Power Risk Assessment of the Ft. Calhoun Degraded Fire Barrier Issue

April 3, 2000
Updated April 20, 2000
S:\DRS\PRA\FOIA\FCS_FIRE_Insp-fnds.wpd

This risk assessment analyzes the condition associated with power and control cable separation in Fire Area 32. Three specific areas within Fire Area 32 were assessed for the impact on power and control cable separation (respective power and control for one train along with the control cable for the second train in Areas C and E and both the control and power cables for Area D). The cable routing reports were reviewed and the spatial interaction with the opposite train was considered.

I. Background

The Ft. Calhoun IPEEE was submitted to the NRC on 6/30/95. The IPEEE reported the total core damage frequency (CDF) due to fires as 2.78E-05/yr. The contribution from fire Area 32 is approximately 6.01E-06/yr). Fire Area 32 involves the compressor area and is located at the east end of the auxiliary building. The inspectors identified three specific areas within Fire Area 32 that were of concern because of inadequate separation between redundant control and power cables. The three areas were identified as areas C, D and E. Area C is located near the air compressors (principally Train A over the compressors), Area E is located over the motor and turbine driven auxiliary feedwater pumps and Area D is open but all the control and power cables run through a pinch point for both trains within a 20 foot space.

This risk analysis considers the failure of one train involving power cables and the control cables along with a failure of the second train's control cable. The second train's power cable was not assumed to be effected because of the approved exemption request which allowed for the existing configuration. *Subsequently, it was determined that both trains of control and power cables should be considered concurrently because of concerns with the completeness of the submittal used to provide the basis for the exemption request.* The one exception is Area D where the minimum requirements were not met for control or power cables. Nominal failure rates for the fire protection system were also assumed. This discussion is provided in the determination of the fire initiating frequency.

The licensee's review of this event from Phase 2 and 3 perspectives is provided as an attachment to this report.

II. IPEEE Insight Discussion

Section 4 of the IPEEE, Internal Fires Analysis, provides an assessment of the different fire areas. Fire Area 32 is discussed below.

K/6

Table 4.1, FPRA Results Summary provides the following insights:

Area	Ignition Freq	Suppression Prob	CCDP	CDF	Comments
FA32AS	5.67E-03	NA	6.99E-06	3.88E-08	Small air compressor
FA 32AL	4.70E-03	9.5E-01	7.7E-04	6.85E-08	Large air comp. Fire with supp.
FA32ALN	4.7E-03	5E-02	1	4.7E-06	Lrge comp fire w/o supp.
FA32FS	1.9E-04	NA	1.36E-06	2.1E-10	Small AFW fire
FA32FL	1.9E-04	9.8E-01	1.6E-02	5.3E-07	Lge FW fire w/ suppression
FA32FL	1.99E-04	2E-02	1	6.77E-07	Lrg AFW fire w/o supp.
Total	5.8E-03			6.01E-06	NOT Screened

The IPEEE assessment of Fire Area 32 is documented between pages 4-29 and 4-31. Specifically, small and large fires for the steam driven AFW pump (FW-10) (Area E) and the air compressor (Area C) were considered.

A small fire at the steam driven AFW pump was not expected to cause damage other than to the pump. A large fire however may result in damage to all equipment and cables in the area without suppression. The 5.5 gallons of oil assumed in the analysis would affect an area of 190 square feet and the fire damage would have a radius of 14 feet. A reactor trip is assumed to occur, along with a turbine trip, loss of condenser vacuum, main feedwater, CCW, raw water or instrument air failures as a result of this fire. The dominant sequences would involve a loss of auxiliary feedwater and spurious opening of the PORV with the inability to isolate the PORV using the associated block valve. The dominant failures given a loss of SUPPRESSION was sequence TQU - Spurious opening of the PORV and loss of the block valve along with the inability to provide HPSI because the HPSI valves could not be opened. The dominant failures with SUPPRESSION were TBF - loss of normal and auxiliary feedwater and failure of the operators initiate feed and bleed along with a random failure of AFW-54. Sequence TBX with SUPPRESSION was also important5 from a loss of normal and AFW feedwater, failure of the containment cooling fans and random failures of RAW water and random failures associated with recirculation.

A large fire involving an air compressor (without successful suppression) could damage components within a forty-foot radius and involve an area of 378 square feet. The dominant sequence was determined to be the TQU sequence. With successful suppression damage to the cables would be limited to approximately 14 feet which places the Train B control and power cables outside the affected radius.

The SRA reviewed this initial assessment with the licensee's probabilistic risk assessment personnel. The licensee's IPEEE assessment assumed loss of the components that were located in the area and the associated load and motor control centers. The licensee indicated

they did not review the power and control cables to determine what may be available for mitigation.

III. Fire Propagation and Damage State Assumptions

The SRA performed a review of the three fire areas (C, D and E) using the insights from the IPEEE, the inspection team, fire significance determination process and through subsequent follow up with licensee.

Area C

This area would involve a compressor fire. The compressors are located along a wall beneath the Train A power and control cables. The safety-related 4160 load centers are located above (next floor) or in the vicinity of the area that would be affected by a fire. Suppression was identified as being important to mitigating the damage from a fire in this area. Although the power cables to either the safety-related busses 1A3 and 1A4 are not directly identified as being affected (depends on which case analyzed), the licensee has stated that a LOSP power to the safety-related busses could occur. The OPLS circuit was considered (in the fire area) and determined that it would not prevent recovery of the EDGs and the associated 4160 busses. In this case, because the power cables are separated by the minimum 20 foot space, only one train's associated power and control cable as well as the complimentary (opposite train) control cable were considered. The licensee confirmed that the reactor coolant pumps would trip on loss of the associated safety-related bus. The power cables for the remaining two reactor coolant pumps are powered from the 1A1 and 1A2 4160 volt buses which also run through this area. A severe fire without suppression would also damage the 1A1 and 1A2 power feeds and cause a loss of the remaining two reactor coolant pumps. The potential exists for either the 1A3 or 1A4 bus to remain energized (power cables outside the 20 feet) and the reactor coolant pumps to remain running. In this case it appears that a CCW pump should also remained powered for reactor coolant pump seal cooling, as well as 4 HPSI valves and the HPSI 2C pump. In addition, the cables for two channels of pressurizer pressure run through Room 19, and on a spurious high signal (two faults) could cause the PORVs to open provided the associated MCCs are energized. The licensee estimated that 1-hour would be available before core uncovery in the event of an open PORV without high pressure makeup.

The HPSI system can be cross-tied to the charging system using DC solenoid operated valves located outside fire area 19.

A revised case was considered where the second power cable train was affected by a fire. This assumption would result in a combined loss of control and power to the components identified in both Cases 1 and 2 which follow. The worst case analysis would include damage to power and control feeds for the HPSI pumps, charging pumps, power operated relief valves, containment spray pumps, motor driven fire pump and power operated relief valves.

CASE 1 POWER and CONTROL CABLES WITHIN 1S AND 2S, and CONTROL CABLES WITHIN 16S-1/17S/19S. Area C contains redundant control cables for LPSI Pump, SI-1B and HPSI Pump SI-2B. Loss of these cables would require manual operation of the breakers at the switchgear for these pumps as needed to support cold shutdown. This scenario best fits the location of the compressors (beneath Train A power and control cables).

Equipment Effected and Assumed Lost Because of a Fire in this Area

Equipment	Component (Power and Control)	Components(Control cable)	Components Remaining
LPSI	1A	1B	
HPSI	2A	2B	2C with feed from1B4A (operator action)
CS	3A	3B	
Raw water	10A and discharge valve	10B and discharge valve	10 C/D
Fire Pumps	1A/6A	1B* (Starts on low system pressure independent of control circuitry)	Both fire pumps from PRA provided successful suppression.
AFW	6 MDAFW	10 (Steam admission valve and flow control valves)	
EDGs	1	2	Recoverable to 1A 3 and 1A4
MCC-3B3	Not significant to fire		
1B3A	MCC-3A1/3A2/3A3/3A4 SI-2A/CH-1A/2 HPSI Valves		
1B3B	MCC-3B1/3B2/3B3 PORV Block/2 HPSI valves/CCW-A		
1B3C	MCC-3C1 Cspray/PORV		MCC-4B1 PORV w/o associated block valve
OPLS	OPLS**	**OPLS	
			Swing Busses 1B3A-4A and 1B3B-4B and 1B3C-4C can be powered from Train B

This area includes both power cable and control cable runs
* FP-1B (Diesel Driven Main Fire Pump)

The control circuitry for FP-1B is such that there is no circuit failure due to a Room 19 fire that would result in the loss of the auto-start or local manual start capability for the pump. The circuits which provide the auto-start / local manual start feature are independent of Room 19 (circuits, including power supplies are located in the intake structure). The FP-1B cables routed through Room 19 are for Control Room start and auto-start following a loss of FP-1A. These cables are isolated from the FP-1B circuitry by an interposing relay located at FP-1B. A loss of the Control Room start circuitry will not impact the local auto-start / manual start circuitry for FP-1B. FP-1B will auto-start as a result of a Room 19 fire and subsequent actuation of the Room 19 suppression system.

** Fire Induced faults to OPLS Cabling

Room 19 also contains circuitry for OPLS and the sequencer. There is no circuit failure that could cause either the OPLS or the sequencer to fail and overload/damage the Diesel Generators. In addition, the necessary control circuitry is available such that at any time, operations personnel can stop / prevent operation of any pump. The OPLS / sequencer circuitry can not fail in such a manner as to damage the Diesel Generators, therefore the Diesel's are expected to be available following a Room 19 fire.
Loss of power to these MCCs will result in the need to manually operate valves for alignment of the charging pumps to either the SIRWT or the BASTs. Also operations has the option of using SI-2C for inventory control if necessary.

Manual actions discussed above are addressed in Station Operating Procedures, station training, and were discussed and demonstrated to the audit team during the on-site portion of the Pilot Inspection.

CASE 2 CONTROL CABLES WITHIN 1S AND 2S, and POWER and CONTROL CABLES WITHIN 16S-1/17S/19S. Area C contains redundant control cables for LPSI Pump, SI-1A and HPSI -2A. Loss of these cables would require manual operation of the breakers at the switchgear for these pumps as needed to support cold shutdown. This case assumes that the Train A power cables are not compromised as a result of a fire based on the power cables meeting the 20 foot separation. This specific case was

Equipment Effected and Assumed Lost Because of a Fire in this Area

Equipment	Component (Control)	Components(Power and/or Control cable)	Components Remaining
LPSI	1A	1B	
HPSI		2B	2A or 2C with feed from1B3A (normal lineup)
CS	3A	3B	
Raw water	10A and discharge valve	10B and discharge valve	10 C/D
Fire Pumps	1A/6A	1B* (Starts on low system pressure independent of control circuitry)	Both fire pumps from PRA provided successful suppression.
AFW	6 MDAFW	10 (Steam admission valve and flow control valves)	
EDGs	1	2	Recoverable to 1A 3 and 1A4
MCC-4B4		Not significant to fire	
1B4A		MCC-4A1/4A2/4A3/4A4 CCW/PORV Block/2 HPSI Valves	
1B4B		MCC-4B1/4B2/4B3 PORV/Cont Spray/	
1B4C		MCC-4C1 Charging/SI-2B/2 HPSI valves	MCC-3C1 PORV w/o associated block valve
OPLS		**OPLS	
			Swing Busses 1B3A-4A and 1B3B-4B and 1B3C-4C can be powered from Train A

* FP-1B (Diesel Driven Main Fire Pump)

The licensee identified that control circuitry for FP-1B is such that there is no circuit failure due to a Room 19 fire that would result in the loss of the auto-start or local manual start capability for the pump. The circuits which provide the auto-start / local manual start feature are independent of Room 19 (circuits, including power supplies are located in the intake structure). The FP-1B cables routed through Room 19 are for Control Room start and auto-start following a loss of FP-1A. These cables are isolated from the FP-1B circuitry by an interposing relay located at FP-1B. A loss of the Control Room start circuitry will not impact the local auto-start / manual start circuitry for FP-1B. FP-1B will auto-start as a result of a Room 19 fire and subsequent actuation of the Room 19 suppression system.

** Fire Induced faults to OPLS Cabling

Room 19 also contains circuitry for OPLS and the sequencer. There is no circuit failure that could cause either the OPLS or the sequencer to fail and overload/damage the Diesel Generators. In addition, the necessary control circuitry is available such that at any time, operations personnel can stop / prevent operation of any pump. The OPLS / sequencer circuitry can not fail in such a manner as to damage the Diesel Generators, therefore the Diesel's are expected to be available following a Room 19 fire.

Loss of power to the MCCs may result in the need to manually operate valves for alignment of the charging pumps to either the SIRWT or the BASTs. Also, operations has the option of using SI-2C for inventory control if necessary.

Area E

Area E contains redundant cables for FW-6 and FW-10. Control cables for FW-6 are routed over FW-10. A fire in this area is mitigated by a dedicated wet pipe suppression system installed above FW-10, a barrier installed between FW-6 and FW-10, and a suppression system installed to protect the cables above the pumps.

CASES 3 and 4

These cases have been subsumed into Cases 1 and 2 respectively. The control and power cables run through this area are the same as for Area C. This analysis assumes the same fire ignition frequency for this area and damage to either the Train A control and power cables and the Train B control cables and its compliment for Case 4. Becasue of the location of the ignition source (FW-10) the worst fire damage would expect to be Case 3.
Area E contains redundant cables for FW-6 and FW-10. Control cables for FW-6 are routed over FW-10. A fire in this area is mitigated by a dedicated wet pipe suppression system installed above FW-10, a barrier installed between FW-6 and FW-10, and a suppression system installed to protect the cables above the pumps.

Manual actions discussed above are addressed in Station Operating Procedures, station training, and were discussed and demonstrated to the audit team during the on-site portion of the Pilot Inspection.

Area D

This area represents a pinch point where the power and control cables are closer than the analyzed exemption provides. In this case one condition has been analyzed involving the affected control and power cables. There is no specific ignition source located beneath the cables as in the cases involving the compressor and the AFW-10 pump.
CASE 5

Equipment Effected and Assumed Lost Because of a Fire in this Area

Equipment	Component (Power and Control)	Components(Power and/or Control cable)	Components Remaining
LPSI	1A	1B	
HPSI	2A	2B	2A or 2C with feed from1B3A (normal lineup)
CS	3A	3B	
Charging pumps	CH-1A	CH-1B	CH-1C
Raw water			
Fire Pumps			
AFW			
ELP-1-XS			
EDGs			
MCC-3A2	Not risk significant		
MCC 3A3	Not risk significant		
MCC3C2	Not risk significant		
MCC4A2		Not risk significant	
MCC-4B3		Not risk significant	
MCC-4C2		Not risk significant	

Redundant pump SI-2C is available for back-up to SI-2A & B. The power supply to the load center would not be affected by a fire in this area. If a loss of power cables to both LPSI pumps is postulated, a cold shutdown repair activity to restore power to the pumps would be required.

Phase 1

Step 1: What is the fire protection finding(s)?

1. The control cable separation in areas C, D and E is less than 20 feet and no exemption request was submitted permitting this configuration

2. Area D does not meet the 10-foot separation for power cables discussed in the exemption request.

3. There are no adverse findings against automatic suppression or the fire brigade. The control cables for the motor driven and diesel driven fire pumps are located in the areas affected by fire Areas C and E. Given automatic actuations of the motor driven pump then the control cables should be protected until manual suppression arrives. A failure of the motor driven pump to start on actuation of either the wet pipe over FW-10 or filling of the sprinkler system on a preactuation would result in a low pressure signal and subsequent automatic start of the diesel driven fire pump. The licensee has stated that the start relays for the diesel driven pump would not be effected by damage to the control cables in Room 19. Therefore, the failure probability associated with a failure of either the motor or diesel driven fire pumps were assumed to be at the nominal values. The screen wash pumps and the offsite fire truck (pumper) can be used to supply the fire mains.

Step 2: Complete the Table below:

Does the finding(s) indicate a degradation or impairment of a fire protection feature?	**YES**	NO
Did the degradation or impairment last > the allowed outage time without compensatory measures OR > 30 days with compensatory measures?	**YES**	NO
Does the finding(s) affect either;(1) Detection & manual suppression, (2) Automatic suppression, **(3) Fire barriers**	**YES**	NO
IF THE ANSWER TO ALL THE QUESTIONS ABOVE WAS YES, CONTINUE TO STEP 3	**CONT.**	

Step 3: From the Safe Shutdown Analysis determine the fire protection scheme used to protect and maintain one train of SSD capability free from fire damage.

Scheme 1 - 3 hour fire barrier separation	YES	NO
Scheme 2 - 1 hour fire barrier enclosing one of the SSD trains	**YES**	NO
Scheme 3 - 20' of horizontal separation between redundant SSD trains (10 foot with exemption)	YES	NO

Phase 2 review performed based on Scheme 3 protection used. Initial success of either the automatic or manual fire suppression system should provide protection for cables until manual suppression initiated. Failure of both pumps would result in a fire without suppression and is considered at the established

Initiating fire frequency and probabilities associated with failure of suppression. Recovery of EDGs/operator action to manually close breakers and operate valves may needed to be initiated within a time restraint.

Step 1: Group Fire Protection and Post-fire Safe Shutdown Findings

The findings are associated with Fire Area 32 and the close proximity of control cables between trains. Three areas were reviewed within Fire Area 32. They are Areas C, D, and E. Area E was subsumed into Area C's risk assessment. The areas are located within the non-radiologically controlled area of the auxiliary building.

Step 2; Define the Fire Scenario

Scenario for Area C:

Cases 1 and 2 were considered for the initiating frequency, suppression mitigation and component failures (control and power cables) as a result of fire damage. Case 1 was determined to be the most risk significant and bounded the cable failures that could occur in Case 2. A fire in the area that would result in Case1 would essentially result in a loss of the 480 volt load and motor control centers feed by the safety-related bus 1A3 (4160 volt). In addition, the LPSI A and FW-6 pumps would loose control power and would require local control to energize. The Train B components, HPSI B, RAWB, LPSI B, containment spray B and charging B would alos loose control power and would require local control. The OPLS circuits for both Trains would be effected and may result in the need to manually close the EDGs onto the safety-related buses. The associated Train A PORV is powered from Bus 1B3C. A loss of power to this bus or the 1A3 would denergize the PORV and close the valve if open (assume some probability that the valve fails to reclose [0.1]). Bus 1B4A which feeds MCC 4A1 on Train B may remain energized based on the cables that were identified as being effected. This would provide a block valve for the Train A PORV. The Train B PORV would retain power from MCC-4B1 but the Train A block valve may be without power. Control power for FW-10 (TDFAW) would likely be lost resulting in secondary heat removal requirements being addressed through AFW-54(Diesel driven AFW (operator action to initiate). The HPSI C pump would remain available provided Train B power to 1B4A was not effected. There are two HPSI injection valves powered by 1B4A and MCC-4C1. Lose of 1BA would result in a loss of the HPSI C pump, therefore a crosstie described the HPSI and charging system outside the fire area was not considered.

The licensee also identified that a LOSP could occur because of a fire in this area although not evident from the effected power or control cables). In this event power to the reactor coolant pumps (off Busses 1A3 and A4) would be lost and the associated power to the PORVs to open would be lost. The power cables to the two remaining reactor coolant pumps also runs in this area and power to these pumps would assume to be lost leaving no RCPs operating and mitigating a RCP seal LOCA after 30 minutes with the pumps running and no seal cooling.

This scenario was revised based on the assertion that the exemption granted for the power cable separation was based on incomplete information. Based on this revised "FINDING" CASES 1 and 2 should be consolidated which effectively results in a loss of all high pressure safety injection sources (HPSI and Charging as well as the swing pump capability on a loss of power to the bus).

** Fire Induced faults to OPLS Cabling

Room 19 also contains circuitry for OPLS and the sequencer. There is no circuit failure that could cause either the OPLS or the sequencer to fail and overload/damage the Diesel Generators. In addition, the necessary control circuitry is available such that at any time, operations personnel can stop / prevent operation of any pump. The OPLS / sequencer circuitry can not fail in such a manner as to damage the Diesel Generators, therefore the Diesel's are expected to be available following a Room 19 fire.

Scenario for Area E:

This fire sequence is subsumed by Fire Area C and no further analysis was performed.

Scenario for Area D:

This fire area involved potential damage to power and control cables for both Trains A and B. Equipment that would be lost included all the low pressure and containment spray pumps. The HPSI A and B pumps would be lost, however, the associated valves and the HPSI 2C pump should retain power to operate. All three charging pumps would also be lost. This scenario did not appear to challenge the PORVs or disable the block valves. This scenario combined with a room fire (i.e Area E) did not result in additional equipment other than CH-1C being lost. This charging pump was not an essential success path identified by the fire scenario for Area E or C and was not considered to be bounding for risk assessment consideration.

Step 3: Qualitative Evaluation of Findings

Fire Barrier - Issue discussed is inadequate separation between train power and control cables, therefore full degradation is assumed.

Manual Fire Suppression - It assumed that some time during the fire the FP-1A motor driven fire pump would be lost because of the control cable. Fire Pump 1B would start initially and remains running throughout a fire. A fire hook up for a pumper truck exists by the RAW water bay which would allow for fire water in the event of a failure of the diesel driven pump.

Step 4: Assignment of Quantitative Values

Table 5.1 Quantification of Degradation Ratings (DR) of the Individual DID Elements					
Level of Degradation	3-Hr Fire Barrier	1-Hr Fire Barrier	Auto Fire Suppress Effectiveness	Manual Fire Fighting Effectiveness	
				Outside CR	Inside CR
High	0	0	0	-0.25	-0.5
Medium	-1	-0.5	-0.75	-0.5	-1
Low	-2 (door)	-1	-1.25	-1	-1.5

Step 5: Determination of Fire Ignition frequency

The ignition frequency should be 5.08E-3/yr. Log (5.08E-3) = -2.3

NRC has independently developed ignition frequencies for PWRs, and in particular for auxiliary buildings. NRC's ignition frequencies take into account welding, transient combustible, and fixed ignition source fires. What is interesting is that NRC's generic ignition frequency for the auxiliary building is very close to the generic value recommended by industry for the auxiliary building. However, industry's calculation accounts for plant specific differences which NRC's does not. With these plant specific differences, industry's calculation would end up being even more conservative than the generic value for auxiliary buildings provided by NRC.

Also NRC's determination of ignition frequency used data from a longer period of time. In fact, NRC's calculation is based on data which includes later data than industry's. And that later data in general in NRC's data base usually has lower ignition frequencies than associated with its earlier data (in particular for the auxiliary building. NRC's data shows a decrease of 2.5 in the ignition frequency as you go from the earlier data (20 years, i.e. 1965 - 1985) to the later data (10 years - i.e. 1986-1994)).

Essentially the numbers are 4.7E-3 (air compressor according to IPEEE and industry source document) and 1.88E-4 for each AFW pump. Note that I am taking the industry as competent to do the coversion from aux feed bldg to this room in aux feed bldg to calculate the frequency of AFW pumps.

So I feel industry ignition frequency is good.

Step 6: Integrated Assessment of DID Findings (Excluding SSD) and Fire Ignition Frequency

FMF = IF + FB + MS + AS + CC (when appropriate)

IF= Fire Ignition Frequency = -2.3,
FB= Fire Barrier = 0, high degradation
AS = Automatic Suppression/Detection = 1.25 The automatic start of the motor and diesel driven fire pumps was considered at the nominal failure probability. The motor driven pump was considered to provide sufficient fire water to allow for manual suppression before cable damage. Failure of the motor driven pump was backed up by the diesel driven pump which receives an independent start signal on low header pressure (pump assumed during LOOP) and would provide suppression until manual suppression occurs. The licensee identified that control circuitry for FP-1B is such that there is no

circuit failure due to a Room 19 fire that would result in the loss of the auto-start or local manual start capability for the pump. The circuits which provide the auto-start / local manual start feature are independent of Room 19 (circuits, including power supplies are located in the intake structure). The FP-1B cables routed through Room 19 are for Control Room start and auto-start following a loss of FP-1A. These cables are isolated from the FP-1B circuitry by an interposing relay located at FP-1B. A loss of the Control Room start circuitry will not impact the local auto-start / manual start circuitry for FP-1B. FP-1B will auto-start as a result of a Room 19 fire and subsequent actuation of the Room 19 suppression system.
MS = Manual Suppression/Detection = - 1.0, low degradation based on actuation of automatic suppression and minimal cable damage initially. As a side note, fire water could be provided from the screen wash pumps or the offsite fire truck.

CC = 0.5 ADJUSTMENT FOR COMMON CAUSE AS A RESULT OF ONE FIREWATER PUMP BEING AVAILABLE

To do this consider two sequences for failure of MS and AS. The first arises due to the loss of the firewater pump alone (since other pump failed due to fire). Note that my failure probabilities are consistent with the SDP. Therefore, the failure probability associated with a single firewater train (motor driven or diesel driven) is 0.01.

The other sequence is random failure of MS and AS. That is about 0.05 times 0.1 which is 0.005. This is what is currently in SDP, and excludes impact of Common cause.

Therefore the sum of the failure of both MS and AS is due to common cause with only one firewater pump, and due to random failure. (Note that some unavailability due to maintenance exists)

So failure due to the case of common cause (0.01) + failure due to random failure of MS and AS (0.005) = 0.015.

Now, how do we derive a new common cause correction for this. We do that by saying the following: Normally we have MS(-1) + AS(-1.25) + CC contribution. All this must equal approx 0.02 (since we will include some unavailability due to maintenance). The answer for the new CC is +0.5. This can be checked since -1 -1.25 + .5 = -1.75. And when we take 10 to the -1.75, that equals around 0.02. Since 0.02 is greater than 0.015 we have included a little maintenance contribution.

Recognize that by being consistent with the rest of the SDP that I have underestimated the failure probability for the diesel driven fire pump. But we do that consistently for RCIC, HPCI, and diesel driven pump trains. We recognize that we have an approximate method. (Actually this would overestimate the common cause with the motor driven pump) This is the flexibility we have in doing this analysis. I could have said let's use the Revision 3 ASP numbers. But I think that would have been inconsistent with phase 2. Now if the licensee comes with a phase 3,we may very well use the full accurate penalty for common cause from loosing the motor driven pump due to fire.

$$FMF = -2.3 + -1.25 + -1 + 0.5$$
$$= 4.05$$

Excerpt from Table 5.6 Association of FMF to Table 5.7 (SDP Table 1) Approximate Frequencies for Calculation of Delta CDF	
Fire Mitigation Frequency (FMF)	**Table 5.7 Approximate Frequencies**
-4 ≥ FMF >-5	**1 per 10-4 to 10 -5**

Table 5.7 Estimated Likelihood Rating for Initiating Event Occurrence During Degraded Period

Approx. Freq.	Example Event Type	Estimated Likelihood Rating		
>1 per 1 - 10 yr	Reactor Trip Loss of condenser	A	B	C
1 per 10 - 10^2 yr	Loss of Offsite Power Total loss of main FW Stuck open SRV (BWR) MSLB (outside cntmt) Loss of 1 SR AC bus Loss of Instr/Cntrl Air Fire causing reactor trip	B	C	D
1 per 10^2 - 10^3 yr	SGTR Stuck open PORV/SV RCP seal LOCA (PWR) MFLB MSLB inside PWR cntmt Loss of 1 SR DC bus flood causing reactor trip	C	D	E
1 per 10^3 - 10^4 yr	Small LOCA Loss of all service water	D	E	F
1 per 10^4 - 10^5 yr	Med LOCA Large LOCA (BWR)	E	F	G
1 per 10^5 - 10^6 yr	Large LOCA (PWR) ISLOCA Vessel Rupture	F	G	H
<1 per 10^6 yr		G	H	H
		> 30 days	30-3days	<3 days
		Exposure Time for Degraded Condition		

Source: SDP Table 1, NUREG/CR-5499

The Estimated Likelihood Rating is E

Step 7: Integration of Adjusted FMF with SSD

Assumptions & Analysis for performing the Risk Estimation Worksheet:

The transient, LOOP and stuck open relief worksheets were considered for each of the fire areas C, D, and E. These evaluations considered that power or control was lost to the effected safety injection pumps and that a spurious action of the PORV(s) (for Spurious actuation, two conductors from separate cables must touch. 0.1 for this probability is good for phase 2) could occur without the associated block valve being powered and capable of isolating the SLOCA. The PORVs were determined to powered by 480 volt and would close on a lose of power (probability of failure to close 0.1). In addition, the reactor coolant pumps power cables all run this area. It is possible for the some of the RCPs to remain energized for some time without seal water cooling depending on the power cables effected. The analysis demonstrated that Fire Area C, Case 1 and 2 provided the bounding risk assessment for the conditions identified. Implementation of the worksheets resulted in a finding other than GREEN. Therefore, a modified Phase 3 review was performed using the SDP worksheets but specifically considering the power supply conditions and component states.

An SDP worksheet review was performed for Area D because of Both Trains A and B being effected at the pinch point. A loss of offsite power was not assumed for a fire in this area. A fire that involved this area from Area E would not have included any additional components used to mitigate core damage.

Type of Remaining Capability	Remaining Capability Rating
Operator Action Under High Stress Definition: Operator action assumed to have about a 1E-1 probability of failing when credited as "remaining mitigation capability".	1
Recovery of Failed Train Definition: Operator action to recover failed equipment that is capable of being recovered after an initiating event occurs that requires the equipment (e.g., equipment was unavailable due to a switch misalignment). Action may take place either in the control room or outside the control room and is assumed to have about a 1E-1 probability of failing when credited as "remaining mitigation capability".	1
1 Automatic Steam-Driven (ASD) Train Definition: A collection of associated equipment that includes a single turbine-driven component to provide 100% of a specified safety function. The probability of such a train being unavailable due to failure, test, or maintenance is assumed to be about 1E-1 when credited as "remaining mitigation capability".	1
Operator Action Definition: Operator action that can occur with sufficient time to have about a 1E-2 probability of failing when credited as "remaining mitigation capability".	2
1 Train (diverse as compared to other trains) Definition: A collection of associated equipment (e.g., pumps, valves, breakers, etc.) that together can provide 100% of a specified safety function and for which the probability of being unavailable due to failure, test, or maintenance is assumed to be about 1E-2 when credited as "remaining mitigation capability". Two or more trains are diverse if they are not considered to be susceptible to common cause failure modes.	2
1 Multi-Train System Definition: A system comprised of two or more trains (as defined above) that are considered susceptible to common cause failure modes. Such a system is assumed to have about a 1E-3 probability of being unavailable, regardless of how many trains comprise the system, when credited as "remaining mitigation capability".	3
2 (diverse) Trains [adding example] (2 diverse trains are assumed to have a combined 1E-4 probability of being unavailable)	4 (= 2 + 2)
1 Train + Recovery of Failed Train [adding example] (1 train plus recovery of failed train is assumed to have a combined 1E-3 probability of being unavailable or failed)	3 (=2 + 1)

Table 3 - Remaining Capability Rating Values

FIRE AREA C Case 1 (Bounding for Area E)

Estimated Frequency (Table 1 Row) ________ Exposure time >30 days 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 / 3 Main Feedwater pumps (3 pumps) through 1/2 SG (operator action)
Secondary Heat Removal (AFW)	MDAFW (1 train) or 1 TDAFW train (1 ASD train) or 1 Diesel Driven train (1 diverse Train, requires operator action for alignment)
Feed/Bleed (FB)	1 / 2 PORVs open for Feed/Bleed (high stress operator action)
High Pressure Recirculation (HPR)	1 / 2 HPSI trains (3 pumps) taking suction from Sump (1 multi-train system)
Contmt Press/Temp Control (CNT)	1 / 2 CS Train (3 pumps) in Recirculation mode through the SDC HXs. (1 multi-train system) or 1/2 CFCU trains (1 diverse train , combination of CU and CFCU even though possible not credited)
Makeup to AFW tank (MUEFWST)[(1)]	1 / 5 Makeup trains to EFWST (condensate, demin. Water, fire water, raw water, or portable water) (Operator Action) Note: Applies only if FW-54 is not available.

Circle Affected Functions	Recovery of Failed Train	*Remaining* Mitigation Capability Rating for Each Affected Sequence	Sequence Color
1 TRANS - PCS -MUEFWST[(1)] (3)		**Not considered given availability of AFW-54**	
2 TRANS - AFW - PCS - HPR (5)		2 (operator action) + 0 +0 (HPSI C powered from 1B4A and HPSI valves powered from MCC-4A1) (operator action because of time to recirculation	2 Green/white
3 TRANS - AFW - PCS - CNT (6)		2 (operator action) + 0 +0 (containment cooling through RAW water C and D)	2 Green/white
4 TRANS - AFW - PCS - FB (7)		2 (operator action) + 0 + 0 (HPSI C powered from 1B4A and HPSI valves powered from MCC-4A1) (operator high stress action)	2 Green/white

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

Cases 1 and 2 were considered for the initiating frequency, suppression mitigation and component failures (control and power cables) as a result of fire damage. Case 1 was determined to be the most risk significant and bounded the cable failures that could occur in Case 2. A fire in the area that would result in Case1 would essentially result in a loss of the 480 volt load and motor control centers feed by the safety-related bus 1A3 (4160 volt). In addition, the LPSI A and FW-6 pumps would loose control power and would require local control to energize. The Train B components, HPSI B, RAWB, LPSI B, containment spray B nd charging B would alos loose control power and would require local control. The OPLS circuits for both Trains would be effected and may result in the need to manually close the EDGs onto the safety-related buses. The associated Train A PORV is powered from Bus 1B3C. A loss of power to this bus or the 1A3 would denergize the PORV and close the valve if open (assume some probability that the valve fails to reclose). Bus 1B4A which feeds MCC 4A1 on Train B may remain energized based on the cables that were identified as being effected. This wouls provide a block valve for the Train A PORV. The Train B PORV would retain power from MCC-4B1 but the Train A block valve may be without power. Control power for FW-10 (TDFAW) would likely be lost resulting in secondary heat removal requirements being addressed through AFW-54(Diesel driven AFW (operator action to initiate). The HPSI C pump would remain available provided Train B power to 1B4A was not effected. There are two HPSI injection valves powered by 1B4A and MCC-4C1. Lose of 1BA would result in a loss of the HPSI C pump, therefore a crosstie described the HPSI and charging system outside the fire area was not considered.

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.

The SORV worksheet was evaluated as an estimated likelihood rating of F. This was based on the spurious actuation probability of 0.1 being added to the likelihood rating E.

2.2 Phase 2 Risk Estimation Worksheet for Fort Calhoun Stuck Open PORV (SORV)

FIRE AREA C Case 1 (Bounding for Area E)

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:**
Recovery From SLOCA (BLK)	The closure of the block valve associated with the stuck open PORV (recovery action)
Early Inventory, HP Injection (EIHP)	1/3 HPSI trains (3 pumps) (1 multi-train systems)
Power Conversion System (PCS)	1/3 Feedwater trains (3 pumps) through 1/2 SG (operator action)
Secondary Heat Removal (AFW)	MDAFW (1 train) or TDAFW (1 ASD train), or Diesel Driven Pump (1 diverse-train, requires operator action for alignment)
Makeup to AFW tank (MUEFWST)	1 / 5 Makeup trains to EFWST (condensate, demin. Water, fire water, raw water, or portable water) (Operator Action) Note: applies only if FW-54 is not available.
Primary Heat Removal, Feed/Bleed (FB)	1/2 PORVs open for Feed/Bleed (high stress operator action)
High Pressure Recirculation (HPR)	1/2 HPSI trains (3 pumps) taking suction from sump (1 multi-train system)
Containment Press/Temp Control (CNT)	1/2 CS Trains (3 pumps) in Recirc. mode through SDC HXs. (1 multi-train system) or 1 / 2 CFCU trains (1 diverse train, combination of CU and CFCU even though possible - not credited)

Circle Affected Functions	**Recovery of Failed Train**	***Remaining* Mitigation Capability Rating for Each Affected Sequence**	**Sequence Color**
1 SORV - BLK - HPR (2,6,10)	1	**2(HPSI C through 1B3B and HPSI valves from MCC4A1)**	**1 Green/white**
2 SORV - BLK - EIHP (3,7)	1	2(HPSI C through 1B3B and HPSI valves from MCC4A1)	1 Green/white
3 SORV - BLK - PCS-MUEFWST (5)		Not considered because AFW-54 available	
4 SORV - BLK - PCS- AFW - CNT (9)	1	2 (operator action) + 0 + 2 (containment cooling through RAW water C and D)	3Green
5 SORV - BLK - PCS- AFW - FB (11)	1	2 (operator action) + 0 + 1 (HPSI C powered from 1B4A and HPSI valves powered from MCC-4A1) (operator high stress action)	3 Green

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:
PORV closes on power being removed from MCC-3C1 (This MCC is expected to be damaged from a fire and not recoverable) The associated block valve may retain power 1B4 and MCC4A1 to close.

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.

FIRE AREA C Case 1 (Bounding for Area E)

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:
Emergency AC Power (EAC)	1 / 2 Emergency Diesel Generators (2 EDGs = 1 multi-train system)
Battery depletes before 8 hours (BAT8)	1 / 2 Batteries (1 multi-train however with potential CCFs)
Recovery of AC Power in < 8 hrs (REC)	Recovery of off site power in less than 8 hours (recovery action) and success of 1 TDAFW train (1 ASD train), or 1Diesel driven Pump (manual alignment) and SBO procedures (operator action)
Early Inventory, HP Injection (EIHP)	1 / 2 HPSI trains (3 pumps) (1 multi-train system)
Secondary Heat Removal (AFW)	1 TDAFW train (1 diverse train), 1 MDAFW trains (1 diverse train), and 1 diesel driven train (1 train requires operator action for alignment)
Feed/Bleed (FB)	1 / 2 PORVs open for Feed/Bleed (operator action under high stress)
High Pressure Recirc (HPR)	1 / 2 HPSI trains (3 pumps) taking suction from Sump (1 multi-train system)
Containment Press / Temperature Control (CNT)	1 / 2 CS Trains (3 pumps) in Recirc. mode through the SDC HXs. (1 multi-train system) or 1 / 2 CFCU trains (1 diverse train, combination of CU and CFCU even though possible- not credited)

Circle Affected Functions	Recovery of Failed Train	*Remaining* Mitigation Capability Rating for Each Affected Sequence	Sequence Color
1 LOOP - AFW - CNT (3) (AC Restored in 8 hrs)		2 (operator action) + 0 + 2 (containment cooling through RAW	2 Green/white
2 LOOP - AFW - HPR (4) (AC restored in 8 hrs)		2 (operator action) + 0(HPSI C powered from 1B4A and HPSI valves powered from MCC-4A1) (operator action because of time to	2 Green/white
3 LOOP - AFW - FB (5) (AC restored in 8 hrs)		2 (operator action) + 0 (HPSI C powered from 1B4A and HPSI valves powered from MCC-4A1) (operator high stress action	2 Green/white
4 LOOP - EAC -HPR (7) (RCP seal LOCA with recovery of AC power)		2(EDG Train B) + 0(HPSI C through 1B3B and HPSI valves from MCC4A1)	2 Green/white
5 LOOP - EAC - EIHP (8) (RCP seal LOCA with recovery of AC power)		2(EDG Train B) + 0(HPSI C through 1B3B and HPSI valves	2 Green/white
6 LOOP - EAC - REC (9)		2(EDG Train B) + 2(recovery using AFW-54)	4 Green
7 LOOP-EAC-BAT8 (10)		2(EDG Train B) +3(Bateries Train B MCC-4A1-C02	5 Green

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

The licensee also identified that a LOSP could occur because of a fire in this area although not evident from the effected power or control cables). In this event power to the reactor coolant pumps (off Busses 1A3 and A4) would be lost and the associated power to the PORVs to open would be lost. The power cables to the two remaining reactor coolant pumps also runs in this area and power to these pumps would assume to be lost leaving no RCPs operating and mitigating a RCP seal LOCA after 30 minutes with the pumps running and no seal cooling.

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.

FIRE AREA D Case 5

Estimated Frequency (Table 1 Row) ________ Exposure time ___>30 days___ 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 / 3 Main Feedwater pumps (3 pumps) through 1/2 SG (operator action)
Secondary Heat Removal (AFW)	MDAFW (1 train) or 1 TDAFW train (1 ASD train) or 1 Diesel Driven train (1 diverse Train, requires operator action for alignment)
Feed/Bleed (FB)	1 / 2 PORVs open for Feed/Bleed (high stress operator action)
High Pressure Recirculation (HPR)	1 / 2 HPSI trains (3 pumps) taking suction from Sump (1 multi-train system)
Contmt Press/Temp Control (CNT)	1 / 2 CS Train (3 pumps) in Recirculation mode through the SDC HXs. (1 multi-train system) or 1/2 CFCU trains (1 diverse train , combination of CU and CFCU even though possible not credited)
Makeup to AFW tank (MUEFWST)(1)	1 / 5 Makeup trains to EFWST (condensate, demin. Water, fire water, raw water, or portable water) (Operator Action) Note: Applies only if FW-54 is not available.

Circle Affected Functions	Recovery of Failed Train	*Remaining* Mitigation Capability Rating for Each Affected Sequence	Sequence Color
1 TRANS - PCS -MUEFWST(1) (3)		**Not considered given availability of AFW**	
2 TRANS - AFW - PCS - HPR (5)		2* (operator action) + 0 + 2 (HPSI C powered from 1B4A and HPSI valves powered from MCC-4A1) (operator action because of time to recirculation	4
3 TRANS - AFW - PCS - CNT (6)		2* (operator action) + 0 + 2 (containment cooling through RAW water A, B, C and D)	4
4 TRANS - AFW - PCS - FB (7)		2* (operator action) + 0 + 1 (HPSI C powered from 1B3A or 1B4A and HPSI valves powered from MCC-3A1/4A1) (operator high stress action)	3

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

*Assume AFW -6/10 is lost because of fire in the room. Some availability of AFW6/10 expected.

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) If makeup to the EFWST is not successful (and it is actually required because FW-54 is unavailable), SDC will not be successful. That is why the SDC does not show in the event tree and the accident sequences for Transients.

2.2 Phase 2 Risk Estimation Worksheet for Fort Calhoun   Stuck Open PORV (SORV)

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:
Recovery From SLOCA (BLK)	The closure of the block valve associated with the stuck open PORV (recovery action)
Early Inventory, HP Injection (EIHP)	1/3 HPSI trains (3 pumps) (1 multi-train systems)
Power Conversion System (PCS)	1/3 Feedwater trains (3 pumps) through 1/2 SG (operator action)
Secondary Heat Removal (AFW)	MDAFW (1 train) or TDAFW (1 ASD train), or Diesel Driven Pump (1 diverse-train, requires operator action for alignment)
Makeup to AFW tank (MUEFWST)	1 / 5 Makeup trains to EFWST (condensate, demin. Water, fire water, raw water, or portable water) (Operator Action) Note: applies only if FW-54 is not available.
Primary Heat Removal, Feed/Bleed (FB)	1/2 PORVs open for Feed/Bleed (high stress operator action)
High Pressure Recirculation (HPR)	1/2 HPSI trains (3 pumps) taking suction from sump (1 multi-train system)
Containment Press/Temp Control (CNT)	1/2 CS Trains (3 pumps) in Recirc. mode through SDC HXs. (1 multi-train system) or 1 / 2 CFCU trains (1 diverse train, combination of CU and CFCU even though possible - not credited)

Circle Affected Functions	Recovery of Failed Train	*Remaining* Mitigation Capability Rating for Each Affected Sequence	Sequence Color
1 SORV - BLK - HPR (2,6,10)	1	**2(HPSI C through 1B3A/3B and HPSI valves from both trains)**	3
2 SORV - BLK - EIHP (3,7)	1	2(HPSI C through 1B3A/3B and HPSI valves from both trains)	3
3 SORV - BLK - PCS-MUEFWST (5)			
4 SORV - BLK - PCS- AFW - CNT (9)	1	2* (operator action) + 0 + 2 (containment cooling through RAW water A, B, C and D)	5
5 SORV - BLK - PCS- AFW - FB (11)	1	2* (operator action) + 0 + 1 (HPSI C powered from 1B4A and HPSI valves powered from both trains) (operator high stress action)	4

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:
*Assume AFW -6/10 is lost because of fire in the room. Some availability of AFW6/10 expected

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.

Initiating Event Likelihood	Remaining Mitigation Capability Rating (with Examples)						
	6	**5**	**4**	**3**	**2**	**1**	**0**
	3 diverse trains OR 2 multi-train systems OR 1 train + 1 multi-train system + recovery of failed train	1 train + 1 multi-train system OR 2 diverse trains + recovery of failed train	2 diverse trains OR 1 multi-train system + recovery of failed train	1 train + recovery of failed train OR 1 multi-train system OR Operator action + recovery of failed train	1 train OR Operator action OR Operator action under high stress + recovery of failed train	Recovery of failed train OR Operator action under high stress	none
A	Green	White	Yellow	Red	Red	Red	Red
B	Green	Green	White	Yellow	Red	Red	Red
C	Green	Green	Green	White	Yellow	Red	Red
D	Green	Green	Green	Green	White	Yellow	Red
E	Green	Green	Green	Green	Green (8)	White	Yellow
F	Green	Green	Green	Green	Green	Green (2)	White
G	Green	Green	Green	Green	Green	Green	Green
H	Green	Green	Green	Green	Green	Green	Green

Table 2 - Risk Significance Estimation Matrix (rev 6/10/99)

The SDP review using the generic initiating frequencies for Fire Area 32 resulted in six (8) and two (2) greens next to a white. This finding required that the initiating frequencies be further considered as well as mitigating capabilities to assure that a "WHITE" condition did not exist.

IV. Conclusions

This modified Phase 3 significance determination evaluation concluded that Case Studies 1-5 resulted in several "Green next to white" findings. This determination was made after detailed review of the fire initiating frequency, suppression system operation (motor and diesel-driven fire water pumps), and mitigating system capabilities for transients, LOOP and stuck open relief valve. The critical assumptions in this analysis were the low degradation of the automatic and manual suppression pool system, the power operated relief valves would re-close on a lose of 480VAC, a fire that causes of loss of the safety-related power would also cause a loss of power to the reactor coolant pumps. *This assessment was revised to reflect that all trains of control and power cables would be effected by a fire in this area and to include the fire pump common cause failure in the FMF. If one power train remained available for Cases 1-4, and then power to mitigate a stuck open PORV (fails to close) and the block valve should also be available.*

Operator actions to manually close breakers without control power (i.e. recover the partially affected train HPSI, etc.) was not specifically evaluated. .

LICENSEE PHASE 3 EVALUATION

An effort was undertaken to evaluate the configuration of Fire Area 32 using the Significance Determination Process (SDP). Appendix 4 of the Draft Inspection Manual was applied to perform the initial screening for this condition. The detailed Fire PRA related information presented herein was taken from the updated analysis for Fire Area 32 (Room 19). The application of the SDP process resulted in the performance of Phase 1, 2, and 3 analyses. The end result of these analyses is the determination that this condition should be assigned the color 'GREEN'. This conclusion is based on the Phase 1 screening, the calculated core damage frequency (CDF) contribution due to postulated fire events for the existing configuration of 2.43E-06/yr. In addition, this CDF value was found to be insensitive to the cable spacing in the range under consideration here. The CDF as also calculated with all cables having a spacing of at least 10 feet and no difference in the CDF was observed.

SDP PHASE 1 ANALYSIS

The application of the Phase 1 screening process concluded that application of the criteria for Figure 4-3 would allow this issue to be screened. This screening is based on the availability of diesel driven AFW FW-54 which is not affected by a postulated fire in Fire Area 32. However, in order to further explore this issue, the analysis proceeded to Phase 2.

SDP PHASE 2 ANALYSIS

The application of the Phase 2 SDP quickly progresses to step 4 of the Phase 2 analysis. Changes in the spacing of the cable trays could be translated into a measure of the effectiveness of the automatic fire suppression system. Therefore, a bounding value of '0' would be selected from Table 5.1. The cumulative fire ignition frequency for Fire Area 32, as obtained from the plant Fire PRA documentation is 5.68E-03/yr. which corresponds with a likelihood rating of 'C' from Table 5.7. With the likelihood rating of 'C', and input from Table 5.8, it can quickly be concluded that, in the most conservative case, the condition is not green. To better determine the risk associated with worst case, a Phase 3 assessment was performed.

SDP PHASE 3 ANALYSIS

The performance of the SDP Phase 3 analysis relies on the detailed analyses performed for the plant Fire PRA. There are two figures of merit to be addressed in this Phase 3 analysis. One is the calculated cumulative CDF contribution due to postulated fire events in this fire area given its existing configuration. The other is the change in the estimated CDF given a plant modification wherein the configuration of the fire area is changed such that all redundant circuits were separated by at least 10 feet.

Baseline CDF Assessment

The existing Fire PRA analysis for Fire Area 32 (Room 19) is based on the evaluation of 6 specific fire scenarios. These scenarios are summarized below.

Scenario 1 – AFW Pump FW-10 Large Fire with Suppression System Failure

This scenario assumes a large fire event occurs involving the oil contained in FW-10. The automatic fire suppression system that is installed in the area is assumed to fail. The key input parameters used to calculation the core damage frequency (CDF) for this scenario are as follows:

Fire Ignition Frequency	1.88E-04
Fire Severity Factor	0.18
Suppression System Failure Probability	5.0E-02
Conditional Core Damage Probability	5.83E-01
Calculated CDF Contribution	9.86E-07

Scenario 2 – AFW Pump FW-10 Large Fire with Suppression System Success and all FW-10 Small Fires

This scenario assumes a large fire event occurs involving the oil contained in FW-10. The automatic fire suppression system that is installed in the area is assumed to succeed. The resultant consequences are the same as for a postulated small FW-10 fire without credit for automatic suppression. As such, these two initiator types were combined. The key input parameters used to calculation the core damage frequency (CDF) for this scenario are as follows:

Fire Ignition Frequency	1.88E-04
Fire Severity Factor	Not considered
Suppression System Failure Probability	Not considered
Conditional Core Damage Probability	1.07E-04
Calculated CDF Contribution	2.01E-08

Scenario 3 – AFW Pump FW-6 Large Fire with Suppression System Failure

This scenario assumes a large fire event occurs involving the oil contained in FW-6. The automatic fire suppression system that is installed in the area is assumed to fail. The key input parameters used to calculation the core damage frequency (CDF) for this scenario are as follows:

Fire Ignition Frequency	1.88E-04
Fire Severity Factor	0.18
Suppression System Failure Probability	5.0E-02
Conditional Core Damage Probability	5.83E-01
Calculated CDF Contribution	9.86E-07

Scenario 4– AFW Pump FW-6 Large Fire with Suppression System Success and all FW-6 Small Fires

This scenario assumes a large fire event occurs involving the oil contained in FW-6. The automatic fire suppression system that is installed in the area is assumed to succeed. The resultant consequences are the same as for a postulated small FW-6 fire without credit for automatic suppression. As such, these two initiator types were combined. The key input parameters used to calculation the core damage frequency (CDF) for this scenario are as follows:

Fire Ignition Frequency	1.88E-04
Fire Severity Factor	Not considered
Suppression System Failure Probability	Not considered
Conditional Core Damage Probability	6.20E-06
Calculated CDF Contribution	1.17E-09

Scenario 5 – Air Compressor Large Fire with Suppression System Failure

This scenario assumes a large fire event occurs involving the oil contained in an air compressor. The automatic fire suppression system that is installed in the area is assumed to fail. The key input parameters used to calculation the core damage frequency (CDF) for this scenario are as follows:

Fire Ignition Frequency – total for 3	4.70E-03
Fire Severity Factor	0.18
Suppression System Failure Probability	5.0E-02
Conditional Core Damage Probability	9.64E-03
Calculated CDF Contribution	4.08E-07

Scenario 6 – Air Compressor Large Fire with Suppression System Success and all Small Fires

This scenario assumes a large fire event occurs involving the oil contained in an air compressor. The automatic fire suppression system that is installed in the area is assumed to succeed. The resultant consequences are the same as for a postulated small air compressor fire without credit for automatic suppression. As such, these two initiator types were combined. The key input parameters used to calculation the core damage frequency (CDF) for this scenario are as follows:

Fire Ignition Frequency – total for 3	4.70E-03
Fire Severity Factor	Not considered
Suppression System Failure Probability	Not considered
Conditional Core Damage Probability	6.26E-06
Calculated CDF Contribution	2.01E-08

Summary of results:

Scenario 1	9.86E-07
Scenario 2	2.01E-08
Scenario 3	9.86E-07
Scenario 4	1.17E-09
Scenario 5	4.08E-07
Scenario 6	2.94E-08
Total Calculated CDF Contribution	2.43E-06
Reported CDF Due to all Fires in IPEEE Submittal	2.78E-05

The cumulative CDF of 2.43E-6/yr. combined with the 5.83E-01 conditional core damage probability (CCDP) of scenarios 1 and 3 indicate that this condition is between 'GREEN' and 'WHITE'. However, it should be noted that scenarios 1 and 3 involve fires originating at equipment that is normally not operating. The fire ignition frequencies were calculated using the guidance in the EPRI FIVE Methodology which does not distinguish between operating and non-operating equipment. As such, it would be expected that a realistic fire ignition frequency for the AFW pumps which are the ignition sources for scenarios 1 and 3 would be much less than the values presented above. The application of the SDP for the baseline condition indicate that the baseline condition is between 'GREEN' and 'WHITE'. However, because of the conservatism in the fire ignition frequency, the baseline condition is considered to be 'GREEN'.

Change in CDF Assessment

The calculation of the overall CDF contribution for this fire area, as presented above, considers four elements – fire ignition frequency, fire severity factor, suppression system failure probability, and conditional core damage probability (CCDP). The issue that is being evaluated in this element of the Phase 3 assessment is the risk significance of the separation of redundant circuits in this Fire Area. The impact of this condition on the four elements of the CDF calculation is evaluated by considering a virtual plant modification wherein the fire area configuration is changed such that the cable spacing is in the range under consideration – at least 10 feet.

Analysis Element	Impacted ?	Discussion
Fire Ignition Frequency (F_i)	No	The physical spacing of circuits does not alter or otherwise affect the likelihood of a fire event.
Severity Factor (SF)	No	The physical spacing of circuits does not alter or otherwise affect the severity of the initiating fire event. The varying consequences of the fire event due to the spacing of the circuits is addressed in the resultant CCDP.
Suppression System Failure Probability (NSP)	No	The physical spacing of circuits does not alter or otherwise affect the actuation failure probability of the automatic fire suppression system.
Conditional Core Damage Probability (CCDP)	Yes	The physical spacing of the circuits could significantly alter the resultant CCDP for a given fire event. This is because the extent of damage that occurs for a postulated fire could be different. These differences could alter the set of equipment that is available for each of the fire scenarios.

Based on the information presented above, the change in the CDF for this Fire Area if the cable spacing were changed to at least 10 feet can be estimated by examining the change in the corresponding CCDP for each of the fire scenarios. This approach was taken to eliminate any potential points of contention related to the various analysis parameters. The change in CDF will therefore be reported as a ratio. This will allow the assessment to focus on only those parameters which affect the result.

Each of the fire scenarios were examined to determine the potential change in the calculated CCDP given the identified issue related to circuit separation.

Scenario 1 – AFW Pump FW-10 Large Fire with Suppression System Failure

The CCDP for this scenario is based on a postulated large fire originating at FW-10 with an assumed failure of the automatic fire suppression system. The analysis was performed using the fire modeling worksheets from the EPRI FIVE Methodology report. The analyses were performed based on a heat loss factor of 0.70. The analysis shows that targets located in the fire plume would be damaged. In addition, the outside of plume

assessment shows a critical radial damage distance of almost 5 feet. This critical radial distance, when combined with a realistic spill area resulted in the damage of redundant cable tray even if the area were modified to increase their spacing to at least 10 feet. Therefore, no change in the CCDP for this scenario occurs if the configuration of this Fire Area were assumed to be modified such that all circuits were separated by at least 10 feet.

Scenario 2 – AFW Pump FW-10 Large Fire with Suppression System Success and all FW-10 Small Fires

The CCDP for this scenario is based on a postulated small fire originating at FW-10, and a postulated large fire originating at FW-10 with an assumed success of the automatic fire suppression system. The analysis was performed using the fire modeling worksheets from the EPRI FIVE Methodology report. The analyses were performed based on a heat loss factor of 0.70. The analysis shows that for a postulated small fire, targets located in the fire plume higher than 8.3 feet would not be damaged. For a postulated large fire with successful suppression system actuation, targets located in the fire plume higher than 11.5 feet would not be damaged. Therefore, the damage potential for these fires is limited to targets located in the fire plume below the heights indicated. Therefore, no change in the CCDP for this scenario occurs if the configuration of this Fire Area were assumed to modified such that all circuits were separated by at least 10 feet.

Scenario 3 – AFW Pump FW-6 Large Fire with Suppression System Failure

The CCDP for this scenario is based on a postulated large fire originating at FW-6 with an assumed failure of the automatic fire suppression system. The analysis was performed using the fire modeling worksheets from the EPRI FIVE Methodology report. The analyses were performed based on a heat loss factor of 0.70. The analysis shows that targets located in the fire plume would be damaged. In addition, the outside of plume assessment shows a critical radial damage distance of 2.6 feet. This critical radial distance, when combined with a realistic spill area resulted in the damage of redundant cable tray even if the area were modified to increase their spacing to at least 10 feet. Therefore, no change in the CCDP for this scenario occurs if the configuration of this Fire Area were assumed to modified such that all circuits were separated by at least 10 feet.

Scenario 4– AFW Pump FW-6 Large Fire with Suppression System Success and all FW-6 Small Fires

The CCDP for this scenario is based on a postulated small fire originating at FW-6, and a postulated large fire originating at FW-6 with an assumed success of the automatic fire suppression system. The analysis was performed using the fire modeling worksheets from the EPRI FIVE Methodology report. The analyses were performed based on a heat loss factor of 0.70. The analysis shows that for a postulated small fire, targets located in the fire plume higher than 8 feet would not be damaged. For a postulated large fire with successful suppression system actuation, targets located in the fire plume higher than 12.7 feet would not be damaged. Therefore, the damage potential for these fires is limited to targets located in the fire plume below the heights indicated. Therefore, no change in the CCDP for this scenario occurs if the configuration of this Fire Area were assumed to modified such that all circuits were separated by at least 10 feet.

Scenario 5 – Air Compressor Large Fire with Suppression System Failure

The CCDP for this scenario is based on a postulated large fire originating at any of the air compressors with an assumed failure of the automatic fire suppression system. The analysis was performed using the fire modeling worksheets from the EPRI FIVE Methodology report. The analyses were performed based on a heat loss factor of 0.70. The analysis shows that targets located in the fire plume would be damaged. In addition, the outside of plume assessment shows a critical radial damage distance of 6.4 feet. This critical radial distance, when combined with a realistic spill area resulted in the damage of redundant cable tray even if the area were modified to increase their spacing to at least 10 feet. Therefore, no change in the CCDP for this scenario occurs if the configuration of this Fire Area were assumed to modified such that all circuits were separated by at least 10 feet.

Scenario 6 – Air Compressor Large Fire with Suppression System Success and all Small Fires

The CCDP for this scenario is based on a postulated small fire originating at any of the air compressors, and a postulated large fire originating at any of the air compressors with an assumed success of the automatic fire suppression system. The analysis was performed using the fire modeling worksheets from the EPRI FIVE Methodology report. The analyses were performed based on a heat loss factor of 0.70. The analysis shows that for a postulated small fire, targets located in the fire plume higher than 9 feet would not be damaged. For a postulated large fire with successful suppression system actuation, targets located in the fire plume higher than 16 feet would not be damaged. Therefore, the damage potential for these fires is limited to targets located in the fire plume below the heights indicated. Therefore, no change in the CCDP for this scenario occurs if the configuration of this Fire Area were assumed to modified such that all circuits were separated by at least 10 feet.

Based on the Phase 3 assessment presented above, there is no expected change in the calculated CDF for this fire area due to the identified separation issue. The existing calculated CDF for this fire area of 2.43E-6/yr. would remain unchanged even if a virtual plant modification were to be applied wherein all redundant circuits were separated by at least 10 feet. Since no change in the fire area CDF resulted from the identified circuit separation issue, and the baseline configuration assessment was assigned a color of 'GREEN', this condition is considered 'GREEN'.

V. Conclusions

The calculations indicate that HGL conditions will not exist in fire area 6 from a "best-estimate" perspective. This would eliminate the need for the water curtain which separates the two fire areas. However, if the required Appendix R assumptions are used, scenarios can exist whereby HGL conditions are possible.