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Revised: September 21, 2012

**UNITED STATES OF AMERICA**
**NUCLEAR REGULATORY COMMISSION**

**BEFORE THE ATOMIC SAFETY AND LICENSING BOARD**

| | | |
|---|---|---|
| In the Matter of | ) | Docket Nos. 50-247-LR and |
| | ) | 50-286-LR |
| ENTERGY NUCLEAR OPERATIONS, INC. | ) | |
| | ) | |
| (Indian Point Nuclear Generating Units 2 and 3) | ) | |
| | ) | March 29, 2012 |

# TESTIMONY OF ENTERGY WITNESSES ALAN B. COX, ROGER B. RUCKER, THOMAS S. MCCAFFREY, AND HOWARD G. SEDDING CONCERNING CONTENTIONS NYS-6/NYS-7 (NON-EQ INACCESSIBLE MEDIUM- AND LOW-VOLTAGE CABLES)


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## I. WITNESS BACKGROUND

### A. Alan B. Cox ("ABC")

**Q1. Please state your full name.**

A1. (ABC) My name is Alan B. Cox.

**Q2. By whom are you employed and what is your position?**

A2. (ABC) I am employed by Entergy Nuclear Operations, Inc. ("Entergy"), the Applicant in this matter, as Technical Manager, License Renewal. My office is located at Entergy's Arkansas Nuclear One ("ANO") facility in Russellville, Arkansas.

**Q3. Please describe your professional qualifications, including relevant professional activities.**

A3. (ABC) My professional qualifications are summarized in the attached *curriculum vitae* (ENT000031). Briefly, I hold a Bachelor of Science degree in Nuclear Engineering from the University of Oklahoma and a Masters of Business Administration from the University of Arkansas at Little Rock. I have more than 34 years of experience in the nuclear power industry, having served in various positions related to engineering and operations of nuclear power plants. I was licensed by the NRC in 1981 as a reactor operator and in 1984 as a senior reactor operator for ANO, Unit 1. Two of my prior positions include Senior Staff Engineer (1993-1996) and Supervisor, Design Engineering (1996 to 2001) at ANO.

Since 2001, I have worked full-time on license renewal supporting the development of integrated plant assessments and license renewal applications ("LRA") for Entergy license renewal projects, as well as license renewal projects for other utilities. Specifically, as a member of the Entergy license renewal team, I have participated in the development of nine LRAs and in industry peer reviews of at least twelve additional LRAs. I have been a member of the Nuclear Energy Institute ("NEI") License Renewal Task Force since approximately 2002 and previously have represented Entergy on the NEI License Renewal Mechanical Working Group and the NEI License Renewal Electrical Working Group.

**Q4. Please describe your role with respect to the LRA for Indian Point Units 2 and 3 ("IP2" and IP3").**

A4. (ABC) As Technical Manager, I was directly involved in preparing the LRA (submitted in April 2007) and developing or reviewing aging management programs ("AMPs") for IP2 and IP3 (referred to jointly as Indian Point Energy Center, or "IPEC"). Those programs include the Non-Environmentally Qualified ("EQ") Inaccessible Medium-Voltage Cable Program and the Non-EQ Insulated Cables and Connections Program discussed below. I was directly involved in developing or reviewing Entergy responses to NRC Staff requests for additional information ("RAIs") concerning the LRA and various revisions to the application (principally as they relate to aging management issues). I also supported Entergy at the related Advisory Committee on Reactor Safeguards ("ACRS") Subcommittee and Full Committee meetings for the IPEC LRA held in March 2009 and in September 2009, respectively. Accordingly, I have personal knowledge of the development and subsequent revision of the LRA, including the aforementioned aging management programs.

**B. Roger B. Rucker ("RBR")**

**Q5. Please state your full name.**

A5. (RBR) My name is Roger B. Rucker.

**Q6. By whom are you employed and what is your position?**

A6. (RBR) I am a self-employed Engineering Consultant, and I am President of Rucker Nuclear Consultants, Inc. in Russellville, Arkansas. My consulting work focuses on electrical and instrumentation and control ("I&C") applications in nuclear power plants, particularly as they relate to nuclear power plant operating license renewal. In this capacity, I provide technical services to Entergy's License Renewal Services Division at its ANO office. I am the License Renewal Electrical Lead for a number of Entergy nuclear power plant license renewal projects, including Entergy's application to renew the operating licenses for IP2 and IP3.

**Q7. Please describe your educational and professional qualifications, including relevant professional activities.**

**A7.** (RBR) My qualifications are described in the attached *curriculum vitae* (ENT000092). In brief, I have over 22 years of work experience, most of which has been in the nuclear power industry. I hold a Bachelor of Science degree in Electrical Engineering from the University of Arkansas. I am a licensed Professional Engineer in the State of Arkansas. I am the Entergy representative for the NEI License Renewal Electrical Working Group. Previously, I have been a member of NEI, Electric Power Research Institute ("EPRI"), and Institute of

Electrical and Electronics Engineers ("IEEE") groups involved in license renewal and aging activities, such as the NEI Medium Voltage Cable Task Force, the NEI License Renewal Task Force, the EPRI cable users group, and the IEEE Standards Association. I served as principal investigator in the preparation of EPRI Report No. 1013475, "Plant Support Engineering: License Renewal Electrical Handbook - Rev. 1 to EPRI Report 1003057" (Feb. 2007). As a member of the NEI MVU Cable Task Force, I contributed to the development of NEI 06-05, "Medium Voltage Underground Cable White Paper" (Apr. 2006) ("NEI 06-05") (ENT000234). Finally, I also participated in the development of EPRI Report No. 1020805, "Plant Support Engineering: Aging Management Program Guidance for Medium-Voltage Cable Systems for Nuclear Power Plants" (Jun. 2010) ("EPRI 1020805") (NYS000158).

**Q8. Please describe your role with respect to the IPEC LRA.**

A8. (RBR) I prepared several documents that support the LRA. Those documents include the electrical AMR report, as well as the electrical portions of the: (1) AMP evaluation report, (2) scoping and screening report, and (3) operating experience review reports. I also reviewed the electrical portions of the LRA before its submittal, and assisted in preparing responses to NRC audit and inspection questions, Staff RAIs, and related Entergy LRA amendments. In addition, I supported Entergy at the ACRS Subcommittee and Full Committee meetings for the LRA held in March 2009, and September 2009, respectively. Accordingly, I have personal knowledge of the development of the LRA, including the Non-EQ Inaccessible Medium-Voltage Cable Program and the Non-EQ Insulated Cables and Connections Program. I also have been involved in the ongoing implementation of those same programs at IPEC.

**C. <u>Thomas S. McCaffrey ("TSM")</u>**

**Q9. Please state your full name.**

A9. (TSM) My name is Thomas S. McCaffrey.

**Q10. By whom are you employed and what is your position?**

A10. (TSM) I am employed by Entergy as the Design Engineering Manager at IPEC. I am responsible for the design engineering staff that maintains the IP2 and IP3 design bases and performs plant modifications for the station.

**Q11. Please describe your professional qualifications, including relevant professional activities.**

**A11.** (TSM) My qualifications are described in the attached *curriculum vitae* (ENT000095). In brief, I have approximately 20 years of work experience, most of which has been in the nuclear power industry. I hold a Bachelor of Engineering degree in Electrical Engineering from the State University of New York – Maritime College. I am a licensed Professional Engineer in the State of New York. I worked in Consolidated Edison's Distribution Business before working at IPEC as an electrical system engineer responsible for the station's medium- and high-voltage electrical systems. I was subsequently promoted to Electrical/I&C Systems Supervisor (2000-2003) and Systems Manager (2003-2005), and assumed oversight responsibility for numerous engineers involved in all aspects of the IPEC electrical and I&C systems. From 2005 to 2007, I spent two years working at the Institute of Nuclear Power Operations ("INPO"), where I reviewed nuclear power plant equipment performance. I assumed my current position, Design Engineering Manager, in July 2007.

**Q12. Please describe your role with respect to the IPEC LRA.**

A12. (TSM) Although I was not directly involved in the preparation of the LRA, given my IPEC-specific engineering experience and responsibilities (past and present), I am very familiar with the station's electrical systems and the programs and procedures that apply to those systems. Therefore, I am familiar with IPEC electrical power cable systems and related programs and procedures implemented to meet 10 C.F.R. Part 50 requirements, including the procedure that implements the license renewal AMP for underground non-EQ medium-voltage cables.

**D. Howard G. Sedding ("HGS")**

**Q13. Please state your full name.**

A13. (HGS) My name is Howard G. Sedding.

**Q14. By whom are you employed and what is your position?**

A14. (HGS) I am employed as the Department Manager, Electrical Safety & Testing by Kinectrics Inc. (formerly Ontario Hydro Research Division), in Toronto, Canada. Kinectrics is an engineering firm that provides technology services to electric utilities, power equipment manufacturers, and large end-users of electrical energy. It employs over 400 engineers and has 25 independent test facilities and labs that are complemented by field inspection services. Kinectrics has advanced capabilities in low-voltage and medium-voltage cable testing for the power generation and transmission and distribution sectors. Its services include, for example, acceptance testing and in-plant cable inspection for all types of extruded polymer and paper-oil cables, post-mortem failure analysis of cable and accessories, estimating remaining cable service life, testing of cables and accessories, cable application engineering, and cable testing. Kinectrics also uses nondestructive evaluation ("NDE") techniques to assess the condition of cables located in hot spots or harsh environment plant areas. In addition, Kinectrics recently teamed with the U.S. firm Structural Integrity Associates to provide integrated services for cable management program implementation for North American nuclear and non-nuclear generation facilities.

**Q15. Please describe your professional qualifications, including relevant professional activities.**

A15. (HGS) My qualifications are summarized in the attached *curriculum vitae* (ENT000235). In brief, I have over 28 years of experience related to testing, condition monitoring and assessment of insulation materials, including extruded and laminar dielectric power cables used by the electrical generating, transmission, and distribution industries. I hold a Bachelor of Science degree in Electrical and Electronic Engineering from the University of Strathclyde in Glasgow, Scotland; Master of Science degree in Crystallography from the University of London; and a Doctor of Philosophy in Electrical Engineering and Applied Physics from Brighton Polytechnic (now the University of Brighton) in Brighton, England.

I spent three years as a Post-Doctoral Research Fellow at Brighton Polytechnic. I joined Ontario Hydro Research Division as a Visiting Researcher in 1987 and accepted a permanent position with Ontario Hydro in 1988. Since joining Ontario Hydro, which eventually became Kinectrics, I have been involved in, or responsible for, numerous projects related to the specification, testing, monitoring and maintenance of solid, liquid and gaseous electrical insulation systems in a wide range of high-voltage electrical equipment. These have included large-scale field projects ranging from commissioning testing of transmission-class cable circuits in Canada, the United States, Mexico, and the Middle East, to the refurbishment of four nuclear power units (two of which already have restarted, and two which are scheduled to restart in 2012) at Bruce Nuclear Generating Station in Ontario. The group of 30 engineers and technologists at Kinectrics that I lead also provides consulting and testing services in the areas of electrical safety equipment, rotating machines, and switchgear.

Over the years, I have been involved in many activities of the IEEE, the International Electrotechnical Commission ("IEC") (a Geneva-based organization that develops worldwide standards for electrical and electronic equipment), and the Conférence Internationale des Grandes Réseaux Electriques ("CIGRE") (a Paris-based organization that provides an international forum for discussion of experiences in the operation of large power systems). I was chair of the IEEE Instrumentation and Measurement Society (Toronto Chapter) from 1991 to 1994 and a member of the Administrative Committee of the Dielectrics and Electrical Insulation Society from 1994 to 1999. In 2006, I chaired the IEEE International Symposium on Electrical Insulation, having previously served as Vice-Chair (2004) and Publication Chair (2000) for this conference. I also have been and remain active in many IEEE, IEC, and CIGRE working groups and committees.

As indicated in my *curriculum vitae*, I am the co-holder of several patents and the co-author of over 90 published articles in the fields of testing and condition monitoring of electrical insulation used in power equipment including cables.

**Q16. Please describe your role with respect to the IPEC LRA.**

A16. (HGS) I have been retained by Entergy to provide expert services in connection with the adjudication of contention NYS-6/7, which challenges the adequacy of Entergy's AMPs for non-EQ inaccessible medium-voltage and low-voltage electrical cables at IPEC. Those programs are described in the LRA and other related documents that I have reviewed in independently assessing the Entergy cable aging management programs discussed herein and in preparing my testimony.

## II. <u>OVERVIEW OF CONTENTIONS NYS-6 AND NYS-7</u>

**Q17. Are you familiar Contention NYS-6, as originally proposed by NYS?**

A17. (ABC, RBR, TSM, HGS) Yes. We have reviewed the "New York State Notice of Intention to Participate and Petition to Intervene," dated November 30, 2007 ("NYS Petition"); the associated Declaration of Paul Blanch (NYS's former consultant), dated November 28, 2007 ("Blanch Decl."); and the "New York State Reply in Support of Petition to Intervene," dated February 22, 2008 ("NYS Reply"). NYS-6 alleged that the LRA fails to comply with 10 C.F.R. §§ 54.21(a) and 54.29 because it purportedly lacks an adequate plan for managing aging of non-environmentally qualified ("Non-EQ") inaccessible medium-voltage cables. NYS Petition at 92. In particular, NYS alleged that Entergy has not (1) identified the location and extent of non-EQ inaccessible medium-voltage cables in use at IP2 and IP3; (2) disclosed its aging management program and certain EPRI guidance documents referenced therein; (3) addressed specific recommendations contained in guidance documents issued by the NRC and the U.S. Department of Energy's ("DOE") Sandia National Laboratories ("Sandia") related to inspection of manholes for water accumulation and testing of medium-voltage cables exposed to significant moisture; and (4) justified differences between programs for aging management of accessible cables and inaccessible cables. *See id.* at 93-100.

**Q18. Are you familiar with Contention NYS-7, as originally proposed by NYS?**

A18. (ABC, RBR, TSM, HGS) Yes. NYS-7 alleged that the LRA fails to comply with 10 C.F.R. §§ 54.21(a) and 54.29, because it allegedly lacks a specific AMP for non-EQ inaccessible low-voltage cables located in or near adverse localized plant environments. Specifically, NYS asserted that the LRA fails to: (1) identify the locations of low-voltage cables, (2) provide any aging management program for such cables, and (3) describe the methodology purportedly used to exclude low-voltage cables from aging management review. *Id.* at 101.

**Q19. On what basis did the Atomic Safety and Licensing Board ("Board") admit contentions NYS-6 and NYS-7 on July 31, 2008?**

A19. (ABC, RBR, TSM, HGS) The Board consolidated NYS-6 and NYS-7 and admitted them as contention NYS-6/7 for further proceedings on whether Entergy has developed AMPs that will adequately manage the effects of aging on non-EQ inaccessible medium-voltage and low-voltage power cables, such that those cables will continue to perform their intended functions during the IP2 and IP3 periods of extended operation. *Entergy Nuclear Operations, Inc.* (Indian Point Nuclear Generating Units 2 and 3), LBP-08-13, 68 NRC 43, 86, 218 (2008).

**Q20. Have you reviewed the statement of position, pre-filed testimony, and supporting exhibits filed by NYS and its current consultant, Mr. Earle Bascom, on December 15, 2011 in support of contention NYS-6/7?**

A20. (ABC, RBR, TSM, HGS) Yes, we have reviewed NYS Exhibits NYS000135 through NYS000162. Those documents include, among others, NYS000136, "Prefiled Written Testimony of Earle C. Bascom III Regarding Contentions NYS-6 and 7" ("Bascom Testimony"); Exhibit NYS000137, the *Curriculum Vitae* of Earle C. Bascom III; and Exhibit NYS000138, "Report of Earle C. Bascom III, P.E. in Support of Contentions NYS-6 and 7" ("Bascom Report").

## III. SUMMARY OF DIRECT TESTIMONY AND CONCLUSIONS

**Q21. What is the purpose of your testimony?**

A21. (ABC, RBR, TSM, HGS) Our testimony will explain that the IPEC LRA describes AMPs for all non-EQ inaccessible medium-voltage and low-voltage cables that perform license renewal intended functions, and why those AMPs provide reasonable assurance that IPEC will adequately manage the effects of aging on cable functionality during the period of extended operation. In doing so, we will address the criticisms presented in Mr. Bascom's prefiled testimony and report concerning NYS-6/7 and demonstrate that those criticisms lack merit.

**Q22. In addition to the testimony and other materials filed by NYS in support of NYS-6/7, have you reviewed other materials in preparation for your testimony?**

A22. (ABC, RBR, TSM, HGS) Yes.

**Q23. What is the source of those materials?**

A23. (ABC, RBR, TSM, HGS) Many are documents prepared by government agencies, peer reviewed articles, or documents prepared by Entergy or the utility industry. These documents include, for example, NRC regulations and guidance documents pertaining to license renewal, the IPEC LRA and its supporting documentation, the NRC Staff's Safety Evaluation Report ("SER") and Supplemental SER, EPRI and IEEE guidance documents, original IPEC cable specifications, and applicable Entergy fleet procedures. Those documents also include the various exhibits filed by NYS and its consultant.

**Q24. Please direct your attention to Exhibit ENT000001. Do you recognize this document?**

A24. (ABC, RBR, TSM, HGS) Yes. It is a list of Entergy's exhibits and includes those documents which we referred to, used, or relied upon in preparing respective portions of our testimony, ENT000012, ENT00015, ENT000031, ENT000041, ENT000092, ENT000095, and ENT000234 through ENT000256.

**Q25. Please direct your attention to Exhibits ENT000012, ENT00015, ENT000031, ENT000041, ENT000092, ENT000095, and ENT000234 through ENT000256. Do you recognize these documents?**

A25. (ABC, RBR, TSM, HGS) Yes. These are true and accurate copies of the documents that we have referred to, used, and/or relied upon in preparing this testimony. Where we have attached only a document excerpt, that is noted on Entergy's exhibit list.

**Q26. How do these documents relate to the work that you do as an expert in forming opinions such as those contained in this testimony?**

A26. (ABC, RBR, TSM, HGS) These documents represent the type of information that persons within our fields of expertise regularly rely upon in forming opinions of the type presented in this testimony. We note at the outset that we cannot offer legal opinions on the language of the NRC regulations or adjudicatory decisions discussed in our testimony. However, reading those regulations and decisions as technical statements, and using our expertise, we can interpret their meaning as they relate to aging management of the medium-voltage and low-voltage cables at issue in NYS-6/7.

**Q27. Please summarize the principal claims set forth by New York State's consultant, Mr. Bascom, in his written testimony and report.**

A27. (ABC, RBR, TSM, HGS) In support of NYS-6, Mr. Bascom asserts that Entergy has not demonstrated that it will manage the effects of aging on non-EQ inaccessible medium-voltage cables exposed to significant moisture because the LRA purportedly "lacks any substantive detail." Bascom Testimony at 5 (NYS000136). Specifically, he alleges that Entergy does not: (1) specify the location or number of the relevant cables, (2) identify their function or the criticality of the systems they serve, (3) describe their physical characteristics (*i.e.*, cable lengths, voltage class, and insulation types), (4) explain what corrective actions it will take if manhole inspections reveal periodic water accumulation, (5) explain what cable condition monitoring tests it will use, (6) explain the criteria for determining whether a cable passes or fails a condition monitoring test, and (7) identify what corrective actions, if any, Entergy will take if a defective cable is found. *Id.*

In support of NYS-7, Mr. Bascom alleges that Entergy has not provided "any plan to manage the effects of aging on non-EQ inaccessible low and medium voltage power cables that are exposed to other localized adverse environmental conditions, such as excessive heat." *Id.* at 6. He further asserts that Entergy has not demonstrated that such a plan is unnecessary by showing that there are no non-EQ inaccessible power cables exposed to excessive heat. *Id.*

**Q28. Please summarize the basis for your disagreement with the claims made by NYS and Mr. Bascom in support of NYS-6.**

A28. (ABC, RBR, TSM, HGS) There is no basis for NYS's claim that the LRA lacks an adequate AMP for non-EQ inaccessible medium-voltage cables exposed to long-term wetting or submergence. LRA Section B.1.23, as amended, includes the Non-EQ Inaccessible Medium-Voltage Cable Program, which is the program described in NUREG-1801, Generic Aging Lessons Learned (GALL) Report, Rev. 2, Sec. XI.E3 (Dec. 2010) ("NUREG-1801, Rev. 2") (NYS00147D).

IPEC operating experience, as described in Entergy's response to NRC Generic Letter 2007-01 and in the LRA, indicates that there have been no prior failures or faults of medium-voltage (or low-voltage) power cables due to wetting or submergence. *See* NL-07-055, Letter from Fred Dacimo, Site Vice President, IPEC, to NRC Document Control Desk, "Submittal of Indian Point Response to Generic Letter 2007-01 at Attach. 1 (May 7, 2007) ("NL-07-055")

(ENT000236); LRA, Appendix B at B-81 (ENT00015B). In response to industry operating experience and Staff RAIs, Entergy has broadened the IPEC Non-EQ Inaccessible Medium-Voltage Cable Program to also include low-voltage power cables. NL-11-032, Letter from Fred Dacimo, Vice President, IPEC, to NRC Document Control Desk, "Response to Request for Additional Information (RAI) Aging Management Programs," Attach. 1 at 10-14 (Mar. 28, 2011) ("NL-11-032") (NYS000151). The NRC Staff has reviewed the amended program, and found that it is consistent with NUREG-1801, Section XI.E3; incorporates current operating experience; and meets the requirements of 10 C.F.R. § 54.21(a)(3). NUREG-1930, "Supplement 1 to Safety Evaluation Report Related to the License Renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3" at 3-5 to 3-9 (Aug. 2011) ("Supplemental SER") (NYS000160).

As expanded, the Non-EQ Inaccessible Medium-Voltage Cable Program (the program name was not changed after low-voltage cables were added to its scope) requires periodic actions to prevent cables from being exposed to significant moisture, such as inspections to identify water accumulation in cable manholes and removal of water if needed. *Id.* at 3-6 to 3-8; *see also* EN-DC-346, "Cable Reliability Program," Rev. 2 at § 5.7 (Jun. 14, 2011) ("EN-DC-346") (ENT000237). It also requires the use of proven, state-of-the art methods for establishing and monitoring the insulation condition of medium- and low-voltage power cables. NL-11-032, Attach. 1 at 12 (NYS000151). These requirements are consistent with recommendations in the NRC and Sandia guidance documents cited by NYS, in addition to the guidelines contained in more recent NRC and industry guidance documents. *See*, *e.g.*, EPRI 1020805 (NYS000158); EPRI Report 1021070, *Medium-Voltage Cable Aging Management Guide*, Rev. 1 (Dec. 2010) ("EPRI 1021070") (ENT000238).

Moreover, Entergy has developed a fleet procedure that contains specific instructions for implementing the Non-EQ Inaccessible Medium-Voltage Cable Program at IPEC. *See* EN-DC-346. As discussed below, Entergy's AMP, the NRC and industry guidance on which that program is based, and Entergy's program-implementing procedure provide the "essential" and "substantive" program details that NYS alleges are missing from the record. Indeed, the program is operational, as Entergy already is testing IPEC underground cables within the scope of the program; albeit largely as part of current plant operations regulated by the NRC under 10 C.F.R. Part 50.

**Q29. Please summarize the basis for your disagreement, if any, with the claims made by NYS and Mr. Bascom in NYS-7.**

A29. (ABC, RBR, TSM, HGS) In support of NYS-7, Mr. Bascom claims that Entergy has not provided a plan to manage the effects of aging on non-EQ inaccessible low-voltage power cables that are exposed to localized adverse environmental conditions, such as elevated temperatures. Bascom Testimony at 6 (NYS000136). His claim is factually unfounded and disregards the relevant AMP described in the LRA Section B.1.25, the Non-EQ Insulated Cables and Connections Program. LRA, App. B at B-85 (ENT00015B).

The Non-EQ Insulated Cables and Connections Program applies to aboveground low-voltage and medium-voltage electrical cables and connections (*i.e.*, accessible and inaccessible cable systems) that are subject to AMR and installed in adverse localized equipment environments ("ALEEs") caused by temperature, radiation, or moisture. *Id*. This program is founded on many years of research and industry operating experience. Similar programs have been successfully implemented at many non-Entergy and Entergy plants, including IPEC. *See* EPRI TR-109619, *Guidelines for the Management of Adverse Localized Equipment*

*Environments* at 1-5, 4-1 (June 1999) ("EPRI TR-109619") (ENT000239). Research and operating experience have shown that identification of ALEEs associated with accessible and inaccessible cables, coupled with inspections of accessible cables and connections in or near the identified ALEEs, provides reasonable assurance that aging effects on all (accessible and inaccessible low- and medium-voltage) cables and connections in such environments will be adequately managed during the period of extended operation. *See generally, id.*; EPRI 1020804, *Plant Support Engineering: Aging Management Program Development Guidance for AC and DC Low-Voltage Power Cable Systems for Nuclear Power Plants*, Chs. 3 & 4 (June 2010) ("EPRI 1020804") (ENT000240).

NYS misses this critical point in alleging that IPEC lacks a program for managing the effects of aging on low-voltage cables due to thermal stress or other adverse localized equipment environments. *See* Bascom Testimony at 6 (NYS000136). Quite to the contrary, Entergy has a specific, NRC-approved AMP that adequately addresses the specific issues raised by NYS. Entergy also has developed an implementing procedure that follows industry standards and is comparable to procedures used at many other plants. *See* EN-DC-348, "Non-EQ Insulated Cables and Connections Inspection," Rev. 2 (July 5, 2011) ("EN-DC-348") (ENT000241). As discussed below, the program already has been implemented at IPEC.

**Q30. In view of the above, is it correct that your testimony focuses on the two IPEC aging management programs mentioned above?**

A30. (ABC, RBR, TSM, HGS) Yes. Our testimony focuses on the Non-EQ Inaccessible Medium-Voltage Cable Program and the Non-EQ Insulated Cables and Connections Program. Together, these programs fully address the issues raised in NYS-6/7 by assuring that medium-voltage and low-voltage cables, potentially subject to long-term wetting or adverse localized environments, will continue to perform their intended functions during the renewal term. Table 1 below summarizes key aspects of those programs, including the relevant LRA sections, corresponding NUREG-1801 programs, the scope of the programs, relevant aging effects, related IPEC procedures, and key industry guidance documents.

**Table 1.** **Overview of Cable Aging Management Programs Relevant to NYS-6/7**

| | **Non-EQ Inaccessible Medium-Voltage Cable Program** | **Non-EQ Insulated Cables and Connections Program** |
|---|---|---|
| **LRA Sections** | A.2.1.22, A.3.1.22, and B.1.23 (ENT00015B) | A.2.1.24, A.3.1.24, and B.1.25 (ENT00015B) |
| **Other Relevant Entergy Licensing Correspondence** | NL-11-032 (NYS000151)<br>NL-11-074 (NYS000152)<br>NL-11-090 (NYS000153)<br>NL-11-096 (NYS000154) | NL-07-153 (NYS000159) |
| **NUREG-1801 Program** | Section XI.E3 (NYS00147D) | Section XI.E1 (NYS00147D) |
| **Scope of Program** | Includes periodic and event-driven inspections for water collection in cable manholes, and periodic testing of below-grade (buried or underground) in-scope medium-voltage (2kV-35kV) and low-voltage (400V-2kV) power cables exposed to significant moisture. All below-grade cables are assumed to be exposed to significant moisture. (NYS00147D at XI E3-2). | Applies to above-grade medium-voltage and low-voltage in-scope cables and connections that are located in adverse localized equipment environments (ALEEs) caused by temperature, radiation, or moisture. Includes identification of ALEEs, visual inspections of accessible electrical cables and connections installed in ALEEs for cable jacket and connection insulation surface anomalies (*e.g.*, embrittlement, discoloration, cracking, melting, swelling, contamination), and identification of accessible and inaccessible cables located in an ALEE. (NYS00147D at XI E1-1 to E1-2.) |
| **Relevant Aging Effect(s)** | Reduced Insulation Resistance – Cable insulation aging degradation (including formation and growth of water trees in medium-voltage cables) caused by wetting or submergence | Reduced Insulation Resistance – Cable insulation aging degradation from temperature, radiation, or moisture conditions that cause cable jacket and connection insulation surface anomalies |
| **Entergy Fleet Procedure** | EN-DC-346, Rev. 2, "Cable Reliability Program" (Jun. 14, 2011) (ENT000237) | EN-DC-348, Rev. 2, "Non-EQ Insulated Cables and Connections Inspection" (Jul. 5, 2011) (ENT000241) |
| **Key Industry Guidance Documents** | EPRI TR-109619 (ENT000239)<br>EPRI 1020804 (ENT000240)<br>EPRI 1020805 (NYS000158) | EPRI TR-109619 (ENT000239)<br>EPRI 1020804 (ENT000240) |
| **SER/SSER Section Evaluating IPEC Program** | SER Section 3.0.3.1.6 (pp. 3-31 to 3-33) (NYS000326B))<br>SSER Section 3.0.3.1.6 (pp. 3-5 to 3-9) (NYS000160) | SER Section 3.0.3.1.8 (pp. 3-36 to 3-38) (NYS000326B) |

## IV. INTRODUCTION TO KEY TECHNICAL CONCEPTS

### A. Non-Environmentally Qualified (Non-EQ) Cables

**Q31. What is a non-environmentally qualified or "non-EQ" cable?**

A31. (ABC, RBR, TSM, HGS) 10 C.F.R. § 50.49 requires that certain nuclear power plant electric equipment (including cables), important to safety, be qualified for the application and specified performance. Such equipment is referred to as "EQ" equipment. "Non-EQ" cables, on the other hand, are cables that are not required to be environmentally qualified in accordance with 10 C.F.R. § 50.49. Such cables are used in mild plant environments or, by design, are not required to remain functional during or following exposure to environmental conditions (*e.g.*, temperature and pressure, humidity, chemical effects, radiation, submergence) caused by a design basis event. 10 C.F.R. § 50.49(d)(3). A mild environment is an environment that would at no time be significantly more severe than the environment that would occur during normal plant operation, including anticipated operational occurrences. *Id*. § 50.49(c).

### B. Inaccessible Cables

**Q32. What is meant by an "inaccessible" cable?**

A32. (ABC, RBR, TSM, HGS) Cable accessibility depends on a cable's environment and physical configuration. When we refer to "inaccessible" cables in connection with NYS-6, we are referring to cables that are inaccessible because they are installed underground or below grade. These may include cables in conduits, trenches, troughs, and duct banks or cables that are directly buried in soil. Such cables may be exposed to long-term wetting due to water accumulation around the cables.

In addressing NYS-7, we sometimes refer to certain aboveground cables as "inaccessible" because they are located inside enclosures that make them difficult to access. For these cables, inaccessibility is not a concern if no adverse localized equipment environment exists near the cables. All below-grade cables are assumed to be exposed to moisture.

## C. Medium-Voltage and Low-Voltage Cable Definitions

**Q33. Please define the terms "low-voltage" and "medium-voltage" power cable and the uses of such cables.**

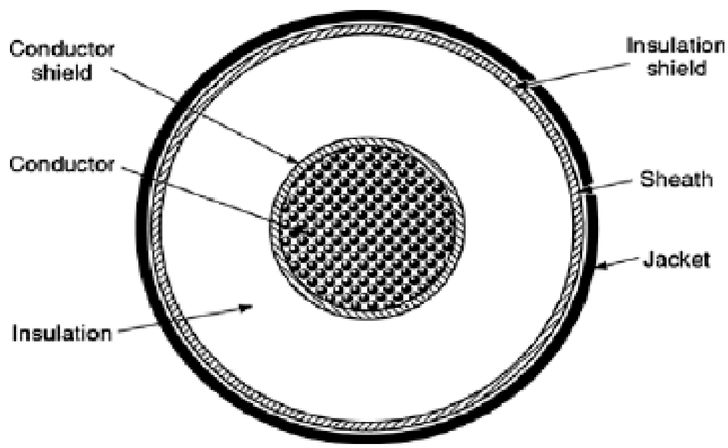
A33. (ABC, RBR, TSM, HGS) As defined in the LRA program, low-voltage power cables have an operating voltage ranging from 400 volts (V) to 2 kilovolts (kV). NL-11-032, Attach. 1 at 12 (NYS000151). Medium-voltage power cables have an operating voltage ranging from 2kV to 35kV. *Id.* These definitions are consistent with those provided in industry guidance. *See* EPRI 1020804 at 1-1 (ENT000240); EPRI 1020805 at 1-1 n.1 (NYS000158).

Low-voltage power cables typically are used to supply power to low-voltage auxiliary devices such as motors (and motor control centers), heaters, and small distribution or lighting transformers. For example, at IPEC, 480V cables feed service water pumps, auxiliary feedwater pumps, and an electric fire pump. *See* IPEC Low-Voltage In-Scope Cable List (ENT000242). Medium-voltage power cables typically are used to supply power to larger loads and distribution centers. For instance, IPEC medium-voltage circuits with a license renewal intended function include 6.9kV or 13.8kV cables that support circulating water pumps, the station blackout generators, and the offsite power supply system. IPEC Medium-Voltage In-Scope Cable List (ENT000243).

## D. Basic Cable Design/Construction Features

**Q34. Please describe the basic construction or configuration of a power cable.**

A34. (HGS, RBR, TSM) A typical electric power cable includes two main components: (1) an insulating material that covers (2) a metallic copper or aluminum electrical conductor. The metallic conductor may be a single strand of solid wire or a bundled group of smaller diameter wires forming a single stranded conductor. Power plant cables typically are single or grouped-stranded conductors. *See*, *e.g.*, NEI 06-05 at 9 (ENT000234). The insulating material of individual cable conductors often is covered by a layer of polymer jacket material to protect the insulating material from physical damage. *Id*. at 9-10. Multiple conductor cables will typically include an overall polymer jacket to protect the individual insulated conductors that make up the cable. *Id*. Figure 1 that follows shows a conceptual cable design for both medium-voltage and low-voltage cables.




**<u>Figure 1</u>. Cross-Section of Conceptual Power Cable Design**
(Source: J. Webster (ed.), *Wiley Encyclopedia of Electrical and Electronics Engineering* at 2 (1999) (ENT000012))

Basic cable components are described below.

- **<u>Conductor</u>:** An uninsulated wire that is suitable for carrying electrical current. The conductor is typically stranded copper or aluminum, the former being more common in nuclear power plants.

- **<u>Conductor shield</u>**: A conductor shield is employed to preclude excessive voltage stress on voids between the conductor and the insulation. To be effective, it must adhere to, or remain in close contact with, the insulation under all conditions. A semiconducting material, normally carbon-black-loaded cross-linked polyethylene ("XLPE"), is applied over the conductor to provide a smooth and compatible interface between the conductor and insulation. This smooth semiconducting shield is at the same potential as the conductor, resulting in dielectric field lines that are not distorted.

- **<u>Insulation</u>:** The material surrounding an electrical conductor that serves to insulate or isolate it from other conductors or grounded objects. Common insulation types include XLPE or ethylene propylene rubber ("EPR"), with the latter being more common in nuclear plants. As discussed below, some older cables at IPEC have polyvinyl chloride ("PVC") insulation systems. The insulation offers high electric resistance suitable for covering the conductor and preventing contact with adjacent conductors that could cause a short circuit.

- **Insulation shield**: An insulation shield has two main functions: (1) to confine the electric field within the cable, and (2) to obtain symmetrical radial distribution of voltage stress within the dielectric field lines, thereby minimizing the possibility of surface discharges by precluding excessive tangential and longitudinal stresses. The insulation shield is made from the same material as the conductor shield. The metallic tape shield provides a continuous drain for the conductor shield and a return path for fault currents.

- **Sheath:** A watertight metallic (*e.g.*, lead) outer covering that is used to protect a conductor's insulating material. A lead sheath is a continuous jacket molded around the insulation/insulation shield to prevent moisture-related damage.

- **Jacket**: The outermost covering that protects the underlying cable core from mechanical, moisture and chemical damage during the installation and service life of the cable. The purpose of the outermost jacket or sheath is to provide mechanical protection, although some jackets also may retard the ingress of moisture into the cable core. Non-metallic jacket materials include polymeric materials such as PVC. Jackets or sheaths also may be made of metallic materials.

*See generally* NEI 06-05 at 9-15 (ENT000234); EPRI 1021070 (ENT000238).

**Q35. How are medium-voltage cables used at nuclear plants typically configured?**

A35. (HGS, RBR, TSM) Nuclear plant underground medium-voltage cables, the principal focus of NYS-6, are configured in one of three ways: (1) as individual insulated single stranded conductors; (2) as a factory-twisted combination of the insulated single stranded conductors known as a "triplexed" assembly; or (3) as a multi-conductor (typically three conductors) cable with an overall jacket. NEI 06-05 at 9-10 (ENT000234); EPRI 1021070 at 4-1 to 4-10 (ENT000238). In any of these configurations, the insulated conductors will share the same basic construction shown in Figures 2A and 2B. Figure 2A shows an "unshielded" cable, which includes a conductor (A), a conductor shield (B), insulation (C), and a jacket (D). Figure 2B shows a "shielded" cable, which includes a conductor (A), a conductor shield (B), insulation (C), an insulation shield (D), a metallic tape shield (E), and a jacket or sheath (F).

**Figure 2A/2B.** **Illustrations of Typical Unshielded Medium-Voltage Cable and Typical Shielded Medium-Voltage Cable (With an Insulation Shield and a Metallic Tape Shield)**
(Source: EPRI 1021070 at 4-2 (Fig. 4-1) & 4-3 (Fig. 4-3)).

Fig. 2A: Unshielded Cable

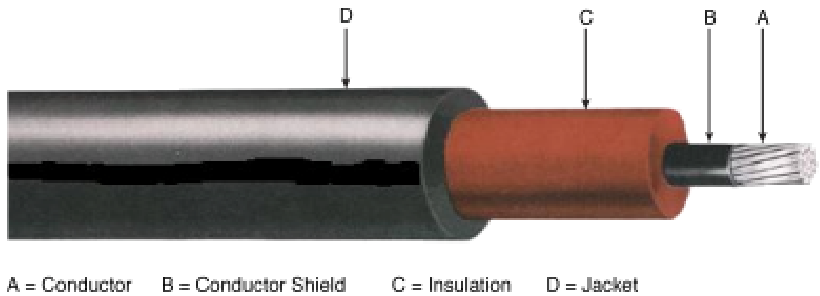
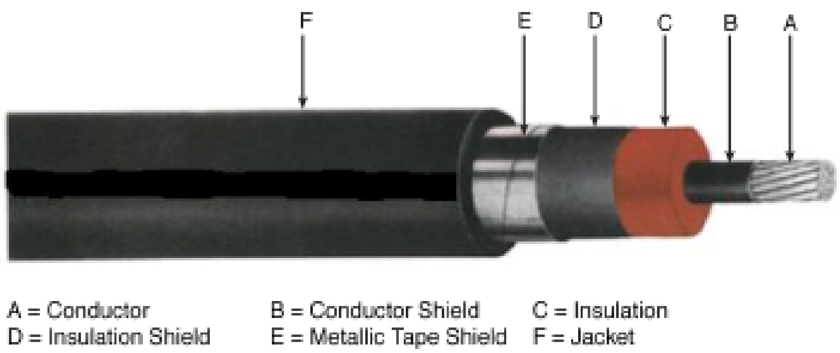



Fig. 2B: Shielded Cable




**Q36. How are underground medium-voltage cables at IPEC configured?**

A36. (TSM, RBR) Approximately 98% of all of the inaccessible (underground) IPEC medium-voltage and low-voltage cables that have a license renewal intended function are lead-sheathed and are triplexed single conductor cables. *See* IPEC Medium-Voltage In-Scope Cable List (ENT000243); IPEC Low-Voltage In-Scope Cable List (ENT000242).

**Q37. What types of materials are used as insulation in the medium-voltage cables at IPEC?**

A37. (TSM, RBR) IPEC medium-voltage cables include paper-insulated, lead-covered ("PILC"), PVC, XLPE, and EPR insulation systems. *See* IPEC Medium-Voltage In-Scope Cable List (ENT000243).

**Q38. What types of materials are used as insulation in the low-voltage cables at IPEC?**

A38. (TSM, RBR) The original low-voltage cables installed at IPEC in the early 1970s are generally PVC insulated. Newer or replacement low-voltage cables that were installed at IPEC in 1990 or later generally have XLPE insulation systems. *See* IPEC Low-Voltage In-Scope Cable List (ENT000242).

**Q39. What are the basic components of a typical PILC cable?**

A39. (TSM, RBR, HGS) Figure 3, below, shows the basic components of a typical PILC cable. The conductor, conductor shield, insulation, insulation shield, and jacket are similar to the other cable examples described above. The type of insulation and the addition of the lead-alloy sheath are the major differences for this example. Specifically, PILC cables are made of copper or aluminum conductors wrapped with paper that is impregnated with dielectric fluid (*i.e.*, a compound mineral oil). The cable is jacketed with a watertight lead alloy sheath that prevents water or moisture ingress into the paper insulation. A steel tape layer or steel wires are used to provide mechanical protection. The outermost jacket of a PILC cable may be a PVC layer or other type of insulating, waterproof material.

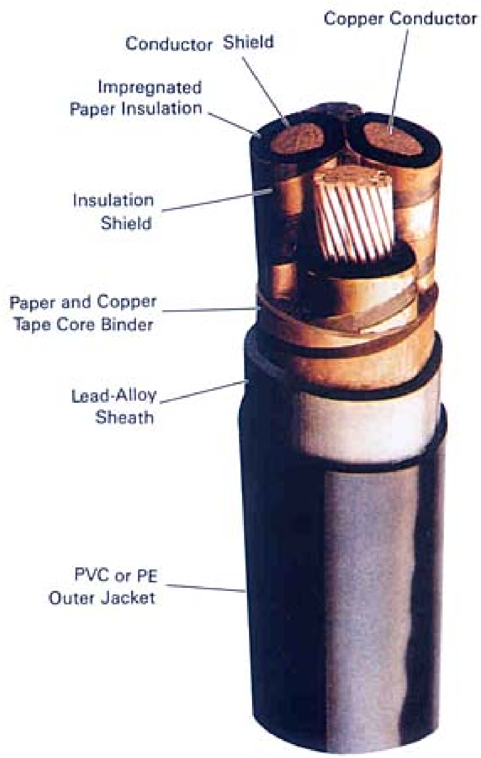



__Figure 3__. **Example of PILC cable construction**

**Q40. Your testimony also refers to cable "connections." Please define that term.**

A40. (TSM, RBR, HGS) A connection is a device used to join or fasten together cable conductors to other cables or electrical devices. Connections or terminations may include plug-in connectors, splices, terminal blocks, and fuse holders. EN-DC-348, Rev. 2 at 8 (ENT000241).

**E. __Relevant Aging Effects__**

**1. __Below-Grade Medium-Voltage and Low-Voltage Power Cables__**

**Q41. What is the principal aging mechanism of concern for the underground non-EQ *medium-voltage* cables at issue in NYS-6?**

A41. (HGS, RBR, TSM) For medium-voltage cables, the primary concern raised by NYS is the possible formation of "water trees." Bascom Testimony at 13 (NYS000136). As shown in Figure 4 below, water trees (also called electrochemical trees) are water-filled, tree-shaped formations that weaken the cable insulation by causing a decrease in the insulation's dielectric strength. Dielectric strength is a measure of the electrical strength of a material as an insulator. W. Thue (ed.), *Electrical Power Cable Engineering* at 49, 109-10 (2nd Ed. 2003) (ENT000244). It is defined as the maximum voltage required to produce a dielectric breakdown through the material and is measured in volts per unit thickness. *Id*. at 110.

**Q42. How do water trees form?**

A42. (HGS, RBR, TSM) Water trees result from water-filled micro-voids that propagate over time in cable insulation in the direction of the electrical field when energized. *See Electrical Power Cable Engineering* at 273-74 (ENT000244).

Although the mechanism for the creation and growth of water trees is not universally agreed upon, the technical community has accepted that two fundamental conditions must be present: (1) polar liquid (usually water); and (2) voltage stress, which refers to the electrical stress or voltage to which a unit thickness of insulation is subjected. *Id*. at 271, 275. Other potential contributing factors identified in the technical literature include (in no particular order of importance): aging time, material type, voids/contaminants in the insulation, temperature, temperature gradient, cable design, voltage stress magnitude, test frequency, presence of antioxidants, use of voltage stabilizers, water composition, and semiconducting layer type. *See* R. Bartnikas & K.D. Srivastava, *Power and Communication Cables: Theory and Application*, at 194-95 (Oct. 1999 (ENT000245); *Electrical Power Cable Engineering* at 271-74 (ENT000244).

**Q43. Do water trees directly cause cable insulation failure?**

A43. (HGS, RBR, TSM) No. Water-tree growth progresses very slowly at the voltage levels present in nuclear power plant cables (*i.e.*, such as those at IPEC) and takes many years to make a cable susceptible to insulation degradation. *See Electrical Power Cable Engineering* at 273 (ENT000244). A water tree may bridge the insulation from conductor to shield without resulting in a dielectric breakdown (although dielectric strength will be reduced). *Power and Communication Cables: Theory and Application* at 194 (ENT000245). However, well-developed water trees may cause voltage stress to be concentrated in an area of good insulation, eventually weakening the material to the point where it is susceptible to voltage surges that can initiate a partial discharge (*i.e.*, a localized breakdown of a small portion of an electrical insulation system under high voltage stress). *See Electrical Power Cable Engineering* at 273.

Once initiated, partial discharge causes progressive deterioration of insulating materials and can lead to an electrical cable's failure. Such failure may occur when an "electrical tree" forms in the insulation. An electrical tree is a defect that occurs in electrical insulation materials and results from the application of voltage stress in the absence of water. Electrical trees in extruded dielectric cables result from internal electrical discharges that decompose the organic materials. *See id.*

Figure 4 contains photographs of water and electrical trees (from a non-IPEC cable) supplied by a cable testing laboratory. Figure 4A shows a series of advanced water trees, starting from the insulation shield, and also an advanced electrical tree that initiated from the conductor shield. Figure 4B shows the electrical tree after the water trees were dried out in an oven.

Figure 4A. Advanced Water Trees and Advanced Electrical Tree

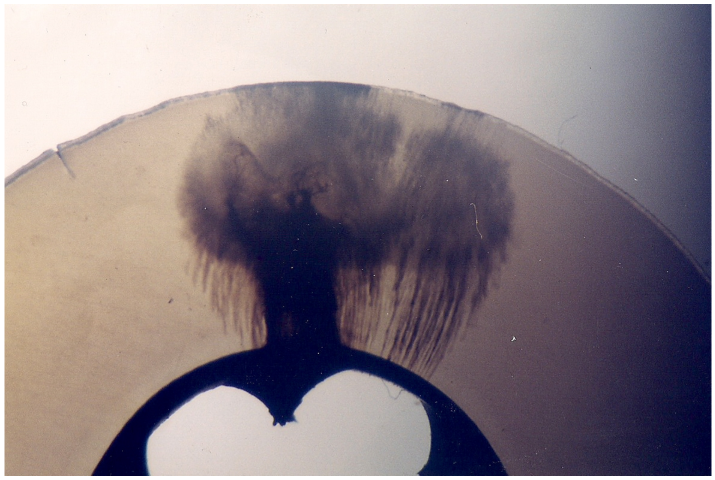
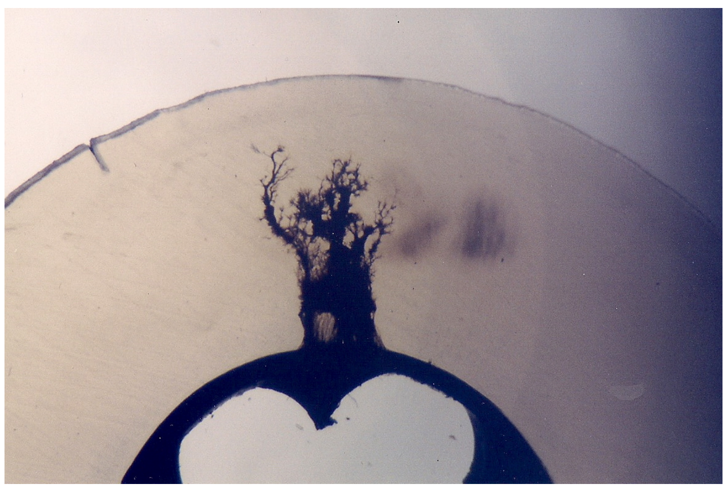


Figure 4B. Advanced Electrical Tree



<u>Figure 4</u>. **Example of Water Trees and Electrical Tree (at the Conductor Shield) in Non-IPEC Cable**
(Source: Cable Technology Laboratories)

**Q44. What is the principal aging mechanism of concern for underground non-EQ *low-voltage* cables at issue in NYS-6?**

A44. (RBR, TSM, HGS) Low-voltage cables are not expected to develop water trees, which are caused by electrical stress concentrations in the cable insulation. EPRI 1020804 at 6-1 to 6-2 (ENT000240). For water trees to incept and to grow, a minimum voltage stress is necessary. Below this voltage stress threshold, no water trees develop. Therefore, low-voltage cables that operate at significantly lower voltage stresses do not have the same susceptibility to water tree growth as medium-voltage cables, if susceptible at all. *See id*.

Nonetheless, long-term wetting of low voltage cables is assumed to have adverse effects on the cable insulation. *Id.* As explained in EPRI 1020804:

> The insulation of low-voltage power cable subjected to long-term wetting may deteriorate over time. Insulated Cable Engineers Association manufacturing standards required insulation stability testing to be performed by manufacturers to prove stability of cable insulation under wet conditions, so that no significant deterioration should occur for an extended period unless the conditions of the soil or water are particularly aggressive. In low-voltage cables, the thickness of insulation and jacketing that are used is driven by mechanical protection capabilities rather than by voltage withstand. Therefore, the voltage stress in the insulation is quite low by comparison to that of medium-voltage cable, and no electrically driven failure mechanism such as water treeing is expected to occur. Failures have occurred, possibly due to long-term chemical deterioration of jackets and insulations, but failures are more often due to installation or post-installation damage.

*Id.* at 6-1.

**Q45. In view of this guidance, what assumptions has Entergy made in the IPEC AMP?**

A45. (RBR, TSM, HGS) For purposes of the IPEC AMP, water-related degradation effects have been assumed to occur in low-voltage cables.

### 2. Above-Grade Medium-Voltage and Low-Voltage Power Cables Installed In or Near Adverse Localized Equipment Environments

**Q46. Earlier in your testimony, you referred to an adverse localized equipment environment, or ALEE, in connection with above-grade cables. Please explain that term.**

A46. (RBR, ABC) An ALEE is a localized environmental condition (*e.g.*, elevated temperature, radiation) within a nuclear power plant that exceeds the plant design basis ambient environment for the cable or connection insulation material and which, as a result, could increase the rate of aging of a component or adversely affect operability. *See* EPRI TR-109619 at 1-2 (ENT000239); NUREG-1801, Rev. 2 at XI E1-1 (NYS00147D).

**Q47. What types of ALEEs may exist at a nuclear power plant, including IPEC?**

A47. (RBR, ABC) For medium-voltage and low-voltage cables, the more common types of ALEEs include high-temperature or high-radiation under normal operating conditions, chemical or moisture contamination (a concern for unsealed terminations, such as at terminal blocks), and oil or hydraulic fluid contamination. *See* EPRI TR-109619 at 2-1 to 2-8 (ENT000239).

**Q48. Please provide an example of an ALEE.**

A48. (RBR, ABC) The most common ALEEs are those created by localized elevated temperatures. EPRI TR-109619 at 2-1 (ENT000239). The areas typically most susceptible to elevated temperatures are areas with high-temperature process fluid piping and vessels, equipment that operates at high temperature, and areas with limited ventilation. *Id.* at 2-3. For example, if the design-basis temperature for a room were 40°C (104°F), and the temperature in the vicinity of a cable within that room were 50°C (122°F), then the temperature at the cable could be an ALEE. If the localized temperature at the cable was 35°C (95°F), then the temperature would not be an ALEE because it is less than the room's design-basis temperature. Chapter 2 of EPRI TR-109619 discusses ALEE types and provides examples. EPRI TR-109619 also includes photographs of cables in plant ALEEs. *Id.* at 3-14 to 3-15 & App. B at B-1 to B-12. We discuss Entergy's specific program for managing aging degradation caused by potential ALEEs at IPEC further in Answers 74 and 75 below.

**Q49. What types of aging effects for cables may be associated with an ALEE?**

A49. (RBR, ABC) The potential aging effect for insulated cables is reduced insulation resistance. *See* NUREG-1801, Rev. 2 XI E1-2 (NYS00147D). As discussed in NUREG-1801, potentially affected electrical cables and connections installed in adverse localized environments are visually inspected for cable jacket and connection insulation surface anomalies indicating signs of reduced insulation resistance due to thermal degradation of organics, degradation of UV sensitive materials, radiation-induced oxidation, and moisture intrusion, as indicated by signs of embrittlement, discoloration, cracking, melting, swelling or surface contamination. *Id.*

## V. PART 54 REQUIREMENTS AND NRC GUIDANCE APPLICABLE TO AGING MANAGEMENT OF NON-EQ INACCESSIBLE POWER CABLES

### A. Applicable Part 54 Requirements

**Q50. Please identify and briefly describe the NRC's aging management requirements in 10 C.F.R. Part 54.**

A50. (ABC, RBR) 10 C.F.R. §§ 54.4(a)(1)-(3) outline the three general categories of SSCs falling within the scope of license renewal. From among these SSCs, license renewal applicants must identify and list, in an integrated plant assessment, those structures and components subject to an aging management review. Section 54.21 provides the standards for determining which structures and components require aging management review.

**Q51. What are the three general categories of SSCs within the initial scope of license renewal, as set forth in 10 C.F.R. § 54.4(a)(1)-(3)**?

A51. (ABC, RBR) The first category consists of all "safety-related" SSCs. 10 C.F.R. § 54.4(a)(1). These are SSCs relied upon to remain functional during and following design-basis events to ensure the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor and maintain it in a safe shutdown condition, or the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to those referred to in §§ 50.34(a)(1), 50.67(b)(2), or 100.11. *See* 10 C.F.R. § 50.2 (defining "safety-related").

The second category consists of all non-safety-related SSCs whose failure could prevent satisfactory accomplishment of any of the safety functions identified above. 10 C.F.R. §

54.4(a)(2). This category would include, for example, auxiliary systems necessary for the function of safety-related systems.

The third category consists of all SSCs relied on in safety analyses or plant evaluations to perform a function that demonstrates compliance with the NRC's regulations for fire protection (10 C.F.R. § 50.48), environmental qualification (10 C.F.R. § 50.49), pressurized thermal shock (10 C.F.R. § 50.61), anticipated transients without scram (10 C.F.R. § 50.62), and station blackout (10 C.F.R. § 50.63). 10 C.F.R. § 54.4(a)(3). These SSCs would include, for example, main or auxiliary systems necessary to meet these regulations, as defined in a plant's final safety analysis report, and a plant's fire protection systems.

**Q52. What in-scope structures and components are subject to AMR?**

A52. (ABC, RBR) If an in-scope structure or component performs no intended function as defined in 10 C.F.R. § 54.4(a)(1)-(3), then it is not subject to AMR. 10 C.F.R. § 54.4(b). Section 54.21(a)(1)(i), in turn, further limits the in-scope structures and components subject to AMR to those structures and components that "perform an intended function [as defined in § 54.4(a)(1)-(3)] . . . without moving parts or without a change in configuration or properties" and that are not subject to replacement based on a qualified life or specified time period. 10 C.F.R. § 54.21(a)(1)(i).

Given the foregoing requirements, the preparation of an LRA involves the following sequential, two-step process: (1) identification of the SSCs within the scope of the license renewal rule (as defined in 10 C.F.R. § 54.4) (also known as "scoping") and then, among those in-scope SSCs, (2) identification of the structures and components that are subject to aging management review (also known as "screening"). Screening is part of an applicant's integrated plant assessment, as defined in 10 C.F.R. § 54.21, and is performed to determine which structures and components in the scope of license renewal require aging management review.

Section 54.21(a)(1)(i) lists examples of structures and components that require aging management review. Electrical cable appears on that list. *See* 10 C.F.R. § 54.21(a)(1)(i).

**Q53. What findings must the NRC make to issue a renewed operating license?**

A53. (ABC, RBR) As a general matter, the NRC must find that there is reasonable assurance that the activities authorized by the renewed license will continue to be conducted in accordance with the plant's CLB during extended operation. 10 C.F.R. § 54.29(a); *see also* 10 C.F.R. § 54.21(a)(3). Section 54.29(a)(1) also requires a finding that the applicant has identified and has taken, or will take, actions for managing the effects of aging during the period of extended operation on the functionality of those structures and components identified as subject to AMR under Section 54.21(a)(1).

**B. <u>Relevant NRC Guidance</u>**

**Q54. What guidance documents has the NRC issued to assist license renewal applicants in meeting the requirements of 10 C.F.R. Part 54?**

A54. (ABC, RBR) The NRC Staff reviews license renewal applications in accordance with the requirements in 10 C.F.R. Part 54, as well as Staff guidance contained in NUREG-1800, "Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants," Rev. 1 (Sept. 2005) ("NUREG-1800" or "SRP-LR") (NYS000195). NUREG-1801 (the GALL Report) provides the technical basis for NUREG-1800 and identifies AMPs that the Staff has accepted as meeting the requirements of Part 54. The NRC issued Rev. 2 of NUREG-1800 and Rev. 2 of NUREG-1801 in December 2010. *See* NYS000161 and NYS00147A-D.

NUREG-1801 is treated in the same manner as an NRC-approved topical report that is generically applicable. NUREG-1801, Rev. 2 at iii. Therefore, an applicant may reference NUREG-1801 in an LRA to demonstrate that the programs at its facility correspond to those reviewed and approved by the NRC Staff in NUREG-1801. *Id.* Adherence to NUREG-1801 guidance thus constitutes one acceptable way to manage aging effects for license renewal. *Id.*

**Q55. Did Entergy follow the guidance in NUREG-1801 in preparing its LRA?**

A55. (ABC, RBR) Yes. Entergy used this guidance in evaluating the effects of aging for in-scope SSCs and in preparing the IPEC LRA. Because Entergy submitted its LRA in April 2007, the LRA followed the guidance contained in Revision 1 of NUREG-1801 (NUREG-1801, Generic Aging Lessons Learned (GALL) Report, Rev. 1 (Sept. 2005) ("NUREG-1801, Rev. 1") (NYS00146A-D). The two programs relevant here are described in Sections XI.E3 and XI.E1 of NUREG-1801. The corresponding IPEC programs are described in Sections B.1.23 (Non-EQ Inaccessible Medium-Voltage Cable Program) and B.1.25 (Non-EQ Insulated Cables and Connections Program) of the LRA. The LRA stated that both IPEC programs would be consistent with the corresponding program described in NUREG-1801, Rev. 1 without exception. *See* LRA at B-81, B-85. Thus, the IPEC programs proposed in LRA Sections B.1.23 and B.1.25 were the programs described in NUREG-1801, Rev. 1, Sections XI.E3 and XI.E1.

## VI. OVERVIEW OF APPLICABLE IPEC AGING MANAGEMENT PROGRAMS

### A. The IPEC Non-EQ Inaccessible Medium-Voltage Cable Program

**Q56. Please describe Entergy's AMP for non-EQ inaccessible (*i.e.*, underground) medium-voltage and low-voltage power cables at IPEC.**

A56. (ABC, RBR) As noted above, the relevant program is described in LRA Section B.1.23, "Non-EQ Inaccessible Medium-Voltage Cable Program." As originally submitted to the NRC in April 2007, IPEC's program applies to non-EQ inaccessible medium-voltage cables (*i.e.*, underground cables with an operating voltage from 2kV to 35kV) that have a license renewal intended function and are exposed to significant moisture simultaneously with significant applied voltage (*i.e.*, exposure to system voltage for > 25% of the time). By letters submitted in March, July, and August 2011, Entergy became one of the numerous license renewal applicants who amended its Non-EQ Inaccessible Medium-Voltage Cable Program to include low-voltage power cables (400V to 2kV). *See* NL-11-032, Letter from Fred Dacimo, Vice President, IPEC, to NRC

Document Control Desk, "Response to Request for Additional Information (RAI) Aging Management Programs," Att. 1 at 10-14 (Mar. 28, 2011) (NYS000151); NL-11-074, Letter from Fred Dacimo, Vice President, IPEC, to NRC Document Control Desk, "Response to Request for Additional Information (RAI) Aging Management Programs," Att. 1 at 15 (July 14, 2011) (NYS000152); NL-11-090, Letter from Fred Dacimo, Vice President, IPEC, to NRC Document Control Desk, "Clarification for Request for Additional Information (RAI) Aging Management Programs," Att. 1 at 1-2 (July 27, 2011) (NYS000153); NL-11-096, Letter from Fred Dacimo, Vice President, IPEC, to NRC Document Control Desk, "Clarification for Request for Additional Information (RAI) Aging Management Programs," Att. 1 at 1-3 (Aug. 9, 2011) (NYS000154). As noted above, Entergy did not change the program name after low-voltage cables were added to the scope of the program.

In addition, Entergy amended its program to increase cable testing and manhole inspections frequencies, including adding provisions to adjust frequencies if warranted by testing and inspection results. Specifically, Entergy made the following enhancements to the 10 C.F.R. Part 54 program described in LRA Sections B.1.23, A.2.1.22 and A.3.1.22, nearly all of which already are being implemented at IPEC as part of CLB requirements and in accordance with Entergy fleet procedure EN-DC-346 (ENT000237):

- The significant voltage exposure criterion (applicable to medium-voltage cable (2kV to 35kV) subjected to system voltage for more than 25% of the time) has been removed from the program screening criteria. NL-11-032, Attach. 1 at 12 (NYS000151). Previously, if a cable was energized less than 25% of the time, then it was assumed that water trees formation would be very slow to non-existent, because voltage is needed for water tree growth. Based on industry operating experience, the expansion of the program's scope to include low-voltage power cables, and the possibility of water-related degradation other than water-treeing, the significant voltage screening criterion was removed to provide more conservatism to Entergy's program. This is reflected in Entergy's Part 50 cable reliability program procedure. EN-DC-346, Rev. 2 at 3.

- The program was expanded to include 400V to 2kV in-scope inaccessible low voltage power cable. NL-11-032, Attach. 1 at 12 (NYS000151). This is reflected in Entergy's Part 50 cable reliability program procedure. EN-DC-346, Rev. 2 at 3, 8, 13-21, 28-29.

- Manhole inspection frequency was increased to occur at least annually. NL-11-032, Attach. 1 at 12 (NYS000151). This is part of Entergy's Part 50 cable reliability program procedure. EN-DC-346, Rev. 2 at 13, 20-21.

- Provisions were added to evaluate manhole inspection results to determine the need to modify the manhole inspection frequency (*e.g.*, to increase the frequency, as appropriate). NL-11-032, Attach. 1 at 12 (NYS000151). This is reflected in Entergy's Part 50 cable reliability program procedure. EN-DC-346, Rev. 2 at 21.

- Event-driven inspections of manholes (*e.g.*, following heavy rain or flooding) have been incorporated into the program. NL-11-032, Attach. 1 at 12 (NYS000151). This is not currently part of Entergy's Part 50 cable reliability program procedure.

- All inaccessible low-voltage and medium-voltage cables (400V to 35kV) will be tested for degradation of cable insulation at least once every six years. NL-11-032, Attach. 1 at 12 (NYS000151). This is reflected in Entergy's Part 50 cable reliability program procedure. EN-DC-346, Rev. 2 at 19.

- Cable test results are evaluated to determine the need for more frequent testing. NL-11-032, Attach. 1 at 12 (NYS000151). This is reflected in Entergy's Part 50 cable reliability program procedure. EN-DC-346, Rev. 2 at 17-20.

**Q57. Did Entergy expand the program scope described in LRA Section B.1.23 to include inaccessible low-voltage cables in response to specific events or conditions at IPEC?**

A57. (ABC, RBR) No. Entergy revised the program in response to ongoing NRC-industry correspondence regarding GL 2007-01 (discussed further in Answer 67) concerning non-EQ inaccessible low-voltage cables – not in response to IPEC operating experience. *See* NL-11-032, Attach. 1 at 10-11 (NYS000151).

**Q58. How does the IPEC Non-EQ Inaccessible Medium-Voltage Cable Program compare to the corresponding program described in Revisions 1 and 2 of NUREG-1801?**

A58. (ABC, RBR) The Non-EQ Inaccessible Medium-Voltage Cable Program described in LRA Section B.1.23 incorporates the ten program attributes described in Section XI.E3 (Inaccessible Medium-Voltage Cables Not Subject To 10 CFR 50.49 Environmental Qualification Requirements) of NUREG-1801, Rev. 1. The IPEC program was revised to also include non-EQ inaccessible low-voltage (400V to 2kV) cables that have a license renewal intended function. Based on our review of the relevant documentation, we conclude that Entergy's revised program also is consistent with the program described in Section XI.E3 of NUREG-1801, Rev. 2 (which includes non-EQ inaccessible low-voltage cables).

**Q59. Has Entergy developed a specific procedure for implementing the Non-EQ Inaccessible Medium-Voltage Cable Program described in LRA Section B.1.23?**

A59. (ABC, RBR, TSM) Yes. The LRA Section B.1.23 program (which, as modified in 2011, now includes low-voltage power cables) will be implemented using fleet procedure EN-DC-346 (ENT000237). Entergy developed EN-DC-346 to address CLB issues related to below-grade power cables at all Entergy nuclear power plants, including IPEC. The procedure is being implemented as part of current plant operations, as regulated by the NRC under Part 50.

**Q60. Does EN-DC-346 take into account current industry guidance?**

A60. (ABC, RBR, TSM) Yes. Section 2.0 of EN-DC-346 lists the specific documents used to develop and implement the procedure. They include the following key documents:

- NEI 06-05, *Medium Voltage Underground Cable White Paper* (Apr. 2006) (ENT000234);
- EPRI 1021070, *Medium Voltage Cable Aging Management Guide*, Rev. 1 (Dec. 2010) (ENT000238);

- EPRI 1020805, *Plant Support Engineering: Aging Management Program Guidance for Medium-Voltage Cable Systems for Nuclear Power Plants* (June 2010) (NYS000158); and

- EPRI 1020804, *Plant Support Engineering: Aging Management Program Development Guidance for AC and DC Low-Voltage Power Cable Systems for Nuclear Power Plants* (June 2010) (ENT000240).

EN-DC-346, Rev. 2 references numerous other documents, including applicable IEEE standards for cable testing.

**Q61. What specific actions will Entergy take to ensure the continuing reliability of in-scope medium- and low-voltage cables and reduce the likelihood of in-service cable failures during the period of extended operation?**

A61. (ABC, RBR) As described in the revised LRA Section B.1.23 program and in EN-DC-346, Entergy will: (1) conduct regular inspections and dewatering (as necessary) of manholes that contain medium-voltage and low-voltage cables covered by the program; and (2) establish and monitor cable insulation condition using appropriate testing, evaluation methods, and test result trending. NL-11-032, Attach. 1 at 12-14 (NYS000151); EN-DC-346 § 5.7 (ENT000237). We discuss these actions further below.

**Q62. With regard to the first action, how often will Entergy perform manhole inspections during the extended operating period, and what will those inspections entail?**

A62. (ABC, RBR) Entergy has revised its program described in LRA B.1.23 to require that manhole inspections be performed at least annually, with the first inspection for license renewal occurring before each unit begins extended operations. NL-11-032, Attach. 1 at 12 (NYS000151). Qualified personnel will perform manhole inspections in accordance with approved site procedures. *See* 0-ELC-418-GEN, Rev. 3 (Oct. 27, 2011) (ENT000247). During inspections—which are in addition to regular preventive maintenance activities—inspectors will directly observe cables in manholes to determine whether they are wetted or submerged, and to confirm that cables/splices and cable support structures are intact. *Id*. Based on the extent of water accumulation observed during preventive maintenance activities and inspections, Entergy will adjust the inspection frequency, with a *minimum* frequency of once per year. In addition, IPEC will evaluate the condition of support structures (*e.g.*, brackets and trays) and the manholes and vaults to confirm that no significant deterioration has occurred. Independent of manhole inspection results, IPEC will perform tests, as required by the LRA Section B.1.23 program, to assess the extent of cable degradation, if any.

**Q63. Please describe the preventive maintenance activities mentioned above.**

A63. (ABC, RBR) In accordance with EN-DC-346, Entergy performs regular preventive maintenance activities, during which it opens manholes, inspects them for water, and pumps any standing water out of the manholes. EN-DC-346, Rev. 2 at 20-21 (ENT000237). These preventive maintenance activities are performed at frequencies ranging from once a month to once every four months (depending on the specific manhole). Again, these activities are in addition to the minimum annual manhole inspections to which Entergy has committed to as part of its revised license renewal AMP. Exhibit ENT000248 lists those IPEC manholes containing cables that are subject to regular preventive maintenance activities. *See* Manhole Preventive Maintenance Frequencies (Mar. 2012) (ENT000248).

**Q64. How often will IPEC test cables within the scope of the Non-EQ Inaccessible Medium-Voltage Cable Program, as revised in 2011?**

A64. (ABC, RBR) In accordance with Entergy's 2011 revisions to the LRA program as governed by license renewal Commitment 15, in-scope medium-voltage cables (2kV to 35kV) and low-voltage power cables (400V to 2kV) will be tested before extended operation of IP2 and IP3 begins, and at least once every six years thereafter, to provide an indication of the conductor insulation condition. NL-11-032, Attach. 1 at 12 (NYS000151).

**Q65. Has the NRC Staff specifically recommended use of a minimum cable test frequency of once every six years?**

A65. (ABC, RBR, HGS) Yes. NUREG-1801, Rev. 2 states as follows:

> For power cables exposed to significant moisture, test frequencies are adjusted based on test results (including trending of degradation where applicable) and operating experience. Cable testing should occur at least once every 6 years. A 6-year interval provides multiple data points during a 20-year period, which can be used to characterize the degradation rate. This is an adequate period to monitor performance of the cable and take appropriate corrective actions since experience has shown that although a slow process, aging degradation could be significant.

NUREG-1801, Rev. 2 at XI E3-2 (NYS00147D).

**Q66. Does IPEC operating experience involving non-EQ inaccessible medium-voltage and low-voltage cables support the use of a six-year cable test interval?**

A66. (ABC, RBR) Yes. In nearly 40 years of operation, there have been no cable faults or failures at IPEC due to aging effects. This fact is documented in Entergy's response to Generic Letter ("GL") 2007-01, "Inaccessible or Underground Power Cable Failures that Disable Accident Mitigation Systems or Cause Plant Transients" (Feb. 7, 2007) (NYS000149) and in a subsequent RAI response that Entergy submitted on the docket of this proceeding. *See* NL-11-032, Attach. 1 at 11 (NYS000151).

**Q67. What is GL 2007-01?**

A67. (ABC, RBR, TSM) The NRC Staff began a detailed review of underground electrical power cables after some plants identified moisture-induced cable failures. GL 2007-01 at 2 (NYS000149). The failed cables were exposed to water, condensation, and other environmental stressors. *Id*. On February 7, 2007, the NRC Staff issued GL 2007-01 to gather information on underground cable failures, for all cables that are within the scope of 10 CFR § 50.65 (the maintenance rule) and for all voltage levels. The NRC Staff requested that reactor licensees supply failure data on inaccessible low- and medium-voltage power cables (between

480V and 35,000V), and also describe the condition monitoring and test methods in use for assessing the condition of inaccessible cable. *Id.* at 4.

**Q68. When did Entergy submit its IPEC-specific response to GL 2007-01, and what did that response state with respect to cable failures?**

A68. (ABC, RBR, TSM) Entergy submitted its response to GL 2007-01 on May 7, 2007. *See* NL-07-055 (ENT000236). Entergy identified only two IP3 cable failures within the scope of GL 2007-01 (occurring in 1994 and 2005), and no IP2 cable failures based on its review of plant records. *Id*. at 2. Both IP3 failures involved low-voltage power cables, and the failures resulted from mechanical damage to the cables, *not* aging effects. *Id.*, Attach. 1 at 1. Both failed IP3 cables were within the maintenance rule's scope and were replaced with appropriate new cables. *Id.* Notably, one of the defective cables was identified by testing conducted prior to its failure; *i.e.*, the event involved a failure to meet a test acceptance criterion, not a failure while it was in-service. *Id.* NL-07-055 provides information concerning the cable type, voltage class/service, manufacturer, number of years in service, type of service, and root cause of the cable failure.

**Q69. Have there been any age-related failures of low-voltage or medium-voltage cables at IPEC since Entergy submitted its response to GL 2007-01?**

A69. (ABC, RBR, TSM) No. As discussed in NL-11-032, searches of plant-specific operating experience since the May 7, 2007 response to GL 2007-01 identified one IP2 cable failure and no IP3 failures of low or medium-voltage power cables that are in the scope of the maintenance rule or license renewal rule. NL-11-032, Att. 1 at 11 (NYS000151). The IP2 cable failure resulted from mechanical damage to the cable, *not* aging effects. *Id*.

**Q70. Looking forward, what measures will Entergy take if future testing identifies aging degradation of non-EQ inaccessible medium- or low-voltage power cables?**

A70. (ABC, RBR) Entergy will evaluate any degradation detected during testing under the IPEC Corrective Action Program: a CLB program found acceptable by the NRC Staff. Specifically, Entergy will evaluate and take any necessary corrective actions in accordance with the requirements of 10 C.F.R. Part 50 and Entergy procedure EN-LI-102, "Corrective Action Process," Rev. 17 (Dec. 8, 2011) (ENT000249). Such an evaluation would consider the significance of the test or inspection results, the operability of the component, the reportability of the event, the extent of the concern, the potential root causes for not meeting the test or inspection acceptance criteria, the corrective actions required, and actions to minimize the likelihood of recurrence.

**Q71. Why does the IPEC Non-EQ Inaccessible Medium-Voltage Cable Program provide reasonable assurance that medium- and low-voltage power cables covered by the program will continue to perform their intended functions throughout the period of extended operation?**

A71. (ABC, RBR, TSM) The Non-EQ Inaccessible Medium-Voltage Cable Program described in LRA Section B.1.23 references, and is consistent with, the corresponding program described in NUREG-1801, Rev. 2, Section XI.E3. *See* NL-11-032, Attach. 1 at 13 (NYS000151). Section XI.E3 specifically states: "This AMP provides reasonable assurance [that] the insulation material for electrical cables and connections will perform its intended function for the period of extended operation." NUREG-1801, Rev. 2 at XI E1-1 (NYS00147D).

As noted previously in Answer 56, the manhole inspection and cable testing methods and frequencies required by the Non-EQ Inaccessible Medium-Voltage Cable Program are based on industry operating experience and consistent with NUREG-1801 and industry guidance. The manhole inspections will minimize cable exposure to moisture and thus minimize the potential for water-related degradation in underground cables. The cable tests will confirm that the cable insulation remains in acceptable condition during the period of extended operation.

Furthermore, the IPEC cable performance history is very good. There have been no cable faults or failures due to aging effects. The few failure events that have occurred (one of which was detected through cable testing) were not the result of aging degradation. *See* Answers 68 and 69, *supra*. Nonetheless, consistent with license renewal Commitment 40, the Non-EQ Inaccessible Medium Voltage Cable Program specifies that cable inspection and test frequencies will be increased if necessary based on cable testing and manhole inspection results. EN-DC-346, Rev. 2 at 21 (ENT000237). Finally, Entergy will incorporate lessons learned from future industry and IPEC operating experience, including test and inspection results obtained during the program's implementation. *Id*. at 13-14.

In view of the above, there is reasonable assurance that the medium-voltage and low-voltage power cables covered by the IPEC Non-EQ Inaccessible Medium-Voltage Cable Program will continue to perform their intended functions during the period of extended operations.

**Q72. Dr. Sedding, based on your independent review of the program, do you agree that IPEC's Non-EQ Inaccessible Medium-Voltage Cable Program provides the reasonable assurance required by NRC regulations?**

A72. (HGS) Yes. I have reviewed the cable program from the perspectives of compliance with NRC requirements/licensee commitments, in particular, and technical requirements in general. Among other things, I have carefully considered the specific cable designs in use at IPEC, the plant operating experience, and Entergy's AMP and implementing procedure. My overall impression of the program, as detailed in the program-implementing procedure, EN-DC-346 (Cable Reliability Program), is that it is comprehensive and contains the required elements of a credible and robust methodology for cable aging management, including periodic manhole monitoring/dewatering and cable testing, for the extended 20-year renewal period.

The numerous technical references on which the program relies, which include the relevant EPRI cable-related studies and IEEE standards applicable to cable testing, provide a solid and appropriate foundation for the program. They also provide additional, detailed guidance to those responsible for implementing the IPEC program. I contributed to the development of EPRI 1020804 and 1020805, two of the key EPRI documents on which the IPEC program is based. Therefore, I am very familiar with the guidance and recommendations set forth in those documents, including their technical bases and the necessary attributes for a robust program that provides the requisite reasonable assurance.

As shown in the IPEC Medium-Voltage and Low-Voltage In-Scope Cable Lists (ENT000243 and ENT000242), the vast majority of in-scope IPEC cable systems were installed with lead sheaths. This fact is significant. The presence of an intact lead sheath serves as a water-impervious barrier. Consequently, the probability of cable insulation degradation due to moisture ingress causing water treeing in these cables is low. This is borne out by the IPEC operating experience. As noted above, there have been no aging-related cable failures or faults of such cables at IPEC to date. This indicates that the installed cables are of good quality and/or are not exposed to environments conducive to the growth of water trees.

The insulation for IPEC cables that perform license renewal intended functions includes PVC, PILC, XLPE, and EPR cable insulation systems. The XLPE and EPR cable insulation systems are newer, having been installed since 1990 and as recently as 2006. *See* IPEC Medium-Voltage In-Scope Cable List (ENT000243); IPEC Low-Voltage In-Scope Cable List (ENT000242). This is significant insofar as the level of cable insulation breakdown over the years has decreased, largely due to improvements in compounds (such as XLPE and EPR) and cable manufacturing practices. *See, e.g.*, *Power and Communication Cables* at 194-95

(ENT000245). Both XLPE and EPR cable insulations are manufactured to meet a number of mechanical, thermal and chemical requirements, and to have high breakdown strength and low dielectric losses. *Id***.**

The PILC cables, while older, have been used by the distribution industry since the early 20th century. Notably, many of these cables are still in service after 60 to 70 years. *See*, *e.g.,* V. Yaroslavskiy, V., Katz, C., Olearczyk, "Condition Assessment of Belted PILC Cables After 7 to 68 Years of Service, *IEEE Transactions on Power Delivery* (July 2011) (ENT000246). These cables are highly reliable due, in large part, to the presence of the outer lead sheath, as discussed previously in Answer 39.

The specific medium-voltage and low-voltage cable tests identified by Entergy in its program implementing procedure are discussed later in this testimony. *See* Answers 113 and 115, *infra*. In my opinion and experience, the particular tests and acceptance criteria selected by Entergy are appropriate for their intended purposes. Entergy's procedure, moreover, permits the use of industry-recommended methods at the time the tests are performed. *See* EN-DC-346, Rev. 2 at 14, 18 (ENT000237). This allows for any necessary adjustments to cable testing methods and acceptance criteria as the state-of-the-art evolves.

The design characteristics and operating experience of the in-scope IPEC medium-voltage and low-voltage cables indicate that the minimum testing frequency of at least once every six years recommended by the NRC in NUREG-1801 is adequate. *See* NUREG-1801, Rev. 2 at XI E3-2 (NYS00147D). In addition, I conclude that the program is capable of detecting the types of degradation mechanisms known to affect underground cables that may be subject to long-term wetting. In conclusion, I agree that Entergy's AMP, if implemented in accordance with EN-DC-346, provides the reasonable assurance required by the NRC.

**Q73. Did the NRC Staff find the IPEC Non-EQ Inaccessible Medium-Voltage Cable Program to be acceptable to meet Part 54 requirements?**

A73. (TCM, ABC, RBR, HGS) Yes. As documented in its SER and Supplemental SER, the Staff performed a detailed review of Entergy's program. *See* NUREG-1930, Vol. 2 at 3-31 to 3-33 (NYS00326B); NUREG-1930, Supp. 1 at 3-5 to 3-9 (NYS000160). The Staff found that the Non-EQ Inaccessible Medium-Voltage Cable Program is consistent with NUREG-1801 Section XI.E3, and that the program enhancements, including the addition of 400V to 2kV power cables, are consistent with current industry operating experience and NRC recommendations. NUREG-1930, Supp. 1 at 3-9. The Staff also reviewed Entergy's UFSAR supplement and concluded that it provides an adequate summary description of the program, as required by 10 C.F.R. § 54.21(d). *Id.* On the basis of these findings, the Staff concluded that Entergy has demonstrated that the pertinent aging effects will be adequately managed so that the intended function(s) will be maintained consistent with the current licensing basis during extended operations, as required by 10 C.F.R. § 54.21(a)(3). *Id.*

**B. <u>The IPEC Non-EQ Insulated Cables and Connections Program</u>**

**Q74. Please describe the IPEC aging management program for non-EQ inaccessible medium-voltage and low-voltage power cables that may be affected by adverse localized equipment environments, or ALEEs.**

A74. (ABC, RBR) As stated above, the applicable program is described in Section B.1.25 of the IPEC LRA. LRA (ENT00015B) at B-85 to B-86. The Non-EQ Insulated Cables and Connections Program is the same as the program described in NUREG-1801, Rev. 1, Section XI.E1, "Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements" and NUREG-1801, Rev. 2, Section XI.E1, "Insulation Material for Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements."

**Q75. What cables are included within the scope of the Non-EQ Insulated Cables and Connections Program?**

A75. (ABC, RBR) The IPEC Non-EQ Insulated Cables and Connections Program encompasses all aboveground non-EQ insulated (medium-voltage and low-voltage) cables and connections that may be exposed to a potential ALEE, regardless of whether they are readily accessible and easily approached and viewed. *See* NUREG-1930, Vol. 2 at 3-37 (NYS00326B).

**Q76. What types of inspections did Entergy commit to perform in LRA Section B.1.25?**

A76. (ABC, RBR) The LRA Section B.1.25 program commitment is to identify ALEEs at IPEC, and to inspect the accessible cables located in the ALEEs. Specifically, in response to an NRC Staff audit question, Entergy revised LRA Sections B.1.25, A.2.1.24, and A.3.1.24 to clarify that the program sample consists of *all* accessible cables and connections in localized adverse environments. That is, Entergy committed to visually inspect all accessible insulated cables and connections in identified ALEEs for cable and connection jacket surface anomalies, such as embrittlement, discoloration, cracking or surface contamination. NL-07-153, Letter from Fred Dacimo, Site Vice President, IPEC, to NRC Document Control Desk, "Amendment I to License Renewal Application (LRA)," Attach. 1 at 24-25 (Dec. 18. 2007) ("NL-07-153") (NYS000159). As explained below, the implementation procedure (EN-DC-348) for the LRA Section B.1.25 program actually exceeds the program commitment.

**Q77. Has Entergy developed a specific procedure for implementing its Non-EQ Insulated Cables and Connections Program?**

A77. (ABC, RBR) Yes. Entergy has developed a procedure to implement the LRA program for all of the Entergy plants seeking renewed operating licenses. Specifically, the implementation instructions for IPEC are contained in fleet procedure EN-DC-348 (ENT000241).

**Q78. Does EN-DC-348 take into account NRC requirements and guidelines and related industry guidance?**

A78. (ABC, RBR) Yes. EN-DC-348 takes into account initial licensing requirements and Entergy license renewal commitments, NRC regulations and guidelines, industry guidelines (EPRI, IEEE), operating experience with plant cables, cable failure trending analysis, and cable manufacturer recommendations. Section 2.0 of EN-DC-348 lists the documents used to develop and implement the Non-EQ Insulated Cables and Connections Inspection Program. EN-DC-348 also is based on the guidance contained in EPRI 1020804 (ENT000240) and EPRI TR-109619 (ENT000239).

**Q79. How are cable inspections performed under EN-DC-348?**

A79. (ABC, RBR) The implementing procedure, EN-DC-348, uses a "plant spaces" approach, which means that *all* accessible plant areas are examined for possible ALEEs using bounding parameters for temperature and radiation. EN-DC-348, Rev. 2 at 9, 12-13 (ENT000241). During these inspections, *all* accessible cables are visually inspected for insulation or jacket surface anomalies. *Id.* at 13. This approach is more robust than the LRA Section B.1.25 program commitment, because it involves inspections of all accessible cables, regardless of whether they are located in or near an ALEE.

The IPEC corrective action process is used to evaluate *inaccessible* cables located in an ALEE and to determine if further actions are needed. *See* EN-LI-102, "Corrective Action Process," Rev. 17 (Dec. 8, 2011) (ENT000249). Specifically, if an unacceptable condition or situation is identified during a visual inspection, then Entergy will determine whether the same condition or situation is applicable to other cables or connections (accessible and inaccessible). If it is applicable, then appropriate corrective action is taken. *See* EN-DC-348, Rev. 2 at 12, 21. Potential corrective actions include testing cables, shielding cables (or otherwise changing their environments), or relocating or replacing the affected cables or connections. NUREG-1801, Rev. 2 at XI E1-2 (NYS00147D).

**Q80. How do inspectors determine which plant areas are ALEEs, and ensure that such areas are adequately inspected?**

A80. (ABC, RBR) As detailed in Section 5.4 of EN-DC-348, IPEC inspectors engage in substantial preparations before inspecting cables and connections. Specifically, inspectors:

- Conduct interviews with Maintenance, Engineering, and Operations personnel to collect information relating to the existence of potential ALEEs and any known cable issues. EN-DC-348, Rev. 2 at 14 (ENT000241).

- Review temperature monitoring data taken since the prior inspection and the design data found in the site EQ documents. *Id.*

- Conduct an operating experience review using the IPEC condition reporting system, which includes industry operating experience since the date of the prior inspection or license renewal operating experience search. The review considers operating experience related to ALEEs, hot spots, environmental changes, cables, and insulating materials that may be related to the long-term performance of the cables within the scope of the procedure. *Id.* at 15.

- Review current radiation protection ("RP") surveys, EQ data, or area radiation monitor data for areas containing in-scope cable to determine the maximum general area dose rate and any hot spots within each room. *Id.*

- Prepare an inspection plan that identifies all locations that will be inspected based on in-scope structures and making use of available RP dose maps to identify potential or actual ALEE locations in relation to major structures or equipment. *Id.* at 17.

- Review the inspection plan for each tour with appropriate plant personnel (*i.e.*, Radiation Protection, Operations, Work Week Manager, or Outage Control Center). *Id.*

- Collect all required tools and equipment (e.g., high-intensity flashlight, inspection mirror, digital camera, thermometers, ALEE data sheets), prior to the specific inspection and ensure that they are in good working order and properly calibrated, if applicable. *Id.*

- Review current EPRI guidance (*e.g.*, EPRI Report No. 1001391 – Training Aids for Visual and Tactile Inspection of Electrical Cables for Detection of Aging) before performing the inspection. *Id.*

**Q81. How are inspections conducted?**

A81. (ABC, RBR) Inspections of non-EQ low-voltage cables are strictly visual inspections that avoid damaging components. EN-DC-348 at 18 (ENT000241). No equipment, piping, cable, or connection is manipulated by hand or with a tool or instrument. *Id*. Inspectors may use high-intensity flashlights (as needed and appropriate), digital cameras with optical zoom lenses, binoculars/spotting scopes, and handheld/non-contact thermometers. *Id*. at 20.

**Q82. What do inspectors look for in identifying potential ALEEs?**

A82. (ABC, RBR) As reflected in the EN-DC-348 ALEE Inspection Data Sheet, inspectors look for evidence of elevated temperatures (> 112 °F), high radiation (> 3805 mrad/hr), moisture, and close proximity to fluorescent lighting (within six inches). EN-DC-348 at 30 (Attach. 9.4) (ENT000241). Inspectors also look for evidence of borated water leakage; unusual vibrations, sounds, and odors; and corrosion/rusting. *Id*. at 16 (Tbl. 5.4-1) & 30 (Attach. 9.4).

**Q83. What cable aging effects do inspectors look for during an inspection?**

A83. (ABC, RBR) The relevant cable "aging effect" is reduced insulation resistance. NUREG-1801, Rev. 2 at XI E1-2 (NYS00147D); EN-DC-348, Rev. 2 at 9 (ENT000241). Inspectors look for indications of cable jacket degradation because it is the precursor to cable insulation degradation. NUREG-1801, Rev. 2 at XI E1-2; EN-DC-348, Rev. 2 at 9. Indications of potential cable degradation include, for example, embrittlement, cracking, melting, swelling, and discoloration of electrical insulation or jackets. NUREG-1801, Rev. 2 at XI E1-2; EN-DC-348, Rev. 2 at 19-20. Attachment 9.1 to EN-DC-348, Rev. 2 lists specific cable conditions that could be identified during inspections and possible causes for those conditions. EN-DC-348, Rev. 2 at 25-27. Attachment 9.1 is based on prior industry inspections of nuclear power plant cables and other relevant operating experience. *Id.* at 21.

**Q84. How do inspectors record or document ALEEs and observed cable degradation?**

A84. (ABC, RBR) If evidence of a potential ALEE is found, then the inspector records the cable number, cable tray, or conduit markings and distinguishing features on the ALEE

Inspection Data Sheet (Attach. 9.4 to EN-DC-348) and attaches notes (written or transcribed from voice recorder), comments, or drawings. EN-DC-348, Rev. 2 at 14, 19-22, 30-31 (ENT000241). The inspector takes clear digital images of suspected ALEE sources and cables and connections in the immediate area and provides sufficient information to allow identification of the ALEE and affected cables (wide-angle photographs, photo captions, height from floor elevation, other relevant directional bearings, etc.). *Id.* at 20. While unrelated to aging management, inspectors also document observed design or installation deficiencies, if any. *Id.* at 19.

The inspectors then conduct a post-inspection de-brief with the Program Coordinator, who is responsible for determining whether additional activities or notifications are required based on the inspection results. *Id.* at 21-22. Such activities may include evaluation of identified conditions within the corrective action process (*i.e.*, issuance of a condition report) or the work management process (*i.e.*, engineering evaluations) in accordance with Entergy procedures. *Id.* at 21. The results of the inspection are documented in an ALEE Cable and Connection Summary Report, the specific contents of which are outlined in Attach. 9.3 to EN-DC-348. *Id.* at 23, 29.

**Q85. How does Entergy determine whether any additional actions are necessary?**

A85. (ABC, RBR) All accessible cables and connections must be free from unacceptable visual indications of surface anomalies indicating cable jacket, conductor insulation, or connection degradation. EN-DC-348, Rev. 2 at 21 (ENT000241). An unacceptable indication is a condition or situation that, if left unmanaged, could lead to a loss of intended function. *Id.* In determining whether corrective action or further evaluations are necessary, IPEC personnel consider the age and operating environment of the component, the severity of the anomaly, and whether such an anomaly previously has been correlated to degradation of conductor insulation or connections. *Id.*

**Q86. What are the possible specific corrective actions?**

A86. (ABC, RBR) Consistent with NUREG-1801, corrective actions may include, but are not limited to, testing cables, shielding cables (or otherwise changing their environments), or relocating or replacing the affected cables or connections. NUREG-1801, Rev. 2 at XI E1-2 (NYS00147D). When an unacceptable condition or situation is identified, plant personnel determine whether the same condition or situation is applicable to inaccessible cables or connections. Any corrective action actions are performed in accordance with the IPEC corrective action program, as required by 10 C.F.R. Part 50. *Id.*; EN-DC-348, Rev. 2 at 12, 21-22 (ENT000241).

**Q87. Why does the IPEC Non-EQ Insulated Cables and Connections Program provide reasonable assurance that medium- and low-voltage power cables will continue to perform their intended functions during the period of extended operation?**

A87. (ABC, RBR) The Non-EQ Insulated Cables and Connections Inspection Program described in LRA Section B.1.25 references, and is consistent with, the corresponding program described in NUREG-1801, Section XI.E1. Section XI.E1 specifically states that the AMP described in the guidance "provides reasonable assurance [that] the insulation material for electrical cables and connections will perform its intended function for the period of extended operation." NUREG-1801, Rev. 2 at XI E1-1 (NYS00147D). Thus, implementing this program at IPEC in the manner described above assures maintenance of the intended functions of accessible and inaccessible insulated cables and connections exposed to adverse environments of heat, radiation, and moisture throughout the period of extended operation.

**Q88. Did the NRC Staff find that the IPEC Non-EQ Insulated Cables and Connections Program is acceptable and meets 10 C.F.R. Part 54 requirements?**

A88. (ABC, RBR) Yes. On the basis of its audit and review of Entergy's Non-EQ Insulated Cables and Connections Program, the Staff found all program elements to be consistent with the NUREG-1801 program elements. NUREG-1930, Safety Evaluation Report Related to the License Renewal of Indian Point Nuclear Generation Units Nos. 2 and 3, Vol. 2 at 3-38 (Nov. 2009) ("SER"). With respect to this program, the Staff concluded that Entergy has demonstrated that the effects of aging will be adequately managed so that its intended functions will be maintained consistent with the IP2 and IP3 CLBs for the period of extended operation, as required by 10 C.F.R. § 54.21(a)(3). *Id.* The Staff also reviewed the Updated Final Safety Analysis Report ("UFSAR") supplement for this program and concluded that it provides an adequate summary description of the program, as required by 10 C.F.R. § 54.21(d). *Id.*

## VII. RESPONSES TO ISSUES RAISED IN CONTENTION NYS-6 AND MR. BASCOM'S ASSOCIATED TESTIMONY AND REPORT

### A. Contrary to New York State's Claim in Its Petition to Intervene, Entergy Has Disclosed Its Aging Management Program for Non-EQ Inaccessible Medium-Voltage and Low-Voltage Power Cables

**Q89. In NYS-6, NYS suggested that Entergy has not provided access to its aging management program for non-EQ inaccessible medium-voltage cables and to certain related EPRI guidance documents. NYS Petition at 93-94. Is that an accurate statement?**

A89. (ABC, RBR) No. In its LRA, Entergy described its proposed AMP for non-EQ inaccessible medium-voltage cables as equivalent (without exception) to Section XI.E3 of NUREG-1801, Rev. 1. *See* LRA, App. B at B-81 (ENT00015B). Furthermore, since the admission of NYS-6/7, Entergy has provided substantial additional information concerning its program, including supporting documentation and implementing procedures discussed herein, through docketed submittals to the NRC and mandatory disclosures to NYS. *See*, *e.g.*, Answer 56, *supra*.

**Q90. As submitted in November 2007, NYS-6 also alleged that Entergy has failed to address specific recommendations from certain NRC and Sandia guidance documents. NYS Petition at 95-100. Please identify the referenced documents.**

A90. (ABC, RBR) NYS-6 references the following documents: NUREG/CR-5643, *Insights Gained From Aging Research* (Mar. 1992); SAND96-0344, *Aging Management Guideline for Commercial Nuclear Power Plants – Electrical Cables and Terminations* (Sept. 1996) (NYS00156A-E); NUREG-1801, Vol. 2, Rev. 1 (NYS00146A-C); and NRC Generic Letter 2007-01, "Inaccessible or Underground Power Cable Failures that Disable Accident Mitigation Systems or Cause Plant Transients" (Feb. 7, 2007) (NYS000149). NRC Generic Letter 2007-01, including Entergy's response thereto, is discussed in Answers 66 to 69 above.

**Q91. What is your response to NYS's allegation that Entergy has failed to consider recommendations contained in the above-listed documents?**

A91. (ABC, RBR) That claim is unfounded. As an initial matter, the NRC Staff has confirmed, through its independent safety review of the IPEC LRA, that Entergy's AMP for non-EQ inaccessible medium-voltage cables is consistent with the program described in LRA Section B.1.23, which references Section XI.E3 of NUREG-1801. Supplemental SER at 3-9 (NYS000160). In turn, Section XI.E3 explicitly states: "This program considers the technical information and guidance provided in NUREG/CR-5643, IEEE Std. P1205-2000, SAND96-0344, and EPRI TR-109619." NUREG-1801, Vol. 2, Rev. 1 at XI E1-3 (NYS00147D). Entergy's program-implementing procedure (EN-DC-346) also specifically references NUREG/CR-5643, SAND96-0344, and EPRI TR-109619 as relevant information sources. EN-DC-346 at 4-6 (ENT000237). Therefore, the IPEC Non-EQ Inaccessible Medium-Voltage Cable Program and implementing procedure fully consider the recommendations contained in the documents cited by NYS.

**Q92. What is NUREG/CR-5643 and how is relevant here?**

A92. (ABC, RBR) NUREG/CR-5643 was published in 1992 to consolidate research results from various assessments of component and system aging sponsored by the NRC to better understand and manage the aging of numerous nuclear power plants SSCs, including cables. NUREG/CR-5643, Insights Gained from Aging Research at vii (Mar. 1992) (ENT000250). For cables, it incorporates the results of cable-related research performed by Sandia. *Id*. at viii. For each SSC, NUREG/CR-5643 summarized the available research results and provided a short "aging assessment guide." *See, e.g., id.* at Cables section, at 5. The information and recommendations contained in NUREG/CR-5643, which is now 20 years old, largely have been superseded by subsequent research and guidance, as discussed below.

**Q93. What is SAND96-0344 and how is relevant here?**

A93. (ABC, RBR) SAND96-0344 was issued over 15 years ago in September 1996. SAND96-0344, Aging Management Guideline for Commercial Nuclear Power Plants – Electrical Cable and Terminations (Sept. 1996) (NYS000156A). It analyzed potential aging mechanisms and their effects on low-voltage and medium-voltage electrical cables and terminations using cable problem and failure data, such as the INPO Nuclear Plant Reliability Data System and License Event Reports, as well as EPRI studies such as TR-103834-Part 1. *Id*. at 2-2 to 2-3. SAND-96-0344 concluded that, while wetting concurrent with operating voltage stress can produce significant aging effects on medium-voltage power cable, "[t]he number of cable and termination failures during normal operating conditions (all voltage classes) that have occurred throughout the industry is extremely low in proportion to the amount of cables and terminations." *Id*. at 3-54 . SAND-96-0344 thus cast the available industry operating experience in a positive light.

SAND-96-0344 proposed a six-step methodology for performing an aging management review for electrical cable and terminations that remains generally valid today. *Id.* at 6-8 to 6-18 (NYS000156C). Steps 1 and 2 focus on identifying the subset of the plant's circuit population that may require additional aging management. *Id*. at 6-9 to 6-14. Step 3 recommends examining plant-specific historical data to further refine this subset. *Id.* at 6-14. Step 4 involves identifying existing aging management activities applicable to these circuits, and Step 5 entails assessing their effectiveness at detecting and mitigating the relevant aging effects. *Id.* at 6-15 to 6-16. SAND-96-0344 states that potentially applicable activities for medium-voltage power cable include: periodic visual/physical inspections (during maintenance or otherwise); surveillance or operability testing of end devices which demonstrates cable system functionality; periodic cable hi-pot testing; periodic thermographic inspection of circuits and their termination; routine monitoring and pumping of spaces in which water accumulates around medium-voltage cables. *Id.* at 6-15. Finally, Step 6 involves identifying any additional activities that may be required based on the Step 5 assessment. *Id.* at 6-17. Contrary to NYS's suggestion, the LRA Section B.1.23 program and implementing procedure EN-DC-346 follow these recommendations, insofar as they still are valid and have been incorporated into current NRC and industry guidance.

### B. <u>The Level of Detail Claimed Necessary by NYS Is Not Required By NRC Regulations or Guidance For Purposes of License Renewal</u>

**Q94. NYS's consultant, Mr. Bascom, claims that Entergy's aging management program for underground non-EQ inaccessible medium and low-voltage cables lacks "critical" details. Bascom Testimony at 34 (NYS000136). What details does Mr. Bascom allege to be missing from Entergy's AMP?**

A94. (ABC, RBR) NYS and Mr. Bascom allege that Entergy's AMP does not: (1) specify the location or number of the relevant cables, (2) identify their function or the criticality of the systems they serve, (3) describe their physical characteristics (*i.e.*, the age of the in-scope cable circuits, the number of cable circuits, the lengths of cable circuits, the voltage class of the cables, and the types of cables, including insulation types), (4) explain what corrective actions it will take if manhole inspections reveal periodic water accumulation, (5) explain what cable condition monitoring tests it will use, (6) explain the criteria for determining whether a cable passes or fails a condition monitoring test, and (7) identify what corrective actions, if any, Entergy will take if a defective cable is found. Bascom Testimony at 5, 34-35 (NYS000136).

**Q95. Is Entergy required to include the details identified by Mr. Bascom in its AMP?**

A95. (ABC, RBR) No. Mr. Bascom points to no regulation or guidance calling for the level of detail he claims is necessary for an LRA or an AMP. In this regard, his claims are inconsistent with NUREG-1801 guidance as it relates to aging management programs. His testimony also appears to conflate the adequacy of an AMP (in relation to Part 54 requirements) with the adequacy of the actual implementation of that program (as verified through post-license renewal inspection processes).

**Q96. Do you believe that Entergy's Non-EQ Inaccessible Medium-Voltage Cable Program is sufficiently detailed to meet NRC requirements in 10 C.F.R. Part 54?**

A96. (ABC, RBR) Yes. Entergy is relying on an AMP that is consistent with the program described in NUREG-1801, Section XI.E3. NUREG-1801 states that an applicant may reference NUREG-1801 to demonstrate compliance with Part 54 requirements, and that use of a program identified in the NUREG-1801 constitutes reasonable assurance that the applicant will manage the effects of aging on component functionality during the extended operating period. NUREG-1801, Rev. 2 at 8 (NYS00147A). As the Staff has explained in this proceeding:

> The GALL Report is treated in the same manner as an NRC-approved topical report that is generically applicable. An applicant may reference the GALL Report in its LRA to demonstrate that its programs correspond to those that the staff reviewed and approved in the GALL Report. If the material presented in the LRA is consistent with the GALL Report and is applicable to the applicant's facility, the staff will accept the applicant's reference to the GALL Report. In making this determination, the staff considers whether the applicant has identified specific programs described and evaluated in the GALL Report, but does not conduct a review of the substance of the matters described in the GALL Report. Rather, the staff determines whether the applicant established that the approvals set forth in the GALL Report apply to its programs.

Audit Report for Plant Aging Management Programs and Reviews For Indian Point Nuclear Generating Units Nos. 2 and 3 at 3 (Jan. 13, 2009) ("NRC Audit Report") (ENT000041).

During its technical review, the Staff reviewed the IPEC LRA (as supplemented by additional information provided by Entergy in response to RAIs) and supporting documentation based on NUREG-1800. It also performed extensive onsite audits and inspections to review onsite documentation supporting the application and to address issues identified during the Staff's review of the LRA, and to verify consistency of IPEC's AMP with the corresponding NUREG-1801 program (*i.e.*, that Entergy's program contains the program elements of the referenced NUREG-1801 program, and that the conditions at IPEC are bounded by the conditions for which the NUREG-1801 program was evaluated). *See* SER at 3-31 to 3-33 (NYS00326B); Supplemental SER at 3-5 to 3-9 (NYS000169). As documented in its safety evaluation reports, the Staff found the Non-EQ Inaccessible Medium-Voltage Cable Program to be acceptable. *See* SER at 3-31 to 3-33; Supplemental SER at 3-5 to 3-9.

**Q97. Does the NRC Staff verify actual implementation of aging management programs as part of the LRA review process?**

A97. (ABC, RBR) No. Before extended operation begins, NRC regional staff perform an inspection in accordance with the guidance in NRC Inspection Manual Chapter 71003, "Post-Approval Site Inspection for License Renewal" (ENT000251). The IP 71003 process includes "[verification] that license conditions added as part of the renewed license, license renewal commitments, selected aging management programs, and license renewal commitments revised after the renewed license was granted, are implemented in accordance with [10 C.F.R. Part 54]." *Id.* at 1. It also verifies that descriptions of AMPs and related activities are, or will be, contained in the UFSAR, and that the descriptions are consistent with the programs being implemented by the licensee. *Id.* As part of this process, the NRC reviews program documents, instructions, or procedures that the licensee has committed to follow in implementing its AMPs.

Thus, actual implementation of license renewal AMPs, including related procedures, is verified through the IP 71003 inspection. Notably, the NRC Staff expressly mentioned this fact in its "Audit Report for Plant Aging Management Programs and Reviews" for IPEC:

> At the time of the audits, the applicant had not yet developed procedures for this new program; and the staff's audit addressed only the applicant's program elements and the corresponding program in the GALL Report. The applicant has committed to implement the program consistent with the GALL Report prior to the period of extended operation. In accordance with IP 71003, the staff will verify that the license renewal commitments are implemented in accordance with 10 CFR Part 54.

NRC Audit Report (ENT000041) at 23.

We note that, given the end of the IP2 initial operating license term in 2013, the NRC Staff issued Temporary Instruction 2516/001 (ENT000252) to allow NRC inspectors to assess an applicant's progress in implementing its license renewal AMPs and commitments during the pendency of the license renewal approval process. NRC Region I inspectors completed an inspection at IP2 under Temporary Instruction 2516/001 during the week of March 5-9, 2012. *See* NRC Staff's Status Report in Reponse to the Atomic Safety and Licensing Board's Order of February 16, 2012 at 3-4 (Mar. 1, 2012).

### C. <u>IPEC's Non-EQ Inaccessible Medium-Voltage Cable Program is Not "Missing" Any "Critical" Details</u>

**Q98. Do you agree with NYS's assertion that IPEC's Non-EQ Inaccessible Medium-Voltage Cable Program lacks the appropriate level of detail?**

A98. (ABC, RBR) No. Entergy's program, which the NRC already has reviewed and approved, is not lacking any "critical" program details. The LRA Section B.1.23 program, which references NUREG-1801, Section XI.E3 and has been revised to address recent operating experience, provides sufficient information to develop an appropriate program implementation procedure (which already exists as EN-DC-346). For the reasons explained above, the specific program details sought by Mr. Bascom generally relate to program implementation; *i.e.*, they need not be included in the LRA or submitted to the NRC Staff to meet the requirements of 10 C.F.R. Part 54. In any event, Entergy has developed fleet procedure EN-DC-346, which incorporates IPEC license renewal requirements and commitments and is being used to implement the IPEC Non-EQ Inaccessible Medium-Voltage Cable Program.

**Q99. Mr. Bascom asserts that Entergy's AMP lacks information about the specific cables within the scope of the IPEC Non-EQ Inaccessible Medium-Voltage Cable Program,**

**including cable characteristics and functions. Bascom Testimony at 5, 26, 34-45. Do you agree?**

A99. (ABC, RBR, TSM) No. LRA Table 2.5-1 identifies the component intended function of electrical cables. *See* LRA at 2.5-4 (ENT00015A). Cables subject to aging management review are treated the same regardless of the system function identified in 10 C.F.R. § 54.4 that they support. EN-DC-346 requires responsible IPEC personnel to develop a Medium Voltage In-scope Cable List and a Low Voltage In-scope Cable List that include the following information for IPEC underground medium-voltage and low-voltage cables: (1) unit, (2) supporting equipment, (3) cable manufacturer, (4) cable insulation type, (5) year of installation, (6) cable length, (7) shielding, (8) number of splices, (9) cable rated voltage, and (10) cable functions. EN-DC-346, Rev. 2 at 16 & 26-29 (Attachs. 9.3 & 9.4) (ENT000237). All of the field and engineering tasks necessary to develop these lists are derived from the implementation procedure and controlled by the IPEC work order process.

Entergy recently developed these lists in accordance with EN-DC-346 as part of its Part 50 program implementation efforts. Entergy's Medium-Voltage In-scope Cable List and Low-Voltage In-scope Cable List are provided in Exhibits ENT000243 and ENT000242, respectively. These lists contain the cable-related information that Mr. Bascom claims is missing from Entergy's AMP, to the extent that information is necessary.

**Q100. Are all of the underground cables listed in the Low-Voltage In-scope Cable List (ENT000242) and Medium-Voltage In-scope Cable List (ENT000243) in the scope of the IPEC license renewal aging management program?**

A100. (ABC, RBR, TSM) All of the underground low-voltage cables (19 cable circuits in total) listed in the Low Voltage In-Scope Cable list are within the scope of the LRA Section B.1.23 program. However, only a portion of the underground medium-voltage cables listed in the Medium-Voltage In-scope Cable List are within the scope of LRA Section B.1.23 program. They include the following five medium-voltage cable circuits:

- 13W92 (13.8KV alternate offsite power recovery feeder for gas turbine (GT) # 1 [IP2]
- 13W93 (13.8KV alternate offsite power recovery feeder for GT # 2) [IP2]
- GT25/GT26 (13.8KV Alternate offsite power recovery feeder bus supply cables (includes SBO section) [IP2]
- GT35 to 6.9KV GT substation bus [IP3]
- GT36 to 6.9KV GT substation bus [IP3]

**Q101. Please briefly summarize the key insights that can be gleaned from the Low-Voltage In-scope Cable List and Medium-Voltage In-scope Cable List with respect those cables that are in-scope for license renewal.**

A101. (RBR, TSM, HGS) The cable lists (ENT000242 and ENT000243) indicate the following:

- All of the low-voltage cable circuits are 480V. The majority of these are safety-related cables.

- Of the 19 underground low-voltage cables, 11 cables were installed in the early 1970s. These cables generally are PVC insulated and lead sheathed. The remaining eight cables were installed in 1990 or later (2000 and 2006). These new cables generally have XLPE insulation systems and are lead-sheathed. One exception is an IP3 service water pump cable installed in 2006, which has an EPR insulation system and no lead sheath.

- The five in-scope medium-voltage cable circuits are 13.8KV and 6.9KV. All five circuits are nonsafety-related.

- The five in-scope medium-voltage cable circuits include PILC, XLPE, and EPR insulation systems. All five of those cable circuits have lead shielding. Three of the five circuits are entirely lead-sheathed, and two of the five are partially lead-sheathed.

**Q102. Why is it significant that nearly all of the underground low- and medium-voltage cables that perform license renewal intended functions are lead-sheathed cables?**

A102. (HGS, RBR, TSM) As stated earlier in Answer 34, a lead sheath serves as a water impervious barrier. Consequently, the probability of cable insulation deterioration due to moisture ingress in these cables is very low. (Additionally, the lead sheaths make these cables conducive to the electrical tests specified in Entergy's program implementing procedure, EN-DC-346.) As one authoritative source on power cable engineering notes:

> The most effective, if not economic, method to avoid the formation of water trees is to keep the insulation absolutely dry. This can be accomplished with an impervious metallic sheath such as lead, copper, or aluminum. Cables with these sheaths have been in service for over 40 years with no known deterioration.

*Electrical Power Cable Engineering* at 278 (ENT000244). That same source recognizes that corrosion of, or mechanical damage to, metallic sheaths could allow moisture ingress. *Id*. However, as noted above, there have been no age-related failures of low-voltage or medium-voltage cables at IPEC, which indicates that the cable design was sound (as was the workmanship associated with the installation), and that the cables are not exposed to environments that are conducive to water-related degradation (including water treeing in the case of the medium-voltage cables). *See* Answers 68-69, 71-72, *supra*.

**Q103. With respect to the issue of water exposure, Mr. Bascom alleges that Entergy has not identified specific plans for addressing water accumulation in manholes/conduits, or corrective actions in the event water intrusion is a "chronic problem." Bascom Testimony at 24-25 (NYS000136). Do you agree?**

A103. (ABC, RBR, TSM) No. As stated in Answers 62 and 63 above, the Non-EQ Inaccessible Medium-Voltage Cable Program, in addition to IPEC's current Part 50 preventive maintenance program, require periodic actions to minimize cable exposure to significant moisture, such as inspecting for water collection in cable manholes and removing water as needed. Consistent with NUREG-1801, possible corrective actions include, but are not limited to, installation of permanent drainage systems or sumps, installation of water-level monitors/alarms, more frequent cable testing or manhole inspections, checking cable/splices for anomalies, and replacing degraded sections of cable. NUREG-1801, Rev. 2 at XI E3-3 (NYS00147D).

**Q104. Mr. Bascom alleges that Entergy has not identified the tests that it will perform on in-scope medium and low-voltage IPEC cables subject to potential long-term wetting or submergence. Bascom Testimony at 28-29 (NYS000136). As an initial matter, what types of tests are available for testing these cables?**

A104. (HGS, RBR, TSM) The particular test depends on a number of factors, such as cable construction, the dielectric material, shield construction (including the presence or absence of an insulation shield), degradation modes, cable system architecture, and the need for circuit modifications to allow testing. NEI 06-05 at 20 (ENT000234). Available tests include two general types: (1) "online"; and (2) "offline" tests. An "online" test is performed with the circuit voltage connected, while an "offline" test is performed with the voltage disconnected. These tests include both "diagnostic" and "withstand" tests. *See id.* at 20-30.

**Q105. What is a diagnostic test?**

A105. (HGS, RBR, TSM) A diagnostic test estimates the actual condition and to some degree, the future performance of the cable insulation system. Diagnostic test results can be used to quantitatively evaluate one or more characteristics of the cable insulation system. The test data are used to make a projection as to when (*i.e.*, immediately or in the future) to remove weakened links of the cable system if weakened cable insulation is identified. Diagnostic testing results can be compared with baseline readings taken on new cables or trended over time. NEI 06-05 at 22 (ENT000234). The dissipation factor (also called tan delta) and partial discharge tests are diagnostic tests. *Id*. at 24-28. Other, less commonly used tests include isothermal return current and return voltage measurements, and dielectric spectroscopy. *See id*., Ch. 4; EPRI 1020805**,** Ch. 5 (NYS000158); EPRI 1021070, Sec. 8.6 (ENT000238).

**Q106. What is a withstand test?**

A106. (HGS, RBR, TSM) In a withstand test, the cable system is tested off line (out of service) to determine whether it can withstand the application of an overvoltage via an external voltage source (*e.g.*, a high potential or "hi-pot" test set). EPRI 1021070 at 8-15 (ENT000238). In principle, the additional applied stress induces the failure at the weakest link in the system. *Id*. at 9-2. A cable that passes this test (*i.e.*, does not fail) should be able to withstand a similar voltage surge during plant operation when the cable is at the same or lower temperature. *Id*. Withstand testing methods include dc hi-pot testing, 60 Hz (ac) hi-pot testing, very low frequency ("VLF") (0.1 Hz) AC hi-pot testing, and oscillating switching wave testing. *See generally* NEI 06-05, Ch. 4 (ENT000234); EPRI 1020805**,** Ch. 5 (NYS000158); EPRI 1021070, Sec. 8.6 & App. E.

**Q107. Are there recommended or preferred tests for assessing the cable insulation condition of underground shielded medium-voltage cables?**

A107. (ABC, RBR) Yes. There are essentially three preferred tests for assessing the cable insulation condition of underground shielded medium-voltage cables: (1) dissipation factor (tan delta) tests, (2) partial discharge tests, and (3) power frequency or VLF AC hi-pot withstand tests. EPRI 1020805 at 5-2 (NYS000158). EPRI also has recognized the use of dielectric spectroscopy as a possible alternate to tan delta testing. *Id.* The specific test(s) selected depend on the cable design and the nature of the potential degradation. *Id*. at 5-1. EPRI has advised that tan delta measurement generally is most useful for detecting water-related degradation for the cable designs commonly used in nuclear plants, and that it can be complemented with VLF withstand testing. *Id*. Passing a withstand test after a successful tan delta test indicates that there is no significant distributed or local degradation in the insulation system. *Id*. at 5-6. Specifically, tan delta testing evaluates the cable for water-related degradation (*i.e.*, it is a global assessment that identifies widespread deterioration in the insulation system), and VLF withstand testing evaluates whether severe localized degradation exists (*i.e.*, it is designed to force a significant local degradation to failure). *Id*.

An alternative to coupling tan delta testing with VLF withstand is to couple tan delta testing with partial discharge testing. *Id*. The tan delta test assesses the cable for distributed water-related degradation, and the partial discharge test assesses the cable for localized, severely degraded conditions. *Id.* Similarly, dielectric spectroscopy can be coupled with partial discharge testing. Using partial discharge testing requires that the cable have acceptable attenuation levels for detection of the high-frequency signals related to partial discharge. *Id.*

Table 2 below summarizes applicable test types mentioned above. More detailed discussions of these tests, test equipment, and test advantages/disadvantages are provided in the industry guidance documents cited above.

**Table 2. Summary of Applicable Medium-Voltage Cable Testing Methods**

| Test Name | General Description |
|---|---|
| **Tan Delta Test**<br><br>Also called:<br>• Dissipation Factor<br>• Power Factor<br>• Loss Angle | The tan delta test is a diagnostic test based on the principle that, if cable insulation is free from defects, then the cable acts like a long coaxial capacitor. In the ideal capacitor, current and voltage are phase-shifted 90 degrees. However, if water trees, voids, and moisture are present in service-aged cable, then the insulation's resistance decreases, which increases resistive current through the insulation. As a result, the dielectric no longer acts like an ideal capacitor, and the resultant phase shift will be something less than 90 degrees. Tan delta testing determines the ratio of the resistive leakage current through the insulation to the capacitive current and provides a figure of merit relating to the condition of the insulation. The degree to which the dielectric departs from the ideal capacitor indicates insulation degradation, assuming that the dielectric was a low-loss material. NEI 06-05 at 24-25 (ENT000234); EPRI 1020805 at 5-3 to 5-4 (NYS000158); EPRI 1021070 at 8-16 to 8-19 (ENT000238). |
| **Partial Discharge Test** | A partial discharge test is a diagnostic test. Partial discharges in cable insulation are localized in nature and cause. When they occur, they cause very high frequency disturbances or pulses that propagate along the length of the cable in both directions and are reflected. Such pulses become attenuated (the gradual loss in intensity of the wave as it travels through the cable insulation) as they move along the cable. By measuring the time lapse between the pulse arrival times at two different locations, it is possible to detect the partial discharge initiation location. It also is possible to perform the detection at one cable end by measuring the difference in arrival times of the original pulse, which arrives first, and its reflection from the other end, which arrives second. Partial discharge characteristics (*e.g.*, magnitude, repetition rate, phase) are a function of the size, location, and type of defect encountered, as well as voltage stress, temperature, and insulation type. NEI 06-05 at 25-26 (ENT000234); EPRI 1020805 at 5-3 (NYS000158); EPRI 1021070 at 8-21 to 8-24 (ENT000238). |
| **Power Frequency or VLF Withstand Test** | This type of testing is a form of withstand testing (also known as a go/no-go test). A high voltage is applied to a cable to determine if the cable has sufficient capability to withstand normal operating voltages and surges for a significant period (i.e., the cable either holds the voltage or fails). DC hi-pot is a destructive test for weakened cable. Therefore, EPRI guidance and IEEE-Standard 400-2001 do not recommend the use of DC hi-pot testing for XLPE cables that have been in-service in a wet environment for more than a few years. NEI 06-05 at 30 (ENT000234). |
| **VLF AC Hi-Pot Test** | VLF AC hi-pot testing was developed in the 1980s as a substitute for DC hi-pot testing and can test for insulation degradation in field-aged medium-voltage cables located in a wet environment. It is a form of withstand testing that uses AC power (instead of DC power) ranging in frequency from 0.01 Hz to 0.1 Hz. It can test cable systems with mixed insulation types (EPR, XLPE, filled XLPE, butyl rubber, and PILC cables). The IEEE has endorsed its use for field testing in IEEE 400.2-2004, "IEEE Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)," (Sept. 23, 2004) ("IEEE 400.2") (ENT000256). *See generally,* NEI 06-05 at 30-31 (ENT000234); EPRI 1020805 at 5-4 (NYS000158). |

**Q108. Have you reviewed Mr. Bascom's discussion of potentially applicable testing provided in his testimony and report?**

A108. (HGS, RBR, TSM) Yes, and we note that the discussion contains several statements that warrant clarification or correction.

**Q109. Do you agree with Mr. Bascom that DC step voltage or insulation dissipation factor testing would be effective for PILC cables? *See* Bascom Testimony at 27 (NYS000136).**

A109. (HGS) I agree, with certain qualifications. Although industry standards discourage the use of DC high voltage as a means of testing aged insulation, it is still recommended for use on PILC and other types of oil-paper insulated cables. EPRI 1021070 at 8-15 (ENT000238). Further, the use of VLF tan delta is recognized as a valid method for PILC cables by virtue of the inclusion of acceptance criteria in IEEE standards.

**Q110. Mr. Bascom also states that "[t]he pass/fail tests, such as AC Voltage Withstand, Step Voltage and VLF, are effective on both shielded and unshielded cables." Bascom Testimony at 22 (NYS000136). Is that accurate?**

A110. (HGS) Mr. Bascom's statement is incorrect insofar as it is intended to apply to unshielded cables. In order for a cable system to be amenable to terminal electrical measurements such as AC voltage withstand and VLF testing, the presence of a continuous ground electrode around the cable insulation is required. This ground electrode is constituted by the lead sheath or taped copper shield found in cables at IPEC. This shield is important because the results of any electrical test are contingent upon applying the electrical stress across the insulation which is subject to test. In the absence of such a ground electrode (or shield), the surface of the insulation will rise up, electrostatically, to whatever potential is applied to the high voltage conductor of the cable. Consequently, the insulation itself will effectively be untested.

**Q111. Mr. Bascom cites a maximum partial discharge level of 5 pC. *See* Bascom Testimony at 28 (NYS000136). Does that value apply to underground cables at IPEC?**

A111. (HGS) No. Mr. Bascom quotes maximum partial discharge (PD) levels adopted for laboratory tests (5 pC) as if they are applicable to field tests. *See* Bascom Testimony at 28. However, in the field, each service provider may have their own suitable set of values. For example, my firm (Kinectrics) employs a maximum PD level of 3 pC for the types of cable installations commonly found in nuclear power plants. However, this value must be viewed in the context of the applied voltage, which is almost always higher than the nominal operating voltage of the cable. Effectively, the intent of this test is to ensure that the cable system is PD free at operating voltage. The 3 or 5 pC level is widely found in most documents but, as stated above, they are germane to factory or lab testing of new cables. *See, e.g.*, IEEE P400.3, "IEEE Guide for Partial Discharge Testing of Shielded Power Cable Systems in a Field Environment" at 5-6 ("IEEE P400.3") (ENT000253). Further, this 3 or 5 pC level is really a function of the "noise floor" of the PD detector. See *id*. at 16, The industry standard, IEEE P400.3, does not provide a maximum acceptable level for such tests.

**Q112. Mr. Bascom suggests the use of time domain reflectometry ("TDR"). *See* Bascom Testimony at 21-22, 27, 29 (NYS000136). Is that an applicable testing technique for cables and aging effects at issue here?**

A112. (HGS, RBR) No. TDR is used to characterize and locate faults in metallic cables (*e.g.*, twisted wire pairs, coaxial cables) or to locate discontinuities in a connector or any other electrical path. IEEE P400.3 at 19 (ENT000253). It is not an effective test for cable insulation condition.

**Q113. Does implementation procedure EN-DC-346 specify the use of particular tests for shielded *medium-voltage* cables?**

A113. (RBR, TSM, HGS) Yes, it does, but consistent with NUREG-1801, it also permits the use of state-of-the-art methods at the time a specific cable system is tested. EN-DC-346, Rev. 2 at 14, 18 (ENT000237). EN-DC-346 specifies the use of tan delta and VLF AC hi-pot tests for shielded medium-voltage cables based on industry recommendations and operating experience, but permits use of other industry-recommended methods for condition monitoring and aging assessment of shielded medium-voltage cables subject to long-term wetting. *Id.* at 14-18. Partial discharge tests may be used if the shield configuration and insulation do not cause excessive attenuation of partial discharge signals. *Id.* at 15. Entergy procedure EN-MA-138, VLF Tan Delta and Withstand Testing of Electrical Power Cables, Rev. 0 (ENT000254), provides the specific instructions for performing tan delta and withstand testing on shielded medium-voltage cables.

**Q114. Dr. Sedding, do you conclude that Entergy has identified appropriate testing for the in-scope medium-voltage cables?**

A114. (HGS) Yes. Entergy's selection of VLF hi-pot and VLF dissipation factor (tan delta) testing is sound and is supported by the growing use of these methods in the electric utility industry in general and nuclear power plants in particular.

**Q115. How will IPEC assess the condition of non-EQ shielded *low-voltage* power cables that are within the scope of the Non-EQ Inaccessible Medium-Voltage Cable Program?**

A115. (RBR, TSM, HGS) Entergy tests low-voltage cables and their connected loads (*e.g.*, motors) as complete circuits. In accordance with EN-DC-346, IPEC inspection, testing and monitoring practices include visual inspection of cable terminations and periodic insulation resistance/motor current analysis of cables and connected equipment. EN-DC-346 at 19-20

(ENT000237). During the insulation resistance/motor current tests, Entergy records step voltage, insulation resistance, resistive and inductive imbalances, and polarization index for trending purposes. *See* Entergy Procedure EN-MA-134, Offline Motor Electrical Testing, Rev. 2 (ENT000255).

**Q116. Dr. Sedding, do you conclude that Entergy has identified an appropriate test for the in-scope low-voltage cables?**

A116. (HGS) Yes. As discussed above in Answer 56, Entergy procedure EN-DC-346 specifies the use of periodic inspections and insulation resistance testing for low-voltage cables. On the basis that these cables have some form of contiguous shield, the use of insulation resistance measurements should be effective to monitor for the effects of aging.

**Q117. Has Entergy identified test acceptance criteria for low- and medium-voltage cables?**

A117. (ABC, RBR, TSM, HGS) Yes. The insulation resistance acceptance criteria for low-voltage cables are provided in Attachment 9.2 to EN-DC-346, Rev. 2 (ENT000237). The tan delta test acceptance criteria for medium-voltage cables are provided in Attachment 9.1 of EN-DC-346, which are based on and consistent with industry guidance in EPRI 1020805. *See* EPRI 1020805 at 5-6 to 5-12 (NYS000158).

**Q118. Mr. Bascom claims that Entergy has not identified corrective actions for any cases in which inspection or test results may not meet applicable acceptance criteria. Bascom Testimony at 5, 35 (NYS000136). Do you agree?**

A118. (ABC, RBR, TSM) No. As discussed in the LRA program, and consistent with IPEC's current operations, any necessary corrective actions will be determined through an evaluation performed in accordance with the IPEC corrective action program. *See* EN-LI-102, Rev. 17 (ENT000249). Section 5.4 (Actions for Shielded Medium-Voltage Underground Cables), Section 5.5 (Actions for Unshielded Medium-Voltage Underground Cables), and

Section 5.6 (Actions for Low Voltage Underground Power Cables) of implementing procedure EN-DC-346 (ENT000237) identify possible cable-specific corrective actions (*e.g.,* more frequent cable testing, checking cable/splices for anomalies, and replacing degraded sections of cable.). For medium-voltage cables, VLF AC hi-pot testing will be used if tan delta testing identifies a degraded insulation condition to determine if the insulation condition is sufficiently stable to allow for an interim period of operation while preparing for cable replacement.

**Q119. Mr. Bascom suggests that IPEC's program lacks appropriate "trending" provisions. Bascom Testimony at 28-29 (NYS000136). Do you agree?**

A119. (ABC, RBR, TSM) No. The IPEC Cable Reliability Program defines trending as "[a]n analysis of cable information over time for the purpose of predicting cable degradation or failures." EN-DC-346, Rev. 2 at 9 (ENT000237). The program specifically requires plant confirmation that: (1) maintenance practices, testing, and *trending* are sufficient to ensure that cables will perform their intended function(s); and (2) manhole maintenance practices and *trending* water levels are sufficient to prevent prolonged submergence of power cables. *Id.* at 3.

**Q120. NYS suggests that Entergy will not have sufficient time to test all cables within the scope of the Non-EQ Inaccessible Medium-Voltage Cable Program before the expiration of the IP2 operating licenses in September 2013. Bascom Testimony at 25-26 (NYS000136). Is that a valid concern?**

A120. (ABC, RBR, TSM) No. Entergy has committed to complete the necessary testing of underground medium-voltage and low-voltage cables listed in Exhibits ENT000242 and ENT000243 before the period of extended operation begins and, to that end, has developed an appropriate work plan and schedule to meet that regulatory commitment. NL-11-032, Attach. 1 at 12 (NYS000151).

As shown in the IPEC Medium-Voltage In-Scope Cable List, there are only five medium-voltage circuits with a license renewal intended function. Entergy has completed tan delta testing on the IP2 13.8 kV feeder cables. The IP3 13.8 kV feeder cable testing is scheduled for the first quarter of 2013, and the remaining IP2 and IP3 6.9 kV circuits are scheduled to be tested prior to the end of 2012. The low-voltage cables identified in Exhibit ENT000242 have been tested using the methods described in Answer 115 above. Thus, contrary to Mr. Bascom's suggestion, there is more than sufficient time to complete the remaining testing and to evaluate the test results before IP2 and IP3 enter their respective periods of extended operation.

## VIII. <u>RESPONSES TO ISSUES RAISED IN CONTENTION NYS-7 AND MR. BASCOM'S ASSOCIATED TESTIMONY AND REPORT</u>

### A. <u>Entergy Has A Program To Manage Aging Effects On Non-EQ Inaccessible Power Cables Exposed To Adverse Localized Environments.</u>

**Q121. Mr. Bascom alleges that Entergy lacks a program for non-EQ inaccessible power cables exposed to adverse localized environments. Bascom Testimony at 30-31 (NYS000136). Is that accurate?**

A121. (ABC, RBR) No. As explained in Section VI.B above, the LRA includes AMR results and describes an appropriate program (the Non-EQ Insulated Cables and Connections Program) that encompasses *all* aboveground non-EQ low-voltage and medium-voltage cables at IPEC performing license renewal intended functions. Under the Non-EQ Insulated Cables and Connections Program, all accessible electrical cables and connections in proximity to any ALEE are visually inspected for insulation or jacket surface anomalies. EN-DC-348, Rev. 2 at 13 (ENT000241).

**Q122. NYS has suggested that there is no technical basis to justify differences between programs for aging management of accessible and inaccessible cables located near adverse local equipment environments. Bascom Report at 20, 28 (NYS000138). Do you agree?**

A122. (ABC, RBR) No. There are obvious technical bases for differences in treatment of accessible and inaccessible cables. Visual inspection is an effective technique for monitoring accessible cables that is obviously not feasible for inaccessible cables. Testing methods used to test inaccessible cables for degradation due to water intrusion would be inappropriate for accessible cables running in cable trays through plant buildings. Nuclear power plants, including IP2 and IP3, contain thousands of electrical cables, some of which are difficult to access because they are located inside conduits or contained in enclosed trays. Consequently, it is not feasible to visually inspect all cables within a plant. However, based on site visits, surveys, and research conducted to develop EPRI TR-109619 (ENT000239), EPRI concluded that ALEEs tend to occur only in a limited number of plant locations, and that the aging effects on cables in ALEEs can be managed to preclude impacts to plant safety and reliability. EPRI TR-109619 at 4-1, 4-3. For example, the inspection procedures described in TR-109619 can be used to identify adverse localized environments and assess their effects on cables. Those effects can be managed by further monitoring, periodic replacement, cable relocation, adding thermal insulation, or improving HVAC systems. *Id.* at 4-3.

Furthermore, it is not necessary to visually inspect all non-EQ inaccessible cables to adequately assess their condition. As EPRI guidance explains:

> *The concept of inaccessibility for cables is related to the ability to determine the environment and physical condition of cable.* For underground cable, inaccessibility makes identification of wetting and submergence more difficult. In dry plant areas, inaccessibility is less of a problem. Even when cables are inside conduits or contained in trays that are difficult to access, identification of heat sources that are close to the tray or conduit is relatively easy, and determining the need for further assessment of condition is possible. *Inaccessibility is not a concern if adverse service and environments do not exist.*

EPRI 1020804 (ENT000240) at 1-8 (emphasis added). If an unacceptable condition or situation is identified for an accessible low-voltage cable or connection, then Entergy will determine whether the same condition or situation is applicable to other accessible or inaccessible cables or connections. EN-DC-348, Rev. 2 at 12, 21 (ENT000241). This evaluation process involves the issuance of a condition report and extent of condition review, as described in EN-LI-102, Rev. 17 (ENT000249). The extent of condition review is designed to determine any potential impact to the operability or functionality of similar components, equipment, or systems.

### B. <u>NYS's Claims Regarding Thermal Degradation Of Cable Insulation Are Technically Flawed And Factually Unfounded</u>

**Q123. Is Mr. Bascom's assertion that IPEC lacks a program to manage the aging effects of excessive heat on inaccessible cables correct? Bascom Testimony at 30-31 (NYS000136).**

A123. (ABC, RBR, HGS) No. Mr. Bascom incorrectly claims that IPEC lacks a program to address elevated temperatures or "thermal stress." Bascom Testimony at 35 (NYS000136). As discussed above, the Non-EQ Insulated Cables and Connections Program identifies ALEEs (including those caused by elevated temperatures or excessive heat) and related aging effects (including thermal embrittlement of cable insulation). *See* Answers 74 and 75, *supra*.

**Q124. Mr. Bascom asserts that cable degradation can result from exposure to adverse temperature environments.** ***See*** **Bascom Testimony at 29-34 (NYS000136); Bascom Report at 27-30 (NYS000138). Is his assertion relevant here?**

A124. (RBR, HGS) No, it is not relevant to the issues raised in NYS-7. First, it is unreasonable to assume that a cable that has been working perfectly well for nearly 40 years will, all at once, be subjected to conditions that will increase its temperature from 90° to 150°C (as suggested in Mr. Bascom's Report at 28-29), and that this temperature will be maintained to the point that it will destroy the cable in a few months. The examples of adverse temperature environments cited by Mr. Bascom are so highly exaggerated that they are completely unrealistic. Temperatures reaching 194°F (90°C), much less temperatures approaching 302°F (150°C), *see* Bascom Report at 28-29, do not occur without an abnormal condition or event, in nuclear power plants, including IP2 and IP3. IPEC's corrective action process requires Entergy to evaluate such abnormal events, implement corrective actions, and conduct appropriate evaluations of affected components. *See, e.g.*, EN-LI-102 at 53, 55 (ENT000249). In fact, under EN-DC-348, Entergy uses 112°F as the temperature threshold for using the corrective action program to further investigate a potential adverse localized temperature environment. EN-DC-348, Rev. 2, at 30 (ENT000241). The basis for 112°F is that PVC insulation, which is the bounding insulation material for temperature, has a 60-year life at 112°F. *See id.* at 16 (Table 5.4-1, Materials, Applications, and 60-Year Service-Limiting Environments for Non-EQ Insulated Cable and Connection ).

In addition, the case cited by Mr. Bascom (an example of thermal degradation of cables in Auckland, New Zealand) is inapplicable to cables installed at a nuclear power plant. Bascom Report at 27. The cables that caused the outage in Auckland, New Zealand were high-voltage self-contained cables. Inquiry into the Auckland Power Failure, Technical Report on Cable Failures Integral Energy at 6 (May 5, 1998) (NYS000155). That cable type has a laminated, paper insulation over a central, hollow conductor through which the oil circulates and that, in the case of a loss of circulating insulating oil would overheat due to ohmic heating from the cable, not from a localized external heat source. In addition, the break in the outer sheath can supply a large amount of pressurized flammable liquid to feed the fire. In contrast, cables in U.S. nuclear power plants (including IP2 and IP3) typically have extruded polymer insulation that cannot lose their insulating or cooling values due to failure of an active system.

**Q125. Mr. Bascom suggests that IPEC inaccessible cables could be retrofitted with a fiber optic sensor that provides temperature readings along the length of the cable every meter. Bascom Testimony at 32 (NYS000136); Bascom Report at 29 (NYS000138). What is your response?**

A125. (RBR, HGS) Retrofitting inaccessible cables with fiber optic sensors is neither necessary nor practical in a nuclear power plant. In contrast, the approach described in NUREG-1801, Section XI.E1 and the corresponding IPEC Non-EQ Insulated Cables and Connections Program is a practical, technically sound, and established approach to managing potential degradation caused by adverse localized environments, including elevated temperatures. Indeed, the NUREG-1801 program considers the technical information and guidance provided in documents cited by NYS and Mr. Bascom, such as NUREG/CR-5643, IEEE Std. 1205-2000, SAND96-0344, and EPRI 109619. The IPEC program similarly relies on these and other guidance documents, including EPRI 1020804. Thus, contrary to Mr. Bascom's claim, IPEC has a "specific plan to manage the effects of excessive heat on inaccessible cables." Bascom Report at 28 (NYS000138).

Mr. Bascom further states that Entergy can identify the critical locations to be monitored through the use of an "integrated approach" that may include: (a) the review of EQ zone maps that show radiation levels and temperatures for various plant areas; (b) consultations with plant staff that are cognizant of plant conditions; (c) performing soil thermal resistivity tests for buried cables; and (d) the review of relevant plant-specific and industry operating experience. Bascom Testimony at 33 (NYS000136). With the exception of "soil resistivity tests for buried cables," the IPEC Non-EQ Insulated Cables and Connections Program includes the actions recommended by Mr. Bascom. *See* Answer 80, *supra*.

As discussed above, below-grade cables are managed through the IPEC Cable Reliability Program (EN-DC-346). Regardless, because such cables have no external heat source, there is no technical basis for performing soil thermal resistivity tests. Potential cable degradation caused by internal (ohmic) heating of below-grade cables, if it occurs, is a design issue, not an aging issue. Moreover, if heat caused degradation, the degradation would be detectable using the same testing as that employed to check for degradation due to moisture exposure.

**Q126. Mr. Bascom states that if cables are allowed to operate above "emergency" operating limits at any time, then corrective actions must be taken. Bascom Testimony at 36 (NYS000136); Bascom Report at 30 (NYS000138). How do you respond to that assertion?**

A126. (RBR, ABC) Mr. Bascom's testimony is not germane to NYS's specific contention or to aging management of non-EQ electrical cables in general. Mr. Bascom does not clearly define "emergency" operating temperature. We only can surmise that he is alluding to abnormal operating temperatures resulting from anticipated events or analyzed accident conditions. Based on this assumption, the plant cables (inaccessible and accessible) that can be exposed to such "emergency" operating temperatures would be considered "EQ" cables (as defined in 10 C.F.R. § 50.49) that have been subject to robust NRC regulation since 1983. Furthermore, below-grade cables are not exposed to external heat sources.

**Q127. Earlier, you testified (*see* Answer 120) that Entergy had more than sufficient time to complete testing of all in-scope cables before the period of extended operation began. Will Entergy have sufficient time to complete the necessary inspections of aboveground medium-voltage and low-voltage cables before the period of extended operation?**

A127. (RBR) Yes. In fact, the necessary inspections already have been completed at IPEC. In July to August of 2010, Entergy completed non-outage walkdowns of IP2 and IP3 non-EQ cables and connections using procedure EN-DC-348 to identify and document any ALEEs and visually inspect accessible cables and connections for signs of degradation. Entergy also conducted outage walkdowns of IP3 non-EQ cables and connections during the 3R16 refueling outage in March 2011. The IP2 outage walkdowns recently were completed during the 2R20 refueling outage in March 2012.

**Q128. Please describe the completed inspections cited above.**

A128. (RBR) Qualified personnel conducted the non-outage and outage inspections in accordance with EN-DC-348. A walkdown inspection plan was used to inspect each area of the plants. The plan identified all areas with potential ALEEs and provided a guide for visually inspecting accessible non-EQ insulated electrical cables and connections. In developing the plan, the inspection team, of which I was a member, reviewed plant arrangement drawings, searched industry and site-specific operating experience, and discussed operating experience with site personnel.

The walkdown plan divided each structure into specific areas using fire protection drawings. The fire protection drawings were used for orientation during walkdowns to ensure that all possible areas were included. Inspection locations were determined by accounting for operational considerations, ALARA concerns, and procedure program guidance (*i.e.*, visual inspection, cables readily accessible, cables easily approached and viewed, no climbing except on approved ladders/scaffolds). Areas were inspected individually. In performing these inspections, the team, among other things:

- Reviewed the walkdown plan.
- Entered the area to be inspected and photographed the general area.
- Focused its attention on one area at a time, from corner to corner and from floor to ceiling.
- Used a spatial approach rather than focusing on specific equipment. This requires an examination of all areas, concentrating on potential heat sources and accessible cable and connections (*e.g.*, cable trays) as well as hidden, dark, and hard-to-reach spaces.
- Documented each area inspection separately.
- Used infrared temperature devices to measure pipe, cable tray, equipment, and ceiling temperatures, as necessary.
- Photographed any suspect ALEE or cable degradation for further evaluation, noting orientation of the photograph.

**Q129. Are the results of these inspections being documented?**

A129. (RBR) Yes. In accordance with procedure EN-DC-348 (ENT000241), Entergy is in the process of preparing a report to document the non-outage and outage walkdown inspections completed as of March 2012.

## IX. <u>CONCLUSIONS</u>

**Q130. Please summarize the bases for your conclusions with respect to NYS's claims as set forth in contentions NYS-6 and NYS-7.**

A130. (ABC, RBR, TSM, HGS) We conclude that NYS's claims lack merit. With respect to NYS-6, there is no basis for NYS's claim that the IPEC LRA lacks an adequate AMP for non-EQ inaccessible medium-voltage cables exposed to long-term wetting or submergence. LRA Section B.1.23, as amended, includes the Non-EQ Inaccessible Medium-Voltage Cable Program, which is consistent with the program recommended in the relevant NRC guidance – NUREG-1801, Section XI.E3. Entergy has developed a fleet procedure that contains specific instructions for implementing the Non-EQ Inaccessible Medium-Voltage Cable Program at IPEC. As discussed above, Entergy's AMP, the NRC and industry guidance on which that program is based, and Entergy's program-implementing procedure provide the "essential" and "substantive" program details that NYS alleges are missing from the record. Indeed, the program is operational, as Entergy is testing IPEC underground cables within the scope of the program. As expanded, the Non-EQ Inaccessible Medium-Voltage Cable Program requires Entergy to take periodic actions to prevent cables from being exposed to significant moisture, such as inspecting cable manholes to identify water accumulation and removing water if needed. Consistent with industry guidance, IPEC's program also requires the use of proven, state-of-the art methods for establishing and monitoring the insulation condition of medium and low-voltage power cables.

With respect to NYS-7, there is no basis for Mr. Bascom's claim that Entergy has not provided a plan to manage the effects of aging on aboveground non-EQ inaccessible low-voltage power cables that are exposed to localized adverse environmental conditions, such as elevated temperatures. Entergy's Non-EQ Insulated Cables and Connections Program applies to aboveground low-voltage and medium-voltage electrical cables and connections (*i.e.*, accessible and inaccessible cable systems) that are subject to AMR and installed in ALEEs caused by temperature, radiation, or moisture. *Id*. This program is founded on many years of research and operating experience, which have shown that identification of ALEEs associated with accessible and inaccessible cables, coupled with inspections of accessible cables and connections in or near the identified ALEEs, provides reasonable assurance that aging effects on all (accessible and inaccessible low and medium-voltage) cables and connections in such environments can be adequately managed during the period of extended operation. Contrary to NYS's claims, Entergy has implemented a specific, NRC-approved AMP that adequately addresses the specific issues raised by NYS. Entergy also has developed an implementation procedure that follows industry standards and is comparable to procedures used at many other plants.

**Q132. Does this conclude your testimony?**

A132. (ABC, RBR, TSM, HGS) Yes.

**Q133. In accordance with 28 U.S.C. § 1746, do you state under penalty of perjury that the foregoing testimony is true and correct?**

A133. (ABC, RBR, TSM, HGS) Yes.

*Executed in accord with 10 C.F.R. § 2.304(d)*
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