

Sensitivity Analysis

7A
 A wide spectrum of sensitivity analyses were completed by requesting that the licensee calculate CCDP values which corresponded to various combinations of HEPs. The analysts determined that the calculated increase in CDF for Fire Zone 99-M was most likely in the range of 7E-6 to 2E-5. The analyst qualitatively determined that an additional increase in the CDF was warranted due the existence of additional fire zones at the facility which also credited the use of operator recovery actions.

The licensee's human reliability analysis (HRA) was completed for non-fire conditions. The dominate recovery actions for a fire in Zone 99-M involved the establishment of emergency feedwater (EFW), the restoration of electrical power, and the establishment of feed and bleed capability. The associated non-fire human error probabilities for these recovery actions were 1.86E-1 for EFW, 1.0E-1 for electrical power, and 6E-3 for feed and bleed. The revised HRA estimate from the licensee included HEP values of 2.6E-1 for EFW, 1E-1 for electric power, and 3.2E-1 for feed and bleed.

The NRC analysts' completed a simplified HRA screening analysis using INEEL/EXT-99-0041, "Revision of the 1994 ASP HRA Methodology (Draft)," January 1999. The HEP values using the assumption that procedures were available, but poor were 1.0 for EFW, 7.5E-1 for electric power, and 7.5E-1 for feed and bleed. The HEP values using the assumption that procedures were adequate were 6E-1 for EFW, 5.5E-1 for electric power, and 5.5E-1 for feed and bleed.

The delta CDF non-fire results were obtained by subtracting the associated recovery term from the NON-FIRE NOMINAL VALUE. The delta CDF revised HRA results (SPAR and Licensee) were obtained by subtracting the associated recovery term from the associated REVISED HRA NOMINAL VALUE.

FIRE ZONE 99M - SEVERITY FACTOR NOT APPLIED				
RECOVERY TERM	CDF	DELTA CDF NON FIRE HRA	DELTA CDF REVISED HRA (SPAR)	DELTA CDF REVISED HRA (LICENSEE)
NON-FIRE NOMINAL VALUE	5.37E-07	N/A	N/A	N/A
REVISED HRA NOMINAL VALUE (SPAR)	2.23E-5	N/A	N/A	N/A
REVISED HRA NOMINAL VALUE ESTIMATE (LICENSEE)	2.28E-6	N/A	N/A	N/A
ELECTRIC POWER 0.3, EFW 0.3, FEED AND BLEED 6E-3	1.21E-06	6.73E-07	N/A	N/A
ELECTRIC POWER 0.3, EFW 0.6, FEED AND BLEED 6E-3	6.05E-06	5.51E-06	N/A	3.77E-6
ELECTRIC POWER 0.6, EFW 0.6, FEED AND BLEED 6E-3	7.73E-06	7.19E-06	N/A	5.45E-6
ELECTRIC POWER 0.3, EFW 0.6, FEED AND BLEED 0.1	8.46E-06	7.92E-06	N/A	6.18E-6
ELECTRIC POWER 0.3, EFW 0.6, FEED AND BLEED 0.3	1.52E-05	1.47E-05	N/A	1.29E-5
ELECTRIC POWER 0.55, EFW 0.6, AND FEED AND BLEED 0.55	2.23E-5	2.18E-5	N/A	2.00E-5
ELECTRIC POWER 0.1, EFW 1.0, FEED AND BLEED 6E-3	2.28E-05	2.23E-05	5.00E-7	2.05E-5
ELECTRIC POWER 1.0, EFW 1.0, FEED AND BLEED 6E-3	2.44E-05	2.39E-05	2.10E-6	2.21E-5
ELECTRIC POWER 0.75, EFW 1.0, FEED AND BLEED 0.75	1.07E-04	1.06E-04	8.47E-5	1.05E-4

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FIRE ZONE 99M WITH SEVERITY FACTOR APPLIED				
RECOVERY TERM	CDF	DELTA CDF NON FIRE HRA	DELTA CDF REVISED HRA (SPAR)	DELTA CDF REVISED HRA (LICENSEE)
NON-FIRE NOMINAL VALUE	3.15E-07	N/A	N/A	N/A
REVISED HRA NOMINAL VALUE (SPAR)	1.31E-5	N/A	N/A	N/A
REVISED HRA NOMINAL VALUE ESTIMATE (LICENSEE)	1.43E-6	N/A	N/A	N/A
ELECTRIC POWER 0.3, EFW 0.3, FEED AND BLEED 6E-3	7.13E-07	3.98E-07	N/A	N/A
ELECTRIC POWER 0.3, EFW 0.6, FEED AND BLEED 6E-3	3.55E-06	3.24E-06	N/A	2.21E-6
ELECTRIC POWER 0.3, EFW 0.6, FEED AND BLEED 0.1	4.97E-06	4.66E-06	N/A	3.63E-6
ELECTRIC POWER 0.3, EFW 0.6, FEED AND BLEED 0.3	8.94E-06	8.63E-06	N/A	7.6E-6
ELECTRIC POWER 0.6, EFW 0.6, FEED AND BLEED 6E-3	9.74E-06	9.43E-06	N/A	8.40E-6
ELECTRIC POWER 0.55, EFW 0.6, FEED AND BLEED 0.55	1.31E-5	1.28E-5	N/A	1.18E-7
ELECTRIC POWER 0.1, EFW 1.0, FEED AND BLEED 6E-3	1.34E-05	1.31E-05	3.00E-7	1.21E-5
ELECTRIC POWER 1.0, EFW 1.0, FEED AND BLEED 6E-3	1.43E-05	1.40E-05	1.20E-6	1.30E-5
ELECTRIC POWER 0.75, EFW 1.0, FEED AND BLEED 0.75	6.31E-05	6.28E-05	5.00E-5	6.18E-5

A qualitative analysis of similarly affected fire zones in Unit 1 and Unit 2 was completed. The analyst compared the remaining 15 fire zones in Unit 1 which required manual actions for safe shutdown to Calculation 85-E-0053-47, "Individual Plant Examination of External Events/Fire," Revision 2, to determine which fire zones were unscreened as part of the FIVE analysis. The following fire zones were unscreened.

Fire Zone	Description	Ignition Frequency	Automatic Suppression	Multiple Redundant Trains
197-X	Turbine Building (A1/A2 Failed)	7.31E-3	Partial	No
149-E	Upper North Electrical Penetration	2.66E-3	Yes	Yes
100-N	South Switchgear Room	1.13E-3	No	Yes
104-S	Electrical Equipment Room	3.71E-3	No	Yes
105-T	Lower South Electrical Penetration Room	3.07E-4	Yes	No
73-W	Bowling Alley	1.06E-3	Partial	Yes
76-W	Compressor Room	3.86E-3	No	Yes
34-Y	Auxiliary Building Piping Area	5.91E-4	No	Yes

The analyst compared the 21 fire zones in Unit 2 which required manual actions for safe shutdown to Calculation 85-E-0053-48, "Individual Plant Examination of External Events/Fire," Revision 2, to determine which fire zones were unscreened as part of the FIVE analysis. The following fire zones were unscreened:

Fire Zone	Description	Ignition Frequency	Automatic Suppression	Multiple Redundant Trains
2200-MM	Turbine Building A1/A2 Failed	1.8E-2	Partial	No
2200-MM	Turbine Building A1/A2 Not Failed	1.18E-3	Partial	No
2100-Z	4160 Volt Switchgear Room A4	1.13E-3	No	Yes
2096-M	MCC (2B63)	1.25E-3	No	Yes
2101-AA	4160 Volt Switchgear Room A3	1.08E-3	No	No
2108-S	Electrical Equipment Room 368	6.3E-4	No	Yes
2109-U	EDG Access Corridor	2.01E-3	Partial	Yes
OO	Intake Structure	1.78E-3	Partial	Yes

Fire Zone	Description	Ignition Frequency	Automatic Suppression	Multiple Redundant Trains
B3SC	Super Compartment for Auxiliary Building (Area of concern is 2091-BB)	9.28E-3	No	Yes
2055SC	Super Compartment for Lower South Electrical and Piping Penetration Room	6.62E-4	2084-DD No 2111-T Yes	2084-DD Yes 2111-T No
2040-JJ	Auxiliary Building Elevation 335	7.92E-3	No	Yes
2063SC	Super Compartment for Auxiliary Building Elevation 354	5.94E-3	Partial	Yes

The analysts' quantitative analysis determined that Fire Zone 98-J was of low safety significance due to the availability of automatic suppression capability and Fire Zone 99-M had either low to moderate or substantial safety significance due to not having automatic suppression capability.

The analysts determined that Fire Zones 98-J and 99-M had ignition frequencies between 2E-3 and 4E-3 and that both fire zones included multiple redundant trains of safe shut down equipment. The analysts determined the significance of a fire in a particular fire zone would be reduced if multiple redundant trains of equipment were "not" affected or if the fire zone had a relatively low ignition frequency (less than 1E-3). Accordingly, the analysts qualitatively removed fire zones from further consideration if any of the following conditions existed: the ignition frequency was less than 1E-3, the affected area had automatic suppression capability, or multiple redundant trains of safe shutdown equipment were "not" affected by a postulated fire.

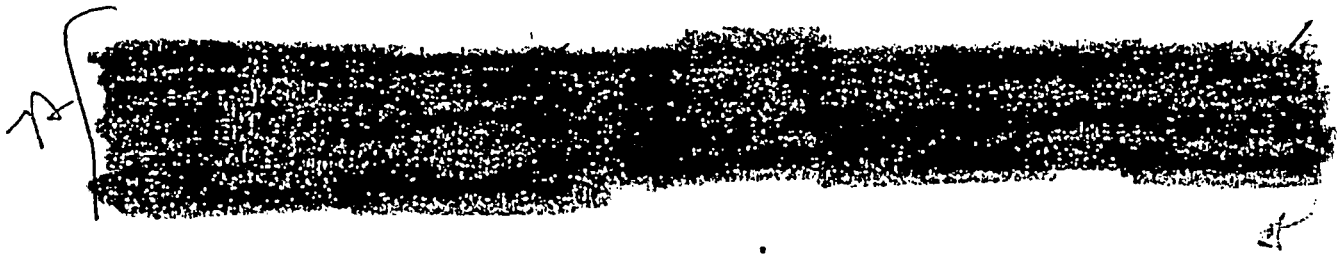
The following fire zones required an additional assessment of the affected trains of redundant equipment:

Unit 1	Unit 2
100-N	2100-Z
104-S	2096-M
76-W	2091-BB
	2040-JJ

The analysts qualitatively compared the safety functions affected in Fire Zone 99-M to the safety functions affected by a fire in the above unscreened fire zones.

Safety Function	Unit 1 Fire Zone				Unit 2 Fire Zone			
	99-M White or Yellow	100-N White	104-S White or Yellow	76-W Green	2100-Z White	2096-M White	2091-BB White	2040-JJ White
Main Feedwater	1/1 ⁽¹⁾	1/1	1/1	0/1	1/1	1/1	1/1	0/1
High Pressure Injection	2/3	2/3	3/3	2/3	1/3	1/3	0/3	3/3
Low Pressure Injection	1/2	1/2	2/2	1/2	1/2	0/2	0/3	1/2
Service Water	1/2	1/2	2/2	1/2	1/3	0/3	0/3	1/3
Diesel Generator	2/2	2/2	2/2	1/2	2/2	1/2	1/2	1/2
Emergency Feedwater Flow-paths	4/4	3/4	4/4	3/4	0/2	2/2	2/2	1/2

1. X/X: Number of failed trains/Number of available trains



Human Reliability Screening Analysis ANO Fire Issue

Background

During the triennial fire inspection, the team determined that the licensee had not implemented appropriate procedural controls for a fire in Fire Areas 99-M (Green Train switchgear room) and 98-J (corridor with Red and Green Train conduit). Specifically, the licensee relied solely on a symptomatic response to a fire in these areas. For example, if control room operator became aware of a loss of feedwater condition, then operators would respond by aligning auxiliary feedwater (AFW) from either the control room or locally. This approach differed from other alternate shutdown areas of the plant. For these areas, specific procedural guidance (Procedure 1203.002, "Alternate Shutdown") existed to direct the operators to isolate and then restore potentially affected components.

The following four broad classes of operator actions were evaluated:

- Manual alignment of emergency feedwater to the steam generators.
- Restoration of service water to the affected emergency diesel generators (EDG).
- Isolation of letdown flow and inventory control.
- Local start of an EDG without DC control power.

For each of the above classes, an operator would be required to successfully diagnose the system failure, determine the appropriate procedure, and then take the appropriate series of operator actions to mitigate the failure. There were several complicating factors in completing the analysis because the operator actions would be required following a major fire. Specifically the fire could result in:

- Suspect indications associated with critical plant parameters.
- Spurious actuations of plant equipment which are detrimental to the event.
- Failure of plant equipment to respond automatically.
- Inability to remotely operate plant equipment from the main control room.
- Previously implemented operator actions could become over-ridden by subsequent operator actions through the use of multiple procedures in lieu of a single prioritized procedure.

Assumptions

1. An "Extreme Stress" classification was used for each class of operator actions. This level of stress is likely to occur when the onset of the stressor is sudden and the stressing situation persists for long periods.

2. An "Available, But Poor" classification was used for the procedural actions necessary to recover failed or degraded mitigating equipment. This classification is used for conditions where a procedure is available but inadequate. This classification level was chosen because of the symptomatic response of operators to a fire instead of a having a pre-planned alternate shutdown procedure. If properly diagnosed, procedures existed for operators to implement the individual system recovery actions. However, there may be dependencies between the procedures which are not accounted for. Specifically, to recover AC power, the operators may need to open the individual breakers on various switchgear. This activity could affect previous actions to restore mitigating systems. A single pre-planned procedure would account for the dependencies between procedures such that subsequent recovery actions do not affect previously implemented recovery actions.
3. A "Barely Adequate Time" classification was used for diagnosing a loss of flow to the steam generators and establishing AFW flow. This classification level was chosen based on the potential for indications and controls not being available in the control room. The timing associated with initiating AFW flow is dependent on operator actions to secure reactor coolant pumps. In addition, the flow rate to the steam generators must be controlled to prevent over-cooling and shrinkage of the reactor coolant system.
4. A "Barely Adequate Time" classification was used for diagnosing an EDG without service water and for securing the affected EDG. The EDG without service water flow must be secured within 7 minutes to prevent overheating and mechanical damage. The failure to secure the EDG could potentially prevent recovery of an emergency AC power source.
5. A "Barely Adequate Time" classification was used for diagnosing the failure of letdown to isolate and for securing letdown. If letdown is isolated within 4 minutes, then inventory control may not be required for 40 minutes. The failure to isolate letdown directly impacts the time available to initiate inventory control.
6. A "Highly Complex" classification was used for a local start of the EDG without DC power. This procedure is infrequently performed, requires a high degree of skill, and includes multiple steps to complete.
7. A "Moderately Complex" classification was used for a local manual start of an AFW pump and for local manual control of AFW flow to a steam generator. This activity is infrequently performed and would require constant communication with personnel monitoring important plant parameters to ensure the appropriate heat removal rate was maintained.
8. Limited personnel would be available during the first hour following a fire. Two individuals would be available for field operations (1 main control room reactor operator and 1 auxiliary operator). The remaining personnel would be assigned other functions. Specifically, the shift manager would be assigned emergency response organization duties, the control room supervisor and one reactor operator would remain in the main control room, the waste control operator and 1 auxiliary operator would be assigned to the fire brigade. The shift engineer would be available to provide assistance where necessary. A Unit 2 operator would be dispatched to start the alternate EDG. The

licensee did not credit the use of Unit 2 operators in the performance of Unit 1 plant manipulations.

The analyst determined that 1 operator would need to be dedicated to the restoration of AFW and the operation of the AFW flow control valves. The remaining operator would be required to complete all other evolutions (Isolate letdown, local start of the EDG, and all breaker manipulations). In contrast, the alternate shutdown procedure requires four operators, as a minimum, for successful completion. The analyst determined that the majority of actions specified in the alternate shutdown procedure could potentially be required for a major fire in Fire Areas 99-M or 98-J.

References

1. INEEL/EXT-99-0041, "Revision of the 1994 ASP HRA Methodology (Draft)," January 1999
2. Procedure 1203.002, "Alternate Shutdown"
3. Procedure 1104.036, "Emergency Diesel Generator Operation"
4. Procedure 1106.006, "Emergency Feedwater Pump Operation"
5. Procedure 1202.008, "Blackout"
6. Procedure 1202.007, "Degraded Power"
7. Procedure 2104.037, "Alternate AC Diesel Generator Operations"
8. Procedure 1107.001, "Electrical System Operations"
9. Procedure 1107.002, "ES Electrical System Operation"
10. Procedure 1104.002, "Makeup & Purification System Operation"
11. Procedure 2104.028, "Component Cooling Water System Operation"
12. Fire Hazards Analysis
13. IPEEE Fire Calculation 85-E-0053-47
14. ANO Appendix R Position Paper, "Emergency Diesel Generator Access Corridor Fire Zone 98-J"

Diagnosis Failure Probability										
Recovery Action	Diagnosis Factor	Time	Stress	Complexity	Experience & Training	Procedures	Ergonomics	Fitness For Duty	Work Processes	Diagnosis Failure Probability
Establish AFW	1E-2	10	5	1	1	1	1	1	1	0.5
Secure EDG Without Service Water	1E-2	10	5	1	1	1	1	1	1	0.5
Local EDG Start	1E-2	1	5	1	1	1	1	1	1	0.05
Isolate Letdown and Inventory Control	1E-2	10	5	1	1	1	1	1	1	0.5

Action Failure Probability Without Adequate Procedures										
Recovery Action	Action Factor	Time	Stress	Complexity	Experience & Training	Procedures	Ergonomics	Fitness For Duty	Work Processes	Action Failure Probability
Establish AFW	1E-3	10	5	2	1	5	1	1	1	0.5
Secure EDG Without Service Water	1E-3	10	5	1	1	5	1	1	1	0.25
Local EDG Start	1E-3	1	5	5	1	5	1	1	1	0.125
Isolate Letdown and Inventory Control	1E-3	10	5	1	1	5	1	1	1	0.25

Task Failure Probability With Adequate Procedures			
Recovery Action	Diagnosis Failure Probability	Action Failure Probability	Task Failure Probability Without Formal Dependence
Establish AFW	0.5	0.1	0.6
Secure EDG Without Service Water	0.5	0.05	0.55
Local EDG Start	0.05	0.025	0..03
Isolate Letdown and Inventory Control	0.5	0.05	0.55