

September 3, 2008

Mr. Rick A. Muench  
President and Chief Executive Officer  
Wolf Creek Nuclear Operating Corporation  
Post Office Box 411  
Burlington, KS 66839

SUBJECT: WOLF CREEK GENERATING STATION - REQUEST FOR ADDITIONAL  
INFORMATION RELATED TO SUBMERGED SAFETY-RELATED MEDIUM  
VOLTAGE POWER CABLES (TAC NO. MD7339)

Dear Mr. Muench:

During the Nuclear Regulatory Commission (NRC) Region IV inspection for license renewal in the fall of 2007, it was discovered that safety-related cables were submerged under water in an underground vault. These cables are 4160V Medium Voltage Cables connecting the power block with Emergency Service Water System routed in duct banks and manholes predominantly located below ground water level and submerged in water. These are High Temperature Kerite (HTK) insulated cables and the Condition Detail Report (CDR) evaluated the operability of these cables for the Wolf Creek Generating Station (WCGS).

In reviewing the above CDR and other documentation, which were provided to NRC by Wolf Creek Nuclear Operating Corporation (WCNOC), the staff concludes that WCNOC has not demonstrated the qualification of the above safety-related cables under submerged condition for long periods of time. The staff had a conference call with WCNOC on August 13, 2008, to discuss the staff's concerns about these cables. In that call, WCNOC requested that the staff provide its concerns by letter and this letter is to provide the staff's evaluation of the information it had available and to state the staff's concerns that lead to the staff's conclusion.

Enclosed is the NRC staff's evaluation of the HTK insulated cables found to be submerged in an underground vault. To expedite our review of the qualification of the HTK insulated cables, the information provided by WCNOC was not provided by letter on the WCGS docket. This is discussed in the enclosed evaluation. You are requested to address the staff's concerns in writing within 60 days of the receipt of this letter. In your response to the staff's concerns, we request that you also include the emailed documentation identified in the enclosed evaluation.

Sincerely,

/RA/

Jack N. Donohew, Senior Project Manager  
Plant Licensing Branch IV  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

Docket No. 50-482

Enclosure:  
As stated

cc w/encl: See next page

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Wolf Creek Generating Station

(7/2/2008)

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EVALUATION AND REQUEST FOR ADDITIONAL INFORMATION

BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO SUBMERGED SAFETY-RELATED MEDIUM VOLTAGE POWER CABLE

WOLF CREEK NUCLEAR OPERATING CORPORATION

WOLF CREEK GENERATING STATION

DOCKET NO. 50-482

1.0 INTRODUCTION

During the Nuclear Regulatory Commission (NRC) Region IV inspection for license renewal in the fall of 2007 at Wolf Creek Generating Station (WCGS), the cover for electrical manhole MHE-1 was removed to inspect the safety-related cables. This inspection identified that the cables were submerged under water. These are 4160 Volt (V) Medium Voltage Cables connecting the power block with Emergency Service Water System (ESWS) routed in duct banks and manholes predominantly located below ground water level submerged in water.

Wolf Creek Nuclear Operating Corporation (the licensee) wrote Condition Detail Report (CDR) # 2007-003567 (dated November 16, 2007) to evaluate the operability concerns of these cables being submerged. Following the completion of the CDR, the NRC project manager for WCGS requested a copy of the CDR from the licensee. In the CDR, the licensee concluded that the cables were operable.

Following its review of the CDR, conference calls were held with licensee on February 26 and 29, 2008, to discuss the CDR. The calls led to the following question being sent to the licensee on February 29, 2008:

Based on our review of the Condition Detail Report (CDR) 2007-003567, 'Submerged [Safety-Related] Electric [Power] Cable,' and the document 'Kerite Engineering Memorandum 223' (Kerite 223), we do not completely understand your basis for concluding the submerged cable in question is qualified for the lifetime of the plant, including the proposed license renewal. We request that you explain the basis for this conclusion with references to the specific pages in the Kerite 223 document that are being relied upon, and show how this basis meets industry standards on the qualification of submerged cable. State if the conditions for the tests performed [envelop] the postulated normal and accident conditions for the plant or, if this is not true, why the tests conditions are acceptable for the qualification of the cable. Provide a justification for how the tests on the degradation of submerged Kerite cable are extended over the expected lifetime of the plant. The NRC staff understands the basis for temperature aging data being extended out to this lifetime, but the staff does not understand the basis for the extension for the test-measured degradation of the submerged over time. Please submit if there is any correspondence from the cable vendor that states that the tests performed demonstrate the submerged cable is qualified for the lifetime of the plant.

Enclosure

In response to the above question, the licensee provided the following documentation via an email dated March 28, 2008:

1. Suitability of Submerged Medium Voltage Cables At Wolf Creek Nuclear Operating Corporation (WCNOC). This is the licensee's summary report. It is a summary of the licensee's justification why the subject High Temperature Kerite (HTK) cables are suitable for use in submerged conditions for long periods of time at WCGS.
2. Discharge Resistance White Paper. It provides information on partial discharge resistance.
3. Robert Fleming presentation on Kerite cable, fall 2002. It provides information on Kerite cable manufacturing and cable construction.
4. Robert Fleming presentation on Kerite cable, fall 2006. It provides information on 28-year-old Kerite cable testing to demonstrate that 28-year cable is as good as new cable and that it can perform its intended function for another 28 years.
5. Kerite promotional material. It provides information on why Kerite cable is unique.
6. Engineering Report E-0029-0003-02 was sent via separate email. This is qualification documentation for Kerite power cables.

The above documents are not in the NRC Agencywide Documents Access and Management System (ADAMS). The NRC staff did not process these documents into ADAMS because the staff agreed to accept the above documentation via email so that the staff could receive the information and complete its review of the qualification of the HTK cable in an expeditious manner. Since the staff has completed its review of the information, it will now request that the above information (items no. 1 through 6) be submitted by the licensee on the WCGS docket. The licensee does not need to submit CDR # 2007-003567 (dated November 16, 2007) since the licensee maintains a copy of the CDR in its records and it can be accessed through its number and date.

## 2.0 BACKGROUND

It is the licensee position that the HTK insulated cables are qualified for submergence. The licensee believes that the qualification test of 1950 hours (reference Engineering Report E-0029-0003-02) under submerged conditions can be extrapolated to 40-year plant life. The licensee stated that HTK ethylene propylene rubber (EPR) cable construction is better than other types of EPR insulated cables.

The NRC staff does not agree with the licensee analysis to extend the 1950-hour test under submerged conditions to 40-year qualification. Even if the HTK EPR insulated cable construction is better than other types of EPR insulated cables, with the available information, the staff can not conclude that these cables are qualified for 40 years under submerged conditions for long periods.

### Service Conditions

The submerged cable operating voltage is nominally 4160V at WCGS. The cables are normally energized but lightly loaded. The cables are installed in duct banks from the Control Building to the ESWs Pump House. Average temperature is 68 degrees Fahrenheit (°F). Duct banks are provided for protection of the cable from physical damage. Each duct bank consists of a bundle of polyvinyl chloride (PVC) conduit encased in concrete. Five manholes are located along the length of the duct bank as pull points for the installation and maintenance of the cable. The manholes are concrete vaults, ranging in depth from 13 to 17 feet below grade. Water stops and waterproofing are provided to minimize intrusion of ground water so that work can be conducted in the manholes. However, the duct banks or manholes are not equipped with sumps, pumps, or drains to prevent the cables from being submerged.

Based on the calls with the licensee, it is uncertain whether the cables are always submerged or that they are above water for periods of time such that the cables are continuously submerged and then dry. It is requested that the licensee clarify the situation.

### Design and Ratings of the Cables:

The HTK cable is 250MCM, copper conductor, triplex, 5000 V rated, 140 mil, HTK insulated, non-shielded, 110 mil fire resistant (HTNS) jacketed power cable. The HTK insulation is an EPR formulation proprietary to Kerite.

### Applicable Regulatory Requirements

These cables are not installed in harsh environments; therefore, Section 50.49 of Title 10 of the *Code of Federal Regulations* (10 CFR) does not apply. The NRC regulations in 10 CFR 50.65(a)(1) state that “[e]ach holder of a license to operate a nuclear power plant ... shall monitor the performance or condition of structures, systems, or components ... in a manner sufficient to provide reasonable assurance that such structures, systems, and components ... are capable of fulfilling their intended functions.”

The following NRC regulations in 10 CFR Part 50, Appendix A, also apply:

1. General Design Criterion (GDC) 4, states that “[s]tructures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation.”
2. GDC 17, states that “[p]rovisions shall be included to minimize the probability of losing electric power from any of the remaining [power] supplies ... [a] loss of power from the transmission network, or the loss of power from the onsite electric power supplies.”
3. GDC 18, states that “[e]lectric power systems important to safety shall be designed to permit appropriate periodic inspection and testing of important ... features, such as wiring, insulation” and “to assess the continuity of the systems and the condition of their components,” “the operability of the systems as a whole,” and “the transfer of

power among the nuclear power unit, the offsite power system, and the onsite power system.”

The following NRC regulations in 10 CFR Part 50, Appendix B, apply:

1. Criterion XI, states that “[a] test program shall be established to assure that all testing required to demonstrate that ... components will perform satisfactorily in service is identified and performed.”
2. Criterion XVI, states that “[m]easures shall be established to assure that conditions adverse to quality ... are promptly identified and corrected. In the case of significant conditions adverse to quality, the measures shall assure that the cause of the condition is determined and corrective action taken to preclude repetition.”

These above regulations require that safety-related cables, which are routed underground, be capable of performing their safety function when subjected to anticipated environmental conditions such as moisture or flooding. Further, the design should minimize the probability of power interruption when transferring power between sources. Licensees are expected to have monitoring programs to demonstrate that the cables, whose failures could disable risk-significant equipment, can perform their safety function when necessary.

### 3.0 TECHNICAL EVALUATION

#### The Licensee's Justification

The NRC staff reviewed the licensee’s documentation and it has summarized below the licensee’s justification:

1. Electric Power Research Institute (EPRI) TR-103834-P1-2, “Effects of Moisture on the Life of Power Plant Cables,” reported that moisture absorption follows Arrhenius models. The manufacturer’s test report shows that wetted insulation life follows Arrhenius relationships that predict the rate at which insulation resistance decreases due to increase in moisture absorption due to increase in service temperature. The slope of the Arrhenius plot indicates that HTK insulated cable submerged at groundwater temperatures will have more than one-half the original insulation resistance remaining after 60 years. (Summary report pages 1 and 8-10, provided via email dated March 28, 2008.)
2. Operating experience of HTK cables has been outstanding. Surveys of nuclear utilities have reported no failures of underground wetted HTK cable. (Summary report pages 1 and 7, and Nuclear Energy Institute (NEI) 06-05 white paper.)
3. HTK insulated cables exposed to wetted service for 28 years have been subjected to a battery of tests. These test results showed no deterioration of performance characteristics, and no treeing. Measured parameters were still within ranges expected for new cable. (Summary report pages 1 and 12 and Robert Fleming presentation, fall 2006.)

4. The amount of water absorbed by a polymer should be the same for two identical materials at the same temperature when one is immersed in water and the other exposed to 100 percent relative humidity. Even if dewatered (pumped out), the environment in the duct banks and manholes would stabilize at 100 percent humidity. Little if any increase in cable life would be gained by dewatering. The potential negative effects of disturbing the cable environment are unknown. Since ample evidence exists that HTK insulated cables are suitable for submerged service, it would be more prudent to maintain the manholes and duct banks in the existing stable condition at this time. (Summary report pages 1 and 12.)
5. HTK insulated cable is rated for installation in underground duct bank, and direct burial in earth in wet and dry locations. (Reference E-029-00003, Summary report page 4, under Design and Rating.)
6. The licensee stated that Kerite insulation was designed to withstand partial discharge without damage and only Kerite insulation meets the discharge resistant classification of the Insulated Cable Engineers Association (ICEA) S-87-682-2000 for Class IV discharge resistance insulation. The licensee also stated that Kerite recognizes that no insulation will be perfect and the partial discharge will be inevitable. (Summary report page 7, reference Kerite promotional material, Robert Fleming presentation on Kerite cable, fall 2002.)
7. The licensee requested additional information from the cable manufacturer on better estimate of insulation life, additional data that would substantiate the Arrhenius plot and latest test data or analysis or any later revisions, amendment or replacement of Engineering Memorandum 223. (Summary report page 10.)
8. The licensee has established periodic inspection requirements to visually inspect the cable tray supports and cables in the manholes for degradation. (Summary report page 1.)

#### The NRC Staff Evaluation

The NRC staff reviewed the licensee's documentation discussed above in Section 1.0, the references in its documentation, and the licensee's responses to the Generic Letter (GL) 2007-01. Based on the above review, the staff provides the following evaluation:

1. The cable vendor performed a test with cable submerged for only 1950 hours (Engineering Report E-0029-0003-02, pages 44 and 97 of 149). The manufacturer's test report shows the relationship of water absorption to the increasing temperature. The staff agrees that the elevated temperatures will accelerate moisture absorption into the cables. The licensee has used Arrhenius model to extrapolate life of the cables for 40 years, using the 1950-hour test in submerged conditions. EPRI TR-103834 P1-2, page 2.4-1 states that no information was identified suggesting that a model such as Arrhenius exists which can be used to extrapolate the accelerated immersion conditions to determine cable life based on actual operating conditions. The Arrhenius model is predominately used to extrapolate accelerated thermal aging test data. The staff



disagrees with the licensee's position to use Arrhenius Model to extrapolate life of the cables in submerged conditions for the current license period.

2. The GL 2007-01 responses for the industry indicate that there were several HTK insulated cable failures. These failures reported by the industry were caused due to water collection in duct banks and/or damaged jacket during installation and several nuclear plants did not identify the cause of these cable failures.
3. The staff reviewed the Robert Fleming presentation sent by email by the licensee. The presentation discussed the 28-year-old direct buried cable and concluded that the test results of this 28-year-old cable are as good as that of a new cable and this cable should last for another 28 years or even more as there is no age-related degradation. The presentation did not reveal that these cables were installed in the submerged conditions as installed at WCGS. The 300-foot cable length was cut into seven 30-foot test lengths and the damaged sections were removed. There is no discussion in the presentation regarding the root cause of the damaged cable sections. By removing the damaged portions of the cable, the age-related degradation or damage due to installation has been excluded from the test. Based on the above review, the staff feels that the test results of this 28-year old cable cannot be applied to the installed cables under the submerged conditions at WCGS.
4. At WCGS, the cables are submerged under several feet under water. The staff does not agree with the licensee that the amount of water absorbed by a polymer should be the same for two identical materials at the same temperature when one is immersed in water and the other exposed to 100 percent relative humidity air. Engineering Report E-0029-0003-02 (pages 44, 49, 97, and 102 of 149) states that the laboratory tests were conducted to determine the effects of alternate wet and dry environments and indicate that continuous water immersion is more severe.
5. HTK insulated cable is rated for installation in underground duct bank, and direct burial in earth in wet and dry locations (Summary report page 4, under Design and Rating). However, the licensee has not established that these cables are designed for use in submerged applications for long periods at WCGS.
6. The licensee's documentation discussed in Section 2.0 indicates that these class IV cables are designed for discharge resistance and not for discharge free. The tests performed at the factory were on new cables and not on aged cables or under the actual plant conditions. The factory tests do not guarantee an expected life of the cables. The staff agrees with Kerite (the manufacturer of the cable) that partial discharge is inevitable. Therefore, the staff concludes that the licensee has not demonstrated that these cables are designed and qualified for use in submerged applications for long periods at WCGS.
7. During the conference call held on August 13, 2008, the NRC staff discussed with the licensee if they had obtained further documentation from the cable vendor (Kerite) stating that the subject cables are qualified to use in submerged applications for long periods as installed at WCGS, without condition monitoring

or testing. The licensee stated that it will not be able to obtain any additional information from the cable vendor.

8. Although visual inspections of the cables may be useful to detect some degradation of cable trays, supports, and cables, the staff believes that only visual inspections of cables are not adequate to detect and predict all potential cable failures.
9. The staff has no disagreement with the licensee's conclusion that the cables are operable because there are no reported failures of these cables because of a failure of the cable insulation.
10. In doing its review, the NRC staff has also considered the following NEI 06-05 white paper recommendations that:
  - a. It is conservative to keep underground cables dry.
  - b. Institute low point manhole inspection and pumping or install and maintain automatic sump pumps.

### 3.0 CONCLUSION

Based on the above evaluation, the NRC staff concludes that it appears that the licensee has not demonstrated the qualification of the subject safety-related cables under submerged conditions for the current license period. Based on this, the licensee is requested to explain why it does not follow the above recommendations of the industry NEI 06-05 white paper.

Principal Contributor: N. Patel

Date: