UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

February 16, 2001

Mr. Craig G. Anderson
Vice President, Operations ANO
Entergy Operations, Inc.
1448 S. R. 333
Russellville, AR 72801

SUBJECT: ARKANSAS NUCLEAR ONE, UNIT 1: SITE-SPECIFIC WORKSHEETS FOR USE IN THE NUCLEAR REGULATORY COMMISSION'S SIGNIFICANCE DETERMINATION PROCESS (TAC NO. MA6544)

Dear Mr. Anderson:

Enclosed to this letter is the site-specific Risk-Informed Inspection Notebook for Arkansas Nuclear One, Unit 1. The notebook incorporates the updated Significance Determination Process (SDP) Phase 2 Worksheets that our inspectors will be using to characterize and risk-inform inspection findings. This document is a key implementation tool within the reactor safety SDP in the reactor oversight process. The notebook is publically available through the Nuclear Regulatory Commission (NRC) Agencywide Documents Access and Management System.

The 1999 Pilot Plant review effort clearly indicated that significant site-specific design and risk information was not captured in the Phase 2 Worksheets forwarded to you last spring. A subsequent site visit was conducted by the NRC to verify and update plant equipment configuration data and to collect site-specific risk information from your staff. The enclosed document reflects the results of this visit.

The Phase 2 Worksheets, contained within the enclosure, have incorporated much of the information we obtained during our site visits. While the Phase 2 Worksheets have been verified by our staff to include the site specific data that we have collected to date, we will continue to assess their accuracy as they are used and will update them based on comments by our inspectors and your staff.

The staff encourages you to provide additional comments if you identify areas for which the Phase 2 Worksheets give inaccurate (high or low) significance determinations. Any written comments may be provided in accordance with 10 CFR 50.4, "Written communications, " with copies to the Chief, Probabilistic Safety Assessment Branch, Office of Nuclear Reactor Regulation (NRR), and Chief, Inspection Program Branch, NRR. We will continue to assess SDP accuracy and update the document based on continuing experience with the program.

We will coordinate our efforts through your licensing or risk organizations as appropriate. If you have any questions, please contact me at 301-415-1323.

Sincerely,

William Reckley

William Reckley, Project Manager, Section 1
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-313

Enclosure: As stated

cc: See next page

We will coordinate our efforts through your licensing or risk organizations as appropriate. If you have any questions, please contact me at 301-415-1323.

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/RA/

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Sincerely,

Will Reckley

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RISK-INFORMED INSPECTION NOTEBOOK FOR

ARKANSAS NUCLEAR ONE

UNIT 1

PWR, BABCOCK & WILCOX, TWO-LOOP PLANT WITH LARGE DRY CONTAINMENT

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NOTICE

This notebook was developed for the NRC's inspection teams to support risk-informed inspections. The activities involved in these inspections are discussed in "Reactor Oversight Process Improvement," SECY-99-007A, March 1999. The user of this notebook is assumed to be an inspector with an extensive understanding of plant-specific design features and operation. Therefore, the notebook is not a stand-alone document, and may not be suitable for use by non-specialists. This notebook will be periodically updated with new or replacement pages incorporating additional information on this plant. All recommendations for improvement of this document should be forwarded to the Chief, Probabilistic Safety Assessment Branch, NRR, with a copy to the Chief, Inspection Program Branch, NRR.

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ABSTRACT

This notebook contains summary information to support the Significance Determination Process (SDP) in risk-informed inspections for the Arkansas Nuclear One, Unit 1.

The information includes the following: Categories of Initiating Events Table, Initiators and System Dependency Table, SDP Worksheets, and SDP Event Trees. This information is used by the NRC's inspectors to identify the significance of their findings, i.e., in screening risk-significant findings, consistent with Phase 2 screening in SECY-99-007A. The Categories of Initiating Event Table is used to determine the likelihood rating for the applicable initiating events. The SDP worksheets are used to assess the remaining mitigation capability rating for the applicable initiating event likelihood ratings in identifying the significance of the inspector's findings. The Initiators and System Dependency Table and the SDP Event Trees (the simplified event trees developed in preparing the SDP worksheets) provide additional information supporting the use of SDP worksheets.

The information contained herein is based on the licensee's Individual Plant Examination (IPE) submittal, the updated Probabilistic Risk Assessment (PRA), and system information obtained from the licensee during site visits as part of the review of earlier versions of this notebook. Approaches used to maintain consistency within the SDP, specifically within similar plant types, resulted in sacrificing some plant-specific modeling approaches and details. Such generic considerations, along with changes made in response to plant-specific comments, are summarized.

CONTENTS

TABLES

FIGURES

1. INFORMATION SUPPORTING SIGNIFICANCE DETERMINATION PROCESS (SDP)

SECY-99-007A (NRC, March 1999) describes the process for making a Phase 2 evaluation of the inspection findings. The first step in this is to identify the pertinent core damage scenarios that require further evaluation consistent with the specifics of the inspection findings. To aid in this process, this notebook provides the following information:

1. Estimated Likelihood Rating for Initiating Event Categories
2. Initiators and System Dependency Table
3. Significance Determination Process (SDP) Worksheets
4. SDP Event Trees.

Table 1, Categories of Initiating Events, is used to estimate the likelihood rating for different initiating events for a given degraded condition and the associated exposure time at the plant. This Table follows the format of Table 1 in SECY-99-007A. Initiating events are grouped in frequency bins that are one order of magnitude apart. The Table includes the initiating events that should be considered for the plant and for which SDP worksheets are provided. The following initiating events are categorized by industry-average frequency: transients (Reactor Trip) (TRANS); transients without power conversion system (TPCS); large, medium, and small loss of coolant accidents (LLOCA, MLOCA, and SLOCA); inadvertent or stuck open relief valve (IORV or SORV); main steam line break (MSLB), anticipated transients without scram (ATWS), and interfacing system LOCA (ISLOCA). The frequency of the remaining initiating events vary significantly from plant to plant, and accordingly, they are categorized by plant-specific frequency obtained from the licensee. They include loss of offsite power (LOOP) and special initiators caused by loss of support systems.

The Initiators and System Dependency Table shows the major dependencies between frontline- and support-systems, and identifies their involvement in different types of initiators. This table identifies the most risk-significant systems; it is not an exhaustive nor comprehensive compilation of the dependency matrix, as known in Probabilistic Risk Assessments (PRAs). For pressurized water reactors (PWRs), the support systems/success criteria for Reactor Coolant Pump (RCP) seals are explicitly denoted to assure that the inspection findings on them are properly accounted for. This Table is used to identify the SDP worksheets to be evaluated, corresponding to the inspection's findings on systems and components.

To evaluate the impact of the inspection's findings on the core-damage scenarios, SDP worksheets are provided. There are two sets of SDP worksheets; one for those initiators that can be mitigated by redundant trains of safety systems, and the other for those initiators that cannot be mitigated; however, their occurrence is prevented by several levels of redundant barriers.

The first set of SDP worksheets contain two parts. The first identifies the functions, the systems, or combinations thereof that have mitigating functions, the number of trains in each system, and the number of trains required (success criteria) for the initiator. It also characterizes the mitigation capability in terms of the available hardware (e.g., 1 train, 1 multi-train system) and the operator action involved. The second part of the SDP worksheet contains the core-damage accident sequences associated with each initiator; these sequences are based on SDP event trees. In the parenthesis next to each sequence, the corresponding event-tree branch number(s) representing the sequence is given. Multiple branch numbers indicate that the different accident sequences identified by the event tree have been merged into one through Boolean reduction. The SDP worksheets are developed for each of the initiating event categories, including the "Special Initiators", the exception being those which directly lead to a core damage (the inspections of these initiators are assessed differently; see SECY-99-007A). The special initiators are those that are caused by complete or partial loss of support systems. A special initiator typically leads to a reactor scram and degrades some frontline or support systems (e.g., Loss of CCW in PWRs).

In considering the special initiators, we defined a set of criteria for including them to maintain some consistency across the plants. These conditions are as follows:

1. The special initiator should degrade at least one of the mitigating safety functions thereby changing its mitigation capability in the worksheet. For example, when a safety function with two redundant trains, classified as a multi-train system, degrades to a one-train system, it is classified as 1 Train, due to the loss of one of the trains as a result of the special initiator.

2. The special initiators which degrade the mitigation capability of the systems/functions associated with the initiator from comparable transient sequences by two and higher orders of magnitude must be considered.

From the above considerations, the following classes of initiators are considered in this notebook:

1. Transients with power conversion system (PCS) available, called Transients (Reactor trip) (TRANS),
2. Transients without PCS available, called Transients w/o PCS (TPCS),
3. Small Loss of Coolant Accident (SLOCA),
4. Stuck-open Power Operated Relief Valve (SORV),
5. Medium LOCA (MLOCA),
6. Large LOCA (LLOCA),
7. Steam Generator Tube Rupture (SGTR),
8. Anticipated Transients Without Scram (ATWS), and
9. Main Steam Line Break (MSLB).

Examples of special initiators included in the notebook are as follows:

1. Loss of Offsite Power (LOOP),
2. LOOP with failure of 1 Emergency AC bus or associated EDG (LEAC),
3. Loss of 1 DC Bus (LDC),

4. Loss of component cooling water (LCCW),
5. Loss of instrument air (LIA),
6. Loss of service water (LSW).

The worksheet for the LOOP includes LOOP with emergency AC power (EAC) available and LOOP without EAC, i.e., Station Blackout (SBO). LOOP with partial availability of EAC, i.e., LOOP with loss of a bus of EAC, is covered in a separate worksheet to avoid making the LOOP worksheet too large. In some plants, LOOP with failure of 1 EAC bus is a large contributor to the plant's core damage frequency (CDF).

The second set of SDP worksheets addresses those initiators that cannot be mitigated, i.e., can directly lead to core-damage. It currently includes the Interfacing System LOCA (ISLOCA) initiator. ISLOCAs are those initiators that could result in a loss of RCS inventory outside the containment, sometimes referred to as a "V" sequence. In PWRs, this event effectively bypasses the capability to utilize the containment sump recirculation once the RWST has emptied. Also, through bypassing the containment, the radiological consequences may be significant. In PWRs, this typically includes loss of RCS inventory through high- and low-pressure interfaces, such as RHR connections, RCP thermal barrier heat-exchanger, high-pressure injection piping if the design pressure (pump head) is much lower than RCS pressure, and, potentially, through excess letdown heat exchanger. RCS inventory loss through ISLOCA could vary significantly depending on the size of the leak path; some may be recoverable with minimal impact. The SDP worksheet for ISLOCA, therefore, identifies the major consequential leak paths, and the barriers that should fail, allowing the initiator to occur.

Following the SDP worksheets, the SDP event trees corresponding to each of the worksheets are presented. The SDP event trees are simplified event trees developed to define the accident sequences identified in the SDP worksheets. For special initiators whose event tree closely corresponds to another event tree (typically, the Transient (Reactor trip) or Transients w/o PCS event tree) with one or more functions eliminated or degraded, a separate event tree may not be drawn.

The following items were considered in establishing the SDP event trees and the core-damage sequences in the SDP worksheets:

1. Event trees and sequences were developed such that the worksheet contains all the major accident sequences identified by the plant-specific IPEs/PRAs. The special initiators modeled for a plant is based on a review of the special initiators included in the plant IPE/PRA and the information provided by the licensee.

2. The event trees and sequences for each plant take into account the IPE/PRA models and event trees for all similar plants. For modeling the response to an initiating event, any major deviations in one plant from similar plants may be noted at the end of the worksheet.

3. The event trees and the sequences were designed to capture core-damage scenarios, without including containment-failure probabilities and consequences. Therefore, branches of event

trees that are developed only for the purpose of a Level II PRA analysis are not considered. The resulting sequences are merged, using Boolean logic.

4. The simplified event trees focus on classes of initiators, as defined above. In so doing, many separate event trees in the IPEs/PRAs often are represented by a single tree. For example, some IPEs/PRAs define four classes of LOCAs rather than the three classes considered here. The sizes of LOCAs for which high-pressure injection is not required are sometimes divided into two classes, the only difference between them being the need for reactor scram in the smaller break size. There may be some consolidation of transient event trees besides defining the special initiators following the criteria defined above.

5. Major actions by the operator during accident scenarios are credited using four categories of Human Error Probabilities (HEPs). They are termed operator action =1 (representing an error probability of 5E-2 to 0.5), operator action=2 (error probability of 5E-3 to 5E-2), operator action=3 (error probability of 5E-4 to 5E-3), and operator action=4 (error probability of 5E-5 to 5E-4). An human action is assigned to a category bin, based on a generic grouping of similar actions among a class of plants. This approach resulted in designation of some actions to a higher bin, even though the IPE/PRA HEP value may have been indicative of a lower category. In such cases, it is noted at the end of the worksheet. On the other hand, if the IPE/PRA HEP value suggests a higher category than that generically assumed, the HEP is assigned to a bin consistent with the IPE/PRA value in recognition of potential plant-specific design; a note is also given in these situations. Operator's actions belonging to category 4, i.e., operator action=4, may only be noted at the bottom of worksheet because, in those cases, equipment failures may have the dominating influence in determining the significance of the findings.

The four sections that follow include Categories for Initiating Events Table, Initiators and Dependency Table, SDP worksheets, and the SDP event trees for Arkansas Nuclear One, Unit 1.

1.1 INITIATING EVENT LIKELIHOOD RATINGS

Table 1 presents the applicable initiating events for this plant and their estimated likelihood ratings corresponding to the exposure time for degraded conditions. The initiating events are grouped into rows based on their frequency. As mentioned earlier, loss of offsite power (LOOP) and special initiators are assigned to rows using the plant-specific frequency obtained from individual licensees. For other initiating events, industry-average values are used.

Table 1 Categories of Initiating Events for Arkansas Nuclear One, Unit 1

Row	Approximate Frequency	Example Event Type	Estimated Likelihood Rating		
I	> 1 per 1-10 yr	Reactor Trip (TRANS), Loss of Power Conversion System (TPCS), Loss of offsite power (LOOP)	A	B	C
II	1 per 10-10^2 yr	Loss of 1 train of support System (L1TRAIN)	B	C	D
III	1 per 10^2 - 10^3 yr	Steam Generator Tube Rupture (SGTR), Stuck open PORV/SRV (SORV), Small LOCA including RCP seal failures (SLOCA), Main Steam Line Break (MSLB), LOOP with loss of 1 EDG (LOOP1EDG), Loss of SW system (LSW)	C	D	E
IV	1 per 10^3 - 10^4 yr	Medium LOCA (MLOCA)	D	E	F
V	1 per 10^4 - 10^5 yr	Large LOCA (LLOCA)	E	F	G
VI	less than 1 per 10^5 yr	ATWS, Interfacing System LOCA (ISLOCA)	F	G	H
			> 30 days	**3-30 days**	**< 3 days**
			Exposure Time for Degraded Condition		

Note:

1. The SDP worksheets for ATWS core damage sequences assume that the ATWS is not recoverable by manual actuation of the reactor trip function. Thus, the ATWS frequency to be used by these worksheets must represent the ATWS condition that can only be mitigated by the systems shown in the worksheet (e.g., boration). Any inspection finding that represents a loss of manual reactor trip capability for a postulated ATWS scenario should be evaluated by a risk analyst for consideration of the probability of a successful manual trip.

1.2 INITIATORS AND SYSTEM DEPENDENCY

Table 2 lists the systems included in the SDP worksheets, the major components in the systems, and the support system dependencies. The systems' involvements in different initiating events are noted in the last column.

Table 2 Initiators and System Dependency for Arkansas Nuclear One, Unit 1

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
Feedwater and Condensate	2 TDMFW pumps and 3 condensate pumps	Main Steam, AC, IA, ICW, ACW	TRANS, SLOCA, SORV, SGTR
AC Power	AC Power Distribution System	DC	All
DC Power	Batteries, Battery Chargers, Distribution Panels	480V AC	All
Instrument Air (IA)	Compressors	AC, DC, ICW	Al except MLOCA and LLOCA
EFWS	1 EFWTDP 1 EFWMDP	125V DC,4.16 KV, 480V AC, Emergency Feedwater Initiation and Control (EFIC)	All except MLOCA and LLOCA
HPI	3 Pumps,Valves I&C including DC for 4.16 KV Breakers	4.16 KV, 480V AC, 125 VDC (Train A uses red bus, train B uses green), SW loops I and II, EFAS	All except LLOCA and LSW
HPI (Recirc.)	3 Pumps,Valves I&C including DC for 4.16 KV breakers	4.16 KV and 480V AC (A:red, B:green), 125V DC (A:red, B: green), SW (loops I and III), DHR heat exchanger, and LPI pumps	All except LSW
LPI/DHR (Recirc.)	2 Pumps, Valves, I&C including DC for 4.16 KV breakers, a single drop line	4.16 KV (A: red, B: green), 125V DC (A:red, B: Green), SW (Loops I and II)	All except ATWS and LSW

Table 2 (Continued)

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
EDG	2 EDGs and 1 black diesel (AAC)	Service Water (Loops I and II), 125V DC, Fuel transfer system, 480V AC, HVAC	LOOP, LOOP1EDG
ICW (Intermediate Cooling Water)	3 Pumps in 2 loops, Valves, Heat Exch.	480V AC(Red and Green) , SW (Loops I and II)	All except MLOCA and LLOCA
Service Water System	2 Pumps and Valves	4.16KV/480V AC (red and green for trains I and II), 125V DC (red and green for trains I&II)	LSW
Auxiliary Cooling Water (ACW)	1 Pump and Valve	AC, DC	TRANS, SLOCA, SORV, SGTR
CFT (Core Flood Tanks)	2 Passive tank trains	NA	LLOCA
Main Steam Isolation Valves (MSIV)	1 MSIV per steam line	DC, IA	MSLB, SGTR
Pressurizer Spray	Valves, 1 RCP, 3 HPI pumps	AC, DC	All except MLOCA and LLOCA
ADVs (SG PORV)	2ADVs (AOVs) and 2 block valves (MOVs)	480V AC (Red and Green), 125V DC, IA	All except MLOCA and LLOCA
Secondary SRVs	16 SRVs	None	Same as EFW
Primary ERV and SRV	1 ERV with a block valve, 2 SRVs	125V DC Red Division (fail closed on loss of DC), and 480V AC green for the block valve	All except MLOCA, LLOCA and LSW

Table 2 (Continued)

Affected Systems	Major Components	Support Systems	Initiating Event Scenarios
RCP	Byron Jackson Seals	ICW to RCP cooling or HPI seal injection to RCP seals or operator trips RCPs within 30 minutes of loss of seal cooling and injection	SLOCA

Note:

1. Plant CDF without ATWS and ISLOCA is 6.3E-6 per year based on rev. 2 of PSA.

1.3 SDP WORKSHEETS

This section presents the SDP worksheets to be used in the Phase 2 evaluation of the inspection findings for the Arkansas Nuclear One, Unit 1. The SDP worksheets are presented for the following initiating event categories:

1. Transients (Reactor Trip) (TRANS)
2. Transients with Loss of PCS (TPCS)
3. Small LOCA (SLOCA)
4. Stuck Open Relief Valve (SORV)
5. Medium LOCA (MLOCA)
6. Large LOCA (LLOCA)
7. Loss of Offsite Power (LOOP)
8. Steam Generator Tube Rupture (SGTR)
9. Anticipated Transients Without Scram (ATWS)
10. Main Steam Line Break (MSLB)
11. LOOP with Loss of One EDG (LOOP1EDG)
12. Loss of Service Water (LSW)
13. Loss of One Train of Support System (L1TRAIN)
14. Interfacing System LOCA (ISLOCA)

Table 3.1 SDP Worksheet for Arkansas Nuclear One, Unit 1 — Transients (Reactor Trip) (TRANS)

Estimated Frequency (Table 1 Row) ________ **Exposure Time** ________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	Full Creditable Mitigation Capability for Each Safety Function:
Power Conversion System (PCS)	1/2 Feedwater trains with 1/3 condensate trains (operator action = 2) (1)
Secondary Heat Removal (EFW)	1/1 MDEFW trains (1 train) or 1 TDEFW train (1 ASD train)
High Pressure Injection (EIHP)	1/2 HPI trains from BWST or operator manually starts and aligns the swing pump (1 multi-train system) (2)
Primary Heat Removal, Feed/Bleed (FB)	1/1 ERVs or 1/2 SRVs open for Feed/Bleed and initiate HPI cooling (operator action = 2) (3)
High Pressure Recirculation (HPR)	1/2 HPI trains (2) taking suction from 1/2 LPI trains through LPI HX (4) (operator action = 3)

Circle Affected Functions	Recovery of Failed Train	Remaining Mitigation Capability Rating for Each Affected Sequence	Sequence Color
1 TRANS - PCS - EFW - FB (6)			
2 TRANS - PCS - EFW -EIHP (5)			
3 TRANS - PCS - EFW - HPR (4)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. The IPE does not document the HEP associated with PCS.
2. The third HPI pump could be manually started and aligned for this function. A credit of 1 should be given to this operator action.
3. The human error for initiation of HPI for FB is 2.89E-3 (event UHFTHPJAD) based on rev 2 of PSA, which is lower than the generic credit of 2 based on the HEPs of B&W plants. In this worksheet, the generic credit is used.
4. The IPE also credits 2/4 RBFC if the LPI HX is not available. Operator action is required to establish recirculation. A generic credit of 3 should be given. The HEP for operator failure to establish recirculation is 2.1E-4 (event XHF1SMALLX) based on rev. 2 of PSA.

Table 3.2 SDP Worksheet for Arkansas Nuclear One, Unit 1 — Transients with Loss of PCS (TPCS)

Estimated Frequency (Table 1 Row) ________ **Exposure Time** ________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Secondary Heat Removal (EFW)	1/1 MDEFW trains (1 train) or 1 TDEFW train (1 ASD train) and secondary relief through 1/2 ADVs or 1/16 SRVs
High Pressure Injection (EIHP)	1/2 HPI trains from BWST or operator manually starts and aligns the swing pump (1 multi-train system) (1)
Primary Heat Removal, Feed/Bleed (FB)	1/1 ERVs or 1/2 SRVs open for Feed/Bleed and initiate HPI cooling (operator action = 2) (2)
High Pressure Recirculation (HPR)	1/2 HPI trains (1) taking suction from 1/2 LPI trains through LPI HX (3) (operator action = 3)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 TPCS - EFW - FB (5)			
2 TPCS - EFW -EIHP (4)			
3 TPCS - EFW - HPR (3)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. The third HPI pump could be manually started and aligned for this function. A credit of 1 should be given to this operator action.

2. The human error for initiation of HPI for FB is 2.89E-3 (event UHFTHPJAD) based on rev 2 of PSA, which is lower than the generic credit of 2 based on the HEPs of B&W plants. In this worksheet, the generic credit is used.

3. The IPE also credits 2/4 RBFC if the LPI HX is not available. Operator action is required to establish recirculation. A generic credit of 3 should be given. The HEP for operator failure to establish recirculation is 2.1E-4 (event XHF1SMALLX) based on rev. 2 of PSA.

Table 3.3 SDP Worksheet for Arkansas Nuclear One, Unit 1 — Small LOCA (SLOCA)(1)

Estimated Frequency (Table 1 Row) ________ **Exposure Time** ________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Early Inventory, HP Injection (EIHP)	1/2 HPI trains from BWST or operator manually starts and aligns the swing pump (1 multi-train system) (2)
Power Conversion System (PCS)	1/2 feedwater trains and 1/3 Condensate pump (operator action = 2) (3)
Secondary Heat Removal (EFW)	1/1 MDEFW trains (1 train) or 1 TDEFW train (1 ASD train)
Primary Bleed (FB)	1/1 ERVs or 1/2 SRVs open for Feed/Bleed and initiate HPI cooling (operator action = 2) (4)
High Pressure Recirculation (HPR)	1/2 HPI trains (2) taking suction from 1/2 LPI trains through LPI HX (operator action = 3)(5)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 SLOCA - EIHP (3,6,9)			
2 SLOCA - HPR (2,5,8)			
3 SLOCA - PCS - EFW - FB (10)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:
If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. Small LOCA model in SDP is developed for more demanding portion of break sizes from 3/8 inches to 1.9 inches where secondary cooling is required. For breaks less than one inch, single phase cooling using natural circulation would take place. For breaks greater than one inch up to 1.9 inches the natural circulation would be interrupted, vessel would void, and secondary cooling would be by the boiler condenser mode (reflux cooling). Also included in this category of small LOCA is the LOCAs through RCP seals. Important to note that loss of SW would result in loss of both HPI and ICW and if the operator fails to trip the RCPs in 30 minutes, small LOCA would occur.

2. The third HPI pump could be manually started and aligned for this function. A credit of 1 should be given to this operator action.

3. ANO1-1 also could rely on a non safety AFW pump to be used for FW purposes after scram which requires operator action for alignment. The IPE does not document the HEP associated with PCS.

4. The human error for initiation of HPI for FB is 2.89E-3 (event UHFTHPJAD) based on rev 2 of PSA which is lower than the generic credit of 2 based on the HEPs of B&W plants. In this worksheet, the generic credit is used.

5. Operator action is required to establish recirculation. A generic credit of 3 should be given. The HEP for operator failure to establish recirculation is 2.1E-4 (event XHF1SMALLX) based on rev. 2 of PSA.

Table 3.4 SDP Worksheet for Arkansas Nuclear One, Unit 1 — Stuck Open Relief Valve (SORV) [1]

Estimated Frequency (Table 1 Row) ________ **Exposure Time** ________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Isolation (ISO)	Operator isolates the SORV by closing the block valve (operator action = 2) [2]
Early Inventory, HP Injection (EIHP)	1/2 HPI trains from BWST or operator manually starts and aligns the swing pump (1 multi-train system) [3]
Power Conversion System (PCS)	1/2 feedwater trains and 1/3 Condensate pump (operator action = 2) [4]
Secondary Heat Removal (EFW)	1/1 MDEFW trains (1 train) or 1 TDEFW train (1 ASD train)
Primary Bleed (FB)	HPI cooling (operator action = 2) [5]
High Pressure Recirculation (HPR)	1/2 HPI trains [3] taking suction from 1/2 LPI trains through LPI HX (operator action = 3) [6]

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 SORV - ISO - EIHP (4,7,10)			
2 SORV - ISO - HPR (3,6,9)			
3 SORV - ISO - PCS - EFW -FB (11)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. This initiating event represents a stuck open ERV or SRV. It is modeled as a small LOCA with possibility of being isolated (if the stuck open valve is the ERV.)

2. The IPE does not document the HEP of this operator action. A generic credit of 2 based on the HEPs of B&W plants is used.

3. The third HPI pump could be manually started and aligned for this function. A credit of 1 should be given to this operator action.

4. ANO1-1 also could rely on a non safety AFW pump to be used for FW purposes after scram which requires operator action for alignment. The IPE does not document the HEP associated with PCS.

5. The human error for initiation of HPI for FB is 2.89E-3 (event UHFTHPJAD) based on rev 2 of PSA which is lower than the generic credit of 2 based on the HEPs of B&W plants. In this worksheet, the generic credit is used.

6. Operator action is required to establish recirculation. A generic credit of 3 should be given. The HEP for operator failure to establish recirculation is 2.1E-4 (event XHF1SMALLX) based on rev. 2 of PSA.

Table 3.5 SDP Worksheet for Arkansas Nuclear One, Unit 1 — Medium LOCA (MLOCA)[1]

Estimated Frequency (Table 1 Row) ________ **Exposure Time** ________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:
Early Inventory, HP Injection (EIHP)
High Pressure Recirculation (HPR)

Full Creditable Mitigation Capability for Each Safety Function:
1/2 HPI trains from BWST or operator manually starts and aligns the swing pump (1 multi-train system)
1/2 HPI trains [2] taking suction from 1/2 LPI trains through LPI HX (operator action = 3) [3]

Circle Affected Functions	Recovery of Failed Train	Remaining Mitigation Capability Rating for Each Affected Sequence	Sequence Color
1 MLOCA - EIHP (3)			
2 MLOCA - HPR (2)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. Medium LOCA is defined for break sizes greater than 1.9 inches up to 4.3 inches. The original IPE does not have this initiating event. It was added in rev. 2 of PSA. The event tree was based on the utility's comments on the MLOCA event tree developed by BNL.

2. The third HPI pump could be manually started and aligned for this function. A credit of 1 should be given to this operator action.

3. Operator action is required to establish recirculation. A generic credit of 3 should be given. The HEP for operator failure to establish recirculation is 2.1E-4 (event XHFMEDXXX) based on rev. 2 of PSA. Operator action is required for this function.

Table 3.6 SDP Worksheet for Arkansas Nuclear One, Unit 1 — Large LOCA (LLOCA) [1]

Estimated Frequency (Table 1 Row) ________ Exposure Time ________ Table 1 Result (circle): A B C D E F G H

Safety Functions Needed:	**Full Creditable Mitigation Capability for each Safety Function:**
Early Inventory Control (EIAC)	1/1 remaining CFT (1 train, credit = 2)
Early Inventory, LP Injection (EILP)	1/2 LPI pump trains (1 multi-train system).
Low Pressure Recirculation (LPR)	1/2 LPI pump trains taking suction from containment sump (operator action = 2)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LLOCA - EILP (3)			
2 LLOCA - LPR (2)			
3 LLOCA - EIAC (4)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. LLOCA represents a LOCA with a break > 4.3".

2. The HEP for operator failure to establish recirculation is 4.8E-2 (event UHF1THPIAD) based on rev. 2 of PSA.

Table 3.7 SDP Worksheet for Arkansas Nuclear One, Unit 1 — Loss of Offsite Power (LOOP)

Estimated Fequency (Table 1 Row) ________ **Exposure Time** ________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	Full Creditable Mitigation Capability for each Safety Function:
Emergency AC Power (EAC)	1/2 EDGs (1 multi-train system) or AAC(operator action=1) [1]
Turbine-driven EFW pump (TDEFW)	Operation of TDEFW pump (1 ASD train) and secondary relief through 1/2 ADVs or 1/16 SRVs[2]
Secondary Heat Removal (EFW)	1/1 MDEFW train (1 train) or 1 TDEFW train (1 ASD train)
Recovery of AC Power in < 1 hrs (REC1)	SBO procedure and Recovery of an AC source in one hour [3] (operator action = 1)
Recovery of AC Power in < 6 hrs (REC6)	SBO procedure and Recovery of an AC source in six hours [4] (operator action = 2)
Early Inventory, HP Injection (EIHP)	1/2 HPI trains from BWST or operator manually starts and aligns the swing pump (1 multi-train system) [5]
Primary Heat Removal (FB)	1/1 ERVs or 1/2 SRVs open for Feed/Bleed and initiate HPI cooling (operator action = 2) [6]
High Pressure Recirculation (HPR)	1/2 HPI trains taking suction from 1/2 LPI trains through LPI HX (operator action = 3) [7]

Circle Affected Functions	Recovery of Failed Train	Remaining Mitigation Capability Rating for Each Affected Sequence	Sequence Color
1 LOOP - EFW - FB (1)			
2 LOOP - EFW - EIHP (1)			
3 LOOP - EFW - HPR (1)			
4 LOOP - EAC - REC6 (7) (failure to recover AC in 6 hours)			

5 LOOP - EAC - TDEFW-REC1 (12)			
6 LOOP - EAC - REC1 - EIHP (6)			
7 LOOP - EAC - REC1 - HPR (4)			
8 LOOP - EAC - REC1 - FB (5)			
9 LOOP - EAC - TDEFW - EIHP (11)			
10 LOOP - EAC - TDEFW - FB (10)			
11 LOOP - EAC - TDEFW - HPR (9)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. The frequency of loss of offsite power is 0.22 per year. EDG day tank has sufficient fuel for one hour and requires fuel transfer pump to operate. Failure of room cooling assumes to fail the EDGs. The black diesel generator AAC requires operator action. A credit of 1 should be used.

2. The batteries are assumed to be depleted in five hours.

3. Core damage is assumed to occur in one hour if no secondary heat removal.

4. Core damage is assumed in one hour after battery depletion. The RCPs are Byron Jackson pumps. Before offsite power is recovered, the RCPs have been tripped due to loss of power, and a seal LOCA is very unlikely.

5. The third HPI pump could be manually started and aligned for this function. A credit of 1 should be given to this operator action.

6. The human error for initiation of HPI for FB is 2.89E-3 (event UHFTHPJAD) based on rev 2 of PSA which is lower than the generic credit of 2 based on the HEPs of B&W plants. In this worksheet, the generic credit is used.

7. The IPE also credits 2/4 RBFC if the LPI HX is not available. Operator action is required to establish recirculation. A generic credit of 3 should be given. The HEP for operator failure to establish recirculation is 2.1E-4 (event XHF1SMALLX) based on rev. 2 of PSA.

Table 3.8 SDP Worksheet for Arkansas Nuclear One, Unit 1 — Steam Generator Tube Rupture (SGTR)

Estimated Frequency (Table 1 row) ________ **Exposure Time** ________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	Full Creditable Mitigation Capability for Each Safety Function:
Power Conversion System (PCS)	1/2 feedwater trains and 1/3 Condensate pump (operator action = 2) [1]
Secondary Heat Removal (EFW)	1/1 MDEFW (1 train) or 1/1 TDEFW (1 ASD train)
Early Inventory HP injection (EIHP)	1/2 HPI trains from BWST or operator manually starts and aligns the swing pump (1 multi-train system) [2]
Rapid Depressurization (RAPDEP)	Operator depressurizes RCS to SDC condition by opening 2/2 ADVs (1 train) [3]
Equalization (EQ)	Operator reduces the RCS pressure below the MSSV set point by using pressurizer spray (operator action = 1) [4]
Cooldown (COOLDOWN)	Operator cools down and depressurizes the RCS to SDC condition (1 multi-train system) [3]
Feed and Bleed (FB)	1/1 ERVs or 1/2 SRVs open for Feed/Bleed and initiate HPI cooling (operator action=2) [5]
Shutdown Cooling (SDC)	1/2 LPI in DHR cooling mode with a single drop line (1 train) [3]
High Pressure Recirculation (HPR)	Operator cools down RCS to below the set point of main steam safety valves, isolate the faulted SG, and establishes high pressure recirculation using 1/2 HPI trains [2] taking suction from 1/2 LPI trains through LPI HX [6] (operator action = 2) [7]

Circle Affected Functions	Recovery of Failed Train	Remaining Mitigation Capability Rating for Each Affected Sequence	Sequence Color
1 SGTR - EQ - SDC (3,10)			
2 SGTR - EQ - COOLDOWN (4,11) [8]			
3 SGTR - EIHP - SDC (6,13)			
4 SGTR - EIHP - RAPDEP (7,14)			

5 SGTR - PCS - EFW - HPR (16)			
6 SGTR -PCS - EFW - FB (17)			
7 SGTR -PCS - EFW - EIHP (18)			
Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.			

Notes:

1. ANO1-1 also could rely on a non safety AFW pump to be used for FW purposes after scram which requires operator action for alignment. (Event RBCAFEED= 7.96E-3). The IPE does not document the HEP associated with PCS.
2. The third HPI pump could be manually started and aligned for this function. A credit of 1 should be given to this operator action.
3. Opertor action is required to establish DHR. A generic credit of 4 should be given. The HEP for operator failure to cold down RCS and isolate break with DHR system is 1E-5 (XHF1SGISOD).
4. The IPE does not document the HEP for the operator action. A generic credit of 4 should be used.
5. The HEP for operator failure to use HPI cooling is 5.96E-3 (event UHF1RHPICD).
6. The IPE also credits 2/4 RBFC if the LPI HX is not available.

7. A few operator actions are needed for this function, depressurizing RCS, isolating faulted SG, and establishing HPR. A generic credit of 2 for isolating the SG should be used. The HEP for operator failure to establish recirculation is 2.1E-4 (event XHF1SMALLX) based on rev. 2 of PSA.

8. The two operator actions in this sequence should be considered the same operator action.

Table 3.9 SDP Worksheet for Arkansas Nuclear One, Unit 1 — Anticipated Transients Without Scram (ATWS)

Estimated Frequency (Table 1 row) ________ **Exposure Time** ________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Turbine Trip (TTP)	Operator trips the turbine (operator action = 2) [1]
Emergency Boration (HPI)	Operator conducts emergency boration using 1/3 HPI pump (operator action = 2) [2]
Secondary Heat Removal (EFW)	1/1 EFWMDP (1 train) or 1/1 EFWTDP (1 ASD Train) with 5 out of 8 SRVs on the intact SG
Primary Relief (SRV)	2/2 SRVs with 1/1 ERV open (1 train)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 ATWS - SRV (4)			
2 ATWS - EFW (3)			
3 ATWS - HPI (2)			
4 ATWS - TTP (5)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:
If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. The IPE did not document the HEP.

2. The operator action related to initiation of emergency boration has a value of 4.5E-3 in the IPE; which is lower than the generic credit of 2 based on the HEPs of B&W plants. In this worksheet the generic credit is used.

Table 3.10 SDP Worksheet for Arkansas Nuclear One, Unit 1 — Main Steam Line Break (MSLB)[1]

Estimated Frequency (Table 1 Row) ________ **Exposure Time** ________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Main Steam Line Isolation (MSLI)	Isolation of Main Steam Lines (1 train)
Secondary Heat Removal (EFW)	1/1 MDEFW trains (1 train) or 1/1 TDEFW (1 ASD train) and secondary relief through 1/2 ADVs or 1/16 SRVs
High Pressure Injection (EIHP)	1/2 HPI trains from BWST or operator manually starts and aligns the swing pump (1 multi-train system) [2]
Primary Heat Removal, Feed/Bleed (FB)	1/1 ERVs or 1/2 SRVs open for Feed/Bleed and initiate HPI cooling (operator action = 2) [3]
High Pressure Recirculation (HPR)	1/2 HPI trains [2] taking suction from 1/2 LPI trains through LPI HX [4] (operator action = 3)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 MSLB - EFW - FB (4)			
2 MSLB - EFW -EIHP (5)			
3 MSLB - EFW - HPR (3)			
4 MSLB - MSLI - FB (8)			
5 MSLB - MSLI -EIHP (9)			

6 MSLB - MSLI - HPR (7)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. It causes trip of main feedwater, main steam line isolation, and initiation of EFW. The IPE models the increased likelihood of loss of steam generator heat removal and HPI actuation leading to a solid RCS. However, it is not clear how.

2. The third HPI pump could be manually started and aligned for this function. A credit of 1 should be given to this operator action.

3. The human error for initiation of HPI for FB is 2.89E-3 (event UHFTHPJAD) based on rev 2 of PSA which is lower than the generic credit of 2 based on the HEPs of B&W plants. In this worksheet, the generic credit is used.

4. The IPE also credits 2/4 RBFC if the LPI HX is not available. Operator action is required to establish recirculation. A generic credit of 3 should be given. The HEP for operator failure to establish recirculation is 2.1E-4 (event XHF1SMALLX) based on rev. 2 of the PSA.

Table 3.11 SDP Worksheet for Arkansas Nuclear One, Unit 1 — LOOP with Loss of One EDG (LOOP1EDG) [(1)]

Estimated Frequency (Table 1 Row) ________ Exposure Time ________ Table 1 Result (circle): A B C D E F G H

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
Stuck Open ERV (SORV)	1/1 ERV reclosed (one train)
Secondary Heat Removal (EFW)	1 TDEFW train (1 ASD train) with secondary relief through 1/1 ADV or 1/8 SRVs
High Pressure Injection (EIHP)	1/1 HPI trains from BWST or operator manually starts and aligns the swing pump (1 multi-train system) [(2)]
Primary Heat Removal, Feed/Bleed (FB)	1/1 ERVs or 1/2 SRVs open for Feed/Bleed and initiate HPI cooling (operator action = 2) [(3)]
High Pressure Recirculation (HPR)	1/1 HPI trains [(2)] taking suction from 1/1 LPI trains through LPI HX [(4)] (1 train)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LOOP1EDG - EFW - FB (5)			
2 LOOP1EDG - EFW -EIHP (4,11)			
3 LOOP1EDG - EFW - HPR (3,10)			
4 LOOP1EDG - SORV - EIHP (8)			
5 LOOP1EDG - SORV - HPR (7)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:
If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. This worksheet supplements the LOOP worksheet in modeling the condition in which a LOOP occurs and one EDG fails. As a result, one 4KV bus is failed. The black generator (AAC) can be modeled as a recovery action to restore power to the failed bus.
2. The third HPI pump could be manually started and aligned for this function.
3. The human error for initiation of HPI for FB is 2.89E-3 (event UHFTHPJAD) based on rev 2 of PSA which is lower than the generic credit of 2 based on the HEPs of B&W plants. In this worksheet, the generic credit is used.
4. The IPE also credits 2/4 RBFC if the LPI HX is not available. Operator action is required to establish recirculation. A generic credit of 3 should be given. The HEP for operator failure to establish recirculation is 2.1E-4 (event XHF1SMALLX) based on rev. 2 of the PSA.

Table 3.12 SDP Worksheet for Arkansas Nuclear One, Unit 1 — Loss of Service Water (LSW) (1)

Estimated Frequency (Table 1 Row) ________ **Exposure Time** ________ **Table 1 Result (circle): A B C D E F G H**

Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**
RCP Trip (RCPTRIP)	Operator trips the RCPs to prevent a seal LOCA (operator action = 3) (2)
Secondary Heat Removal (EFW)	1/1 MDEFW trains (1 train) or 1 TDEFW train (1 ASD train) and secondary relief through 1/2 ADVs or 1/16 SRVs

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 LSW - EFW (2)			
2 LSW - RCPTRIP (3)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. The frequency of LSW is 1.E-3 per year. It causes a loss of all mitigating systems except EFW.
2. The HEP for operator failure to trip the RCPs given a loss of seal cooling is 2.12E-3 (event QHF1RCPPTRP) based on rev. 2 of the PSA.

Table 3.13 SDP Worksheet for Arkansas Nuclear One, Unit 1 — Loss of One Train of Support System (L1TRAIN) (1)

Estimated Frequency (Table 1 Row) ________	Exposure Time ________	Table 1 Result (circle): A B C D E F G H	
Safety Functions Needed:	**Full Creditable Mitigation Capability for Each Safety Function:**		
Secondary Heat Removal (EFW)	1 TDEFW train (1 ASD train) with secondary relief through 1/1 ADV or 1/8 SRVs		
High Pressure Injection (EIHP)	1/1 HPI trains from BWST or operator manually starts and aligns the swing pump (1 multi-train system) (2)		
Primary Heat Removal, Feed/Bleed (FB)	1/1 ERVs or 1/2 SRVs open for Feed/Bleed and initiate HPI cooling (operator action = 2)(3)		
High Pressure Recirculation (HPR)	1/1 HPI trains(2) taking suction from 1/1 LPI trains through LPI HX(4) (1 train)		
Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 L1TRAIN - EFW - FB (6)			
2 L1TRAIN - EFW -EIHP (5)			
3 L1TRAIN - EFW - HPR (4)			

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. This initiating event represents loss of one train of a support system, i.e., service water, 4KV AC bus, 480VAC bus, and DC bus. Due to lack of information on specific impacts of these initiating events, they are combined into one single initiating event. The total frequency is 6.68E-2 per year. TheTPCS event tree can be used for this initiating event.

2. The third HPI pump could be manually started and aligned for this function. A credit of 1 should be given to this operator action.

3. The human error for initiation of HPI for FB is 2.89E-3 (event UHFTHPJAD) based on rev 2 of PSA which is lower than the generic credit of 2 based on the HEPs of B&W plants. In this worksheet, the generic credit is used.

4. The IPE also credits 2/4 RBFC if the LPI HX is not available. Operator action is required to establish recirculation. A generic credit of 3 should be given. The HEP for operator failure to establish recirculation is 2.1E-4 (event XHF1SMALLX) based on rev. 2 of the PSA.

Table 3.14 SDP Worksheet for Arkansas Nuclear One, Unit 1 — Interfacing System LOCA (ISLOCA)(1)

Estimated Frequency (Table 1 Row) ________ **Exposure Time** ________ **Table 1 Result (circle): A B C D E F G H**

Initiating Pathways:	**Mitigation Capability: Ensure Component Operability for Each Pathway:**
DHR Suction Line	Two normally closed and pressure-interlocked MOVs (CV-1050 and 1410)
LPI Injection Line A	Two sets of two check valves (DH-14A and DH-13A or DH-14B and DH-17) and a normally closed MOV (CV-1401)
LPI Injection Line B	Two sets of two check valves (DH-14B and DH-13B or DH-14A and DH-18) and a normally closed MOV (CV-1400)
RCP Seal Cooler	Failure of seal cooler (tube rupture) has to be isolated by MOV CV-2215
RCS Piping Drains	4 lines > 1.5", each is isolated by two normally closed manual valves (RBD-8A and RBD-9A, RBD-8B and RBD-9B, RBD-8C and RBD-9C, or RBD-8D and RBD-9D)

Circle Affected Functions	**Recovery of Failed Train**	**Remaining Mitigation Capability Rating for Each Affected Pathway**	**Sequence Color**

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Note:

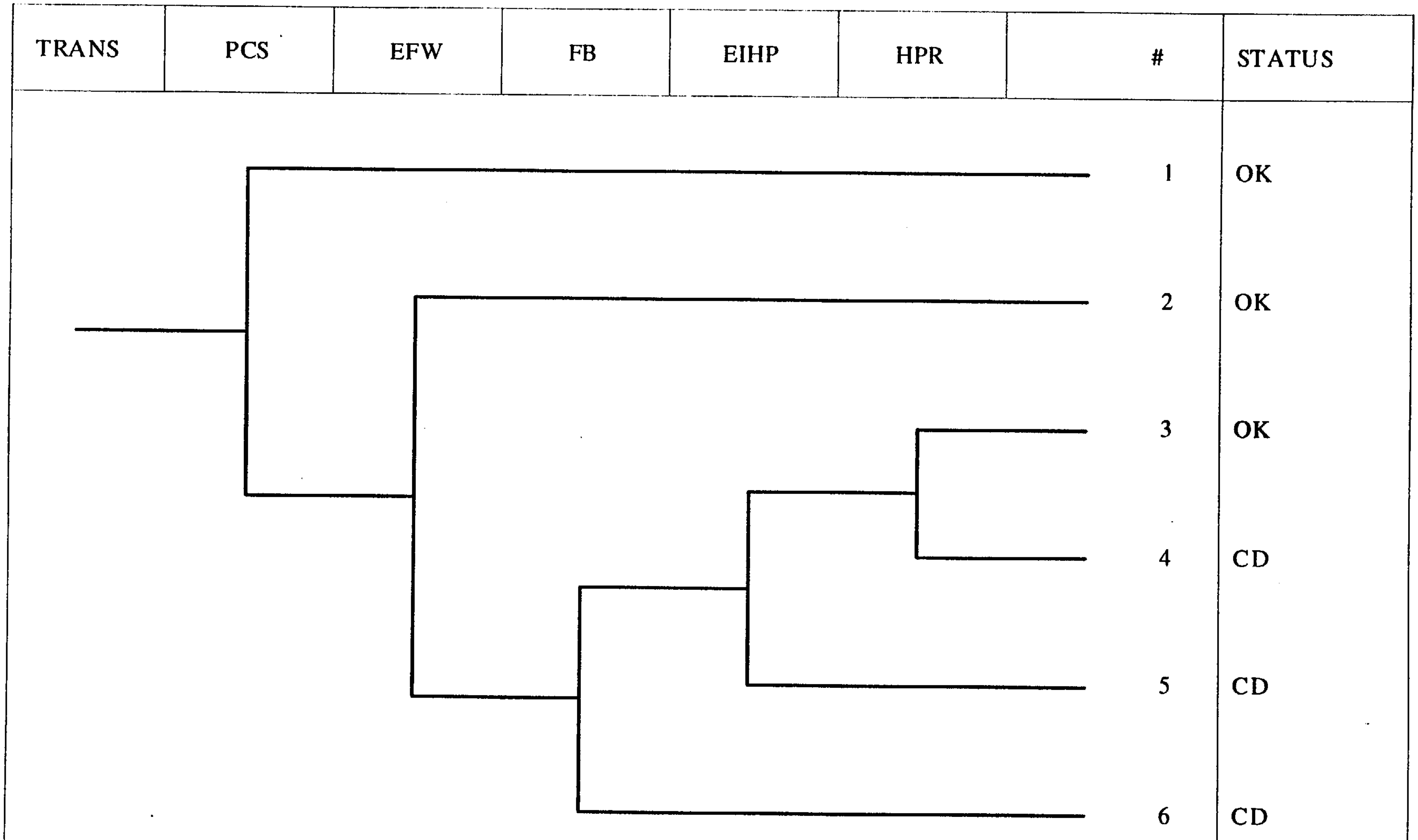
1. The interfacing lines are based on ANO-1 PSA rev. 2 summary. The valve arrangements are taken from the IPE.

1.3 SDP EVENT TREES

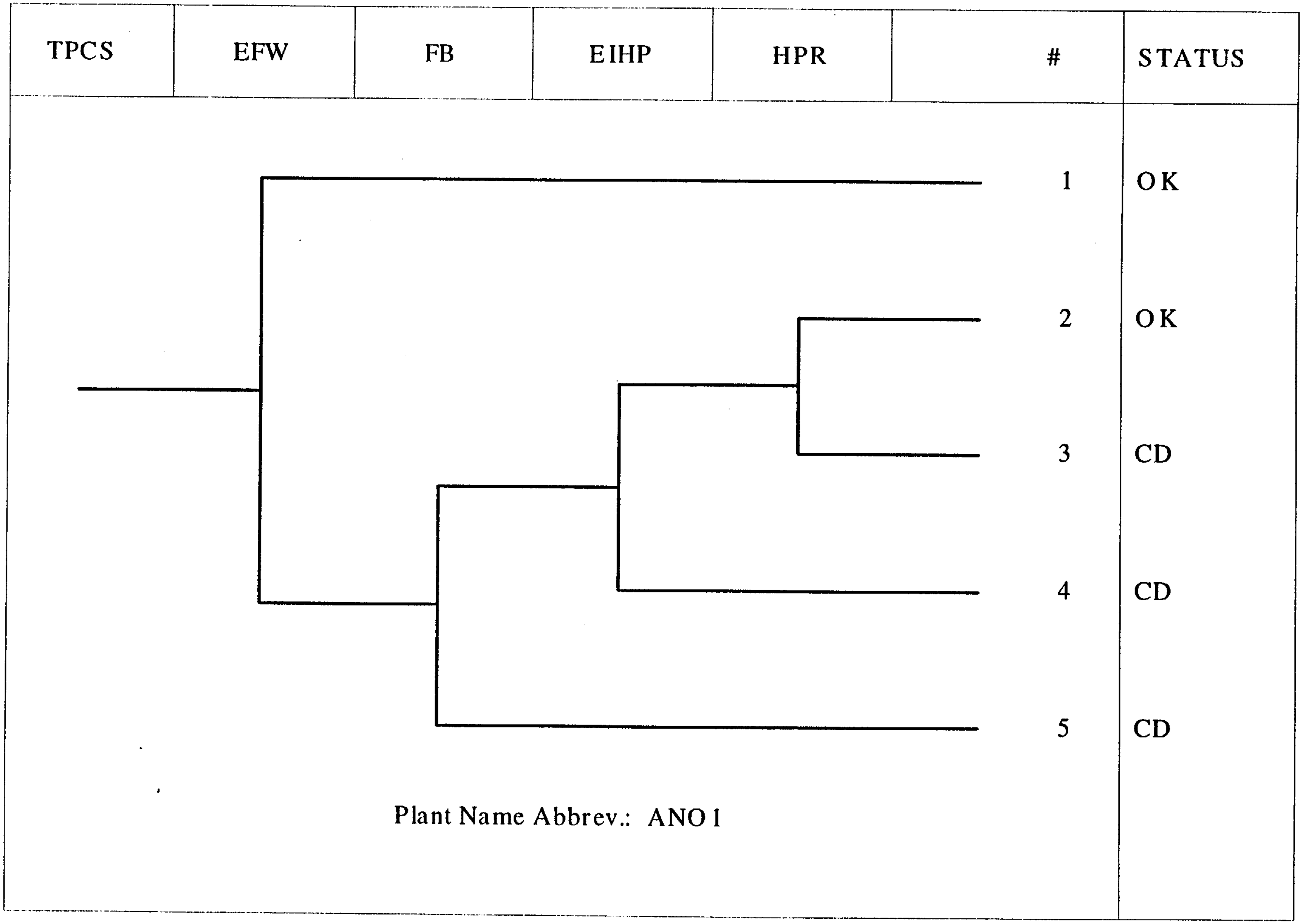
This section provides the simplified event trees called SDP event trees used to define the accident sequences identified in the SDP worksheets in the previous section. An event tree for the stuck-open PORV is not included since it is similar to the small LOCA event tree. The event tree headings are defined in the corresponding SDP worksheets.

The following event trees are included:

1. Transients (Reactor Trip) (TRANS)
2. Transients with Loss of PCS (TPCS)
3. Small LOCA (SLOCA)
4. Stuck Open Relief Valve (SORV)
5. Medium LOCA (MLOCA)
6. Large LOCA (LLOCA)
7. Loss of Offsite Power (LOOP)
8. Steam Generator Tube Rupture (SGTR)
9. Anticipated Transients Without Scram (ATWS)
10. Main Steam Line Break (MSLB)
11. LOOP with Loss of One EDG (LOOP1EDG)
12. Loss of Service Water (LSW)



Plant Name Abbrev.: ANO1


TPCS
EFW
FB
EIHP
HPR
#
STATUS
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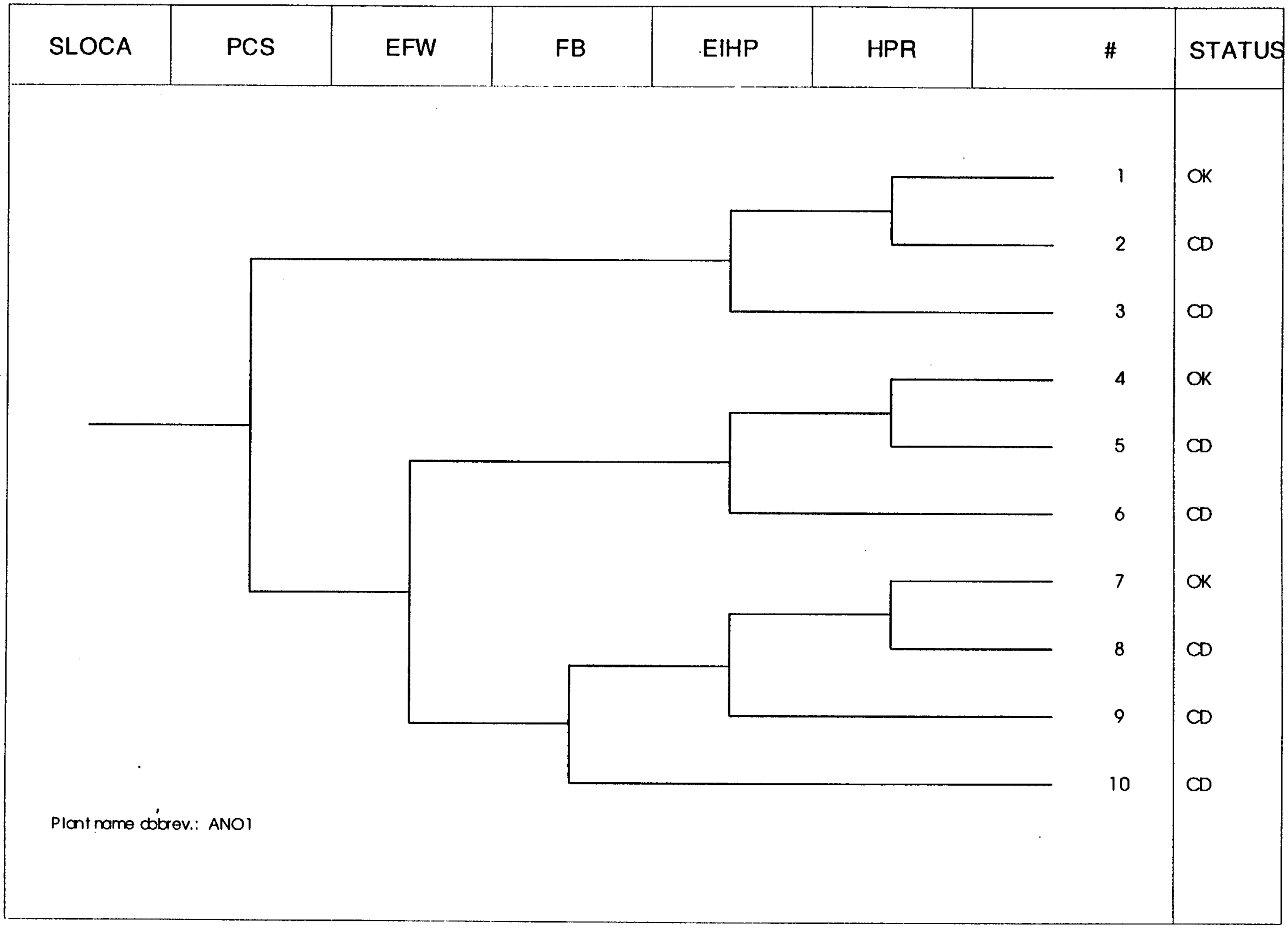
2
OK
3
CD
4
CD
5
CD
Plant Name Abbrev.: ANO1


SLOCA
PCS
EFW
FB
EIHP
HPR
#
STATUS
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2 CD
3 CD
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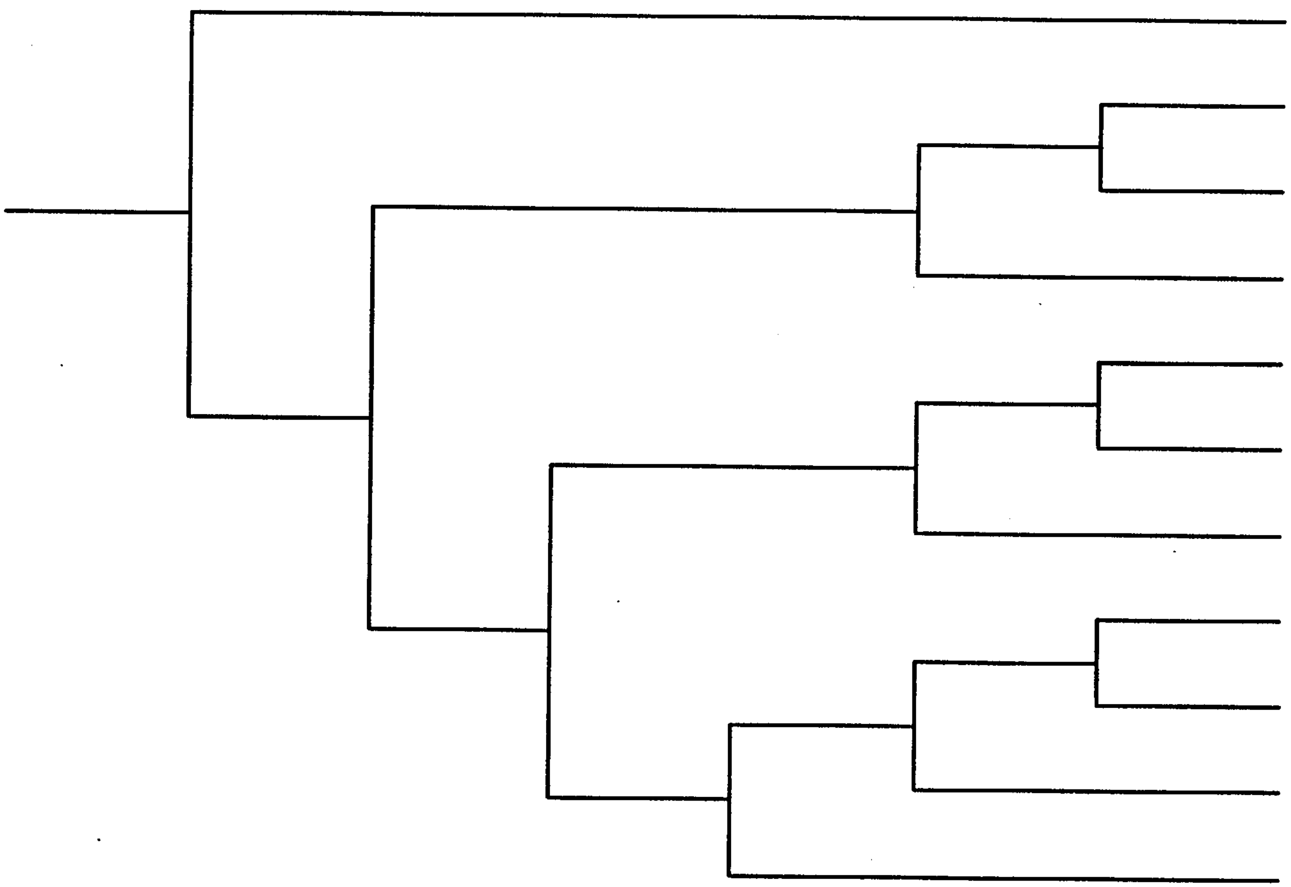
8 CD
9 CD
10 CD
Plant name abbrev.: ANO1

SORV	ISO	PCS	EFW	FB	EIHP	HPR	#	STATUS



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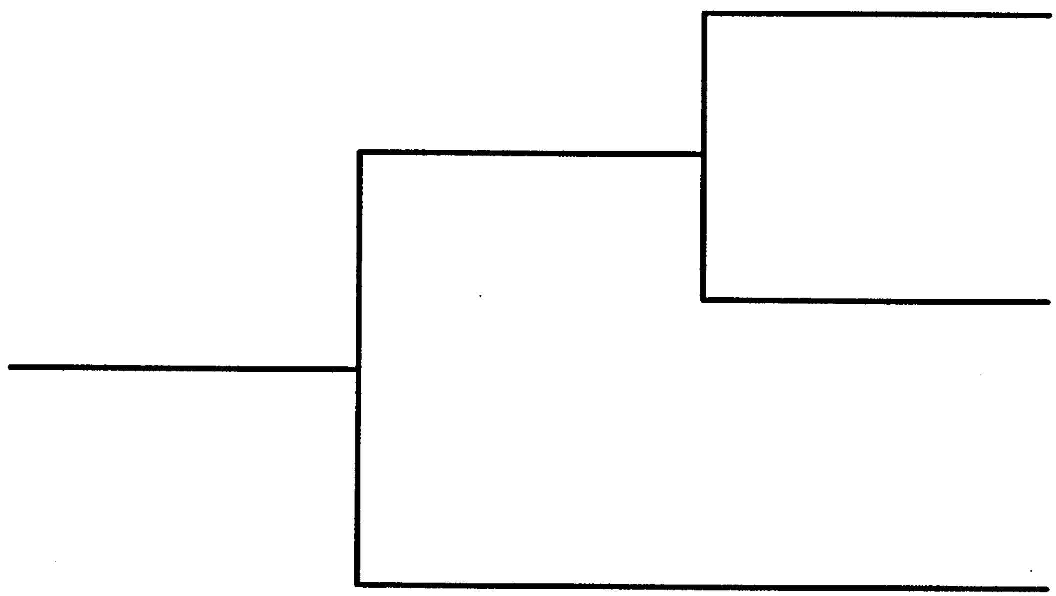
Plant Name Abbrev.: ANO1



MLOCA	EIHP	HPR		#	STATUS
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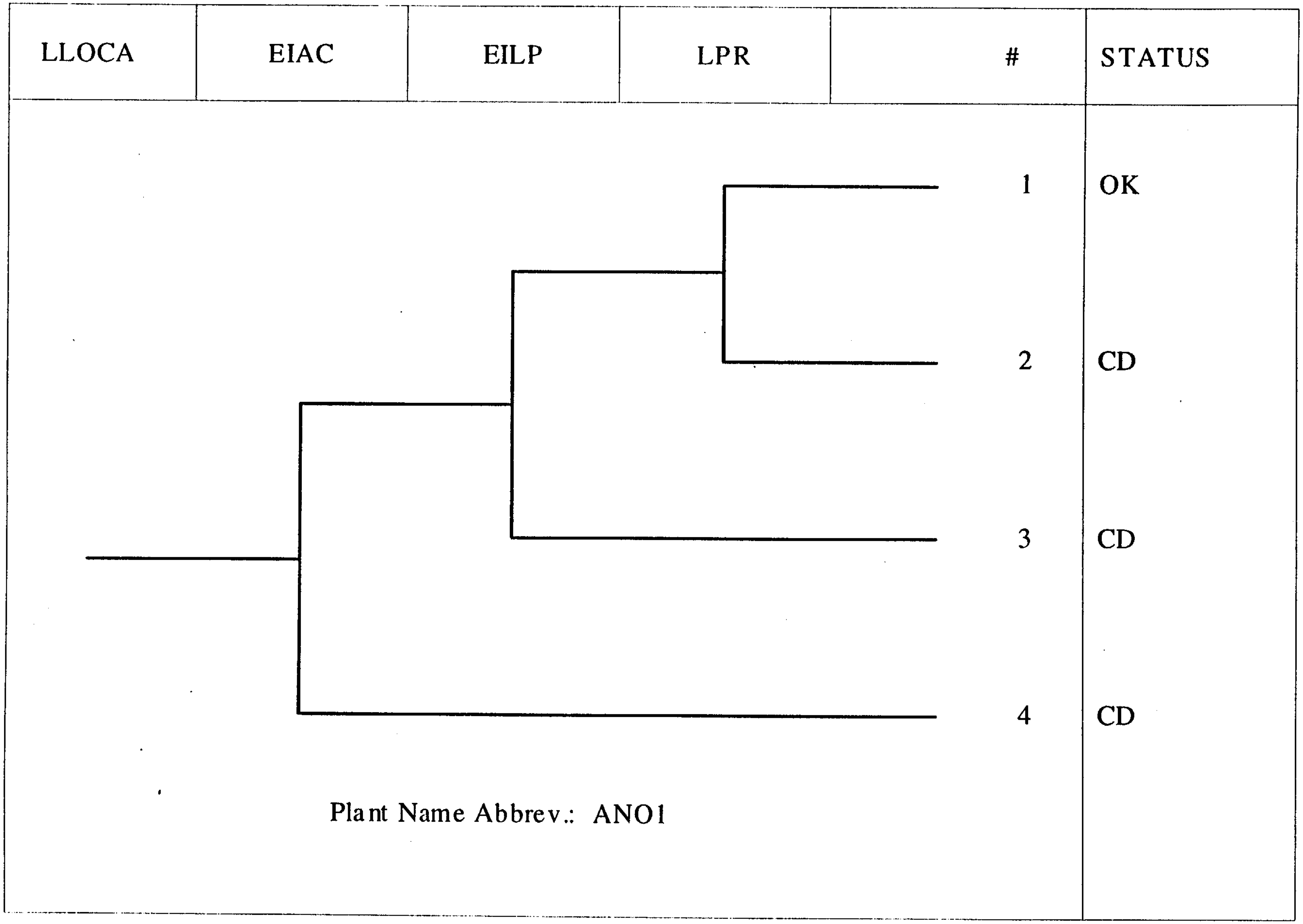
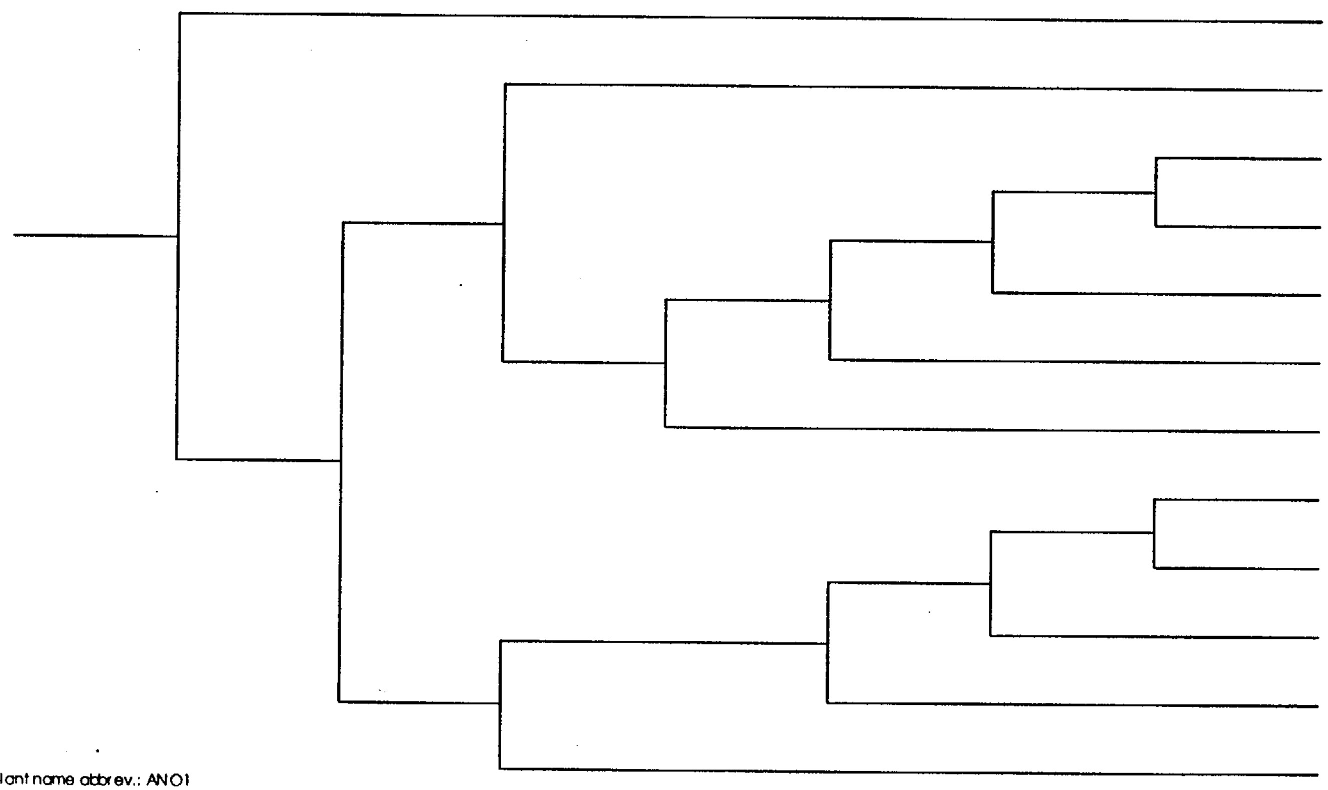
				2	CD
				3	CD

Plant Name Abbrev.: ANO1


LLOCA
EIAC
EILP
LPR
#
STATUS
1
OK
2
CD
3
CD
4
CD
Plant Name Abbrev.: ANO1

LOOP	EAC	TDEFW	REC1	REC3	EIHP	FB	HPR		#	STATUS



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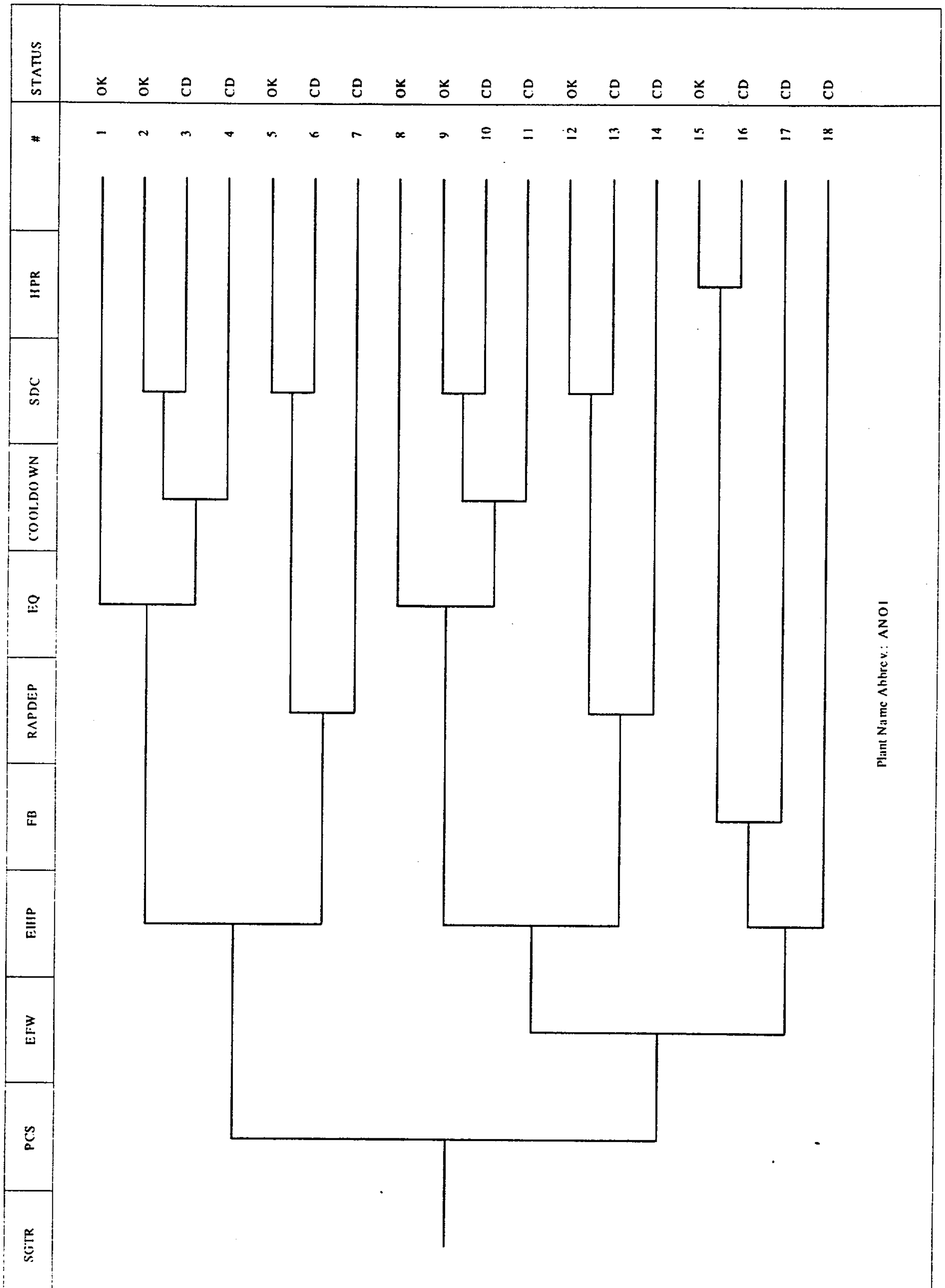
Plant name abbrev.: ANO1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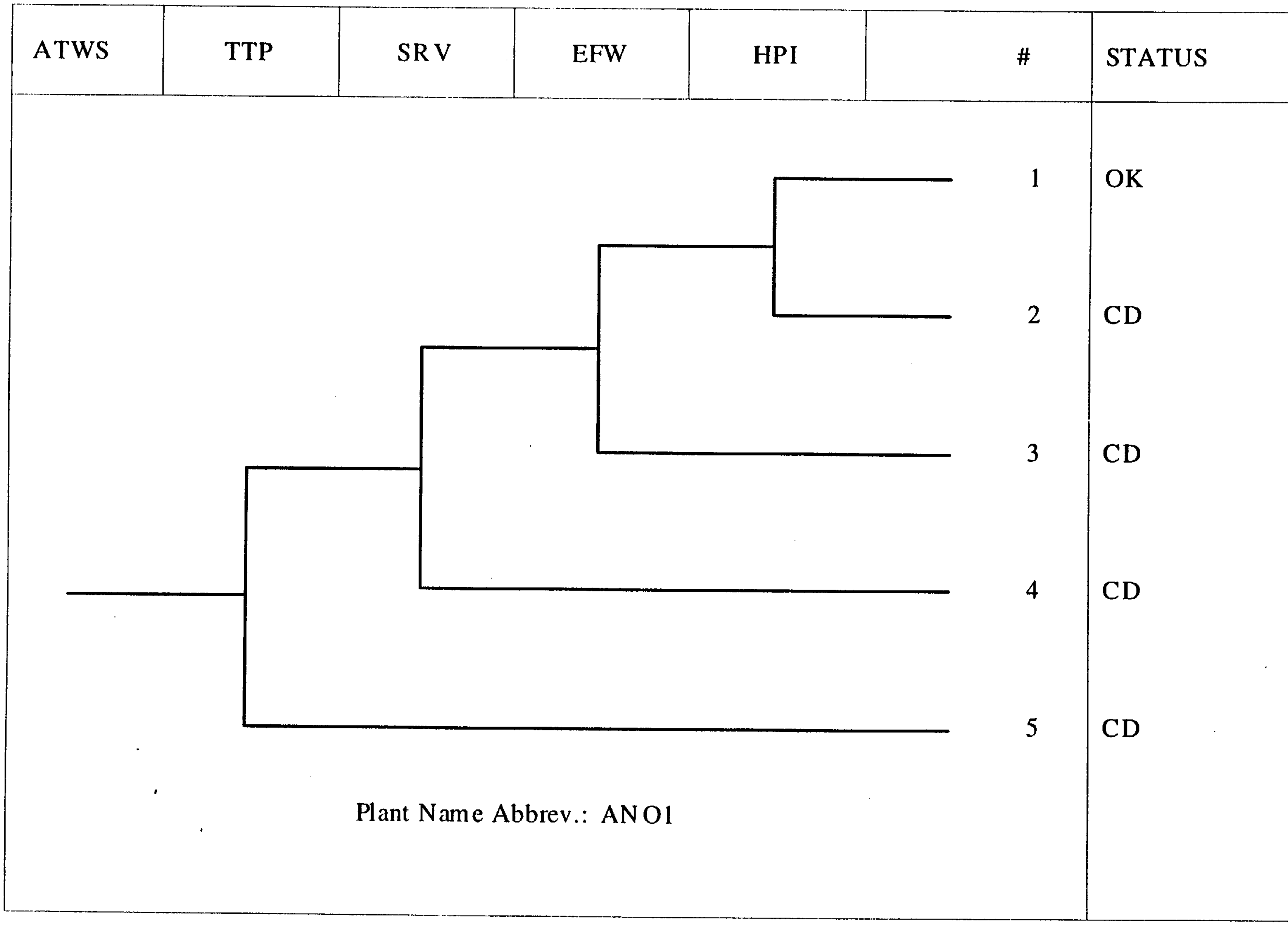
HPR
SDC
COOLDOWN
EQ
RAPDEP
FB
EHP
EFW
PCS
SGTR
Plant Name Abbrev.: ANO1


ATWS
TTP
SRV
EFW
HPI
#
STATUS
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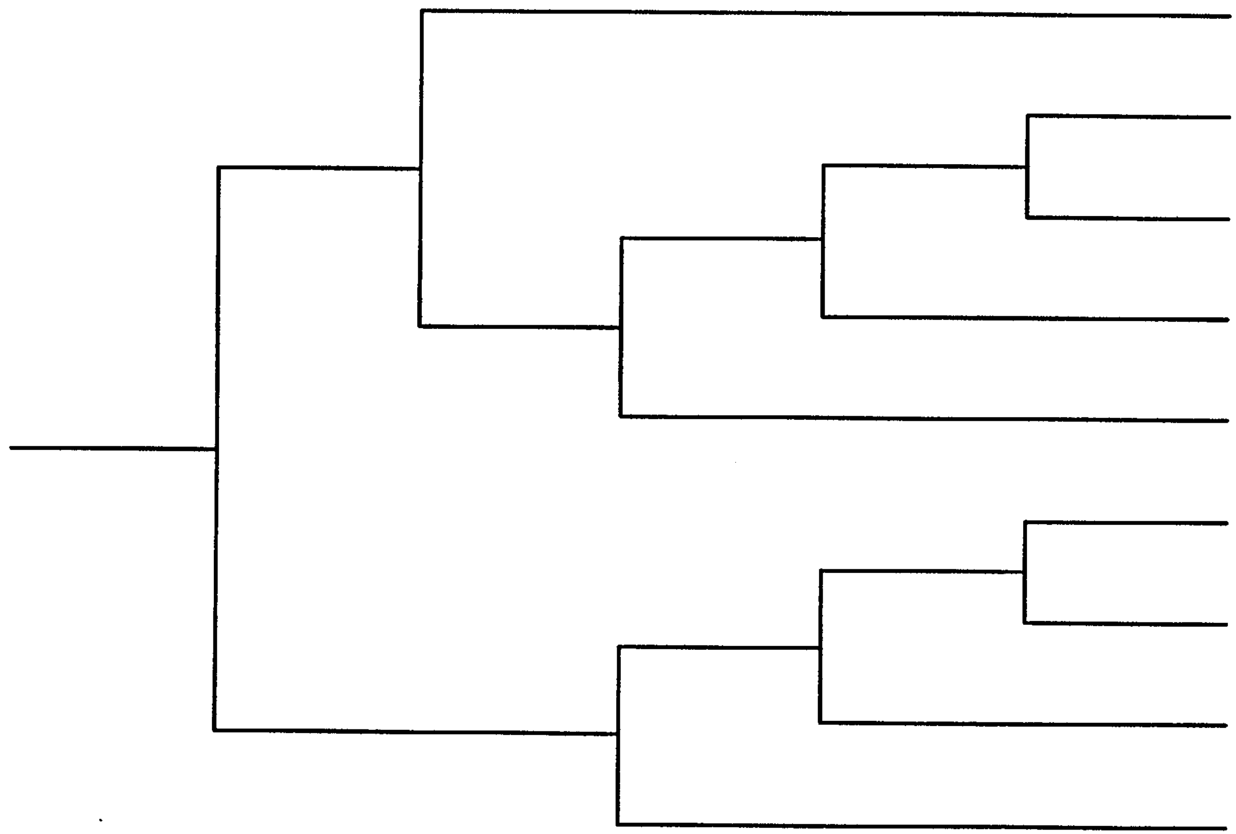
CD
3
CD
4
CD
5
CD
Plant Name Abbrev.: ANO1

MSLB	MSLI	EFW	EIHP	FB	HPR		#	STATUS



#	STATUS
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2	OK
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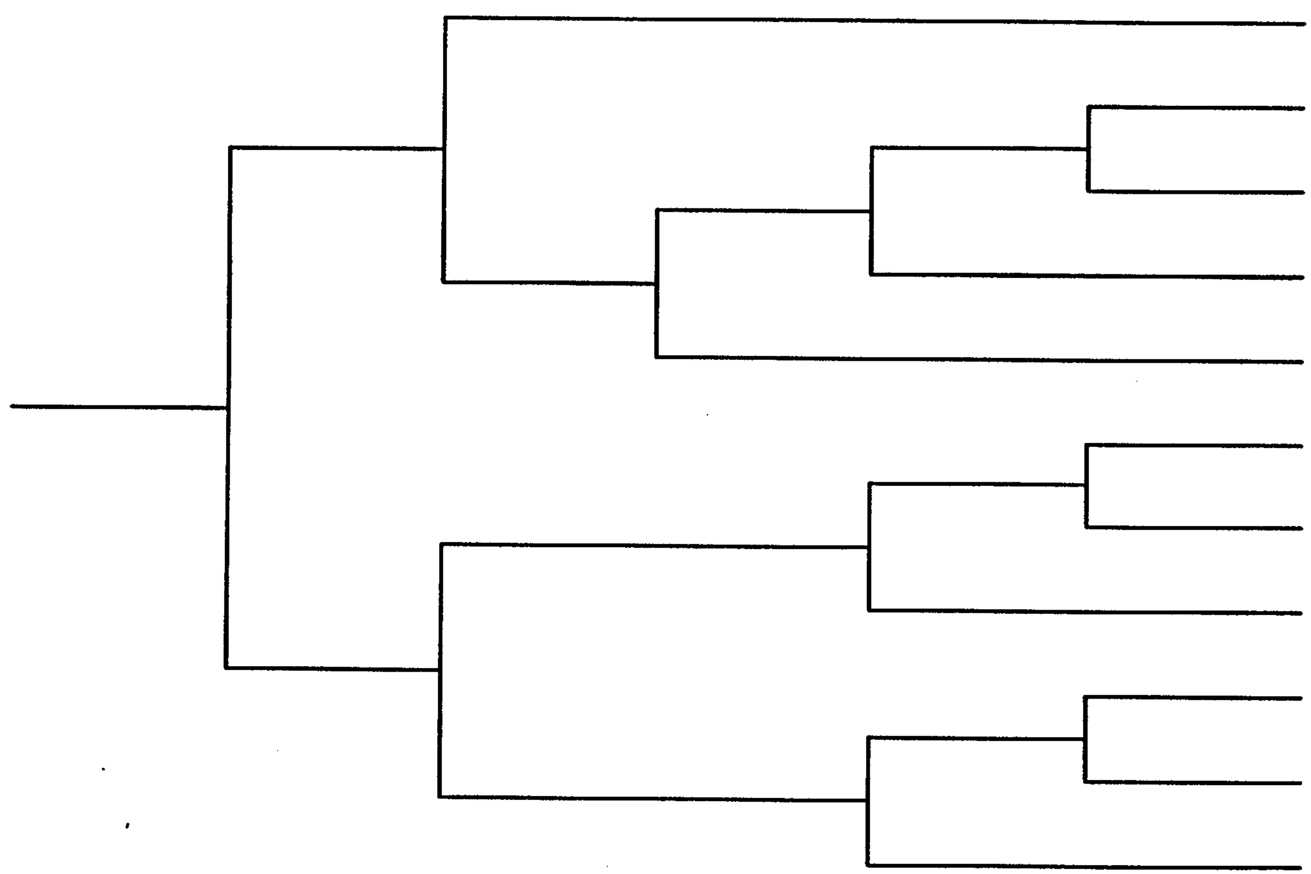
5	CD
6	OK
7	CD
8	CD
9	CD

Plant Name Abbrev.: ANO1

LOOPIEDG	SORV	EFW	FB	EIHP	HPR	#	STATUS



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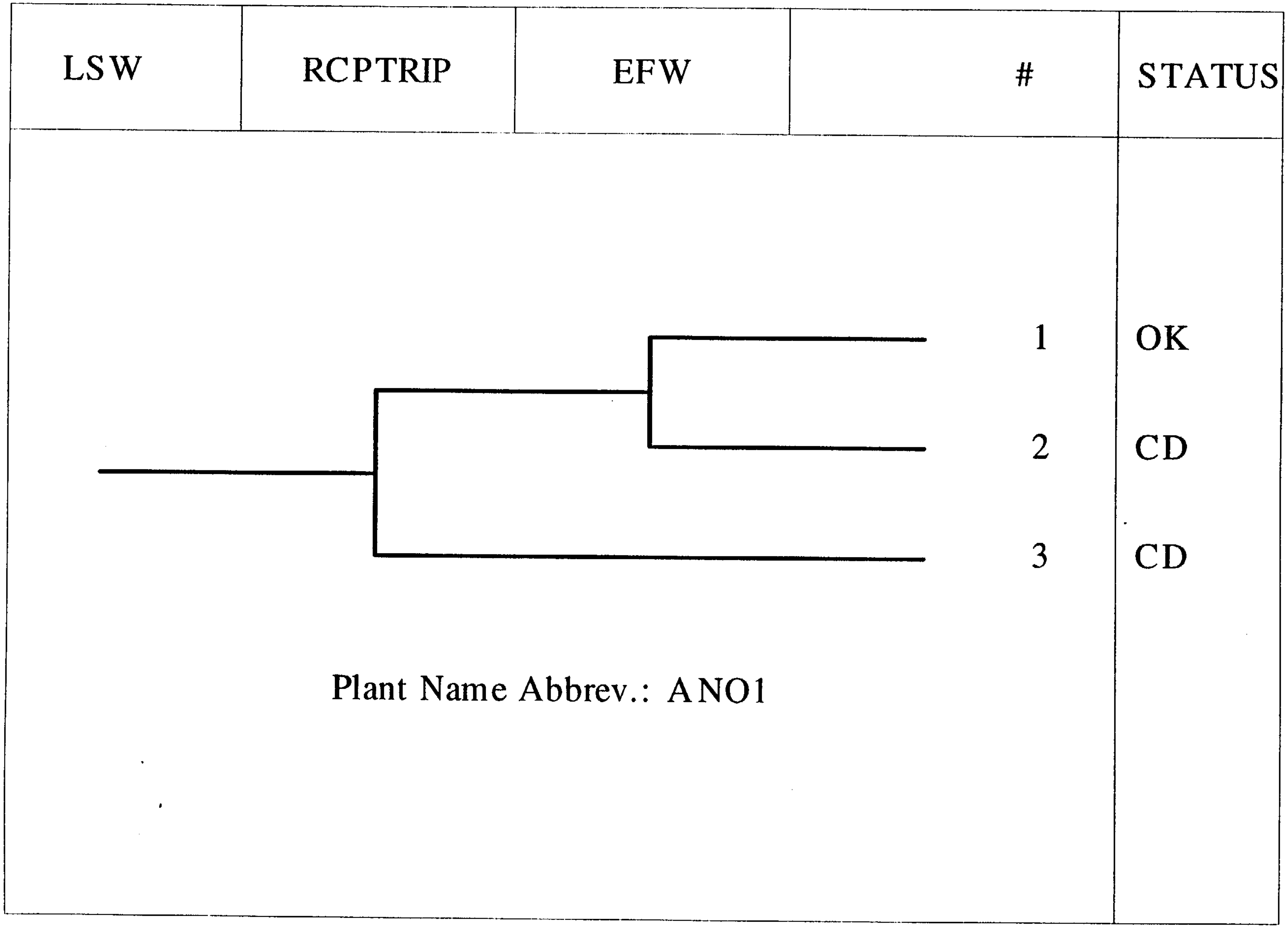
11	CD

Plant Name Abbrev.: ANO1


LSW
RCPTRIP
EFW
#
STATUS
1
OK
2
CD
3
CD
Plant Name Abbrev.: ANO1

2. RESOLUTION AND DISPOSITION OF COMMENTS

This section is composed of two subsections. Subsection 2.1 summarizes the generic assumptions that were used for developing the SDP worksheets for the PWR plants. These guidelines were based on the plant-specific comments provided by the licensee on the draft SDP worksheets and further examination of the applicability of those comments to similar plants. These assumptions which are used as guidelines for developing the SDP worksheets help the reader better understand the worksheets' scope and limitations. The generic guidelines and assumptions for PWRs are given here. Subsection 2.2 documents the plant-specific comments received on the draft version of the material included in this notebook and their resolution.

2.1 GENERIC GUIDELINES AND ASSUMPTIONS (PWRs)

The following generic guidelines and assumptions were used in developing the SDP worksheets for PWRs. These guidelines and assumptions were derived from a review of the licensee's comments, the resolutions of those comments, and the applicability to similar plants.

1. Assignment of plant-specific IEs into frequency rows:

Transient (Reactor trip) (TRANS), transients without PCS (TPCS), small, medium, and large LOCA (SLOCA, MLOCA, LLOCA), inadvertent or stuck-open PORV/SRV (SORV), main steam and feedwater line break (MSLB), anticipated transients without scram (ATWS), and interfacing system LOCAs (ISLOCA) are assigned into rows based on a consideration of the industry-average frequency. Plant-specific frequencies are considered for loss of offsite power (LOOP) and special initiators, and are assigned to the appropriate rows in Table 1.

2. Stuck open PORV/SRV as an IE in PWRs:

This event typically is not modeled in PRAs/IPEs as an initiating event. The failure of the PORVs/SRVs to re-close after opening is typically modeled within the transient event trees subsequent to the initiators. In addition, the intermittent failure or excessive leakage through PORVs as an initiator, albeit with much lower frequency, needed to be considered. To account for such failures and to keep the transient worksheets simple in the SDP, a separate worksheet for the SORV initiator was set up to explicitly model the contribution from such failures. This SDP worksheet, and the associated event tree, is similar to that of SLOCA. The frequency of PORV to re-close depends on the status of pressurizer. If the pressurizer is solid, then the frequency would be higher than the case in which the pressurizer level is maintained. Typically, this depends on early availability of secondary heat removal. However, the frequency for the SORV initiator is generically estimated for all PWR plants in Table 1.

3. Inclusion of special initiators:

The special initiators included in the worksheets are those applicable to this plant. A separate worksheet is included for each of them. The applicable special initiators are primarily based on the plant-specific IPEs/PRAs. In other words, the special initiators included are those modeled in the IPEs/PRAs unless shown to be negligible contributors. In some cases, a particular special initiator may be added for a plant even if it is not included in the IPE/PRA, if it is included in other plants of similar design, and is considered applicable for the plant. However, no attempt is made at this time to have a consistent set of special initiators across similarly designed plants. Except for the interfacing system LOCA (ISLOCA), if the occurrence of the special initiator results in a core damage, i.e., no mitigation capability exists for the initiating event, then a separate worksheet is not developed. For such cases, the inspection's focus is on the initiating event and the risk implication of the finding can be directly assessed. For ISLOCA, a separate worksheet is included noting the pathways that can lead to it.

4. Inclusion of systems under the support system column of the Initiators and System Dependency Table:

This Table shows the support systems for the support- and frontline systems. The intent is to include only the support systems, and not the systems supporting that support system, i.e., those systems whose failure will result in failure of the system being supported. Partial dependency, e.g., a backup system, is not included. If they are, this should be so noted. Sometimes, some subsystems on which inspection findings may be noted were included as a support system, e.g., the EDG fuel oil transfer pump as a support system for EDGs.

5. Coverage of system/components and functions included in the SDP worksheets:

The Initiators and System Dependency Table includes systems and components which are included in the SDP worksheets and those which can affect the performance of these systems and components. One-to-one matching of the event tree headings/functions to that included in the Table was not considered necessary.

6. Crediting of non-safety related equipment:

SDP worksheets credit or include safety-related equipment and also, non-safety related equipment, as used, in defining the accident sequences leading to core damage. In defining the success criteria for the functions needed, the components included are those covered under the Technical Specifications (TS) and the Maintenance Rule (MR). Credits for other components may have been removed in the SDP worksheets.

7. No credit for certain plant-specific mitigation capability:

The significance determination process (SDP) screens inspection findings for Phase 3 evaluations. Some conservative assumptions are made which result in not crediting some plant-specific features. Such assumptions are usually based on comparisons with plants of similar design, and they help to maintain consistency across the SDP worksheets for similar plant designs.

8. Crediting system trains with high unavailability:

Some system component/trains may have unavailability higher than 1E-2, but they are treated similarly to other trains with lower unavailability in the range of 1E-2. In this screening, this approach is considered adequate to keep the process simple. An exception is made for steam-driven components which are designated as Automatic Steam Driven (ASD) train with a credit of 1E-1.

9. Treating passive components (of high reliability) the same as active components:

Passive components, namely accumulators, are credited similarly to active components, even though they exhibit higher reliability. Considering the potential for common-cause failures, the reliability of a passive system is not expected to differ by more than an order of magnitude from active systems. Pipe failures were excluded, except as part of initiating events where the appropriate frequency is used. Accordingly, a separate designation for passive components was not considered necessary.

10. Crediting accumulators:

SDP worksheets assume the loss of the accumulator unit associated with the failed leg in LOCA scenarios. Accordingly, in defining the mitigation capability for the accumulators, the worksheets refer to the remaining accumulators. For example, in a plant with 4 accumulators with a success criteria of 1 out of 4, for large LOCA the mitigation capability is defined as 1/3 remaining accumulators (1 multi-train system), assuming the loss of the accumulator in the failed leg. For a plant with a success criteria of 2 out of 4 accumulators, the mitigation capability is defined as 2/3 remaining accumulators (1 multi-train system).

The inspection findings are then assessed as follows (using the example of the plant with 4 accumulators and success criteria of 2 out of 4):

4 Acc. Available	Credit=3
3 Acc. Available (1 Acc. is considered unavailable, based on inspection findings)	Credit=2
< 3 Acc. Available (2 or more Acc. are considered unavailable, Based on inspection findings)	Credit=0

11. Crediting operator actions

The operator's actions modeled in the worksheets are categorized as follows: operator action=1 representing an error probability of 5E-2 to 0.5; operator action=2 representing an error probability of 5E-3 to 5E-2; operator action=3 representing an error probability of 5E-4 to 5E-3; and operator action=4 representing an error probability of 5E-5 to 5E-4. Actions with error probability > 0.5 are not credited. Thus, operator actions are associated with credits of 1, 2, 3, or 4. Since there is large variability in similar actions among different plants, a survey of the error probability across plants of similar design was used to categorize different operator actions. From this survey, similar actions across plants of similar design are assigned the same credit. If a plant uses a lower credit or recommends a lower credit for a particular action compared to our assessment of similar action based on plant survey, then the lower credit is assigned. An operator's action with a credit of 4, i.e., operator action=4, is noted at the bottom of the worksheet; the corresponding hardware failure, e.g., 1 multi-train system, is defined in the mitigating function.

12. Difference between plant-specific values and SDP designated credits for operator actions:

As noted, operator actions are assigned to a particular category based on a review of similar actions for plants with similar design. This results in some differences between plant-specific values and credit for the action in the worksheet. The plant-specific values are usually noted at the bottom of the worksheet.

13. Dependency among multiple operator actions:

IPEs or PRAs, in general, account for dependencies among the multiple operator actions that may be applicable. In the SDP screening approach, if multiple actions are involved in one function, then the credit for the function is designated as one operator action to the extent possible, considering the dependency involved.

14. Crediting the standby high-pressure pump:

The high-pressure injection system in some plants consists of three pumps with two of them auto-aligned and the third spare pump requiring manual action. The mitigating capability then is defined as : 1/2 HPI trains or use of a spare pump (1 multi-train system). Also, a footnote is added to reflect that the use of a spare pump could be given a credit of 1 (i.e.,1E-1) as a recovery action.

15. Emergency AC Power:

The full mitigating capability for emergency AC could include dedicated Emergency Diesel Generators (EDG), Swing EDG, SBO EDG, and finally, nearby fossil-power plants. The following guidelines are used in the SDP modeling of the Emergency AC power capability:

a) Describe the success criteria and the mitigation capability of dedicated EDGs.

b) Assign a mitigating capability of "operator action=1" for a swing EDG. The SDP worksheet assumes that the swing EDG is aligned to the other unit at the time of the LOOP (in a sense a dual unit LOOP is assumed). The operator, therefore, should trip, transfer, re-start, and load the swing EDG.

c) Assign a mitigating capability of "operator action=1" for an SBO EDG similar to the swing EDG. Note, some of the PWRs do not take credit for an SBO EDG for non-fire initiators. In these cases, credit is not given.

d) Do not credit the nearby power station as a backup to EDGs. The offsite power source from such a station could also be affected by the underlying cause for the LOOP. As an example, overhead cables connecting the station to the nuclear power plant also could have been damaged due to the bad weather which caused the LOOP. This level of detail should be left for a Phase 3 analysis.

16. Treatment of HPR and LPR:

The operation of both the HPR and LPR rely on the operation of the RHR pumps and the associated heat exchangers. Therefore, failure of LPR could imply failure of both HPR and LPR. A sequence which contains failure of both HPR and LPR as independent events will significantly underestimate the CDF contribution. To properly model this configuration within the SDP worksheets, the following procedure is used. Consider the successful depressurization and use of LPR as the preferred path. HPR is credited when depressurization has failed. In this manner, a sequence containing both HPR and LPR failures together is not generated.

17. SGTR event tree:

Event trees for SGTR vary from plant to plant depending on the size of primary-to-secondary leak, SG relief capacity, and the rate of rapid depressurization. However, there are several common functional steps that are addressed in the SDP worksheet: early isolation of the affected SG, initiation of primary cool-down and depressurization, and prevention of the SG overfill. These actions also include failure to maintain the secondary pressure below that of Main Steam safety valves which could occur either due to the failure of the relief valves to open or the operator's failure to follow the procedure. Failure to perform this task (sometimes referred to as early isolation and equalization) is assumed to cause continuous leakage of primary outside the containment. The success of this step implies the need for high-pressure makeup for a short period, followed by depressurization and cooldown for RHR entry (note, relief valves are assumed to re-close when primary pressure falls below that of the secondary). If the early makeup is not available or the operator fails to perform early isolation and equalization, rapid depressurization to RHR entry is usually assumed. This would typically require some kind of intermediate- or low-pressure makeup. Finally, depending on the size of the Refueling Water Storage Tank (RWST), sometimes it would be necessary to establish makeup to the RWST to allow sufficient time to enter the RHR mode.

18. ATWS scenarios:

The ATWS SDP worksheet assumes that these scenarios are not recoverable by operator actions, such as a manual trip. The failure of the scram system, therefore, is not recoverable, neither by the actuation of a back-up system nor through the actuation of manual scram. The initiator frequency, therefore, should only account for non-recoverable scrams, such as mechanical failure of the scram rods.

19. Recovery of losses of offsite power:

Recovery of losses of offsite power is assigned an operator-action category even though it is usually dominated by a recovery of offsite AC, independent of plant activities. Furthermore, the probability of recovery of offsite power in "X" hours (for example 4 hours) given it is not recovered earlier (for example, in the 1st hour) would be different from recovery in 4 hours with no condition. The SDP worksheet uses a simplified approach for treating recovery of AC by denoting it as an operator action=1 or 2 depending upon the HEP used in the IPE/PRA. A footnote highlighting the actual value used in the IPE/PRA is provided, when available.

20. RCP seal LOCA in a SBO:

The RCP seal LOCA in a SBO scenario is included in the LOOP worksheet. RCP seal LOCA resulting from loss of support functions is considered only if the loss of support function is a special initiator. The dependencies of RCP seal cooling are identified in Table 2.

21. RCP Seal LOCA for Westinghouse Plants during SBO Scenarios:

The modeling of the RCP seal failures upon loss of cooling and injection as occurs during SBO scenarios has been the subject of many studies (e.g., BNL Technical report W6211-08/99 and NUREG/CR-4906P). These studies are quite complex and assign probabilities of seal failure as a function of time (duration of SBO) and the associated leak rates. The leak rates, in turn, will determine what would be the safe period for recovery of the AC source and the use of SI pumps before core uncovery and damage. On the contrary, the SDP worksheets simplify the analysis of the RCP seal LOCA during the SBO scenarios using the following two assumptions: (1) The probability of catastrophic RCP seal failure is assumed to be 1 if the SBO lasts beyond two hours, and (2) Given a catastrophic seal LOCA, the available time prior to core damage for recovery of offsite power and establishing injection is about two hours. Therefore, in almost all cases, to prevent a core damage, a source of AC should be recovered within 4 hours in SBO scenarios.

22. Tripping the RCP on loss of CCW:

Upon loss of CCW, the motor cooling will be lost. The operation of RCPs without motor cooling could result in overheating and failure of bearings. Bearing failure, in turn, could cause the shaft to vibrate and thereby result in the potential for seal failure if the RCP is not tripped. In Westinghouse plants, the operator is instructed to trip the RCPs early in the scenario (from 2 to 10 minutes after detecting the loss of cooling). Failure to perform this action is conservatively assumed to result in seal failure and, potentially in a LOCA. This failure mechanism (occurrence of seal LOCA) due to failure to trip the RCPs upon loss of cooling is not considered likely in some plants, whereas it has been modeled explicitly in other plants. To ensure consistency, the trip of the RCP pumps are modeled in the SDP worksheets, and the operator failure to do this is assumed to result in a LOCA. In many cases, the failure to trip RCP following a loss of CCW results in core damage.

23. Hot leg/Cold leg switchover:

The hot leg to cold leg switchover during ECCS recirculation is typically done to avoid boron precipitation. This is typically part of the procedure for PWRs during medium and large LOCA scenarios. Some IPEs/PRAs do not consider the failure of this action as relevant to core damage. For plants needing the hot /cold switchover, it usually can only be accomplished with SI pumps and the ECCS recirculation also uses the SI pumps.

2.2 RESOLUTION OF PLANT-SPECIFIC COMMENTS

1. Table 1 support systems information was incorporated.
2. MLOCA event tree was modified based on utility comment.
3. SGTR event tree was modified to make it similar to the event tree of IPE.
4. ATWS event tree was not modified, because it follows the generic event tree.

REFERENCES

1. NRC SECY-99-007A, Recommendations for Reactor Oversight Process Improvements (Follow-up to SECY-99-007), March 22, 1999.

2. Entergy Operations, Inc., "Arkansas Nuclear One, Unit 1 Individual Plant Examination," April 29, 1993.