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SOUTH CAROLINA ELECTRIC & GAS COMPANY
VIRGIL C. SUMMER NUCLEAR STATION (VCSNS) UNIT 1
LICENSE AMENDMENT REQUEST – LAR-16-01490
NFPA 805 PROGRAM REVISIONS
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

By letter dated August 29, 2018 (Agencywide Document Access and Management System (ADAMS) Package Accession No. ML18242A658), South Carolina Electric and Gas (SCE&G), submitted a license amendment request (LAR) for the Virgil C. Summer Nuclear Station, Unit 1 (VCSNS), to make changes to its approved Fire Protection Program (FPP) under 10 CFR 50.48(c). By email dated March 13, 2019 (ML19072A144), the Nuclear Regulatory Commission (NRC) staff provided a request for additional information (RAI).

The VCSNS responses to PRA RAI 01 and PRA RAI 02 are provided in the attachment to this letter. PRA RAI 03 was revised by email dated April 4, 2019 (ML19095A653) and will be addressed in a forthcoming submittal.

Should you have any questions, please call Mr. Michael Moore at (803) 345-4752.

I declare under penalty of perjury that the foregoing is true and correct.

4/29/19
Executed on

George A. Lippard
Site Vice President
V.C. Summer Nuclear Station

Commitments contained in this letter: None

Attachment: VCSNS Response to NRC Request for Additional Information

cc: G. J. Lindamood – Santee Cooper
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RTS (CR-16-01490)
File (813.20)
PRSF – VCS

Email: NSRC – (Secretary, Reg. & Oversight Committee)

Concurrences
See Correspondence Routing and Approval CHOP Sheet

Verification of Accuracy
Technical Verification Team

Action Plan
CR-16-01490 tracking review of LAR and Responses to RAIs

Changes to the UFSAR, USAR, QA Topical Report, ISFSI FSAR, DSAR or PSDAR:
None

ATTACHMENT

LAR-16-01490 – NFPA 805 Program Revisions
Response to Request for Additional Information

Virgil C. Summer Nuclear Station – Unit 1
South Carolina Electric and Gas

LICENSE AMENDMENT REQUEST LAR-16-01490
NFPA 805 PROGRAM REVISIONS
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

VIRGIL C. SUMMER NUCLEAR STATION UNIT 1

NRC Comment:

By letter dated August 29, 2018 (Agencywide Document Access and Management System (ADAMS) Package Accession No. ML18242A657), South Carolina Electric and Gas (SCE&G), submitted a license amendment request (LAR) for the Virgil C. Summer Nuclear Station, Unit 1 (VCSNS), to make changes to its approved fire protection program (FPP) under 10 CFR 50.48(c). In its LAR, the licensee proposed to make several changes to its FPP including changes to plant modifications, use of performance-based alternatives to the requirements of NFPA 805, Chapter 3, and several clarifications and editorial corrections. Based on the information provided by the licensee, the NRC staff requests that the licensee provide the information below.

Probabilistic Risk Assessment (PRA), Request for Additional Information (RAI) 01

In Enclosure 1, Attachment 1, to the licensee's letter dated August 29, 2018, the licensee stated that refinements were made in the main control room abandonment (MCR) model, to make the model symptom-based. The LAR is not clear on whether these refinements go beyond those described in the NFPA 805 LAR (ADAMS Package Accession No. ML113320227). Describe the refinements to the MCR abandonment model and identify the human reliability analysis (HRA) approach used to modify the model, and discuss whether it was used previously to support the NFPA 805 LAR or in another plant LAR and subsequent amendment. In addition, provide clarification regarding whether this refinement to the PRA model is consistent with plant procedures for MCR abandonment.

SCE&G Response:

Refinements to the MCR Abandonment Model

The fire probabilistic risk assessment (FPRA) that supports the 2014 VCSNS NFPA 805 SE dated February 11, 2015 (ML14287A289) and the FPRA that supports the 2018 Supplemental License Amendment Request model the plant response given fire scenarios leading to MCR abandonment due to (a) loss of the ability of operators to control the plant from the MCR or (b) loss of MCR habitability. The discussion below describes the 2018 FPRA MCR abandonment model refinements as compared to the 2014 FPRA.

Loss of Control from the MCR

The 2014 FPRA modeled control room abandonment based on entry conditions of the procedure in effect at the time. The entry conditions for AOP-900.02, Control Room Evacuation Due to Fire, were as follows:

> Spurious equipment operation is observed AND the fire is of such a nature that there is concern about maintaining the ability to safely control the Plant.

Subsequent to the 2014 FPRA model, discussions were held with VCSNS Operations and Training Departments, as well as PRA staff, to clarify the circumstances under which the MCR should be abandoned. This was motivated by the additional guidance in NUREG-1921 Supplement 1 to specify abandonment criteria, as clearly as possible to facilitate the decision to abandon. Procedure changes were made in conjunction with corresponding FPRA model changes.

To refine the MCR abandonment modeling, new logic has been introduced into the FPRA at the top of the CDF and LERF fault trees. The abandonment criteria for loss of control correspond to the entry conditions for the current VCSNS procedure AOP-900.02, Control Room Evacuation Due to Fire, which is entered for fires in the alternate shutdown (ASD) areas if:

> Emergency Feedwater is required AND cannot be established OR maintained from the Main Control Room.

The refined PRA logic at the top of the CDF and LERF fault trees addresses the following point of guidance in NUREG-1921 Supplement 1, EPRI/NRC-RES Fire Human Reliability Analysis Guidelines: Qualitative Analysis for Main Control Room Abandonment Scenarios:

> The plant conditions that would constitute a LOC [loss of control] or LOH [loss of habitability] for the specific plant are defined based on HRA operator interviews and procedure review. Appropriate logic is then included in the model to capture when those conditions occur.

Additional refinements were introduced into the MCR abandonment logic to improve consistency with guidance in NUREG-1921 Supplement 1 regarding proper treatment of equipment required for remote shutdown, to improve internal consistency of the model, or to remove logic that was not required.

- Logic was introduced into the MCR abandonment model to preclude successful shutdown from the Control Room Evacuation Panel (CREP) given:
  - The following accident sequences: consequential small LOCA, medium LOCA, secondary side break, or interfacing systems LOCA.
  - Failure of the turbine driven EFW pump to start and run or unavailability of the EFW pump due to test and maintenance.
  - Failure of RCP seal injection AND consequential catastrophic RCP seal failure (the logic previously did not require consequential catastrophic RCP seal failure).

- The CREP failure logic was examined and logic that was not required was removed.
- The MCR abandonment logic that distinguishes MCR abandonment under station blackout (SBO) conditions from MCR abandonment under non-SBO conditions was revised to more reliably distinguish the two cases.
- The separate redundant basic event for failure to abandon the control room was removed from the 2018 FPRA logic because the detailed MCR abandonment human failure events (HFEs) (for SBO and non-SBO conditions) already include the cognitive failure to realize that the MCR should be abandoned. The redundant basic event was a legacy of an earlier modeling approach that was no longer relevant.
- Logic that modeled an erroneous decision to abandon the MCR when control capability has not been lost was removed.

Loss of MCR Habitability

The MCR abandonment logic models failure to control the reactor remotely from the CREP after a fire that is severe enough that the environmental effects of the fire (i.e., smoke and hot gasses) force operators to abandon the MCR. This logic only applies to MCR fire scenarios that are not designated MCR abandonment scenarios due to loss of control. As discussed above under Loss of Control from the MCR, new logic has been introduced at the top of the CDF and LERF fault trees to implement the refined MCR abandonment modeling.

The MCR habitability abandonment probability is calculated based on detailed fire modeling for MCR fire scenarios. The probability of abandonment in this case represents the likelihood of a fire generating adverse environmental conditions that meet the criteria for control room evacuation described in Task 11 of NUREG/CR-6850. This approach is unchanged from the 2014 FPRA and is consistent with the abnormal operating procedure AOP-900.02, Control Room Evacuation Due to Fire, which provides entry conditions for MCR abandonment related to loss of habitability for fires in the ASD areas as follows:

- Smoke is affecting Control Room personnel breathing
- Operators have difficulty reading main control board (MCB) control panel instrumentation
- Temperatures/flames prevent continuous occupancy of the Control Room.

For the 2018 FPRA, the abandonment probability calculation has been updated to use guidance from (a) NUREG-2178, Refining And Characterizing Heat Release Rates From Electrical Enclosures During Fire (RACHELLE-FIRE) - Volume 1: Peak Heat Release Rates and Effect of Obstructed Plume and (b) NUREG-2169, Nuclear Power Plant Fire Ignition Frequency and Non-Suppression Probability Estimation Using the Updated Fire Events Database: United States Fire Event Experience Through 2009. In addition, the modeling approach is consistent with the guidance on MCR abandonment modeling provided in Chapter 3 of NUREG-1921 Supplement 1.

HRA Approach Used to Modify the MCR Abandonment Model

For the 2014 and 2018 FPRAs, the MCR abandonment HRA was performed using the same detailed HRA methods and practices cited in NUREG-1921, the EPRI/NRC-RES Fire HRA Guidelines, which supplements the guidance provided in NUREG/CR-6850 Task 12. During the 2018 FPRA, the HRA was reviewed against the recently published qualitative analysis guidance on MCR abandonment HRA from NUREG-1921 Supplement 1 and was found to be consistent with that guidance.

Previous Use of the Approach to MCR Abandonment Modeling

As noted above under HRA Approach Used to Modify the MCR Abandonment Model, the 2018 HRA modeling approach is essentially unchanged from the 2014 FPRA, which was used to support the NFPA 805 LAR and associated 2014 NFPA 805 SE. This same approach was used to incorporate the model refinements discussed in the Refinements to the Main Control Room Abandonment Model section discussed above.

Consistency of the MCR Abandonment Modeling with Plant Procedures

As discussed above under Refinements to the MCR Abandonment Model, the MCR abandonment modeling in the 2018 FPRA is consistent with current VC Summer procedures. VC Summer Operations and Training personnel were directly involved in the discussions regarding the model refinement process. These discussions ensured that the MCR abandonment procedure direction was properly correlated to the model logic changes, the post-abandonment action timing and locations, and the specific personnel modeled by the HRA for the operator actions.

PRA RAI 02

In Enclosure 1, Attachment 1, to the licensee's letter dated August 29, 2018, the licensee stated that heat release rates (HRRs) were increased to account for secondary combustibles of insulation and high density polyethylene (HDPE) piping. The LAR is not clear on the approach used and its basis. Provide a summary of the approach used for increasing the HRRs and discuss whether it was used previously to support the NFPA 805 LAR or in another plant LAR and subsequent amendment.

SCE&G Response:

Approach and Basis for Increasing HRR Due to Non-Cable Secondary Combustibles

The approach used for increasing the HRR due to non-cable secondary combustibles is similar to the approach used in the VCS Fire PRA for cable trays that are secondary combustibles. The potential impact of the non-cable secondary combustibles to existing fire scenarios was analyzed, using the following steps:

1. Determination of the ignition criteria (heat flux and temperature) for each non-cable secondary combustible. For example:

   High-Density Polyethylene (HDPE) piping: This material typically forms a pool when exposed to a heat source and will burn as a pool fire if ignited (NIST 1493). Therefore, the ignition criteria for HDPE is taken as the melting temperature as listed in the Material Safety Data Sheet and as the incident heat flux evaluated at the melting temperature, using the critical incident heat flux equation in NUREG/CR-6931, Vol. 3 (Equation 2.6).

   Foam pipe insulation: This insulation is a low density closed-cell rubber material that is a blend of polyvinyl chloride and nitrile butadiene rubber. The ignition temperature and the critical incident heat flux is based on the minimum ignition temperature listed in the Safety Data Sheet for Nitrile Butadiene Rubber (NBR) (MSDS-NBR).

   Cork-filled insulation: This insulation is used to retard unwanted moisture condensation on moderately cold surfaces. The insulation material is composed mostly of cork, therefore, the ignition temperature and critical incident heat flux for cork are used in the analysis. (Krause and Schmidt, Journal of Loss Prevention in the Process Industries 13, 2000, Fig. 6).

2. Determination of the zone of influence (ZOI) for a transient fire using the same models as NUREG-1805 Supplement 1, Fire Dynamic Tools (FDT^S) for plume temperature (Chapter 9) and heat flux point source model (Chapter 5) based on the ignition criteria.

3. Determination of the heat release rate by multiplying the heat release rate per unit area (HRRPUA) for each combustible by A_{comb}, the area of the impacted combustible, using values of HRRPUA from fire industry journals and handbooks.

For example, in the case of HDPE piping, the value of A_{comb} is the pool area of the melted HDPE material; for the foam pipe insulation and the cork-filled insulation, it is the area of insulation exposed to the fire.

4. Identification of ignition sources with non-cable combustibles located within the calculated ZOI distances in fire zones with detailed fire modeling. The impacts of the non-cable combustibles were incorporated, as applicable, using one of the following approaches:

   a. An additional damage state scenario was added to include targets due to this potential fire propagation.

   b. The shortest distance to the closest combustible was reduced, which caused an increase in the severity factor, and an increase in the scenario frequency.

   c. Target set was expanded due to the increase in HRR.

The impacts due to the presence of non-cable combustibles, as mentioned above, are included in the Fire PRA model from 2018, and are reflected in the quantification results presented in the LAR dated August 29, 2018.

Other Plants Approach for Increasing HRR Due to Non-Cable Secondary Combustibles

Other nuclear plants that have addressed additional HRR and impact on fire risk due to non-cable secondary combustibles include the following:

1. HDPE:
   a. Catawba – NFPA 805 SE dated February 8, 2017 (ML16137A308, p. 97)
2. Insulation:
   a. Brunswick NFPA 805 SE dated July 6, 2018 (ML18106B169, pp. 8-10)
   b. Robinson NFPA 805 SE dated February 3, 2017 (ML16337A264, pp. 52-56)
   c. McGuire NFPA 805 SE dated December 6, 2016 (ML16077A135, pp. 55-56),
   d. Cooper NFPA 805 SE dated April 24, 2014 (ML14055A023, pp. 88-89),
   e. Browns Ferry NFPA 805 SE dated October 9, 2018 (ML18241A319, pp. 8-9).