August 4, 2000

MEMORANDUM TO: Loren R. Plisco, Director
Division of Reactor Projects
Region II

FROM: Suzanne C. Black, Deputy Director ***RA by John A. Zwolinski for/***
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

SUBJECT: TASK INTERFACE AGREEMENT 2000-04, "EVALUATION OF ST. LUCIE REPLY TO TIA 99-01 RELATED TO THE DESIGN ADEQUACY OF THE HALON SYSTEM FOR THE UNIT 1 CABLE SPREADING ROOM" (TAC NOS. MA8564 AND MA8565)

SUMMARY

On May 8, 2000, you forwarded Task Interface Agreement (TIA) 2000-04 to NRR. You requested that NRR review the March 7, 2000, licensee's reply to NRR response dated November 29, 1999, to TIA 99-01 dated January 26, 1999. The request was for NRR to determine if the Halon 1301 fire suppression system design for the Unit 1 cable spreading room (CSR) is adequate and consistent with the licensing basis for Florida Power & Light (FP&L) Company's St. Lucie Nuclear Plant.

This memorandum provides the NRR, Plant Systems Branch, review of TIA 2000-04 and the March 7, 2000, FP&L submittal. This issue was identified as unresolved item URI 50-335, 389/98-201-09. The March 7, 2000, FP&L response is documented in Fire Protection Evaluation Record PSL-FPER-00-007.

On the basis of the review of PSL-FPER-00-007, the staff concludes that the Halon 1301 system in the St. Lucie Unit 1 CSR does not meet the requirements of 10 CFR 50, Appendix R, Section G.III.3, which requires that a fire suppression system be installed in a fire area requiring alternative shutdown.

INTRODUCTION

During a pilot fire protection functional inspection (FPFI) at St. Lucie during March 9-13, 1998, and March 30-April 3, 1998, the U.S. Nuclear Regulatory Commission (NRC) inspection team identified a technical issue concerning the Halon 1301 fire suppression system installed in the Unit 1 CSR. Based on the inspection results, the inspection team found that neither the CSR Halon 1301 fire suppression system design, nor acceptance tests of the system performed by the licensee, demonstrated that the system would be adequate to suppress a deep-seated cable fire; therefore the system would be unable to perform as required by 10 CFR Part 50, Appendix R. This was identified as URI 50-335, 389/98-201-09 in Inspection Report Nos. 50-335/98-201 and 50-389/98-201.

By memorandum dated January 26, 1999, RII transmitted TIA 99-01, concerning URI 50-335, 389/99-201-09 regarding the design of fire suppression system. NRR responded to the TIA in a

memorandum dated October 1, 1999. The TIA 99-01 response was also sent to the licensee. Subsequent to the TIA 99-01 response, the licensee transmitted PSL-FPER-00-007, dated March 7, 2000. By the memorandum dated May 8, 2000, RII requested that NRR review the licensee's reply to TIA 99-01, and determine if the Halon 1301 system design for the Unit 1 CSR is adequate and consistent with the licensing basis. This TIA response focuses on the FP&L evaluation of the Halon system.

LICENSING BASIS

St. Lucie Unit 1 was granted an operating licensee by the NRC on March 03, 1976. Later, certain provisions of 10 CFR 50.48(a) and (b) required that plants licensed to operate prior to January 1, 1979, implement Appendix R to 10 CFR Part 50. This rule specifies that plants that had received NRC acceptance of fire protection features satisfying the provisions of Appendix A to Branch Technical Position (BTP) APCSB 9.5-1 were required to only implement the additional requirements of Appendix R, Sections III.G, III.J, and III.O. St. Lucie Unit 1 did not receive an acceptance of the Halon 1301 system using the BTP APCSB 9.5-1 guidelines.

Section III.G.1 of Appendix R requires that one train of systems needed to achieve and maintain hot shutdown conditions will remain free of fire damage. Section III.G.2 specifies fire protection methods to demonstrate that one train will remain free of fire damage.
Section III.G.3 requires that, in areas where it is not possible to meet one of the III.G.2 methods of ensuring that one train of equipment will remain free of fire damage, alternative or dedicated shutdown capability must be provided. Section III.G.3 of Appendix R also requires that a fire suppression system be provided for the area. Implicit in this requirement is the understanding that the system will be adequate to perform fire suppression activities for the fire hazards in the area.

St. Lucie Unit 1 operating license condition C.3 requires that the licensee implement and maintain in effect all provisions of the approved fire protection program, as described in the Updated Final Safety Analysis Report (UFSAR). The license condition also lists the licensee submittals provided as a part of the approved program. Licensee letter L-83-514, dated October 7, 1983, is listed as part of the approved program. In this letter the licensee stated that the separation requirements defined in Appendix R, Section III.G.2, could not be provided for essential components and circuits in the CSR and that alternative shutdown is provided. On February 4, 1980, the Plant Systems Branch of NRR issued a review of fire protection open items at St. Lucie Unit 1 and concluded that a Halon 1301 or a carbon dioxide gaseous system was needed at St. Lucie for the CSR. During this review, the staff noted that a fixed fire suppression is required in this area to satisfy the requirements of Appendix R, Section III.G.3.

In Section 9.5 of the UFSAR, which provides a comparison of plant conformance to Appendix A to BTP 9.5-1 Guidelines, Paragraph E.4, the licensee states that "The Halon 1301 automatic fire suppression system in the cable spreading room is installed utilizing the guidelines of NFPA 12A."

Summary of the Fire Protection Evaluation Record (FPER) PSL-FPER-00-007, Rev 0 - Evaluation of Unit 1 Cable Spreading Room Halon 1301 Design for Conformance with 10 CFR Part 50, Appendix R, Section III.G.3

In general, the licensee's reply (PSL-FPER-00-007) disagrees with NRR's conclusion that the Halon fire suppression system installed in the CSR is inadequate to extinguish a deep-seated

fire. The licensee considers that the Halon 1301 system installed in the CSR is not required to extinguish a deep-seated electrical cable fire because the quantity of combustibles and the ignition sources present in the CSR do not represent probable fires of magnitude or duration that would result in a deep-seated fire. The licensee claims that they only considered surface related cable fire hazard in the Unit 1 CSR during design/installation of the Halon system. The installed Halon 1301 system is only adequate to suppress flaming surface fires with an agent concentration of 5% for a 10-minute-soak time.

The staff's review of the licensee's reply (PSL-FPER-00-007) with respect to the installed Halon 1301 fire suppression system indicates that the licensee did not demonstrate that the total flooding Halon 1301 system, as designed for the Unit 1 CSR, could meet the requirements to extinguish a potential deep-seated cable fire. A deep-seated fire is defined by the NFPA as a fire involving Class A solid materials that would not be extinguished with a 5 percent concentration of Halon with 10 minutes of application. The system is designed (per the licensee) to suppress a surface or flaming fire in the CSR. This report discussed NRC-sponsored tests results (NUREG/CR-3656) to justify that the installed system complies with the NFPA standard 12A and field testing. Additional review of the fire detection system used to actuate the Halon 1301 fire suppression system indicates that cross-zoned thermal detectors are used to actuate Halon 1301 system.

DISCUSSION

This section presents the staff's evaluation in response to licensee report PSL-FPER-00-007, Rev. 0.

(1) The licensee states that "fire tests demonstrate that the combustible materials present in the CSR exhibit fire characteristics representative of surface fires, not the deep-seated fire, therefore there is no technical basis for a Halon fire suppression systems design that is required to extinguish a deep-seated cable fire in Unit 1 CSR."

Evaluation

The licensee did not address the NFPA 12A, 1980 edition (the Code of Record (COR) for the St. Lucie installation) criteria discussed in Sections 1-5.4, 2-2.1.4, 2-4.3. A-2-2 and A-2-4 regarding the minimum concentrations and soak times necessary for extinguishment of deep-seated electrical cable fires. Further, Section A-2-1 specifically recommends that appropriate testing be performed to properly address the hazard.

The fire loading in the CSR consists of large amounts of electrical cables. Regardless of the ignition sources present, cable insulation will develop deep-seated fires when externally ignited and allowed to burn, or the fire may originate as deep-seated if conductors inside the cable overheat (Grant, 1995). Initially, the cables installed in the CSR will undergo flaming (surface) combustion. Over time, they may develop a char layer and may become deep-seated. Pyrolysis of cable insulation can result from smoldering combustion. Smoldering combustion involves surface oxidation of a char layer which provides sufficient heat necessary to cause further thermal degradation of the neighboring layer of combustible materials. Successful propagation requires that volatiles be progressively driven out ahead of the zone of active combustion to expose fresh char, which then begins to burn.

For combustible solids fires, the possibility and consequences of developing a deep-seated fire must be considered in designing suppression systems. The fire hazard in the CSR is potentially a deep-seated cable fire. The licensee has not acknowledged the concept of deep-seated fires which may develop in the CSR and failed to provide an equivalent level of fire protection to that required by section III.G.3 of Appendix R to 10 CFR Part 50 and the St. Lucie fire protection program.

(2) The licensee states that design of Halon suppression supported by the NFPA and field testing indicates that the St. Lucie Unit 1 CSR Halon suppression system was designed to deliver a minimum Halon concentration of 5% for 10 minutes for flaming fires.

Evaluation

The licensee's description of the Halon system states that the design concentration of the system is 5 percent for 10 minutes, which is valid for surface or flaming fires involving Class A or Class B fires. However, Class C fires also have the potential to develop deep-seated fires in addition to flaming combustion. Note that cable insulation and jacket materials (typical Class A combustibles) are classified as Class C fires due to the energy source and additional hazard presented by the live electrical conductors. For the deep-seated fires, much higher concentrations are required to achieve complete extinguishment. NFPA standard 12A "Halon 1301 Fire Extinguishing Systems," 1980 edition (the COR for the St. Lucie installation), Section A-2-4, states that the deep-seated fires usually require much higher concentrations than 10 percent and much longer soaking times than 10 minutes. According to the NFPA Handbook, 18th edition, flaming fires (surface fires) can be extinguished with low, 4 to 6 percent, concentrations of Halon, but for a deep-seated fire higher agent concentrations, 18 to 30 percent, are required for effective and complete extinguishment.

In 1986, the NRC commissioned Sandia National Laboratories (SNL) to research the question of effectiveness of fire suppressants on electrical cable fires. The results were published in NUREG/CR-3656, *"Evaluation of Suppression Methods for Electrical Cable Fires*." SNL documented the results of its evaluation of the extinguishment capabilities of Halon 1301 on cable fires. On the basis of its full-scale fire experiments, SNL concluded that a Halon concentration of 6 percent with a soak time of 10 minutes for unqualified cables or 15 minutes for IEEE-383 qualified cables is adequate to suppress fully-developed cable tray fires. SNL defined full-developed fires as "fires that involved four of five cable trays. This represented a fire that had been burning for some time. Four burning cable trays represent a significant fuel load."

The licensee did not appear to consider the effect of a deep-seated fire in the design of the Halon 1301 system for the CSR. Further, the licensee failed to modify the agent concentrations for the installed Halon system as described in NFPA 12A, 1980 edition (the licensee COR for Halon 1301 system). The licensee provided no qualification tests of the Halon 1301 system to demonstrate that the required concentrations are maintained for the entire soak time.

(3) The licensee states that the thermal detection system provides reasonable assurance that the application of the Halon 1301 agent would occur before any major fire damage occurred. This is based on a CSR automatic Halon 1301 system equipped with cross-zoned thermal and ionization detectors.

Evaluation

The licensee has provided thermal detectors to actuate the Halon system in the CSR with a fixed temperature of 200 °F. To optimize the speed of the fire detection system that actuates the Halon 1301 fire suppression system, the detector must be sensitive enough to the products of combustion (heat, smoke, etc.) to rapidly respond to the fire during its incipient stage. Smoke detectors may have been a better design choice for early detection of fire signature. Photoelectric (preferred) or ionization smoke detectors are typically used to actuate a Halon system since they have different response characteristics (photoelectric detectors respond more to larger particles as produced in smoldering or deep-seated fires, while ionization detectors can provide very fast response to flaming fires), whereas thermal detectors react much slower to fire conditions. Therefore, use of photoelectric or ionization detectors in the CSR would result in early detection of the fire and thus quicker actuation. The use of thermal detectors could result in excessive delay in agent discharge which would allow time for the fire to grow and become deep-seated. There are strong recommendations in NFPA 12A for the use of automatic actuation of the Halon 1301 system coupled with sensitive detectors. The primary reason behind these recommendations is to limit the size and severity of fire as well as to prevent a surface fire from becoming deep-seated. This point is a secondary concern since the installed Halon 1301 system is not adequate to meet the guidelines of NFPA12A for a deep-seated fire as required by the operating license.

(4) The licensee states that “CSR fire suppression system concentration and hold times were designed to suppress the fire hazards associated with the CSR by industry fire test reports and NFPA guidelines. Therefore, the design of the St. Lucie Unit 1 CSR suppression system did not require extinguishment of deep-seated fires.”

Evaluation

Flammable solids may be classified as those that have the ability to develop deep-seated fires and those that do not have the ability to develop into deep-seated fires. Electrical cables (Class C fires) are classified as a material which will develop into a deep-seated fire (in accordance with NFPA 10, electrical cables are classified as Class C fires when energized, otherwise cables are Class A fires). Class A combustible solids that develop deep-seated fires do so after exposure to flaming combustion for a certain length of time which varies with the material. Additionally, some materials may begin as deep-seated through internal heating such as spontaneous ignition or overheating of a conductor inside a cable. Materials that do not become deep-seated undergo surface combustion only and may be treated much the same as those in a flammable liquid fire.

For deep-seated fires involving cables subject to smoldering combustion, the required extinguishment concentration is 18 to 30 percent, as recommended in the NFPA handbook. Note this concentration is more conservative than that recommended by SNL. This concentration must be maintained for a sufficient period of time to allow the smoldering to be extinguished and the cable to cool to a point at which reignition will not occur. Reignition of the fire is a potential concern if the effective concentrations are not maintained. Therefore, the required concentration to extinguish the fire must be determined in the initial system design, including allowance for leakage from the space. When a system cannot achieve and maintain the concentration, continuous addition of Halon 1301 must be provided at a rate which will compensate for leakage out of the enclosure during soaking time. It is important to remember

that in most cases, the halogenated agent extinguishing systems have only a single chance to extinguish an unwanted fire.

CONCLUSIONS

The results of the licensee's report (PSL–FPER-00-007) indicate:

1. The licensee did not demonstrate that the installed Halon system was designed to extinguish a deep-seated cable fire. The discussion on the Halon 1301 system evaluation in the licensee's response focused only on surface or flaming fire hazard in the CSR. The assessments reported in PSL-FPER-00-007 did not provide any justifications based on the fire dynamics principles that smoldering combustion is not a hazard associated with cables, and how to prevent a cable fire from becoming deep-seated. There is no reasonable assurance that the Halon 1301 fire suppression system installed in its current configuration in the Unit 1 CSR will extinguish a potential deep-seated fire involving the cable insulation and jackets. Therefore, the installed system does not provide adequate level of fire safety as required by Section III.G.3 of Appendix R to 10 CFR Part 50, and 10 CFR Part 50, Appendix A, GDC 3. Consequently, the staff concludes that the URI 50-335, 389/99-201-09 is still an unresolved item.

2. Detection devices in the CSR are fixed temperature heat detectors (200 °F) and ionization smoke detectors. Fixed temperature rated thermal detectors are not typically considered as being the type of detection device to be installed when protecting cable fire hazards with a Halon 1301 system. This type of hazard is typically protected with early warning ionization or photoelectric smoke detection. The use of thermal detection will result in a delay in the actuation of the Halon system which increases the likelihood for the development of a deep-seated fire. The use of a cross-zoned thermal detection system which activates the Halon 1301 system is further restricted in that the system is also interconnected with the fire door and HVAC damper interlocks. This could further delay the discharge of Halon 1301. The slow response time of the installed Halon 1301 fire suppression system would allow time for the fire to continue to grow and become further deep-seated, potentially challenging the installed fire barriers.

3. Based on the high combustible loading (greater than 3 hours) and the potential for a deep-seated fire in the CSR, the Halon 1301 system is considered to be important to safety, since the combustible loading can challenge the fire barriers which provide separation between the main control room and the remote shutdown panel. If the Halon 1301 fire suppression system fails to completely extinguish a deep-seated fire in its first attempt, a severe fire can develop. Under the conditions of a severe fire in the CSR, smoke may spread into the main control room and the area adjacent to the CSR where the remote shutdown panel is located. This is considered to be an unacceptable increase in risk due to fire since a single CSR fire can potentially damage both the main control room and remote shutdown panels.

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