UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

February 28, 2018

Mr. J. Ed Burchfield, Jr.
Site Vice President
Oconee Nuclear Station
Duke Energy Carolinas, LLC
7800 Rochester Highway
Seneca, SC 29672-0752

SUBJECT: OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3 – SAFETY EVALUATION FOR ALTERNATIVE TO CODES AND STANDARDS REQUIREMENTS ASSOCIATED WITH BRONZE TAPE WRAPPED EMERGENCY POWER CABLES (CAC NOS. MF7365, MF7366, AND MF7367; EPID L-2016-LLR-0001)

Dear Mr. Burchfield:

By letter ONS-2016-17 dated February 15, 2016, as supplemented by letters ONS-2018-016 and ONS-2018-015 dated February 12, and February 19, 2018, respectively, Duke Energy Carolinas, LLC (the licensee) submitted a request to the U.S. Nuclear Regulatory Commission (NRC or the Commission) to authorize the use of alternatives at the Oconee Nuclear Station, Units 1, 2, and 3 (Oconee). The licensee requested the NRC to authorize alternatives to the single failure criteria requirements of Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Paragraph 50.55a(h) for certain cable configurations. Pursuant to 10 CFR 55a(z)(1), the licensee proposed that the NRC authorize permanent acceptance of current cable configurations in certain locations and application of Paragraph 6.1.4, "Limited Hazard Areas," of Institute of Electrical and Electronic Engineers (IEEE) Standard (Std.) 384-1992, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits," as a means of providing acceptable cable separation in certain areas.

The NRC staff reviewed the subject request and, as set forth in the enclosed safety evaluation, concludes that the licensee adequately addressed the regulatory requirements in 10 CFR 50.55a(z)(1). The NRC staff concludes the proposed alternatives provide an acceptable level of quality and safety for the cable configurations and locations discussed in the enclosed safety evaluation. Therefore, the NRC staff authorizes the permanent use of the alternative.

All other single failure requirements for which relief was not specifically requested and approved remain applicable.

Any inquiries can be directed to Ms. Audrey Klett at 301-415-0489 or via e-mail at Audrey.Klett@nrc.gov.

Sincerely,

Michael T. Markley, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-269, 50-270, and 50-287

Enclosure:
Safety Evaluation

cc: Listserv

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

PROPOSED ALTERNATIVE TO CABLE SEPARATION REQUIREMENTS

DUKE ENERGY CAROLINAS, LLC

OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3

DOCKET NOS. 50-269, 50-270, AND 50-287

1.0 INTRODUCTION

By letter ONS-2016-17 dated February 15, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16062A052), as supplemented by letters ONS-2018-016 and ONS-2018-015 dated February 12, and February 19, 2018, respectively (ADAMS Accession Nos. ML18046A090 and ML18053A132), Duke Energy Carolinas, LLC (the licensee) submitted a request to the U.S. Nuclear Regulatory Commission (NRC or the Commission) to authorize the use of alternatives at the Oconee Nuclear Station, Units 1, 2, and 3 (Oconee). The licensee requested the NRC to authorize alternatives to the single failure criteria requirements of Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Paragraph 50.55a(h)(2) for certain cable configurations. Pursuant to 10 CFR 55a(z)(1), the licensee proposed that the NRC authorize permanent acceptance of the current (i.e., "as-is") cable configuration in certain locations and application of Paragraph 6.1.4, "Limited Hazard Areas," of Institute of Electrical and Electronic Engineers (IEEE) Standard (Std.) 384-1992, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits," as a means of providing acceptable cable separation in certain areas.

In January 2018, the NRC staff performed a regulatory audit using an internet-based portal from the NRC Headquarters office in Rockville MD. By letter dated February 20, 2018 (ADAMS Accession No. ML18026A541), the NRC issued a summary of the audit. By electronic mail (email) dated February 1, and February 15, 2018, respectively (ADAMS Accession Nos. ML18032A216 and ML18047A379), the NRC staff issued requests for additional information to the licensee. By letters dated February 12, and February 19, 2018, the licensee responded to the NRC staff's requests and confirmed that it completed the modifications identified in Attachment 1 of its submittal dated February 15, 2016, and, therefore, withdrew portions of its request that were no longer applicable because of the completed modifications. The licensee also clarified which portions of a cable for which the proposed alternatives were applicable for two areas in the request. Section 3 of this safety evaluation has a detailed description of the proposed alternatives.

Enclosure

2.0 REGULATORY EVALUATION

Paragraph 50.55a(h)(2), "Protection Systems," of 10 CFR states:

> For nuclear power plants with construction permits issued after January 1, 1971, but before May 13, 1999, protection systems must meet the requirements in IEEE Std. 279-1968, "Proposed IEEE Criteria for Nuclear Power Plant Protection Systems," or the requirements in IEEE Std. 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations," or the requirements in IEEE Std. 603-1991, "Criteria for Safety Systems for Nuclear Power Generating Stations," and the correction sheet dated January 30, 1995. For nuclear power plants with construction permits issued before January 1, 1971, protection systems must be consistent with their licensing basis or may meet the requirements of IEEE Std. 603-1991 and the correction sheet dated January 30, 1995.

In its submittal dated February 15, 2016, the licensee stated:

> Although the [Oconee] construction permit was issued prior to January 1, 1971, the current licensing bases is that [Oconee] will satisfy Section 4.2 of IEEE Std. 279-1971 for the Oconee Emergency Power and Emergency Core Cooling systems. NRC acceptance of the IEEE Std. 279-1971 single failure criteria is documented in three (3) 1976 safety evaluations associated with changes to the Emergency Core Cooling System model which conformed to the requirements of 10 CFR 50.46. IEEE Std. 279-1971, Section 4.2, "Single Failure Criterion," requires, in part, that any one single failure within the protection system shall not prevent the proper protective action at the system level when required [...]. The potential for not satisfying the single failure criteria (based on the requirements of 10 CFR 50.55a(h)) due to interactions between cables in certain cable transition areas is the specific issue addressed by this request. Options available to Duke Energy under this circumstance include 10 CFR 50.55a(z).

The licensee's letter dated May 13, 1976 (ADAMS Accession No. ML16008A753), states, in part, "[T]he design of the Oconee onsite emergency AC and DC power systems conforms to the single failure requirements of IEEE Std. 279-1971." The licensee is required to satisfy the single failure requirements of IEEE Std. 279-1971, which includes Section 4.2 of IEEE Std. 279-1971 in addition to other sections. The staff considered the licensee's submittal to be proposed alternatives to the single failure requirements in Section 4.2 of IEEE Std. 279-1971.

Pursuant to 10 CFR 50.55a(z)(1), alternatives to the requirements of paragraphs (b) through (h) of Section 50.55a, or portions thereof, may be used when authorized by the NRC if the licensee demonstrates that the proposed alternatives provide an acceptable level of quality and safety.

Based on the above, and subject to the following technical evaluation, the NRC staff finds that regulatory authority exists for the NRC to authorize the alternative requested by the licensee for permanent use. Accordingly, the NRC staff reviewed and evaluated the licensee's request pursuant to 10 CFR 50.55a(z)(1).

3.0 TECHNICAL EVALUATION

3.1 Components Affected by the Proposed Alternative

The licensee's proposed alternatives pertain to medium voltage single conductor cables related to operation of the Keowee Hydroelectric Station's (KHS's) 13.8-kilovolt (kV) and 4.16-kV underground power paths, the 13.8-kV Protected Service Water (PSW) power paths from the KHS, and areas where the cables are routed in proximity to certain Keowee safety-related control cables. The following list contains the medium voltage power cables that are the subject of the proposed alternatives.

- Six (6) 13.8-kV Keowee underground feeder cables to Transformer CT-4;
- Three (3) 4.16-kV KHS Auxiliary CX transformer power feeder cables,
- Six (6) 13.8-kV B6T and B7T feeder cables from the KHS to the PSW switchgear building;
- Six (6) 4.16-kV feeder cables from PSW Switchgear B6T to the 600-volt alternating current (VAC) PSW load center PX13 transformer.

The specific areas associated with this request are the PSW System Ductbank Manholes 1 through 6, the KHS Mechanical Equipment Gallery, and the PSW Building Cable Spreading Area.

PSW System Ductbank Manholes 1 through 6

In its submittal dated February 15, 2016, the licensee stated that the KHS-to-PSW 13.8-kV power feed initially routes from Keowee through an underground trench and then diverts into a separate ductbank/manhole system before reaching the CT-4 blockhouse. The PSW ductbank system from the underground trench to the PSW building consists of an underground duct with six intervening manholes. The manhole closest to the underground trench is designated Manhole-1, and the one closest to the PSW switchgear building is designated Manhole-6. The KHS-to-PSW 13.8-kV power feed is the Technical Specification credited power path, but it is not the normal power feed for this system. These cables are typically energized only during PSW system power path surveillance testing that performed on a quarterly basis (i.e., about 33 hours per year). The feed from the KHS to the PSW building is not normally energized.

The PSW ductbank system also contains low voltage instrumentation and control cables routed in separate ductbank conduits consisting of supervisory functions for both Keowee Hydro Units (KHUs), one train of KHU emergency start, one train of switchyard isolation complete, Power Circuit Breaker (PCB)-9 control, and breaker control for the PSW Keowee Power Feeder (KPF) switchgear. In its submittal, the licensee indicated that future station changes may route a second channel of KHU Emergency Start and Switchyard Isolation Complete via the PSW ductbank. The NRC staff did not review these future changes as part of this request and is not authorizing any future changes as part of this safety evaluation.

The KHS-to-PSW power cables in the PSW ductbank are routed through individual concrete encased conduits that are separate from the instrumentation and control cables and conduit within the same ductbank. The area of concern for interaction is within the PSW ductbank manholes, where power cables and instrumentation and control cables are not contained within individual conduits. The licensee indicated that there are no physical interactions possible between the medium voltage and control cables in ductbanks because they are in separate conduits separated by concrete and that the possibility of adverse interactions between the medium voltage cables and control cables would only exist in the manholes should a fault occur in medium voltage cables whenever they are energized. The staff reviewed the extent of these adverse interactions.

KHS Mechanical Equipment Gallery

In its submittal dated February 15, 2016, as supplemented by letter dated February 12, 2018, the licensee stated that the KHS Mechanical Equipment Gallery contains motor control centers, cooling water strainers, governors, and KPF Switchgear KPF-1 and KPF-2. In addition, cabling for the CT-4 underground feeder, the KHS-to-PSW underground feeder, the KHS-to-PSW Switchgear (KPF) line side cable bus, the feeder from the 4.16-kV switchgear 1TC to transformer CX, and adjacent safety-related control cables all route through the area.

PSW Building Cable Spreading Area

In its submittal dated February 15, 2016, the licensee stated that the PSW Building Cable Spreading Area is a section of the PSW building into which cables enter from the PSW ductbank system. In addition to the power feeds, low voltage instrumentation and control cables consisting of supervisory functions for both KHUs, one train of KHU emergency start cables, one train switchyard isolation complete (safety-related), PCB-9 control, and breaker control for the PSW KPF switchgear also enter the PSW building via these ductbanks. Additionally, power and control cables for other PSW functions are present.

3.2 Applicable IEEE Code Edition and Addenda

The staff considered the licensee's submittal to be proposed alternatives to the single failure requirements in Section 4.2 of IEEE Std. 279-1971. For some cable configurations, the licensee requested to use IEEE Std. 384-1992, which provides criteria and requirements for establishing and maintaining the independence of Class 1E equipment and circuits and auxiliary supporting features by physical separation and electrical isolation. The 1992 revision of IEEE Std. 384 incorporated separation criteria changes based on the results of separation testing completed by the nuclear industry on internally generated electrical faults. The licensee requested acceptance of the application of IEEE Std. 384-1992, Paragraph 6.1.4, "Limited Hazard Areas," as a means of providing acceptable cable separation in certain areas of the plant. Paragraph 6.1.4 states, "The minimum separation distances used for these areas are based on hazards being limited to failures or faults internal to the electrical equipment or cables. Limited hazard areas (previously called general plant areas) are those plant areas from which potential hazards such as missiles, non-electrically induced fires, and pipe failure are excluded." The minimum separation distances for circuits requiring separation are identified in Table 2 of this paragraph. According to Table 2, one-inch separation distance between medium voltage cables and instrumentation and control cables would be acceptable for enclosed-to-enclosed configurations.

3.3 Licensee's Proposed Alternatives and Bases

The licensee requested the NRC to authorize permanent acceptance of the current configuration in the PSW System Ductbank Manholes and the 13.8-kV B6T and B7T Feeder cables from the KHS to the PSW Switchgear Building based on cable design, operation, and testing. The licensee requested the NRC to authorize the following proposed alternatives for permanent use.

PSW System Ductbank Manholes

For the PSW System Ductbank Manholes 1 through 6, the licensee requested the NRC to authorize the as-is configuration of the normally de-energized 13.8-kV KHS-to-PSW building power feed as an alternative configuration to that required by 10 CFR 50.55a(h)(2). The as-is configuration is described in Section 3.1 of this safety evaluation and Sections 3.1 and 4.1 of the licensee's supplement dated February 12, 2018.

The licensee stated that the proposed alternative demonstrates an acceptable level of quality and safety because of the following reasons:

- satisfactory cable crush test results, which were provided in the licensee's submittal,
- satisfactory cable fault test results, which were provided in the licensee's submittal,
- the potential for power cable to control cable interaction in the manholes represents a small portion of the overall cable run total (about 180 feet out of about 4,500 feet),
- robust power cable design and cables are procured to Quality Assurance (QA)-1[1] standards, which minimize the likelihood of cable interactions,
- the KHS-to-PSW power cables are not normally energized, which minimizes the likelihood of cable interactions; for a PSW event, these cables would only be energized if the Fant Line is unavailable,
- high impedance grounding system limits fault current (KHS-to-PSW feeder) and minimizes the effect of any cable interaction should a fault occur,
- station power cables are evaluated as described in Section 18.3.14, "Insulated Cables and Connections Aging Management Program," of the Updated Final Safety Analysis Report (UFSAR), and
- the cables are housed in a steel-reinforced concrete ductbank/manhole engineered to withstand earthquakes and tornado missiles and to minimize water entry.

PSW System Ductbank Manholes 1 through 6 contain six 13.8-kV feeder cables from the KHS to the PSW switchgear building. In Attachment 3B of its supplement dated February 12, 2018, the licensee provided details of medium voltage cables and typical control and instrumentation cables. Each 13.8-kV feeder cable consists of a single-conductor shielded cable, 750-kilocircular mils (kcmil) copper compact round conductor, extruded semiconducting strand and insulation screens, 15-kV ethylene-propylene rubber (EPR) at 173 percent insulation level (i.e., 260 mils EPR), two helically applied 10-mil layers of bronze tape shield, and a jacket.

The typical control cables consist of multiconductors (i.e., eight #9 American wire gauge (AWG) conductors and nineteen #12 AWG conductors), 1-kV cross-linked polyethylene (XLPE) insulation, polyester and copper tapes over cable core, galvanized steel interlocked armor, and a jacket. For comparison, typical instrument cables consist of multi-shielded pairs (e.g., sixteen shielded #16 AWG pairs with drain wire), 300-V XLPE insulation, aluminum and polyester taps, galvanized steel interlocked armor, and a jacket.

In its supplement dated February 12, 2018, the licensee responded to request for additional information (RAI) 3(c) and provided criteria for grounding shields and armor of power,

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[1] Section 3.1.1.1, "Oconee QA-1 Program," of the Updated Final Safety Analysis Report describes the licensee's quality assurance program for meeting the requirements of 10 CFR Part 50, Appendix B.

instrumentation, and control cables. For medium voltage cables, only the cable shield is applicable, which is grounded at each termination. For control cables, only armor is applicable, which is grounded at each termination. For instrumentation cables, both shield and armor are applicable – the shield is grounded at one end of the cable, and the armor is grounded at each termination.

In its submittal dated February 15, 2016, the licensee requested for Manhole-6 that the NRC allow temporary acceptance of the as-is configuration of the Fant line feeder and adjacent KHS control cables as an alternative to 10 CFR 50.55a(h)(2) requirements until the Fant line power feeder relocation modification is complete. In its supplement dated February 12, 2018, the licensee confirmed that it completed the modification and withdrew its request for the NRC to approve the proposed alternative for temporary acceptance of that configuration.

KHS Mechanical Equipment Gallery

For the KHS Mechanical Equipment Gallery, the licensee requested the NRC to authorize a proposed modification to the separation requirements for a Limited Hazard Area as discussed in IEEE Std. 384-1992, Paragraph 6.1.4 with respect to the CX auxiliary power feed to the KHS, the KHS underground emergency power feeder to CT-4, the PSW KPF switchgear line side cable bus, and adjacent control cables as an alternative configuration to 10 CFR 50.55a(h)(2) requirements. IEEE Std. 384-1992 requires the openly routed medium voltage power cables and low voltage Keowee control cables be separated by three feet horizontally and five feet vertically, which is not achieved at all locations in the Keowee Mechanical Equipment Gallery. Where open distance requirements are not achieved, the licensee has provided enclosures for the medium voltage power cables and low voltage control cables to meet the enclosed raceway separation distance requirement of IEEE Std. 384-1992. The licensee stated that the proposed incorporation of IEEE Std. 384-1992 is limited to Paragraph 6.1.4 and is only for the scope of cables specified in Section 4.2 of its supplement dated February 12, 2018. The licensee indicated that adoption of the IEEE Std. 384-1992 Limited Hazard Area classification is appropriate because the KHS Mechanical Equipment Gallery contains power cables without any Hazard Area drivers present (e.g., missiles or high energy lines).

The licensee also requested the NRC to authorize the as-is configuration of the normally de-energized 13.8-kV power feed from the KHS to the PSW building as an alternative configuration to 10 CFR 50.55a(h)(2) requirements. In its supplement dated February 12, 2018, the licensee clarified that that this request pertains only to the cable portions and potential cable interactions within the KHS Mechanical Equipment Gallery. In its supplement dated February 19, 2018, the licensee stated that the separation requirements of IEEE Std. 384-1992 for the subject power and control cables are not met and that it is impractical to install cable enclosures per IEEE Std. 384-1992 because of physical interferences with other plant equipment and structures, limited free space, and limited ability to structurally support the additional enclosures.

The licensee stated that the proposed alternatives demonstrate an acceptable level of quality and safety because of the following reasons:

- satisfactory cable crush test results,
- satisfactory cable fault test results,
- modifications to meet enclosed raceway separation requirements for a Limited Hazard Area as noted by IEEE Std. 384-1992, paragraph 6.1.4, as endorsed in NRC Regulatory Guide 1.75,

- robust power cable design and cables procured to QA-1 standards, which minimize the likelihood of cable interactions,
- KHS power cables (CT-4 and KPF) are not normally energized, which minimizes the likelihood of cable interactions; for a PSW event, these cables would only be energized if the Fant Line is unavailable,
- high impedance grounding system limits fault current (KPF and CT-4) and minimizes the effect of any cable interaction should a fault occur,
- limited exposure distance (approximately 100 feet), which minimizes the opportunity of cable interactions,
- station power cables are evaluated as described in Section 18.3.14 of the UFSAR, and
- the cables are protected from the environment in that they are in the KHS powerhouse and not exposed to environmental hazards.

In its supplement dated February 19, 2018, the licensee stated that this bulleted list represents a collective basis for acceptability of the proposed alternatives and that the third bullet is only associated with the enclosure modifications. For the first alternative associated with the enclosure modifications, the licensee stated that by providing a fully metallic enclosed raceway to meet the enclosed raceway separation distance, Paragraph 6.1.4 of IEEE Std. 384-1992 is met and sufficient physical separation between the power and control circuits is achieved. By fully and separately enclosing the medium voltage power cables and the low voltage control cables, the separation distance required by IEEE Std. 384-1992, Paragraph 6.1.4 is reduced to one inch in each direction, which is maintained with the proposed design.

In its submittal dated February 15, 2016, the licensee also requested that the NRC allow temporary acceptance of the as-is configuration in the KHS mechanical equipment gallery as an alternative to 10 CFR 50.55a(h)(2) requirements until the cable enclosure modifications were complete. In its supplement dated February 12, 2018, the licensee confirmed that it completed the modifications and withdrew its request for the NRC to approve the proposed alternative for temporary acceptance of that configuration. In its supplement dated February 19, 2018, the licensee stated that the cable "limited exposure distance" identified in the bulleted list bounds the original, pre-modification, temporary as-is configurations of the request, but they also bound the much shorter distances associated with the request to authorize the as-is configuration of the normally de-energized 13.8-kV power feed from the KHS to the PSW building as an alternative configuration to 10 CFR 50.55a(h)(2) requirements.

PSW Building Cable Spreading Area

For the PSW Building Cable Spreading Area, the licensee requested the NRC to authorize a proposed modification to meet the separation requirements for a Limited Hazard Area as discussed in IEEE Std. 384-1992, Paragraph 6.1.4, with respect to the normally energized Fant line power supply feeder, normally energized feeder from switchgear B6T to the PX13 transformer, and adjacent KHS control cables as an alternative configuration to 10 CFR 50.55a(h)(2). IEEE Std. 384-1992 requires the openly routed medium voltage bronze armor power cables and low voltage control cables be separated by three feet horizontally and five feet vertically, which is not achieved at all locations in the PSW Building Cable Spreading Area. Where open distance requirements are not achieved, the licensee has provided enclosures for medium voltage power bronze armor cables and low voltage control cables to meet the enclosed raceway separation distance requirement of IEEE Std. 384-1992. The licensee stated that the proposed incorporation of IEEE Std. 384-1992 is limited to Paragraph 6.1.4 and is only for the scope of cables specified in Section 4.3 of its supplement dated February 12, 2018. The licensee indicated that adoption of the IEEE Std. 384-1992 Limited Hazard Area classification is appropriate because the PSW Building Cable Spreading Area contains power cables without any Hazard Area drivers present (e.g., missiles or high energy lines).

The licensee also requested the NRC to authorize the as-is configuration of the normally de-energized 13.8-kV power feed from the KHS to the PSW building as an alternative configuration to 10 CFR 50.55a(h)(2) requirements. In its supplement dated February 12, 2018, the licensee clarified that that this request pertains only to the cable portions and potential cable interactions within the PSW Building Cable Spreading Area. In its supplement dated February 19, 2018, the licensee stated that the separation requirements of IEEE Std. 384-1992 for the subject power and control cables are not met and that it is impractical to install cable enclosures per IEEE Std. 384-1992 because of physical interferences with other plant equipment and structures, limited free space, and limited ability to structurally support the additional enclosures.

The licensee stated that the proposed alternatives demonstrate an acceptable level of quality and safety because of the following reasons:

- satisfactory cable crush test results,
- satisfactory cable fault test results,
- modifications to meet enclosed raceway separation requirements for a Limited Hazard Area as noted by IEEE Std. 384-1992, paragraph 6.1.4, as endorsed in RG 1.75,
- robust power cable design and cables procured to QA-1 standards, which minimize the likelihood of cable interactions,
- KHS power cables are not normally energized, which minimizes the likelihood of cable interactions; for a PSW event, these cables would only be energized if the Fant Line is unavailable,
- high impedance grounding system limits fault current (KHS-to-PSW feeder), which minimizes the likelihood of cable interactions,
- limited exposure distance (less than 90 feet),
- station power cables are evaluated, as described in Section 18.3.14 of the UFSAR, and
- the cables are housed in a protected area engineered to withstand earthquakes and tornado missiles, and to minimize water entry.

In its supplement dated February 19, 2018, the licensee stated that this bulleted list represents a collective basis for acceptability of the proposed alternatives and that the third bullet is only associated with the enclosure modifications. For the first alternative associated with the enclosure modifications, the licensee stated that by providing a fully metallic enclosed raceway to meet the enclosed raceway separation distance, Paragraph 6.1.4 of IEEE Std. 384-1992 is met and sufficient physical separation between the power and control circuits is achieved. By fully and separately enclosing the medium voltage power cables and the low voltage control cables, the separation distance required by IEEE Std. 384-1992, Paragraph 6.1.4 is reduced to one inch in each direction, which is maintained with the proposed design.

In its submittal dated February 15, 2016, the licensee also requested that the NRC allow temporary acceptance of the as-is configuration of Fant line feeder, normally energized feeder from switchgear B6T to PX13 transformer, and adjacent KHS control cables as an alternative to 10 CFR 50.55a(h)(2) requirements until the cable enclosure modifications were complete. In its supplement dated February 12, 2018, the licensee confirmed that it completed the modifications and withdrew its request for the NRC to approve the proposed alternative for temporary acceptance of that configuration. In its supplement dated February 19, 2018, the licensee stated that the cable "limited exposure distance" identified in the bulleted list bounds the original, pre-modification, temporary as-is configurations of the request, but they also bound the much shorter distances associated with the request to authorize the as-is configuration of the normally de-energized 13.8-kV power feed from the KHS to the PSW building as an alternative configuration to 10 CFR 50.55a(h)(2) requirements.

Licensee's Risk Insights

The licensee's submittal dated February 15, 2016, included risk insights for the potential risk impact of the current plant configuration with respect to cable separation in the locations of concern. To develop its risk insights, the licensee evaluated the failures of the proposed configuration in each of the impacted areas of the plant (i.e., the PSW System Ductbank Manholes, KHS Mechanical Equipment Gallery, and PSW Building Cable Spreading Area) and considered the failure of each of the medium voltage cables and the consequential impact on the low voltage instrumentation and control cables. The licensee's analysis considered the following aspects: frequency of cable faults, probability that a fault is a multi-phase or high energy arc fault, probability of a large imposed voltage on one or both vital 125-volt direct current (VDC) trains, probability of a failure of one or both vital 125-VDC trains given an imposed voltage, and probability of a failure of mitigation strategies. The licensee also considered the probability of damaging multi-phase faults assuming maximum worst-case fault current.

As discussed in its submittal, the licensee's analysis concluded that the overall core damage frequency (CDF) and large early release frequency (LERF) increase for the three cable locations is approximately 2E-11/yr. In Manholes 1 through 6, the CDF and LERF increase is less than 1E-13/yr. In the KHS Mechanical Equipment Gallery, the CDF and LERF increase is approximately 5E-12/yr. In the PSW cable spreading area, the CDF and LERF increase is approximately 1E-11/yr. In its submittal, the licensee also provided its calculated frequency of cable faults in the PSW System Ductbank Manholes, KHS Mechanical Equipment Gallery, and PSW Building Cable Spreading Area, which were 1.2E-06, 8.9E-05, and 1.6E-04, respectively. In its supplement dated February 12, 2018, the licensee stated that it did not revise the risk insights provided in the original submittal but that the completed modifications associated with the Fant and CT4 cables in the KHU Mechanical Equipment Gallery and the PSW Building Cable Spreading Area would drive the original CDF and LERF risk increase value even lower.

3.4 Licensee's Reason for the Proposed Alternative

By letter dated June 27, 2014 (ADAMS Accession No. ML14290A136), the NRC informed the licensee that it identified a concern that postulated short circuits or ground faults in electrical cabling located in an underground concrete raceway could potentially impact the functionality of the emergency power system that is required to mitigate certain design basis events. The concern was associated with the licensee's compliance with the single failure requirements in IEEE Std. 279-1971 and the potential of a power cable fault causing an adverse interaction with control cables in close proximity to the faulted power cable. In its submittal dated February 15, 2016, the licensee stated that it was taking several anticipatory actions to address the concern and that the proposed alternatives address the concern and provide an acceptable level of quality and safety.

3.5 NRC Staff's Technical Evaluation

3.5.1 NRC Staff's Method of Review

Pursuant to 10 CFR 50.55a(z)(1), alternatives to the requirements of Paragraph 50.55a(h), or portions thereof, may be used when authorized by the NRC if the licensee demonstrates that the proposed alternatives provide an acceptable level of quality and safety. Therefore, the staff reviewed the licensee's submittal to determine whether the proposed alternatives provide an acceptable level of quality and safety for the cables, cable locations, and cable configurations described in Sections 3.1 and 3.3 of this safety evaluation. The staff reviewed information showing the cable composition, grounding, and separation and routing distances. The staff also reviewed the licensee's design for fault protection. The staff reviewed the risk insights provided by the licensee in its submittal. The staff used its own analyses to confirm whether the incremental risk associated with the proposed alternatives is small and, therefore, supports the engineering conclusions for the adequacy of the licensee's proposed alternatives.

3.5.2 Risk Insights Evaluation

The licensee did not submit a risk-informed application intending to meet the guidance in NRC Regulatory Guide 1.174, Revision 2, "An Approach for Using Probabilistic Risk Assessment [PRA] in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis" (ADAMS Accession No. ML100910006); however, the licensee provided risk insights in its submittal. The licensee stated in its submittal that the risk insights were not part of the basis for acceptance. Rather, the licensee used a defense-in-depth approach as a technical basis for its proposed alternatives. Because the submittal was not a risk-informed application, the staff did not review any licensee PRA models to determine their acceptability to support this submittal. Therefore, the staff did not rely on the numerical results provided by the licensee. However, the staff considered the licensee-provided risk insights to aid in the review of the proposed alternatives. The staff also performed an independent assessment using the NRC's Standardized Plant Analysis Risk (SPAR) model for Oconee to evaluate the risk contribution of the proposed alternatives. In addition to the risk insights, the staff also considered Oconee's defense-in-depth features, safety margins, and performance monitoring.

With regard to defense-in-depth features, Oconee has systems, structures, and components, such as the Standby Shutdown Facility, turbine-driven emergency feedwater pumps, and PSW being powered from the Fant line, that are available to mitigate a loss of power caused by cable faults interacting with the 125-VDC instrument and control cables in the PSW System Ductbank Manholes, KHS Mechanical Equipment Gallery, and PSW Building Cable Spreading Area. The loss of the control cables could cause the loss of both KHUs and the 125-VDC control power at the Oconee units. The Standby Shutdown Facility is a fully independent means of providing the functions necessary to achieve hot shutdown (i.e., reactivity control, decay heat removal, inventory and pressure control, and related instrumentation). In addition, each Oconee unit has a turbine-driven emergency feedwater pump capable of providing decay heat removal and being started and operated without any AC or DC power. Defense-in-depth is also provided in some scenarios by the PSW system because PSW can be powered from the Fant line, which would not be affected by a failure in either the PSW System Ductbank Manholes or the KHS Mechanical Equipment Gallery.

With regard to safety margins, the staff considered the PSW power cable and 125-VDC instrument and control cable design, installation, and testing in its determination of whether they provide a level of safety margin that a multi-phase fault will not occur. The PSW power cables are designed and manufactured with a grounded bronze shield that makes a short-to-ground more probable. The PSW power cables are installed in a configuration that uses a high resistance grounded Wye connection that would limit the ground fault current to a value that would not be damaging to the cable in the event of a phase-to-ground fault. The PSW power cables are designed, procured, and installed as a QA-1 cable and have undergone cable crush and electrical fault testing with satisfactory results. The 125-VDC instrument and control target cables of concern are armored, which provides a physical and electrical barrier to conductor damage. The staff's risk analysis was more conservative than the licensee's risk insights because the staff did not assume these factors; rather, the staff assumed cable faults would cause damage.

The staff considered the licensee's monitoring of the condition and continued performance of the medium voltage cables. The licensee performs full-load testing of the PSW power cables on a quarterly basis in accordance with the Oconee Technical Specifications. The 4.16-kV power supply to the CX Transformer is continuously energized. The licensee performs full-load testing of the KHS-to-CT-4 cable in accordance with the Oconee Surveillance Frequency Control Program, and the licensee has included all medium voltage power cables under consideration in the proposed alternatives within the scope of the Oconee Insulated Cables and Connections Aging Management Program as described in Section 18.3.14 of the UFSAR.

For each location of the proposed alternatives, the staff evaluated the incremental risk increase as well as the total risk increase for the proposed alternatives. The staff determined that the licensee's key assumptions in its analysis (e.g., the duration the cables were energized, the length of exposed cable, and the relatively low frequency of cable failures) provide assurance that the risk is low. The staff determined that the licensee used conservative assumptions that bound the adverse impacts of electromagnetic and radio frequency interference and the failure of the proposed modifications to provide protection. The portion of the licensee's risk analysis that relied on the existing internal events and fire PRAs to evaluate other mitigation strategies was limited. However, when the staff performed its independent analysis, it concluded that the values used by the licensee and the values used by the staff obtained from the SPAR model were consistent. Although several of the other assumptions have considerable uncertainty (e.g., the probability of an induced voltage and probability that both trains of 125-VDC would be impacted), the staff concludes that even with these uncertainties, the risk increase would still be very low. The staff performed an independent analysis of risk and concluded that these configurations would result in a low risk impact individually and cumulatively.

3.5.3 <u>PSW System Ductbank Manholes</u>

For the PSW System Ductbank Manholes 1 through 6, the licensee requested the NRC to authorize the as-is configuration of the normally de-energized 13.8-kV KHS-to-PSW building power feed as an alternative configuration to that required by 10 CFR 50.55a(h)(2). The licensee stated that the proposed alternative demonstrates an acceptable level of quality and safety for the reasons discussed in Section 3.3 of this safety evaluation.

Cable shield and armor serve multipurpose functions. Medium voltage cable shields, which typically consist of copper and bronze tape, confine dielectric field to the inside of cables or conductor insulation; evenly distribute electrical field; reduce induced voltage on the external equipment or parallel circuits; and increase safety to personnel. For a high-impedance grounded system, a licensee can take credit for the shield to carry ground fault current if the shield is of sufficient size. Control cable armor, which consists of galvanized steel interlock armor, provide physical protection and protection from external electromagnetic interference.

Instrumentation cable armor and shield provide physical protection and electromagnetic interference protection. The staff considered the justifications provided by the licensee in its submittal, as supplemented, and finds that the interaction between power and control cables in the manholes will be minimal because of the following reasons.

1. Because the 13.8-kV cables are single conductor cables, individually insulated, and provided with bronze wrapped shield, and the shield is grounded at each end of cable, the likelihood of a single phase-to-ground fault on any cable becoming a multi-phase fault and thus having a higher fault energy is expected to be minimal. The cable fault test results provided by the licensee in Attachment 3B of its supplement dated February 12, 2018, verified this information. As per the test results, a phase-to-ground fault did not result in creating a short circuit on other power cables. The test results also showed that a phase-to-ground fault on a medium voltage cable did not damage the insulation of the nearby control cables. Therefore, the staff does not expect direct impacts between medium voltage power cables and control cables.

2. The electromagnetic interactions (i.e., indirect impacts) between medium voltage and control cables during faults is expected to be minimal because power, control, and instrumentation cables are provided with either grounded shield or grounded armor. In Attachment 3C of its supplement dated February 12, 2018, the licensee provided induced control voltage calculations due to single-phase to ground fault on medium voltage cable. The licensee's Calculation 0079-0191-CALC-002 states that for a typical duct bank configuration, the fault current is 16,000 amperes, lengths of cables are 300 feet, and the distance between medium voltage cables and control cables is considered to be 3 inches. Both power and control cables are considered in separate conduits in a concrete ductbank. According to Attachment 3C of its supplement dated February 12, 2018 [Page 3 of Calculation No. 0079-0191-CALC-002], the licensee conservatively selected the 3-inch separation based on minimum spacing of two neighboring embedded cable ducts based on Oconee PSW Ductbank drawing O-398-A1-200B, Revision 0. Based on this calculation, the differential voltage induced between two conductors within a control cable was calculated as 0.2 V, and the common mode voltage was considered to be 14.4 V. The differential voltage can cause mal-operation of control equipment, whereas the common mode voltage can impact only the insulation of control cable. As described in Section 3.3 of this safety evaluation, the control cables have 1-kV XLPE insulation, which can withstand a voltage of 1000 V. Similarly, instrument cables have 300-V XLPE insulation, which can withstand a voltage of 300 V.

   The staff finds that the differential and common mode voltages are too small to impact control circuits. These induced voltages are directly proportional to the length of cable and the magnitude of fault current. For the circuits under consideration, although the length of cable exposed to interference is longer, the single phase-to-ground fault current is low because of high or medium resistance grounding systems. For the circuit of concern between CT-4 and the PSW switchgear, the length is approximately 4500 feet, but because of high impedance grounding, the fault is restricted to only approximately 18 amperes, as described in the fault current values in Attachment 3A of the licensee's supplement dated February 12, 2018. Therefore, the staff finds that any induced differential and common mode voltages on control cables during credible single phase-to-ground faults are minimal.

3. In its supplement dated February 12, 2018, the licensee stated that the analysis provided for control cable impacts would also bound any impacts on the instrument

cables, which includes twisted pairs with each pair individually shielded and grounded. The staff finds this justification reasonable and, therefore, acceptable.

Based on above evaluation, the staff finds that for the cable configuration in the PSW System Ductbank Manholes 1 through 6, the interactions between the medium voltage power cables and instrumentation and control cables would be minimal. The staff also finds that the as-is cable configuration, as described by the licensee in its submittal, as supplemented, relating to the PSW System Ductbank Manholes 1 through 6, provides an acceptable level of quality and safety and meets the requirements of 10 CFR 50.55a(z)(1) and, therefore, is acceptable.

3.5.4 KHS Mechanical Equipment Gallery

For the KHS Mechanical Equipment Gallery, the licensee requested the NRC to authorize a proposed modification to the separation requirements for a Limited Hazard Area as discussed in IEEE Std. 384-1992, Paragraph 6.1.4 with respect to the CX auxiliary power feed to the KHS, the KHS underground emergency power feeder to CT-4, the PSW KPF switchgear line side cable bus, and adjacent control cables as an alternative configuration to 10 CFR 50.55a(h)(2) requirements. Where open distance requirements are not achieved, the licensee stated that enclosures are or will be provided for the medium voltage power cables and low voltage control cables to meet the enclosed raceway separation distance requirement of IEEE Std. 384-1992. The licensee also requested the NRC to authorize the as-is configuration of the normally de-energized 13.8-kV power feed from the KHS to the PSW building as an alternative configuration to 10 CFR 50.55a(h)(2) requirements.

Regarding the first proposed alternative involving the enclosures, the staff finds that according to IEEE Std. 384-1992 (which is endorsed by Regulatory Guide 1.75, Revision 3), Table 2, "Minimum Separation Distances for Limited Hazard Area," the minimum distance recommended between medium voltage power cables and instrumentation and control cables enclosed in separate enclosures is one inch. Because the licensee meets this criterion, the staff finds the licensee's proposed alternative acceptable. The staff finds that the proposed alternative provides an acceptable level of quality and safety and meets the requirements of 10 CFR 50.55a(z)(1) and, therefore, is acceptable.

Regarding the second proposed alternative for the as-is configuration, the staff considered the justifications provided by the licensee in its submittal, as supplemented, and finds that the interactions between power and control cables in the KHS Mechanical Equipment Gallery will be minimal because of the following reasons.

1. Because the 13.8-kV cables are single conductor and individually insulated, provided with bronze-wrapped shield, and the shield is grounded at each end of cable, the likelihood of single phase-to-ground fault on any cable becoming a multi-phase fault and thus having a higher fault energy is expected to be minimal. The cable fault test results provided by the licensee in Attachment 3B of its supplement dated February 12, 2018, verified this information. The test results show that a phase-to-ground fault did not result in creating a short-circuit on other power cables. The test results also showed that a phase-to-ground fault on a medium voltage cable did not damage the insulation of the nearby control cables. Therefore, the staff does not expect direct impacts between medium voltage power cables and control cables.

2. The electromagnetic impacts between power and control cables will be similar to those discussed above for the PSW System Ductbank Manholes. In the KHS Mechanical

Equipment Gallery, the single phase-to-ground fault current may be higher, but the portions of cables that could be exposed to electromagnetic interference between power and control cables are much smaller. Therefore, induced voltages on control cables will remain minimal.

Based on the above evaluation, the staff finds that the as-is cable configuration in the KHS Mechanical Equipment Gallery provides an acceptable level of quality and safety and meets the requirements of 10 CFR 50.55a(z)(1) and, therefore, is acceptable.

3.5.5 PSW Building Cable Spreading Area

For the PSW Building Cable Spreading Area, the licensee requested the NRC to authorize a proposed modification to meet the separation requirements for a Limited Hazard Area as noted by IEEE Std. 384-1992, Paragraph 6.1.4, with respect to the normally energized Fant line power supply feeder, normally energized feeder from switchgear B6T to the PX13 transformer, and adjacent KHS control cables as an alternative configuration to 10 CFR 50.55a(h)(2) requirements. The licensee stated that where open distance requirements are not achieved, enclosures are or will be provided for medium voltage power bronze armor cables and low voltage control cables to meet the enclosed raceway separation distance requirement of IEEE Std. 384-1992. The licensee also requested the NRC to authorize the as-is configuration of the normally de-energized 13.8-kV power feed from KHS to the PSW building as an alternative configuration to 10 CFR 50.55a(h)(2) requirements.

Regarding the first proposed alternative involving the enclosures, the staff finds that according to IEEE Std. 384-1992 (which is endorsed by Regulatory Guide 1.75, Revision 3), Table 2, "Minimum Separation Distances for Limited Hazard Area," the minimum distance recommended between medium voltage power cables and instrumentation and control cables enclosed in separate enclosures is one inch. Because the licensee meets this criterion, the staff finds the licensee's proposed alternative acceptable. The staff finds that the proposed alternative provides an acceptable level of quality and safety and meets the requirements of 10 CFR 50.55a(z)(1) and, therefore, is acceptable.

Regarding the second proposed alternative for the as-is configuration, the staff considered the justifications provided by the licensee in its submittal, as supplemented, and finds that the interaction between power and control cables in the PSW Building Cable Spreading Area will be minimal because of the following reasons.

1. Because the 13.8-kV cables are single conductor and individually insulated, provided with bronze-wrapped shield, and the shield is grounded at each end of cable, the likelihood of single phase-to-ground fault on any cable becoming a multi-phase fault and thus having a higher fault energy is expected to be minimal. The cable fault test results provided by the licensee in Attachment 3B of its supplement dated February 12, 2018, verified this information. The test results show that a phase-to-ground fault did not result in creating a short-circuit on other power cables. The test results also showed that a phase-to-ground fault on a medium voltage cable did not damage the insulation of nearby control cables. Therefore, the staff does not expect direct impacts between medium voltage power cables and control cables.

2. The electromagnetic impacts between power and control cables will be similar to those discussed above for the PSW System Ductbank Manholes. In the PSW Building Cable Spreading Area, the single phase-to-ground fault current may be higher, but the portions

of cables that could be exposed to electromagnetic interference between power and control cables are much smaller. Therefore, induced voltages on control cables will remain minimal.

Based on the above evaluation, the staff finds that the as-is cable configuration in the PSW Building Cable Spreading Area provides an acceptable level of quality and safety and meets the requirements of 10 CFR 50.55a(z)(1) and, therefore, is acceptable.

3.5.6 Technical Evaluation Summary

Based on this evaluation, the NRC staff concludes that each of the licensee's proposed alternatives provides an acceptable level of quality and safety. The combined change in risk of the proposed alternatives for the three locations is low. The staff's review is only applicable to the specific cables, cable configurations, and cable locations discussed in the licensee's submittal and as noted in Sections 3.1 and 3.3 of this safety evaluation. The staff's review is not applicable to other cables, configurations, or locations at Oconee.

4.0 REGULATORY COMMITMENTS

In its submittal dated February 15, 2016, the licensee provided the following regulatory commitment.

	Commitment	**Completion Date**
1	Complete field implementation of: • Cable separation modifications to the PSW System Cable Spreading Area and the KHS Equipment Gallery, and • Fant feeder line relocation out of PSW ductbank manhole 6.	9/15/17

In its supplement dated February 12, 2018, the license stated that it completed this commitment. As stated in Sections 4.2 and 4.3 of its supplement dated February 12, 2018, the alternatives include enclosures that have been provided for the medium voltage power cables and low voltage control cables in the KHS Equipment Gallery and the PSW Building Cable Spreading Area. Because the field implementation of these enclosures was completed and included in the supplemented description of the proposed alternatives, and because the licensee's supplement dated February 12, 2018, withdrew the proposed alternatives regarding the Fant feeder line, the staff's authorization of the alternatives does not rely on this commitment. The staff concludes that reasonable controls for the regulatory commitment are best provided by the licensee's administrative processes.

5.0 CONCLUSION

As set forth in this safety evaluation, the NRC staff determines that the proposed alternatives provide an acceptable level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in

10 CFR 50.55a(z)(1). Therefore, the NRC staff authorizes the permanent use of the proposed alternative at Oconee.

All other IEEE Std. 279-1971 requirements for which relief was not specifically requested and approved remain applicable.

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Date: February 28, 2018

SUBJECT: OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3 – SAFETY EVALUATION FOR ALTERNATIVE TO CODES AND STANDARDS REQUIREMENTS ASSOCIATED WITH BRONZE TAPE WRAPPED EMERGENCY POWER CABLES (CAC NOS. MF7365, MF7366, AND MF7367; EPID L-2016-LLR-0001) DATED FEBRUARY 28, 2018

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