UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
SAM NUNN ATLANTA FEDERAL CENTER
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ATLANTA, GEORGIA 30303-8931

April 5, 2002

EA-02-033

Florida Power and Light Company
ATTN: Mr. J. A. Stall, Senior Vice President
Nuclear and Chief Nuclear Officer
P. O. Box 14000
Juno Beach, FL 33408-0420

SUBJECT: ST. LUCIE NUCLEAR POWER PLANT - NRC INSPECTION REPORT 50-335/02-06; PRELIMINARY WHITE FINDING

Dear Mr. Stall:

On April 3, 2002, the NRC completed an in-office open item review for your St. Lucie facility. The attached enclosure presents the results of that review, which was discussed on April 4, 2002, with Mr. D. Jernigan, St. Lucie Plant Vice President and other members of your staff.

This review was an in-office examination of an unresolved item (URI) which was identified in NRC Inspection Report 50-335, 389/98-201 and forwarded to Florida Power and Light Company on July 9, 1998. The URI was: URI 50-335, 389/98-201-09, Fire Mitigation System Does Not Meet Plant Licensing Basis Requirements/Commitments or Minimum Industry Codes and Standards for System Design and Testing. The URI included four fire protection program issues concerning the design and testing of requirements of (1) fire protection systems, (2) water suppression systems, (3) Halon 1301 fire suppression system, and (4) standpipe and fire hose system. Issues 1 and 2 were resolved and documented in NRC Inspection Report 50-335, 389/01-03. Issue 4 was resolved and documented in NRC inspection Report 50-335, 389/98-14. Issue 3 was unresolved pending further NRC review of the adequacy of the St. Lucie Unit 1 Halon system.

Based on the results of this review, the inspector identified a finding involving failure to have an installed fixed fire suppression system in an Alternative Shutdown Area. This finding was assessed using the applicable significance determination process (SDP) and preliminarily determined to be White (i.e., an issue with low to moderate safety significance, which may require additional NRC inspections.) This issue was also determined to be an apparent violation of Section III.G.3 of 10 CFR Part 50, Appendix R requirements. The apparent violation is being considered for escalated enforcement action in accordance with the "General Statement of Policy and Procedure for NRC Enforcement Actions - May 1, 2000" (Enforcement Policy), NUREG-1600.

The NRC acknowledges that compensatory measures were implemented in response to the URI, which included stationing a fire watch in the affected area. In addition, this matter was entered into your corrective action program.

Before the NRC makes a final decision on this matter, we are providing you an opportunity to request a regulatory conference where you would be able to provide your perspectives on the significance of the finding, the bases for your position, and whether you agree with the apparent violation. If you choose to request a regulatory conference, we encourage you to submit your evaluation and any differences with the NRC's evaluation at least one week prior to the conference in an effort to make the conference more efficient and effective. If a regulatory conference is requested, it will be held in the NRC Headquarters office in Rockville, Maryland and open for public observation. The NRC will also issue a press release to announce the regulatory conference.

Please contact Mr. Randall A. Musser at (404) 562-4540 within seven days of the date of this letter to notify the NRC of your intentions. If we have not heard from you within 10 days, we will continue with our significance determination and associated enforcement processes on the finding and you will be advised by separate correspondence of the results of our deliberations on this matter.

Since the NRC has not made a final determination in this matter, no Notice of Violation is being issued for the finding at this time. In addition, please be advised that the characterization of the apparent violation described in the enclosure may change as a result of further NRC review.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter and its enclosure will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Document system (ADAMS). ADAMS is accessible from the NRC web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

If you have any questions regarding this letter, please contact me at 404-562-4500.

Sincerely,

/RA/

Victor M. McCree, Deputy Director
Division of Reactor Projects

Docket No. 50-335
License No. DPR-67

Enclosure: Inspection Report No. 50-335/02-06
w/Attachment (Phase 3 SDP Analysis)

cc w/encl: (See page 3)

cc w/encl:
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NAME	~~TRoss~~	RMusser	COgle	~~VMcCree~~	WRogers	LWert	~~SSparks~~
DATE	4/ /2002	***3/29/02***	***4/5/02***	4/ /2002	***4/5/02***	***4/5/02***	4/ /2002
E-MAIL COPY?	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO

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DATE	4/ /2002	4/ /2002	4/ /2002	4/ /2002	4/ /2002	4/ /2002	4/ /2002
E-MAIL COPY?	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO

U.S. NUCLEAR REGULATORY COMMISSION

REGION II

Docket No:	50-335
License No:	DPR-67
Report No:	50-335/02-06
Licensee:	Florida Power & Light Company (FPL)
Facility:	St. Lucie Nuclear Plant, Unit 1
Location:	6351 South Ocean Drive Jensen Beach, FL 34957
Dates:	March 14 - April 3, 2002
Inspector:	S. Ninh, Senior Project Engineer
Approved by:	Randall A. Musser, Acting Chief Reactor Projects Branch 3 Division of Reactor Projects

Enclosure

SUMMARY OF FINDINGS

IR 05000335-02-06 on 03/14-4/3/02, Florida Power & Light Company, St. Lucie Plant Unit 1. Region-based follow up review of fire protection Unresolved Item 50-335, 389/98-201-09.

This in-office review was conducted by a regional senior project engineer. The inspector identified one preliminary White finding with an apparent violation. The significance of an issue is indicated by it color (green, white, yellow, red) using IMC 0609 "Significance Determination Process" (SDP). Findings for which the SDP does not apply are indicated by "No Color" or by the severity level of the applicable violation. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described at its Reactor Oversight Process website at *http://www.nrc.gov/NRR/OVERSIGHT/index.html*.

A. Inspector Identified Findings

Cornerstone: Mitigating Systems

To Be Determined. An apparent violation of Section III.G.3 of 10 CFR 50, Appendix R was identified for failure to have an installed fixed fire suppression system in an Alternative Shutdown Area. The licensee's Cable Spreading Room (CSR) is designated as an area requiring Alternative Shutdown capability. The St Lucie Unit 1 CSR Halon 1301 fire suppression system would not be able to extinguish a deep-seated fire involving cable insulation and jacket material.

This finding appears to have a low to moderate safety significance because a completely failed Halon system would result in a change in core damage frequency (CDF) of 4.9E-6. (Section 1R05).

B. Licensee Identified Violations

None

1. REACTOR SAFETY

Cornerstone: Mitigating Systems

1R05 Fire Protection

.1 (Closed) Unresolved Item (URI) 50-335, 389/98-201-09: Fire Mitigation System Does not Meet Plant Licensing Basis Requirements/Commitments or Minimum Industry Codes and Standards for System Design and Testing.

a. Inspection Scope

The inspector reviewed the adequacy of the St. Lucie Unit 1 Cable Spreading Room (CSR) Halon 1301 fire suppression system issue associated with the above URI. The inspector also reviewed the St. Lucie Unit 1 Final Safety Analysis Report. The inspector evaluated the licensee's compliance with the requirements of 10 CFR 50.48(a)(1)(i), Criterion 3 of Appendix A to Part 50, 10 CFR 50.48(b), and Section III.G.3 of 10 CFR Part 50, Appendix R.

b. Findings

An apparent violation of Section III.G.3 of 10 CFR 50, Appendix R was identified for failure to have an installed fixed fire suppression system in an Alternative Shutdown Area (To Be Determined). The licensee's CSR is designated as an area requiring Alternative Shutdown capability. The St Lucie Unit 1 CSR Halon 1301 fire suppression system would not be able to extinguish a deep-seated fire involving cable insulation and jacket material.

The URI was identified during a Nuclear Regulatory (NRC) Fire Protection Functional Inspection at the St. Lucie Plant in March and April, 1998. The URI included four fire protection program issues concerning the design and testing of requirements of (1) fire protection systems, (2) water suppression systems, (3) Halon 1301 fire suppression system, and (4) standpipe and fire hose system. Issues 1 and 2 were resolved and documented in NRC Inspection Report 50-335, 389/01-03. Issue 4 was resolved and documented in NRC inspection Report 50-335, 389/98-14. Issue 3 was identified concerning a design deficiency of the Halon 1301 fire suppression system installed in the Unit 1 CSR. The inspector questioned the minimum required concentration and the minimum soak time requirements. The licensee could not produce design-basis tests for the concentrations and soak times of the system or demonstrate operability to the inspectors. The inspector determined this system to be limited in its ability to mitigate a fire since the system was not designed to extinguish the expected hazard (i.e., a "deep-seated" cable fire). Issue 3 was unresolved pending further NRC review of the adequacy of the St. Lucie Unit 1 Halon system.

Region II requested the Office of Nuclear Reactor Regulation (NRR) to evaluate this issue in two Task Interface Agreements (TIAs), TIA 99-001, dated January 26, 1999, and TIA 2000-04, dated May 8, 2000, to determine the design adequacy of the Halon system for the Unit 1 CSR. NRR completed its review of the TIAs and documented their conclusions by memoranda dated November 29, 1999 (TIA 99-01), August 4, 2000 (TIA 2000-04), and August 30, 2000 (TIA 2000-04). Additionally, several conference calls with the licensee, Region II and NRR staff were conducted to discuss this issue in 2000 and 2001. The licensee provided additional information related to the CSR smoke and thermal detection systems and the vendor's performance tests of the Halon system for NRC review.

Risk Assessment

This issue affected the mitigating systems cornerstone due to a design deficiency of a fire defense-in-depth element, therefore, it was assessed in accordance with the NRC Reactor Oversight Process's Significance Determination Process (SDP) as described in NRC Inspection Manual Chapter 0609, Appendix F. The Phase III risk evaluation is attached. This finding appears to have a low to moderate safety significance because a completely failed Halon system would result in a change in core damage frequency (CDF) of 4.9E-6. This finding is preliminarily characterized as a White finding in accordance with the Fire Protection SDP. The issue was entered into the licensee's corrective action program as CR 98-0131, and the licensee has implemented compensatory measures in the affected areas.

Apparent Violation

10 CFR 50.48(a)(1)(i) requires that each operating nuclear power plant have a fire protection plan that satisfies Criterion 3 of Appendix A to Part 50.

Criterion 3 of Appendix A to Part 50 states that fire detection and fighting systems of "appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on structures, systems and components important to safety".

10 CFR 50.48(b) provides that Appendix R to Part 50 establishes fire protection features required to satisfy Criterion 3.

Section III.G.3 of 10 CFR Part 50, Appendix R, requires that fire areas which require Alternative Shutdown have fire detection and a fixed fire suppression system installed in the area.

Contrary to the above, the licensee does not have an installed fixed fire suppression system in an Alternative Shutdown Area. The licensee's Cable Spreading Room (CSR) is designated as an area requiring Alternative Shutdown capability. In 1986, the licensee installed a Halon 1301 fire protection suppression system in the CSR. In order to suppress a fire for special hazards such as a Halon fire suppression system, it must be capable of extinguishing a fire. The licensee's Halon 1301 system is designed to achieve a minimum 5-7% halon concentration and minimum soak time of 10 minutes, while a minimum 10% halon concentration and minimum soak time of 10 minutes is necessary to extinguish a fire in a CSR. This failure to comply with Section III.G.3 of 10 CFR Part 50, Appendix R is identified as an apparent violation (AV) 50-335/02-06-01, Failure to Have an Installed Fixed Fire Suppression System in an Alternative Shutdown Area.

4OA6 Management Meeting

Exit Meeting Summary

Mr. R. Musser, Acting Chief, Reactor Projects Branch 3, Region II presented results to Mr. D. Jernigan, Site Vice President and other members of the licensee' staff via telephone on April 4, 2002.

KEY POINTS OF CONTACT

Licensee

D. Jernigan, Site Vice President, St. Lucie

NRC

T. Ross, Senior Resident Inspector, St. Lucie
L. Wert, Acting Chief, Fuel Facilities Branch, Region II

ITEMS OPENED AND CLOSED

Opened

50-335/02-06-01	AV	Failure to Have an Installed Fixed Fire Suppression System in an Alternative Shutdown Area.

Closed

50-335, 389/98-201-09	URI	Fire Mitigation System Does not Meet Plant Licensing Basis Requirements/Commitments or Minimum Industry Codes and Standards for System Design and Testing.

Attachment

Phase 3 SDP Analysis: St. Lucie CSR Halon System Deficiency

1. Performance Deficiency

The St. Lucie Unit 1 Cable Spreading Room (CSR) [Fire Zone 57] Halon 1301 fire suppression system did not meet regulatory or National Fire Code minimum requirements for concentration and hold time to extinguish a “deep-seated” fire involving cable insulation and jacket material. This condition has existed since 1986 and was identified as Unresolved Item (URI) 50-335, 389/98-201-09 in NRC Inspection Report 50-335, 389/98-201, dated July 9, 1998, i.e. greater than 3 years.

2. Fire Scenario

The fire loading for combustibles in the St. Lucie Unit 1 CSR is over 3 hours, with the primary combustibles being electrical cables located above numerous potential ignition sources. The potential ignition sources include the pressurizer heater transformers, power programmer cabinets, 480V load centers, DC distribution panels, and reactor trip switchgear. Other potential ignition sources, such as a power cable failure in a tray, or other electrical originated failures (in distribution panels, circuit boards, electrical wiring, internal cable fault, electrical circuit fault in switchgear cabinets, etc.) leading to ignition of the in-situ combustibles (cables), are considered in the fire scenario. Although creditable, outside ignition sources such as hot work (welding) or transient sources were not factored into this analysis due to the large number of potential in-situ ignition sources in the area.

One credible fire scenario is based on postulating that a fire develops from any one of the potential in-situ electrical ignition sources, if undetected and unsuppressed, would grow to a rate of heat release of 600 kW and ignite the cable insulation of electrical cables resulting in “deep-seated” fires. The St. Lucie Unit 1 CSR Halon system is actuated by a cross-zoned thermal detection system. The cross-zoned thermal detection system requires two independent detectors, spaced some distance apart, to reach their preset actuation temperature to initiate operation of the Halon system. After the Halon system control panel has been activated, all the “permissive” circuits must be completed to start the 30-second release delay alarm (for evacuation) followed by system discharge. The permissive circuits include electrical confirmation that 3 HVAC fans have stopped, 3 electrically-melted fusible links have operated and their associated fire dampers closed, one motor-operated damper has cycled closed, and 5 fire doors are verified closed. If any one of these permissive circuits does not confirm its operation (e.g., electrical melting of the fusible link in fire damper FPPR-25-117 fails), the Halon system will not automatically discharge its gaseous inventory.

The CSR area also has a fire detection system equipped with ionization smoke detectors that only alarms in the Main Control Room (MCR). The Halon system was designed to maintain a concentration of 5 to 7 percent for a minimum of 10 minutes for extinguishing fires. However, the NFPA Standard 12A states that "deep-seated fires usually require much higher concentrations than 10 percent and much longer soaking times than 10 minutes." Thus, a fully developed deep-seated fire in the CSR fire zone

57 would overpower the suppressive capability of the Halon fire suppression system resulting in damage to electrical cables performing safe shutdown functions and loss of plant control from the MCR. In the event of an uncontrollable fire in the cable spreading room, alternate shutdown of the plant outside the MCR would be required from the hot shutdown control panel room in the Electrical Equipment Room1B which is located adjacent to the cable spreading room.

In this fire scenario, it is assumed that a fire starts from a specific ignition source (e.g., pressurizer heater transformers, power programmer cabinets, etc.) and has sufficient flame spread (i.e., flame height and radius) to ignite a cable tray closest to the ignition source. Deep-seated fires (which are the concern of the finding related to the Halon system design concentration and soak time at St. Lucie Unit 1 CSR) can be either severe or non-severe (i.e. depending on whether fire damage is limited to the component of fire origin). Severe fires are defined as fires that have grown beyond the incipient stage and have the potential to damage structures, systems or components (SSCs) beyond the SSC in which the fire originates. However, all severe fires, as defined above, involving cables routed in cable trays are expected to result in a deep-seated fire due to the combustible characteristics of cable insulation (i.e., the fire burns internally as opposed to a surface fire). Based on the SPLB fire hazards analysis (see attachment), it is postulated that a credible fire propagation pathway exists in the power programmer cabinets, 480 V reactor auxiliary common MCC 1AB, vital AC supply panels, and DC bus 1AB-1. The failure of 480V reactor auxiliary common MCC 1AB, vital AC supply panels, and DC bus 1AB-1 would cause preheating of cables leading to cable failure, thus initiating a secondary fire in the cable trays. Three different cases of cable tray fire were postulated to bound the fire scenario: (1) a cable tray fire with mechanical ventilation on (i.e., HVAC system was not shut down during the fire), (2) a cable tray fire with exhaust fan on only (i.e., smoke purge during suppression), and (3) a cable tray fire with mechanical ventilation off. In modeling the fire growth and damage potential, Case 2 was considered to be the better representation of actual conditions in the CSR. In the event of a fire, supply fan(s) in the CSR should shut down automatically and the ventilation is limited only by the exhaust flow rate from the CSR.

The CFAST (Consolidated Model of Fire Growth and Smoke Transport) computer code was used to model the fire growth of cable tray fire that is, by definition, considered to be a deep-seated fire. The cable trays were assumed to ignite at the bottom of the lowest tray which means that the entire cable tray will burn to produce a larger peak heat release rate (HRR). For this analysis, the HRR for cable tray fires will be approximated as “slow” fire growth rate. Results from the CFAST simulation of the three ventilation conditions in the CSR show that there is sufficient oxygen available in the CSR, even without mechanical ventilation and the door closed, such that a significant fire can be sustained for some period of time. The upper gas layer temperature with mechanical ventilation on (supply and exhaust) and with exhaust fan on only, can lead to a flashover. Flashover is a phenomenon, which defines the point in a compartment fire where all combustibles in the compartment are involved and flames appear to fill the entire volume. During a fire, the exhaust fan will remove smoke from the hot gas layer and raise the elevation of the layer interface. This exhaust will allow the fire to burn at a higher intensity since more fresh air will be entrained into the fire from the lower layer. Due to high temperatures of the upper gas layer, it is possible that the exhaust fan could fail during the fire. In the case of cable tray fire with exhaust fan on only (Case 2), the CFAST results show that the time to flashover ranges from 23 minutes to 29 minutes depending on the tray surface area.

During normal operations, the doors from CSR to other areas are closed. As such, there are no large openings available (according to the licensee) to allow air into the CSR to feed the fire. This will result in the fire becoming ventilation limited such that it will burn at a lower intensity with a greater production of toxic smoke. The peak HRR is ultimately determined by the amount of fresh air available to the fire. However, the CSR is not perfectly sealed, gaps around the door and small cracks around the CSR will allow the passage of air from the outside. Flashover occurs when all of the combustible materials located in the compartment are involved and the fire is ventilation limited. Backdraft is a phenomenon that results when a relatively well-sealed compartment is ventilated near the floor level after the fire has been burning for an extended period of time (i.e., hours) and almost all of the oxygen has been consumed, the compartment accumulates a large quantity of non-combusted fuel-rich gases and the compartment temperatures have increased significantly due to a smoldering fire in a semi-quiescent state. The sudden addition of air (containing oxygen) results in the ignition of the fuel-rich gases in a detonation or deflagration (i.e., backdraft occurs). The CFAST modeling appears to indicate that flashover can occur without additional ventilation. If this is the case, a backdraft cannot occur regardless of the fire brigade actions and the likelihood that the fire would be allowed to develop for hours is small. Since there is sufficient ventilation in the compartment for flashover, the fire brigade's actions are not relevant to the issue.

The effects of CSR fire were modeled using the HRR from the PE/PVC cable jacket insulation with various cable tray exposed surface areas. Temperatures and products of combustion in the CSR could result in damage to the entire CSR and all in-situ combustibles therein. Without prompt automatic/manual fire suppression, hazardous conditions are expected to occur in a relatively short period of time, i.e., about 23 minutes, in the CSR.

Non-IEEE-383 qualified cables were installed in the St. Lucie 1 CSR during its original construction. These cables installed in the CSR cable trays were coated with *Flamastic* fire-retardant coatings in order to offset the rapid flame spread of the thermoplastic cables in the event of fire. However, Flamastic cable-coating is combustible, i.e., it does not "*fire-proof*" the cables as initially thought. Table III of the Sandia National Laboratories (SNL) report, "A Preliminary Report on Fire Protection Research Program Fire Retardant Coatings Tests," SAND 78-0518, 1978 provides the following data points:

(a) Test 13, non-IEEE-383 cable without cable coating had a burning duration of 36 minutes and an affected length of 70 inches.

(b) Test 9, IEEE-383 cable without cable coating had a burning duration of 13 minutes and an affected length of 27 inches.

(c) Test 3, Same cable as Test 9 with Flamastic coating had a burning duration of 7 minutes and an affected length of 40 inches.

The Sandia cable test program did not test non-IEEE-383 cables with Flamastic coatings (which were installed in St. Lucie 1 CSR cable trays). The cable trays in the Sandia tests were only tested in the horizontal configuration which is not the worst case configuration for cable tray fires. (Vertical cable tray configurations provide a more challenging configuration, in that heat from the burning cables in the lower trays will expose the cables above, causing the exposed cables to offgas and support more rapid combustion. St. Lucie 1 CSR has both vertical and horizontal cable tray arrays.) Based on this limited test data, it can be conjectured that the non-IEEE-383 qualified cables with Flamastic coating in the St. Lucie 1 CSR, will perform better than Test #13 (Non-IEEE 383 cables without coating) but not as well as Test#9 (IEEE-383 cables) or Test #3 (IEEE-383 cables with Flamastic coating). It is also assumed that any post-1980 modifications at St. Lucie 1 included the installation of IEEE-383 qualified cables, such that the current as-installed plant configuration has both IEEE-383 qualified and non-qualified cables with Flamastic coatings. Based on this information, even though non-IEEE-383 qualified cables had been installed in the St. Lucie 1 CSR, no penalty has been assessed in the analysis. Likewise, no credit for the Flamastic coatings was assessed in the analysis.

Based on the results of the fire modeling, SPLB fire protection staff concluded that a fire in the CSR would have a significant impact on the CSR. Depending on the ventilation condition and exposed surface areas involved, it is possible for the room to flashover and this could result in failure of the CSR structure.

3. Assumptions

(a) Fire Barrier - The licensee had replaced the Thermo-Lag 330 fire barrier wall separating the Unit 1 cable spreading room and the Electrical Equipment Room 1B, with a sheet metal and ceramic fibre barrier (See NRC Inspection Report 50-335/99-08, January 31, 2000). As a result of the modification, the barrier can be considered to be in the normal operating state. Therefore, in the event that both equipment trains in the CSR are affected by fire, the remote hot shutdown panel in Electrical Equipment Room 1B could be used to achieve safe shutdown of the plant.

(b) Fire Detection and Manual Fire Suppression - The Unit 1 CSR is equipped with a cross-zoned thermal detection system, which activates the Halon system. The cross-zoned thermal detection system has two independent detectors per ceiling bay, spaced some distance apart and preset to reach their actuation temperature to initiate the discharge of the Halon system. The CSR area is also equipped with a detection system of ionization smoke detectors that provide alarm conditions in the Main Control Room (MCR). The 1998 Fire Protection Functional Inspection (FPFI) found a number of problems with the Fire Alarm Control Panel (FACP) annunciator located in the MCR, most notably the audible levels in the MCR (Section F7.4.1 of FPFI report). The licensee had initiated a Condition Report, CR98-0453, to correct this problem. With this condition corrected, alarms from the ionization fire detection system would result in the dispatch of an operator to investigate the CSR, and plant-specific procedures (1-ONP-100.01) would be implemented to notify the fire brigade for fire-fighting response. The time taken for operator response to the fire alarm and arriving at the CSR area should be reasonably rapid since the CSR is located directly below the MCR.

Based on previous four fire drills, all (five) members of the fire brigade arrived at the CSR area in about 10 minutes after the MCR personnel sounds the alarm. The arrival time of the assembled fire brigade in 10 minutes may not include the time from fire ignition to the time that the alarm is sounded by MCR operators. This unaccounted time begins when the fire must ignite (time = 0), grow and generate products of combustion in sufficient quantity to initiate the local spot detector, the spot detector then sends an alarm to the Local Fire Alarm Control Panel (LFACP) which in turn transmits an alarm to the main FACP in the MCR. The operator must then acknowledge the alarm and determine the location of the fire. By normal procedures, a member of the operations staff would be dispatched to investigate the origin of the alarm. Upon confirmation of the fire, the operations staff will then determine if the fire brigade should be activated. In IPEEE reviews, the IPEEE Senior Review Team considered that the time from the start of the fire until fire brigade arrival was a minimum of 30 minutes across industry-wide experience. Consistent with the Reactor Oversight Process, a fire brigade rating of normal operating state is attributed to the fire brigade response capability in order to evaluate the significance of the degraded halon system.

The fire-induced core damage frequency (CDF) equation for the CSR area can be defined as follows:

$$F_{CDF} = F_i * S_f * P1 * P2 * P3$$

where F_i = Fire ignition frequency of ignition source
S_f = Severity factor for a challenging fire
P1 = Failure probability of Halon system
P2 = Failure probability of manual suppression by fire brigade
P3 = Conditional core damage probability, or failure probability of operator to operate remote hot shutdown panel in Electrical Equipment Room 1B

This fire-induced CDF equation does not account for geometry factors for a large fire to damage the critical equipment. Geometry factors are not recognized as an accepted partitioning method for fire events. The use of geometry factors was proposed in some early fire PRAs. However, this approach was rejected by NRC reviewers during the IPEEE review process. Most fires that have challenged the safe shutdown capability of a plant have not been characterized as “large” (Nureg/CR-6738), and also, the definition of “severe fires” in the EPRI Fire PRA Implementation Guide include more than large fires.

4: Fire Ignition Frequencies

The various ignition sources in the CSR area and their associated fire ignition frequency estimates, as provided on the Ignition Source Data Sheet (ISDS) for the St. Lucie Unit 1 CSR, are shown below:

Ignition Source	Fire Ignition Frequency
1. Transformers	1.09E-3
2. Electrical Cabinets	3.20E-3
3. Ventilation Systems	3.39E-4
4. Cable Runs	7.65E-4
5. Fire Protection Panels	1.75E-4

The ignition frequency estimate of 1.09E-3/yr for transformers represents the total contribution from 10 transformers in the CSR. However, only two of the 10 transformers are high voltage, dry-type transformers. The other transformers are small and low voltage transformers, and are not located near to the combustible loads. In the case of high voltage, dry-type transformers, vendor-specific information from ABB Power T& D Co., indicated that only two transformer fires involving the VPE and VPI dry-type transformers have occurred during 100,453 service years. This provides an estimate of 2.0E-5/yr for the fire ignition frequency of transformers in the CSR. This component-specific fire ignition frequency estimate, rather than the IPEEE generic estimate of 1.09E-3/yr for transformers in the CSR, was used in the risk analysis because the estimate of 2.0E-5/yr reflects realistic operational experience of the transformers.

The ignition frequency of 3.2E-3/yr for electrical cabinets represents the total contribution from all electrical cabinets including the reactor trip switchgear (240V AC, with solid bottom tray and solid cover above), 125 V DC bus, battery chargers, 480V motor control centers, and programmer cabinets. It was conservatively estimated that there are at least 80 electrical cabinets in the CSR. As identified in the CSR layout drawing, the only electrical cabinet housing medium voltage electrical equipment is the 480V Motor Control Center 1AB cabinet. The licensee's fire hazard analysis showed that MCCs have concentrated combustible loading of 830,000 BTUs. The remaining electrical cabinets located in the CSR contain low voltage electrical equipment, and each appear to have low combustible loadings (i.e., the volume fraction of cable insulation and non-metal combustibles is estimated to be 10 percent or less). Based on these considerations, the evaluation of risk impacts from electrical cabinets is divided into two scenarios, beginning with: (1) 480V MCC 1AB cabinet, and (2) remaining low voltage electrical cabinets. Therefore, the ignition frequencies for the 480V MCC 1AB cabinet and remaining low voltage electrical cabinets used in the risk analysis were estimated as follows:

(1) 480V MCC 1AB cabinet: (1/80)x (3.2E-3) = 4.0E-5 events/yr

(2) Low voltage electrical cabinets: (79/80)x(3.2E-3) = 3.16E-3 events/yr

The ignition frequency estimate of 1.75E-4/yr for the fire protection panels represents the total contribution from two supervisory electrical cabinets containing relays and annunciator lights alarming the fire zones affected by fire.

5: Conditional Core Damage Probability (CCDP)

In the various fire scenarios considered (i.e., each scenario initiated by a different ignition source), the conditional core damage probability was estimated to be 3.0E-4 (using licensee's PRA model) if there is one equipment train available to perform mitigating functions. In the event that both equipment trains in the CSR are affected by fire, the CCDP would be dominated by operator actions to achieve safe shutdown at the remote hot shutdown (HSD) panel at the Electrical Equipment Room 1B.

In the licensee's IPEEE study, the human error probability (HEP) of failing to control the plant safe shutdown at the HSD control panel was estimated to be 0.1. In the "deep seated" fire scenario, performance shaping factors (PSFs) for the HEP of operator failure to start the HVAC fan to prevent heat and smoke buildup before operating safe shutdown equipment must be considered. Using the ASP human error worksheet, the total PSF value for the nominal HEP of the action to start the HVAC fan was determined to be 300 based on the multiplication of each PSF (i.e., nominal time = 1, extreme stress

= 5, moderately complex = 2, low experience, or training = 3, available, but poor procedures = 5, nominal ergonomics = 1, nominal fitness for duty = 1, poor work processes = 2). Since the nominal HEP for a single action of starting the HVAC fan is 1E-3, the estimated HEP is 0.3 for the case of the available procedure having poor instructions for achieving proper ventilation and smoke control. In a hostile, fire-induced environment, an important PSF for consideration is the opacity effects of smoke on the operator to manipulate the HSD control panel. If the smoke effects on the operator's vision to manipulate the HSD control panel and potential ineffectiveness of the HVAC system after its restart (based on an inspection finding discussed in NRC IR 98-201) are taken into account, an additional probability value of 0.1 should be included in the overall estimation of the operator failure to achieve safe shutdown. Therefore, a reasonable value of the HEP for operator failure to manually start the HVAC and operate the HSD control panel was estimated to be 0.4 for the stated case. This probability value is more conservative than the probability of 0.1 assumed in the licensee's analysis.

6. Integrated Assessment of Fire-Induced Core Damage Frequency

The fire-induced CDF estimate for fire in the CSR with a failed Halon system is calculated as shown below:

Ignition Source	F_i	S_f	P1	P2	P3	F_{CDF}
1. Transformers	2.00E-5	1.00	1.0	0.5	4.0E-1	4.0E-6
2. 480V MCC 1AB Cabinet	4.00E-5	0.12	1.0	0.5	4.0E-1	9.6E-7
3. Low Voltage Electrical Cabinets	3.16E-3	0.12	1.0	0.5	3.0E-4	5.7E-8
4. Ventilation Systems	3.39E-4	0.08	1.0	0.5	3.0E-4	4.1E-9
5. Cable Runs	7.65E-4	0.01	1.0	0.5	4.0E-1	1.5E-6
6. Fire Protection Panels	1.75E-4	0.12	1.0	0.5	3.0E-4	3.2E-9
Total CDF						6.5E-6

(a) <u>Severity Factors, S_f</u> - A fire severity factor is a fractional value (between 0 and 1) that is used to adjust fire frequency estimates to reflect some specific mitigating pattern of behavior of the fire event. The severity factor is applied to reflect a split in challenging versus non-challenging fires. In the absence of plant-specific information, the severity factors for the electrical cabinets, ventilation systems, and fire protection panels were based on the EPRI Fire PRA Implementation Guide (FPRAIG), December 1995 (Section D.3). The FPRAIG severity factors ranged from 0.08 to 0.2, and engineering judgment was used to determine these severity factors. The question of "double counting" was raised concerning the use of severity factors and credit for manual suppression by the fire brigade in this risk analysis. The severity factors used for the fire risk analysis of the electrical cabinets, ventilation systems, and fire protection panels reflect the ratio of severe fires to the total number of fires observed in each fire source group. The severity factor approach used in the risk analysis model is to account for the probability of fire growth, and the severity factors are independent of the credit for subsequent fire-fighting efforts by the fire brigade.

The severity factor used for the pressurizer heater transformers in the risk analysis is 1.0 because it is assumed that the transformer fire would be a single-point source of flames with height of at least 5 feet, and the distances from the top of the transformers to the lowest cable trays were less than 5 feet. The use of the severity factor of 1.0 is a conservative assumption because the reported transformer fires (based on vendor historical information) were self-extinguished when the fires were not sustained after ignition.

In the case of cable runs in the CSR, it is the analyst's judgment that the severity factor used in the risk analysis is 0.01 based on the assumption that one percent of self-ignited cable tray fires may grow into a large fire if the original fire is undetected and unsuppressed. Although cable self-ignition events have occurred in the past, none of the self-ignited cable fires in the current operating U.S. plants have led to a large fire (see NUREG/CR-6738). Furthermore, some of the cable trays in the CSR are vented trays with solid covers, and the average fill of the cable trays near to the major ignition sources (i.e., pressurizer heater transformers and programmer cabinets) is, at the most, about 25 percent.

(b) <u>Halon system failure probability, P1</u> - The failure probability of the Halon system to extinguish a fully-developed fire in the CSR was assumed to be 1.0. The major in-situ fire hazard in the CSR is of electrical origin. The major in-situ fuel loading in the CSR is cable insulation and jacket (for both IEEE-383 and non-IEEE-383 qualified cables). Electrical cable fires are deep-seated fires. St. Lucie Station's NFPA Code of Record (COR) for the installation of the Halon system is NFPA 12A, "Halon 1301 Fire Extinguishing Systems," 1980 Edition. The code recommends a minimum of 10% concentration Halon 1301, held in the enclosure for a minimum of 10 minutes (Section A-2-4), or allows a different concentration and hold time that is approved by the Authority Having Jurisdiction (AHJ). The NRC, i.e., the AHJ, had sponsored testing of fire suppressant agent effectiveness, and established the minimum concentrations and hold times for fire suppressant agents used to extinguish cable fires in nuclear power plants. As documented in NUREG/CR -3656, "Evaluation of Suppression Methods for Electrical Cable Fires," October 1986, Table 8 shows that a minimum of 6% concentration of Halon 1301 should be held for 15 minutes for IEEE-383 qualified cables and 10 minutes for non-IEEE-383 qualified cables to result in no re-ignition from fully developed, five-tray cable fires. At the lowest cable tray elevation, the CSR Halon 1301 system drops below 6% concentration after 4 minutes and continues to decrease to approximately 4.5% at 15 minutes. Concentrations measured at the lowest levels of the CSR (i.e., on the floor far below the cable fire hazard) are less than the minimum 6% concentration at 15 minutes. Therefore, no credit was given to the Halon 1301 suppression system. Furthermore, research studies have shown that the ineffective Halon 1301 agent which thermally decomposes will increase the generation of toxic products of combustion (smoke). Most notably, halogen acid products, particularly hydrogen fluoride, are generated. This condition will further hamper fire brigade personnel in performing manual suppression activities, and affect operations personnel in adjacent locations performing alternate shutdown.

(c) <u>Manual Suppression by Fire Brigade, P2</u> - Historical records of fire brigade drills performed for the CSR (on 11/14/85, 9/19/97, 3/6/98, and 3/8/98) have shown that all required members of the fire brigade team arrived at the CSR in less than 10 minutes after notification. Additionally, historical records of fire brigade response to fires in the CSR due to capacitor failures in battery charger cabinets (on 12/6/83 and 11/14/85) indicated that the two fires were successfully extinguished by operators investigating the scene prior to the arrival of the full fire brigade in 6 minutes after notification from the Control Room.

Based on the above considerations, together with the discussion in Section 3b, entitled: "Fire Detection and Manual Fire Suppression," and since the fire brigade response capability was considered to be in the normal operating state (due to the Reactor Oversight Process guidance to consider findings separately in significance evaluations unless a common root cause exists), the failure probability of manual suppression by the fire brigade associated with severe fires was estimated to be 0.5 in this risk analysis.

(d) <u>Conditional Core Damage Probability, P3</u> - In the fire scenarios involving ignition of the electrical cabinets, ventilation systems, and fire protection panels, an analysis was performed to determine whether a redundant cable train would be affected by fire damage from the specified ignition source. In this analysis, the critical radiant flux distances were estimated for various peak fire intensities (e.g., 65 BTU/sec to 500 BTU/sec) using the single-point source equation on page 10.4-23 of the Fire-Induced Vulnerability Evaluation (FIVE) Report. The critical radiant flux distance varies from 2.0 ft. for 65 BTU/sec to 5.6 ft. for 500 BTU/sec heat release rate and 0.5 BTU/s/ft^2 for unqualified cables. These critical heat flux distances were then compared to the horizontal distances between the redundant trains of cable trays with the specific ignition source directly below its nearest cable tray. Based on review of layout drawings of the cable tray configurations and ignition source locations, and information on measured distances provided by the licensee, the minimum horizontal distance between redundant cable trains was estimated to be 6 ft (for the low voltage electrical cabinets such as 125 VDC Bus 1AB-1, 1AB Battery Charger, 1AB DC Switchgear, and Vital AC Supply cabinets), while the maximum distance between A and B trains is about 19 ft (for the pressurizer heater transformers). Based on observations of low combustible loadings of the low voltage electrical cabinets (i.e., the volume fraction of cable insulation and non-metal combustibles is estimated to be 10 percent or less) and the minimum distance separation of redundant cable trains being greater than the critical radiant heat flux distances with conservative heat release rates, it is reasonable to assume that one equipment train would be available to perform mitigating functions if any of the low voltage electrical cabinets were to ignite. Therefore, the CCDP estimate of 3.0E-4 was used in the risk analysis of the fire scenarios involving the low voltage electrical cabinets. Similar arguments can be made to use the CCDP estimate of 3.0E-4 for analyzing the fire scenarios involving the ventilation systems and fire protection panels. The air handling units, HVA-4 and HVA-5, located in the CSR contained less than 4 lb. of plastic filter material and wiring insulation and a few ounces of grease associated with the fan and motor. The air handling units are about 3 ft. below the nearest cable trays, and the distance between redundant cable trains appear to be greater than 6 ft. The two fire protection panels are small enclosed metal boxes with small indicator lights that show the location of specific detectors in the alarm mode. Each fire protection panel contains about 10 lb of plastic/insulation, and are located about 3 ft horizontally and 4 ft vertically from the nearest cable tray.

In the case of the transformers and cable runs, it is assumed that a fire from these sources would result in a deep-seated fire and the operators would have to gain access to the remote HSD panel to achieve safe shutdown of the plant. Based on the ASP Human Reliability Analysis method, the operator failure to operate the HSD control panel was estimated to be at least 0.4, and this probability was used in the risk analysis as the CCDP estimate. The risk impact of spurious actuations from hot shorts is subsumed in this CCDP estimate of 0.4.

In the case of 480V Motor Control Center 1AB cabinet, the licensee's fire hazard analysis showed that MCCs have concentrated combustible loading of 830,000 BTUs. This 830,000 BTU combustible loading can result in a fire of peak fire intensity of 332 BTU/sec (using the equation on page E-8, Fire PRA Implementation Guide). The critical radiant flux distance for this fire peak intensity was estimated to be 4.7 ft. Although the minimum separation distance between redundant cable trays for the nearest cable tray above the 480V MCC 1AB cabinet is about 6 ft., it is assumed that a fire from the 480V MCC 1AB could damage both redundant cable trains as a bounding analysis. Therefore, the CCDP estimate of 0.4 was used in the risk analysis of a fire from the 480V MCC 1AB.

7: Incremental Fire-Induced CDF

The baseline CDF (conforming case) for the cable spreading room without a degraded Halon system is calculated by assuming the Halon system failure probability of 0.05, and the manual suppression failure probability of 0.1. These values were used for the non-degraded Halon system and manual suppression capability because the values were considered to be appropriate for the entire population of fires (including deep-seated fires) arising from an ignition source. It is expected that failure probabilities for these fire protection systems and features would be much higher if a severity factor was used since the severity factor represents the case where only severe fires are considered. Severe fires are defined as fires that have grown beyond the incipient stage and would have the potential to damage structures, systems or components (SSCs) beyond the SSC in which the fire originates. Severe fire events are a subset of the entire population of fires.

Deep-seated fires (which are the concern of the finding related to the Halon system design concentration and soak time at St. Lucie Unit 1 CSR) can be either severe or non-severe (i.e. depending on whether fire damage is limited to the component of fire origin). Based on data from currently available databases of fire events, it is presently not feasible to partition the deep-seated fire events from the non-deep-seated fire events to develop a "deep-seated fire factor" to adjust the fire ignition frequency similar to that done for severe fires. However, all severe fires, as defined above, involving cables routed in cable trays are expected to result in a deep-seated fire due to the combustible characteristics of cable insulation (i.e., the fire burns internally as opposed to a surface fire). Additionally, an accurate determination of the effectiveness of a code compliant Halon system on a severe fire is beyond the current state-of-the-art methods.

The basis for using the failure probability value of 0.05 for the non-degraded Halon system in the conforming case of this analysis is found in EPRI's Fire-Induced Vulnerability Evaluation (FIVE) guidance (page 10.3-7). This probability value is the accepted value used by the community of fire risk analysis practitioners for a non-degraded Halon system. The basis for using the probability of 0.1 for failure of manual suppression in this conforming-case analysis is, as discussed above, that the value of 0.1 is appropriate for the entire population of fires. The fire protection SDP methodology, which uses the entire population of fires as the basis to derive an ignition frequency, also uses the probability value of 0.1, in general, for the failure probability of nondegraded manual suppression capability.

Based on the preceding discussions, the baseline CDF for the St. Lucie Unit 1CSR without a degraded Halon system is calculated as shown below:

Ignition Source	F_i	P1	P2	P3	F_{CDF}
1. Transformers	2.00E-5	0.05	0.1	4.0E-1	4.0E-8
2. 480V MCC 1AB Cabinet	4.00E-5	0.05	0.1	4.0E-1	8.0E-8
3. Low Voltage Electrical Cabinets	3.16E-3	0.05	0.1	3.0E-4	4.7E-9
4. Ventilation Systems	3.39E-4	0.05	0.1	3.0E-4	5.1E-10
5. Cable Runs	7.65E-4	0.05	0.1	4.0E-1	1.5E-6
6. Fire Protection Panels	1.75E-4	0.05	0.1	3.0E-4	2.6E-10
Baseline CDF					1.6E-6

The incremental CDF change due to a failed Halon system in the CSR would be:

6.5E-6 - 1.6E-6 = 4.9E-6

CONCLUSION: The change in CDF due to a completely failed Halon system is 4.9E-6. Therefore, the significance characterization of this issue is WHITE.