Occurs Before or Within 4 Hours of Vessel Breach."

Based on this general guideline for early release and the MAAP analyses summarized in Table 4.5.5-3, only the TEEQ and TEER damage states among the top 100 dominant sequences contribute early releases. Both are ATWS sequences with containment failure before vessel failure. For the TEEQ damage state, the containment failure occurs in the wetwell gas space; consequently, scrubbing action by the suppression pool is credited for the TEEQ damage state. For the TEER damage state, however, the containment failure occurs in the drywell and no scrubbing is credited. The environmental release

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[1] The analysis of "CO" type sequences indicates that containment structural failure due to high temperature would occur at about 27-28 hours into the event. Although potentially CAM sequences, the "CO" sequences are considered in this study to be containment failure sequences. (See Table 4.5.5-3 for the source term analysis results.)

fractions given in Table 4.5.5-3 for the TEEQ and TEER damage states illustrate the benefit of scrubbing. For these ATWS damage states, the main benefit of scrubbing is a large reduction in the release fractions for non-volatile fission products and Tellurium-based fission products.

Therefore, the only damage state among the top 100 dominant sequences that gives an unscrubbed, early release (and thus a contribution to LERF) is TEER. Other damage states included in the analysis also contribute to LERF, but those damage states together contribute less than 0.1% of the total CDF and therefore give an insignificant contribution to LERF. Based on the TEER data given in Table 4.6.2-4, therefore, the Modified IPE gives a LERF of 1.6E-7/yr, less than 5% of the total CDF value. This LERF value corresponds to approximately once in 6,100,000 years.

The TEEQ damage state falls outside the LERF definition because credit is given for scrubbing due to the location of the containment failure and because a scrubbed release does not meet the definition of ***Large*** given by the PSA Applications Guide. Nevertheless, as shown in Table 4.5.5-3, the volatile fission product release fraction (as represented by CsI and RbI) is significant, although some benefit of scrubbing is seen. The only damage state among the top 100 dominant sequences that gives an scrubbed, early release is TEEQ. Other damage states included in the analysis (but not contributing to the top 100 dominant sequences) also give a scrubbed, early release, but those damage states together contribute less than 0.1% of the total CDF. Therefore, based on the TEEQ damage state data given in Table 4.6.2-4, the Modified IPE gives a scrubbed, early release frequency of 5.9E-7/yr, approximately 18% of the total CDF value.

Combined, the TEEQ and TEER damage states have a frequency of 7.6E-07/yr for an early release, or approximately once in 1,300,000 years.

> Note: The LERF definition discussed above was not available at the time of the orginal IPE Submittal Report. Several other types of release frequencies were reported. Those other types of release frequencies are not being used by ComEd for PSA applictions and, as a consequence, were not calculated as part of the Modified IPE.

4.7.2 Evaluation Against NUMARC Severe Accident Issue Closure Guidelines

The results of the Dresden IPE have been evaluated against the NUMARC (now NEI) Severe Accident Closure Guidelines. The guidelines were used to assess the proposed enhancements developed via insights related to severe accidents.

The first step in using the Severe Accident Closure Guidelines was to group the core damage sequences; the groupings used were those of Table B-1 of that document. The grouping was carried out for all core damage sequences down to the quantification frequency cutoff of 1E-12 for a given sequence. The following groups contain some contribution to the total core damage frequency:

IA Accident sequences involving loss of coolant inventory makeup in which the reactor pressure remains high.

IB Accident sequences involving a loss of all AC power and loss of coolant inventory makeup (i.e., station blackout).

ID Accident sequences involving a loss of coolant inventory makeup in which reactor pressure has been successfully reduced.

II Accident sequences involving loss of containment heat removal leading to containment failure and subsequent loss of coolant inventory makeup.

IIIB Accident sequences initiated or resulting in small or medium LOCAs for which the reactor cannot be depressurized and inadequate coolant inventory makeup is available.

IIIC Accident sequences initiated or resulting in medium or large LOCAs for which the reactor cannot be depressurized and inadequate coolant inventory makeup is available.

IV Accident sequences involving an ATWS leading to containment failure due to high pressure and subsequent loss of inventory makeup.

V Unisolated LOCA outside containment leading to loss of effective coolant inventory makeup.

The sequence numbers of the top 100 sequences included in each group are listed in Table 4.7.2-1 with the resulting mean group core damage frequency and percent contribution to the total core damage frequency. The group core damage frequency and contribution is based upon all sequences.

TABLE 4.7.2-1
NUMARC SEVERE ACCIDENT CLOSURE GUIDELINES
SEQUENCE GROUPING INFORMATION

SEQUENCE GROUP	SEQUENCE NUMBERS[1]	TOTAL GROUP CORE DAMAGE FREQUENCY	% CONTRIBUTION TO TOTAL CDF
IA	9, 10, 11, 17, 18, 25, 26, 32, 34, 40, 44, 49, 50, 61, 63, 65, 69, 73, 74, 75, 77, 79, 81, 82, 83, 85, 87, 93, 98, 100	4.3E-07	12.7%
IB	2, 5, 19, 22, 28, 31, 38, 47, 48, 51, 53, 56, 58, 62, 76, 84, 86, 88, 92, 99	7.4E-07	21.9%
ID	29, 60, 72	2.1E-08	0.6%
II	None in top 100 sequences		
IIIB	1, 3, 42, 54, 71	1.0E-06	30.4%
IIIC	4, 35, 43, 45, 67, 70, 90, 91, 96	2.9E-07	8.5%
IV	6, 7, 8, 12, 13, 14, 15, 16, 20, 21, 23, 24, 27, 30, 33, 36, 37, 39, 41, 46, 52, 55, 57, 59, 64, 66, 68, 78, 80, 89, 94, 95, 97	7.3E-07	21.7%
V	None in top 100 sequences		

[1] Refers to the sequence position in the ranking of core damage sequences in descending magnitude of core damage frequency.

The core damage frequency and percent contribution to the total core damage frequency for each group were then evaluated against Tables 1 and 2 of the Severe Accident Closure Guidelines. Table 2 was used for the containment bypass sequences (group V only), and Table 1 was used for all other groups. The comparison shows that the IB, IIIB, and IV groupings are of interest with respect to the Severe Accident Closure Guidelines.

The IIIB group CDF falls into the Table 1 category range of mean CDF 1E-5 to 1E-6 that suggests the licensee ensure that Severe Accident Management Guidance (SAMG) is in place with emphasis on prevention/mitigation of core damage or vessel failure, and containment failure.

The IB, IIIB, IV groups fall into the Table 1 category range of 20% to 50% of total CDF that suggests the licensee:

1. Find a cost effective treatment in EOPs or other plant procedure or minor hardware change with emphasis on prevention of core damage.

2. If unable to satisfy above response, ensure SAMG is in place with emphasis on prevention/mitigation of core damage or vessel failure, and containment failure.

These suggested actions were again considered for potential plant enhancements. The addition of the SBO Diesel Generators should significantly reduce the contribution of sequence group IB. It is anticipated that the core damage and containment release frequency contribution within sequence groups IIIB and IV will be reduced by the implementation of SAMGs.

4.7.3 Results of IPE Enhancement Evaluations

The utilization of the NUMARC Severe Accident Issue Closure Guidelines in the original IPE submittal identified the need for the implementation of one or more plant enhancements at Dresden station related to sequences in which suppression pool cooling has failed. A prodedure enhancement related to alignment of LPCI or Core Spray pump suction to the condensate storage tank when suppression pool cooling cannot be established has been implemented. As a result, no group II events now appear in the top 100 sequences. A procedure enhancement to maintain the function of the Isolation Condenser during long-term SBO events resulted in a reduction of the group 1B sequences.

Because all of the groups have a core damage frequency of less than or equal to 1E-6, a vigorous pursuit of further enhancements is not warranted at this time. It is anticipated, however, that the core damage and containment release frequency contribution within many of these sequence groups will be reduced by the implementation of SAMGs issued by the BWROG.

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5.0 ACCIDENT MANAGEMENT

Commonwealth Edison (CECo) has integrated the development of an Accident Management (AM) Program with the performance of the IPE. This process was used in the belief that an effective approach to AM is a structured evaluation process that is tightly coupled with the knowledge base developed during the IPE program. Potential and possibly subtle strategies and insights are best identified and documented while related information is actively under evaluation by the IPE analysts.

The CECo AM program development and considerations for future direction are described in this section. The AM insights derived from the Dresden IPE will be evaluated in conjunction with industry and owners group guidance during implementation of the NEI formal industry position on Severe Accident Management (SAM).

It should be noted that CECo, in common with other nuclear plant operators, has an accident management program already in place. Such a program has existed almost from the inception of the industry. Within CECo, the current program consists of two parts. The first of these are the plant Emergency Operating Procedures (EOPs), the trained personnel who implement them, and the plant staff who support that implementation. For events which may proceed beyond the design bases, this first phase is supported by one which centers around the Generating Stations Emergency Plan (GSEP), the trained respondents, and the facilities and tools to implement that plan.

CECo believes that the management of severe accidents with potential or actual core damage, where the situation is beyond the realm of the EOPs, should primarily be the responsibility of the emergency response organization outside the Control Room. The CECo AM program is being developed with this philosophy.

5.1 Introduction to CECo's Accident Management Program

The AM program is part of CECo's overall effort to identify, evaluate, and resolve severe accident issues with emphasis on 1) the prevention of such accidents, and 2) the need to respond effectively in the unlikely event of an accident. The objective of developing the input to the AM program in parallel with the performance of the IPE is to prevent the potential loss of valuable information that might occur if observations are not elicited and documented at the same time system performance, system interactions, operator actions, and accident progression are under study by the IPE analyst. Improved understanding of the plant capability to respond to accidents and the operator response to accident symptoms is one of the most important benefits to be obtained from the Dresden IPE, and the decision to develop and evaluate AM insights as part of the IPE for Dresden has maximized this benefit.

The CECo process used to define the AM Program for Dresden is comparable to those developed by EPRI (Reference 5.1) and the NRC (Reference 5.2). Both the EPRI and the NRC methodologies for developing AM programs are based on an evaluation of the IPE results to identify accident management activities. The methodology used by CECo for Dresden is a forward looking process based on evaluation of each phase of the IPE work.

The CECo approach encompasses the key aspects of the EPRI and NRC methodologies and employs a simultaneous "top-down" and "bottom-up" method as illustrated in Figure 5.1-1. The top-down evaluation has logically defined the elements of an intuitive AM program framework and identified where the various aspects of the IPE effort could support enhancement of these elements. The bottom-up approach examined the technical analysis at each of the major steps of the IPE for observations that could fall into one or more of the five AM framework elements.

The CECo AM framework elements are similar to those proposed by the NRC. The five elements of the CECo AM program are:

- Organization and Decision Making,
- Accident Management Guidance (Strategies),
- Calculational Tools,
- Training, and
- Plant Status Information

A major feature of the CECo framework is the broadening of the element definition to include more information and/or organizational ties within the framework. Differences include the expansion of the plant instrumentation area to include vital plant information needs for AM, the expansion of AM guidance to include the interface with the site emergency plan, and the consideration of predictive and decision making tools within the calculational tool element.

The individual insights identified by the bottom-up approach were then evaluated on their technical merit. A qualitative assessment of their potential benefit, as well as potential impact, was also performed. Since individual insights related to the same plant feature can be contradictory or supplementary due to the nature of the insight identification process, all insights related to a given plant feature were then evaluated on an aggregate basis. A qualitative assessment was then performed for each set of combined insights. In some cases, a quantitative assessment of the benefits, in terms of improvements in the Dresden severe accident risk indicators (core damage frequency, or source term characteristics), was performed using the IPE model.

This process is compatible with the AM guidelines developed by the industry. However, the approach is believed to have two distinct advantages. First, the search for insights is conducted while the analysts have the information fresh in their minds. Second, the search covers all aspects of the analysis, not just the dominant accident sequences. Thus, the approach supports an AM program that takes maximum advantage of the performance of the IPE for Dresden.

It was recognized that the insights derived from a PRA might not fully address the human side of an AM program. To consider this aspect, a task analysis of key GSEP positions

The AM insights identified in the current study are, in many cases, different from those identified from previous PRA studies. The primary difference is in completeness of the search for AM insights and the comprehensive coverage of all of the aspects of the IPE.

A major aspect of the approach used in the Dresden IPE, as it relates to identification and evaluation of AM insights, is the realistic modeling of the accident progression including EOP directed operator actions, and the definition of realistic success criteria. This approach ensures that insight identification is not driven by conservatisms in the IPE model, but are 'real' insights which can be used to enhance emergency response.

Another aspect to the AM insights identified during this study is the overall IPE approach of using best estimate analyses, and of mapping the plant normal and emergency operating procedures and general abnormal procedures to the accident progression to determine those operator actions which can impact the accident progression. This has resulted in a comprehensive review of the plant procedures for their impact on the progression of accidents. As a result of this procedure review, a number of previously identified AM insights (e.g., the NRC "A" Strategies) were found to be already addressed in the current procedures. Some enhancements to the procedures have been suggested, primarily to improve clarity and enhance the chances for appropriate operator response to plant parameters. (See Section 4.7.1).

5.3 Accident Management Insights

Over 60 individual AM insights for Dresden station were identified by the IPE analysts for evaluation by the review Team. The distribution of insights to the AM framework elements concentrated on AM strategies and information as expected:

Organization	1 %
AM Guidance	39 %
AM Tools	19 %
AM Training	1 %
AM Information	40 %

In this tabulation, the insights are distributed to only the primary element. For example, in the case of suggested AM computational tools, training was not identified separately even though training on new AM tools would most likely be necessary.The Team also sorted the AM insights into goal oriented categories as presented in Figure 5.3-1.

As a result of the process described above, the insights in each category were developed from a narrow perspective (i.e., a particular IPE task such as the large LOCA Plant Response Tree construction), without regard to potential benefit or impact. Thus, the Tiger Team evaluation was necessary to provide a perspective of the importance of the insights.

Observations from the evaluation of the AM insights are summarized below. The AM insights judged to have generic procedure implications were provided to the BWR Owners Group for further evaluation. However, due to the 1991 BWR Owners Group generic review cut-off date, these insights were not explicitly evaluated. The Dresden-specific implementation of the BWR Owners Group generic SAM guidance will include disposition of the Dresden insights. See Paragraph 5.3.6.

5.3.1 Organization and Decision Making

CECo has evaluated the organizational needs for accident management using three approaches:

- The first involved examination of the results of AM insight development and assessment effort described above.
- The second approach involved the use of a top down, or logical intuitive, AM examination by experienced personnel.
- The third, noted earlier, involved a task analyses, performed by a behavioral scientist, of the key GSEP positions.

Current Organization

CECo's current organization and decision making structure is built around the plant staff for events which lie within the design bases of the plant, and the emergency plan staff for AM activities for events which pass beyond that envelope. The GSEP command, control, and communications channels are well established within each of these areas and at the interfaces between areas. Moreover, those same lines between CECo and outside agencies are equally well defined and established.

It has been determined that the existing GSEP organizational structure and delineation of decision-making responsibility for AM activities are both clear and well-understood.

AM Recommendations on Current Organization

As noted earlier, it is CECo's philosophy that AM should primarily be the responsibility of the GSEP organization, not limited to the Control Room staff. Our evaluation suggests that AM activities are best addressed by the established Technical Support Center (TSC) organization. AM recommendations include, for example, specifying the role of the TSC personnel, upon initial manning, to conduct a review of the accident progression up to that time and to verify the status of all DEOP-required mitigative actions. CECo further endorses the full complement of NUMARC recommendations to ensure the TSC personnel have the calculational and diagnostic tools available to determine the progression of the accident and to monitor the status of mitigative plant features. Consistent with the NEI formal industry position on SAM, implementation of SAM will be achieved within the constraints of existing personnel and plant hardware.

Additionally, to maintain technical awareness and expertise in severe accident state-of-the-art, a corporate resource is suggested. This resource would supplement the GSEP organization as needed, similar to the support provided by any corporate organization during an emergency condition. The corporate group would follow severe accident research, evaluate new information, interact with the technical community on

severe accident issues, and maintain the technical aspects of the program at a level consistent with the state-of-the-art in severe accident technology.

5.3.2 Accident Management Guidance

As noted in Section 5.3 above, a number of insights were identified during the IPE/AM insight process and classified as potential AM guidance. Included in this process was a review of the NRC's "A" Strategies provided in Supplement 2 to GL 88-20 and the BWR "B" Strategies discussed in NUREG/CR-5780 (Reference 5.4).

Two conclusions from the evaluation of AM guidance insights merit discussion:

Prevention of Reactor Pressure Vessel Failure

A series of experiments performed as part of the Dresden IPE / AM Program verified that submerging the bottom portion of the reactor vessel can prevent the failure of the reactor vessel after relocation of the damaged core to the lower head, given that the RPV support skirt is modified to allow the egress of steam from it. The RPV support skirt would require modification such that holes were placed in it near its junction with the RPV. The holes would provide for the escape of both air from the skirt during pedestal flooding and any steam produced given core debris relocation inside the lower plenum. The Dresden experiments with a support skirt without vent holes showed that steam blanketing would occur in the skirt and greatly reduce the ability to protect the lower head from failure.

As a result of the experimental verification and the IPE analyses, a number of AM insights were identified to ensure that the reactor pedestal could be flooded prior to core damage in order to prevent failure of the reactor vessel and maintain the core debris inside the vessel. If vessel failure is prevented during a severe accident, then all of the ex-vessel phenomena can be precluded. This eliminates the potential for several postulated containment challenges (direct containment heating, ex-vessel steam explosions, and core concrete interactions) and the potential fission product releases associated with them or containment failure. The current plant configuration and existing guidance per the emergency operating procedures provide for flooding the containment. The time required to flood the containment encompasses a large range which depends upon the system available to supply water to the containment. The current procedures would result in the flooding of the torus and a portion of the drywell. The large volume of water required to flood the containment and to submerge the RPV directly impacts the timing for such flooding. Additionally, the complete flooding of the torus eliminates the suppression pool as a heat sink should the primary system rupture following floodup. Furthermore, the flooding of the wetwell gas space would preclude the use of the wetwell vents. Therefore, plant modifications which would allow the reactor pedestal to be flooded independently of the rest of the containment would be needed to assure that the RPV could be flooded prior to vessel failure and core damage. The pedestal would require structural modifications such that it could be flooded by an independent water supply without flooding the drywell and wetwell gas spaces. This would provide the advantage of a more rapid floodup and submergence of the RPV and would eliminate the adverse

impact of the loss of the suppression pool as a heat sink or as a fission product removal mechanism during wetwell venting. However, consistent with the NEI formal industry position on SAM, no plant modifications will be made such as the RPV support skirt venting.

Alternate Sources for Containment Spray for Source Term Reduction

Two classes of accidents assessed in the Dresden IPE indicate the potential for large fission product release fractions. These classes are an unrecovered station blackout and an ATWS event. Accident management strategies which employ the drywell sprays would be an effective means of controlling the fission product release fractions. For a station blackout at a given unit, alternate sources of containment spraying would include the cross-connection to the other unit's low pressure core injection system or to the plant's fire protection system. The operation of the drywell sprays even in an intermittent manner will effectively remove the fission products from the containment gas space. Additionally, containment spray operation will remove energy from the gas space such that both the drywell temperature and pressure would be reduced and thereby delay containment failure. A delay of containment failure provides additional time for the recovery of AC power. The operation of the containment sprays also provide cooling which would retard the revaporization of fission products deposited on the containment surfaces. The spray water would flood the core debris accumulated on the drywell and pedestal floor and would help to quench it and thereby terminate core concrete interactions. The water layer overlying the debris bed would also scrub fission products that could be evolved from the debris bed during its quenching and stabilization.

5.3.3 Calculational Tools

CECo currently has a number of post-accident instruments to aid the GSEP organization for the current scope of accident management. It was recognized during the IPE/AM insight process that development of additional computational aids or tools would be desirable to aid the emergency response organizations in being able to monitor and forecast accident progression. In particular, the ability to predict changes in fission product releases and to predict the impact of various AM guidance alternatives is important in selecting optimal AM actions. CECo will implement the recently developed BWR Owners Group generic Severe Accident Guidelines (SAG) and recommended changes to the EPGs consisent with the NEI formal industry position on SAM.

5.3.4 Training

CECo, like other utilities, conducts training relative to accident management through the EOP training provided to licensed personnel, through the annual training given to GSEP respondents, and through the conduct of GSEP exercises.

The industry IPE effort is yielding a number of insights which may lead directly to enhancements in the EOPs. Training on these potential EOP changes is expected to be integrated into the normal license training process.

For accident management, the positions expected to require additional training generally involve those respondents who are active in the accident recovery and mitigation decision making process, primarily located in the TSC organization. The degree of training ranges from general familiarity with AM to that associated with obtaining a degree of expertise in severe accident behavior and the calculations necessary to monitor and understand accident progression.

It is recognized that the area of training for the SAM guidance under consideration will be a first time effort. The ability to effectively assimilate and use this new SAM guidance will evolve over time to address industry and regulatory initiatives, in addition to individual utility activities.

5.3.5 AM Information

The IPE/AM insight process identified areas where development of supplemental information regarding severe accidents might be useful to AM personnel. Examples include:

- The preferential use of Core Spray (over core injection) for debris cooling.
- Heat removal capabilities and limitations for alternate residual heat removal systems.
- The critical EOP steps required for successful core cooling, containment heat removal, and fission product mitigation.
- Minimum equipment needs for core cooling and containment heat removal, based on IPE success criteria.
- Sources, system flooding rates, and inventory available for containment flooding.
- Use of a status board to display the critical plant information required as input for the TSC personnel responsible for performing the AM calculations identified by the BWR Owners Group generic SAM guidance, as well as the results of these calculations.

5.3.6 Insight Implementation

The preparation of IPEs for nuclear plants prior to December 1991, in conjunction with industry research, provided additional insights that were incorporated into the recently developed BWR Owners Group generic Severe Accident Guidelines (SAG) and recommended changes to the EPGs. After completion of the initial Dresden IPE, the IPE/AM insights identified during the Dresden insight process were provided to the GE BWR Owners Group for consideration in the development of the Owners Group severe AM guidance. However, due to the 1991 BWR Owners Group generic review cut-off date, these insights were not explicitly evaluated. The Dresden-specific implementation of the BWR Owners Group generic guidance will include the disposition of the Dresden insights.

6.0 IPE REQUANTIFICATION

The original IPE results included a recommendation to change the Dresden Emergency Operating Procedures for maintaining reactor vessel level during conditions of loss of the ability to remove heat from the suppression pool. The procedure change enables the suctions for either LPCI or CS pumps to be aligned to the condensate storage tank (CST) when the net positive suction head limits for the emergency core cooling system (ECCS) pumps are reached. The original IPE's sensitivity study of a change in the ECCS pump suction alignment procedure are presented in Section 6.1; the changes in the core damage frequency and the uncontrolled release frequency from this sensitivity study are presented in Section 6.2.

Note: The sensitivity study results in Sections 6.1 and 6.2 have been retained for historical information. These results have been superseded by the Modified Dresden IPE model which incorporates the actual procedure change.

6.1 IPE Model Modification

Changes to DEOP-100 have been recommended to improve the chances for successful continuation of ECCS makeup to the reactor vessel during conditions in which cooling of the suppression pool is unavailable. This change includes aligning the LPCI and CS pump suctions to the condensate storage tank and controlling pump flow to control level in the vessel. This suction realignment would be made prior to exceeding the temperature in the suppression pool at which the ECCS pumps would lose NPSH and potentially due to cavitation. The CST would provide a relatively long term source of cool water independent of the containment environment, eliminating the NPSH concerns and greatly the extending the time for recovery of normally used equipment.

The changes to the procedures result in two changes to the IPE model:

a) requantification of the suppression pool cooling node (SPC) to include the realignment of the ECCS pumps and a means of recovery from failure of this node, and

b) requantification of the operator action to align for suppression pool cooling (OSPC) to include the recovery action of aligning to the CST.

The requantification of the suppression pool cooling node (SPC) on the PRTs was based on the following ECCS realignments:

- The suction to the LPCI pumps from the CST must be manually opened and the suction from the torus must be closed by shutting the suction MOV or the manual valve in this line,

- The suction to the CS pumps from the CST must be manually opened and the suction from the torus must be closed by shutting the suction MOV or the manual valve in this line.

TABLE 6.2-2
CORE DAMAGE FREQUENCY BY INITIATING EVENT WITH ECCS PUMP SUCTION REALIGNMENT EOP CHANGES

Initiating Event	Initiator Frequency (per year)	Core Damage Frequency (per year)	Percent Contribution
Loss of DC in One Unit	8.7E-04	8.23E-07	22.0
Single Unit LOSP	9.6E-02	8.21E-07	21.9
Dual Unit LOSP	1.6E-02	7.57E-07	20.2
Medium LOCA	8.0E-04	6.88E-07	18.4
Anticipated Transient without Scram	2.2E-04[1]	5.35E-07	14.3
General Transient	7.4	6.12E-08	1.6
Large LOCA	3.0E-04	3.67E-08	1.0
Inadvertent Opening of Relief Valve	7.1E-02	1.52E-08	0.4
Small LOCA	3.0E-03	6.20E-09	0.2
Interfacing System LOCA	1.1E-07	4.67E-10	<<0.1

[1] This "initiating event frequency" is the combination of 7.4 transients per year and the likelihood of the rods failing to insert (3E-05 per event).

7.0 SUMMARY AND CONCLUSIONS

7.1 Summary of IPE Results

The core damage frequency for the Modified Dresden IPE model was calculated to be 3.4E-06 per year. The top contributor to core damage frequency is Medium LOCA at 39% followed by Dual Unit Loss of Offsite Power at 24%, Anticipated Transient Without Scram at 23%, Single Unit Loss of Offsite Power at 8%, and General Transient at 4%.

Both the original and this Modified IPE were developed for Dresden Unit 2. An estimate of the Unit 3 risk profile was also performed that included the Loss of 125VDC initiator and different initiating event frequencies for initiators related to loss of AC switchgear because of Unit 3 water spray concerns. The Loss of 125VDC initiator, which is only appropriate for Unit 3, will be eliminated by the installation of a Unit 3 modification during the fall, 1996, outage. Upon the elimination of the Loss of 125 VDC initiator for Unit 3, the Unit 3 risk profile will be very similar to the Unit 2 risk profile. The current Unit 3 risk profile is provided in Table 7-1.

7.2 Conclusions

The Modified IPE for Dresden Station, as presented in this report, models the baseline response of the station to a wide range of initiating events based on, for the most part, the plant design, equipment reliability and availability, and operating practices that were existing at the beginning of 1991. The main exceptions to this statement are the hardened containment vent installation, the diesel-driven IC makeup pump installation, the procedure enhancement related to alignment of low pressure coolant injection or core spray to the condensate storage tank, and the DC modification to eliminate loss of DC as an initiator. Also, the revised Human Reliability Analysis was based on emergency response procedures in place as of December 1995.

The IPE models and results are based on realistic predictions of the plant and operator response to accident initiators. The predictions are based on best estimate models of the plant response, system and operator action success criteria, and a comprehensive modeling of Dresden Emergency Operating Procedures (DEOPs) and abnormal operating procedures. The study includes calculations of realistic timing, a plant-specific evaluation of plant and common cause data, and a human reliability analysis that incorporates the steps in the DEOPs. Evaluation of severe-accident phenomena is based on Dresden-specific features and capacities.

The study shows that Dresden Station functions well within accepted severe accident safety limits due to the safety margins incorporated in the design and the effectiveness of the emergency procedures. Dresden's systems are effective, and they have redundancy and diversity, as well as excess capacity. There is no critical dependence of the plant on instrument air or HVAC. The dual-unit site is beneficial, providing electric power and CRD hydraulic system cross-ties to the other unit, and providing shared service water. Torus water, DC power, and condensate storage tank inventory are also available from the other unit.

The BWR Owners Group-based EOPs are effective in responding to severe accidents. The study found a number of small potential EOP improvements. The Modified IPE HRA indicated that no EOP vulnerabilities were found. This result is supported by the sensitivity analysis discussed in Section 4.5.4 in which key human error probabilities were reduced by an order of magnitude resulting in only a very small decrease in core damage frequency.

The IPE investigation has resulted in an accurate portrayal of current risk, as well as the development of a model which can be used with a high degree of confidence to address any number of future issues regarding core damage accidents, including the development of a comprehensive Accident Management Program for Dresden Station.

The frequency of the most likely sequence, a Medium LOCA, is 6.4E-07 per year which constitutes about 19% of the total core damage frequency. The frequency of next most likely sequence, a Dual Unit Loss of Offsite Power, is 4.0E-07 per year which contributes about 12% to the total core damage frequency. The third most likely sequence is another Medium LOCA with an 11% contribution.

A review of the results of the Modified IPE using the Fussell-Vesely importance measures indicates that the most significant hardware contributors are the emergency diesel generators and the most significant operator contributor is the operator action to initiate the Automatic Depressurization System (ADS). The hardware enhancement with the greatest potential for reducing core damage frequency is completing the installation of the station blackout diesel generators. There is a minor contribution from operator actions such as failure to inhibit the automatic depressurization system, failure to provide makeup to the isolation condenser, failure to initiate the standby liquid control system, and failure to initiate the recirc pump trip. Based on the low overall core damage frequency, however, it is concluded that these contributions do not represent plant vulnerabilities.

A review of the Modified IPE results against NUMARC Severe Accident Issue Closure Guidelines (NUMARC 91-04, January 1992), shows the need for improvements to reduce several classes of accidents. The future installation of the SBO Diesel Generator and the effective implementation of accident management guidelines will accomplish these improvements.

A class of accident sequences has been identified in this IPE study as SAM (Success with Accident Management). The SAM accident sequences do not result in core damage within the first 24 hours of the initiating event, but require some additional operator action after the first 24 hours to achieve a long term safe, stable state. Consistent with traditional PRA philosophy, these have not been classified as core damage sequences in the IPE results. The SAM sequences have a predicted frequency of occurrence of 1.5E-06 per year, or 44% of the base core damage frequency of 3.4E-06 per year. The frequency of the most likely SAM sequence is 9.7E-08 per year.

The frequency of large, early release (LERF) for the Modified IPE is 1.6E-07 per year, less than 5% of the total CDF value. This LERF value is based on unscrubbed releases.

The total early release, (scrubbed and unscrubbed) is 7.6E-07 per year or 22% of the base core damage frequency. The only sequences that contribute significantly to the early release frequencies are initiated by an ATWS.

The IPE analyses also show no vulnerability to bypass and failure to isolate sequences. The initiating event frequency for interfacing system LOCAs is 1.1E-07/yr. Failure to isolate sequences are precluded because inerted containments will not be operating at full power unless the containment is isolated.

The capability of the Dresden Station design is very good. The likelihood that its operating/emergency response staff could bring the plant to a safe, stable state in the unlikely event of a severe accident without significant fission product releases (i.e., no core damage and/or no containment failure) is very high. It is concluded that there are no "vulnerabilities" for Dresden Station which require immediate attention to improve the plant risk profile.

As part of the Dresden IPE, a systematic search for insights was conducted at every phase of the study. This search for insights developed the key plant improvement ideas implemented as a result of the original IPE. The search also developed a large number of other insights for improvement in plant equipment, procedures, and training; for development of an Accident Management program; and for good features of the current plant. These remaining insights will be evaluated further within the existing framework for addressing potential changes to the station.

A number of good features of Dresden station contribute to the capability of the plant design and operating staff to respond to accidents. These features include the isolation condensers, a reliable SW system which is shared between Units 2 and 3, a low pressure coolant injection cross-connect capability, a control rod drive hydraulic system cross-connect capability, and shared condensate storage tanks.

As a result of the methodology used in this study to integrate accident management considerations into the performance of the IPE, at a task level, enhancements and changes to Dresden Station have been identified which can have an impact on the risk profile of Dresden Station and on the capabilities of the Commonwealth Edison emergency response capabilities. The key insight (ECCS pump suction realignment) had been quantified as a part of the original IPE to assess the impact of its implementation on the risk profile of Dresden station. This enhancement has since been implemented.

The Dresden IPE demonstrated that MAAP is a very useful tool for plant analysis. It was found to be of value for system success criteria and for event timing, as well as for calculation of radioactive releases.

As a result of the Integrated IPE/AM Program, CECo has developed a unique understanding of the behavior of the plant under accident conditions and of the total plant capabilities to respond to accidents. The enhanced knowledge of Dresden Station developed by CECo will be invaluable in the continuing development and evaluation of

Accident Management and IPE insights. This evaluation will be part of the periodic review and update of the Dresden PRA - the "Living PRA" process.

TABLE 7-1

DRESDEN UNIT 3 RISK PROFILE

INITIATING EVENT	CORE DAMAGE FREQUENCY	PERCENT CONTRIBUTION
LOSS OF DC POWER	1.6E-06	32.2%
MEDIUM LOCA	1.3E-06	26.5%
DUAL UNIT LOSP	8.2E-07	16.4%
ATWS	7.7E-07	15.4%
SINGLE UNIT LOSP	2.8E-07	5.6%
GENERAL TRANSIENT	1.4E-07	2.8%
LOSS OF SERVICE WATER	3.8E-08	0.8%
SMALL LOCA	9.0E-09	0.2%
LARGE LOCA	5.0E-09	0.1%
IORV	2.3E-09	0.05%
INTERFACING SYSTEM LOCA	4.6E-10	0.01%
LOSS OF BUS 33	2.5E-10	0.01%
LOSS OF INSTRUMENT AIR	2.1E-10	0.00%
LOSS OF BUS 34	1.8E-10	0.00%
LOSS OF BUS 38	9.3E-11	0.00%
LOSS OF MCC 38-2	6.1E-11	0.00%
LOSS OF BUS 31	4.7E-11	0.00%
LOSS OF BUS 32	4.4E-11	0.00%
Totals:	**5.0E-06**	**100%**

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DRESDEN NUCLEAR POWER STATION
UNITS 2 AND 3

INDIVIDUAL PLANT EXAMINATION
SUBMITTAL REPORT

VOLUME 2

REVISION 1

JUNE 1996

Submitted By

COMMONWEALTH EDISON COMPANY

FIGURE 4.1.2-1

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS1

Entry Conditions: Any initiating event other than Loss of Offsite Power or Loss of 125VDC

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2AA

Entry Conditions: Main and Reserve 125VDC available
Buses 23 and 24 available
Bus 25 or 27 or both available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2AB

Entry Conditions: Main and Reserve 125VDC available
Buses 23 and 24 available
Buses 25 and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2BA

Entry Conditions: Main and Reserve 125VDC available
Bus 23 available, Bus 24 not available
Bus 25 available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2BB

Entry Conditions: Main and Reserve 125VDC available
Bus 23 available, Bus 24 not available
Buses 25 and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2CA

Entry Conditions: Main and Reserve 125VDC available
Bus 24 available, Bus 23 not available
Bus 25 or 27 or both available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2CB

Entry Conditions: Main and Reserve 125VDC available
Bus 24 available, Bus 23 not available
Buses 25 and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2DB

Entry Conditions: Main and Reserve 125VDC available
Buses 23, 24, 25, 26, and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2EA

Entry Conditions: Main 125VDC available, Reserve 125VDC not available
Bus 23 available, Bus 24 not available
Bus 25 available

FIGURE 4.1.2-1 *(Continued)*

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2EB

Entry Conditions: Main 125VDC available, Reserve 125VDC not available
Bus 23 available, Bus 24 not available
Bus 25 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2FB

Entry Conditions: Main 125VDC available, Reserve 125VDC not available
Buses 23, 24, 25, 26, and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2GA

Entry Conditions: Reserve 125VDC available, Main 125VDC not available
Bus 24 available, Bus 23 not available
Bus 27 available, Bus 25 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2GB

Entry Conditions: Reserve 125VDC available, Main 125VDC not available
Bus 24 available, Bus 23 not available
Buses 25 and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2HC

Entry Conditions: Reserve 125VDC available, Main 125VDC not available
Buses 23, 24, 25, 26, and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2IA

Entry Conditions: Main 125VDC available, Reserve 125VDC not available
Buses 23 and 24 available
Bus 25 or 27 or both available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2IB

Entry Conditions: Main 125VDC available, Reserve 125VDC not available
Buses 23 and 24 available
Buses 25 and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2JA

Entry Conditions: Main 125VDC available, Reserve 125VDC not available
Bus 24 available, Bus 23 not available
Bus 27 available, Bus 25 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2JB

Entry Conditions: Main 125VDC available, Reserve 125VDC not available
Bus 24 available, Bus 23 not available
Buses 25 and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2KE

Entry Conditions: Main and Reserve 125VDC not available
Bus 24 available, Bus 23 not available
Bus 27 available, Bus 25 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2KF

Entry Conditions: Main and Reserve 125VDC not available
Bus 24 available, Bus 23 not available
Buses 25 and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2LA

Entry Conditions: Reserve 125VDC available, Main 125VDC not available
Buses 23 and 24 available
Bus 25 or 27 or both available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2LB

Entry Conditions: Reserve 125VDC available, Main 125VDC not available
Buses 23 and 24 available
Buses 25 and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2MA

Entry Conditions: Reserve 125VDC available, Main 125VDC not available
Bus 23 available, Bus 24 not available
Bus 25 available, Bus 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2MB

Entry Conditions: Reserve 125VDC available, Main 125VDC not available
Bus 23 available, Bus 24 not available
Buses 25 and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2NE

Entry Conditions: Main and Reserve 125VDC not available
Bus 23 and 24 available
Bus 25 or 27 or both available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2NF

Entry Conditions: Main and Reserve 125VDC not available
Buses 23 and 24 available
Buses 25 and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2PE

Entry Conditions: Main and Reserve 125VDC not available
Bus 23 available, Bus 24 not available
Bus 25 available, Bus 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2PF

Entry Conditions: Main and Reserve 125VDC not available
Bus 23 available, Bus 24 not available
Buses 25 and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS2R

Entry Conditions: Main and Reserve 125VDC not available
Buses 23 and 24 not available
Buses 25 and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS3A

Entry Conditions: Main or Reserve or both 125VDC Buses available
Bus 23 or 24 or both available
Bus 25 or 27 or both available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS3B

Entry Conditions: Main or Reserve or both 125VDC Buses available
If Main 125VDC Bus is available, Buses 23 and 24 can be available or not available.
If Main 125VDC Bus is not available, Bus 23 or 24 must be available.
Buses 25 and 27 are not available.

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS3C

Entry Conditions: Reserve 125VDC available, Main 125VDC not available
Buses 23, 24, 25, 26, and 27 not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS3D

Entry Conditions: Main and Reserve 125VDC Buses not available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS3E

Entry Conditions: Main and Reserve 125VDC Buses not available
Bus 23 or 24 or both available
Bus 25 or 27 or both available

FIGURE 4.1.2-1 (Continued)

TRANSIENT, LOCA, AND SPECIAL INITIATORS SUPPORT MODEL

SUBTREE TS3F

Entry Conditions: Main and Reserve 125VDC Buses not available
Bus 23 or 24 or both available
Buses 25 and 27 not available

INADVERTENTLY OPEN RELIEF VALVE PRT

TREE IORV1	IORV - INITIAL PHASE	(1 PAGE)
TREE IORV2	IORV - LOW PRESSURE PHASE	(4 PAGES)
TREE IORV3	IORV - LOW PRESSURE PHASE AFTER HPCI/FW FAILURE	(4 PAGES)

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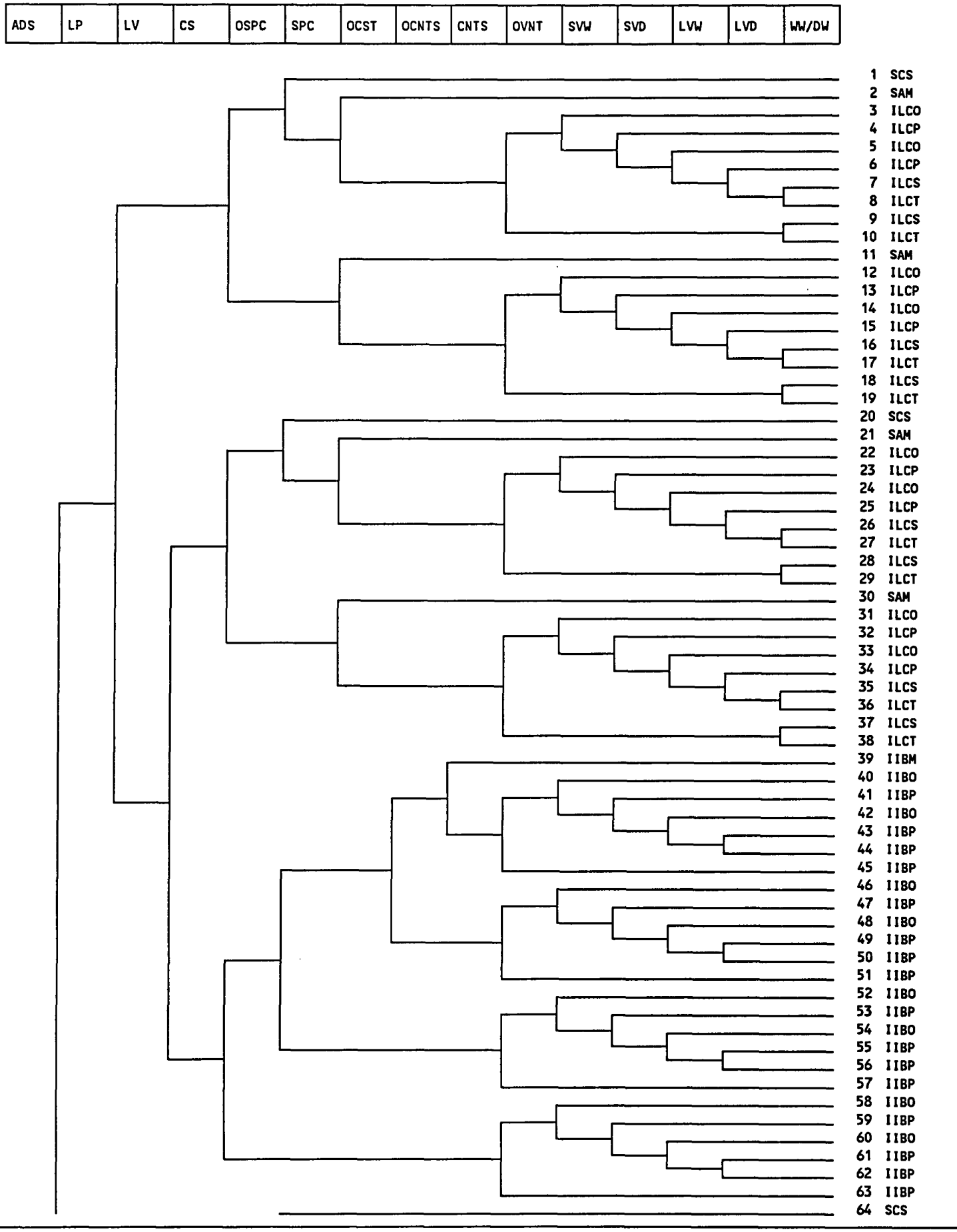
IORV - LOW PRESSURE PHASE



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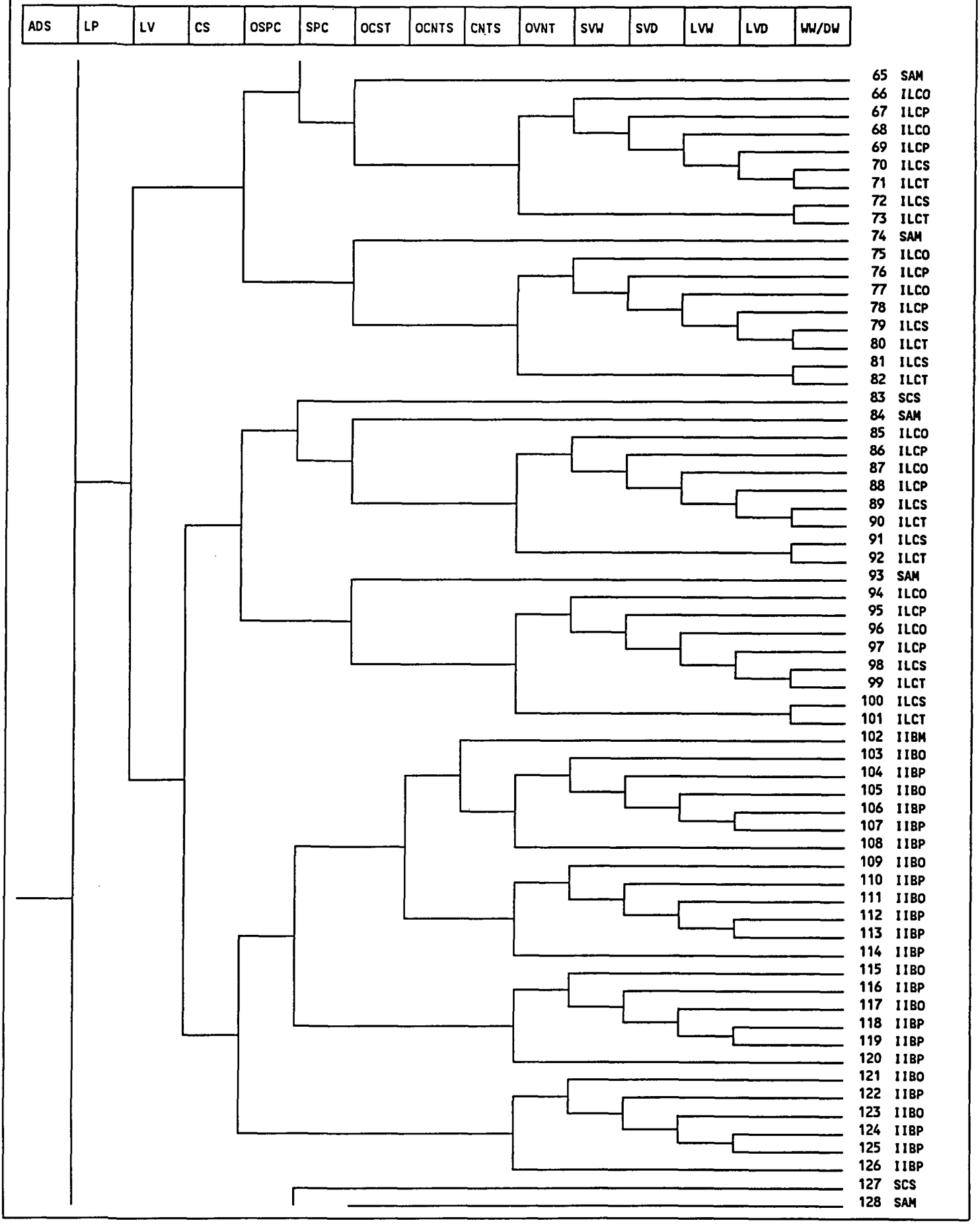

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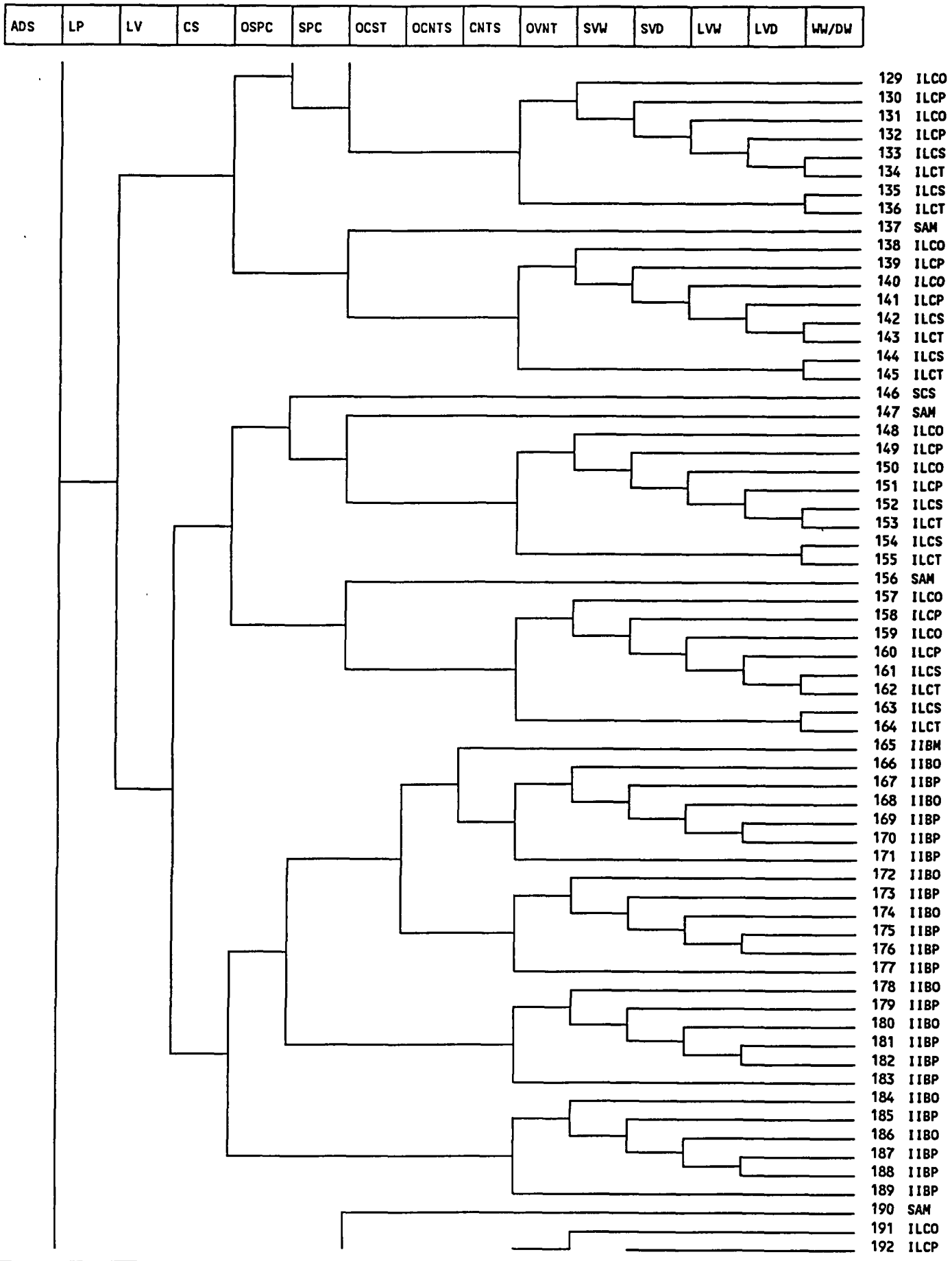

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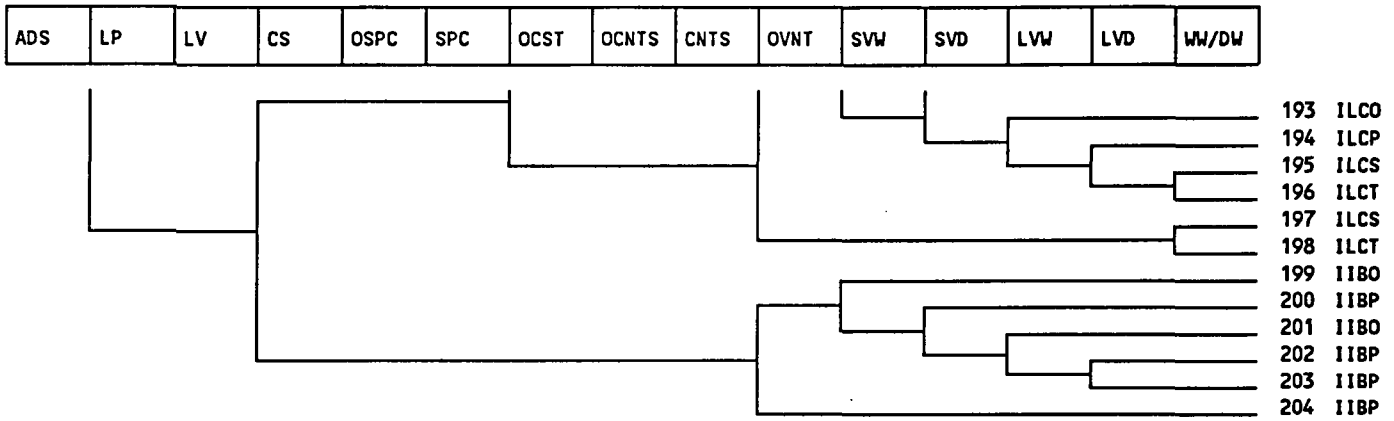

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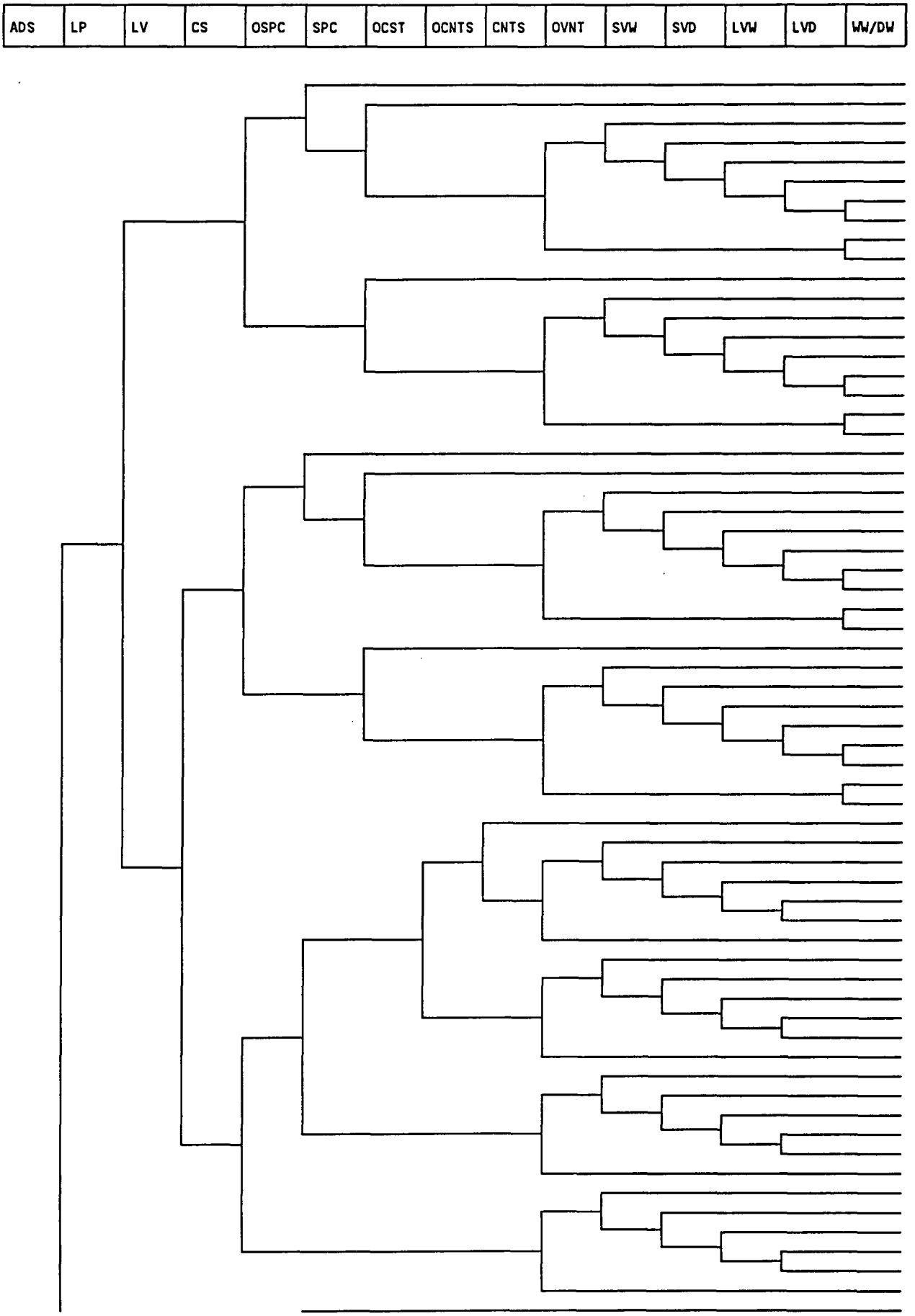

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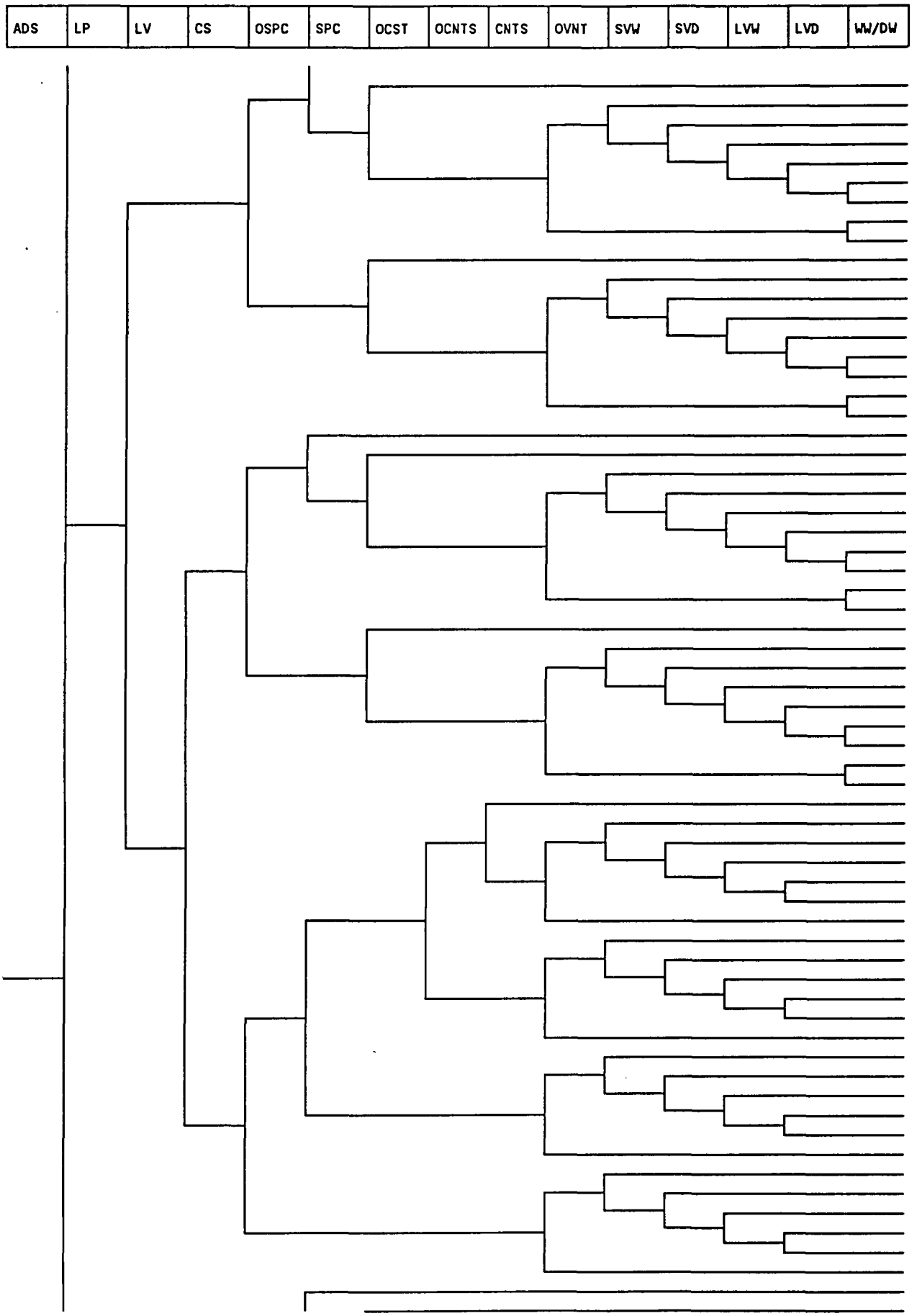

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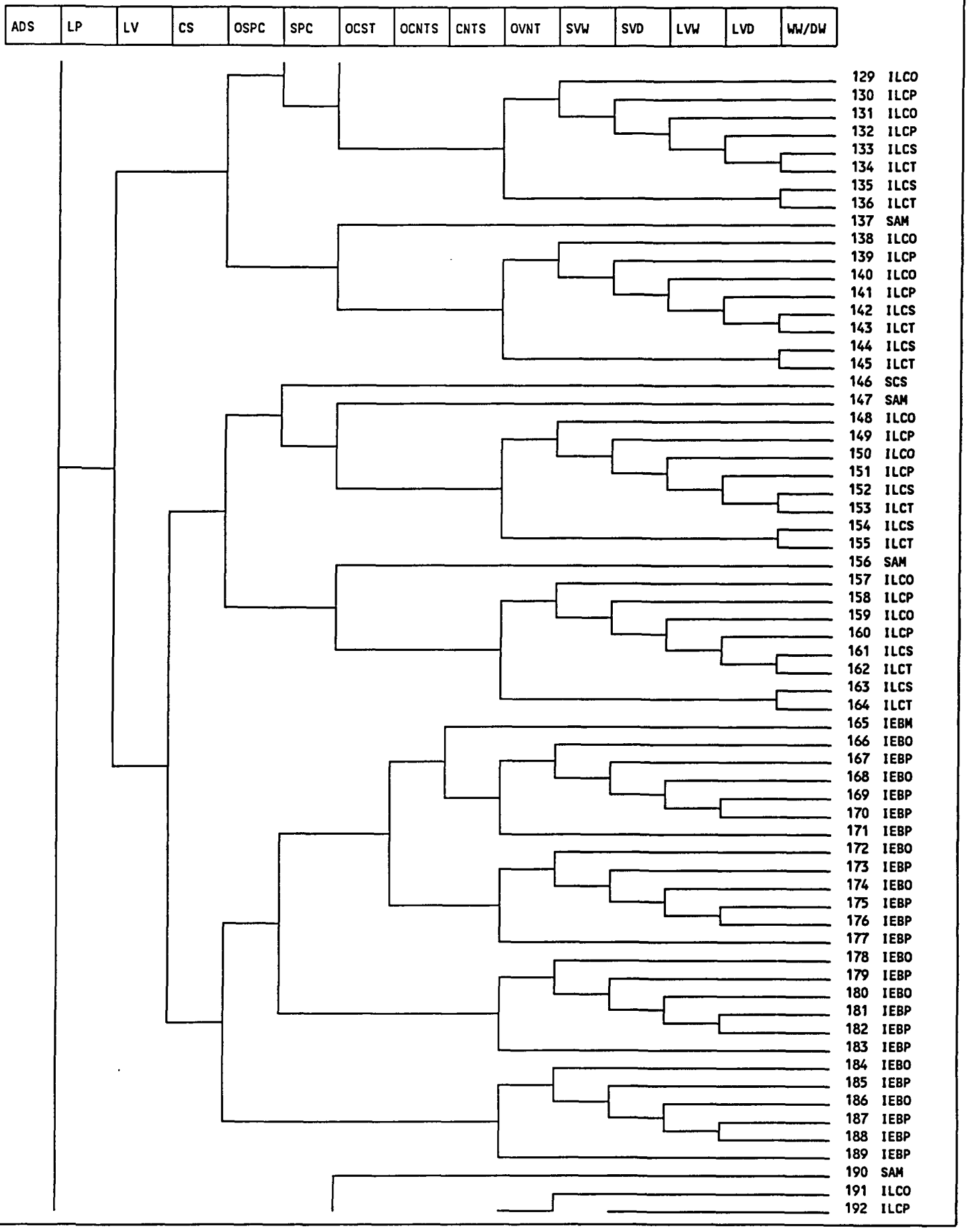

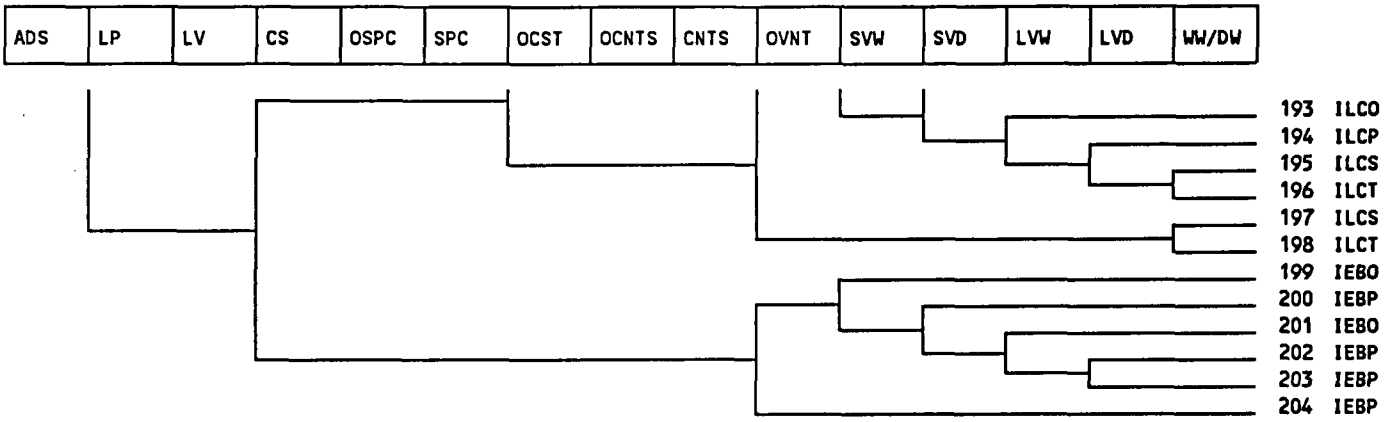
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194 ILCP
195 ILCS
196 ILCT
197 ILCS
198 ILCT
199 IEBO
200 IEBP
201 IEBO
202 IEBP
203 IEBP
204 IEBP

GENERAL TRANSIENT PRT

TREE TRAN1	TRANSIENT - INITIAL PHASE	(1 PAGE)
TREE TRAN2	TRANSIENT - LOW PRESSURE PHASE, HPI FAILURE	(4 PAGES)
TREE TRAN3	TRANSIENT - LOW PRESSURE PHASE, CD/VF AT HI PRSR, HPI FAILURE	(3 PAGES)
TREE TRAN4	TRANSIENT - LOW PRESSURE PHASE AFTER HPCI SUCCESS	(4 PAGES)
TREE TRAN5	TRANSIENT - LOW PRESSURE PHASE AFTER HPCI SUCCESS, CD/VF AT HI PRSR	(4 PAGES)

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TRANSIENT - LOW PRESSURE PHASE, HPI FAILURE
Page 1 of 4

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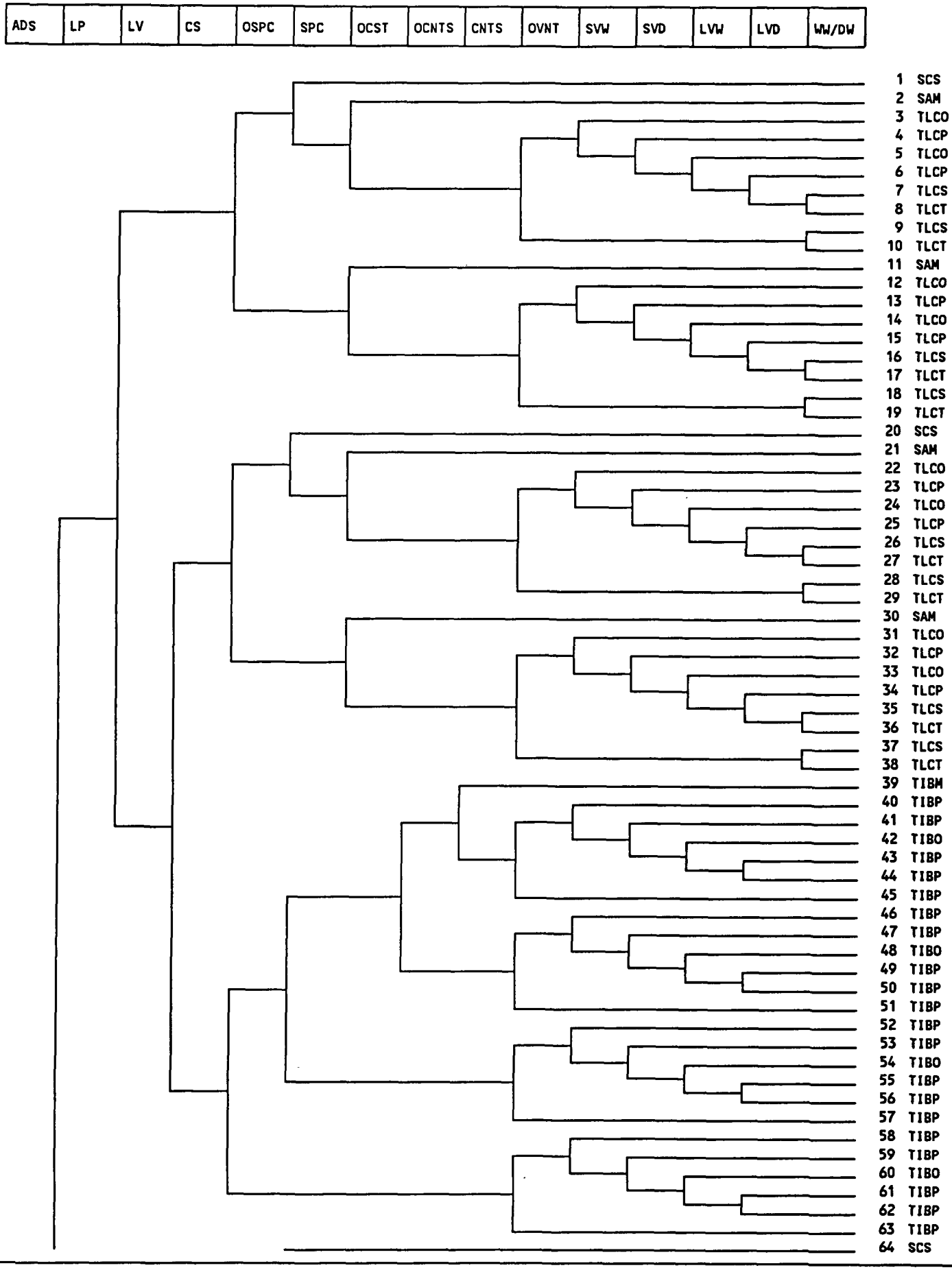

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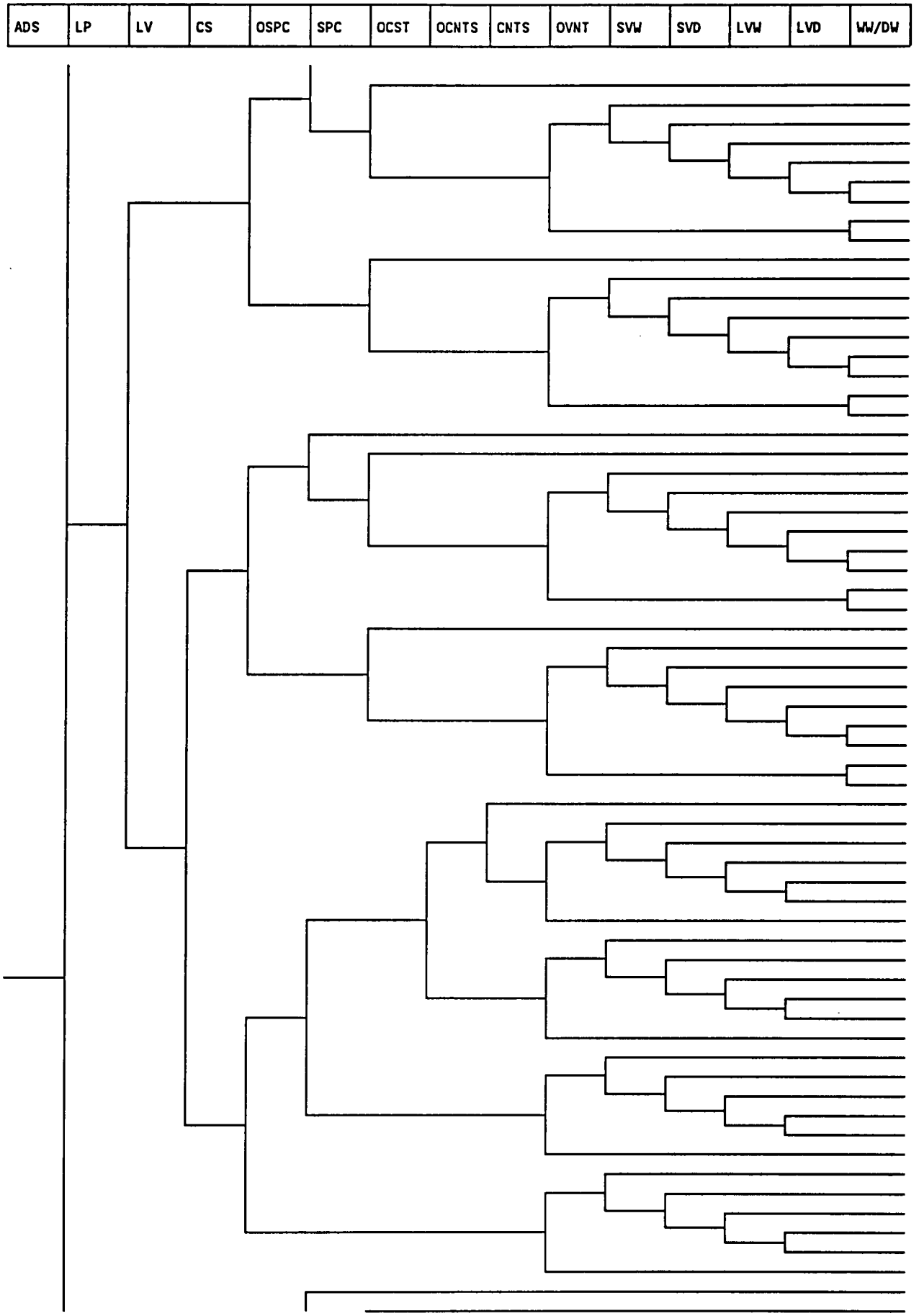

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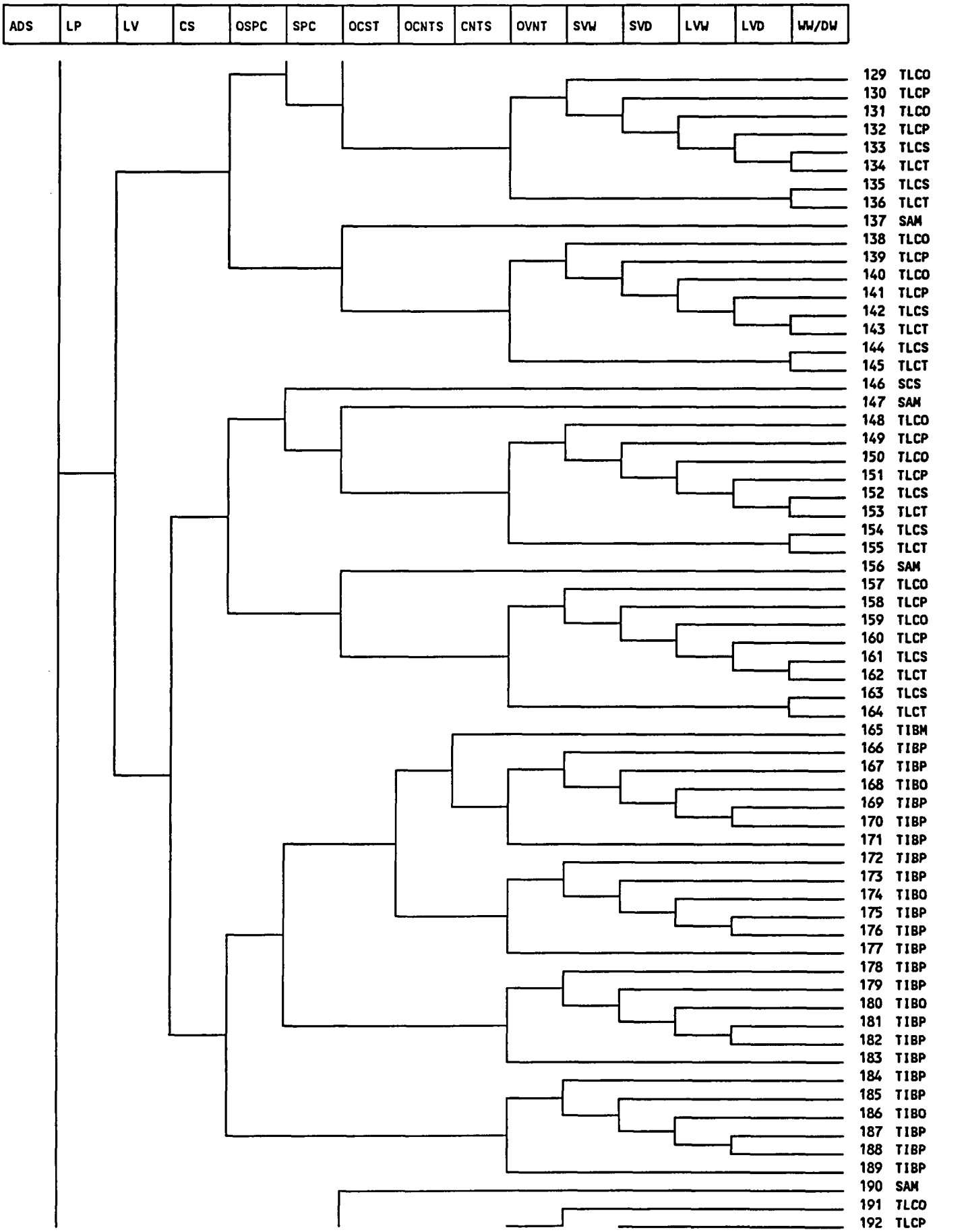

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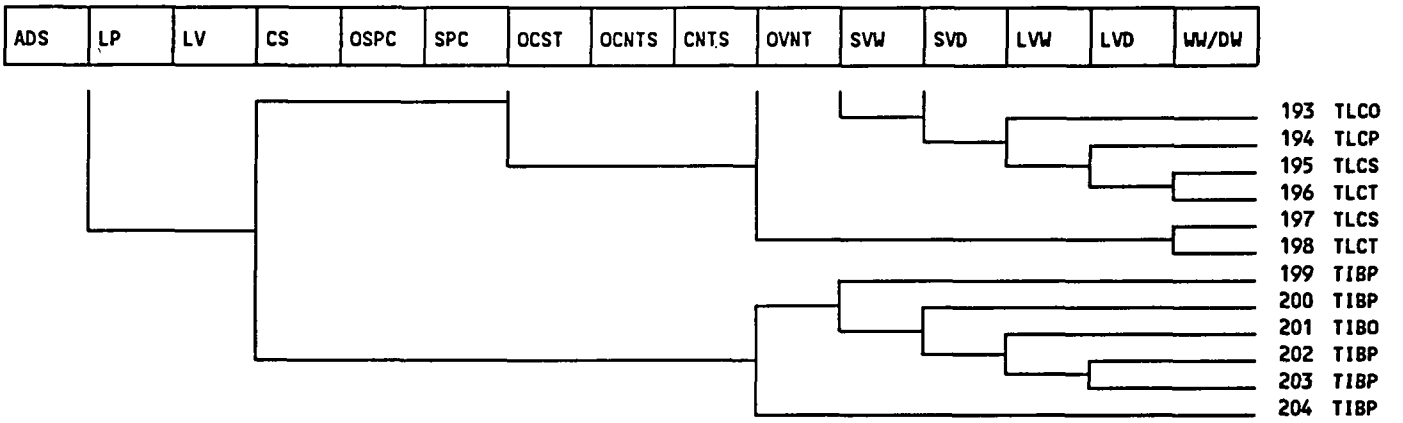

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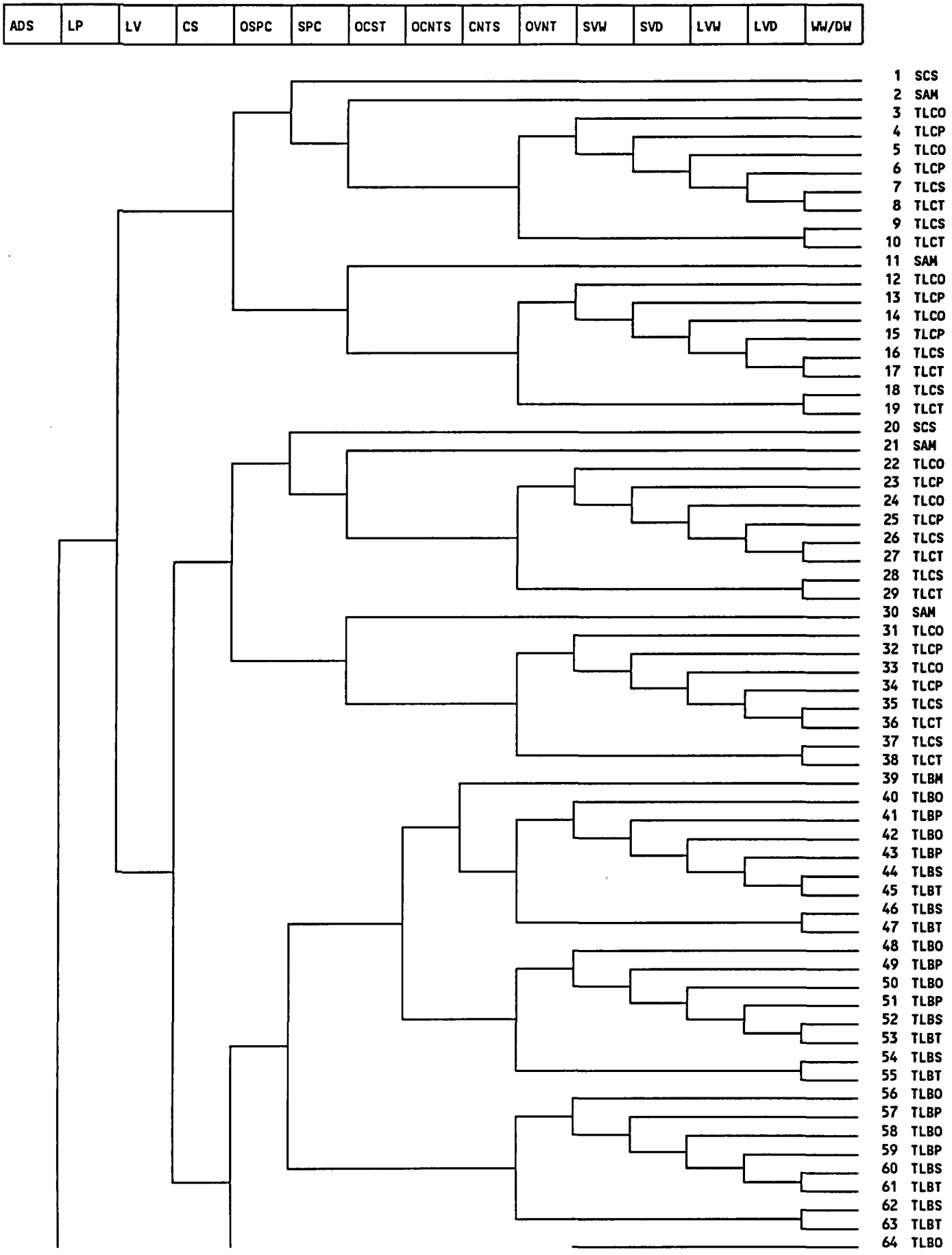

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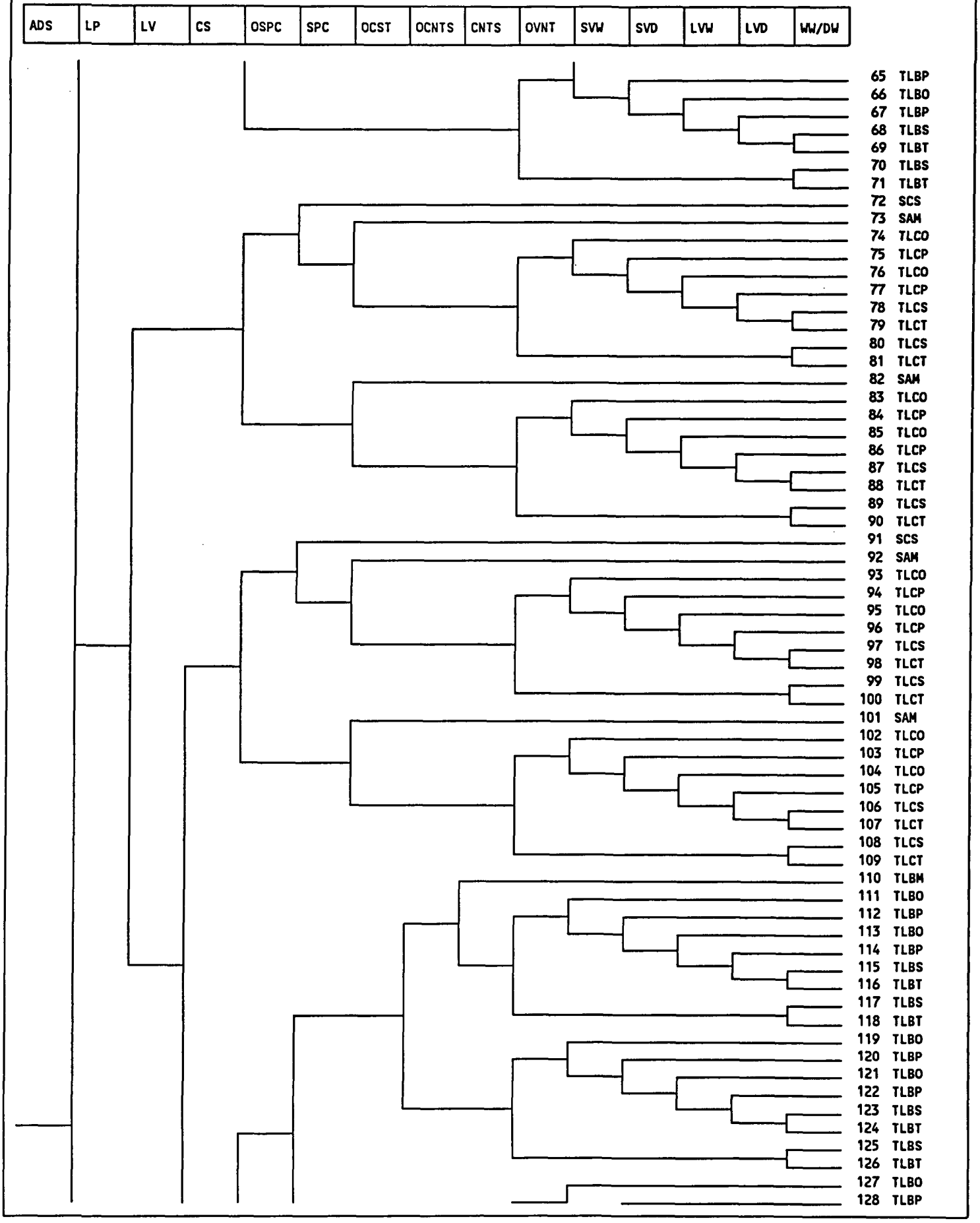

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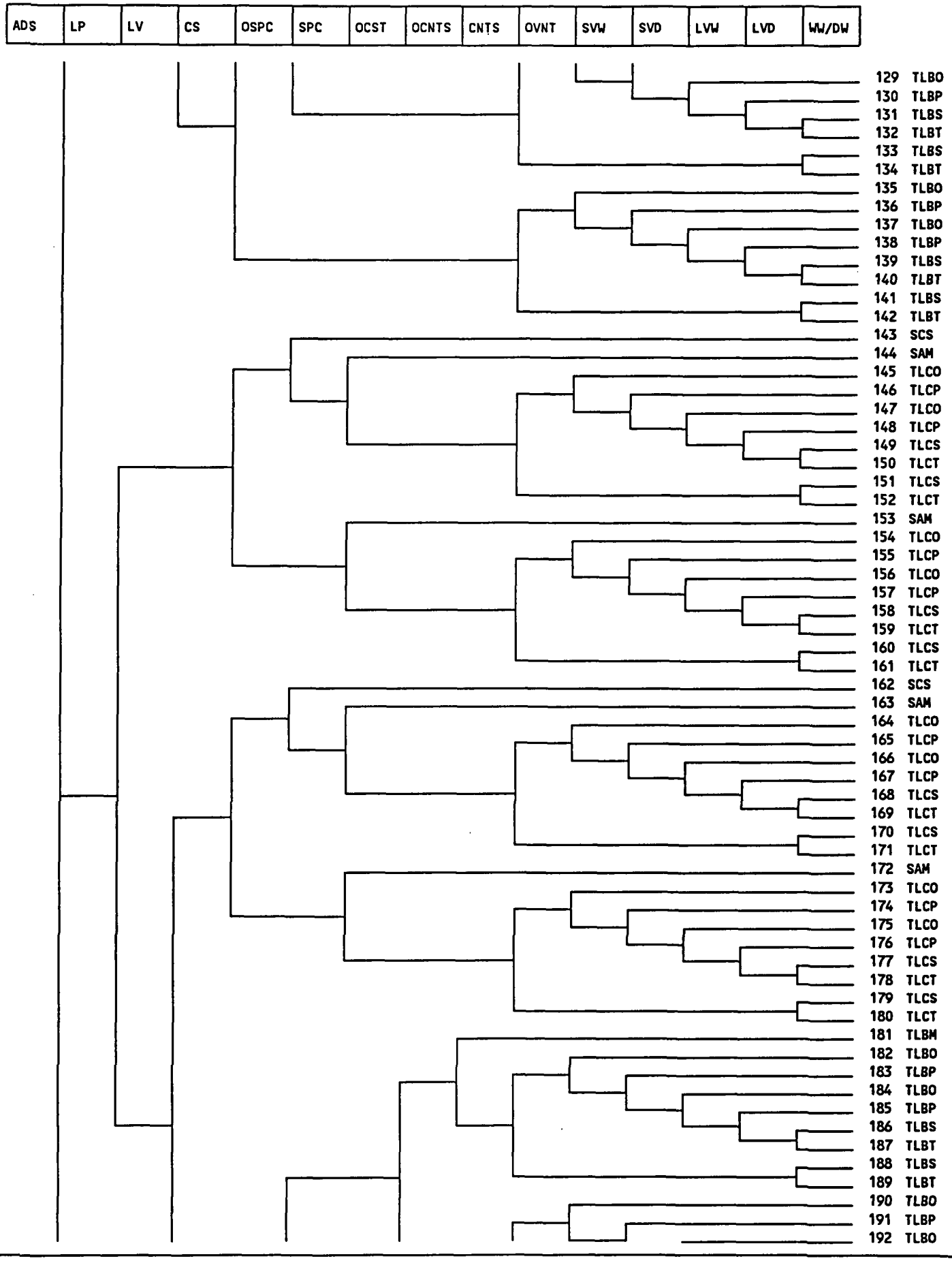

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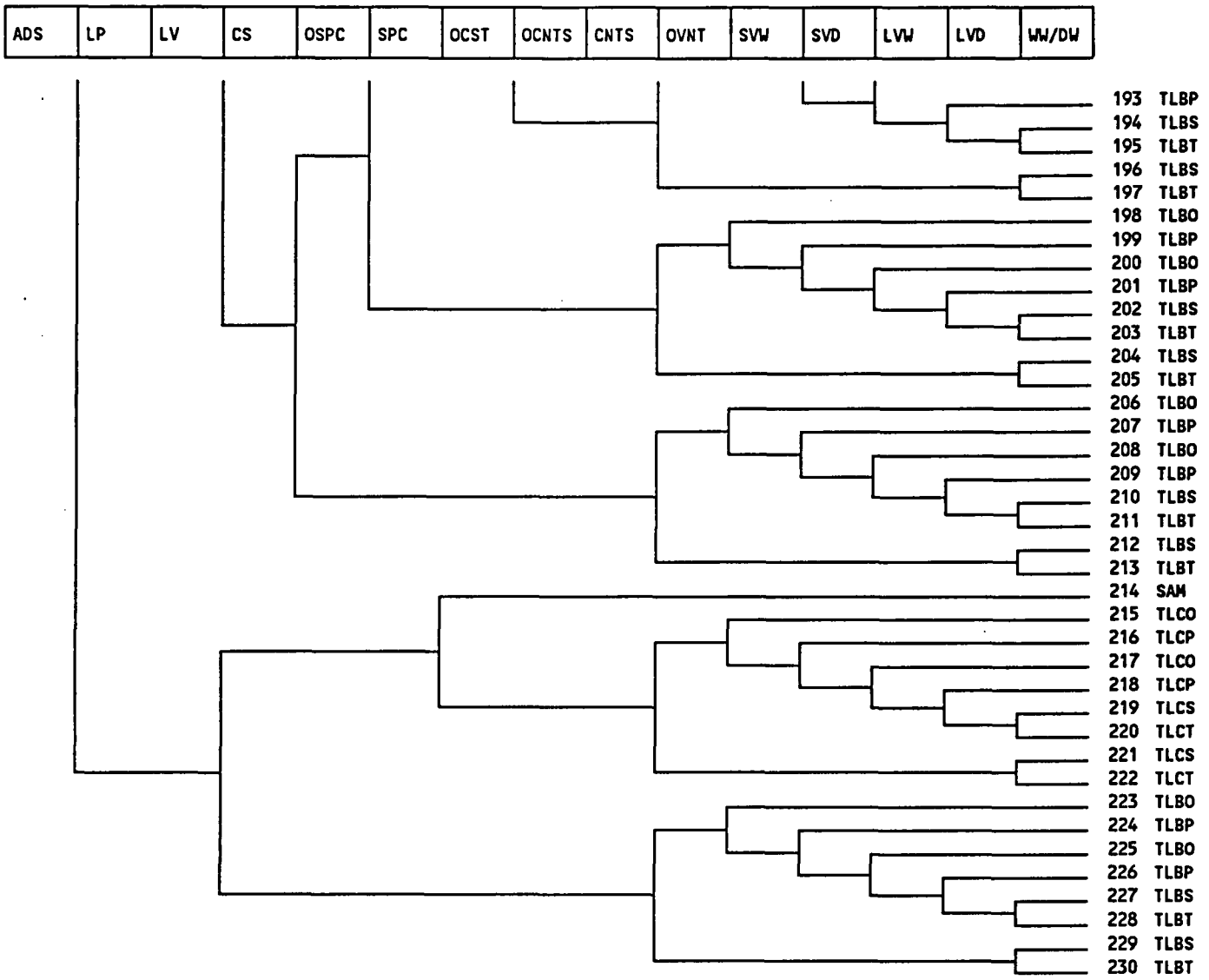

ATWS PRT

TREE ATW1	ATWS - INITIAL PHASE	(3 PAGES)
TREE ATW2	ATWS - FW AND MC BOTH AVAILABLE, RPT SUCCESS, ARI FAILED	(1 PAGE)
TREE ATW3	ATWS - FW AVAILABLE, MC UNAVAILABLE, RPT SUCCESS, ARI FAILED	(1 PAGE)
TREE ATW4	ATWS - FW UNAVAILABLE, MC AVAILABLE, RPT SUCCESS, ARI FAILED	(1 PAGE)
TREE ATW5	ATWS - FW UNAVAILABLE, MC UNAVAILABLE, RPT SUCCESS, ARI FAILED	(1 PAGE)
TREE ATW6	ATWS - ARI OR SLC SUCCESS, DECAY HEAT REMOVAL PHASE	(1 PAGE)
TREE ATW7	ATWS - LOW PRESSURE DECAY HEAT REMOVAL PHASE	(4 PAGES)
TREE ATW8	ATWS - LOW PRESSURE DECAY HEAT REMOVAL PHASE, CD/VF AT HI PRSR	(3 PAGES)

ATWS TREE 2
FW AND MC BOTH AVAILABLE, RPT SUCCESS, ARI FAILED
ATWS PRT ENTRY CONDITION SUMMARY

	EQUIPMENT										
ATWS PRT	FWA	MC	RCFM	RPT[9]	OAT/ARI	RVO	OIADS	(OSL1 OR OSL2)/SLC	HP1	IC[8]/HP2	OAD/ADS
ATWS-2	S	S	S	S	F	S					
ATWS-3	S	F	S	S	F	S					
ATWS-4	F	S	S	S	F	S					
ATWS-5	F	F	S	S	F	S					
ATWS-6	F	S	S	F	S	S					
ATWS-6[4]			S	S	S	S					
ATWS-6[6]			F	S		S	S	S	S		
ATWS-7[6]			F	F		S	S	S	F		S
ATWS-7[7]			F	F		S	S	S	S	F[5]	S
ATWS-8[6]			F	F		S	S	S	F		F
ATWS-8[7]			F	F		S	S	S	S	F[5]	F

Notes:

1. S = Success
2. F = Failure
3. Blank denotes "not applicable"
4. If FWA and MC are both success, then no transfer to ATWS-6, end state is SCS.
5. Success leads to SCS
6. This tree may be entered from ATWS-3, 4, or 5. Therefore, equipment response for nodes FWA and MC will be the same as ATWS-3, -4, or -5.
7. This tree may be entered from ATWS-6. Therefore, equipment response for nodes FWA and MC will be the same as ATWS-3, -4, or -5.
8. This node consists of nodes AIC, ICH2, OMUP, and MUP. Success of IC requires the equipment response of all four nodes to be success.
9. This node consists of nodes AT/RPT1 or ORP/RPT2. Success of RPT requires the equipment response of either set of nodes to be success.

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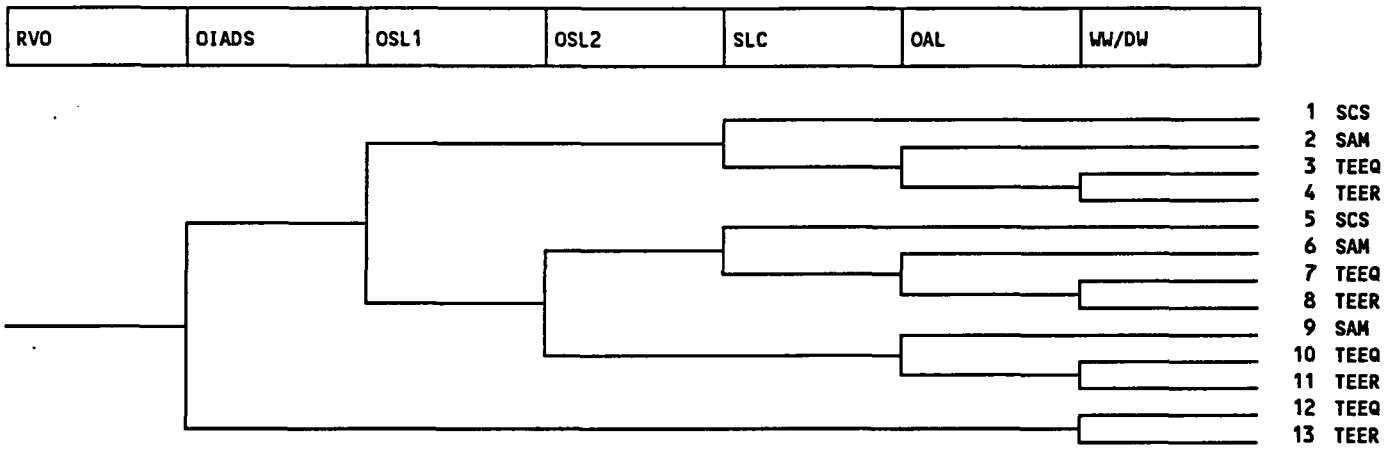
ATW2
ATWS - FW AND MC BOTH AVAILABLE, RPT SUCCESS, ARI FAILED



ATWS TREE 3
FW AVAILABLE, MC UNAVAILABLE, RPT SUCCESS, ARI FAILED
ATWS PRT ENTRY CONDITION SUMMARY

	EQUIPMENT										
ATWS PRT	FWA	MC	RCFM	RPT[9]	OAT/ARI	RVO	OIADS	(OSL1 OR OSL2)/SLC	HP1	IC[8]/HP2	OAD/ADS
ATWS-2	S	S	S	S	F	S					
ATWS-3	S	F	S	S	F	S					
ATWS-4	F	S	S	S	F	S					
ATWS-5	F	F	S	S	F	S					
ATWS-6	F	S	S	F	S	S					
ATWS-6[4]			S	S	S	S					
ATWS-6[6]			F	S		S	S	S	S		
ATWS-7[6]			F	F		S	S	S	F		S
ATWS-7[7]			F	F		S	S	S	S	F[5]	S
ATWS-8[6]			F	F		S	S	S	F		F
ATWS-8[7]			F	F		S	S	S	S	F[5]	F

Notes:

1. S = Success
2. F = Failure
3. Blank denotes "not applicable"
4. If FWA and MC are both success, then no transfer to ATWS-6, end state is SCS.
5. Success leads to SCS
6. This tree may be entered from ATWS-3, 4, or 5. Therefore, equipment response for nodes FWA and MC will be the same as ATWS-3, -4, or -5.
7. This tree may be entered from ATWS-6. Therefore, equipment response for nodes FWA and MC will be the same as ATWS-3, -4, or -5.
8. This node consists of nodes AIC, ICH2, OMUP, and MUP. Success of IC requires the equipment response of all four nodes to be success.
9. This node consists of nodes AT/RPT1 or ORP/RPT2. Success of RPT requires the equipment response of either set of nodes to be success.

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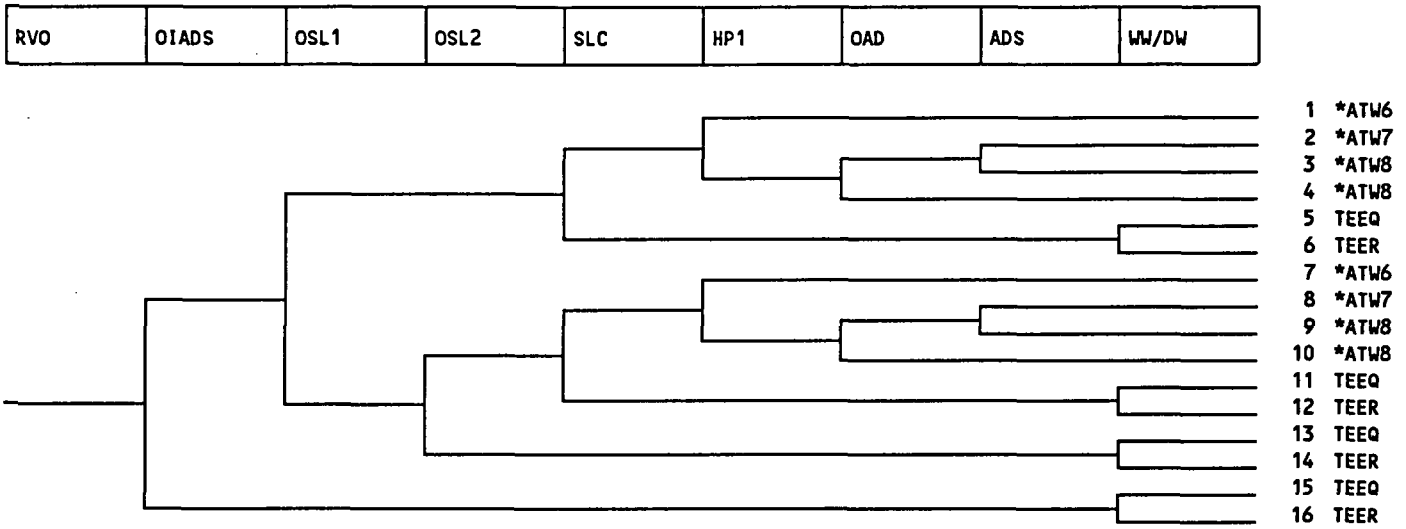
ATW3
ATWS - FW AVAILABLE, MC UNVAILABLE, RPT SUCCESS, ARI FAILED



ATWS TREE 4
FW UNAVAILABLE, MC AVAILABLE, RPT SUCCESS, ARI FAILED
ATWS PRT ENTRY CONDITION SUMMARY

	EQUIPMENT										
ATWS PRT	FWA	MC	RCFM	RPT[9]	OAT/ARI	RVO	OIADS	(OSL1 OR OSL2)/SLC	HP1	IC[8]/HP2	OAD/ADS
ATWS-2	S	S	S	S	F	S					
ATWS-3	S	F	S	S	F	S					
ATWS-4	F	S	S	S	F	S					
ATWS-5	F	F	S	S	F	S					
ATWS-6	F	S	S	F	S	S					
ATWS-6[4]			S	S	S	S					
ATWS-6[6]			F	S		S	S	S	S		
ATWS-7[6]			F	F		S	S	S	F		S
ATWS-7[7]			F	F		S	S	S	S	F[5]	S
ATWS-8[6]			F	F		S	S	S	F		F
ATWS-8[7]			F	F		S	S	S	S	F[5]	F

Notes:

1. S = Success
2. F = Failure
3. Blank denotes "not applicable"
4. If FWA and MC are both success, then no transfer to ATWS-6, end state is SCS.
5. Success leads to SCS
6. This tree may be entered from ATWS-3, 4, or 5. Therefore, equipment response for nodes FWA and MC will be the same as ATWS-3, -4, or -5.
7. This tree may be entered from ATWS-6. Therefore, equipment response for nodes FWA and MC will be the same as ATWS-3, -4, or -5.
8. This node consists of nodes AIC, ICH2, OMUP, and MUP. Success of IC requires the equipment response of all four nodes to be success.
9. This node consists of nodes AT/RPT1 or ORP/RPT2. Success of RPT requires the equipment response of either set of nodes to be success.

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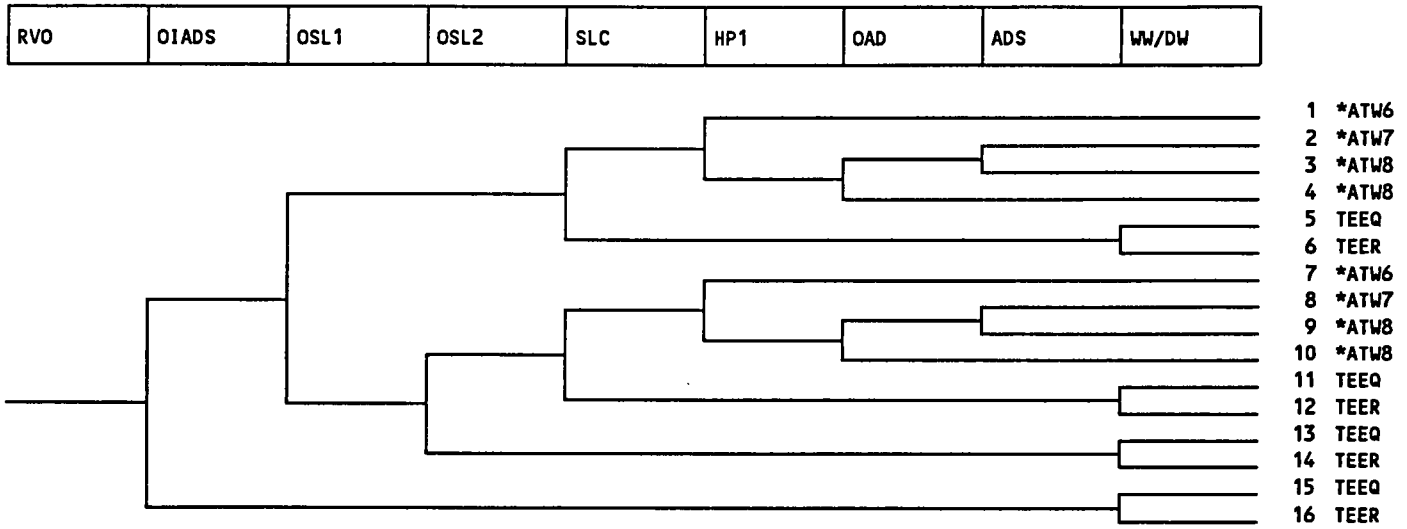
ATW4
ATWS - FW UNAVAILABLE, MC AVAILABLE, RPT SUCCESS, ARI FAILED



ATWS TREE 5
FW AND MC UNAVAILABLE, RPT SUCCESS, ARI FAILED
ATWS PRT ENTRY CONDITION SUMMARY

	EQUIPMENT										
ATWS PRT	FWA	MC	RCFM	RPT[9]	OAT/ARI	RVO	OIADS	(OSL1 OR OSL2)/SLC	HP1	IC[8]/HP2	OAD/ADS
ATWS-2	S	S	S	S	F	S					
ATWS-3	S	F	S	S	F	S					
ATWS-4	F	S	S	S	F	S					
ATWS-5	F	F	S	S	F	S					
ATWS-6	F	S	S	F	S	S					
ATWS-6[4]			S	S	S	S					
ATWS-6[6]			F	S		S	S	S	S		
ATWS-7[6]			F	F		S	S	S	F		S
ATWS-7[7]			F	F		S	S	S	S	F[5]	S
ATWS-8[6]			F	F		S	S	S	F		F
ATWS-8[7]			F	F		S	S	S	S	F[5]	F

Notes:

1. S = Success
2. F = Failure
3. Blank denotes "not applicable"
4. If FWA and MC are both success, then no transfer to ATWS-6, end state is SCS.
5. Success leads to SCS
6. This tree may be entered from ATWS-3, 4, or 5. Therefore, equipment response for nodes FWA and MC will be the same as ATWS-3, -4, or -5.
7. This tree may be entered from ATWS-6. Therefore, equipment response for nodes FWA and MC will be the same as ATWS-3, -4, or -5.
8. This node consists of nodes AIC, ICH2, OMUP, and MUP. Success of IC requires the equipment response of all four nodes to be success.
9. This node consists of nodes AT/RPT1 or ORP/RPT2. Success of RPT requires the equipment response of either set of nodes to be success.

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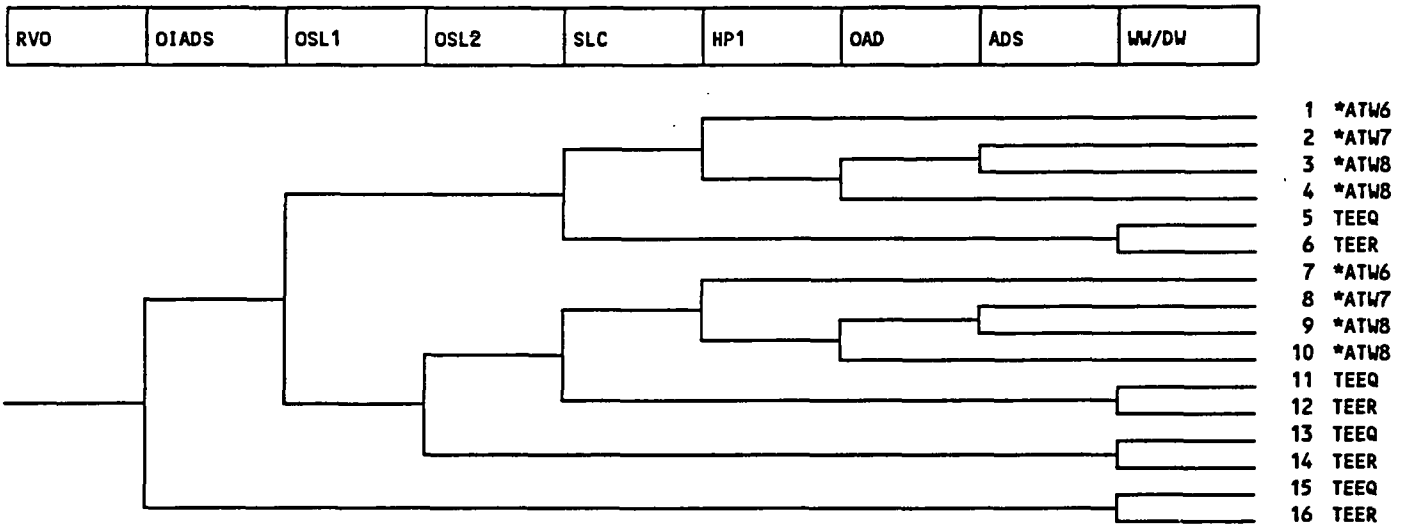
ATW5

ATWS - FW UNAVAILABLE, MC UNAVAILABLE, RPT SUCCESS, ARI FAILED



ATWS TREE 7
LOW PRESSURE DECAY HEAT REMOVAL PHASE
ATWS PRT ENTRY CONDITION SUMMARY

	EQUIPMENT										
ATWS PRT	FWA	MC	RCFM	RPT[9]	OAT/ARI	RVO	OIADS	(OSL1 OR OSL2)/SLC	HP1	IC[8]/HP2	OAD/ADS
ATWS-2	S	S	S	S	F	S					
ATWS-3	S	F	S	S	F	S					
ATWS-4	F	S	S	S	F	S					
ATWS-5	F	F	S	S	F	S					
ATWS-6	F	S	S	F	S	S					
ATWS-6[4]			S	S	S	S					
ATWS-6[6]			F	S		S	S	S	S		
ATWS-7[6]			F	F		S	S	S	F		S
ATWS-7[7]			F	F		S	S	S	S	F[5]	S
ATWS-8[6]			F	F		S	S	S	F		F
ATWS-8[7]			F	F		S	S	S	S	F[5]	F

Notes:

1. S = Success
2. F = Failure
3. Blank denotes "not applicable"
4. If FWA and MC are both success, then no transfer to ATWS-6, end state is SCS.
5. Success leads to SCS
6. This tree may be entered from ATWS-3, 4, or 5. Therefore, equipment response for nodes FWA and MC will be the same as ATWS-3, -4, or -5.
7. This tree may be entered from ATWS-6. Therefore, equipment response for nodes FWA and MC will be the same as ATWS-3, -4, or -5.
8. This node consists of nodes AIC, ICH2, OMUP, and MUP. Success of IC requires the equipment response of all four nodes to be success.
9. This node consists of nodes AT/RPT1 or ORP/RPT2. Success of RPT requires the equipment response of either set of nodes to be success.

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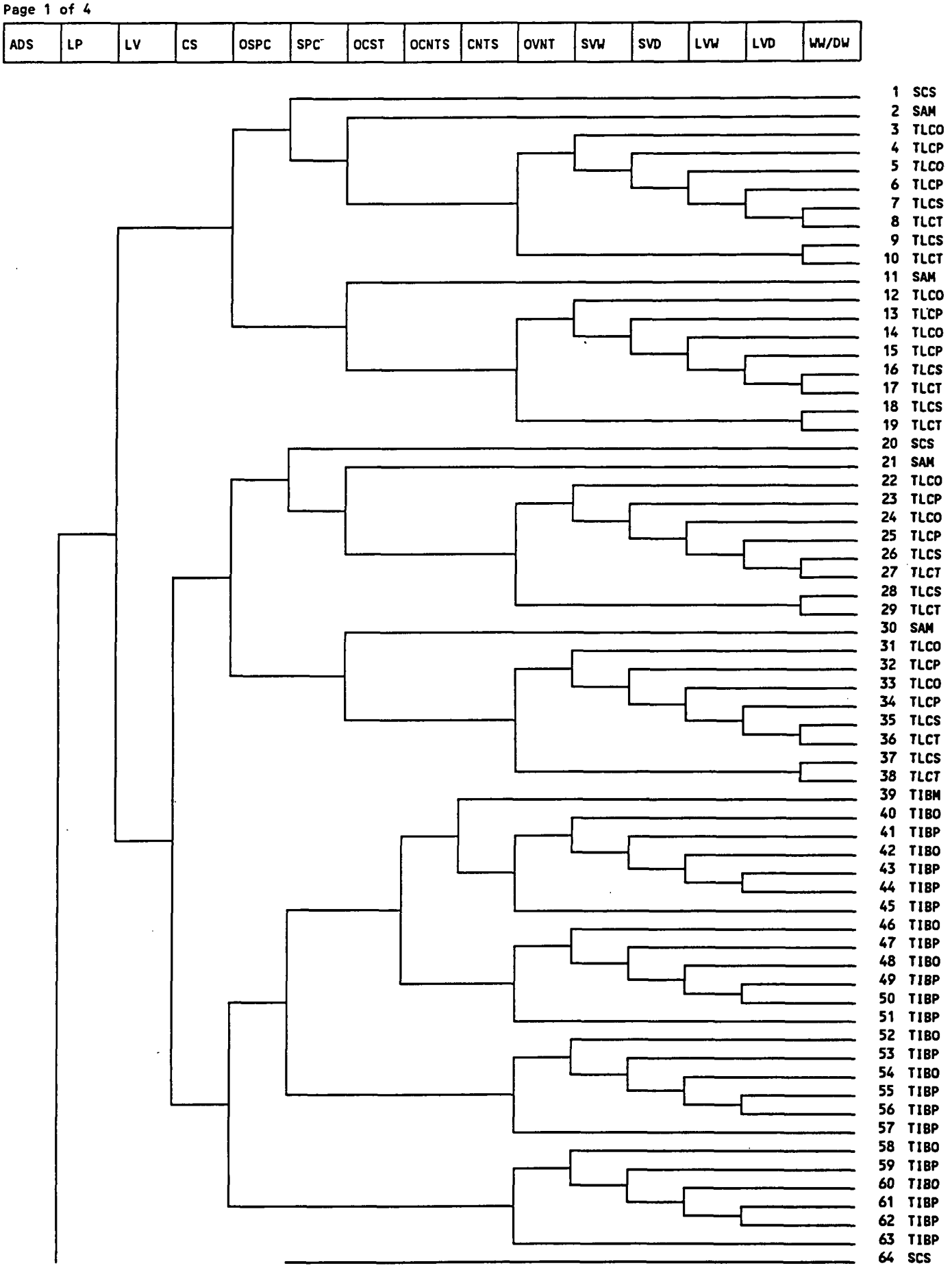
ATW7
ATWS - LOW PRESSURE DECAY HEAT REMOVAL PHASE



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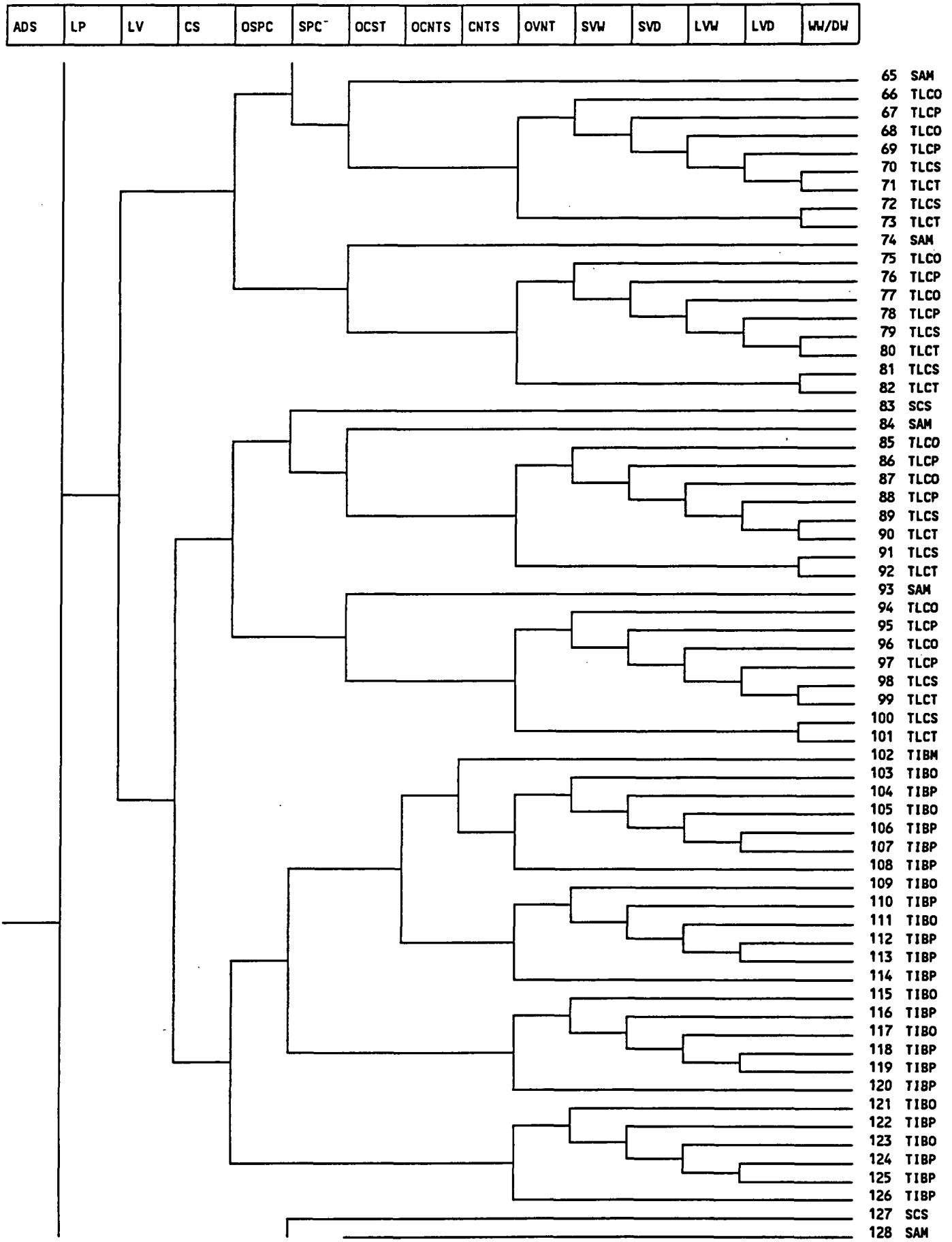
ATW7
ATWS - LOW PRESSURE DECAY HEAT REMOVAL PHASE



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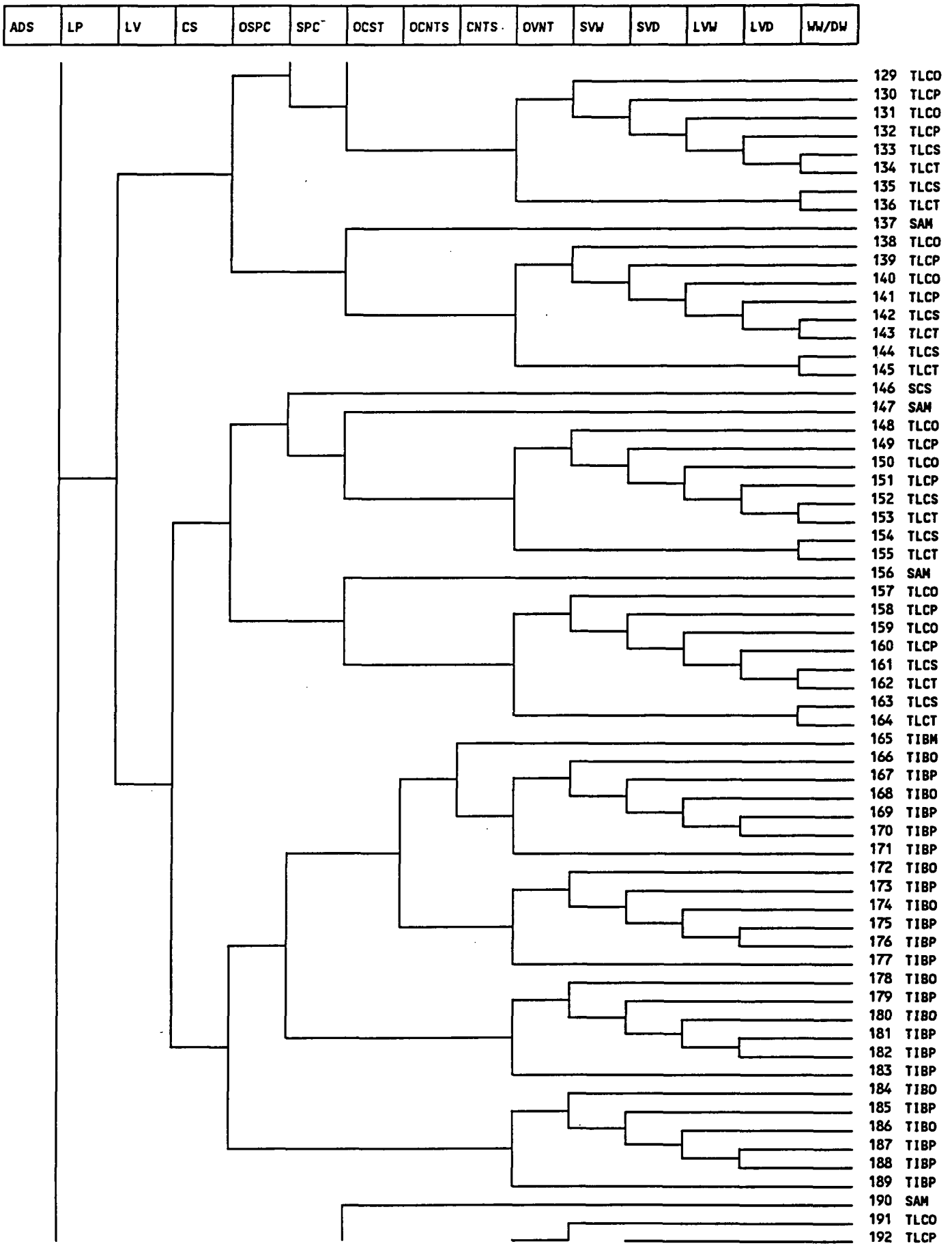
ATW7
ATWS - LOW PRESSURE DECAY HEAT REMOVAL PHASE



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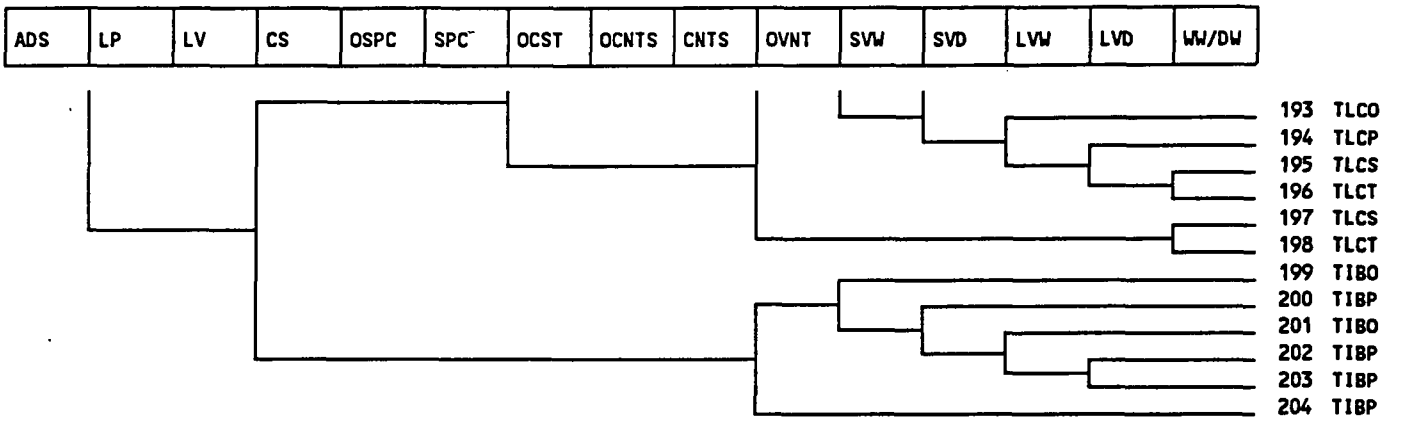
ATW7
ATWS - LOW PRESSURE DECAY HEAT REMOVAL PHASE



LOSS-OF-OFFSITE-POWER PRT

TREE LOOP1	LOSP - INITIAL PHASE	(2 PAGES)
TREE LOOP2	LOSP - LOW PRESSURE INJECTION PHASE, OSP NOT RECOVERED, HPCI SUCCESS	(4 PAGES)
TREE LOOP3	LOSP - LOW PRESSURE PHASE AFTER CD/VF AT HI PRSR, OSP NOT RECOVERED	(3 PAGES)
TREE LOOP4	LOSP - LOW PRESSURE INJECTION PHASE AFTER HPCI FAILURE, OSP NOT RECOVERED	(4 PAGES)
TREE LOOP5	LOSP - SYSTEM RESTORATION AFTER OSP RECOVERY, AT HIGH PRESSURE	(1 PAGE)
TREE LOOP6	LOSP - LOW PRESSURE PHASE AFTER CD/VF AT HI PRSR, HPCI FAILURE, OSP RECOVERED	(3 PAGES)
TREE LOOP7	LOSP - LOW PRESSURE INJECTION PHASE AFTER HPCI FAILURE, OSP RECOVERED	(4 PAGES)
TREE LOOP8	LOSP - LOW PRESSURE PHASE, HPCI SUCCESS, DEPRESS FAILURE, OSP NOT RECOVERED	(4 PAGES)
TREE LOOP9	LOSP - LOW PRESSURE PHASE, HPCI SUCCESS, DEPRESS FAILURE, OSP RECOVERED	(4 PAGES)
TREE LOOP10	LOSP - SYSTEM RESTORATION AFTER DEPRESSURIZATION AND OSP RECOVERY	(1 PAGE)
TREE LOOP11	LOSP - LOW PRESSURE INJECTION PHASE, OSP RECOVERED, HPCI SUCCESS	(4 PAGES)

LOOP TREE 2
LPI PHASE, OSP NOT RECOVERED, HPCI SUCCESS
LOOP PRT ENTRY CONDITION SUMMARY

	EQUIPMENT								
LOOP PRT	RC	OIC/ICH1 OR AIC/ICH2	RVO OR RVC	OMUP /MUP	HP1	OAD/ADS	HP2	ROP1	OSS /OFW /FW
LOOP-2	S	S/F	S/N	F[1]/N	S	S	N	F	N
LOOP-3	S	S/F	S/N	F[1]/N	F	F	N	F	N
LOOP-4	S	S/F	S/N	F[1]/N	F	S	N	F	N
LOOP-5	S	S/F	S/N	F[1]/N	S	F	F[1]	S	N
LOOP-6	S	S/F	S/N	F[1]/N	F	F	N	S	N
LOOP-7	S	S/F	S/N	F[1]/N	F	S	N	S	N
LOOP-8	S	S/F	S/N	F[1]/N	S	F	F[1]	F	N
LOOP-9	S	S/F	S/N	F[1]/N	S	F	F[1]	S	F[1]
LOOP-10	S	S/F	S/N	F[1]/N	S	S	N	S	N
LOOP-11	S	S/F	S/N	F[1]/N	S	S	N	S	F[1]

Notes:

1. Success of this node leads to SCS
2. S = Success
3. F = Failure
4. N = Not demanded

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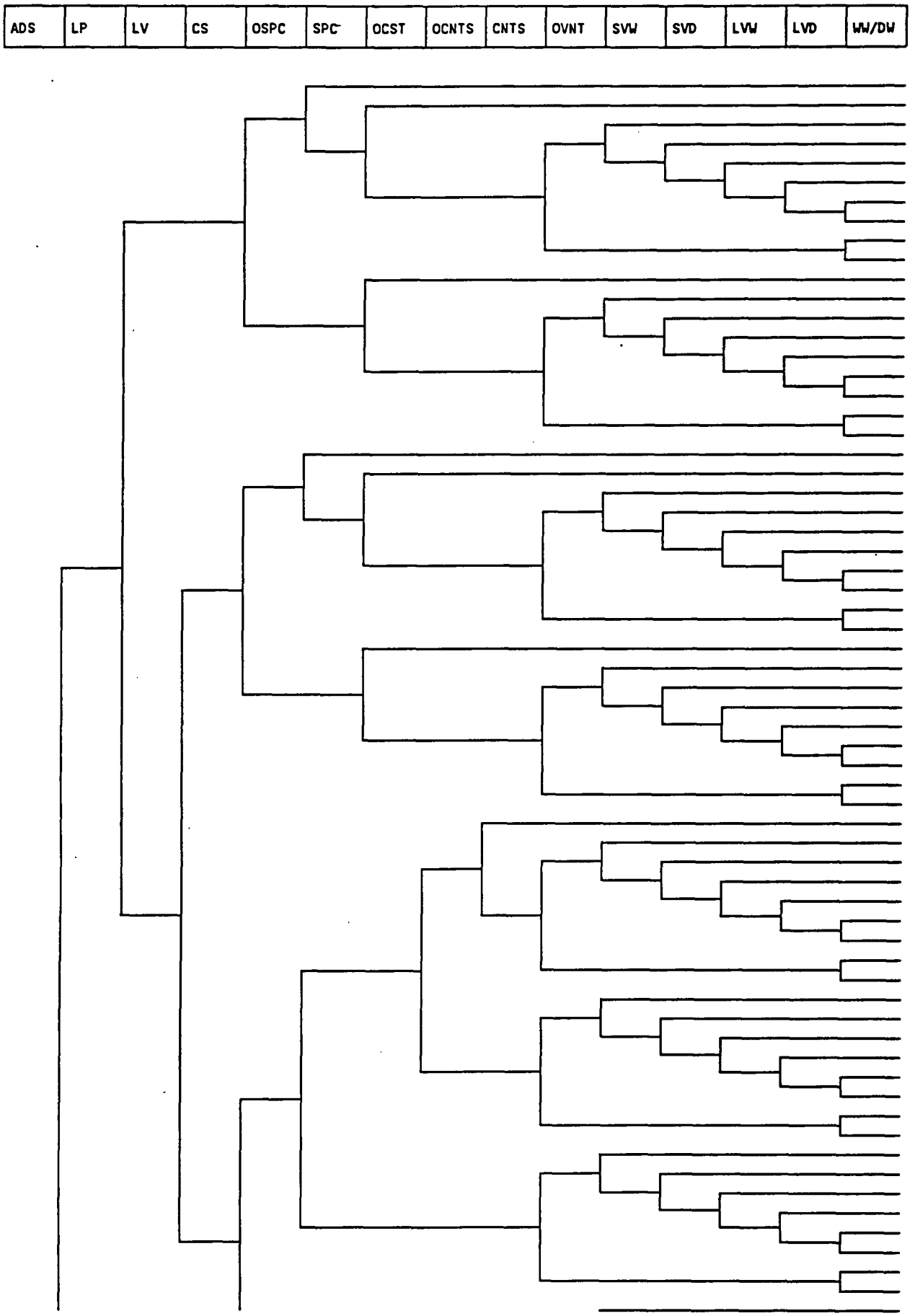
LOOP2
LOSP - LOW PRESSURE INJECTION PHASE, OSP NOT RECOVERED, HPCI SUCCESS



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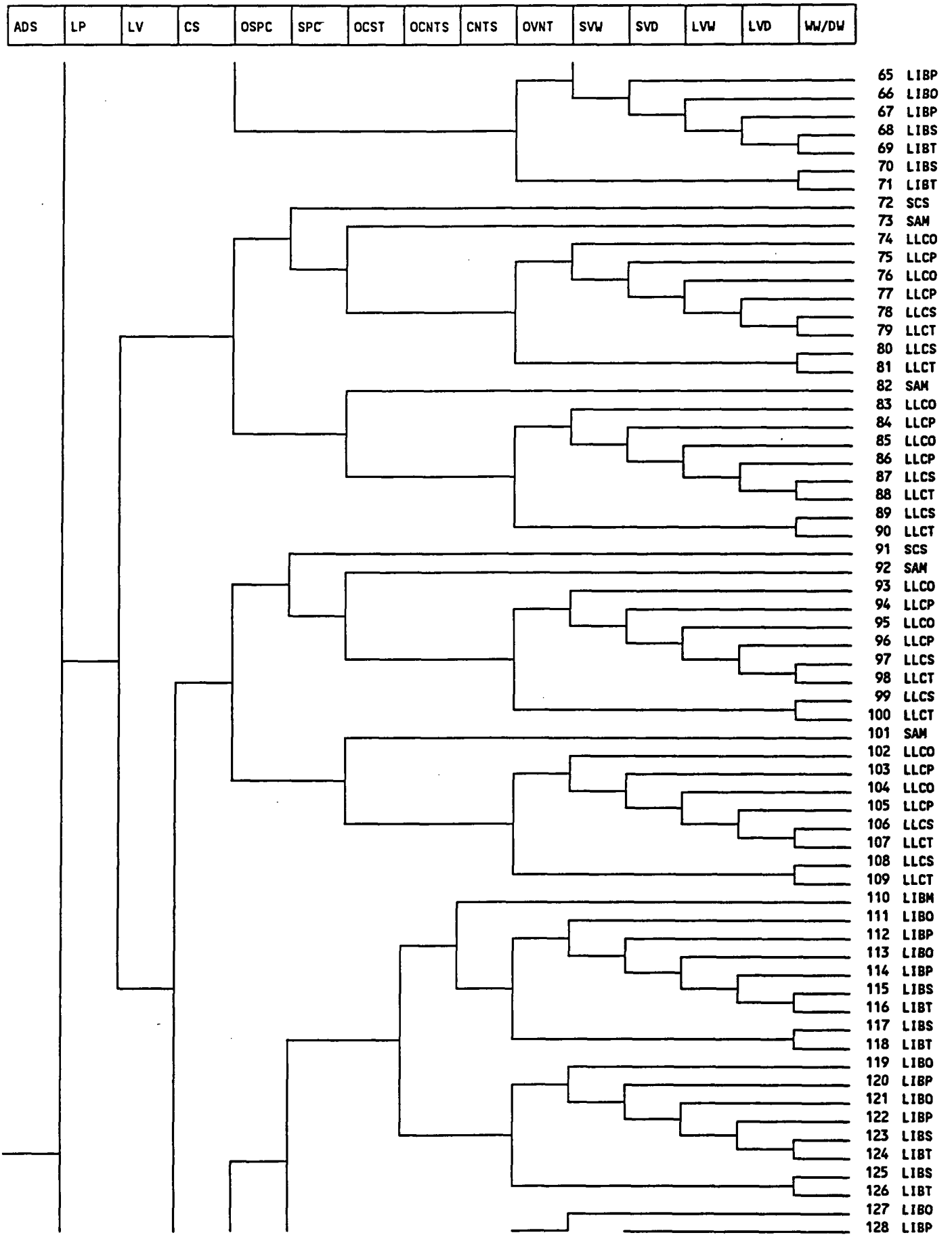
LOOP2
LOSP - LOW PRESSURE INJECTION PHASE, OSP NOT RECOVERED, HPCI SUCCESS



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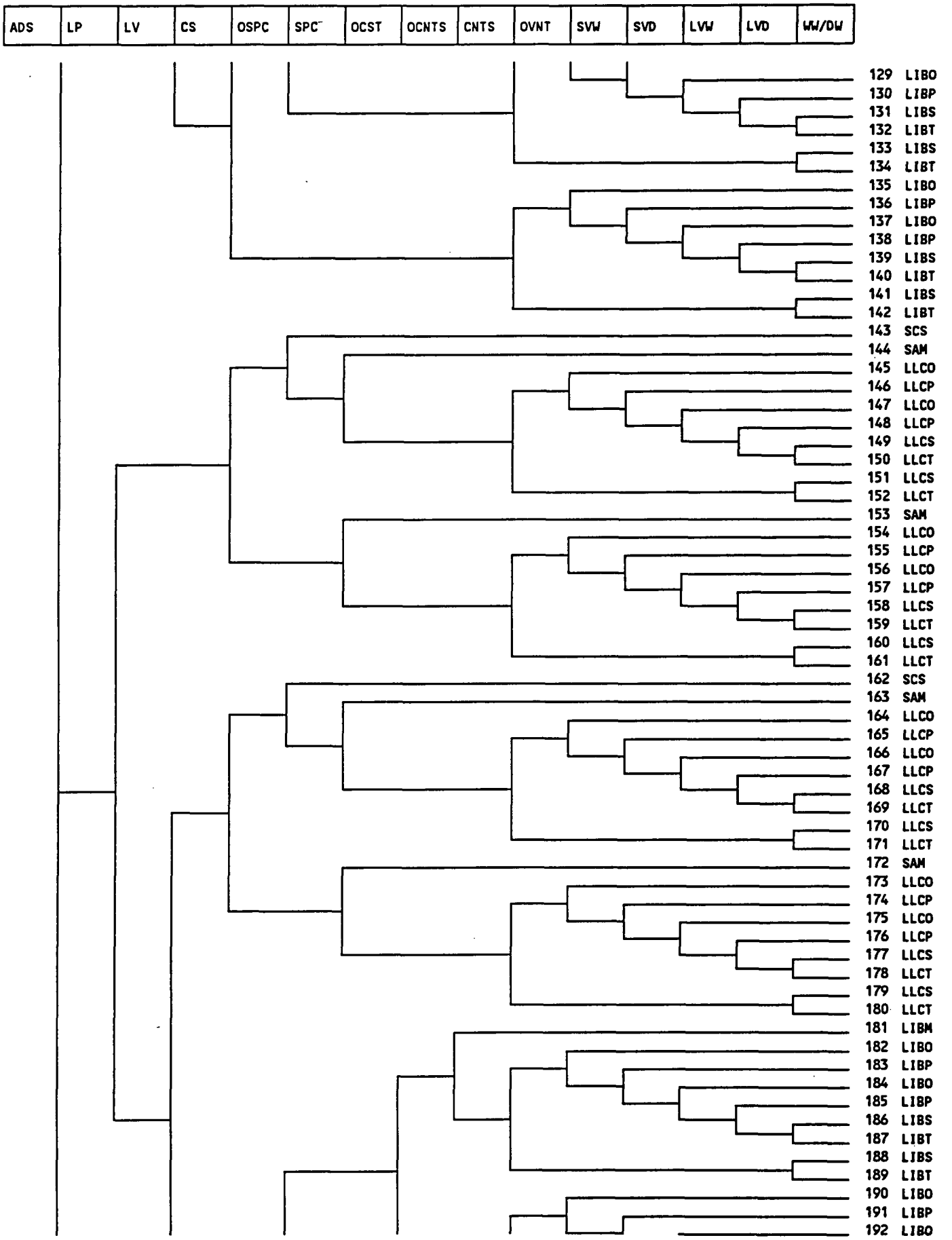
LOOP2
LOSP - LOW PRESSURE INJECTION PHASE, OSP NOT RECOVERED, HPCI SUCCESS



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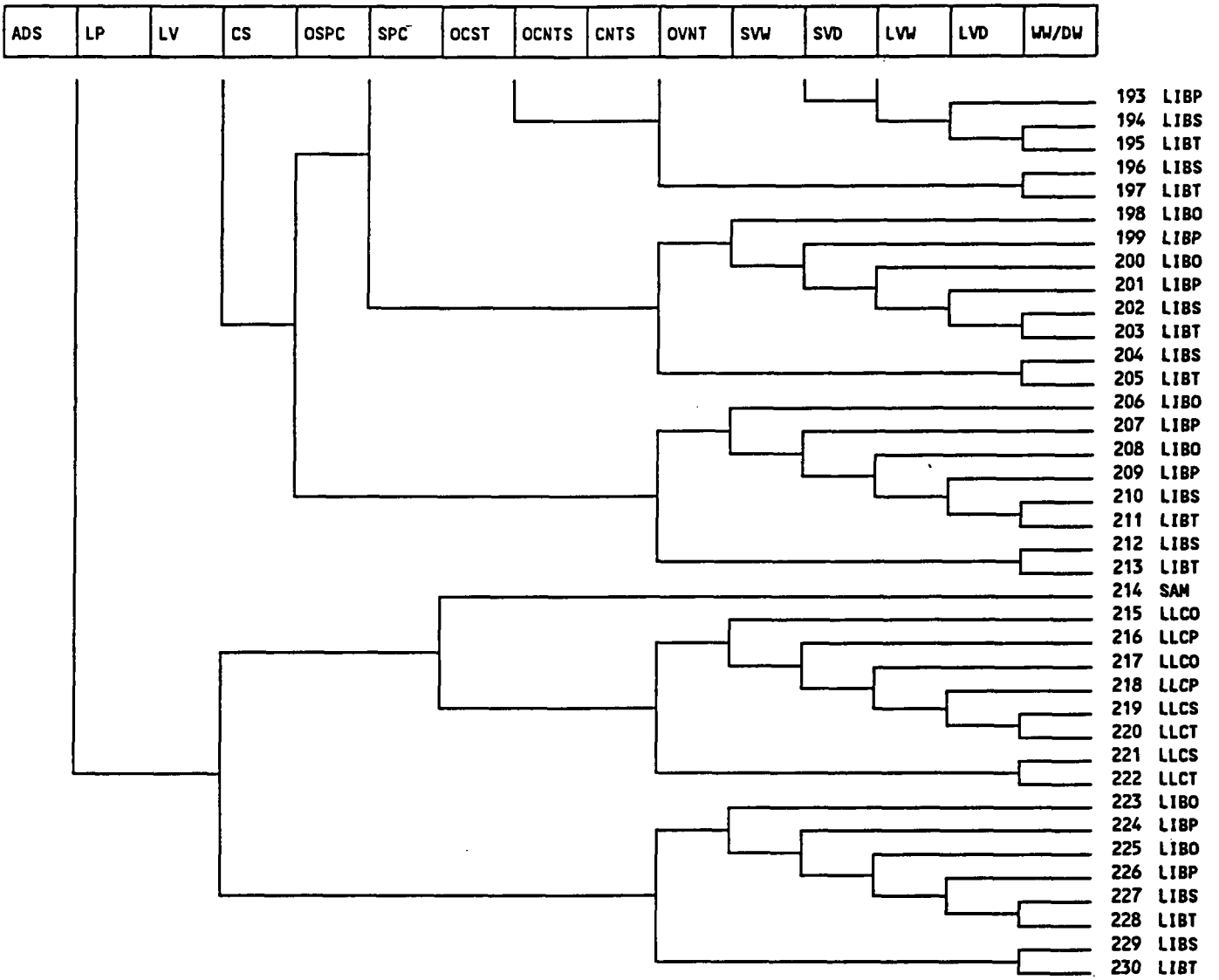
LOOP2
LOSP - LOW PRESSURE INJECTION PHASE, OSP NOT RECOVERED, HPCI SUCCESS



LOOP TREE 4
LPI PHASE AFTER HPCI FAILURE, OSP NOT RECOVERED
LOOP PRT ENTRY CONDITION SUMMARY

	EQUIPMENT								
LOOP PRT	RC	OIC/ICH1 OR AIC/ICH2	RVO OR RVC	OMUP /MUP	HP1	OAD/ADS	HP2	ROP1	OSS /OFW /FW
LOOP-2	S	S/F	S/N	F[1]/N	S	S	N	F	N
LOOP-3	S	S/F	S/N	F[1]/N	F	F	N	F	N
LOOP-4	S	S/F	S/N	F[1]/N	F	S	N	F	N
LOOP-5	S	S/F	S/N	F[1]/N	S	F	F[1]	S	N
LOOP-6	S	S/F	S/N	F[1]/N	F	F	N	S	N
LOOP-7	S	S/F	S/N	F[1]/N	F	S	N	S	N
LOOP-8	S	S/F	S/N	F[1]/N	S	F	F[1]	F	N
LOOP-9	S	S/F	S/N	F[1]/N	S	F	F[1]	S	F[1]
LOOP-10	S	S/F	S/N	F[1]/N	S	S	N	S	N
LOOP-11	S	S/F	S/N	F[1]/N	S	S	N	S	F[1]

Notes:

1. Success of this node leads to SCS
2. S = Success
3. F = Failure
4. N = Not demanded

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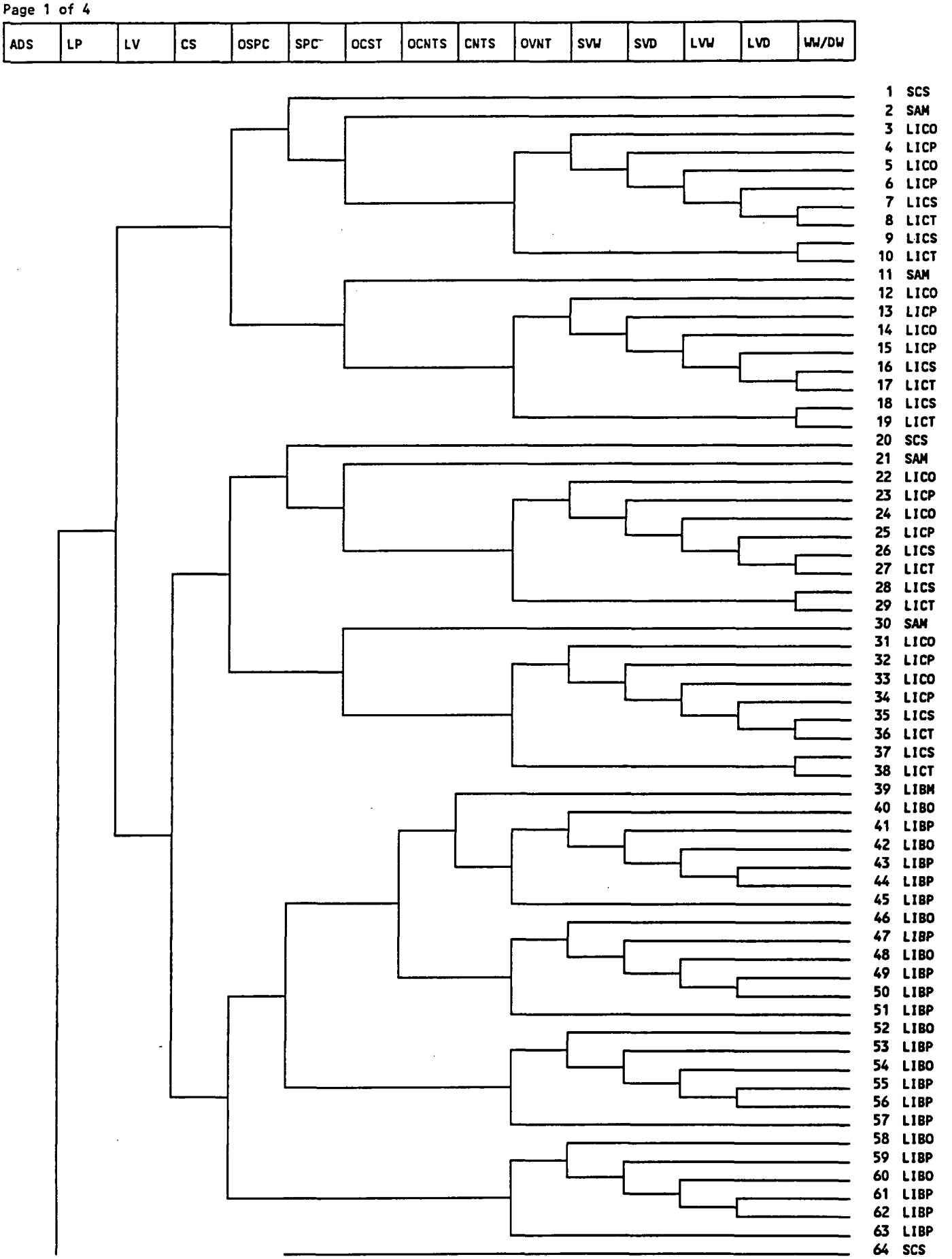
LOOP4
LOSP - LOW PRESSURE INJECTION PHASE AFTER HPCI FAILURE, OSP NOT RECOVERED



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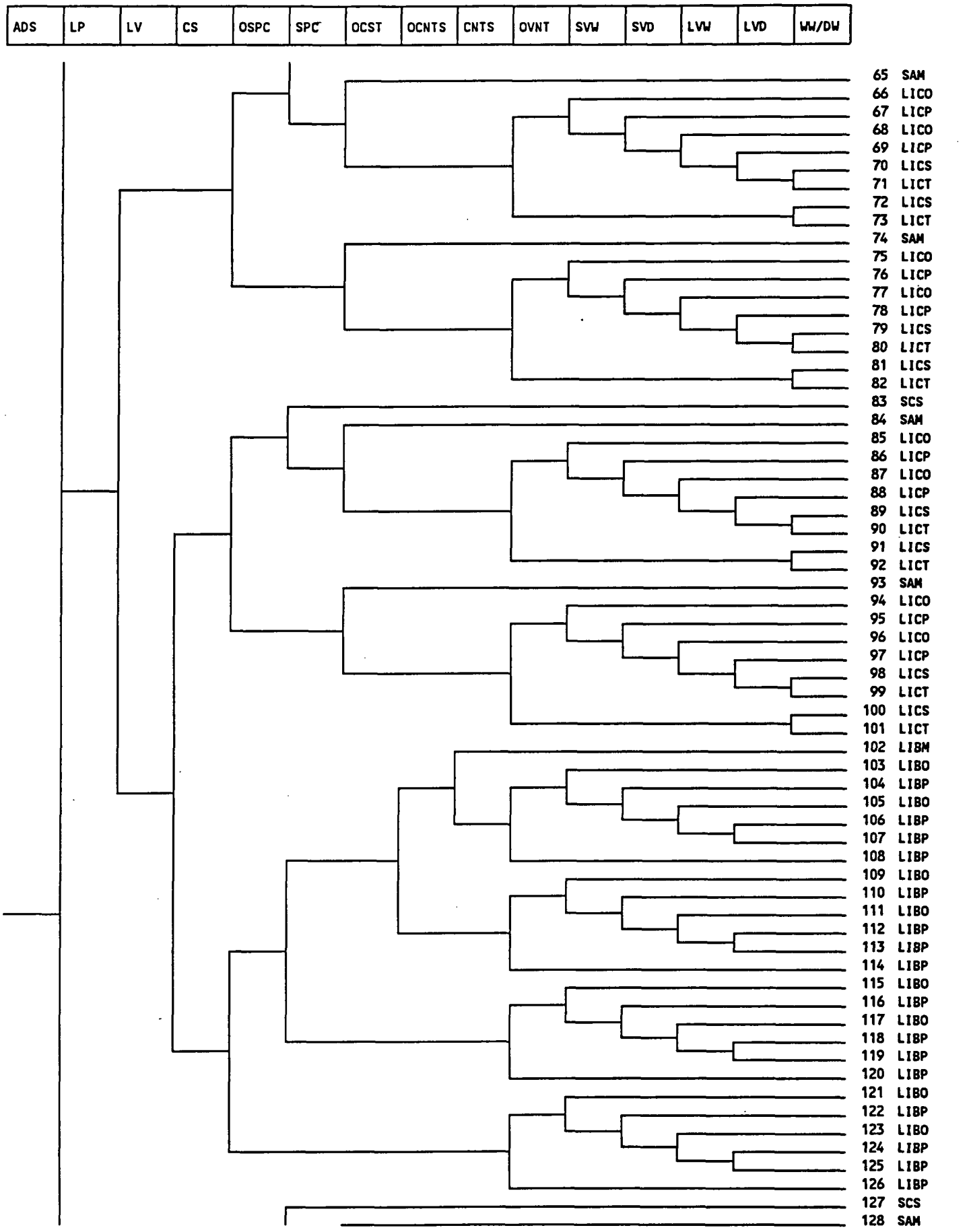
LOOP4
LOSP - LOW PRESSURE INJECTION PHASE AFTER HPCI FAILURE, OSP NOT RECOVERED



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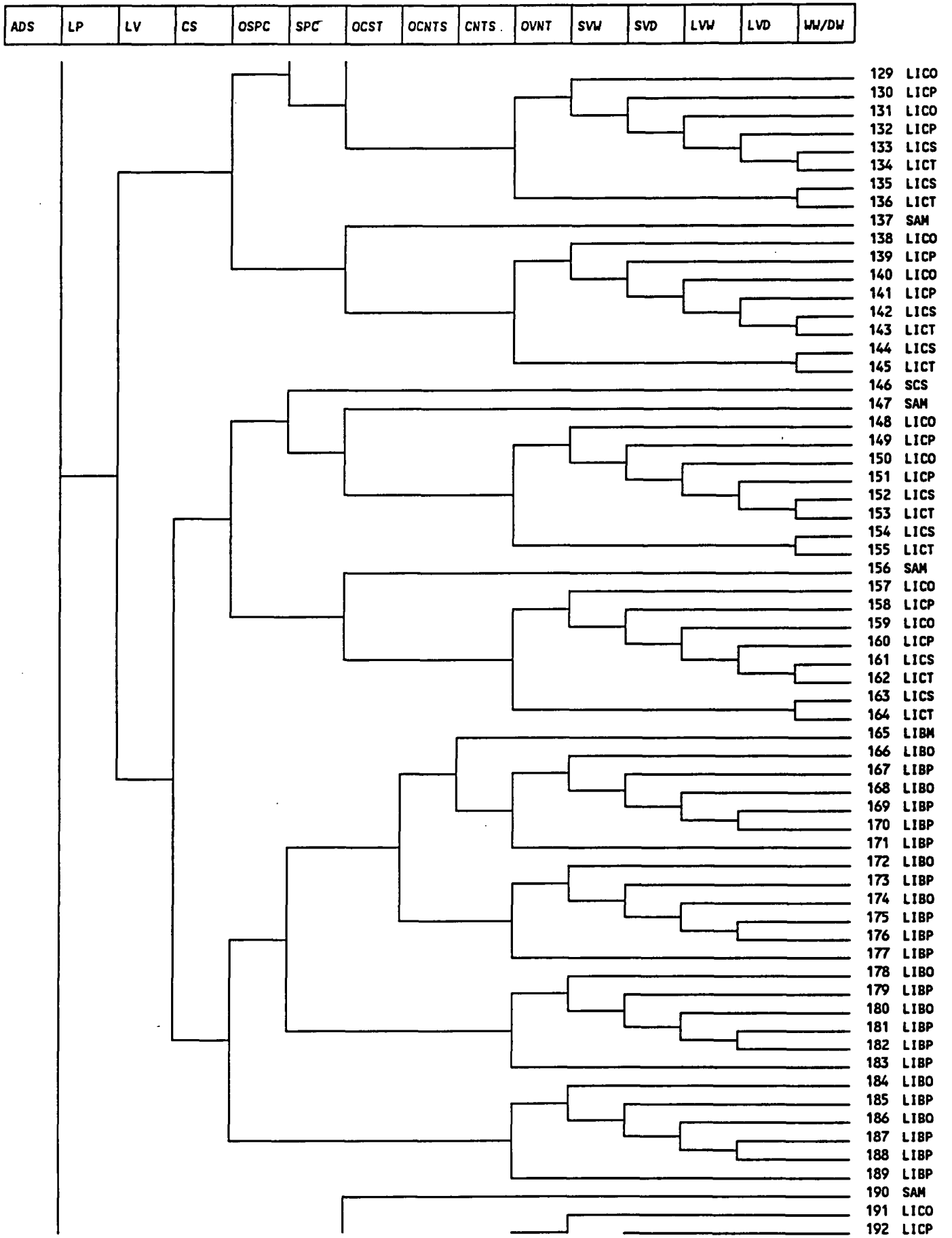
LOOP4
LOSP - LOW PRESSURE INJECTION PHASE AFTER HPCI FAILURE, OSP NOT RECOVERED



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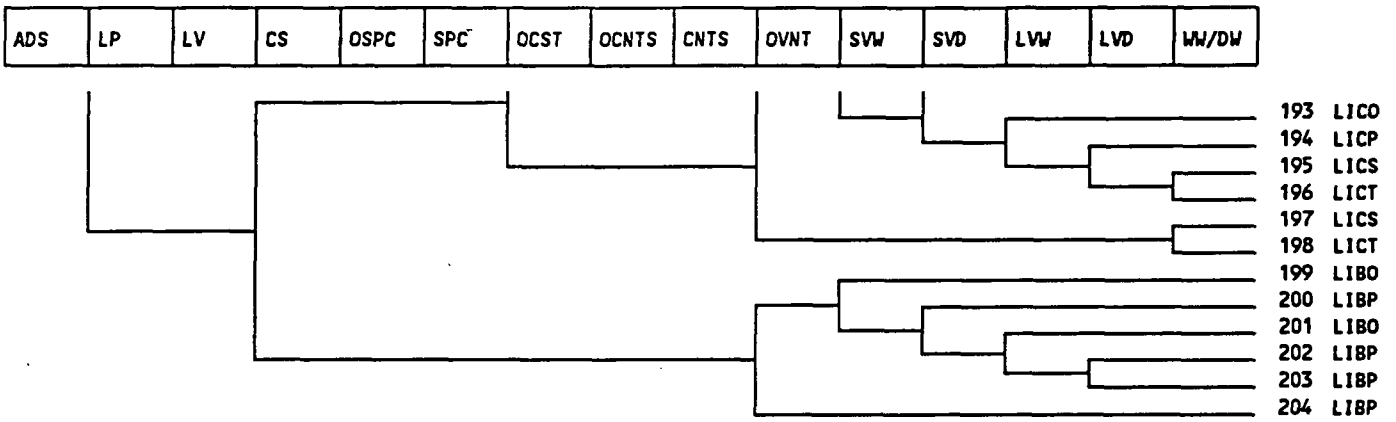
LOOP4

LOSP - LOW PRESSURE INJECTION PHASE AFTER HPCI FAILURE, OSP NOT RECOVERED



LOOP TREE 7
LPI PHASE AFTER HPCI FAILURE, OSP RECOVERED
LOOP PRT ENTRY CONDITION SUMMARY

	EQUIPMENT								
LOOP PRT	RC	OIC/ICH1 OR AIC/ICH2	RVO OR RVC	OMUP /MUP	HP1	OAD/ADS	HP2	ROP1	OSS /OFW /FW
LOOP-2	S	S/F	S/N	F[1]/N	S	S	N	F	N
LOOP-3	S	S/F	S/N	F[1]/N	F	F	N	F	N
LOOP-4	S	S/F	S/N	F[1]/N	F	S	N	F	N
LOOP-5	S	S/F	S/N	F[1]/N	S	F	F[1]	S	N
LOOP-6	S	S/F	S/N	F[1]/N	F	F	N	S	N
LOOP-7	S	S/F	S/N	F[1]/N	F	S	N	S	N
LOOP-8	S	S/F	S/N	F[1]/N	S	F	F[1]	F	N
LOOP-9	S	S/F	S/N	F[1]/N	S	F	F[1]	S	F[1]
LOOP-10	S	S/F	S/N	F[1]/N	S	S	N	S	N
LOOP-11	S	S/F	S/N	F[1]/N	S	S	N	S	F[1]

Notes:

1. *Success of this node leads to SCS*
2. S = Success
3. F = Failure
4. N = Not demanded

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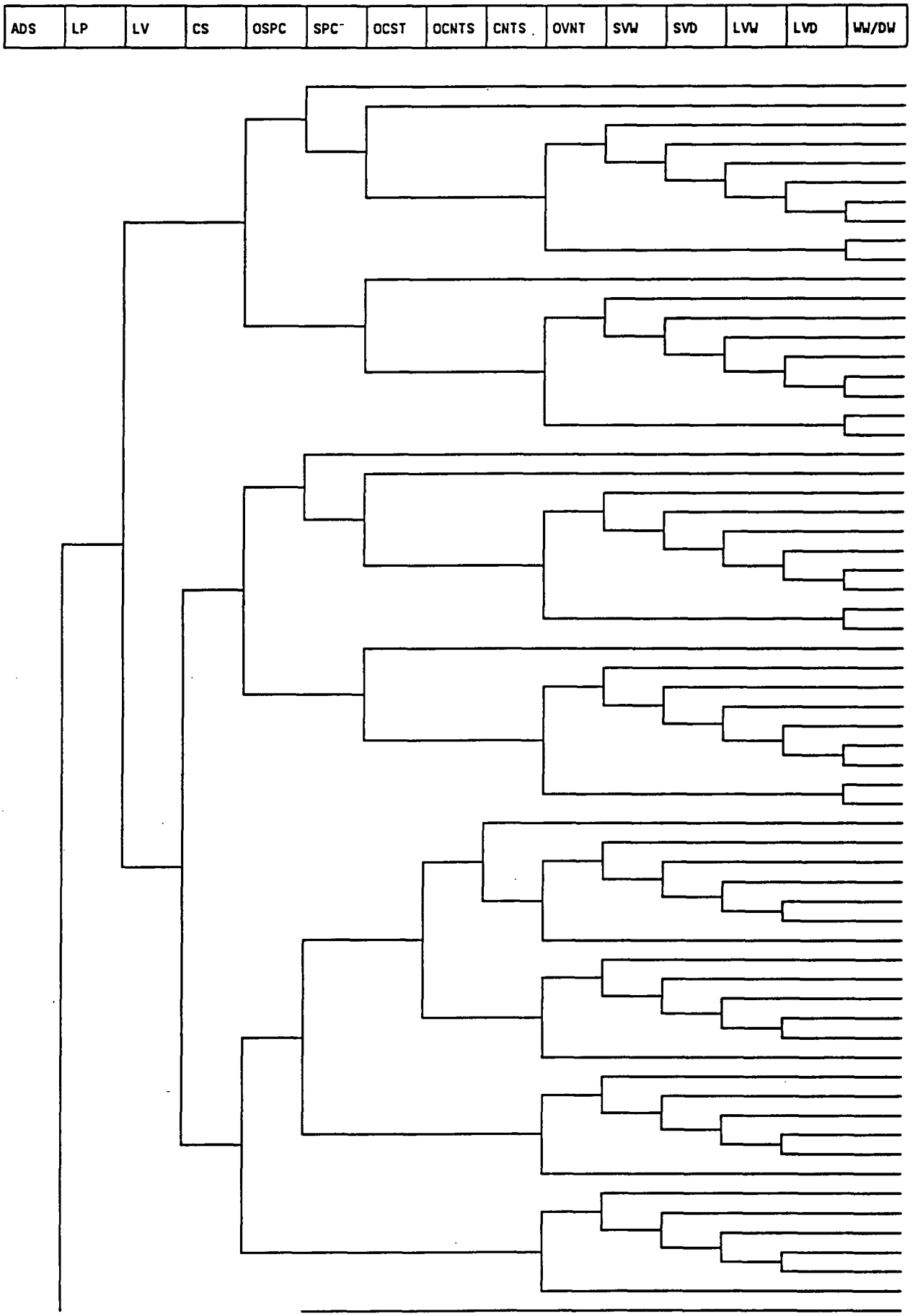
LOOP7
LOSP - LOW PRESSURE INJECTION PHASE AFTER HPCI FAILURE, OSP RECOVERED



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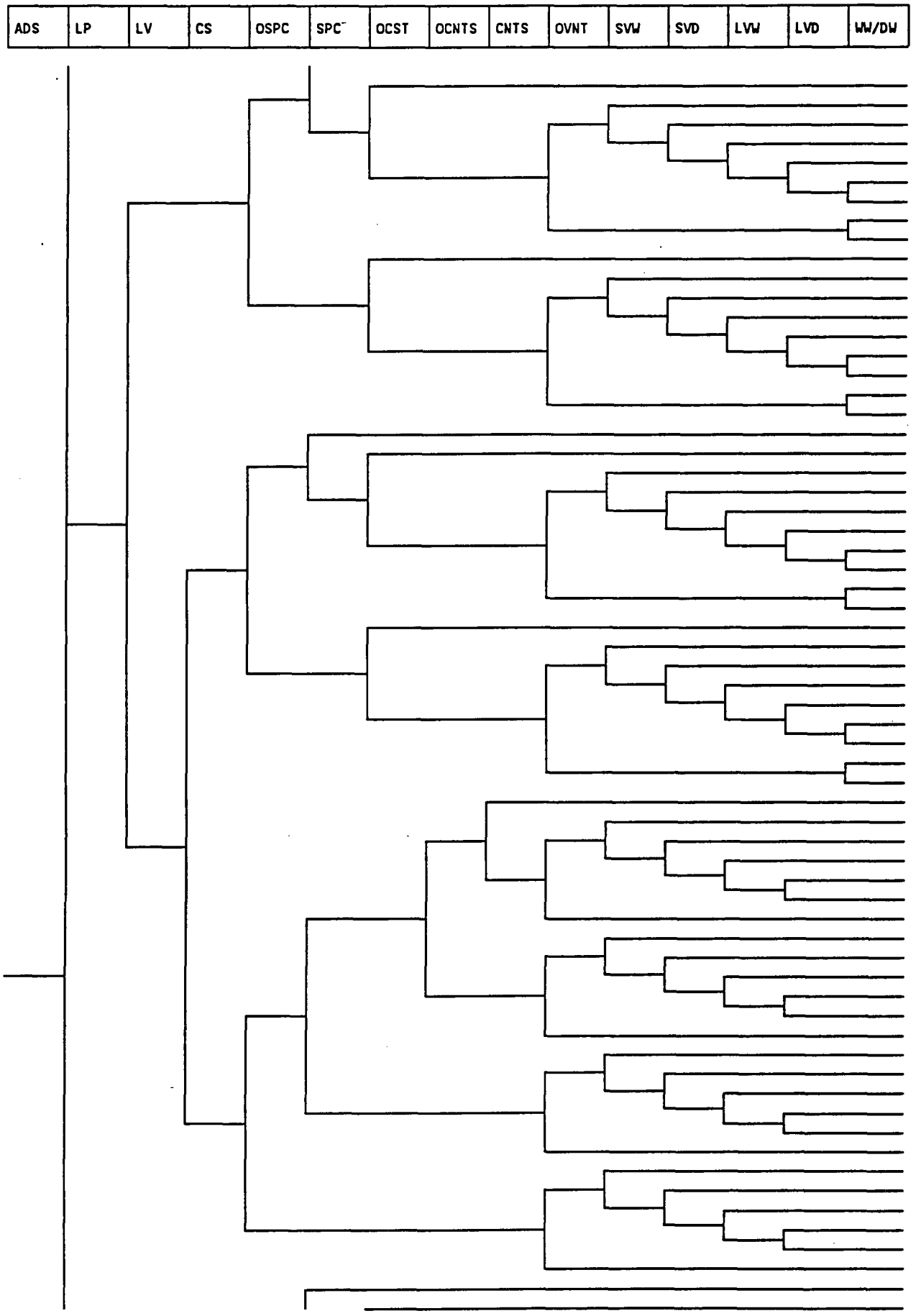
LOOP7
LOSP - LOW PRESSURE INJECTION PHASE AFTER HPCI FAILURE, OSP RECOVERED



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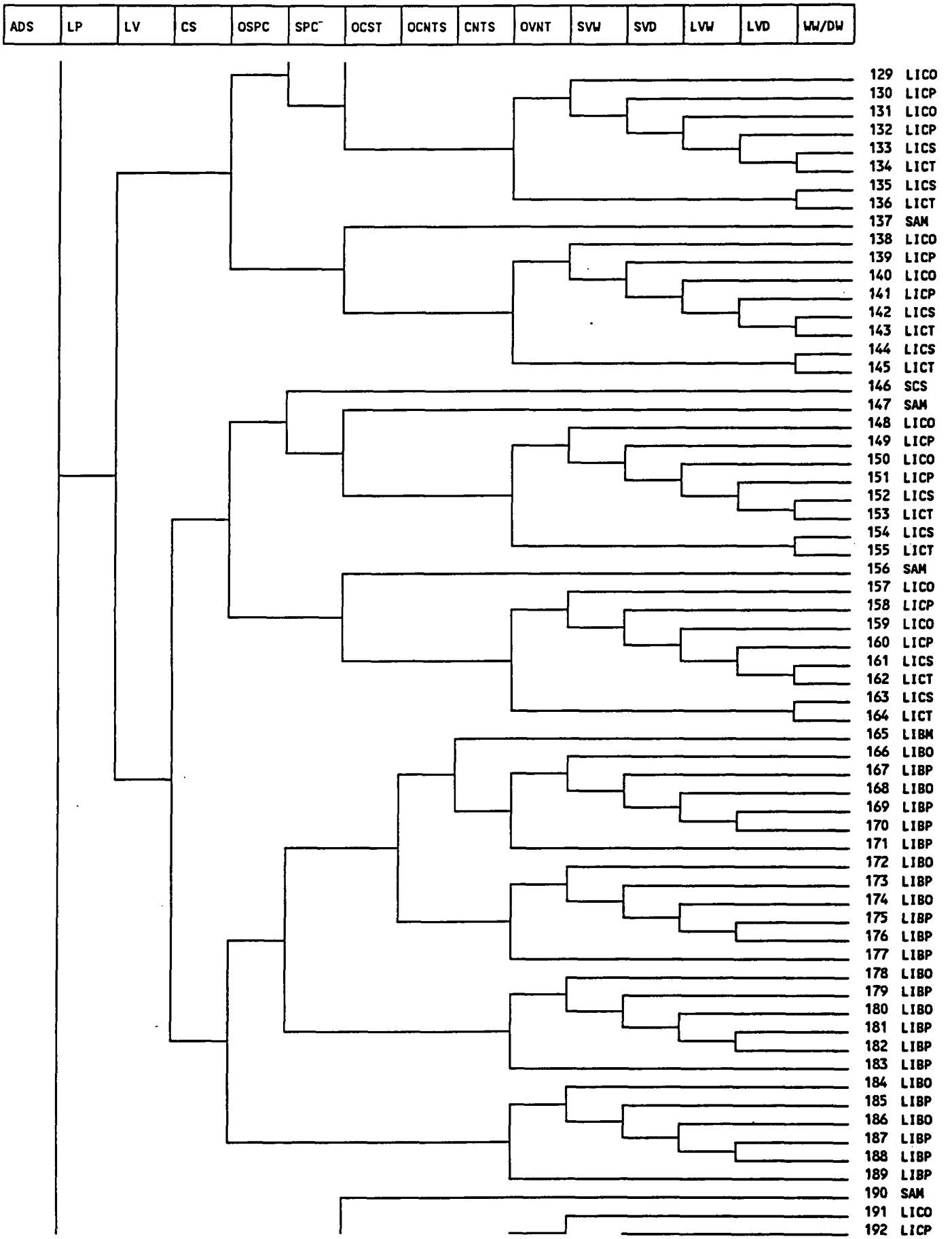
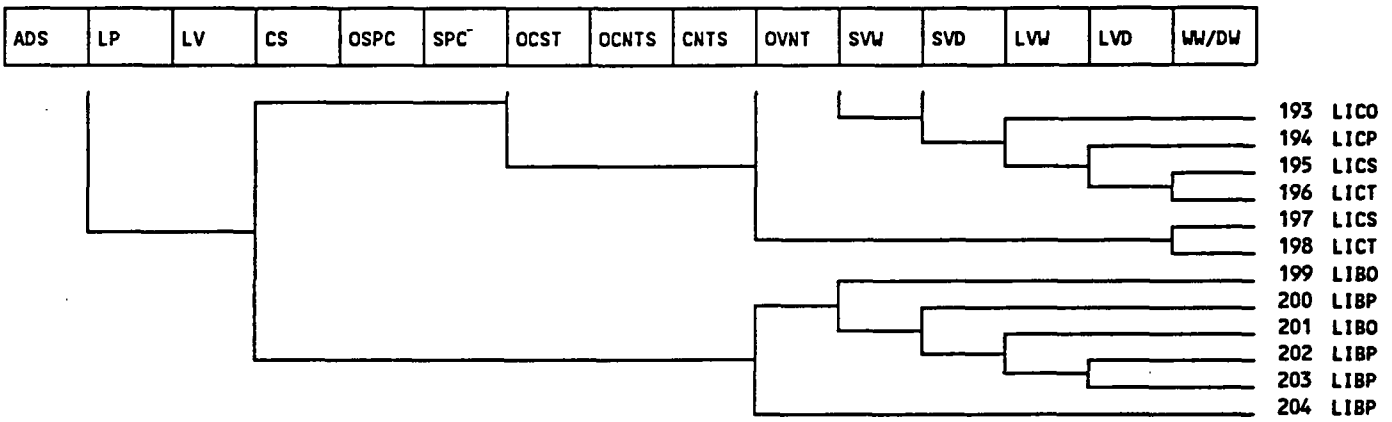
LOOP7
LOSP - LOW PRESSURE INJECTION PHASE AFTER HPCI FAILURE, OSP RECOVERED



06/10/96 05:36:27 CADET 1.00
LOOP7
LOSP - LOW PRESSURE INJECTION PHASE AFTER HPCI FAILURE, OSP RECOVERED



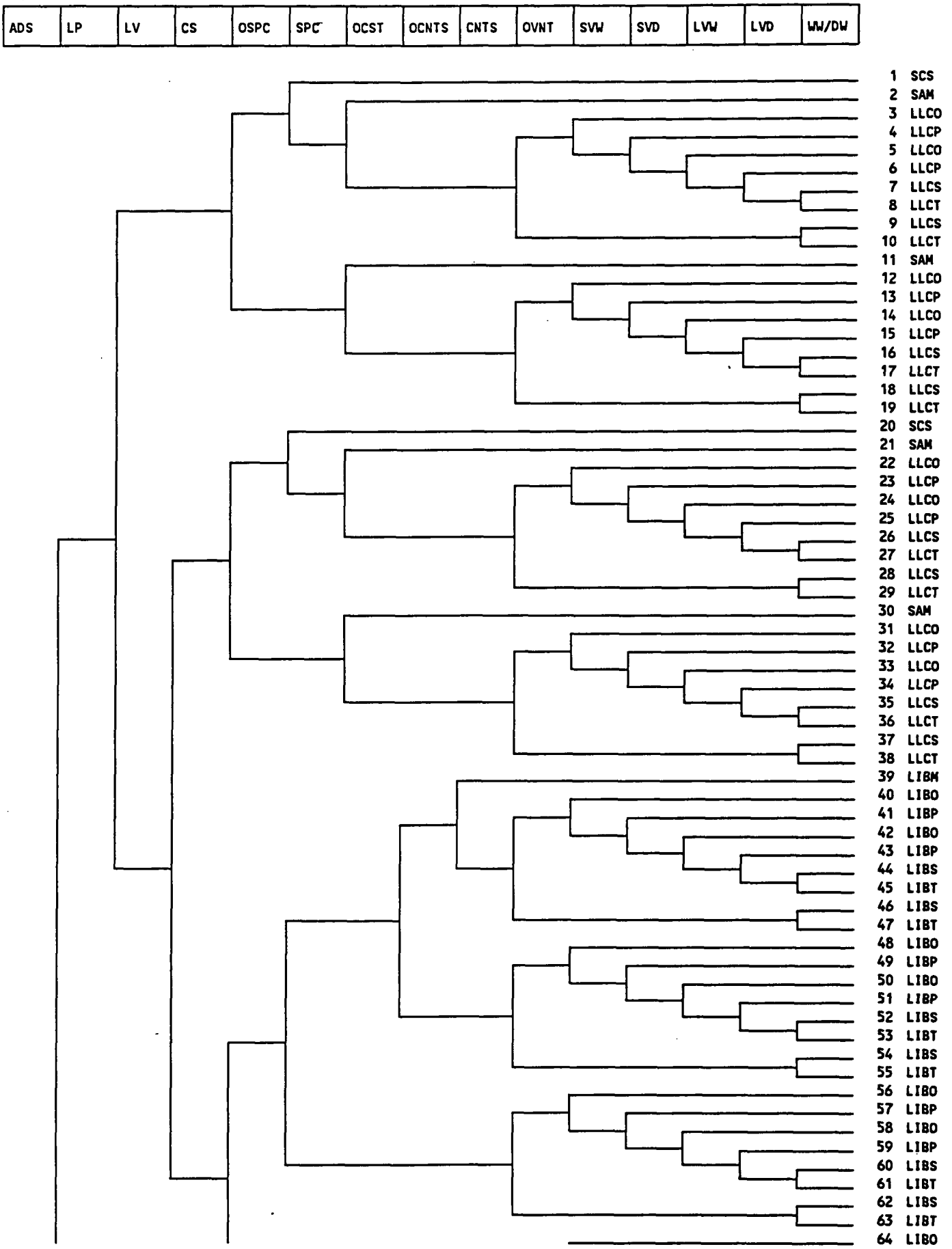
LOOP TREE 11
LPI PHASE, OSP RECOVERED, HPCI SUCCESS
LOOP PRT ENTRY CONDITION SUMMARY

	EQUIPMENT								
LOOP PRT	RC	OIC/ICH1 OR AIC/ICH2	RVO OR RVC	OMUP /MUP	HP1	OAD/ADS	HP2	ROP1	OSS /OFW /FW
LOOP-2	S	S/F	S/N	F[1]/N	S	S	N	F	N
LOOP-3	S	S/F	S/N	F[1]/N	F	F	N	F	N
LOOP-4	S	S/F	S/N	F[1]/N	F	S	N	F	N
LOOP-5	S	S/F	S/N	F[1]/N	S	F	F[1]	S	N
LOOP-6	S	S/F	S/N	F[1]/N	F	F	N	S	N
LOOP-7	S	S/F	S/N	F[1]/N	F	S	N	S	N
LOOP-8	S	S/F	S/N	F[1]/N	S	F	F[1]	F	N
LOOP-9	S	S/F	S/N	F[1]/N	S	F	F[1]	S	F[1]
LOOP-10	S	S/F	S/N	F[1]/N	S	S	N	S	N
LOOP-11	S	S/F	S/N	F[1]/N	S	S	N	S	F[1]

Notes:

1. Success of this node leads to SCS
2. S = Success
3. F = Failure
4. N = Not demanded

06/10/96 05:36:27 CADET 1.00
LOOP11
LOSP - LOW PRESSURE INJECTION PHASE, OSP RECOVERED, HPCI SUCCESS



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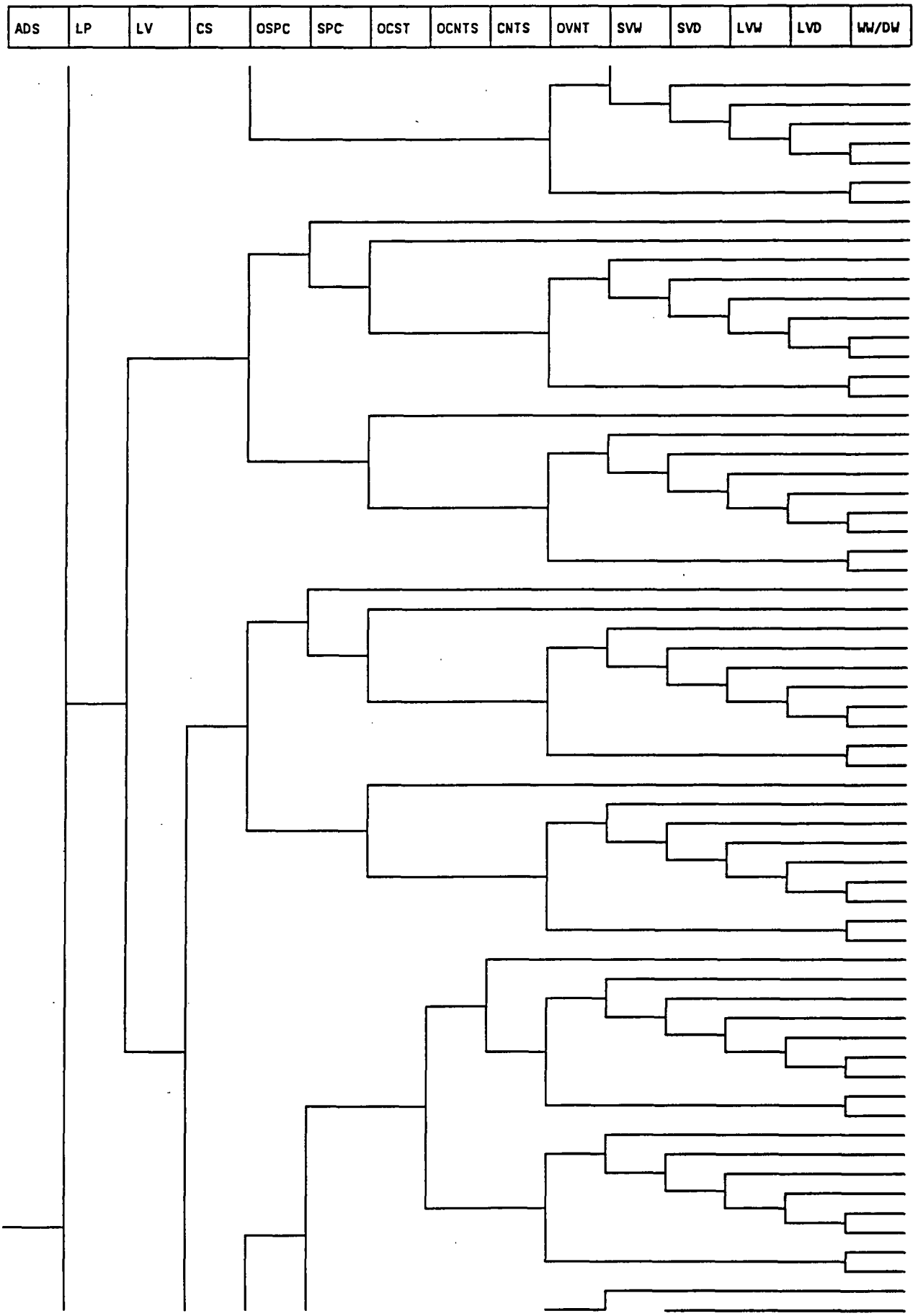
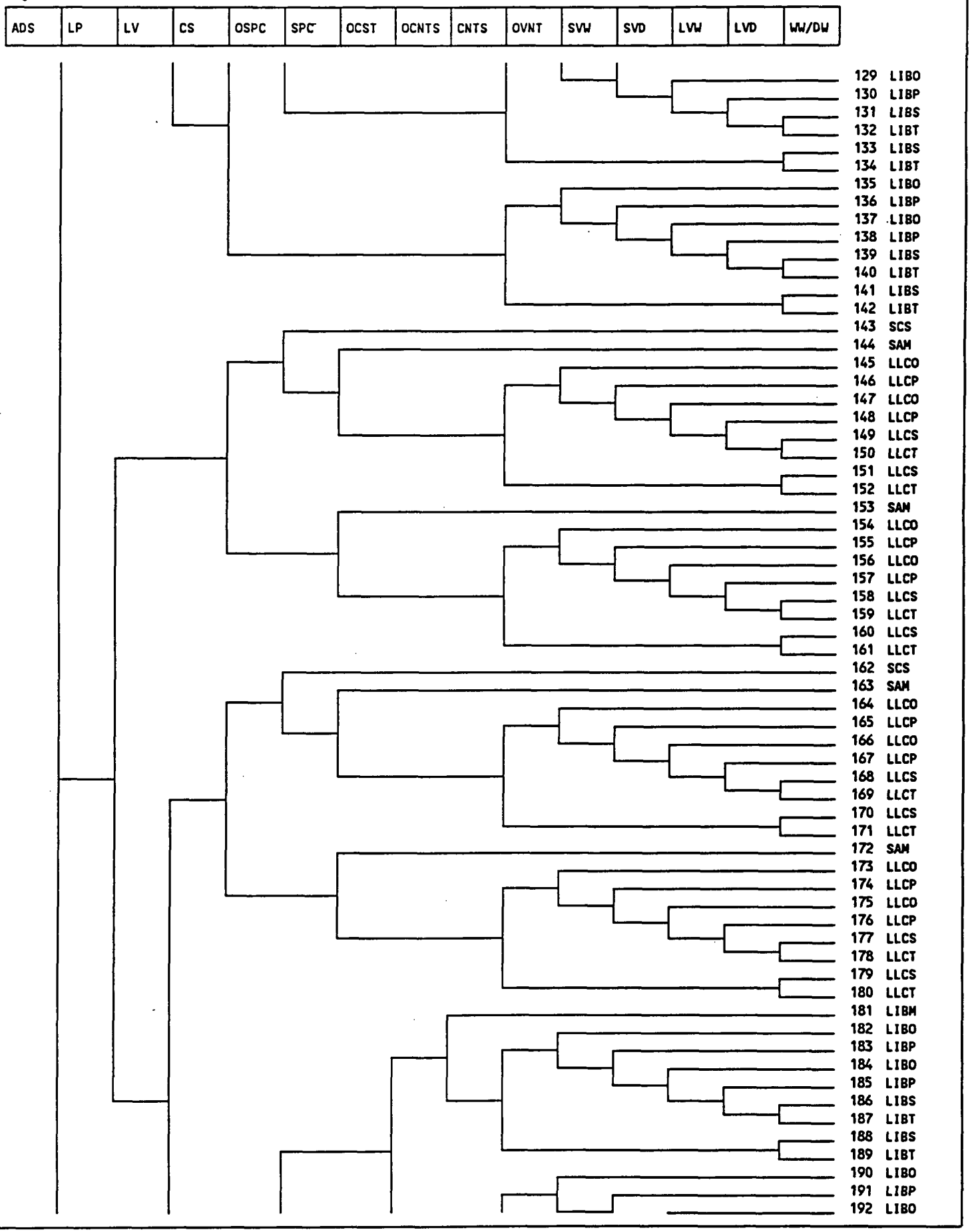
LOOP11
LOSP - LOW PRESSURE INJECTION PHASE, OSP RECOVERED, HPCI SUCCESS



06/10/96 05:36:27 CADET 1.00
LOOP11
LOSP - LOW PRESSURE INJECTION PHASE, OSP RECOVERED, HPCI SUCCESS



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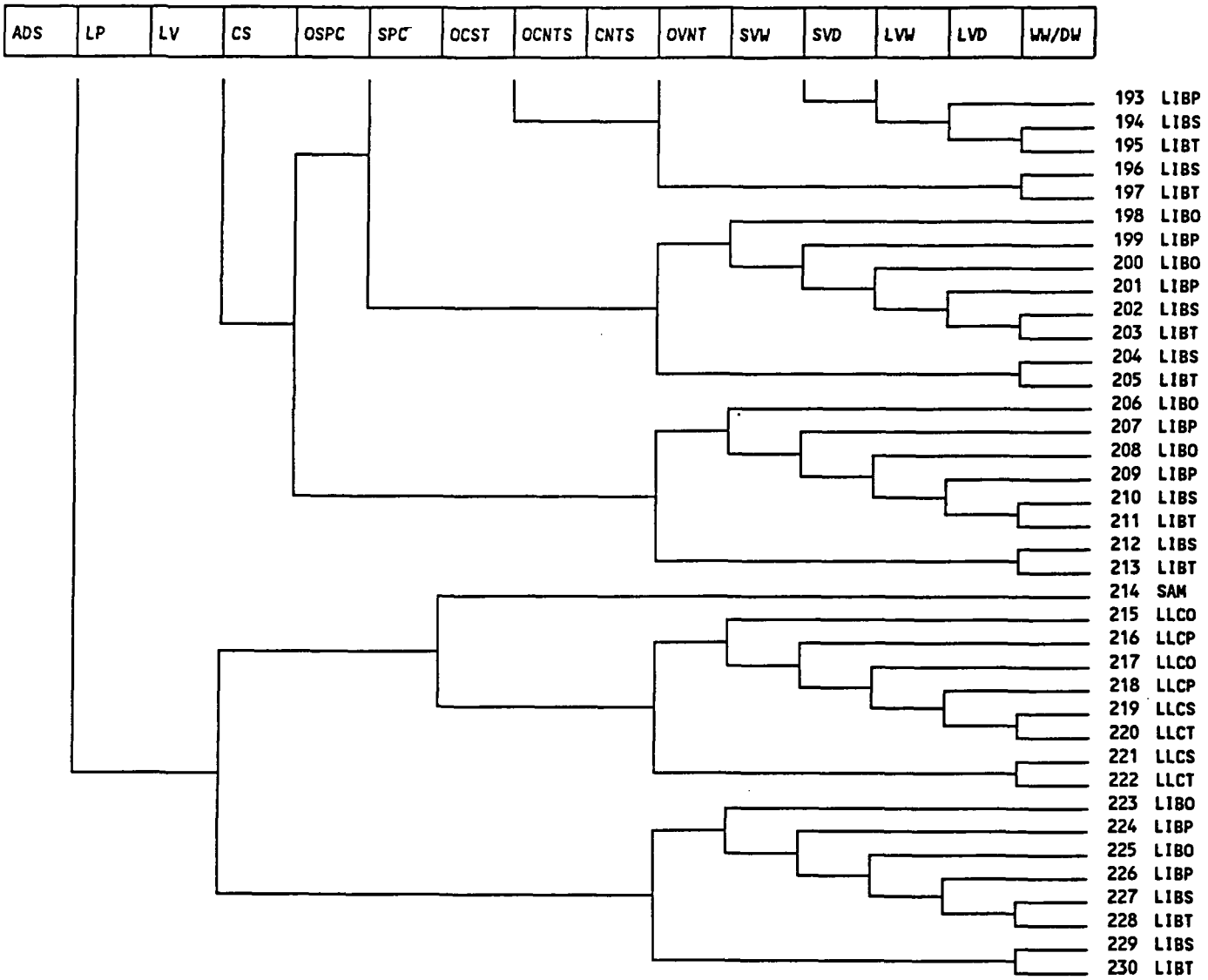
LOOP11
LOSP - LOW PRESSURE INJECTION PHASE, OSP RECOVERED, HPCI SUCCESS

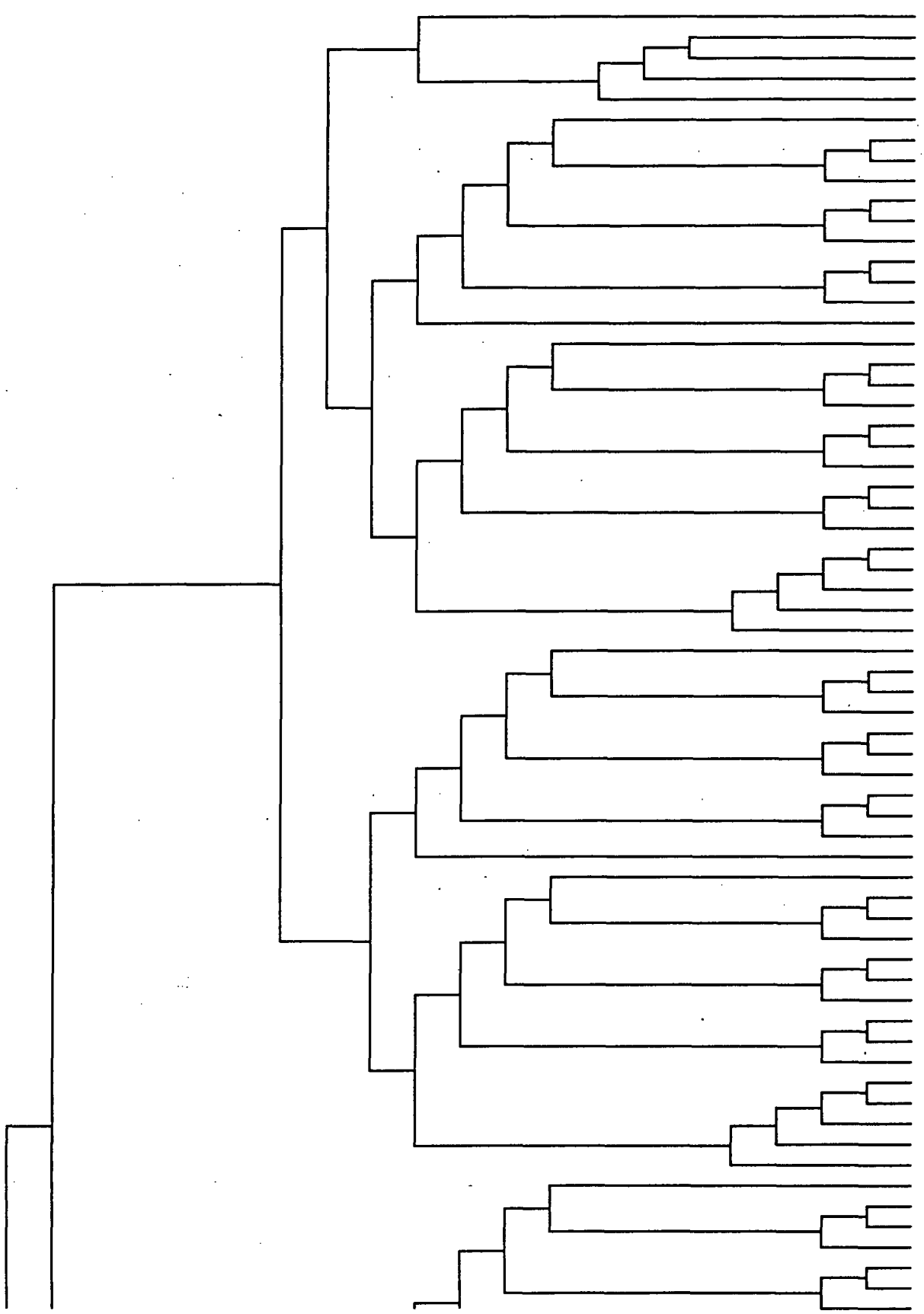


STATION BLACKOUT PRT

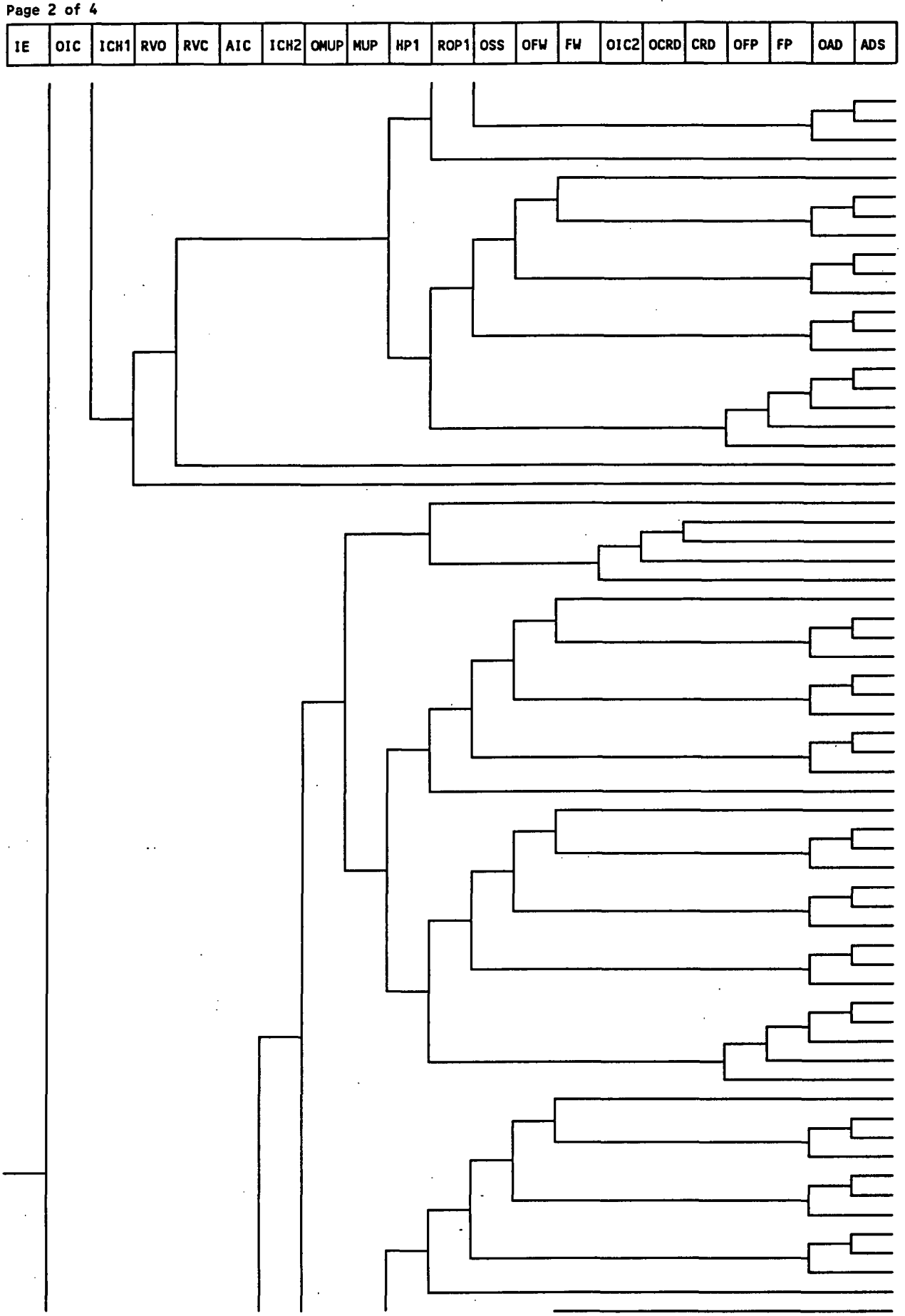
I	TREE SBO1	SBO - INITIAL PHASE	(4 PAGES)
	TREE SBO2	SBO - LOW PRESSURE PHASE AFTER CD/VF AT HIGH PRESSURE	(3 PAGES)
I	TREE SBO3	SBO - LOW PRESSURE PHASE AFTER HPI FAILURE, OSP RECOVERED	(4 PAGES)
	TREE SBO4	SBO - LOW PRESSURE PHASE AFTER HPI FAILURE, FP SUCCESS	(2 PAGES)
	TREE SBO5	SBO - LOW PRESSURE PHASE AFTER HPI FAILURE, CD/VF AT HI PRSR, OSP RECOVERED	(3 PAGES)
	TREE SBO6	SBO - LOW PRESSURE PHASE AFTER HPCI SUCCESS, CD/VF AT HI PRSR	(3 PAGES)
I	TREE SBO7	SBO - LOW PRESSURE PHASE AFTER HPCI SUCCESS, OSP RECOVERED	(4 PAGES)
	TREE SBO8	SBO - LOW PRESSURE PHASE AFTER CD/VF AT HI PRSR, HPCI SUCCESS, OSP RECOVERED	(3 PAGES)

06/10/96 05:33:30 CADET 1.00
SB01
SBO - INITIAL PHASE

IE	OIC	ICH1	RVO	RVC	AIC	ICH2	OMUP	MUP	HP1	ROP1	OSS	OFW	FW	OIC2	OCRD	CRD	OFP	FP	OAD	ADS

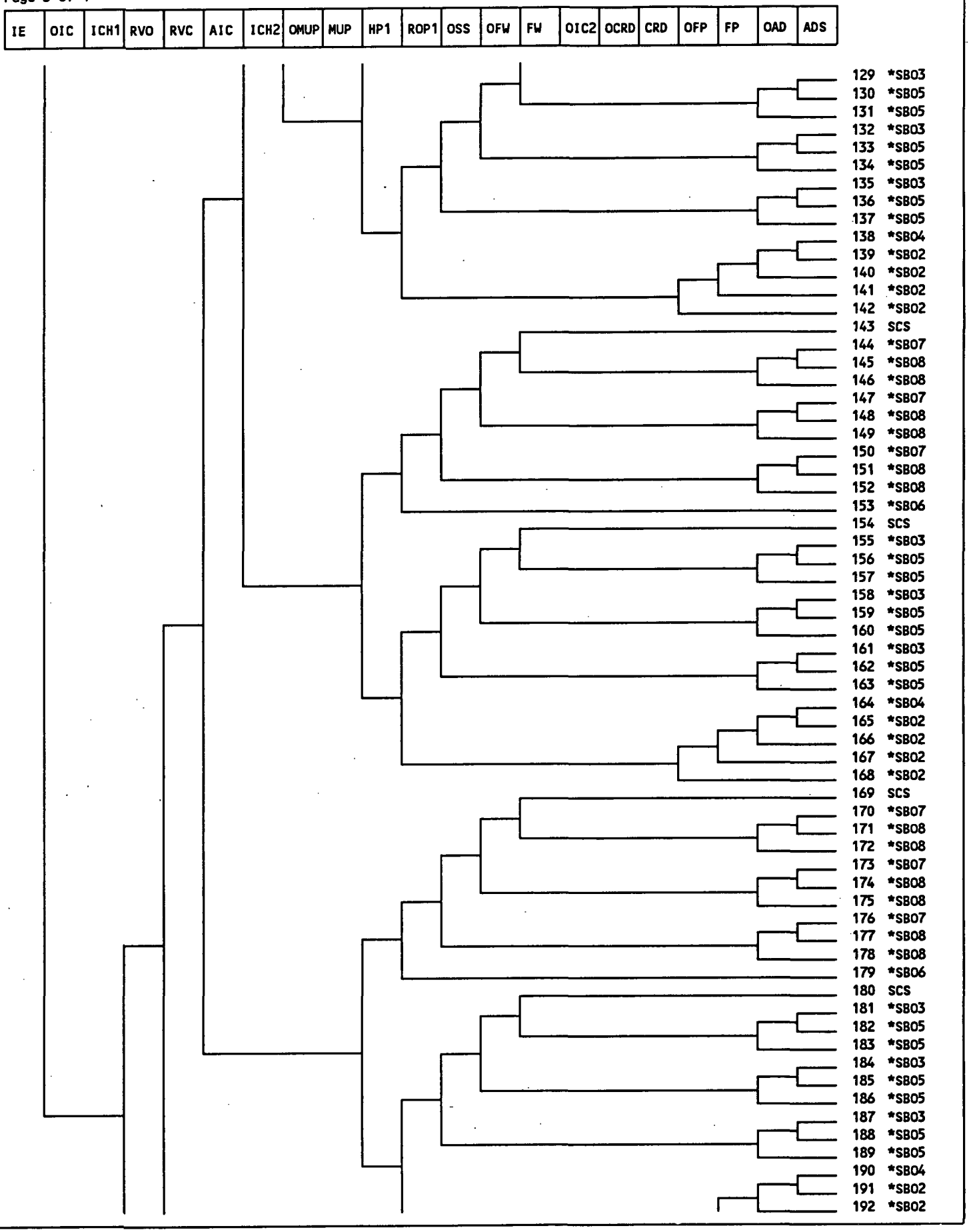


06/10/96 05:33:30 CADET 1.00
SB01
SBO - INITIAL PHASE



06/10/96 05:33:30
SB01
SBO - INITIAL PHASE

CADET 1.00



IE	OIC	ICH1	RVO	RVC	AIC	ICH2	OMUP	MUP	HP1	ROP1	OSS	OFW	FW	OIC2	OCRD	CRD	OFP	FP	OAD	ADS

193 *SBO2
194 *SBO2
195 *SBO2
196 *SBO2

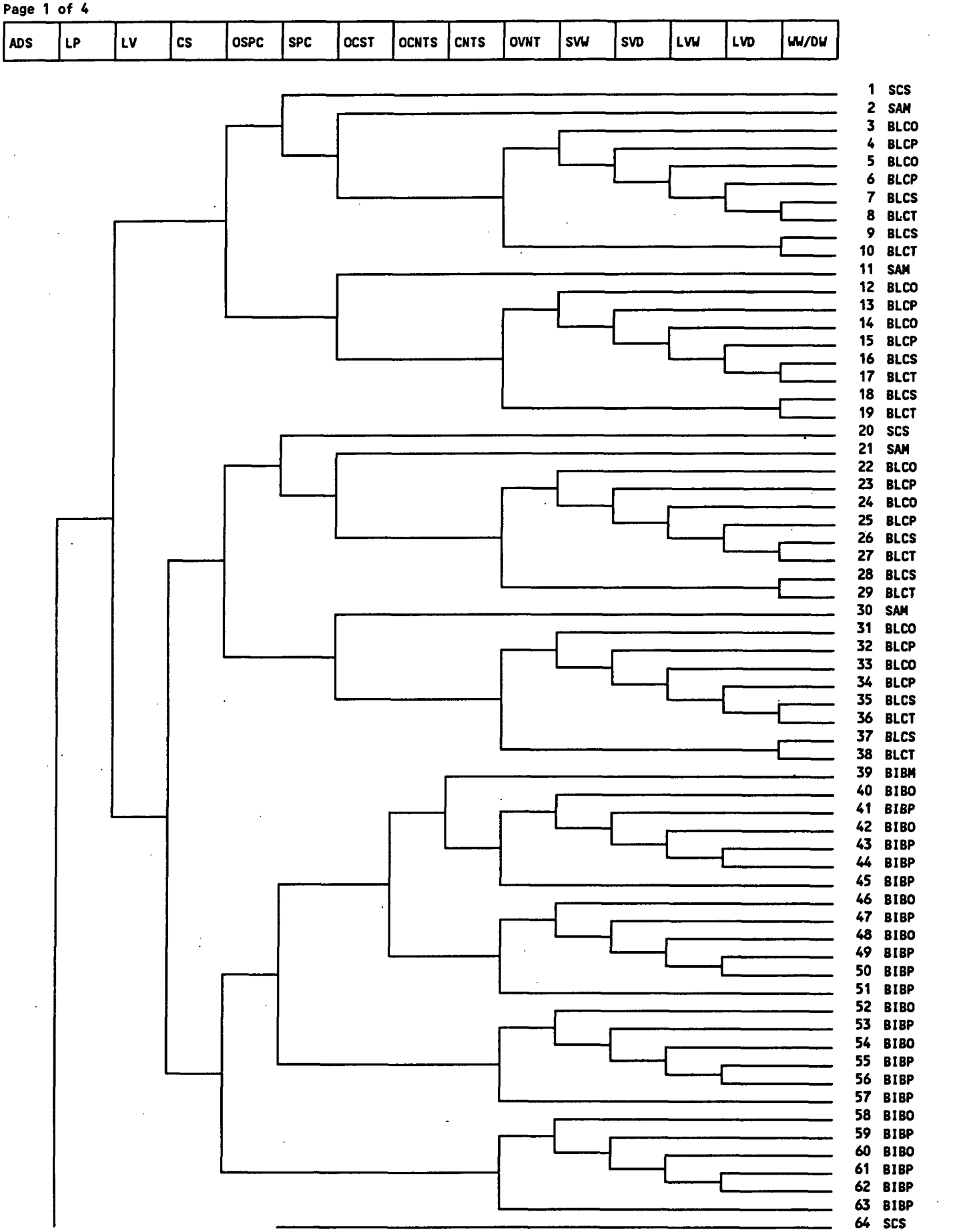
SBO TREE 3
LOW PRESSURE PHASE AFTER HPI FAILURE, OSP RECOVERED
SBO PRT ENTRY CONDITION SUMMARY

	EQUIPMENT									
SBO PRT	OIC/ICH1 OR AIC/ICH2	RVO OR RVC	OMUP/MUP	HP1	ROP1	OSS/ OFW/ FW	OIC2	OCRD/CRD	OFP/FP	OAD/ADS[2]
SBO-2	S/F	S/F	F	F	F				S/F	F
SBO-3	S/F	S	F[1]	F	S	F[1]				S
SBO-4	S/F	S	F	F	F				S	S
SBO-5	S/F	S	F	F	S	F[1]				F
SBO-6	S	S	S		F		S	F[6]		
SBO-6	S		S		F		S	F[6]		
SBO-6	S/F	S	S		F		F			
SBO-6	S/F	S	F	S	F					
SBO-7	S/F	S	F	S	S	F[1]				S
SBO-8	S/F	S	F	S	S	F[1]				F

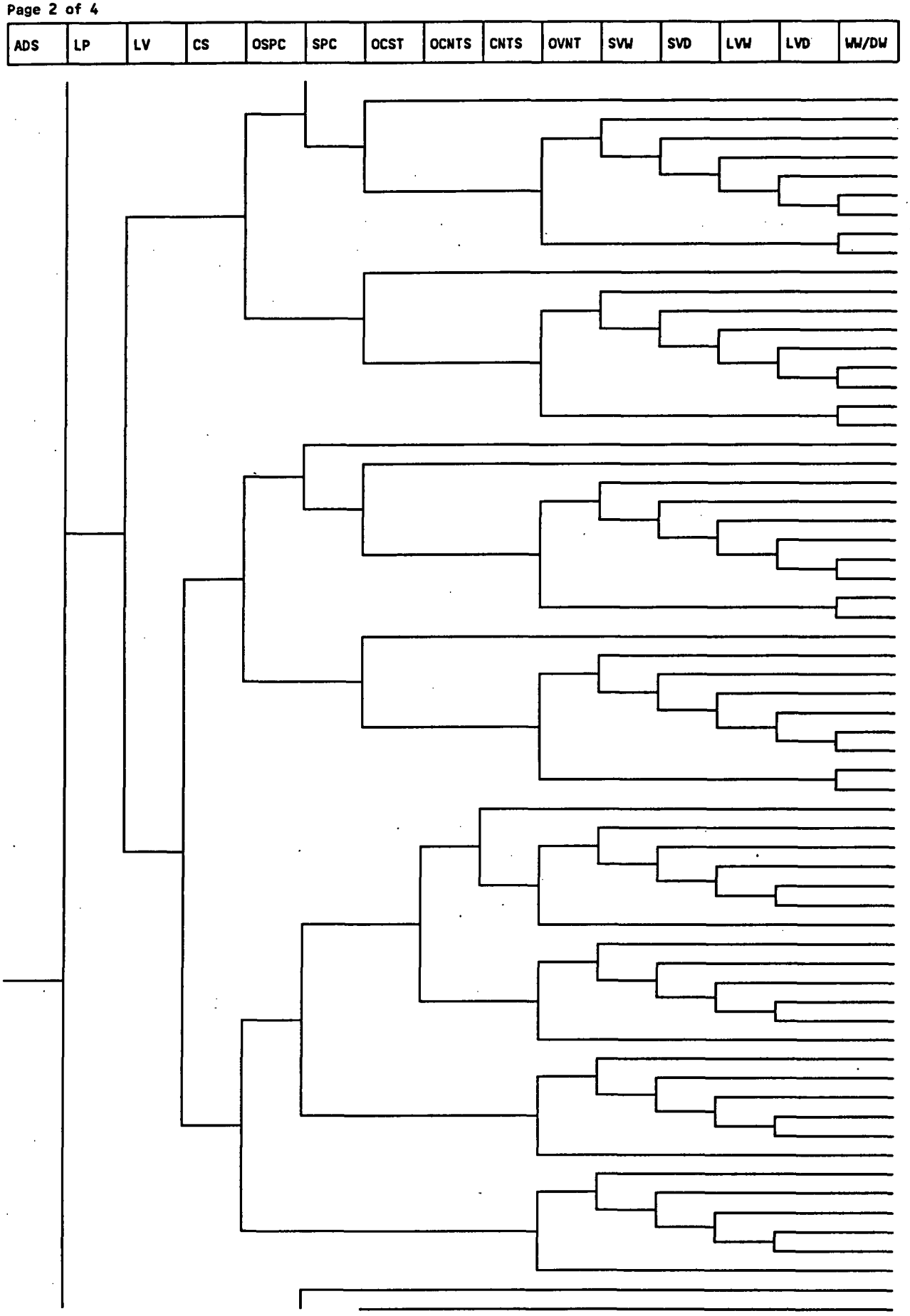
Notes:

1. Success of this node leads to SCS
2. ADS valves will fail closed after four hours (battery depletion) unless offsite power is recovered
3. S = Success
4. F = Failure
5. Blank denotes "not applicable"
6. Success of both nodes lead to SCS.

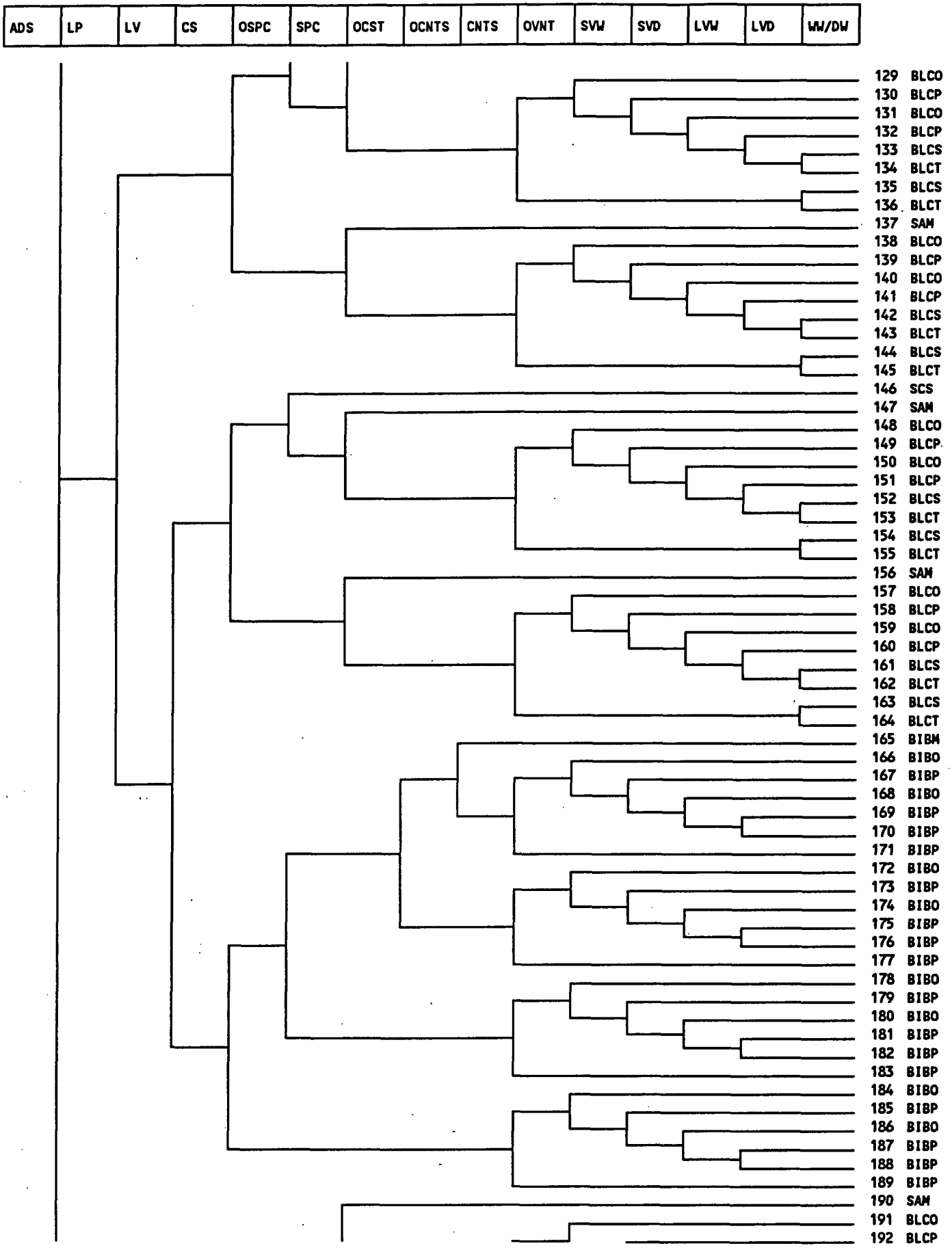
06/10/96 05:36:27 CADET 1.00
SB03
SBO - LOW PRESSURE PHASE AFTER HPI FAILURE, OSP RECOVERED



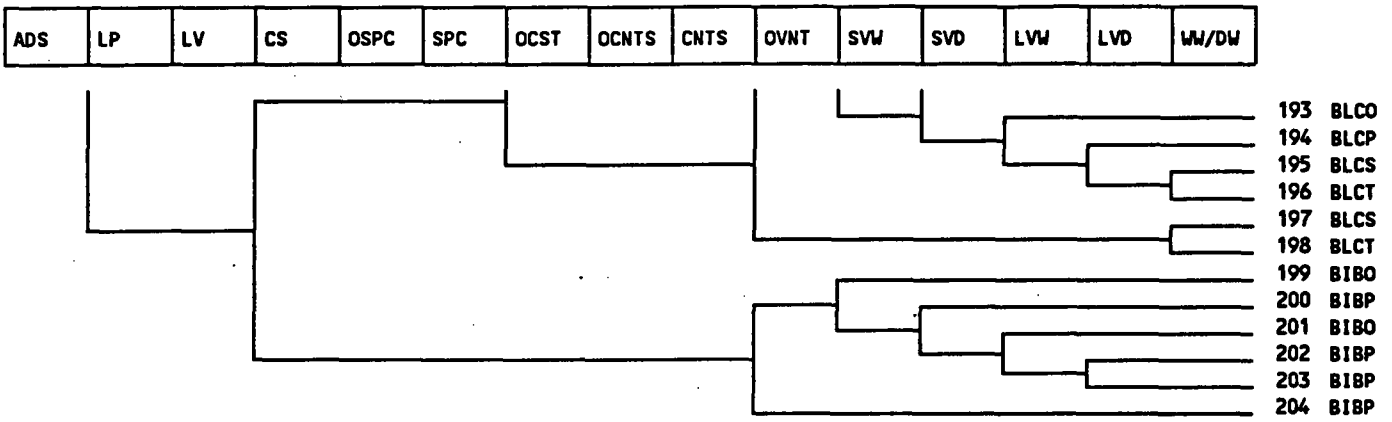
06/10/96 05:36:27 CADET 1.00
SBO3
SBO - LOW PRESSURE PHASE AFTER HPI FAILURE, OSP RECOVERED



06/10/96 05:36:27 CADET 1.00
SBO3
SBO - LOW PRESSURE PHASE AFTER HPI FAILURE, OSP RECOVERED



06/10/96 05:36:27 CADET 1.00
SBO3
SBO - LOW PRESSURE PHASE AFTER HPI FAILURE, OSP RECOVERED



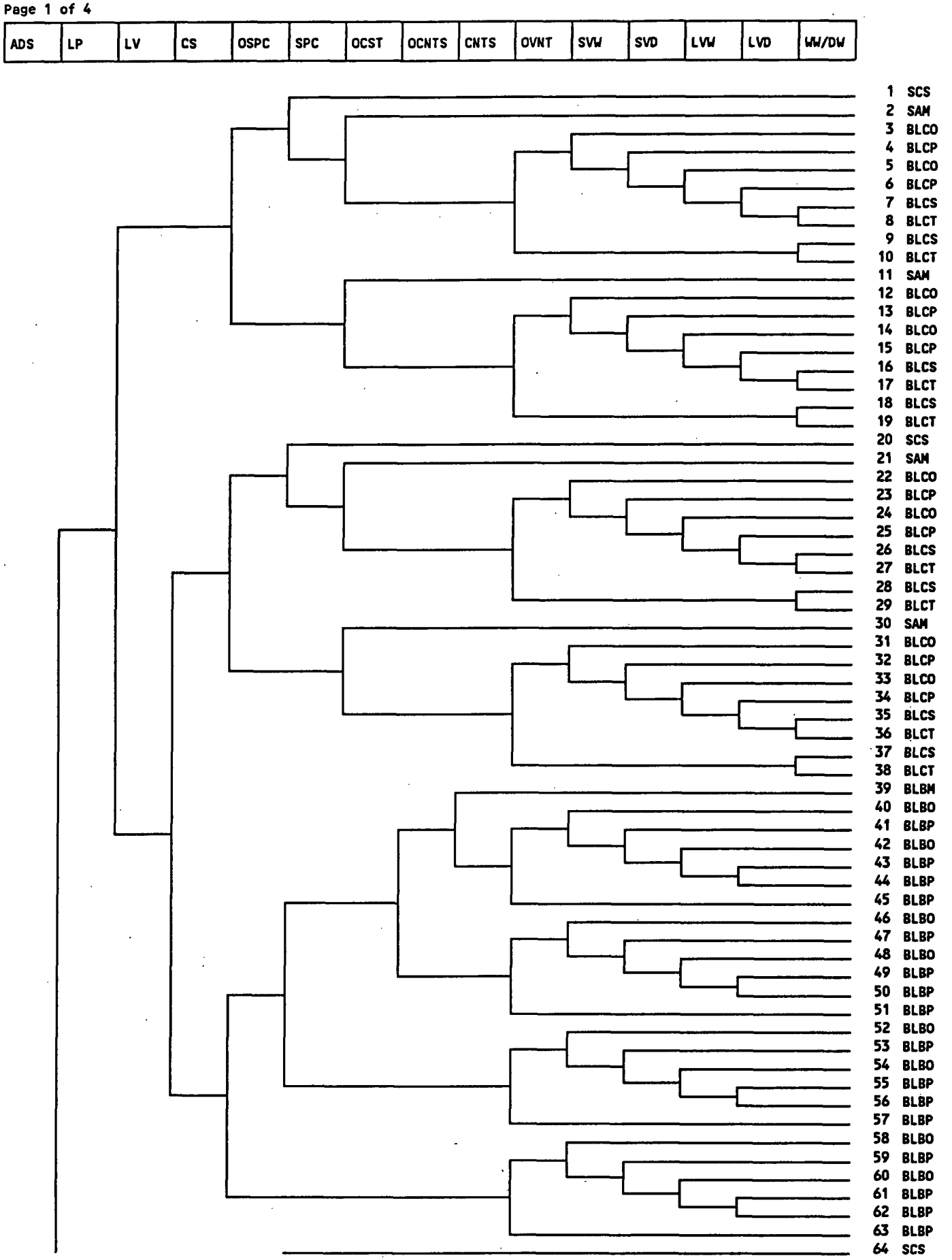
SBO TREE 7
LOW PRESSURE PHASE AFTER HPCI SUCCESS, OSP RECOVERED
SBO PRT ENTRY CONDITION SUMMARY

	EQUIPMENT									
SBO PRT	OIC/ICH1 OR AIC/ICH2	RVO OR RVC	OMUP/MUP	HP1	ROP1	OSS/ OFW/ FW	OIC2	OCRD/CRD	OFP/FP	OAD/ADS[2]
SBO-2	S/F	S/F	F	F	F				S/F	F
SBO-3	S/F	S	F[1]	F	S	F[1]				S
SBO-4	S/F	S	F	F	F				S	S
SBO-5	S/F	S	F	F	S	F[1]				F
SBO-6	S	S	S		F		S	F[6]		
SBO-6	S		S		F		S	F[6]		
SBO-6	S/F	S	S		F		F			
SBO-6	S/F	S	F	S	F					
SBO-7	S/F	S	F	S	S	F[1]				S
SBO-8	S/F	S	F	S	S	F[1]				F

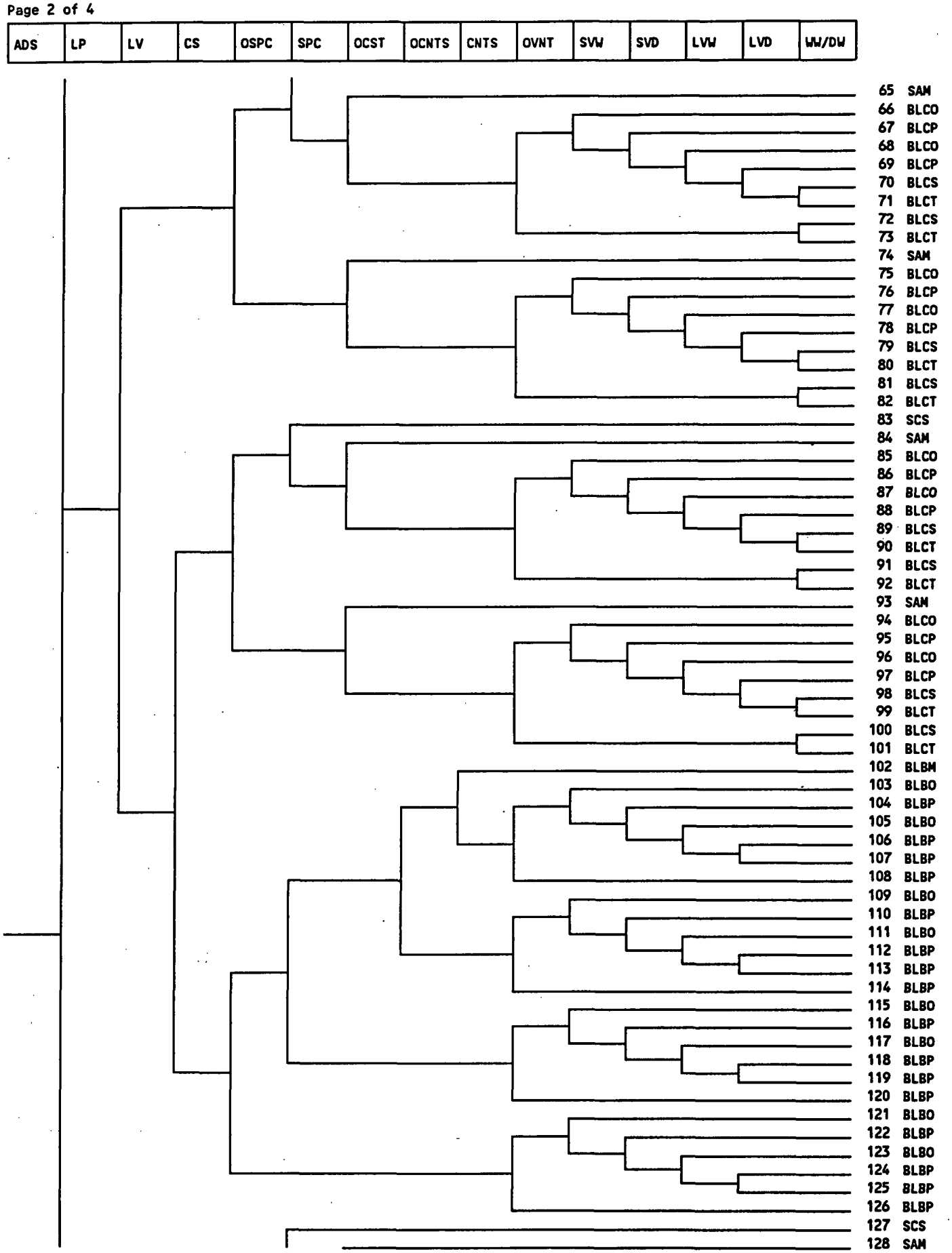
Notes:

1. Success of this node leads to SCS
2. ADS valves will fail closed after four hours (battery depletion) unless offsite power is recovered
3. S = Success
4. F = Failure
5. Blank denotes "not applicable"
6. Success of both nodes lead to SCS.

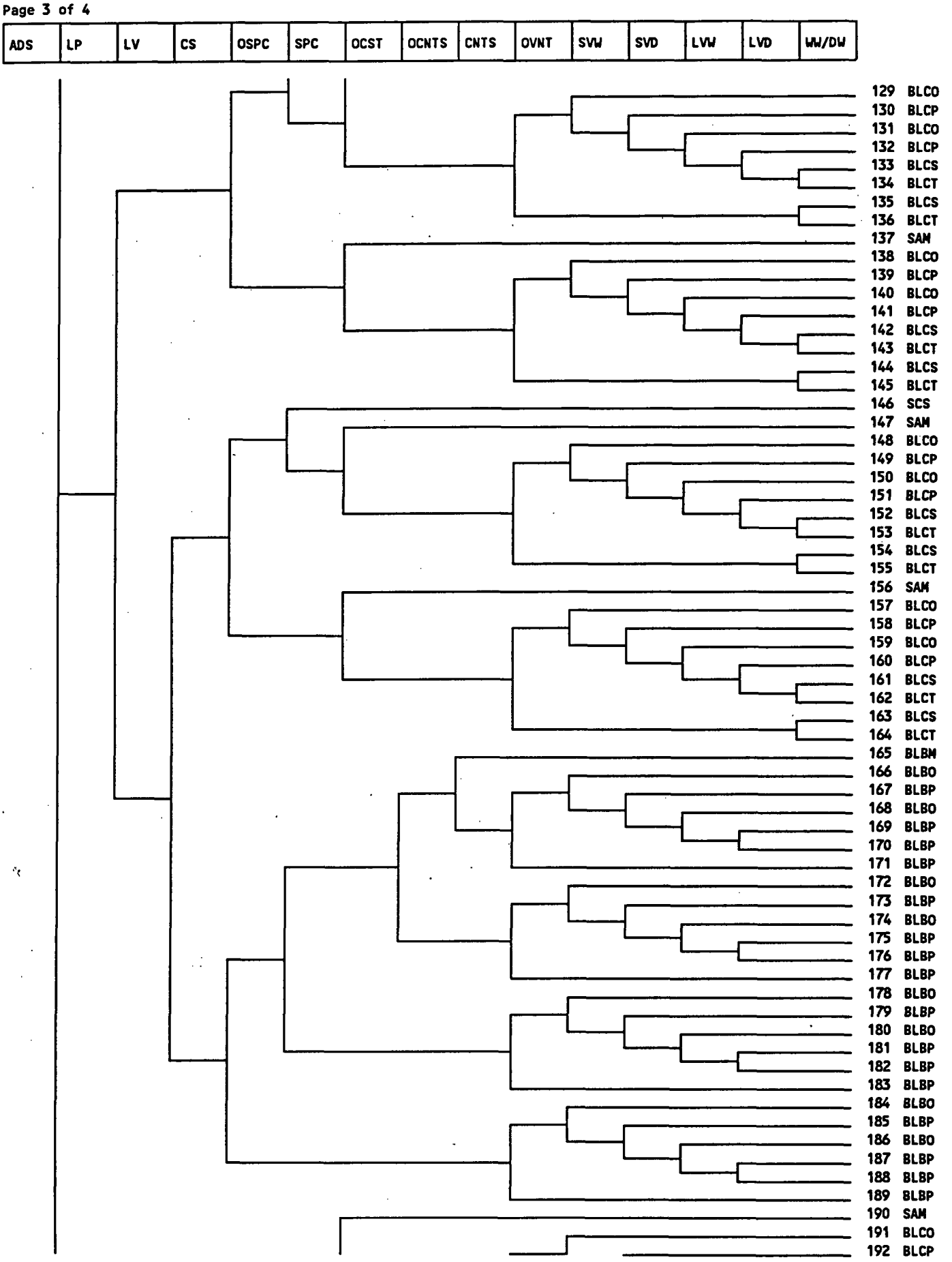
06/10/96 05:36:27 CADET 1.00
SBO7
SBO - LOW PRESSURE PHASE AFTER HPCI SUCCESS, OSP RECOVERED



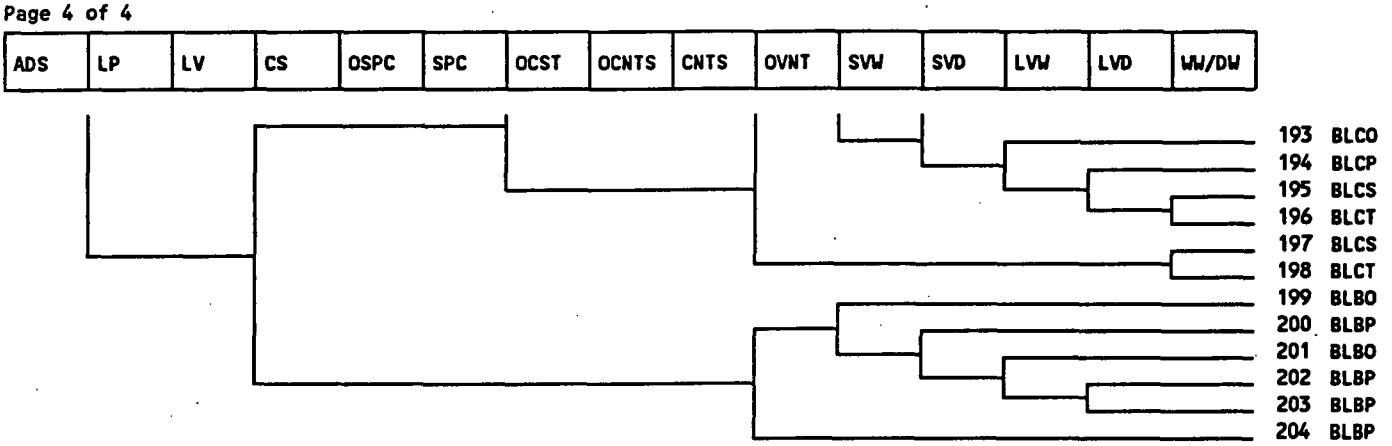
06/10/96 05:36:27 CADET 1.00
SBO7
SBO - LOW PRESSURE PHASE AFTER HPCI SUCCESS, OSP RECOVERED



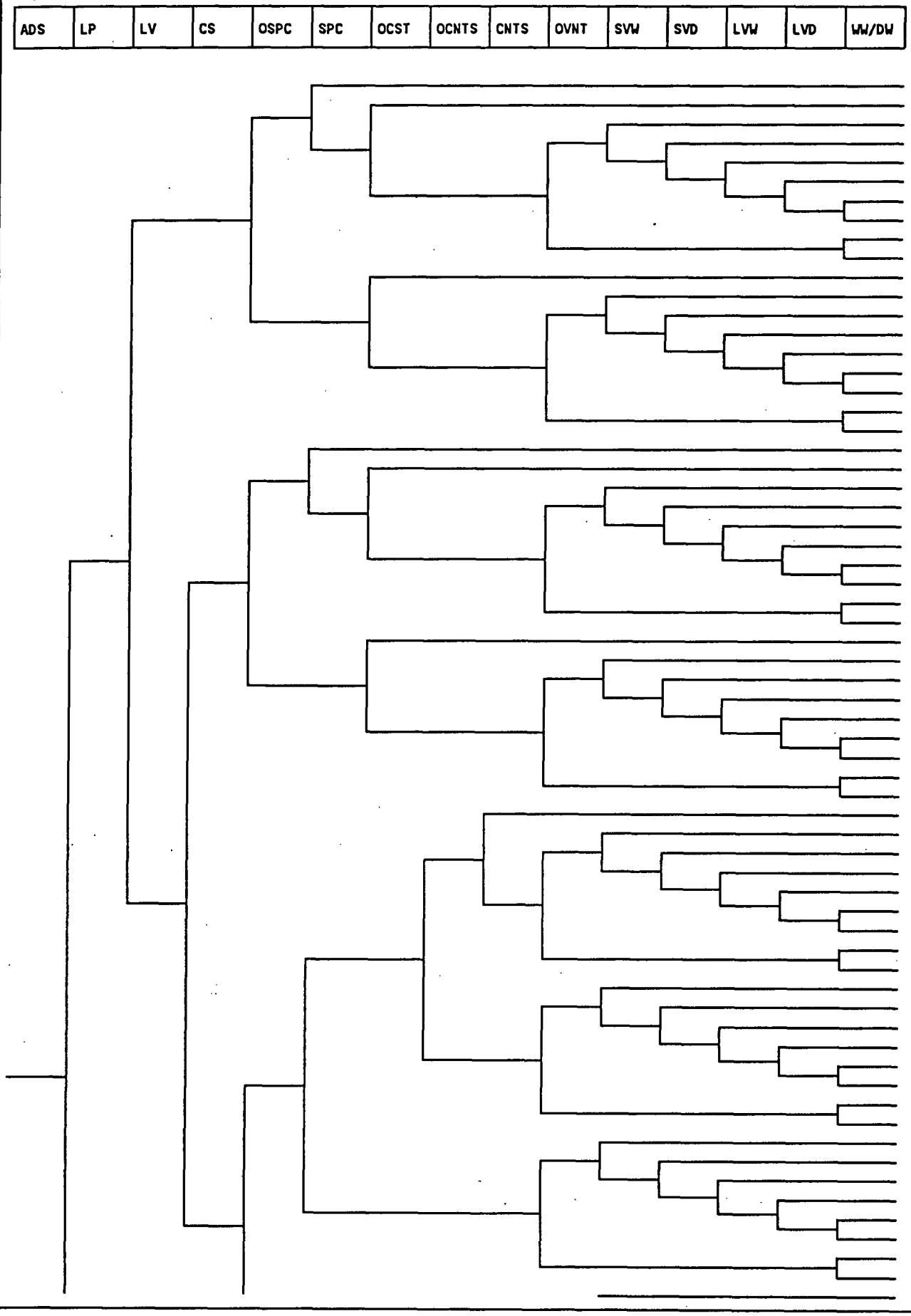
06/10/96 05:36:27 CADET 1.00
SBO7
SBO - LOW PRESSURE PHASE AFTER HPCI SUCCESS, OSP RECOVERED



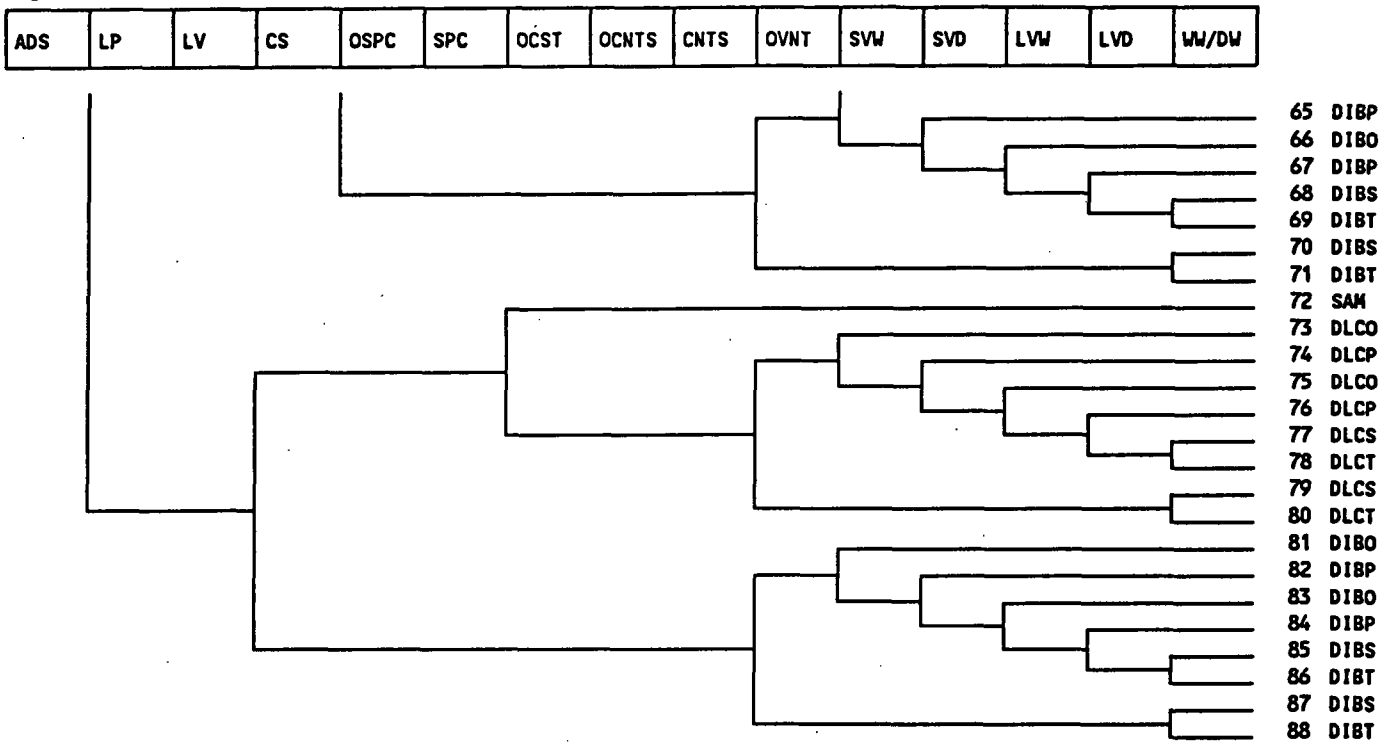
06/10/96 05:36:27 CADET 1.00
SB07
SBO - LOW PRESSURE PHASE AFTER HPCI SUCCESS, OSP RECOVERED



06/10/96 05:36:27 CADET 1.00
TRDC2
LODC (UNIT 2) - LOW PRESSURE PHASE



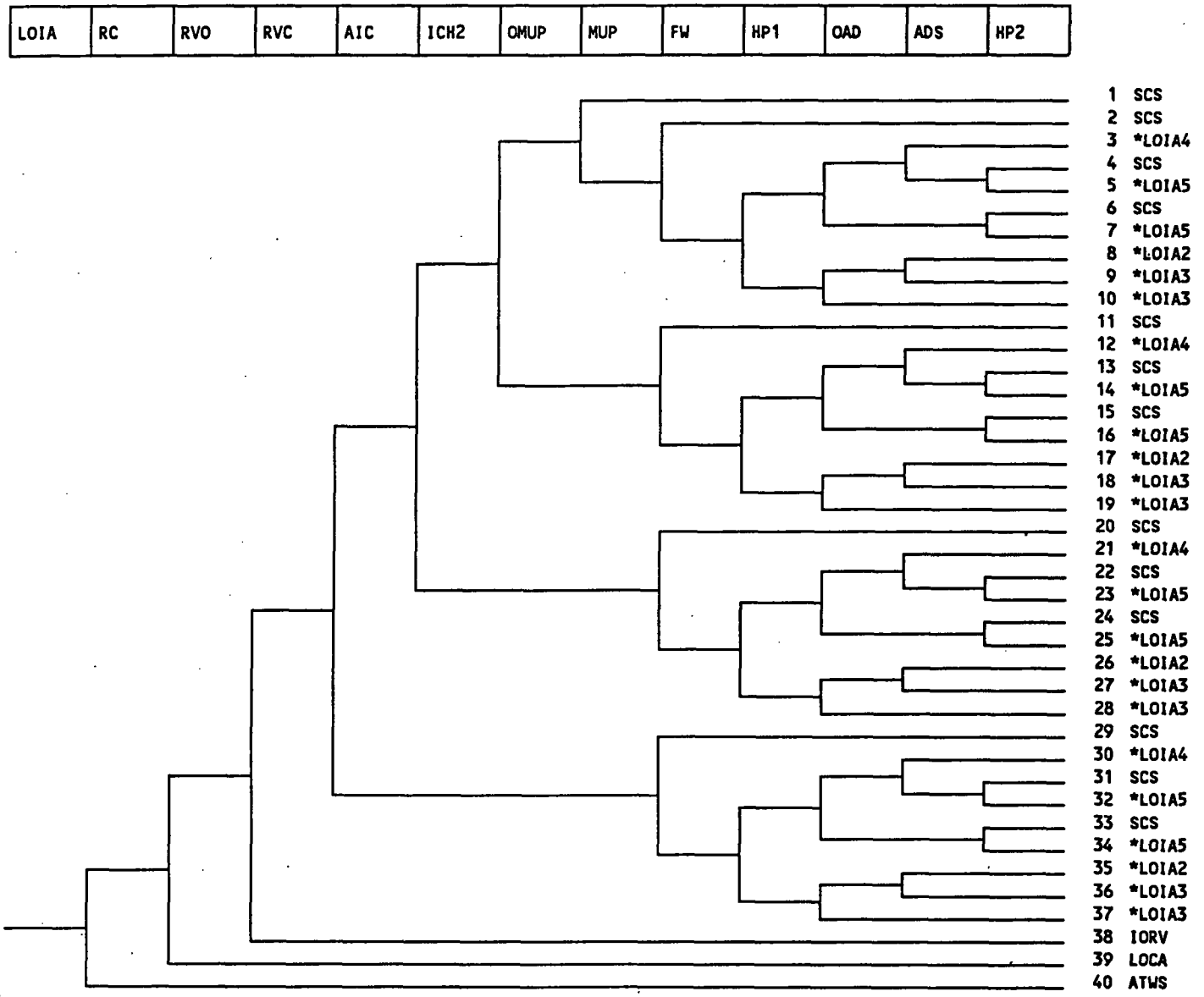
06/10/96 05:36:27 CADET 1.00
TRDC2
LODC (UNIT 2) - LOW PRESSURE PHASE



LOSS OF INSTRUMENT AIR PRT

TREE LOIA1	LOIA - INITIAL PHASE	(1 PAGE)
TREE LOIA2	LOIA - LOW PRESSURE PHASE, HPI FAILURE	(1 PAGE)
TREE LOIA3	LOIA - LOW PRESSURE PHASE, CD/VF AT HI PRSR, HPI FAILURE	(1 PAGE)
TREE LOIA4	LOIA - LOW PRESSURE PHASE AFTER HPCI SUCCESS	(2 PAGES)
TREE LOIA5	LOIA - LOW PRESSURE PHASE AFTER HPCI SUCCESS, CD/VF AT HI PRSR	(1 PAGE)

06/10/96 05:36:27 CADET 1.00
LOIA1
LOIA - INITIAL PHASE



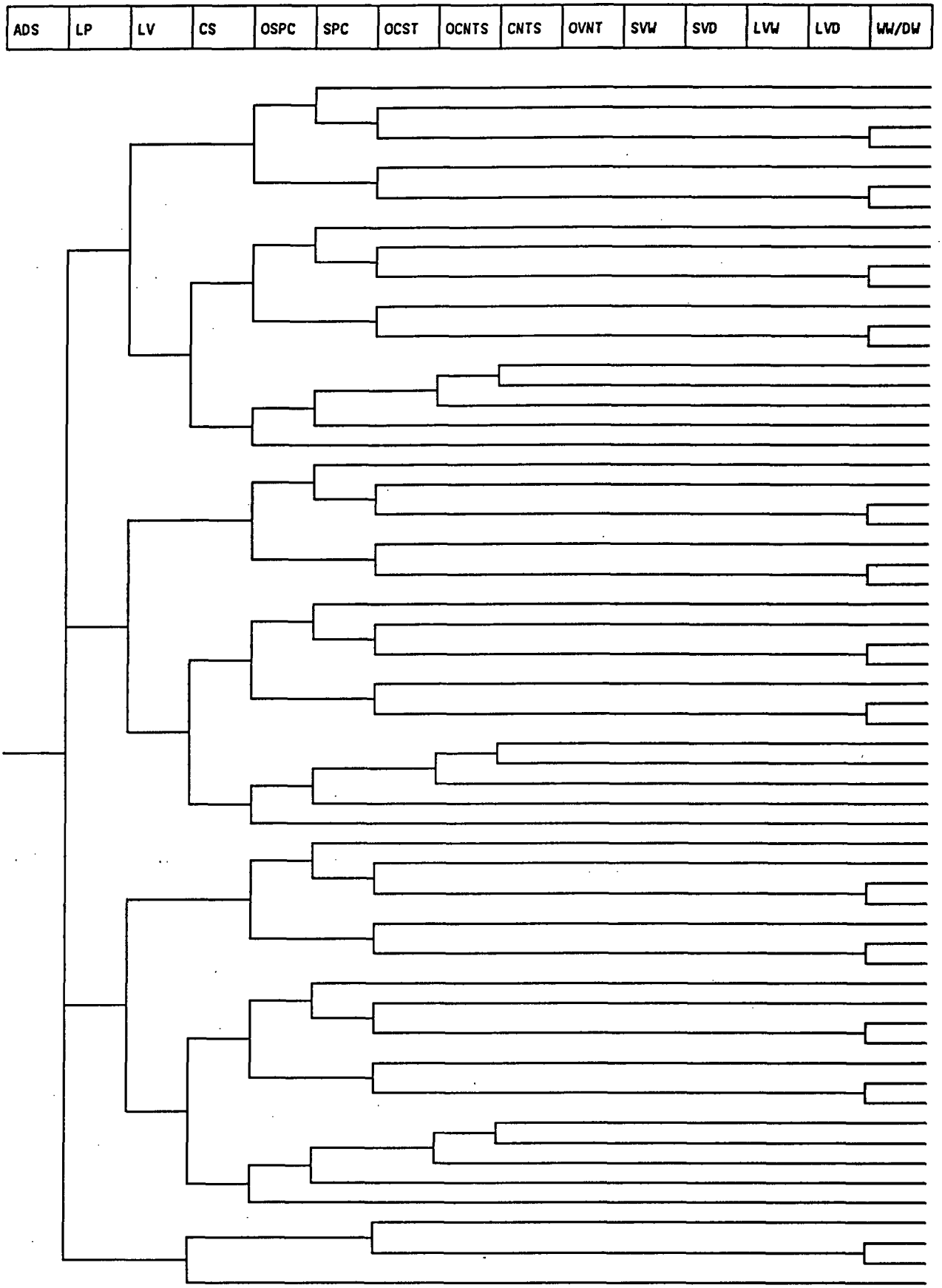
LOIA TREE 2
LOW PRESSURE PHASE, HPI FAILURE
LOIA PRT ENTRY CONDITION SUMMARY

	EQUIPMENT							
LOIA PRT	RC	RVO+RVC	AIC/ICH2	OMUP/MUP[4]	FW[4]	HP1	OAD/ADS	HP2[4]
LOIA-2	S	S	F/S	N/F	F	F	S	N
LOIA-3	S	S	F/S	N/F	F	F	F	N
LOIA-4	S	S	F/S	N/F	F	S	S	N
LOIA-5	S	S	F/S	N/F	F	S	F	F

Notes:

1. S = Success
2. F = Failure
3. N = Not demanded
4. Success of this node leads to SCS

06/10/96 05:36:27 CADET 1.00
LOIA2
LOIA - LOW PRESSURE PHASE, HPI FAILURE



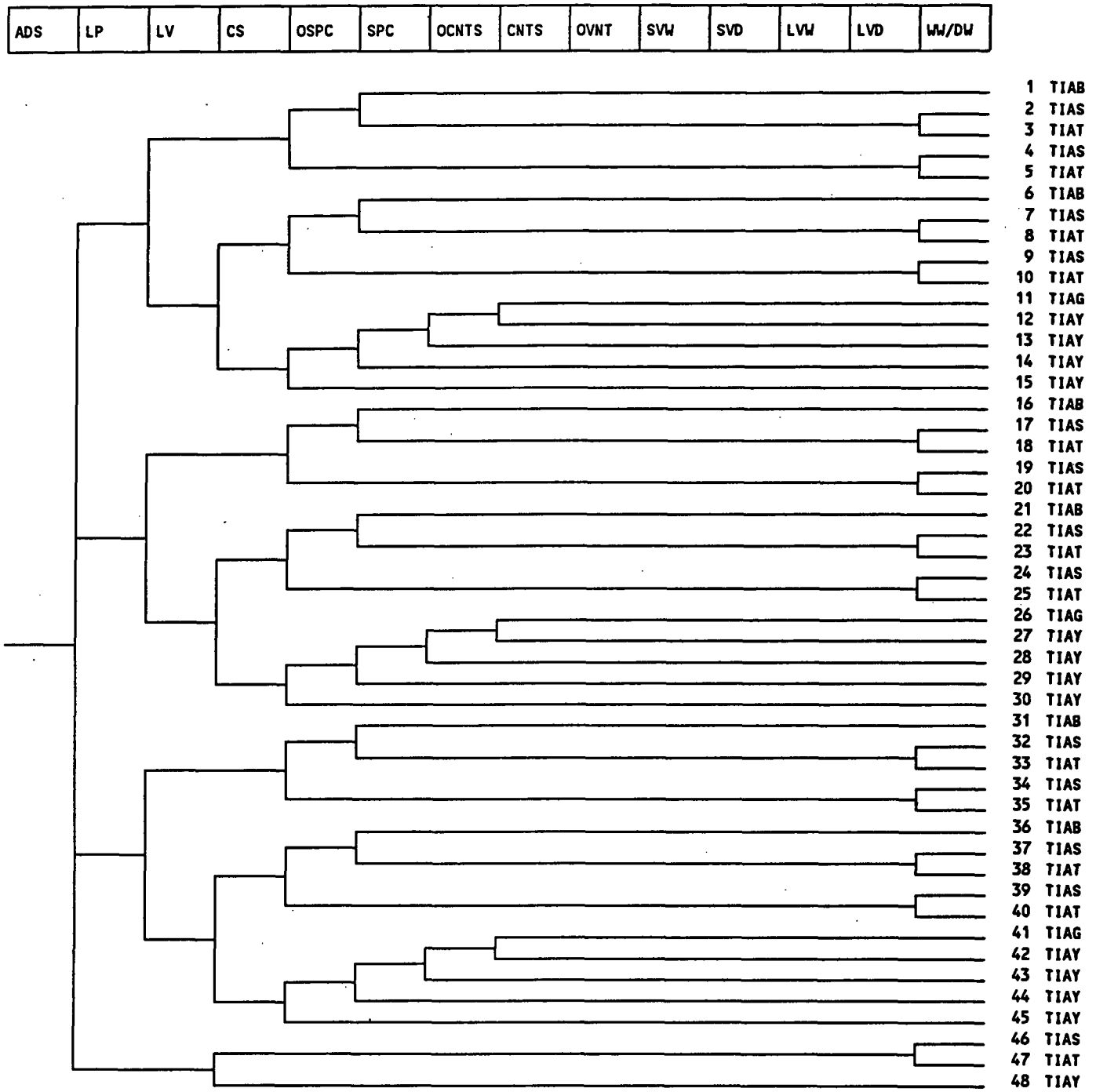
LOIA TREE 3
LOW PRESSURE PHASE, CD/VF AT HIGH PRESSURE, HPI FAILURE
LOIA PRT ENTRY CONDITION SUMMARY

	EQUIPMENT							
LOIA PRT	RC	RVO+RVC	AIC/ICH2	OMUP/MUP[4]	FW[4]	HP1	OAD/ADS	HP2[4]
LOIA-2	S	S	F/S	N/F	F	F	S	N
LOIA-3	S	S	F/S	N/F	F	F	F	N
LOIA-4	S	S	F/S	N/F	F	S	S	N
LOIA-5	S	S	F/S	N/F	F	S	F	F

Notes:

1. S = Success
2. F = Failure
3. N = Not demanded
4. Success of this node leads to SCS

06/10/96 05:36:27 CADET 1.00
LOIA3
LOIA - LOW PRESSURE PHASE, CD/VF AT HI PRSR, HPI FAILURE



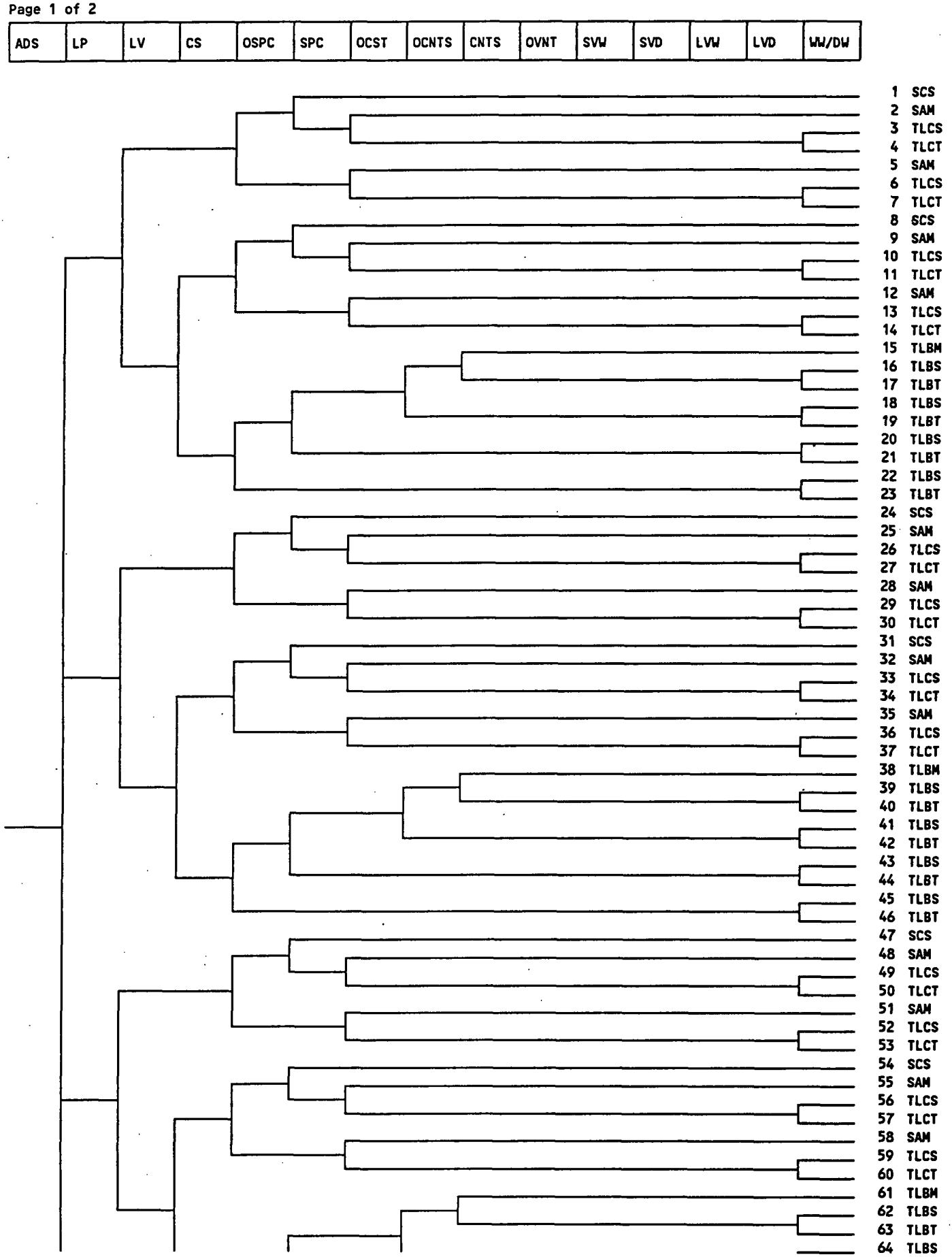
LOIA TREE 4
LOW PRESSURE PHASE AFTER HPCI SUCCESS
LOIA PRT ENTRY CONDITION SUMMARY

	EQUIPMENT							
LOIA PRT	RC	RVO+RVC	AIC/ICH2	OMUP/MUP[4]	FW[4]	HP1	OAD/ADS	HP2[4]
LOIA-2	S	S	F/S	N/F	F	F	S	N
LOIA-3	S	S	F/S	N/F	F	F	F	N
LOIA-4	S	S	F/S	N/F	F	S	S	N
LOIA-5	S	S	F/S	N/F	F	S	F	F

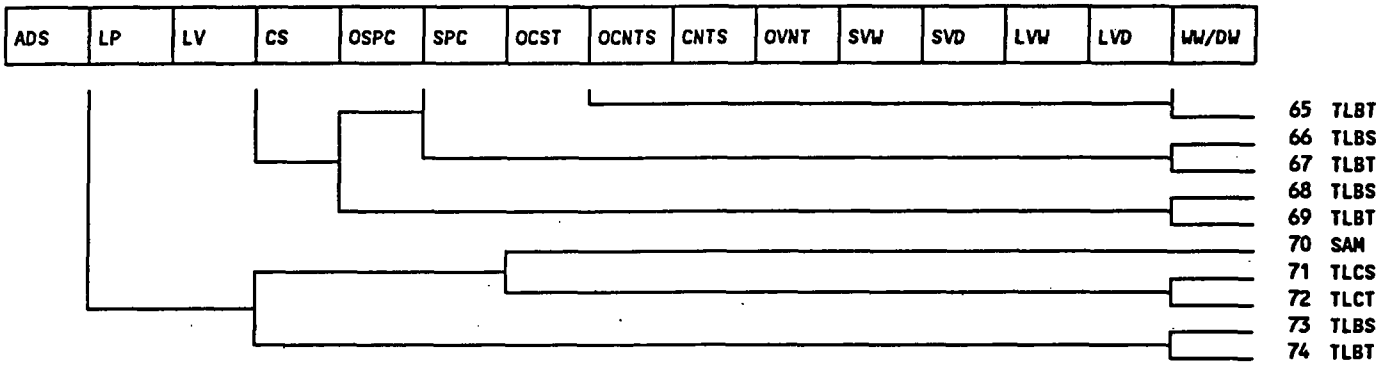
Notes:

1. S = Success
2. F = Failure
3. N = Not demanded
4. Success of this node leads to SCS

06/10/96 05:36:27 CADET 1.00
LOIA4
LOIA - LOW PRESSURE PHASE AFTER HPCI SUCCESS



06/10/96 05:36:27 CADET 1.00
LOIA4
LOIA - LOW PRESSURE PHASE AFTER HPCI SUCCESS



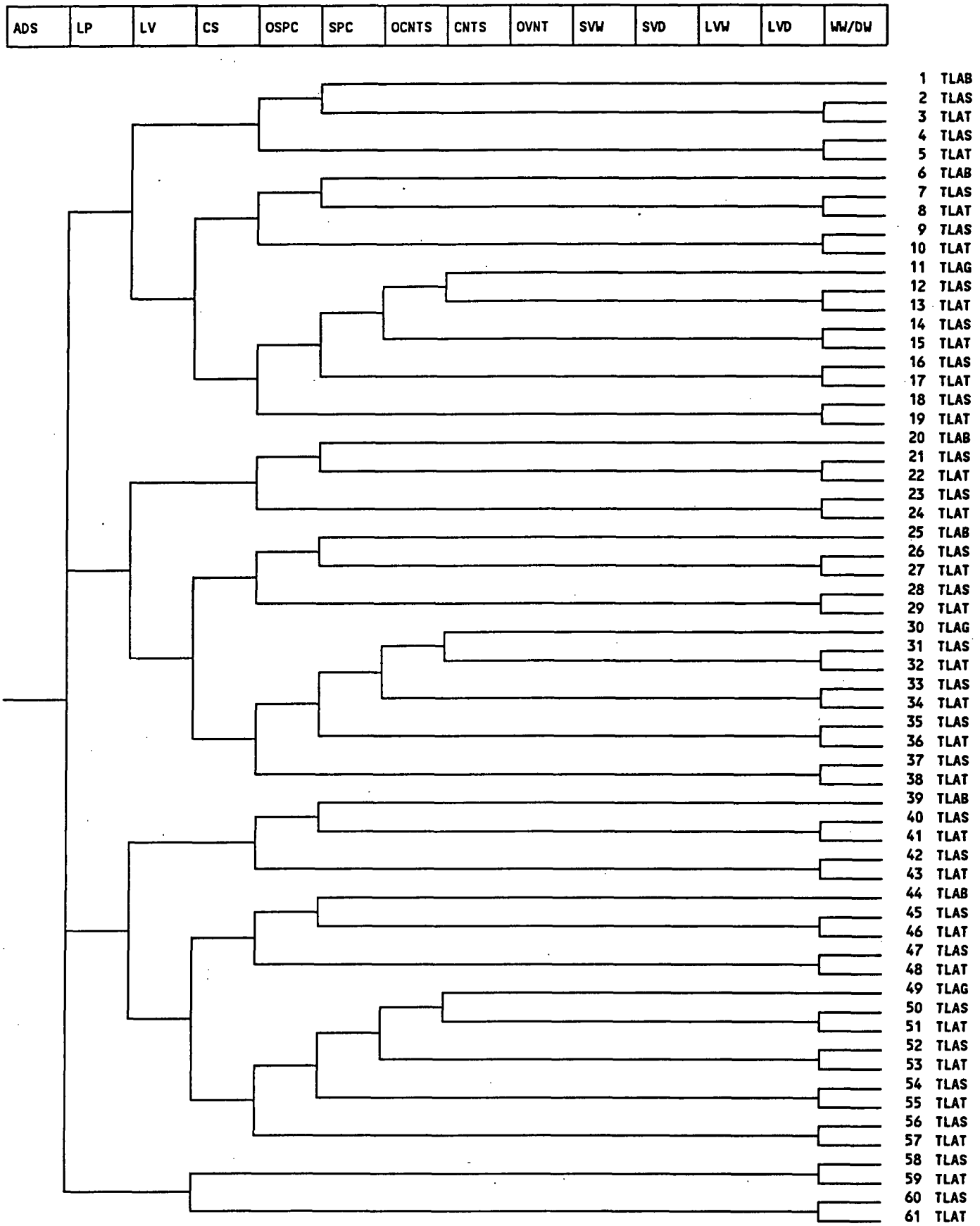
LOIA TREE 5
LOW PRESSURE PHASE AFTER HPCI SUCCESS, CD/VF AT HIGH PRESSURE
LOIA PRT ENTRY CONDITION SUMMARY

	EQUIPMENT							
LOIA PRT	RC	RVO + RVC	AIC/ICH2	OMUP/MUP[4]	FW[4]	HP1	OAD/ADS	HP2[4]
LOIA-2	S	S	F/S	N/F	F	F	S	N
LOIA-3	S	S	F/S	N/F	F	F	F	N
LOIA-4	S	S	F/S	N/F	F	S	S	N
LOIA-5	S	S	F/S	N/F	F	S	F	F

Notes:

1. S = Success
2. F = Failure
3. N = Not demanded
4. Success of this node leads to SCS

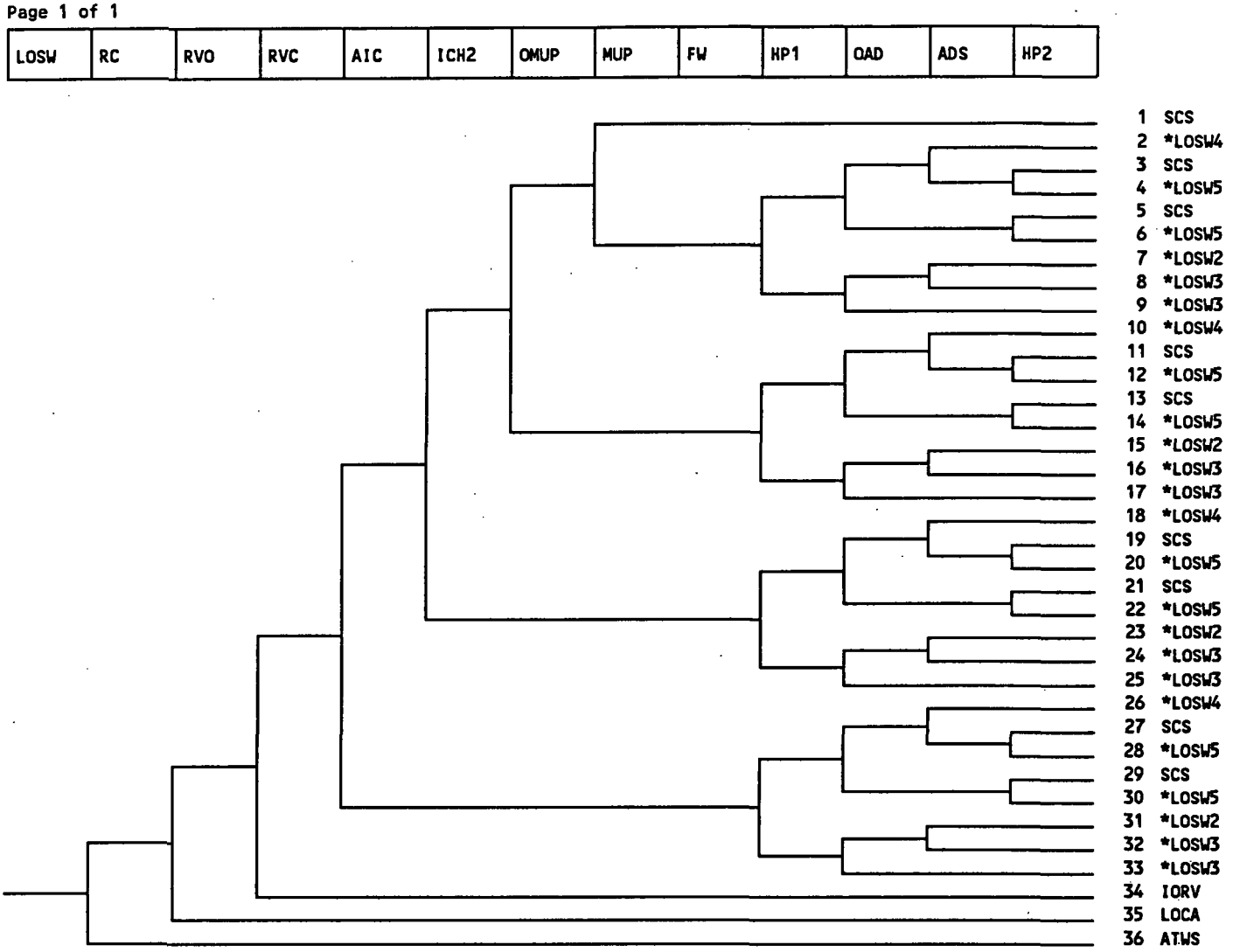
06/10/96 05:36:27 CADET 1.00
LOIA5
LOIA - LOW PRESSURE PHASE AFTER HPCI SUCCESS, CD/VF AT HI PRSR



LOSS OF SERVICE WATER PRT

TREE LOSW1	LOSW - INITIAL PHASE	(1 PAGE)
TREE LOSW2	LOSW - LOW PRESSURE PHASE, HPI FAILURE	(1 PAGE)
TREE LOSW3	LOSW - LOW PRESSURE PHASE, CD/VF AT HI PRSR, HPI FAILURE	(1 PAGE)
TREE LOSW4	LOSW - LOW PRESSURE PHASE AFTER HPCI SUCCESS	(2 PAGES)
TREE LOSW5	LOSW - LOW PRESSURE PHASE AFTER HPCI SUCCESS, CD/VF AT HI PRSR	(1 PAGE)

06/08/96 08:56:34 CADET 1.00
LOSW1
LOSW - INITIAL PHASE



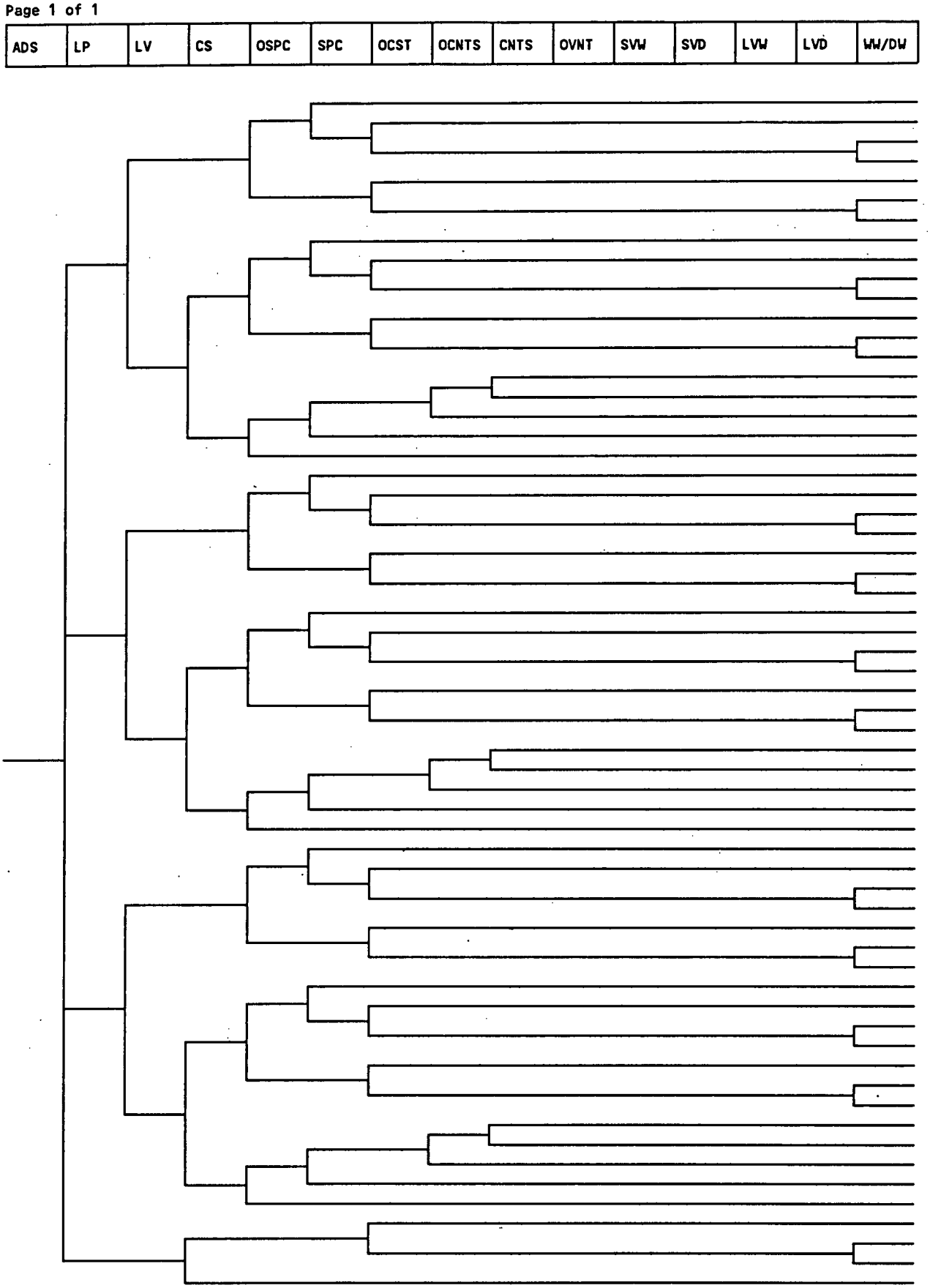
LOSW TREE 2
LOW PRESSURE PHASE, HPI FAILURE
LOSW PRT ENTRY CONDITION SUMMARY

	EQUIPMENT							
LOSW PRT	RC	RVO+RVC	AIC/ICH2	OMUP/MUP[4]	FW[4]	HP1	OAD/ADS	HP2[4]
LOSW-2	S	S	F/S	N/F	F	F	S	N
LOSW-3	S	S	F/S	N/F	F	F	F	N
LOSW-4	S	S	F/S	N/F	F	S	S	N
LOSW-5	S	S	F/S	N/F	F	S	F	F

Notes:

1. S = Success
2. F = Failure
3. N = Not demanded
4. FW fails on LOSW

06/08/96 08:56:34 CADET 1.00
LOSW2
LOSW - LOW PRESSURE PHASE, HPI FAILURE



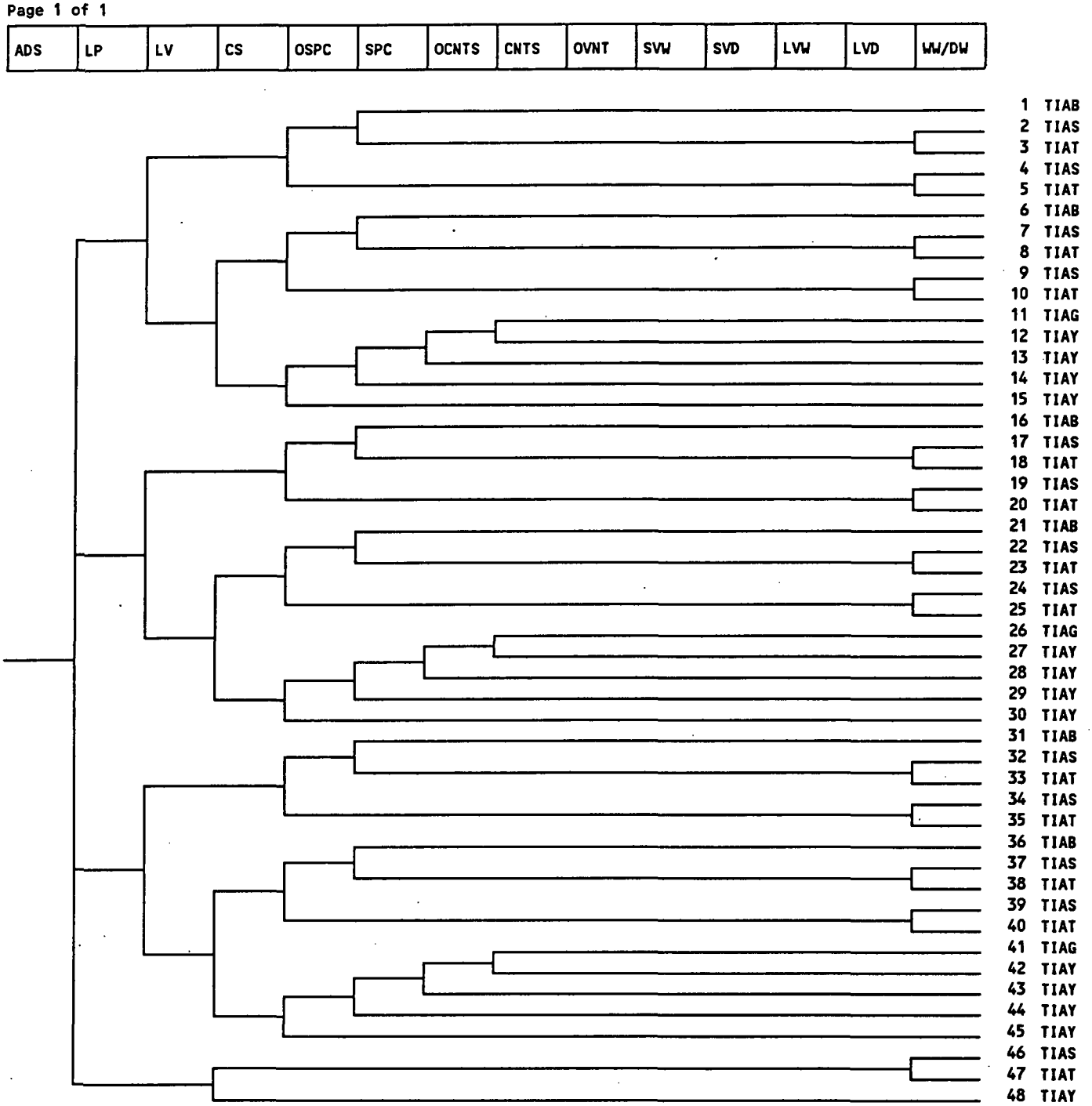
LOSW TREE 3
LOW PRESSURE PHASE, CD/VF AT HIGH PRESSURE, HPI FAILURE
LOSW PRT ENTRY CONDITION SUMMARY

	EQUIPMENT							
LOSW PRT	RC	RVO+RVC	AIC/ICH2	OMUP/MUP[4]	FW[4]	HP1	OAD/ADS	HP2[4]
LOSW-2	S	S	F/S	N/F	F	F	S	N
LOSW-3	S	S	F/S	N/F	F	F	F	N
LOSW-4	S	S	F/S	N/F	F	S	S	N
LOSW-5	S	S	F/S	N/F	F	S	F	F

Notes:

1. S = Success
2. F = Failure
3. N = Not demanded
4. FW fails on LOSW

06/08/96 08:56:34 CADET 1.00
LOSW3
LOSW - LOW PRESSURE PHASE, CD/VF AT HI PRSR, HPI FAILURE



LOSW TREE 4
LOW PRESSURE PHASE AFTER HPCI SUCCESS
LOSW PRT ENTRY CONDITION SUMMARY

	EQUIPMENT							
LOSW PRT	RC	RVO+RVC	AIC/ICH2	OMUP/MUP[4]	FW[4]	HP1	OAD/ADS	HP2[4]
LOSW-2	S	S	F/S	N/F	F	F	S	N
LOSW-3	S	S	F/S	N/F	F	F	F	N
LOSW-4	S	S	F/S	N/F	F	S	S	N
LOSW-5	S	S	F/S	N/F	F	S	F	F

Notes:

1. S = Success
2. F = Failure
3. N = Not demanded
4. FW fails on LOSW

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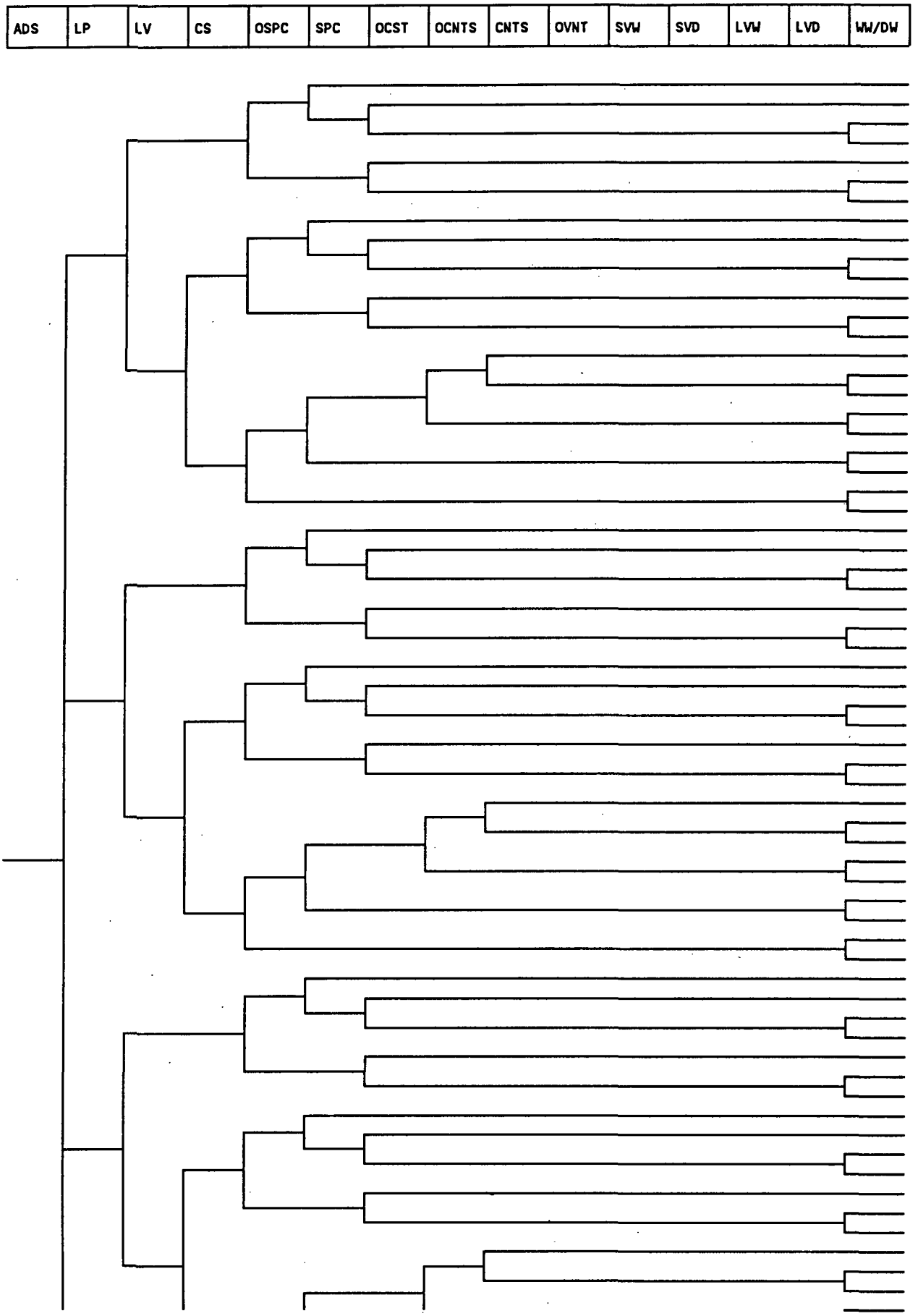
LOSW4
LOSW - LOW PRESSURE PHASE AFTER HPCI SUCCESS



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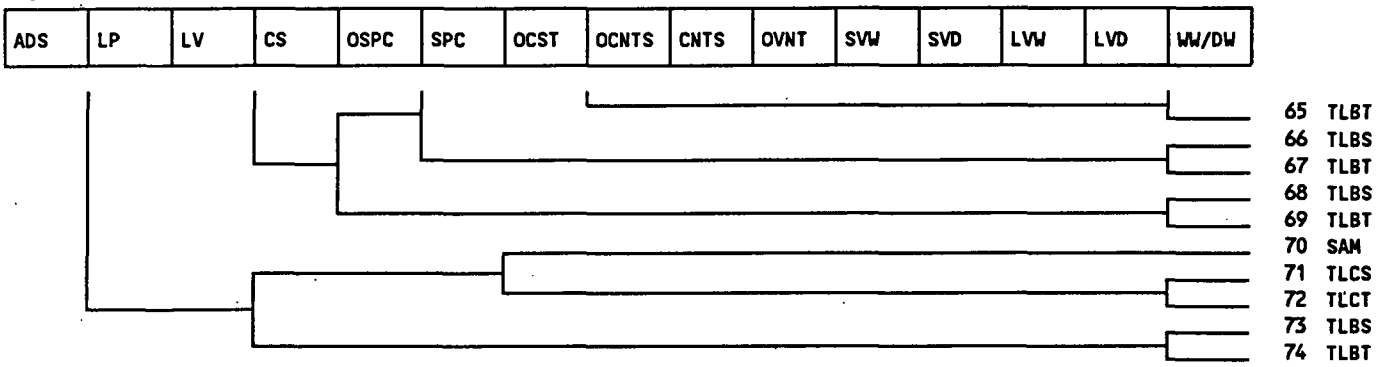
LOSW4

LOSW - LOW PRESSURE PHASE AFTER HPCI SUCCESS



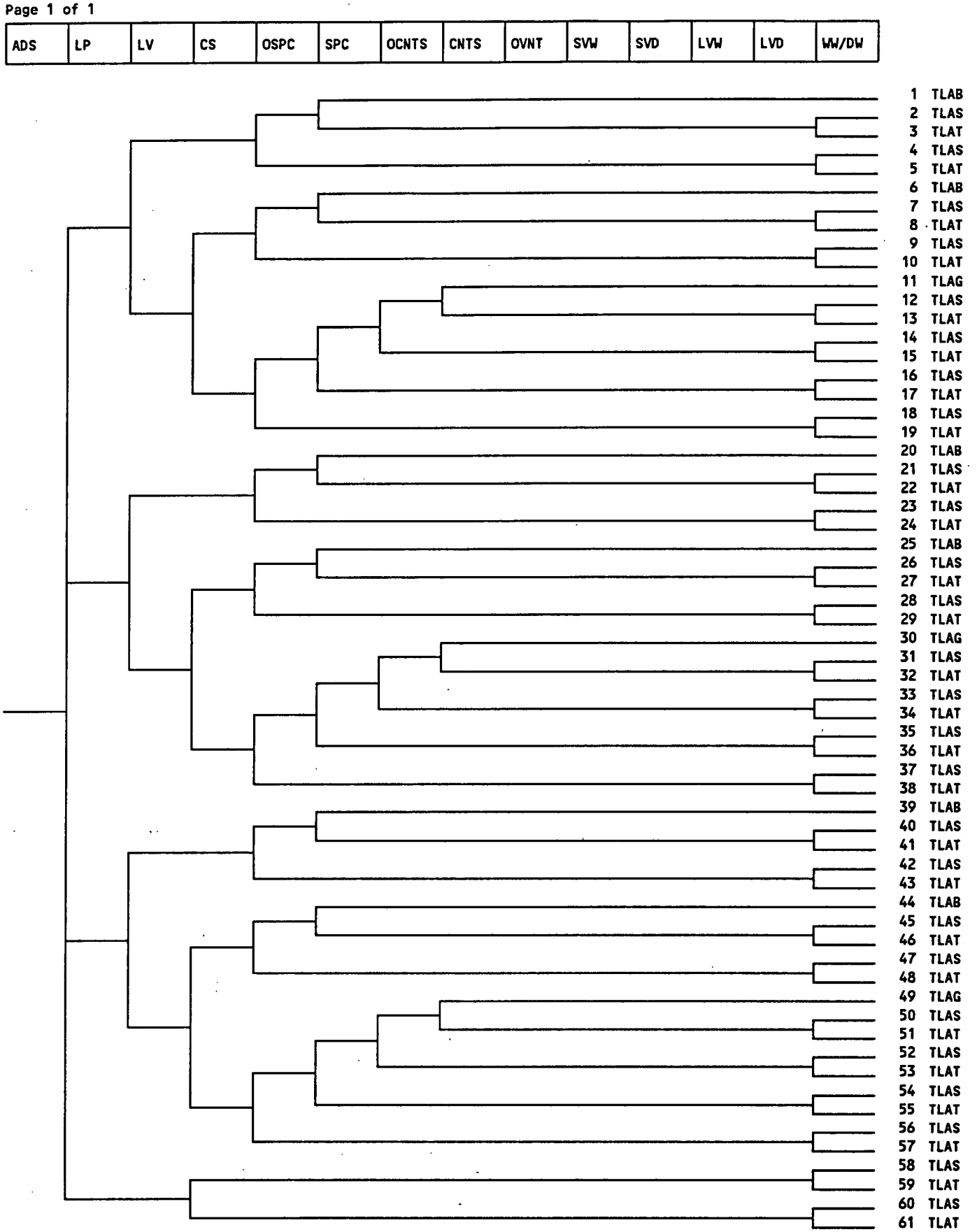
LOSW TREE 5
LOW PRESSURE PHASE AFTER HPCI SUCCESS, CD/VF AT HIGH PRESSURE
LOSW PRT ENTRY CONDITION SUMMARY

	EQUIPMENT							
LOSW PRT	RC	RVO+RVC	AIC/ICH2	OMUP/MUP[4]	FW[4]	HP1	OAD/ADS	HP2[4]
LOSW-2	S	S	F/S	N/F	F	F	S	N
LOSW-3	S	S	F/S	N/F	F	F	F	N
LOSW-4	S	S	F/S	N/F	F	S	S	N
LOSW-5	S	S	F/S	N/F	F	S	F	F

Notes:

1. S = Success
2. F = Failure
3. N = Not demanded
4. FW fails on LOSW

06/08/96 08:56:34 CADET 1.00
LOSW5
LOSW - LOW PRESSURE PHASE AFTER HPCI SUCCESS, CD/VF AT HI PRSR



DEPENDENCY MATRICES

General Notes

The format of each matrix is similar. The first column on the left is the system or event to be examined. An entry in one of the subsequent columns indicates that the system listed at the top of the table is dependent to some degree upon the system(s) or event(s) listed in the first column. The level of dependence is indicated by a "C", "P", "D", "I" or "A".

C
The system at the top of the column is completely dependent upon the system or event listed on the left. If the system at the left fails or is unavailable, or if the initiating event occurs, the system at the top of the matrix will be unavailable.

P
Partial dependence of the system at the top on the event or the system at the left. The event may degrade a system's ability to perform its function but not completely fail the system.

D
Delayed impact on the system at the top of the matrix by the event or system failure at the left. Delayed dependence is exemplified by the support system providing room cooling. Loss of room cooling may not immediately cause a failure of other systems, but may, over an extended period, cause a system to fail during its mission time.

I
An interconnection between systems that is not technically defined as a dependency but is utilized by the system at the top of the matrix in some way. Components (other than piping) are shared.

A
System on the left can be used as an alternate (or backup) source to the system at the top of the matrix. For example, the primary water source for isolation condenser makeup is the clean demineralized water system; alternate water sources are from the contaminated Condensate Storage Tanks (CSTs) and the fire protection water system.

A blank row/column intersection means that the system at the top is not directly dependent on the system/event at the left. "Cascading" dependencies may still exist, however. For example, system Y has a delayed dependency on system X, and system Z has a partial dependence on system Y, but no other dependence on system X. In this case, the dependency of Y on X would be shown by the matrix, as would the dependency of Z on Y; the Z/X intersection would generally be left blank, however.

An additional column U 2/3 DEP (Unit 2/3 Dependency) has been added to each system/system matrix to indicate the degree of inter-unit dependence for each system for Units 2 and 3. The systems at the Dresden Site are noted on the matrix as belonging to one of three categories: I = Independent, S = Shared, X = Cross-tied. Independent systems are those which function solely at the unit where they are located. For example, the High Pressure Coolant Injection (HPCI) systems at Units 2 and 3 are independent. Shared systems normally serve both units simultaneously, e.g., the service water system. Cross-tied systems are those which normally operate independently at each unit but are capable of serving as a backup to the opposite unit's system by supplying support through the cross-tie between the systems, e.g., the instrument air system at each unit.

For the purposes of identification, frontline systems are defined as those systems that are operational at the time of the transient. Safety systems are those systems required to respond to the event. The "Additional Systems" are defined as those systems which are identified in the Emergency Operating Procedures or which prove useful in accident management strategies. Support systems are those systems providing support in the form of AC or DC electrical power or other motive power (such as air), or cooling/lubrication to components of the front line, safety or additional systems. These are not plant designations. They are used only to simplify the application of dependency analysis.

TABLE 4.2.2-1

INITIATOR/FRONTLINE SYSTEMS DEPENDENCY MATRIX

INITIATING EVENT	FW	COND	RPS
Transient w/ FW and MC available			
Transient w/ FW available & MC unavailable		C(1)	
Transient w/ FW unavailable & MC available	C(1)		
Transient FW & MC unavailable	C(1)	C(1)	
LOOP (single unit)	C(2)	P(3)	P(6)
LOOP (dual unit)	C(2)	P(3)	P(6)
IORV	D(5)	D(5)	
Loss of 125VDC (main bus)	P(4)	P(4)	
Loss of Service Water	D(8)	D(8)	
LLOCA	D(5)	D(5)	
MLOCA	D(5)	D(5)	
SLOCA	D(5)	D(5)	
ISLOCA	D(5)	D(5)	
Loss of 4 kV Bus 21	P(2)		
Loss of 4 kV Bus 22	P(2)		
Loss of 4 kV Bus 23		P(7)	A(6)
Loss of 4 kV Bus 24		P(7)	A(6)
Loss of 480 VAC Bus 28		D(9)	P(10)
Loss of 480 VAC Motor Control Center 28-2		D(9)	P(10)
Loss of Instrument Air	P(11)	D(12)	

Notes for Table 4.2.2-1:

1. Frontline system has failed as part of the IE definition.

2. Feed pumps are powered from 4160 Buses 21, 22.

3. Condensate pumps are powered from 4160 Buses 23, 24. The diesel generators provide alternate power. A LOOP will leave the system in a degraded state.

4. 125VDC power is required to close the 4160VAC pump current breakers. Although the loss of 125 VDC (main bus) initiator was eliminated for unit 2 after submittal of the original IPE, dependency information has been left in the tables for historical information.

5. A LOCA will deplete the inventory of the condenser leading to a loss of suction to the FW and COND pumps.

6. The RPS Motor Generators (MGs) are powered from 480VAC buses 28 & 29. The diesel generators provide alternate power to these buses. A LOOP will leave the system power supply in a degraded state; however, RPS is a fail-safe system and a loss of power will lead to a reactor scram. Reserve power to RPS buses is supplied from MCC 25-2.

7. Condensate pumps are powered from 4 kV Buses 23, 24.

8. Service Water is the heat sink for the TBCCW system. Loss of SW would result in a delayed failure of TBCCW. Loss of TBCCW system would result in loss of cooling to RFP oil coolers and overheating of RFP bearings.

9. Bus 28 feeds MCC 28-2 which provides power to Condensate Transfer Jockey Pump and Condensate Transfer Pump 2A.

10. Bus 28 feeds MCC 28-2 which powers RPS MG set A which is the normal power supply to RPS Bus A. Reserve power to the RPS buses is supplied from MCC 25-2.

11. Instrument air supplies all air-operated valves in FW&C systems. Feedwater Regulating Valves fail as-is on loss of IA or control signal. The RFP recirculation valves fail open on loss of instrument air or control power.

12. Makeup to the hotwell is via two air-operated valves (LCV 2-3301, 3302), air service is instrument air, and control power is from the Essential Service Bus.

TABLE 4.2.2-2

INITIATOR/SAFETY SYSTEMS DEPENDENCY MATRIX

INITIATING EVENT	RPT	ARI	ERV	TR/SRV	SV	HPCI	ADS	LPCI	CS	IC
Transient w/ FW and MC available			I(9)	I(9)	I(9)					
Transient w/ FW available & MC unavailable			I(9)	I(9)	I(9)					
Transient w/ FW unavailable & MC available			I(9)	I(9)	I(9)					
Transient FW & MC unavailable			I(9)	I(9)	I(9)					
LOOP (single unit)								P(8)	P(8)	P(8)
LOOP (dual unit)								P(8)	P(8)	P(8)
IORV			P(10)	P(10)	P(10)	D(3)				
Loss of 125VDC (main bus)	P(1)	P(1)	P(1)			P(1)	P(1)	P(1)	P(1)	C(7)
Loss of Service Water										
LLOCA						C(3)		P(4)	P(4)	
MLOCA						D(3,4)		P(4)	P(4)	
SLOCA						D(3,4)		P(4)	P(4)	

INITIATING EVENT	RPT	ARI	ERV	TR/SRV	SV	HPCI	ADS	LPCI	CS	IC
ISLOCA						D(3,4)		P(5)	P(5)	P(5)
Loss of 4 kV Bus 21										
Loss of 4 kV Bus 22										
Loss of 4 kV Bus 23										
Loss of 4 kV Bus 24										
Loss of 480 VAC Bus 28								P(2)	P(2)	
Loss of 480 VAC Motor Control Center 28-2										
Loss of Instrument Air						P(11)				

Notes for Table 4.2.2-2:

1. Loss of single DC will degrade these systems.

2. LPCI system components powered by 480 VAC Bus 28 include:

MCC 28-1	MOV 1501-3A
	MOV 1501-27A
	MOV 1501-28A
	LPCI/CS AREA COOLER 2A
	MOV 1501-5A
	MOV 1501-5B

Notes for Table 4.2.2-2 (continued):

MOV 1501-11A
MOV 1501-13A
MOV 1501-18A
MOV 1501-19A
MOV 1501-20A
MOV 1501-32A
MOV 1501-38A

MCC 28-7 MOV 1501-21A, 22A

CS System Components powered by 480 VAC Bus 28 include:

MCC 28-1 Power to valves MO2-1402-3A, 38A, 4A, 24A, 25A

3. HPCI requires steam from the reactor to operate; depending on the time to lose steam pressure, HPCI may be available for a short time.

4. A LOCA may create a path by which injected coolant can bypass the core and flow directly out the break to the containment.

5. These systems interface with the RPV and are evaluated as initiators of ISLOCAs. An ISLOCA could cause at least one train of these systems to be unavailable.

6. The IC isolation valves are powered from 250VDC which gets the power supply from 28, 29.

7. Loss of either 125VDC bus activates the IC high steam flow signal and isolates the IC for both units.

8. These systems involve pumps that are powered from ESF AC buses. The alternate power source is from diesel generators 2 and 2/3. A LOOP will leave the system in a degraded state.

9. The rapid pressure surge in the reactor vessel due to an ATWS would challenge the relief valve system and could cause them to stick open.

10. IORV fails at least one of the ERVs or SVs or the TR/SRV.

11. Instrument Air is required to maintain HPCI steamline drain valves 64, 65 open. Valves fail closed on loss of IA. The drain valves would automatically close on HPCI initiation, however.

TABLE 4.2.2-3
INITIATOR/ADDITIONAL SYSTEMS DEPENDENCY MATRIX

INITIATING EVENT	SLC	SBCS	SPC	CNTS	FP	SBGT	HARD VENT
Transient w/ FW and MC available							
Transient w/ FW available & MC unavailable							
Transient w/ FW unavailable & MC available							
Transient FW & MC unavailable							
LOOP (single unit)	P(1)	P(1)	P(1)	P(1)	P(4)	P(1)	P(1)
LOOP (dual unit)	P(1)	P(1)	P(1)	P(1)	P(4)	P(1)	P(1)
IORV							
Loss of 125VDC (main bus)			P(2)	P(2)			
Loss of Service Water		C(5)			A(6)		
LLOCA							
MLOCA							
SLOCA							
ISLOCA							
Loss of 4 kV Bus 21							
Loss of 4 kV Bus 22							
Loss of 4 kV Bus 23		P(7)					
Loss of 4 kV Bus 24		P(7)					
Loss of 480 VAC Bus 28	P(8)		P(9)	P(10)		P(13)	

INITIATING EVENT	SLC	SBCS	SPC	CNTS	FP	SBGT	HARD VENT
Loss of 480 VAC Motor Control Center 28-2						P(13)	
Loss of Instrument Air						C(11)	C(12)

Notes for Table 4.2.2-3:

1. These systems involve equipment that is powered from ESF buses. Alternate power sources are the DG2 and DG 2/3. A LOOP will leave the system in a degraded state using emergency power sources.

2. Loss of a single DC bus will degrade these systems.

3. Loss of both DC buses will fail these systems.

4. Fire Protection is backed up with diesel fire pumps. A loss of AC would leave the system in a degraded state using emergency equipment.

5. SW is the SBCS supply.

6. Service Water is one of the backups to the diesel-driven fire pumps. SW, via cross-tie, maintains normal pressure in the fire protection header. Loss of SW would result in an auto-start signal for one or both of the diesel-driven fire pumps.

7. SBCS requires at least one SW pump. The SW pumps are powered by 4 kV buses 23, 24, 33, and 34.

8. SLC pump A, Explosive Valve 2A-1106A and SBLC suction line heat tracing supplied by 480 VAC MCC 28-1.

9. Power supplies for LPCI components used in Division I suppression pool cooling mode are given in Note 2 of Table 4.2.2-2.

10. Power supplies for LPCI components used in Division I contanment spray cooling mode are given in Note 2 of Table 4.2.2-2.

11. The containment vent valves to SBGT are supplied by instrument air.

12. The valves in the hardened vent (APCV) system are air-operated valves supplied by instrument air.

13. The A train of SBGT is dependent on 480 VAC Bus 28 and MCC 28-2.

TABLE 4.2.2-4
INITIATOR/SUPPORT SYSTEMS DEPENDENCY MATRIX

INITIATING EVENT	TBCCW	SW	CCSW	DGCW	ECCS-FILL	CLEAN DEMIN	COND TRANS	INST AIR
Transient w/ FW and MC available								
Transient w/ FW available & MC unavailable								
Transient w/ FW unavailable & MC available								
Transient FW & MC unavailable								
LOOP (single unit)	P(1)	P(1)	P(1)	P(1)	P(1)	P(1)	P(1)	P(1)
LOOP (dual unit)	P(1)	P(1)	P(1)	P(1)	P(1)	P(1)	P(1)	P(1)
IORV								
Loss of 125VDC (main bus)		P(8)	P(8)					
Loss of Service Water	D(10)		I(11)					
LLOCA								
MLOCA								
SLOCA								
ISLOCA								
Loss of 4 kV Bus 21								
Loss of 4 kV Bus 22								
Loss of 4 kV Bus 23	P(12)	P(12)	P(12)			P(12)		P(12)
Loss of 4 kV Bus 24	P(12)	P(12)	P(12)			P(12)		P(12)
Loss of 480 VAC Bus 28		D(15)	P(16)	C(17)	C(17)		C(17)	
Loss of 480 VAC Motor Control Center 28-2		D(15)	P(16)				C(17)	
Loss of Instrument Air	P(2)	D(15)						

TABLE 4.2.2-4 INITIATOR/SUPPORT SYSTEMS DEPENDENCY MATRIX (Continued)

INITIATING EVENT	PUMPBACK AIR	HVAC	CST	SUPP POOL	HW	CAS	OFFSITE POWER	DG2	DG 2/3
Transient w/ FW and MC available									
Transient w/ FW available & MC unavailable									
Transient w/ FW unavailable & MC available									
Transient FW & MC unavailable									
LOOP (single unit)	P(1)	P(1)					C(10)	D(4)	D(4)
LOOP (dual unit)	P(1)	P(1)					C(10)	D(4)	D(4)
IORV									
Loss of 125VDC(main bus)						P(3)		C(4)	P(4)
Loss of Service Water		P(13)			A(14)				
LLOCA									
MLOCA									
SLOCA									
ISLOCA									
Loss of 4 kV Bus 21									
Loss of 4 kV Bus 22									
Loss of 4 kV Bus 23		P(12)							
Loss of 4 kV Bus 24		P(12)							
Loss of 480 VAC Bus 28	P(17)	C(17)						P(17)	C(17)
Loss of 480 VAC Motor Control Center 28-2		C(17)						P(17)	
Loss of Instrument Air									

TABLE 4.2.2-4 INITIATOR/SUPPORT SYSTEMS DEPENDENCY MATRIX (Continued)

INITIATING EVENT	NON-ESF AC BUSES	NON-EMERGENCY ESF AC BUSES	4160VAC BUS 23-1	4160VAC BUS 24-1	480VAC BUS 28	480VAC BUS 29	250VDC TB MCC2	250VDC TBMCC3
Transient w/ FW and MC available								
Transient w/ FW available & MC unavailable								
Transient w/ FW unavailable & MC available								
Transient FW & MC unavailable								
LOOP (single unit)	C(5)	P(1)	P(1)	P(1)	P(1)	P(1)	P(1)	P(1)
LOOP (dual unit)	C(5)	P(1)	P(1)	P(1)	P(1)	P(1)	P(1)	P(1)
IORV								
Loss of 125VDC (main bus)	P(6)	P(6)	C(6)		C(6)			
Loss of Service Water								
LLOCA								
MLOCA								
SLOCA								
ISLOCA								
Loss of 4 kV Bus 21								
Loss of 4 kV Bus 22								
Loss of 4 kV Bus 23								
Loss of 4 kV Bus 24								
Loss of 480 VAC Bus 28						A(17)	P(17)	
Loss of 480 VAC Motor Control Center 28-2							P(17)	
Loss of Instrument Air								

TABLE 4.2.2-4 INITIATOR/SUPPORT SYSTEMS DEPENDENCY MATRIX (Continued)

INITIATING EVENT	125VDC MN Bus 2A-1	125VDC MN Bus 3A	INST Bus	ESS SER Bus	RPS Buses
Transient w/ FW and MC available					
Transient w/ FW available & MC unavailable					
Transient w/ FW unavailable & MC available					
Transient FW & MC unavailable					
LOOP (single unit)			P(1)	P(1)	C(9)
LOOP (dual unit)			P(1)	P(1)	C(9)
IORV					
Loss of 125VDC (main bus)	C(7)				
Loss of Service Water					
LLOCA					
MLOCA					
SLOCA					
ISLOCA					
Loss of 4 kV Bus 21					
Loss of 4 kV Bus 22					
Loss of 4 kV Bus 23			A(12)	A(12)	
Loss of 4 kV Bus 24			A(12)	A(12)	
Loss of 480 VAC Bus 28	A(17)		P(17)	A(17)	P(17)
Loss of 480 VAC Motor Control Center 28-2	A(17)		P(17)	A(17)	P(17)
Loss of Instrument Air					

Notes for Table 4.2.2-4:

1. Unavailability of offsite power eliminates one of the redundant power supplies of these components and requires the use of emergency power supplies.
2. Instrument air is required to open an expansion tank level control valve. Manual bypass is provided.
3. CAS is separated into Division I and II, and will operate degraded on loss of one 125VDC, and will not function on loss of all 125VDC.
4. Both DGs must have DC to start and remain running. The loss of AC power supplies creates the operating requirement for the DGs.
5. Non-ESF AC buses (4160VAC 21, 22) do not have an emergency power supply backup.
6. Breaker control power comes from one DC bus, alternate from the other bus.
7. Loss of DC is defined as loss of the buses.
8. Control power for pump breakers is supplied from the 125VDC bus.
9. The RPS Motor Generators (MGs) are powered from 480VAC buses 28 & 29. The diesel generators provide alternate power to these buses. A LOOP will leave the system power supply in a degraded state; however, RPS is a fail-safe system and a loss of power will lead to a reactor scram.
10. SW removes heat from the TBCCW heat exchangers. Loss of SW would lead to a delayed failure of TBCCW.
11. The Keep-Fill system uses service water to keep the CCSW discharge piping pressurized to avoid leakage of contaminated water from the shell side (LPCI) of the LPCI heat exchanger to the river water on the tube side (CCSW).
12. 4 kV buses 23 and 24 (directly or via 480 VAC buses and MCCs) power the TBCCW pumps (via MCCs), SW pumps, clean demin pumps, CCSW pumps, instrument air compressors, fans, and (as a backup) can power the Instrument and ESS buses.
13. Emergency air coolers normally supplied by SW can be supplied by DGCW through check valves on loss of SW.
14. SW (via SBCS) is a backup to provide makeup water to the hotwell.
15. AC power from MCC 28-2 and instrument air is needed to swap SW strainers. Loss could lead to delayed strainer plugging and loss of SW.
16. Bus 28 (via MCC 28-2) provides power for the CCSW pump B & C pump cubicle coolers.

Notes for Table 4.2.2-4 (continued):

17. Bus 28 powers the Unit 2/3 DGCWP via MCC 28-3, Unit 2/3 DG diesel oil transfer pump and room exhaust fan via MCC 28-1, the ECCS keep-fill jockey pump via MCC 28-1, the condensate jockey pump via MCC 28-2, pumpback air compressor 2A via MCC 28-1, steam tunnel coolers via MCC 28-2 (various HVAC components have a partial dependence on Bus 28), power for Unit 2 DG starting air compressor 2A and other support equipment via MCC 28-2, backup feed to Bus 29 via a cross-tie, 250 VDC Battery Charger 2 via MCC 28-2, 125 VDC Battery Charger 2A via MCC 28-2, Instrument Bus via MCC 28-2, backup to essential service bus via MCC 28-2, and RPS MG Set 2A via MCC 28-2.

TABLE 4.2.2-5
SYSTEM/SYSTEM DEPENDENCY MATRIX - UNIT 2

SYSTEM	U2/3 DEP	FW	COND	RPS	RPT	ARI	ERV	TR/ SRV	SV	HPCI	ADS	LPCI	CS	IC	SLC	SBCS	SPC	CNTS	FP	SBGT	HARD VENT
FW	I																				
COND	I	C(1)																			
RPS	I																				
RPT	I					I(10)															
ARI	I				I(10)																
ERV	I										P(9)										
TR/SRV	I										P(9)										
SV	I																				
HPCI	I																				
ADS	I											P(5)									
LPCI	X																C(2)	C(3)			
CS	I																				
IC	I																				
SLC	I																				
SBCS	I	D(6)	D(6)																		
SPC	I											D(4)	D(4)								
CNTS	I																				
FP	S											A(7)		A(7)							
SBGT	I																				
HARD VENT	I																			A(8)	

Notes for Table 4.2.2-5:

1. Feedwater suction is dependent on the condensate pumps.

2. Motive force to Suppression Pool Cooling is the LPCI pumps.

3. Motive force for CNTS is the LPCI Pumps.

4. The heatup of the suppression pool without SPC over time will cause a failure of LPCI, CS.

5. For high pressure sequences, LPCI will not be able to inject without ADS.

6. Feedwater and condensate pumps will fail after pumping down the hotwell without SBCS.

7. FP can be used as a backup water supply to the IC and as an alternate water injection source to the RPV.

8. The HARD VENT provides an alternate means of depressurizing the containment.

9. ADS uses the ERV and TR/SRV in ADS mode of operation.

10. RPT and ARI use the same ATWS system sensors. Upon exceeding 1240 psig in the reactor vessel or upon reaching -59 inches reactor water level, RPT trips the recirculation pumps and ARI energizes valves to vent the scram air header, initiating a reactor scram.

TABLE 4.2.2-6
FRONTLINE SYSTEM/SUPPORT SYSTEM DEPENDENCY MATRIX - UNIT 2

SUPPORT SYSTEM	U2/3 DEP	FW	COND	RPS
TBCCW	I	C(1)	D(1)	
SW	S			
CCSW A	I			
CCSW B	I			
DGCW	X			
ECCS FILL	I			
CLEAN DEMIN	S			
COND TRANS	S			
INST AIR	X	P(2)	D(3)	
PUMPBACK AIR	I			
HVAC	I	D(3)		
CST	S	D(4)	D(2)	
SUPP POOL	I			
HOTWELL	I	C(5)	C(3)	
CAS	I			
OFFSITE POWER	S			
DG2	I			
DG2/3	S			
NON-ESF AC BUSES	I	C(6)		
NON-EMERGENCY ESF AC BUSES	I		C(4)	A(1)
4160VAC BUS 23-1	I			
4160VAC BUS 24-1	X			
480VAC BUS 28	I		D(4)	P(1)
480VAC BUS 29	I		D(4)	P(1)
250VDC TBMCC2	S			
250VDC TBMCC3	S			
125VDC MN BUS 2A-1	S	P(7)	P(4)	A(2)
125VDC MN BUS 3A	S	P(7)	P(4)	P(2)
120/240 MN INST BUS	I			
ESSENTIAL SERVICE BUS	I	P(2)	D(3)	
RPS BUSES	I			C(1)

Notes for Table 4.2.2-6:

FW

1. Loss of flow in TBCCW system would result in loss of cooling to RFP oil coolers and overheating of RFP bearings.

2. Instrument air supplies all air-operated valves in FW&C systems. Feedwater Regulating Valves fail as-is on loss of IA or control signal. The RFP recirculation valves fail open on loss of instrument air or control power.

3. Interlocked with RFPs to prevent start unless ventilation fan is running. Ventilation fans required for air cooling for RFP motors.

4. Low hotwell level results in delayed dependence upon the CST. Makeup water is usually supplied by vacuum drag from the CST, via the normal makeup valve. Emergency makeup water supplied by two hotwell makeup pumps when emergency makeup valve opens on a "low-low level" signal for hotwell.

5. Feedwater pumps require condensate and condensate booster pumps to provide sufficient NPSH, or pumps trip on low suction pressure. Depletion of hotwell would result in low suction pressure.

6. RFP Pump 2A is supplied by 4160VAC SWGR 21, RFP Pump 2B is supplied by 4160VAC SWGR 22; RFP Pump 2C can be powered from either 4160VAC SWGR 21 or 22.

7. 125VDC power is required to close 4160VAC pump circuit breakers to provide motive power to start non-operating pumps.

COND

1. Loss of flow in TBCCW system would result in delayed failure of condensate pumps due to loss of pump seal cooling.

2. Low hotwell level results in delayed dependence upon the CST. Makeup water is usually supplied by vacuum drag from the CST, via the normal makeup valve. Emergency makeup water supplied by two hotwell makeup pumps when emergency makeup valve opens on a "low-low level" signal for hotwell.

3. Makeup to the hotwell is via two air-operated valves (LCV 2-3301, 3302), air service is instrument air, and control power is from the Essential Service Bus.

4. Condensate system components are powered by the following buses:

AC POWER

4160V -

SWGR 23	Power to Condensate and Condensate Booster pumps 2A and 2B
SWGR 24	Power to Condensate and Condensate Booster pumps 2C and 2D

480V -

SWGR 26	Power to Condensate Vacuum Pump and RFP Vent. Fan 2B
SWGR 27	Power to Condensate Demineralizer Air Compressor
MCC 25-2	Power to various motor-operated valves and pumps
MCC 26-1	Power to various motor-operated valves and pumps
MCC 27-1	Power to various motor-operated valves and pumps
MCC 28-2	Power to Condensate Transfer Jockey Pump and Condensate Transfer Pump 2A
MCC 29-2	Power to Condensate Transfer Pump 2B

Notes for Table 4.2.2-6 (continued):

DC POWER
125V -

MN BUS 2A-1	Control power to SWGR-23-powered components
RES BUS 2B-1	Control power to SWGR-24-powered components

RPS

1. Normal power to RPS buses A and B is supplied by two MG sets. The A and B MG sets are powered from MCCs 28-2 and 29-2 respectively. Reserve power to RPS buses is supplied from MCC 25-2.

2. Backup scram valve solenoids.

TABLE 4.2.2-7
SAFETY SYSTEM/SUPPORT SYSTEM DEPENDENCY MATRIX - UNIT 2

SUPPORT SYSTEM	U2/3 DEP	RPT	ARI	ERV	TR/SRV	SV	HPCI	ADS	LPCI A	LPCI B	CS A	CS B	IC
TBCCW	I												
SW	S												
CCSW A	I								D(1)				
CCSW B	I									D(1)			
DGCW	X												
ECCS FILL	I						C(1)		C(2)	C(2)	C(2)	C(2)	
CLEAN DEMIN	S												P(1)
COND TRANS	S												A(1)
INST AIR	X						P(4)						
PUMPBACK AIR	I							P(1)					
HVAC	I						D(2)						
CST	S						C(5)		A(4)	A(4)	A(4)	A(4)	
SUPP POOL	I						A(5)		C(4)	C(4)	C(4)	C(4)	
HOTWELL	I												
CAS	I						C(3)	C(2)	C(3)	C(3)	C(3)	C(3)	
OFFSITE POWER	S												
DG2	I												
DG2/3	S												
NON-ESF AC BUSES	I												
NON-EMERGENCY ESF AC BUSES	I												
4160VAC BUS 23-1	I								C(5)		C(6)		
4160VAC BUS 24-1	X									C(5)		C(6)	
480VAC BUS 28	I								C(5)		C(6)		
480VAC BUS 29	I						D(2)			C(5)		C(6)	
250VDC TBMCC2	S												
250VDC TBMCC3	S						C(6)						C(2)
125VDC MN BUS 2A-1	S	P(1)	P(1)	C(1)			A(6)	P(3)	C(5)	P(5)	C(6)		C(3)
125VDC MN BUS 3A	S	P(1)	P(1)	A(1)			C(6)	P(3)	P(5)	C(5)		C(6)	C(3)
120/240 MN INST BUS	I	A(2)	A(2)										
ESSENTIAL SERVICE BUS	I	A(2)	A(2)										
RPS BUSES	I												

Notes for Table 4.2.2-7:

RPT & ARI

1. The ATWS Division I logic is powered from 125VDC RB DC Panel 2 with alternate power from the instrument bus. ATWS Division II logic is powered from TB Reserve Bus 2B-1 with alternate power from the essential bus. The ATWS valves and RPT field breaker relay are powered by 125VDC alone.

2. Nuclear Boiler Instrumentation for pressure and level setpoint trips are provided by Rosemount transmitters which provide an electrical output signal to the Analog Trip System (ATS) and ATWS system. Power supplies for the ATS system are as follows:

   Division I - 24/48VDC Distribution Panel 2A and 120VAC from MCC 28-1 (stepped down)

   Division II - 24/48VDC Distribution Panel 3A and 120VAC from MCC 29-1 (stepped down)

   The Instrument Bus powers battery chargers for the 24/48VDC Batteries.

ERV

1. Electromatic relief valves require 125VDC power to open. Normal supply is from TB MN Bus 2A-1 with alternate power available from TB Res. Bus 2B-1.

HPCI

1. Failure of Keep-Fill system could potentially cause damage to front-line system at startup due to water hammer if the suction is from the torus.

2. There is a delayed dependency on HVAC for room cooling but it is insignificant for the HPCI mission time. A Sargent & Lundy study of April 1985 indicates HPCI can operate 152 hours without HVAC before HPCI Area high temperature (200°F) occurs. Power for HPCI area cooler is supplied by 480V MCC 29-4.

3. HPCI system auto-starts on low-low Reactor water level (-59 in.) or High Drywell Pressure (+2 psig).

4. Instrument Air is required to maintain HPCI steamline drain valves 64, 65 open. Valves automatically close on HPCI initiation and fail closed on loss of IA.

5. Initial source of water is CST, but suction switches to suppression pool on high SP level or low level in CST.

Notes for Table 4.2.2-7 (continued):

6. Power supplies for HPCI components and logic are as follows:

125VDC TB 2A-1	Reserve Feed to HPCI Sys Logic and Control Panel 902-39, 12E-2322
125VDC TB 2B-1	Main Feed to HPCI Sys Logic and Control Panel 902-39, 12E-2322A
120/240VAC Essential Serv. Bus	HPCI Instrument Panels 902-3, 902-19, 12E-2325
120/240VAC Instrument Bus	Panels 902-3, 902-4, 902-19, 902-38, 902-39, 12E-2325
250VDC Reactor Building MCC #2, Bus 2A 12E-2321	Condenser Hotwell Condensate Pump Gland Seal Exhauster Auxiliary Lube Oil Pump Emergency Lube Oil Pump
250VDC Reactor Building MCC #2, Bus 2B 12E-2321	MO2-2301-3, HPCI Steam Supply Valve MO2-2301-6, CST Supply to HPCI Pump Suction MO2-2301-8, HPCI Pump Discharge to Feedwater Line MO2-2301-14, HPCI Pump Minimum Flow Discharge to the Torus MO2-2301-35, Torus Supply to HPCI Pump Suction MO2-2301-36, Torus Supply to HPCI Pump Suction MO2-2301-48, Gland Seal Condensate/Lube Oil Cooling Return to HPCI Pump Suction

ADS

1. Target Rock SRV requires nitrogen from Pumpback Air System to open valve for ADS mode of operation. The TR/SRV does not have an accumulator at the valve, so the TR/SRV is assumed to fail on loss of pumpback air.

2. ADS auto initiates on Reactor Water level less than -59 in. AND Drywell Pressure above +2 psig after 120 seconds if a low pressure ECCS pump is running with 100 psig discharge; or on low-low reactor water level (-59 in.) alone after 8.5 minutes if a low pressure ECCS pump is running.

3. 125VDC power is required for ADS logic and valve solenoids as noted:

Logic:

Div. I	TB Main Bus 2A-1
Div. II	TB Res Bus 2B-1 (TB MN Bus 2A-1 alternate)

Valves:

Normal	TB Main Bus 2A-1
Alternate	TB Res Bus 2B-1

Notes for Table 4.2.2-7 (continued):

LPCI & CS

1. LPCI used in the injection cooling mode requires CCSW to the LPCI Heat Exchangers for transfer of decay heat to ultimate heat sink. In this mode, LPCI provides containment heat removal function, as well.

2. Failure of ECCS Fill system could potentially cause damage to frontline system at startup due to water hammer. Tech Specs require the ECCS Fill system to be in operation in order to consider LPCI and Core Spray systems operable.

3. Common Actuation Sensors auto-start both Core Spray and LPCI pumps on High Drywell Pressure (+2 psig) OR Low-Low Reactor water level (-59 in.) AND Reactor Low Pressure (<350 psig) OR Low-Low Reactor water level maintained for greater than 8.5 minutes.

4. Initial source of water is the suppression pool; suction can be switched to CST manually if required.

5. LPCI system components are powered by the following buses:

AC POWER

4160V -

BUS 23-1	LPCI PUMPS 2A, 2B
BUS 24-1	LPCI PUMPS 2C, 2D

480V -

MCC 28-1	MOV 1501-3A
	MOV 1501-27A
	MOV 1501-28A
	LPCI/CS AREA COOLER 2A
	MOV 1501-5A
	MOV 1501-5B
	MOV 1501-11A
	MOV 1501-13A
	MOV 1501-18A
	MOV 1501-19A
	MOV 1501-20A
	MOV 1501-32A
	MOV 1501-38A
MCC 28-7	MOV 1501-21A, 22A
MCC 29-1	MOV 1501-27B, 28B
MCC 29-4	MOV 1501-3B
	MOV 1501-5C
	MOV 1501-5D
	MOV 1501-11B
	MOV 1501-13B
	MOV 1501-18B
	MOV 1501-19B
	MOV 1501-20B
	MOV 1501-32B
	MOV 1501-38B
	LPCI/CS AREA COOLER 2B
MCC 29-7	MOV 1501-21B, 22B

Notes for Table 4.2.2-7 (continued)

DC POWER

125V -

RB DC PNL 2	LPCI Pumps 2A, 2B circuit breaker control power (main feed) LPCI Pumps 2C, 2D circuit breaker control power (alternate feed)
TB RES BUS 2B-1	LPCI Pumps 2C, 2D circuit breaker control power (main feed) LPCI Pumps 2A, 2B circuit breaker control power (alternate feed) LPCI Loop B System II initiation circuitry Permissive Circuitry
TB MN BUS 2A-1	LPCI Loop A System I initiation circuitry Permissive Circuitry

6. CS System Components are powered by the following buses:

AC POWER

4160V -

SWGR 23-1	Power to Pump 2A-1401
SWGR 24-1	Power to Pump 2B-1401

480V -

MCC 28-1	Power to valves MO2-1402-3A, 38A, 4A, 24A, 25A
MCC 29-4	Power to valves MO2-1402-3B, 38B, 4B
MCC 29-1	Power to valves MO2-1402-24B, 25B

DC POWER

125V -

RB DC PNL 2	Power to close circuit breaker for CS Pump 2A-1401
TB RES BUS 2B-1	Power to close circuit breaker for CS Pump 2B-1401; also used for System II initiation control logic
MN BUS 2A-1	Power for System I initiation control logic

IC

1. Primary water source for isolation condenser makeup is the clean demin system; alternate water sources are from the contaminated CSTs and the fire protection water system.

2. 250VDC Power Bus RB MCC 2A provides power to MO2-1301-2,3. 480VAC MCC 28-1 or 38-1 (selectable) provide power to MO2-1301-1, 4. MO2-1301-3 is the only valve that requires operation to initiate IC.

3. 125VDC Main Bus 2A-1 AND Reserve Bus 2B-1 are required to provide power to High Steam Flow Sensing Logic. Steam flow isolation logic is de-energize to actuate, therefore, loss of either DC supply simulates an isolation signal. Due to the sharing of the DC system, loss of DC in one unit will cause an isolation of both units' ICs.

TABLE 4.2.2-8
ADDITIONAL SYSTEMS/SUPPORT SYSTEM DEPENDENCY MATRIX - UNIT 2

SUPPORT SYSTEM	U2/3 DEP	SLC	SBCS	SPC A	SPC B	CNTS	FP	SBGT	HARD VENT
TBCCW	I								
SW	S		C(1)				A(1)		
CCSW A	I			C(1)		C(1)			
CCSW B	I				C(1)	C(1)			
DGCW	X								
ECCS FILL	I			C(2)	C(2)	C(2)			
CLEAN DEMIN	S								
COND TRANS	S								
INST AIR	X							C(2)	C(1)
PUMPBACK AIR	I								
HVAC	I								
CST	S					A(3)			
SUPP POOL	I					C(3)			
HOTWELL	I								
CAS	I								
OFFSITE POWER	S								
DG2	I								
DG2/3	S								
NON-ESF AC BUSES	I								
NON-EMERGENCY ESF AC BUSES	I		C(2)				D(2)		
4160VAC BUS 23-1	I			C(3)		P(4)			
4160VAC BUS 24-1	X				C(3)	P(4)			
480VAC BUS 28	I	P(1)		C(3)		P(4)		P(1)	
480VAC BUS 29	I	P(1)			C(3)	P(4)			
250VDC TBMCC2	S								
250VDC TBMCC3	S								
125VDC MN BUS 2A-1	S			C(3)	P(3)	P(4)			
125VDC MN BUS 3A	S			P(3)	C(3)	P(4)			
120/240 MN INST BUS	I								
ESSENTIAL SERVICE BUS	I							C(2)	C(1)
RPS BUSES	I								

Notes for Table 4.2.2-8:

SLC

1. SLC pump A, Explosive Valve 2A-1106A and SBLC suction line heat tracing supplied by 480VAC MCC 28-1; SLC Pump B, Explosive Valve 2A-1106B, SBLC suction line heat tracing and SBLC tank heater supplied by 480VAC MCC 29-1.

SBCS

1. Secondary water makeup source to hotwell (Primary is CST). Requires operable SW pump.

2. 480VAC power MCC 25-1 provides power to open normally closed MOV 2-3901, 3902 valves to Unit 2 Hotwell.

SPC

1. LPCI in suppression pool or injection cooling mode requires CCSW to LPCI Heat Exchangers for transfer of decay heat to ultimate heat sink.

2. Failure of ECCS Fill system could potentially cause damage to frontline system at startup due to water hammer. Tech Specs require the ECCS Fill system to be in operation in order to consider LPCI systems operable.

3. Power supplies for LPCI components used in suppression pool cooling mode are the same as described in Note 6 of Table 4.2.2-7 under the LPCI heading. Power is required to shut LPCI injection line valves for suppression pool cooling mode of operation.

CNTS

1. LPCI in Containment Spray cooling mode requires CCSW to LPCI Heat Exchangers for transfer of decay heat to ultimate heat sink.

2. Failure of ECCS Fill system could potentially cause damage to frontline system at startup due to water hammer. Tech Specs require the ECCS Fill system to be in operation in order to consider LPCI systems operable.

3. Initial source of water is suppression pool; suction can be switched to CST manually if required.

4. Power supplies for LPCI components used in containment spray cooling mode are the same as described in Note 6 of Table 4.2.2-7 under the LPCI heading. Power is required to shut LPCI injection line valves and suppression pool cooling valves for containment spray cooling mode of operation.

FP

1. Unit 2 service water maintains pressure in fire main during normal plant conditions in addition to serving as a backup for the fire protection water system.

2. Unit 2/3 fire pump and Unit 1 fire pump are started and controlled by DC power from two dedicated 24V batteries. 120VAC from MCC 20-2 (fed from Bus 24) is required for the battery charger for these batteries. Delayed dependence.

Notes for Table 4.2.2-8 (continued):

SBGT

1. Isolation valve, air supply valve and Unit 2/3 Fan (A) is powered from MCC 28-2. Fan discharge valve and electric heater is powered from MCC 28-3.

2. The containment vent valves to SBGT are supplied by instrument air. Control power to these valves is supplied from the ESS Bus.

HARD VENT

1. The valves in the Augmented Primary Containment vent system are all air operated valves supplied from instrument air. Control power is supplied from the Essential Services Bus.

TABLE 4.2.2-9
SUPPORT SYSTEM/SUPPORT SYSTEM DEPENDENCY MATRIX - UNIT 2

SUPPORT SYSTEM	U2/3 DEP	TBCCW	SW	CCSW A	CCSW B	DGCW	ECCS FILL	CLEAN DEMIN	COND TRANS	INST AIR
TBCCW	I									D(1)
SW	S	D(1)		I(1)	I(1)					
CCSW A	I									
CCSW B	I									
DGCW	X									
ECCS FILL	I									
CLEAN DEMIN	S	D(2)								
COND TRANS	S						A(1)			
INST AIR	X	P(3)	D(2)							
PUMPBACK AIR	I									
HVAC	I			D(2)	D(2)					
CST	S									
SUPP POOL	I									
HOTWELL	I									
CAS	I									
OFFSITE PWR	S									
DG 2	I									
DG 2/3	S									
NON-ESF AC BUSES	I									
NON-EMERGENCY ESF AC BUSES	I	C(4)	C(1)	C(3)	C(3)			C(1)		C(3)
4160VAC BUS 23-1	I									
4160VAC BUS 24-1	X									
480VAC BUS 28	I		D(1)	C(3)		C(1)	C(2)		C(1)	
480VAC BUS 29	I				C(3)	C(1)		P(1)		
250VDC TBMCC2	S		P(1)							
250VDC TBMCC3	S									
125VDC MN BUS 2A-1	S		P(1)	C(3)	A(3)					
125VDC MN BUS 3A	S		P(1)	A(3)	C(3)					C(3)
120/240 MN INST BUS	I									
ESSENTIAL SERVICE BUS	I									
RPS BUSES	I									

TABLE 4.2.2-9 (Continued)
SUPPORT SYSTEM/SUPPORT SYSTEM DEPENDENCY MATRIX - UNIT 2

SUPPORT SYSTEM	PUMP-BACK AIR	HVAC	CST	SUPP POOL	HW	CAS	DG2	DG2/3	NON-ESF BUS	NON-EMERG ESF BUS
TBCCW										
SW		P(2)			A(1)					
CCSW A										
CCSW B										
DGCW		A(2)					C(1)	C(1)		
ECCS FILL										
CLEAN DEMIN										
COND TRANS					C(1)					
INST AIR										
PUMPBACK AIR										
HVAC							D(2)	D(2)		
CST										
SUPP POOL										
HOTWELL										
CAS										
OFFSITE PWR									C(1)	C(1)
DG 2										A(2)
DG 2/3										A(2)
NON-ESF AC BUSES										
NON-EMERGENCY ESF AC BUSES		P(1)								
4160VAC BUS 23-1										
4160VAC BUS 24-1										
480VAC BUS 28	P(2)	P(1)					P(3)	C(3)		
480VAC BUS 29	P(2)	P(1)					C(3)	P(3)		
250VDC TBMCC2										
250VDC TBMCC3										
125VDC MN BUS 2A-1						P(1)	A(3)	C(3)	P(2)	P(3)
125VDC MN BUS 3A						P(1)	C(3)	A(3)	P(2)	P(3)
120/240 MN INST BUS										
ESSENTIAL SERVICE BUS										
RPS BUSES										

TABLE 4.2.2-9 (Continued)
SUPPORT SYSTEM/SUPPORT SYSTEM DEPENDENCY MATRIX - UNIT 2

SUPPORT SYSTEM	4160 23-1	4160 24-1	480V 28	480V 29	250V TB MCC2	250V TB MCC3	125VDC MN BUS 2A-1	125VDC MN BUS 3A	INST BUS	ESS SER BUS	RPS BUS
TBCCW											
SW											
CCSW A											
CCSW B											
DGCW											
ECCS FILL											
CLEAN DEMIN											
COND TRANS											
INST AIR											
PUMPBACK AIR											
HVAC											
CST											
SUPP POOL											
CAS											
HOTWELL											
OFFSITE PWR	C(1)	C(1)									
DG 2		A(2)									
DG 2/3	A(2)										
NON-ESF AC BUSES											
NON-EMERGENCY ESF AC BUSES									A(1)	A(1)	
4160VAC BUS 23-1			C(1)								
4160VAC BUS 24-1				C(1)							
480VAC BUS 28				A(1)	P(1)		A(1)		P(1)	A(1)	P(1)
480VAC BUS 29			A(1)		A(1)	A(1)	D(1)			C(1)	P(1)
250VDC TBMCC2										A(1)	
250VDC TBMCC3											
125VDC MN BUS 2A-1	C(3)	A(3)	C(2)	A(2)							
125VDC MN BUS 3A	A(3)	C(3)	A(2)	C(2)							
120/240 MN INST BUS											
ESSENTIAL SERVICE BUS											
RPS BUSES											

Notes for Table 4.2.2-9:

TBCCW

1. Cooling water for the TBCCW heat exchangers is provided by the service water system. Delayed failure on loss of SW.

2. Clean demineralized water is used for makeup to the TBCCW Expansion Tank. Delayed failure if level cannot be maintained.

3. Instrument air is required to open expansion tank level control valve. Manual bypass around level control valve is provided.

4. Power to pump 2A-3801 is provided by MCC 25-1. Power to pump 2B-3801 is provided by MCC 27-1. 120VAC power for solenoid for LCV-2-3801 is provided by stepped-down power from MCC 27-1.

SW

1. Power for SW system components is provided by the following buses:

AC POWER

4160V -

SWGR 23	Power to Pump 2-A-3901
SWGR 24	Power to Pump 2-B-3901, 2/3-3901

480V -

MCC 25-1	Power for MOV 2-3901, 3902

120V -

MCC 28-2	Power for Strainers 2-3902, 2/3-3902 (stepped down)

DC POWER

250V -

TB MCC 2	Power for MOV 2A-3903, 2B-3903, 2-3904, 2-3905

125V -

TB BUS 2A-1 (2B-1 alternate)	Power to close CB for Pump 2A
TB BUS 2B-1 (2A-1 alternate)	Power to close CB for Pumps 2B, 2/3

2. Instrument air is necessary to shift the SW pump strainers and operate the flush and drain valves.

CCSW

1. The Keep-Fill system uses service water to keep the CCSW discharge piping pressurized to avoid leakage of contaminated water from the shell side (LPCI) of the LPCI heat exchanger to the river water on the tube side (CCSW).

2. Delayed dependency on loss of HVAC to CCSW pumps B & C pump cubicle coolers.

Notes for Table 4.2.2-9 (continued):

3. Power for CCSW system components is provided by:

AC POWER

4160V -

SWGR 23	Power to Pumps A, B
SWGR 24	Power to Pumps C, D

480V -

MCC 28-1	Power for MOV 2-1501-3A
MCC 29-4	Power for MOV 2-1501-3B
MCC 28-2	CCSW cubicle cooler fans
MCC 29-2	CCSW cubicle cooler fans

DC POWER

125V -

TB MN BUS 2A-1 (2B-1 alternate)	Control Power to close CB for CCSW Pumps A, B
TB RES BUS 2B-1 (2A-1 alternate)	Control Power to close CB for CCSW Pumps C, D

DGCW

1. Power for the DGCW system pumps is provided by 480VAC buses:

AC POWER

480V -

MCC 29-2	DGCW pump 2
MCC 28-3	DGCW pump 2/3

ECCS Keep-Fill

1. The condensate transfer jockey pump provides a backup supply for the ECCS Keep-Fill system.

2. Power for the ECCS Keep-Fill jockey pump is from 480VAC Bus MCC 28-1.

Clean Demin

1. Clean demin system is completely shared between units and its pumps are powered from Unit 2. Power for the clean demineralizer pumps and IC supply valve is provided by 480VAC power:

480V -

MCC 25-2	Power to Clean Demin Pump 2/3 A, B
MCC 29-3	Power to Clean Demin Supply Valve (MOV-4399-74) to Isolation Condenser

COND TRANS

1. Condensate jockey pump is powered by 480VAC MCC 28-2.

Notes for Table 4.2.2-9 (continued):

INST AIR

1. TBCCW system provides cooling water to IA compressors and aftercoolers. Air compressors are assumed to fail immediately upon loss of cooling; systems with air receivers will continue to perform their function for some period after compressor failure.

2. Service air system provides a backup to the IA system.

3. Power to components of the IA system is as follows:

AC POWER
480V -

SWGR 26	Power to Compressor 2-4706
SWGR 27	Power to Compressor 2-4715
SWGR 37	Power to Compressor 3-4732

120V -

MCC 25-1	Control power for Compressors 2-4706, 4715
MCC 25-2	Power for IA/SA cross-tie valve AO-2-4701-500

DC POWER
125V -

TB RES BUS 2B-2	Control power for Compressor 2-4706

Pumpback Air

1. Unit 2 RBCCW supplies cooling water to pumpback air compressors in both Unit 2 and Unit 3.

2. Pumpback air compressors 2A and 2B are powered by 480VAC MCC 28-1 and 29-1, respectively. Nitrogen makeup supply provides backup to the Pumpback Air system.

HVAC

1. Power supplies for various HVAC components are noted under the frontline or support systems listed as having a dependency upon HVAC, e.g., LPCI, CCSW, etc.

2. HPCI and Reactor Building emergency air coolers normally supplied by SW can be supplied by DGCW through check valves on loss of SW.

HW

1. Condensate transfer system provides makeup to the hotwell. Backup is provided by the Service Water Standby Coolant Supply (SBCS) line.

CAS

1. The Common Actuation System (CAS) provides actuation signals to HPCI, LPCI, ADS, and CS. The power supplies to CAS are:

Division I - 125VDC TB MN BUS 2A-1

Division II - 125VDC TB RES BUS 2B-1

Notes for Table 4.2.2-9 (continued):

DG 2

1. Diesel Cooling Water (DGCW) pump 2 provides cooling to DG 2. Failure after a short delay if lost. The service water return piping is used, but requires no valves for return water to the river.

2. DG Room Exhaust Fan 2 provides HVAC for DG 2. Leads to loss of engine control circuitry on prolonged loss of ventilation.

3. Power for components required for DG 2 support are as follows:

AC POWER
480V -

MCC 29-2	Power for Diesel Oil Transfer Pump 2, DGCW Pump 2, and DG Room Exhaust Fan 2
MCC 28-2	Power for Diesel Starting Air Compressor 2A, Turbocharger Lubricating Oil Pump, Circulating Lubricating Oil Pump, and cooling water immersion heater.

DC POWER
125V -

TB RES BUS 2B-1	Control and excitation, and related loads for DG 2
RB DIST PANEL 2	Backup for control and excitation

DG 2/3

1. Diesel Cooling Water (DGCW) pump 2/3 provides cooling to DG 2/3. Failure after a short delay if lost. The service water return piping is used, but requires no valves for return water to the river.

2. DG room exhaust fan 2/3 provides HVAC for DG 2/3. Leads to loss of engine control circuitry on prolonged loss of ventilation.

3. Power for components required for DG 2/3 support are as follows:

AC POWER
480V -

MCC 28-1	Power for Diesel Oil Transfer Pump 2/3, Power for DG Room Exhaust Fan 2/3
MCC 28-3	Power for DGCW Pump 2/3
MCC 29-4	Power for Turbocharger Lubricating Oil pump, circulating lubricating oil pump, and cooling water immersion heater.

DC POWER
125V -

RB DC PANEL 2 (RB DC PANEL 3) (alternate power)	Control and excitation,and related loads for DG 2/3

Non-ESF Buses

1. Offsite power sources provide power for 4160VAC buses 21 and 22, via the normal unit auxiliary transformer (TR21) or the alternate reserve auxiliary transformer (TR22).

2. Control power is supplied from the 125VDC buses. The normal control power for 4160VAC Bus 21 is supplied from TB 125VDC Bus 2A-2 with alternate power from TB Res Bus 2B-2. The normal control power for 4160VAC Bus 22 is supplied from TB Res Bus 2B-2 with alternate power from TB 125VDC Bus 2A-2.

Notes for Table 4.2.2-9 (continued):

NON-Emergency ESF Buses and 4160VAC Buses 23-1 and 24-1

1. Offsite power sources provides power for 4160VAC buses 23 and 24 via the unit auxiliary transformer (TR 21) or the reserve auxiliary transformer (TR 22). Buses 23 and 24 provide normal feed to 4160VAC buses 23-1 and 24-1.

2. 4160VAC buses 23 and 24 can receive power from the onsite emergency DGs through manual connections with buses 23-1 and 24-1, respectively. Bus 23-1 can be connected to Unit 2 emergency swing DG 2/3. Bus 24-1 can be connected to the Unit 2 emergency DG 2.

3. The 4160VAC non-ESF emergency buses receive DC control power from the 125VDC buses. A primary feed and alternate feed is provided. 4160VAC Bus 23-1 receives 125VDC control power for circuit breakers from RB DC Panel 2 with alternate power from TB Res Bus 2B-1. 4160VAC Bus 24-1 receives 125VDC control power for circuit breakers from TB Res Bus 2B-1 with alternate power from RB DC PNL 2.

480VAC Buses 28 and 29

1. 480VAC Buses 28 and 29 receive power from 4160VAC Buses 23-1 and 24-1, respectively. 480VAC Buses 28 and 29 can be cross-tied together.

2. 125VDC control power for supply to MCCs 28 and 29 are provided by RB DC PNL 2 and TB Res Bus 2B-1, respectively. MCC 28 receives alternate 125VDC control power from TB Res Bus 2B-1; MCC 29 receives alternate 125VDC control power from RB DC PNL 2.

250VDC TBMCC2

1. 250VDC Bus TBMCC2 normally receives power from 250VDC Battery Charger 2 or it can receive power from Battery Charger 2/3, or the 250VDC Unit 2 batteries. Battery Charger 2 is powered by 480VAC MCC 28-2. Battery Charger 2/3 is powered by 480VAC MCC 29-2 (or 39-2). TBMCC2 supplies 250VDC loads in both Units 2 and 3.

250VDC TBMCC3

1. 250VDC Bus TBMCC3 normally receives power from 250VDC Battery Charger 3 or it can receive power from Battery Charger 2/3, or the 250VDC Unit 3 batteries. Battery Charger 3 is powered by 480VAC MCC 38-2 (Unit 3 480VAC supplies are not shown in Table). Battery Charger 2/3 is powered by 480VAC MCC 29-2 (or 39-2). TBMCC 3 supplies 250VDC loads in both Units 2 and 3.

125VDC TB MN BUS 2A-1 and TB MN BUS 3A

1. The 125VDC TB Main Bus 2A-1 receives power from Battery Bus 2 which is normally powered by Battery Charger 2 or it can receive power from Battery Charger 2A, or the Unit 2 125VDC batteries. Battery Charger 2 is powered by 480VAC MCC 29-2. Battery Charger 2A is powered by 480VAC MCC 28-2. TB MN Bus 2A-1 supplies 125VDC loads in both Units 2 and 3. The 125VDC TB Main Bus 3A receives power from Battery Bus 3 which is normally powered by Battery Charger 3 or it can receive power from Battery Charger 3A, or the Unit 3 125VDC batteries. Battery Charger 3 is powered by 480VAC MCC 39-2. Battery Charger 3A is powered by 480VAC MCC 38-2. TB MN Bus 3A supplies 125VDC loads in both Units 2 and 3. (Unit 3 480VAC supplies are not shown in Table).

Notes for Table 4.2.2-9 (continued):

INST BUS

1. The 120/240V main instrument bus normally receives power via a 480VAC/120-240V transformer from 480VAC MCC 28-2. A reserve power supply is available from MCC 25-2 via the reserve instrument and RPS transformer.

ESS SERV BUS

1. The essential services bus normally receives power by 480VAC MCC 29 which is rectified to 250VDC and then inverted to 120VAC via a static switch. The 250VDC TB Battery Bus also taps into the normal feed path between the rectifier and inverter. If the normal supply path fails, alternate AC feeds the static switch from 480V MCC 25 through a 120V regulator. A second alternate AC power supply comes from MCC 28-2 through a power-seeking Automatic Bus Transfer.

RPS Buses

1. The RPS buses A and B receive power via 480V MCCs 28 and 29, respectively. Each uses a motor-generator (MG) to regulate the power supply to the sensors and instrumentation in the RPS. A flywheel on each MG prevents momentary losses of power to the MG set from generating a trip signal to the reactor.

TABLE 4.4.1-3
DRESDEN-SPECIFIC COMPONENT FAILURE RATES

COMPONENT TYPE GROUPING AND FAILURE MODE	SYSTEM	COMPONENT TYPE	FAILURE CODE	TOTAL NUMBER OF COMPONENTS	NUMBER OF FAILURES[3]	NUMBER OF DEMANDS OR HOURS	FAILURE RATE
U-2 Diesel Generator Failure to Start	DG	DG	A	1	2	129 D	1.55×10^{-2}/D
U-2 Diesel Generator Failure to Run	DG	DG	X	1	4	316 H	1.27×10^{-2}/H
U-3 Diesel Generator Failure to Start	DG	DG	A	1	6	117 D	5.13×10^{-2}/D
U-3 Diesel Generator Failure to Run	DG	DG	X	1	3	265 H	1.13×10^{-2}/H
2/3 Diesel Generator Failure to Start	DG	DG	A	1	4	117 D	3.42×10^{-2}/D
2/3 Diesel Generator Failure to Run	DG	DG	X	1	1	321 H	3.12×10^{-3}/H
Diesel Generator Cooling Water Pump Failure to Start	DG	PM	A	3	1	1011 D	9.89×10^{-4}/D
Diesel Generator Cooling Water Pump Failure to Run/Function	DG	PM	X, F	3	2	1794 H	1.12×10^{-3}/H
4160 Supply Breaker Failure to Open/Close	AC	CB	D, K	38	4	4510 D	8.87×10^{-4}/D
4160 Supply Breakers Spurious Opening/Fails to Function	AC	CB	U, F	38	4	2331984 H	1.72×10^{-6}/H
Diesel Generator Output Breaker Failure to Open/Close	DG	CB	D, K	4	3	1396 D	2.15×10^{-3}/D
Diesel Generator Output Breaker Spurious Opening/Fails to Function	DG	CB	U, F	4	0.5	1210 H	4.13×10^{-4}/H
HPCI Turbine Failure to Start	HI	PT	A	2	1	145 D	6.90×10^{-3}/D
HPCI Turbine Failure to Run/Function	HI	PT	X, F	2	0.5	235 H	2.20×10^{-4}/H (IEEE)[2]
Condensate/Condensate Booster Pumps Failure to Start[1]	FW	PM	A	16	4	2018 D	1.98×10^{-3}/D

TABLE 4.4.1-3 (Continued)
DRESDEN-SPECIFIC COMPONENT FAILURE RATES

COMPONENT TYPE GROUPING AND FAILURE MODE	SYSTEM	COMPONENT TYPE	FAILURE CODE	TOTAL NUMBER OF COMPONENTS	NUMBER OF FAILURES[3]	NUMBER OF DEMANDS OR HOURS	FAILURE RATE
Condensate/Condensate Booster Pumps Failure to Run/Function	FW	PM	X, F	16	7	526881 H	1.33×10^{-5}/H
CCSW Pumps Failure to Start	CC	PM	A	8	5	828 D	6.04×10^{-3}/D
CCSW Pump Failure to Run/Function	CC	PM	X, F	8	5	18922 H	2.64×10^{-4}/H
Reactor Feed Pump Failure to Start	FW	PM	A	6	0.5	830 D	6.02×10^{-4}/D
Reactor Feed Pump Failure to Run/Function	FW	PM	X, F	6	5	154930 H	3.23×10^{-5}/H
SBGT Fan Failure to Start	GT	FN	A	2	0.5	463 D	1.00×10^{-5}/D (4550)[2]
SBGT Fans Failure to Run/Function	GT	FN	X, F	2	0.5	6767 H	7.39×10^{-5}/H
SBGT Dampers Failure to Open/Close/Function	GT, ALL	DM	D, K, F	10	1	1277 D	7.83×10^{-4}/D
Motor Operated Valve Failure to Open/Close/Function	ALL	MV	D, K, F	370	86	45840 D	1.88×10^{-3}/D
AC Transformers Failure to Function (UAT & RAT)	AC	TR	F	4	0.5	210379 H	7.10×10^{-7}/H (IEEE)[2]
Diesel Fire Pumps Failure to Start	FP	PD	A	2	1	742 D	1.35×10^{-3}/D
Diesel Fire Pumps Failure to Run/Function	FP	PD	X, F	2	4	364 H	1.10×10^{-2}/H
Core Spray Pump Failure to Start	CS	PM	A	4	2	636 D	3.14×10^{-3}/D
Service Water Pump Failure to Start	SW	PM	A	5	0.5	84 D	2.78×10^{-3}/D (IEEE)[2]
Service Water Pump Failure to Run/Function	SW	PM	X, F	5	0.5	303169 H	1.65×10^{-6}/H

TABLE 4.4.1-3 (Continued)
DRESDEN-SPECIFIC COMPONENT FAILURE RATES

COMPONENT TYPE GROUPING AND FAILURE MODE	SYSTEM	COMPONENT TYPE	FAILURE CODE	TOTAL NUMBER OF COMPONENTS	NUMBER OF FAILURES[3]	NUMBER OF DEMANDS OR HOURS	FAILURE RATE
125/250VDC Batteries Failure to Function	DC	BY	F	4	0.5	245472 H	6.10×10^{-7}/H (IEEE)[2]
125/250VDC Battery Chargers Failure to Function	DC	BC	F	7	0.5	429576 H	1.16×10^{-6}/H
CRD Pumps Failure to Start	CR	PM	A	4	0.5	733 D	6.82×10^{-4}/D
CRD Pumps Failure to Run/Function	CR	PM	X, F	4	0.5	99261 H	5.04×10^{-6}/H
LPCI Pumps Failure to Start	LI	PM	A	8	4	1656 D	2.42×10^{-3}/D
LPCI and Core Spray Pumps Failure to Run/Function	LI, CS	PM	X, F	12	2	8191 H	2.44×10^{-4}/H
All Air Operated Valves Failure to Open/Close/Function	ALL	AV	D, K, F	88	21	22405 D	9.37×10^{-4}/D
SLC Pumps Failure to Start	SC	PM	A	4	0.5	306 D	1.63×10^{-3}/D
SDC Pumps Failure to Run/Function	SD	PM	X, F	4	1	52939 H	1.89×10^{-5}/H
TBCCW Pumps Fails to Run/Function	TB	PM	X, F	4	0.5	122736 H	4.07×10^{-6}/H
HPCI Room Coolers Fails to Start	HI	BL	A	2	1	28 D	1.00×10^{-6}/D (2815)[2]
Pressure Switch Fails to Function[4]	ALL	PS	F	116	1	2920 D	3.4×10^{-4}/D

Notes for Table 4.4.1-3:

1. Fails to start is considered common to each pump. Fails to run is on a case-by-case basis. Further explanation is provided in the system notebook.
2. Generic Data (IEEE, 2815, and 4550) used in accordance with "Special Conditions" of Data Collection Guide.
3. All "Number of Failures" shown as 0.5 indicate that a failure did not occur for the subject components during the review period.
4. Pressure switch data is based on a plant-specific review of "pre-initiator" events. Data includes 8 level switches. Number of demands is estimated based on surveillance intervals. Review was for period of 1991-1995.

TABLE 4.4.1-4
SUMMARY OF DRESDEN-SPECIFIC MAINTENANCE UNAVAILABILITIES
Period of Record: January 1984 through November 1990

COMPONENT TYPE	SYSTEM	COMPONENT TYPE	FAILURE CODE	NUMBER OF COMPONENTS	NO. OF EVENTS (X)	TIME REQUIRED OPERATIONAL PER COMPONENT (HR)	AVERAGE OOS (HR/EVENT)	MAINT-ENANCE UNAVAIL
U-2 Diesel Generator	DG	DG	M	1	28	45563	55.47	3.41×10^{-2}
U-3 Diesel Generator	DG	DG	M	1	14	42128	31.33	1.04×10^{-2}
2/3 Diesel Generator	DG	DG	M	1	29	59028	59.87	2.94×10^{-2}
AC Transformers (UAT + RAT)	AC	TR	M	4	1	61368	3.00	1.22×10^{-5}
AC 4KV X-Tie Breaker	AC	CB	M	36	22	61368	40.41	7.24×10^{-3}
AC 4KV Breakers Non-X-Tie, Non-Pump Supply	AC	CB	M	2	1	59028	129.5	5.76×10^{-5}
Diesel Generator Output Breaker	DG	CB	M	4	2	51437	3.17	3.08×10^{-5}
HPCI Turbine	HI	PT	M	2	26	43846	29.83	8.85×10^{-3}
CCSW Pump	CC	PM	M	8	58	43846	61.68	1.02×10^{-2}
Core Spray Pump	CS	PM	M	4	9	61368	40.31	1.48×10^{-3}
Service Water Pump	SW	PM	M	5	13	59028	82.76	3.65×10^{-3}

TABLE 4.4.1-4 (Continued)
SUMMARY OF DRESDEN-SPECIFIC MAINTENANCE UNAVAILABILITIES
Period of Record: January 1984 through November 1990

COMPONENT TYPE	SYSTEM	COMPONENT TYPE	FAILURE CODE	NUMBER OF COMPONENTS	NO. OF EVENTS (X)	TIME REQUIRED OPERATIONAL PER COMPONENT (HR)	AVERAGE OOS (HR/EVENT)	MAINT-ENANCE UNAVAIL
Condensate/ Condensate Booster Pump[1]	FW	PM	M	16	53	43846	85.90	6.49×10^{-3}
Reactor Feed Pump	FW	PM	M	6	37	43846	35.86	5.04×10^{-3}
TBCCW Pump	TB	PM	M	4	9	61368	20.44	7.50×10^{-4}
125/250VDC Batteries	DC	BY	M	4	13	61368	68.48	3.63×10^{-3}
125/250VDC Battery Chargers	DC	BC	M	7	44	61368	89.31	9.15×10^{-3}
SBGT Fan	GT	FN	M	2	29	61368	54.22	1.28×10^{-2}
SBGT Dampers	GT	DM	M	10	8	61368	91.32	1.19×10^{-3}
Control Rod Drive Pump[2]	CR	PM	M	4	19	43846	99.09	1.07×10^{-2}
All Motor Operated Valves	ALL	MV	M	370	99	43846	91.69	5.60×10^{-4}
LPCI Pumps	LI	PM	M	8	12	61368	35.24	8.61×10^{-4}
Diesel Driven Fire Pumps	FP	PD	M	2	111	61368	67.58	6.11×10^{-2}
LPCI Heat Exchangers	LI	HE	M	4	7	61368	68.84	1.97×10^{-3}
All Air Operated Valves	ALL	AV	M	88	21	43846	52.15	2.84×10^{-4}

TABLE 4.4.1-4 (Continued)
SUMMARY OF DRESDEN-SPECIFIC MAINTENANCE UNAVAILABILITIES
Period of Record: January 1984 through November 1990

COMPONENT TYPE	SYSTEM	COMPONENT TYPE	FAILURE CODE	NUMBER OF COMPONENTS	NO. OF EVENTS (X)	TIME REQUIRED OPERATIONAL PER COMPONENT (HR)	AVERAGE OOS (HR/EVENT)	MAINT-ENANCE UNAVAIL
Diesel Generator Cooling Water Pumps	DG	PM	M	3	5	51437	69.58	2.25×10^{-3}
TBCCW Heat Exchanger	TB	HE	M	4	18	61368	8.67	6.35×10^{-4}
SLC Pumps	SL	PM	M	4	25	43846	22.81	3.25×10^{-3}
SDC Pumps	SD	PM	M	4	26	43846	35.02	5.19×10^{-3}
HPCI Room Cooler	HI	BL	M	2	7	43846	10.02	8.00×10^{-4}

Notes:

1. Unavailabilities are considered common to each pump. Further explanation is provided in the system notebook.

2. CRD pump unavailability was gathered for periods of unit operation, but the CRD system was not included in the original IPE. The modified Dresden IPE (1996) included use of the opposite unit's CRD system as a vessel makeup source during extended SBO events.
Based on recent plant experience, the total CRD system unavailability (including outage periods) was estimated as 5.6×10^{-2}. This system unavailability was used in the Modified Dresden IPE.

TABLE 4.4.1-5
COMMON CAUSE FAILURE DATA FOR DRESDEN IPE

COMP	SYSTEM	EVENT DESCRIPTION	VALUE	UNIT	SOURCE
AC	ALL[1]	CC event (3 out of 3) MGL factor: 1.33E-02 Generic - Air Compressor Fails to Run (per hr.), Rate: 5.95E-05	7.91E-07	HR	IEEE
AM	ALL	CC event (2 out of 2) MGL factor: 1.00E-02, Generic - Safety Valve Prematurely Opens (per hr.), Rate: 3.00E-06	3.00E-08	HR	IEEE
AS	PC	CC event (2 out of 4) MGL factor: 8.00E-02, Generic - PORV Fails to Open (per dem.), Rate: 3.00E-04	2.40E-05	D	IREP
AS	PC	CC event (3 out of 4) MGL factor: 5.68E-02, Generic - PORV Fails to Open (per dem.), Rate: 3.00E-04	1.70E-05	D	IREP
AS	PC	CC event (4 out of 4) MGL factor: 1.70E-01, Generic - PORV Fails to Open (per dem.), Rate: 3.00E-04	5.10E-05	D	IREP
AV	ALL	CC event (2 out of 2) MGL factor: 6.50E-02, All Air Operated Valves Failure to Function/Open/Close (per dem.), Rate: 9.37E-04	6.09E-05	D	DRESDEN
CB	AC	CC event (2 out of 2) MGL factor: 5.40E-02, 4160 Supply Breakers Spurious Opening (per hr.), Rate: 1.72E-06	9.29E-08	HR	DRESDEN
CB	AC	CC event (2 out of 2) MGL factor: 5.40E-02, Generic - 480V Circuit Breaker Fails Spurious Open (per hr.), Rate: 1.00E-08	5.40E-10	HR	IEEE
CB	AC	CC event (2 out of 3) MGL factor: 2.80E-02, 4160 Supply Breakers Spurious Opening (per hr.), Rate: 1.72E-06	4.82E-08	HR	DRESDEN
CB	AC	CC event (2 out of 3) MGL factor: 2.80E-02, Generic - 480V Circuit Breaker Fails Spurious Open (per hr.), Rate: 1.00E-08	2.80E-10	HR	IEEE
CB	AC	CC event (2 out of 4) MGL factor: 2.80E-02, 4160 Supply Breaker Failure to Open/Close/Function (per dem.), Rate: 8.87E-04	2.84E-05	D	DRESDEN
CB	AC	CC event (2 out of 4) MGL factor: 2.80E-02, 4160 Supply Breakers Spurious Opening (per hr.), Rate: 1.72E-06	4.82E-08	HR	DRESDEN
CB	AC	CC event (3 out of 3) MGL factor: 5.21E-02, 4160 Supply Breakers Spurious Opening (per hr.), Rate: 1.72E-06	8.96E-08	HR	DRESDEN

TABLE 4.4.1-5 (Continued)
COMMON CAUSE FAILURE DATA FOR DRESDEN IPE

COMP	SYSTEM	EVENT DESCRIPTION	VALUE	UNIT	SOURCE
CB	AC	CC event (3 out of 3) MGL factor: 5.21E-02, Generic - 480V Circuit Breaker Fails Spurious Open (per hr.), Rate: 1.00E-08	5.21E-10	HR	IEEE
CB	ALL	CC event (2 out of 2) MGL factor: 5.40E-02, Generic - Circuit Breaker Fails to Transfer/Function/Open/Close (per dem.), Rate: 3.00E-03	1.62E-04	D	4550
CN	ALL	CC event (2 out of 2) MGL factor: 1.80E-02, Generic - Relay Contacts Fail to Open/Close/Function (per dem.), Rate: 8.50E-06	1.53E-07	D	TOPS
CO	ALL	CC event (2 out of 2) MGL factor: 1.80E-02, Generic - Relay Coil Shorted/Fails to Function (per hr.), Rate: 3.00E-06	5.40E-08	HR	4550
CV	ALL	CC event (2 out of 2) MGL factor: 1.00E-02, Generic - CV Fails to Open (per dem.), Rate: 8.00E-05	8.00E-07	D	IEEE
CV	ALL	CC event (2 out of 4) MGL factor: 3.33E-03, Generic - CV Fails to Open (per dem.), Rate: 8.00E-05	2.66E-07	D	IEEE
CV	ALL	CC event (3 out of 4) MGL factor: 2.40E-03, Generic - CV Fails to Open (per dem.), Rate: 8.00E-05	1.92E-07	D	IEEE
CV	ALL	CC event (4 out of 4) MGL factor: 4.25E-03, Generic - CV Fails to Open (per dem.), Rate: 8.00E-05	3.40E-07	D	IEEE
DG	2DG	CC event (2 out of 3) MGL factor: 5.00E-03, U-2 Diesel Generator Failure to Run (per hr.), Rate: 1.27E-02	6.35E-05	HR	DRESDEN
DG	2DG	CC event (3 out of 3) MGL factor: 1.60E-03, U-2 Diesel Generator Failure to Run (per hr.), Rate: 1.27E-02	2.03E-05	HR	DRESDEN
DG	3DG	CC event (2 out of 3) MGL factor: 5.00E-03, U-3 Diesel Generator Failure to Start (per dem.), Rate: 5.13E-02	2.57E-04	D	DRESDEN
DG	3DG	CC event (3 out of 3) MGL factor: 1.60E-03, U-3 Diesel Generator Failure to Start (per dem.), Rate: 5.13E-02	8.21E-05	D	DRESDEN
DM	ALL	CC event (2 out of 2) MGL factor: 1.80E-02, Dampers Failure to Open/Close/Function (per dem.), Rate: 7.83E-04	1.40E-05	D	DRESDEN

TABLE 4.4.1-5 (Continued)
COMMON CAUSE FAILURE DATA FOR DRESDEN IPE

COMP	SYSTEM	EVENT DESCRIPTION	VALUE	UNIT	SOURCE
ES	ALL	CC event (2 out of 2) MGL factor: 1.80E-02, Generic - Level Switch Fails to Open/Close/Function (per hr.), Rate: 5.30E-06	9.53E-08	HR	IEEE
EV	ALL	CC event (2 out of 2) MGL factor: 1.80E-02, Explosive valve does not open (per dem.), Rate: 3.00E-03	5.40E-05	D	4550
FL	ALL	CC event (2 out of 3) MGL factor: 1.15E-02, Generic - Strainer/Filter Plugged (per hr.), Rate: 3.00E-05	3.45E-07	HR	2815
FL	ALL	CC event (3 out of 3) MGL factor: 1.33E-02, Generic - Strainer/Filter Plugged (per hr.), Rate: 3.00E-05	3.99E-07	HR	2815
FN	GT	CC event (2 out of 2) MGL factor: 1.20E-02, SBGT Fans Failure to Function/Run (per hr.), Rate: 7.39E-05	8.86E-07	HR	DRESDEN
FN	GT	CC event (2 out of 2) MGL factor: 1.20E-02, SBGT Fans Failure to Start (per dem.), Rate: 1.00E-05	1.20E-07	D	4550
FN	ALL	CC event (2 out of 2) MGL factor: 1.20E-02, Generic - HVAC Fan Fails to Run (per hr.), Rate: 1.00E-05	1.20E-07	HR	4550
FN	ALL	CC event (2 out of 2) MGL factor: 1.20E-02, Generic - HVAC Fan Fails to Start (per dem.), Rate: 3.00E-04	3.60E-06	D	4550
KV	ALL	CC event (2 out of 2) MGL factor: 1.80E-02, Generic - Stop Check Valve Fails to Open (per dem.), Rate: 1.00E-04	1.80E-06	D	IREP
MV	ALL	CC event (2 out of 2) MGL factor: 1.00E-02, Motor Operated Valve Failure to Open/Close/Function (per dem.), Rate: 1.87E-03	1.87E-05	D	DRESDEN
PD	FP	CC event (2 out of 2) MGL factor: 1.80E-02, Diesel Fire Pumps Failure to Run/Function (per hr.), Rate: 1.10E-02	1.98E-04	HR	DRESDEN
PD	FP	CC event (2 out of 2) MGL factor: 1.80E-02, Diesel Fire Pumps Failure to Start (per dem.), Rate: 1.35E-03	2.43E-05	D	DRESDEN
PD	ALL	CC event (2 out of 2) MGL factor: 1.80E-02, Generic - Diesel Driven Pump Fails to Run (per hr.), Rate: 8.00E-04	1.44E-05	HR	4550

TABLE 4.4.1-5 (Continued)
COMMON CAUSE FAILURE DATA FOR DRESDEN IPE

COMP	SYSTEM	EVENT DESCRIPTION	VALUE	UNIT	SOURCE
PD	ALL	CC event (2 out of 2) MGL factor: 1.80E-02, Generic - Diesel Driven Pump Failure to Start (per dem.), Rate: 3.00E-02	5.39E-04	D	4550
PM	CC	CC event (2 out of 4) MGL factor: 3.33E-03, CCSW Pump Failure to Run/Function (per hr.), Rate: 2.64E-04	8.79E-07	HR	DRESDEN
PM	CC	CC event (2 out of 4) MGL factor: 3.33E-03, CCSW Pumps Failure to Start (per dem.), Rate: 6.04E-03	2.01E-05	D	DRESDEN
PM	CC	CC event (3 out of 4) MGL factor: 2.60E-03, CCSW Pump Failure to Run/Function (per hr.), Rate: 2.64E-04	6.86E-07	HR	DRESDEN
PM	CC	CC event (3 out of 4) MGL factor: 2.60E-03, CCSW Pumps Failure to Start (per dem.), Rate: 6.04E-03	1.57E-05	D	DRESDEN
PM	CC	CC event (4 out of 4) MGL factor: 4.45E-03, CCSW Pump Failure to Run/Function (per hr.), Rate: 2.64E-04	1.17E-06	HR	DRESDEN
PM	CC	CC event (4 out of 4) MGL factor: 4.45E-03, CCSW Pumps Failure to Start (per dem.), Rate: 6.04E-03	2.69E-05	D	DRESDEN
PM	CD	CC event (2 out of 4) MGL factor: 3.33E-03, Condensate/Condensate Booster Pumps Failure to Run/Function (per hr.), Rate: 1.33E-05	4.43E-08	HR	DRESDEN
PM	CD	CC event (2 out of 4) MGL factor: 3.33E-03, Condensate/Condensate Booster Pumps Failure to Start (per dem.), Rate: 1.98E-03	6.59E-06	D	DRESDEN
PM	CD	CC event (3 out of 4) MGL factor: 2.60E-03, Condensate/Condensate Booster Pumps Failure to Run/Function (per hr.), Rate: 1.33E-05	3.46E-08	HR	DRESDEN
PM	CD	CC event (3 out of 4) MGL factor: 2.60E-03, Condensate/Condensate Booster Pumps Failure to Start (per dem.), Rate: 1.98E-03	5.15E-06	D	DRESDEN
PM	CD	CC event (4 out of 4) MGL factor:4.45E-03, Condensate/Condensate Booster Pumps Failure to Run/Function (per hr.), Rate: 1.33E-05	5.92E-08	HR	DRESDEN
PM	CD	CC event (4 out of 4) MGL factor: 4.45E-03, Condensate/Condensate Booster Pumps Failure to Start (per dem.), Rate: 1.98E-03	8.81E-06	D	DRESDEN

TABLE 4.4.1-5 (Continued)
COMMON CAUSE FAILURE DATA FOR DRESDEN IPE

COMP	SYSTEM	EVENT DESCRIPTION	VALUE	UNIT	SOURCE
PM	CS	CC event (2 out of 2) MGL factor: 5.10E-02, Core Spray Pump Failure to Run/Function (per hr.), Rate: 2.44E-04	1.24E-05	HR	DRESDEN
PM	CS	CC event (2 out of 2) MGL factor: 5.10E-02, Core Spray Pump Failure to Start (per dem.), Rate: 3.14E-03	1.60E-04	D	DRESDEN
PM	DG	CC event (2 out of 3) MGL factor: 5.00E-03, Diesel Generator Cooling Water Pump Failure to Run/Function (per hr.), Rate: 1.12E-03	5.60E-06	HR	DRESDEN
PM	DG	CC event (3 out of 3) MGL factor: 600E-03, Diesel Generator Cooling Water Pump Failure to Run/Function (per hr.), Rate: 1.12E-03	6.72E-06	HR	DRESDEN
PM	FW	CC event (2 out of 3) MGL factor: 5.00E-03, Reactor Feed Pump Failure to Run/Function (per hr.), Rate: 3.23E-05	1.62E-07	HR	DRESDEN
PM	FW	CC event (2 out of 3) MGL factor: 5.00E-03, Reactor Feed Pump Failure to Start (per dem.), Rate: 6.02E-04	3.01E-06	D	DRESDEN
PM	FW	CC event (3 out of 3) MGL factor: 6.00E-03, Reactor Feed Pump Failure to Run/Function (per hr.), Rate: 3.23E-05	1.94E-07	HR	DRESDEN
PM	FW	CC event (3 out of 3) MGL factor: 6.00E-03, Reactor Feed Pump Failure to Start (per dem.), Rate: 6.02E-04	3.61E-06	D	DRESDEN
PM	LI	CC event (2 out of 4) MGL factor: 3.33E-03, LPCI Pumps Failure to Run/Function (per hr.), Rate: 2.44E-04	8.13E-07	HR	DRESDEN
PM	LI	CC event (2 out of 4) MGL factor: 3.33E-03, LPCI Pumps Failure to Start (per dem.), Rate: 2.42E-03	8.06E-06	D	DRESDEN
PM	LI	CC event (3 out of 4) MGL factor: 2.60E-03, LPCI Pumps Failure to Run/Function (per hr.), Rate: 2.44E-04	6.34E-07	HR	DRESDEN
PM	LI	CC event (3 out of 4) MGL factor: 2.60E-03, LPCI Pumps Failure to Start (per dem.), Rate: 2.42E-03	6.92E-06	D	DRESDEN
PM	LI	CC event (4 out of 4) MGL factor: 4.45E-03, LPCI Pumps Failure to Run/Function (per hr.), Rate: 2.44E-04	1.09E-06	HR	DRESDEN

TABLE 4.4.1-5 (Continued)
COMMON CAUSE FAILURE DATA FOR DRESDEN IPE

COMP	SYSTEM	EVENT DESCRIPTION	VALUE	UNIT	SOURCE
PM	LI	CC event (4 out of 4) MGL factor: 4.45E-03, LPCI Pumps Failure to Start (per dem.), Rate: 2.42E-03	1.08E-05	D	DRESDEN
PM	SL	CC event (2 out of 2) MGL factor: 3.20E-02, SLC Pumps Failure to Start (per dem.), Rate: 1.63E-03	5.22E-05	D	DRESDEN
PM	SL	CC event (2 out of 2) MGL factor: 3.20E-02, Generic - Motor Driven Pump Fails to Run (per hr.), Rate: 1.00E-04	3.20E-06	HR	2815
PM	SW	CC event (2 out of 4) MGL factor: 3.33E-03, Service Water Pump Failure to Run/Function (per hr.), Rate: 1.65E-06	5.49E-09	HR	IEEE
PM	SW	CC event (2 out of 4) MGL factor: 3.33E-03, Service Water Pump Failure to Start (per dem.), Rate: 2.78E-03	9.26E-06	D	IEEE
PM	SW	CC event (3 out of 4) MGL factor: 2.60E-03, Service Water Pump Failure to Run/Function (per hr.), Rate: 1.65E-06	4.29E-09	HR	IEEE
PM	SW	CC event (3 out of 4) MGL factor: 2.60E-03, Service Water Pump Failure to Start (per dem.), Rate: 2.78E-03	7.23E-06	D	IEEE
PM	ALL	CC event (2 out of 2) MGL factor: 1.00E-02, Generic - Motor Driven Pump Fails to Start (per dem.), Rate: 3.90E-03	3.90E-05	D	IEEE
PS	ALL	CC event (2 out of 2) MGL factor: 1.80E-02, Generic - Pressure Switch Fails to Operate/Open/Close (per hr.), Rate: 2.00E-07	3.60E-09	HR	2815
PS	ALL	CC event (2 out of 2) MGL factor: 1.80E-02 Pressure Switch fails to Function (per dem.), Rate: 3.4E-04	6.1E-06	D	DRESDEN
RE	ALL	CC event (2 out of 2) MGL factor: 1.80E-02, Generic - Relay Fails During Operation (per hr.), Rate: 5.10E-07	9.17E-09	HR	TOPS
SV	ALL	CC event (2 out of 4) MGL factor: 8.33E-03, Generic - SOV Fails to Operate/Open/Close (per dem.), Rate: 9.40E-07	7.83E-09	D	IEEE
SV	ALL	CC event (3 out of 4) MGL factor: 6.00E-03, Generic - SOV Fails to Operate/Open/Close (per dem.), Rate: 9.40E-07	5.64E-09	D	IEEE

TABLE 4.4.1-5 (Continued)
COMMON CAUSE FAILURE DATA FOR DRESDEN IPE

COMP	SYSTEM	EVENT DESCRIPTION	VALUE	UNIT	SOURCE
SW	ALL	CC event (2 out of 2) MGL factor: 1.80E-02, Generic - Switch (General Type) Fails (per hr.), Rate: 1.70E-07	3.05E-09	HR	TOPS
TI	ALL	CC event (2 out of 2) MGL factor: 1.80E-02, Timing relay fails to function, Rate: 5.10E-07	9.17E-09	HR	TOPS
TR	AC	CC event (2 out of 2) MGL factor: 1.80E-02, AC Transformers Failure to Function (UAT & RAT) (per hr.), Rate: 7.10E-07	1.28E-08	HR	IEEE
TR	AC	CC event (2 out of 3) MGL factor: 1.15E-02, AC Transformers Failure to Function (UAT & RAT) (per hr.), Rate: 7.10E-07	8.17E-09	HR	IEEE
TR	AC	CC event (3 out of 3) MGL factor: 1.33E-02, AC Transformers Failure to Function (UAT & RAT) (per hr.), Rate: 7.10E-07	9.44E-09	HR	IEEE
TS	ALL	CC event (2 out of 2) MGL factor: 1.80E-02, Generic - Temperature Switch Fails to Open/Close/Function (per hr.), Rate: 3.90E-07	7.02E-09	HR	IEEE

Notes:

1. This compressor common cause failure rate was used as the system failure rate for the Instrument Air and Pumpback Air systems.

TABLE 4.5.2-1
UNAVAILABILITY OF SYSTEMS AND PLANT FUNCTIONS

EVENT	UNAVAILABILITY
ATWS	
ATWS ACTUATION FAILS; ALL SUPPORTS AVAILABLE	1.50E-02
ARI FAILS; ALL SUPPORTS AVAILABLE	6.46E-07
ARI FAILS; 2M1 FAILED	1.13E-04
ARI FAILS; 2R1 FAILED	1.13E-04
AUTO RPT FAILS; ALL SUPPORTS AVAILABLE	5.99E-03
AUTO RPT FAILS; 2M1 FAILED	6.05E-03
AUTO RPT FAILS; 2R1 FAILED	6.05E-03
MANUAL RPT FAILS	5.99E-03
CONTROL ROD DRIVE	
UNIT 3 AVAILABLE TO UNIT 2 DURING SINGLE UNIT SBO	5.60E-02
UNITS 2 & 3 UNAVAILABLE DURING DUAL UNIT SBO	1.00E-00
CORE SPRAY	
CS FAILS; 1/2 PUMPS, ALL SUPPORTS AVAILABLE	6.74E-04
CS FAILS; 1/2 PUMPS, ALL SUPPORTS AVAILABLE (LB28/LB38)	1.45E-02
CS FAILS; 1 PUMP; 24-1, 29, OR 2R1 FAILED	1.41E-02
CS FAILS; 1 PUMP; 23-1, 28, OR 2M1 FAILED	1.42E-02
FEEDWATER & CONDENSATE	
FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE (ILOC)	7.55E-05
FW FAILS; 1 PUMP, 23 FAILED (ILOC)	3.98E-04
FW FAILS; 1 PUMP, 24 FAILED (ILOC)	4.17E-04
FW FAILS; 1 PUMP, 24 FAILED (LB22/LB32)	2.06E-03
FW FAILS; 1 PUMP, 24 FAILED (LB21/LB31)	3.74E-03
FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE (TRAN)	1.52E-03
FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE (LB22/LB32)	1.74E-03
FW FAILS; 1 PUMP, ALL SUPPORTS AVAILABLE (LB21/LB31)	3.42E-03
FW FAILS; 1 PUMP, 23 FAILED (TRAN)	1.68E-03
FW FAILS; 1 PUMP, 23 FAILED (LB22/LB32)	1.89E-03
FW FAILS; 1 PUMP, 23 FAILED (LB21/LB31)	3.58E-03
FW FAILS; 1 PUMP, 24 FAILED	1.84E-03
FW FAILS; 1 PUMP, 25 FAILED	2.05E-03
FW FAILS; 1 PUMP, 23 AND 25 FAILED	2.21E-03
FW FAILS; 1 PUMP, 26 FAILED	4.98E-03
FW FAILS; 1 PUMP, 24 AND 26 FAILED	5.31E-03

TABLE 4.5.2-1 (Continued)
UNAVAILABILITY OF SYSTEMS AND PLANT FUNCTIONS

EVENT	UNAVAILABILITY
FW FAILS; 1 PUMP, 2R1 FAILED (TRAN)	1.64E-03
FW FAILS; 1 PUMP, 2R1 FAILED (LB22/LB32)	1.84E-03
FW FAILS; 1 PUMP, 23 AND 2R1 FAILED (TRAN)	1.79E-03
FW FAILS; 1 PUMP, 23 AND 2R1 FAILED (LB22/LB32)	2.00E-03
FW FAILS; 1 PUMP, 24 AND 2R1 FAILED (TRAN)	1.96E-03
FW FAILS; 1 PUMP, 24 AND 2R1 FAILED (LB22/LB32)	2.17E-03
FW FAILS; 1 PUMP, 25 AND 2R1 FAILED (TRAN)	2.17E-03
FW FAILS; 1 PUMP, 25 AND 2R1 FAILED (LB22/LB32)	2.38E-03
FW FAILS; 1 PUMP, 23, 25 AND 2R1 FAILED (TRAN)	2.33E-03
FW FAILS; 1 PUMP, 23, 25 AND 2R1 FAILED (LB22/LB32)	2.54E-03
FW FAILS; 1 PUMP, 26 AND 2R1 FAILED (TRAN)	5.10E-03
FW FAILS; 1 PUMP, 26 AND 2R1 FAILED (LB22/LB32)	5.31E-03
FW FAILS; 1 PUMP, 24, 26 AND 2R1 FAILED (TRAN)	5.42E-03
FW FAILS; 1 PUMP, 24, 26 AND 2R1 FAILED (LB22/LB32)	5.63E-03
HPCI	
HP FAILS; 2R1 FAILED	2.93E-02
HP FAILS; 2M1 FAILED	2.93E-02
HP FAILS; ALL SUPPORTS AVAILABLE	2.93E-02
HP FAILS; 2R1 FAILED, MANUAL START	5.22E-02
HP FAILS; 2M1 FAILED, MANUAL START	5.50E-02
HP FAILS; ALL SUPPORTS AVAILABLE, MANUAL START	5.22E-02
ISOLATION CONDENSER	
IC1 OR IC2 FAILS; ALL SUPPORTS AVAILABLE	3.87E-03
MUP FAILS; 25 FAILED	6.98E-03
MUP FAILS; ALL SUPPORTS AVAILABLE	2.56E-03
MUP FAILS; 28 AND 29 FAILED	2.56E-03
AIC FAILS (AUTO INITIATION OF IC)	1.84E-04
TORUS/DRYWELL VENT	
SMALL TORUS VENT FAILS; 28, 29, 25, 39 AVAILABLE (TRAN)	1.76E-03
SMALL TORUS VENT FAILS; 28, 29, 25, 39 AVAILABLE (LB282/LB382)	1.81E-02
SMALL TORUS VENT FAILS; 28, 29, 25, 39 AVAILABLE (LB28/LB38)	3.87E-02
SMALL TORUS VENT FAILS; 29, 25, 39 AVAILABLE	2.29E-02
SMALL TORUS VENT FAILS; 28, 29, 25 AVAILABLE	2.28E-02
SMALL TORUS VENT FAILS; 28, 25, 39 AVAILABLE (TRAN)	1.75E-03

TABLE 4.5.2-1 (Continued)
UNAVAILABILITY OF SYSTEMS AND PLANT FUNCTIONS

EVENT	UNAVAILABILITY
SMALL TORUS VENT FAILS; 28, 25, 39 AVAILABLE (LB282/LB382)	1.81E-02
SMALL TORUS VENT FAILS; 28, 25, 39 AVAILABLE (LB28/LB38)	3.87E-02
SMALL TORUS VENT FAILS; 28, 29, 39 AVAILABLE (TRAN)	1.75E-03
SMALL TORUS VENT FAILS; 28, 29, 39 AVAILABLE (LB282/LB382)	1.95E-02
SMALL TORUS VENT FAILS; 28, 29, 39 AVAILABLE (LB28/LB38)	4.01E-02
SMALL TORUS VENT FAILS; 25, 39 AVAILABLE	2.29E-02
SMALL TORUS VENT FAILS; 29, 39 AVAILABLE	2.43E-02
SMALL TORUS VENT FAILS; 28, 25 AVAILABLE	2.28E-02
SMALL TORUS VENT FAILS; 28, 29 AVAILABLE	2.28E-02
SMALL TORUS VENT FAILS; 28, 39 AVAILABLE (TRAN)	1.75E-03
SMALL TORUS VENT FAILS; 28, 39 AVAILABLE (LB282/LB382)	1.95E-02
SMALL TORUS VENT FAILS; 28, 39 AVAILABLE (LB28/LB38)	4.01E-02
SMALL TORUS VENT FAILS; 39 AVAILABLE	2.43E-02
SMALL TORUS VENT FAILS; 28 AVAILABLE	2.28E-02
LARGE TORUS VENT FAILS; 28, 29, 25, 39 AVAILABLE (TRAN)	2.38E-03
LARGE TORUS VENT FAILS; 28, 29, 25, 39 AVAILABLE (LB28/LB38)	2.40E-03
LARGE TORUS VENT FAILS; 28, 29, 25, 39 AVAILABLE (LB282/LB382)	2.40E-03
LARGE TORUS VENT FAILS; 29, 25, 39 AVAILABLE	2.40E-03
LARGE TORUS VENT FAILS; 28, 25, 39 AVAILABLE (TRAN)	2.38E-03
LARGE TORUS VENT FAILS; 28, 25, 39 AVAILABLE (LB28/LB38)	2.40E-03
LARGE TORUS VENT FAILS; 28, 25, 39 AVAILABLE (LB282/LB382)	2.40E-03
LARGE TORUS VENT FAILS; 28, 29, 39 AVAILABLE (TRAN)	2.38E-03
LARGE TORUS VENT FAILS; 28, 29, 39 AVAILABLE (LB28/LB38)	3.84E-03
LARGE TORUS VENT FAILS; 28, 29, 39 AVAILABLE (LB282/LB382)	3.84E-03
LARGE TORUS VENT FAILS; 25, 39 AVAILABLE	2.40E-03
LARGE TORUS VENT FAILS; 29, 39 AVAILABLE	3.84E-03
LARGE TORUS VENT FAILS; 28, 39 AVAILABLE (TRAN)	2.38E-03
LARGE TORUS VENT FAILS; 28, 39 AVAILABLE (LB28/LB38)	3.86E-03
LARGE TORUS VENT FAILS; 28, 39 AVAILABLE (LB282/LB382)	3.86E-03
LARGE TORUS VENT FAILS; 39 AVAILABLE	3.86E-03
SMALL DRYWELL VENT FAILS; 28, 29, 25, 39 AVAILABLE (TRAN)	5.53E-01
SMALL DRYWELL VENT FAILS; 28, 29, 25, 39 AVAILABLE (LB282/LB382)	9.57E-01
SMALL DRYWELL VENT FAILS; 28, 29, 25, 39 AVAILABLE (LB28/LB38)	9.80E-01
SMALL DRYWELL VENT FAILS; 29, 25, 39 AVAILABLE	9.66E-01

TABLE 4.5.2-1 (Continued)
UNAVAILABILITY OF SYSTEMS AND PLANT FUNCTIONS

EVENT	UNAVAILABILITY
SMALL DRYWELL VENT FAILS; 28, 29, 25 AVAILABLE	9.67E-01
SMALL DRYWELL VENT FAILS; 28, 25, 39 AVAILABLE (TRAN)	5.53E-01
SMALL DRYWELL VENT FAILS; 28, 25, 39 AVAILABLE (LB282/LB382)	9.57E-01
SMALL DRYWELL VENT FAILS; 28, 25, 39 AVAILABLE (LB28/LB38)	9.80E-01
SMALL DRYWELL VENT FAILS; 28, 29, 39 AVAILABLE (TRAN)	5.53E-01
SMALL DRYWELL VENT FAILS; 28, 29, 39 AVAILABLE (LB282/LB382)	9.60E-01
SMALL DRYWELL VENT FAILS; 28, 29, 39 AVAILABLE (LB28/LB38)	9.81E-01
SMALL DRYWELL VENT FAILS; 25, 39 AVAILABLE	9.66E-01
SMALL DRYWELL VENT FAILS; 29, 39 AVAILABLE	9.68E-01
SMALL DRYWELL VENT FAILS; 28, 25 AVAILABLE	9.67E-01
SMALL DRYWELL VENT FAILS; 28, 29 AVAILABLE	9.67E-01
SMALL DRYWELL VENT FAILS; 28, 39 AVAILABLE (TRAN)	5.53E-01
SMALL DRYWELL VENT FAILS; 28, 39 AVAILABLE (LB282/LB382)	9.60E-01
SMALL DRYWELL VENT FAILS; 28, 39 AVAILABLE (LB28/LB38)	9.81E-01
SMALL DRYWELL VENT FAILS; 39 AVAILABLE	9.69E-01
SMALL DRYWELL VENT FAILS; 28 AVAILABLE	9.67E-01
LARGE DRYWELL VENT FAILS; 28, 29, 25, 39 AVAILABLE (TRAN)	6.72E-01
LARGE DRYWELL VENT FAILS; 28, 29, 25, 39 AVAILABLE (LB28/LB38)	6.74E-01
LARGE DRYWELL VENT FAILS; 28, 29, 25, 39 AVAILABLE (LB282/LB382)	6.74E-01
LARGE DRYWELL VENT FAILS; 29, 25, 39 AVAILABLE	6.74E-01
LARGE DRYWELL VENT FAILS; 28, 25, 39 AVAILABLE (TRAN)	6.72E-01
LARGE DRYWELL VENT FAILS; 28, 25, 39 AVAILABLE (LB28/LB38)	6.74E-01
LARGE DRYWELL VENT FAILS; 28, 25, 39 AVAILABLE (LB282/LB382)	6.74E-01
LARGE DRYWELL VENT FAILS; 28, 29, 39 AVAILABLE (TRAN)	6.72E-01
LARGE DRYWELL VENT FAILS; 28, 29, 39 AVAILABLE (LB28/LB38)	7.97E-01
LARGE DRYWELL VENT FAILS; 28, 29, 39 AVAILABLE (LB282/LB382)	7.97E-01
LARGE DRYWELL VENT FAILS; 25, 39 AVAILABLE	6.74E-01
LARGE DRYWELL VENT FAILS; 29, 39 AVAILABLE	7.97E-01
LARGE DRYWELL VENT FAILS; 28, 39 AVAILABLE (TRAN)	6.72E-01
LARGE DRYWELL VENT FAILS; 28, 39 AVAILABLE (LB28/LB38)	7.98E-01
LARGE DRYWELL VENT FAILS; 28, 39 AVAILABLE (LB282/LB382)	7.98E-01
LARGE DRYWELL VENT FAILS; 39 AVAILABLE	7.98E-01
LOW PRESSURE COOLANT INJECTION	
LPCI PUMP CROSS-TIE FAILS; ISLOCA ALL SUPPORTS AVAILABLE	2.44E-05

TABLE 4.5.2-1 (Continued)
UNAVAILABILITY OF SYSTEMS AND PLANT FUNCTIONS

EVENT	UNAVAILABILITY
LPCI PUMP & INJECTION VALVE FAILS; ISLOCA ALL SUPPORTS AVAILABLE	2.68E-03
LPCI PUMP CROSS-TIE FAILS; ISLOCA 28 AVAILABLE	2.44E-03
LPCI PUMP & INJECTION VALVE FAILS; ISLOCA 241, 2R1, 2M1, 29,	2.75E-03
LPCI PUMP CROSS-TIE FAILS; ISLOCA 29 AVAILABLE	2.44E-03
LPCI PUMP TRAIN A FAILS; 231 AND 2M1 AVAILABLE	1.27E-04
LPCI PUMP TRAIN B FAILS; 241 AND 2R1 AVAILABLE	1.27E-04
LPCI PUMP TRAINS A&B FAIL; ALL SUPPORTS AVAILABLE	1.39E-05
INJECT. VALVE FAILS; ALL SUPPORTS AVAILABLE	2.54E-03
INJECT. VALVE FAILS; 28, 2R1 AND 2M1 AVAILABLE	5.54E-03
INJECT. VALVE FAILS; 29, 2M1 AND 2R1 AVAILABLE	2.54E-03
INJECT. VALVE FAILS; 28 AND 2M1 AVAILABLE	5.60E-03
INJECT. VALVE FAILS; 29 AND 2R1 AVAILABLE	5.59E-03
INJECT. VALVE FAILS; 28, 2R1 AND 2M1 AVAILABLE, CAS NOT REQ	5.89E-03
INJECT. VALVE FAILS; 29, 2M1 AND 2R1 AVAILABLE, CAS NOT REQ	2.89E-03
INJECT. VALVE FAILS; 28 AND 2M1 AVAILABLE, CAS NOT REQ	5.89E-03
INJECT. VALVE FAILS; 29 AND 2R1 AVAILABLE, CAS NOT REQ	2.89E-03
INJECT. VALVE FAILS; ALL SUPPORTS AVAILABLE, CAS NOT REQ	2.88E-03
INJECT. VALVE FAILS; 28, 29, 2R1, CAS AVAILABLE	5.59E-03
INJECT. VALVE FAILS; 28, 29, 2M1, CAS AVAILABLE	2.60E-03
INJECT. VALVE FAILS; 29, 2M1, CAS AVAILABLE	2.60E-03
INJECT. VALVE FAILS; 28, 2R1, CAS AVAILABLE	8.58E-03
INJECT. COOLING FAILS; ALL SUPPORTS AVAILABLE	2.64E-04
INJECT. COOLING FAILS; 23, 28, 2M1 AVAILABLE	5.79E-03
INJECT. COOLING FAILS; 24, 29, 2R1 AVAILABLE	5.79E-03
SUPPRESSION POOL COOLING FAILS; ALL SUPPORTS AVAILABLE	3.25E-04
SUPPRESSION POOL COOLING FAILS; ALL SUPPORTS AVAILABLE (LB28/LB38)	1.11E-02
SUPPRESSION POOL COOLING FAILS; ALL SUPPORTS AVAILABLE (LB282/LB382)	4.84E-04
SUPPRESSION POOL COOLING FAILS; 23, 28, 29, 2M1 AVAILABLE	5.89E-03
SUPPRESSION POOL COOLING FAILS; 23, 28, 29, 2M1 AVAILABLE (LB282/LB382)	2.80E-02
SUPPRESSION POOL COOLING FAILS; 23, 28, 2M1 AVAILABLE	1.07E-02
SUPPRESSION POOL COOLING FAILS; 23, 28, 2M1 AVAILABLE (LB282/LB382)	3.27E-02
SUPPRESSION POOL COOLING FAILS; 24, 28, 29, 2R1 AVAILABLE	5.87E-03
SUPPRESSION POOL COOLING FAILS; 24, 28, 29, 2R1 AVAILABLE (LB28/LB38)	1.07E-02
SUPPRESSION POOL COOLING FAILS; 24, 29, 2R1 AVAILABLE	1.07E-02

TABLE 4.5.2-1 (Continued)
UNAVAILABILITY OF SYSTEMS AND PLANT FUNCTIONS

EVENT	UNAVAILABILITY
CONTAINMENT SPRAY FAILS; ALL SUPPORTS AVAILABLE	1.30E-05
CONTAINMENT SPRAY FAILS; 28, 2M1, 2R1 AVAILABLE	5.92E-05
CONTAINMENT SPRAY FAILS; 29, 2M1, 2R1 AVAILABLE	5.92E-05
CONTAINMENT SPRAY FAILS; 28, 2M1 AVAILABLE	7.63E-04
CONTAINMENT SPRAY FAILS; 29, 2R1 AVAILABLE	7.63E-04
AUTOMATIC DEPRESSURIZATION SYSTEM	
ADS FAILS; 2M1 AVAILABLE	5.15E-08
ADS FAILS; ALL SUPPORTS AVAILABLE (TRAN)	4.78E-08
ADS FAILS; ALL SUPPORTS AVAILABLE (LOSW)	5.15E-08
ADS FAILS; 2R1 AVAILABLE	1.40E-05
SLC	
SLC FAILS; 1/2 PUMPS; ALL SUPPORTS AVAILABLE	2.96E-04
SLC FAILS; 2/2 PUMPS; ALL SUPPORTS AVAILABLE	1.04E-02
SLC FAILS; 28 FAILED	8.24E-03
SLC FAILS; 29 FAILED	8.24E-03
REACTOR PROTECTION SYSTEM	
FRAC OF RPS FAILURES THAT ARE MECHANICAL	3.33E-01
FAILURE OF RPS	3.00E-05
RVC	
RVC FAILS; RELIEF VALVES CLOSING (TRANS)	2.70E-02
RVC FAILS; RELIEF VALVES CLOSING (ATWS W/MC)	1.60E-01
RVC FAILS; RELIEF VALVES CLOSING (ATWS W/O MC)	3.60E-01
RVC FAILS; RELIEF VALVES OPENING (TRANS)	8.00E-12
RVC FAILS; RELIEF VALVES OPENING (ATWS W/MC)	1.10E-04
RVC FAILS; RELIEF VALVES OPENING (ATWS W/O MC)	1.50E-07
AC ELECTRIC POWER	
LOSS OF BUS 24 AFTER 23/ 24-1 AVAILABLE, 24HR	3.52E-02
LOSS OF BUS 26 AFTER 25, 24HR	1.17E-02
LOSS OF BUS 27 AFTER 26, 24HR	1.24E-04
LOSS OF BUS 27 AFTER 26/LOSS OF BUS 24, 24HR	5.68E-02
LOSS OF BUS 27 AFTER 25, 24HR	1.17E-02
LOSS OF BUS 27 AFTER 25 AND 26, 24HR	1.00e+00
LOSS OF BUS 29 AFTER 28, 24HR	2.18E-02
LOSS OF BUS 29 AFTER 28, 24HR (LB28/LB38)	1.20E-04

TABLE 4.5.2-1 (Continued)
UNAVAILABILITY OF SYSTEMS AND PLANT FUNCTIONS

EVENT	UNAVAILABILITY
LOSS OF BUS 24-1 AFTER 23-1/BUS 24 AVAILABLE, 24HR	2.35E-02
LOSS OF DG2 AFTER DG2/3, 6 HRS	1.57E-01
LOSS OF DG2 AFTER DG2/3, 24 HRS	4.19E-01
LOSS OF DG2 AFTER DG2/3, 24 HRS (LB28/LB38)	4.20E-01
LOSS OF DG3 AFTER DG2, 24 HRS	3.89E-01
LOSS OF DG3 AFTER DG2/3, 24 HRS	3.97E-01
LOSS OF DG3 AFTER DG2/3 AND DG2, 24 HRS	3.89E-01
LOSS OF DG3 AFTER DG2, 6 HRS	1.60E-01
LOSS OF DG3 AFTER DG2/3, 6 HRS	1.60E-01
LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS	1.30E-01
LOSS OF BUS 23, 24HR	1.13E-04
LOSS OF BUS 23/23-1 AVAILABLE, 24HR	3.09E-03
LOSS OF BUS 24, 24HR	1.13E-04
LOSS OF BUS 24/24-1 AVAILABLE, 24HR	3.09E-03
LOSS OF BUS 25, 24HR	1.53E-06
LOSS OF BUS 25/LOSS OF BUS 23	1.54E-05
LOSS OF BUS 25/LOSS OF BUS 24	1.18E-04
LOSS OF BUS 26, 24HR	1.87E-06
LOSS OF BUS 26/LOSS OF BUS 24	3.01E-03
LOSS OF BUS 26/LOSS OF BUS 25	1.18E-04
LOSS OF BUS 27, 24HR	1.87E-06
LOSS OF BUS 27/LOSS OF BUS 24	3.01E-03
LOSS OF BUS 27/LOSS OF BUS 25	1.18E-04
LOSS OF BUS 28, GIVEN BUS 23-1, BUS 29 AVAILABLE	3.14E-06
LOSS OF BUS 28, GIVEN BUS 29 AVAILABLE	1.39E-02
LOSS OF BUS 28, GIVEN BUS 23-1 AVAILABLE	1.18E-04
LOSS OF BUS 29, GIVEN BUS 24-1, BUS 28 AVAILABLE	3.14E-06
LOSS OF BUS 29, GIVEN BUS 28 AVAILABLE	1.39E-02
LOSS OF BUS 29, GIVEN BUS 24-1 AVAILABLE	1.18E-04
LOSS OF BUS 23-1, GIVEN BUS 23 AVAILABLE	2.00E-04
LOSS OF BUS 23-1, GIVEN DG2/3 AVAILABLE	1.52E-06
LOSS OF BUS 24-1, GIVEN BUS 24 AVAILABLE	1.99E-04
LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE	8.12E-03
LOSS OF BUS 24-1, GIVEN DG2 AVAILABLE	1.52E-06

TABLE 4.5.2-1 (Continued)
UNAVAILABILITY OF SYSTEMS AND PLANT FUNCTIONS

EVENT	UNAVAILABILITY
LOSS OF DG2, 6 HRS	1.38E-01
LOSS OF DG2, 24 HRS	3.65E-01
LOSS OF DG2/3, 6 HRS	9.50E-02
LOSS OF DG2/3, 24 HRS	1.65E-01
LOSS OF DG2/3, 24 HRS (LB28/LB38)	1.70E-01
LOSS OF BUS 34 AFTER 33/ 34-1 AVAILABLE, 24HR	3.52E-02
LOSS OF BUS 36 AFTER 35, 24HR	1.17E-02
LOSS OF BUS 37 AFTER 36, 24HR	1.24E-04
LOSS OF BUS 37 AFTER 36/LOSS OF BUS 34, 24HR	5.68E-02
LOSS OF BUS 37 AFTER 35, 24HR	1.17E-02
LOSS OF BUS 37 AFTER 35 AND 36, 24HR	1.00E-00
LOSS OF BUS 39 AFTER 38, 24HR	2.18E-02
LOSS OF BUS 34-1 AFTER 33-1/BUS 34 AVAILABLE, 24HR	2.35E-02
LOSS OF BUS 33, 24HR	1.13E-04
LOSS OF BUS 33/33-1 AVAILABLE, 24HR	3.09E-03
LOSS OF BUS 34, 24HR	1.13E-04
LOSS OF BUS 34/34-1 AVAILABLE, 24HR	3.09E-03
LOSS OF BUS 35, 24HR	1.53E-06
LOSS OF BUS 35/LOSS OF BUS 33	1.54E-05
LOSS OF BUS 35/LOSS OF BUS 34	1.18E-04
LOSS OF BUS 36, 24HR	1.87E-06
LOSS OF BUS 36/LOSS OF BUS 34	3.01E-03
LOSS OF BUS 36/LOSS OF BUS 35	1.18E-04
LOSS OF BUS 37, 24HR	1.87E-06
LOSS OF BUS 37/LOSS OF BUS 34	3.01E-03
LOSS OF BUS 37/LOSS OF BUS 35	1.18E-04
LOSS OF BUS 38, GIVEN BUS 33-1, BUS 39 AVAILABLE	3.14E-06
LOSS OF BUS 38, GIVEN BUS 39 AVAILABLE	1.39E-02
LOSS OF BUS 38, GIVEN BUS 33-1 AVAILABLE	1.18E-04
LOSS OF BUS 39, GIVEN BUS 34-1, BUS 38 AVAILABLE	3.14E-06
LOSS OF BUS 39, GIVEN BUS 38 AVAILABLE	1.39E-02
LOSS OF BUS 39, GIVEN BUS 34-1 AVAILABLE	1.18E-04
LOSS OF BUS 33-1, GIVEN BUS 33 AVAILABLE	2.00E-04
LOSS OF BUS 33-1, GIVEN DG2/3 AVAILABLE	1.52E-06

TABLE 4.5.2-1 (Continued)
UNAVAILABILITY OF SYSTEMS AND PLANT FUNCTIONS

EVENT	UNAVAILABILITY
LOSS OF BUS 34-1, GIVEN BUS 34 AVAILABLE	1.99E-04
LOSS OF BUS 34-1, GIVEN 24-1 CROSSTIE AVAILABLE	8.12E-03
LOSS OF BUS 34-1, GIVEN DG3 AVAILABLE	1.52E-06
LOSS OF DG3, 6 HRS	1.38E-01
LOSS OF DG3, 24 HRS	3.65E-01
COMMON ACTUATION SYSTEM	
LOSS OF UNIT 2 CAS, LP INIT ON HDP & LLRL	8.36E-05
LOSS OF UNIT 2 CAS, LP INIT ON HDP & LLRL, LOSS 2A-1	4.23E-03
LOSS OF UNIT 2 CAS, LP INIT ON HDP & LLRL, LOSS 2B	4.23E-03
LOSS OF UNIT 2 CAS, LP INIT ON HDP & LLRL	1.12E-09
LOSS OF UNIT 2 CAS, LP INIT ON HDP & LLRL; LOSS 2A-1	4.86E-06
LOSS OF UNIT 2 CAS, LP INIT ON HDP & LLRL, LOSS 2B	3.08E-08
LOSS OF UNIT 2 CAS, HP INIT ON HDP, ALL DC AVAIL	4.97E-05
LOSS OF UNIT 2 CAS, HP INIT ON HDP, LOSS 2A-1	7.19E-04
LOSS OF UNIT 2 CAS, HP INIT ON HDP, LOSS 2B	6.19E-05
LOSS OF UNIT 2 CAS, HP INIT ON LLRL, ALL DC AVAIL	1.13E-04
LOSS OF UNIT 2 CAS, HP INIT ON LLRL, LOSS 2A-1	3.88E-03
LOSS OF UNIT 2 CAS, HP INIT ON LLRL, LOSS 2B	3.89E-03
DC ELECTRIC POWER	
LOSS OF BUS 2A-1, 24HR	2.40E-06
LOSS OF BUS 2B, 24HR	3.36E-06
LOSS OF UNIT 2 RB 250VDC, 24HR	1.68E-06
LOSS OF BUS 3A, 24HR	2.40E-06
LOSS OF BUS 3B-1, 24HR	3.36E-06
TURBINE BUILDING CLOSED COOLING WATER	
LOSP, LOSS OF UNIT 2 TBCCW, 24HR	6.10E-05
LOSP, LOSS OF UNIT 2 TBCCW/LOSS OF BUS 27	4.00E-03
LOSP, LOSS OF UNIT 2 TBCCW/LOSS OF BUS 25	4.91E-03
LOSS OF UNIT 2 TBCCW, 24HR	3.04E-06
LOSS OF UNIT 2 TBCCW/LOSS OF BUS 27	1.01E-04
LOSS OF UNIT 2 TBCCW/LOSS OF BUS 25	6.50E-03
SERVICE WATER	
DULOSP LOSS OF SERVICE WATER/24, 33, 34 AVAILABLE	1.11E-04
DULOSP LOSS OF SERVICE WATER/33, 34 AVAILABLE	2.74E-04

TABLE 4.5.2-1 (Continued)
UNAVAILABILITY OF SYSTEMS AND PLANT FUNCTIONS

EVENT	UNAVAILABILITY
DULOSP LOSS OF SERVICE WATER/24, 34 AVAILABLE	2.74E-04
DULOSP LOSS OF SERVICE WATER/24, 33 AVAILABLE	2.74E-04
DULOSP LOSS OF SERVICE WATER/34 AVAILABLE	1.31E-02
DULOSP LOSS OF SERVICE WATER/24 AVAILABLE	1.31E-02
DULOSP LOSS OF SERVICE WATER/23, 24, 34 AVAILABLE	1.11E-04
DULOSP LOSS OF SERVICE WATER/23, 34 AVAILABLE	2.74E-04
DULOSP LOSS OF SERVICE WATER/23, 24 AVAILABLE	2.74E-04
LOSP LOSS OF SERVICE WATER, 24HR	9.56E-06
LOSP LOSS OF SERVICE WATER/LOSS OF BUS 23 OR 2A-1	1.62E-04
LOSP LOSS OF SERVICE WATER/LOSS OF BUS 24 OR 2B	8.09E-05
LOSP LOSS OF SERVICE WATER/LOSS OF 23/2A-1 & 24/2B	1.39E-02
LOSS OF SERVICE WATER, 24HR (TRAN)	1.21E-06
LOSS OF SERVICE WATER, 24HR (LOIA)	2.75E-05
LOSS OF SERVICE WATER/LOSS OF BUS 23 OR 2A-1 (TRAN)	1.14E-04
LOSS OF SERVICE WATER/LOSS OF BUS 23 OR 2A-1 (LOIA)	1.40E-04
LOSS OF SERVICE WATER/LOSS OF BUS 24 OR 2B (TRAN)	1.14E-04
LOSS OF SERVICE WATER/LOSS OF BUS 24 OR 2B (LOIA)	1.40E-04
LOSS OF SERVICE WATER/LOSS OF BUSES 23/2A-1 & 24/2B (TRAN)	1.39E-02
LOSS OF SERVICE WATER/LOSS OF BUSES 23/2A-1 & 24/2B (LOIA)	1.39E-02
PRT SPECIAL EVENTS / OTHERS	
SBCS FAILS; STANDBY COOLANT SUPPLY VALVES OPENING	7.86E-03
RVNT FAILS; ALL SUPPORTS AVAILABLE XXX	1.00E-03
FIRE PROTECTION FAILS; ALL SUPPORTS AVAILABLE	1.18E-01
SBO IN UNIT 2, NO SBO IN UNIT 3	1.00E-00
SBO IN UNIT 3, SBO IN UNIT 2	1.00E-00
SBO IN UNIT 3, NO SBO IN UNIT 2	1.00E-00
SBO OCCURS IN UNIT 2	1.00E-00
FRAC OF CONT FLRS IN DW (VS. WW)	2.16E-01
FW FAILS (% OF IEs THAT ARE LOFW)	1.28E-01
MAIN COND FAILS (GIVEN FW SUCCESS) AFTER ATWS	1.37E-01
MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS	7.28E-01
RECOVER OFF-SITE POWER	
FAILURE TO REC OSP TO PREVENT CM (0-.5 HR)	4.98E-01
FAILURE TO REC OSP TO PREVENT CM (.5-1 HR)	2.48E-01

TABLE 4.5.2-1 (Continued)
UNAVAILABILITY OF SYSTEMS AND PLANT FUNCTIONS

EVENT	UNAVAILABILITY
FAILURE TO REC OSP TO PREVENT CM (1-2 HRS)	6.15E-02
FAILURE TO REC OSP TO PREVENT CM (2-4 HRS)	2.96E-02
FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)	2.05E-02
FAILURE TO REC OSP TO PREVENT CM (>8 HRS)	1.42E-02
COND FAILURE TO REC OSP (AFTER ROP1) (4 HR)	4.80E-01
FAILURE TO REC OSP TO PREVENT CF (NR IN 0-.5 HR)	1.30E-02
FAILURE TO REC OSP TO PREVENT CF (NR IN 0-1 HR)	2.66E-02
FAILURE TO REC OSP TO PREVENT CF (NR IN 0-4 HRS)	2.23E-01
FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)	3.22E-01