

1 UNITED STATES

2 NUCLEAR REGULATORY COMMISSION

3 BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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5 In re: Docket Nos. 50-247-LR; 50-286-LR
6 License Renewal Application Submitted by ASLBP No. 07-858-03-LR-BD01
7 Entergy Nuclear Indian Point 2, LLC, DPR-26, DPR-64
8 Entergy Nuclear Indian Point 3, LLC, and
9 Entergy Nuclear Operations, Inc. December 14, 2011

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11 PREFILED WRITTEN TESTIMONY OF

12 Earle C. Bascom III

13 REGARDING CONTENTIONS NYS-6 and 7

14 On behalf of the State of New York ("NYS" or "the State"),
15 the Office of the New York State Attorney General hereby submits
16 the following testimony by Earle Bascom regarding Contentions
17 NYS-6 and 7.

18 Q. Please state your full name.

19 A. Earle Clarke Bascom, III

20 Q. By whom are you employed and what is your position?

21 A. I am employed by Electrical Consulting Engineers, P.C.
22 ("ECE"), a company I founded in 2010. I am the president and a
23 principal engineer.

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1 Q. What kind of consulting does ECE do?

2 A. Electrical Consulting Engineers, P.C. (ECE) provides
3 engineering consulting services to the electric power industry
4 and focuses on underground transmission and distribution cable
5 systems. Our work includes engineering design and analysis for
6 new cable circuits, rating capacity studies, and cable system
7 assessments on existing cable systems. Most of our work is
8 performed for utilities, though occasionally we work as
9 subcontractors for architect-engineering firms that lack
10 expertise in underground cables.

11 Q. Please summarize your educational and professional
12 qualifications.

13 A. I hold an Associate's of Science degree in Engineering
14 Science from Hudson Valley Community College, a Bachelor's of
15 Science and Master's of Engineering degrees in Electric Power
16 Engineering from Rensselaer Polytechnic Institute, and an MBA
17 degree from the State University of New York at Albany.

18 Q. Please summarize your employment before you founded
19 ECE in 2010.

20 A. Prior to founding ECE, I worked for nine years with
21 Power Technologies, Inc (PTI, now part of Siemens) focusing on
22 underground cable systems within the Transmission & Distribution
23 Department. At the time I was employed there, PTI provided

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1 transmission and distribution engineering consulting services
2 for overhead, underground, substation and generation equipment
3 as well as being a supplier of power system analysis (load flow,
4 etc.) software. In 1999, I left PTI and joined Power Delivery
5 Consultants, Inc. (PDC); PDC was focused on providing
6 engineering consulting services for underground transmission and
7 distribution systems, but also offered limited services for
8 overhead line and power transformer ratings. I was with PDC for
9 eleven years.

10 Q. What is the purpose of your testimony?

11 A. I was retained by New York State to review Entergy's
12 discussion in its License Renewal Application of the aging
13 management of non-environmentally qualified inaccessible low and
14 medium voltage power cables at Entergy's Indian Point nuclear
15 generating units 2 and 3 that are exposed to adverse localized
16 environments, and to assess whether Entergy has demonstrated
17 that it will adequately manage the effects of aging on those
18 cables so that the cables will perform their intended function
19 during the license renewal period.

20 Q. Have you reviewed materials in preparation for your
21 testimony?

22 A. Yes.

23 Q. What is the source of those materials?

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1 A. Many are documents prepared by government agencies,
2 or documents prepared by Entergy or by the Electric Power
3 Research Institute ("EPRI"), the research arm of the utility
4 industry.

5 Q. I show you NYS Exhibits 000139 through 000145. Do you
6 recognize these documents?

7 A. Yes. These are true and accurate copies of the
8 documents that I referred to, used and/or relied upon in
9 preparing my report and this testimony. In some cases, where
10 the document was extremely long and only a small portion is
11 relevant to my testimony, an excerpt of the document is
12 provided. If it is only an excerpt, that is noted on the first
13 page of the Exhibit.

14 Q. How do these documents relate to the work that you do
15 as an expert in forming opinions such as those contained in this
16 testimony?

17 A. These documents represent the type of information that
18 persons within my field of expertise reasonably rely upon in
19 forming opinions of the type offered in this testimony.

20 Q. I show you what has been marked as Exhibit NYS000138.
21 Do you recognize that document?

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1 A. Yes. It is a copy of the report that I prepared for
2 the State of New York in this proceeding. The report reflects
3 my analysis and opinions.

4 Q. Please give a brief summary of your testimony.

5 A. Entergy has not demonstrated that it will manage the
6 effects of aging on non-environmentally qualified ("non-EQ")
7 inaccessible low and medium voltage cables exposed to
8 significant moisture because its License Renewal Application
9 lacks any substantive detail. Entergy does not specify the
10 location or number of the relevant cables, does not identify
11 their function or the criticality of the systems they serve,
12 does not describe their physical characteristics, does not
13 explain what corrective actions it will take if manhole
14 inspections reveal periodic water accumulation, does not explain
15 what cable condition monitoring tests it will use, does not
16 explain the criteria for determining whether a cable passes or
17 fails a condition monitoring test, and does not identify what
18 corrective actions, if any, Entergy will take if a defective
19 cable is found. Without this essential detail, Entergy has not
20 demonstrated that its Aging Management Plan will insure the
21 continued integrity and function of the non-EQ inaccessible
22 cables that are exposed to significant moisture during the
23 period of extended operation.

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1 In addition, Entergy has not provided any plan to manage
2 the effects of aging on non-EQ inaccessible low and medium
3 voltage power cables that are exposed to other localized adverse
4 environmental conditions, such as excessive heat. Also, Entergy
5 has not demonstrated that such a plan is unnecessary because
6 there are no non-EQ inaccessible power cables exposed to
7 excessive heat. Cable insulation exposed to excessive heat may
8 degrade faster than cable insulation exposed to significant
9 moisture.

10 Q. What does the term non-environmentally qualified mean
11 in the context of these cables?

12 A. A cable is non-environmentally qualified if it is not
13 designed to withstand the adverse effects of the environment in
14 which it is located.

15 Q. In the context of IP2 and IP3, in what way are the
16 non-EQ low and medium voltage cables inaccessible?

17 A. In this context, inaccessible cables are either
18 directly buried underground or pulled through a buried conduit.

19 Q. I would like to ask you some very basic questions
20 about electric circuits. First, what is an electric current?

21 A. An electric current is a flow of electrons through a
22 conductor. A conductor is generally a wire made of copper or
23 aluminum -- materials that offer low resistance to the electron

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1 flow. In order for an electric current to perform work, the
2 conductor must be part of a circuit through which the current
3 continuously flows.

4 Q. What causes electrons to flow through a conductor?

5 A. In alternative current systems, voltage produced by an
6 electric generator produces the force (electro-motive force) to
7 move the electrons through the conductor and around an electric
8 circuit. That force is measured in volts and is described as
9 voltage. Electric current is measured in amperes. Electric
10 power, or the work electricity can do, is the product of amperes
11 and voltage and is expressed as watts.

12 Q. What are the basic components of an underground
13 electric cable?

14 A. There are two basic components - the conductor that
15 carries the current and the cable insulation that prevents the
16 electricity in the conductor from discharging into the
17 surroundings. Other components of the cable help assure that
18 these two basic functions are maintained. If insulation is no
19 longer capable of preventing the electricity from discharging
20 into the surroundings, the voltage of the electricity drops, the
21 electricity faults to ground, the cable circuit fails and the
22 circuit is then unable to perform its task. In an electric
23 cable, the voltage between the conductor and the outer cable

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1 layers is called "line to ground voltage." It represents the
2 electrical potential on the conductor to drive the movement of
3 the electrons

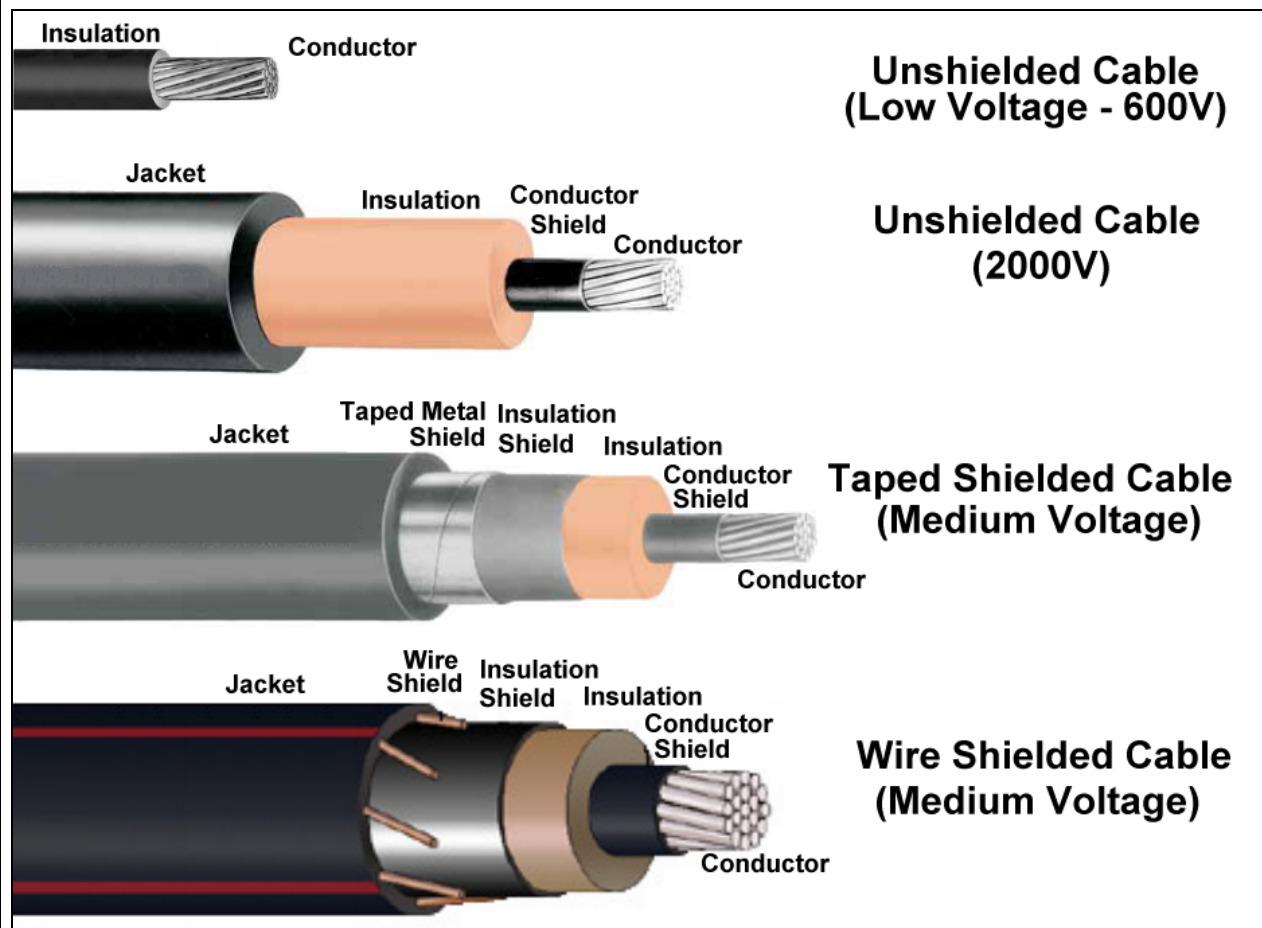
4 Q. Please define the terms "low voltage cable" and
5 "medium voltage cable."

6 A. Low voltage cable generally refers to cables that are
7 classified for operation at 2,400 volts or less and typically do
8 not contain a metallic shield. In general, medium voltage cable
9 refers to cables that are classified for operation from above
10 2,400 volts up to 69,000 volts and typically include a metallic
11 shield. Power equipment is often designated by voltage "class"
12 which is based on the magnitude of the voltage with which the
13 equipment operates. "Transmission" class equipment generally
14 operates at or above 69,000 volts. "Distribution" class
15 equipment generally operates below 69,000 volts. In a utility
16 setting, "medium" voltage equipment is a subset of distribution
17 class and usually refers to equipment that operates above 2,400
18 volts to 69,000 volts. "Low" voltage equipment refers to
19 equipment that operates at 2,400 volts or less. All underground
20 distribution cables are low or medium voltage.

21 Q. Please describe the construction of a low or medium
22 voltage cable.

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A. To help make my testimony on this subject easier to follow, I have created Figure 2 below, which is a composite of pictures showing various cable types, to illustrate the parts of an insulated power cable. Detailed descriptions of the various components are provided below the figure.



Low and Medium Voltage Underground Cable Components

A. A cable contains a conductor that carries the electrical current. The conductor is made of either copper or

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1 aluminum and is usually manufactured using stranded wires that
2 improve its flexibility. Because the conductor has
3 imperfections and non-uniformity that can cause electrical
4 stress in the overlying insulation layer, a thin semi-conducting
5 layer of material, known as the conductor shield, is applied
6 over the conductor to provide a smooth interface between the
7 conductor and the surrounding insulation.

8 The insulation layer on a cable supports the rated line-to-
9 ground voltage between the conductor and outer cable layers --
10 that is, it prevents the electricity from leaving the cable
11 circuit, flowing into the environment and causing a voltage drop
12 in the cable that breaks the circuit.

13 The insulation on cables constructed in the 1960s and 1970s
14 was generally made of cross-linked polyethylene ("XLPE"), or
15 ethylene-propylene-rubber ("EPR"), which is also known as high
16 molecular weight polyethylene ("HMWPE"). The chemical
17 components of these materials are combined using reagents, heat
18 and pressure and then pumped, or extruded through a die, at high
19 temperature over the conductor and conductor shield.

20 An insulation shield, similar to the conductor shield, is then
21 applied to the insulation to provide a smooth interface between
22 the insulation and the outer cable layers.

23 Some medium voltage cables -that is, above 2.4 kV, also

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1 include a metallic shield over the insulation shield. The
2 metallic shield can consist of helical copper or aluminum wire
3 strands, helical copper or aluminum tapes or longitudinal copper
4 or aluminum foil wrap. Some cables have a foil laminate and
5 wires. The longitudinal foil and, to a lesser degree, the
6 helical tapes provide a degree of moisture barrier (i.e., a
7 "sheath") to the cable insulation but generally do not form a
8 hermetic seal.

9 An insulating jacket made of polyvinyl chloride or
10 polyethylene is then placed over the insulation, insulation
11 shield, and metallic shield, if there is one. The jacket
12 provides mechanical protection to the shield and insulation,
13 prevents corrosion of the metallic shield, and electrically
14 insulates the metallic shield from the surrounding environment.
15 The jacket is not a hermetic barrier and does not alone prevent
16 moisture intrusion into the insulation.

17 Q. Are underground cables directly buried in the ground?

18 A. They can either be directly buried in the ground or
19 pulled through buried conduits. Often more than one low or
20 medium voltage cable will be installed in a single conduit.

21 Q. Please explain what a power cable failure is.

22 A. A power cable failure prevents the cable from carrying
23 power to the intended location or equipment. This occurs when

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1 the cable stops carrying current because of a failure or
2 interruption of the conductor, or when the cable insulation
3 stops supporting line to ground voltage because of a failure of
4 the insulation allowing some of the current to reach ground.

5 Q. Please explain the term "line to ground" voltage?

6 A. Power equipment is generally specified based upon
7 system voltage, or the voltage at which a particular system will
8 operate. System voltage or rated voltage is sometimes referred
9 to as the systems' "class" or by electrical engineers as the
10 "line-to-line" voltage or the difference in voltage between two
11 phase (e.g., "line") conductors. Since the outside of the cable
12 is in contact with the ground or contains a metallic shield that
13 is grounded at one location, the voltage appearing between the
14 conductor and the metallic shield or the outside of the cable is
15 the "line to ground voltage". The magnitude of the line to
16 ground voltage is equal to the system voltage divided by the
17 square root of three.

18 Q. What is a cable failure?

19 A. In the simplest terms, a "failure" occurs when a
20 component or apparatus no longer performs its intended function.
21 In this regard, a "power cable failure" prevents the circuit
22 from carrying power to the intended location or equipment.
23 Fundamentally, this means that the cable circuit stops carrying

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1 current due to a failure or interruption of the conductor or if
2 the insulation stops supporting line-to-ground voltage due to a
3 breakdown of the insulation, or both.

4 Q. What are the major causes of cable failures?

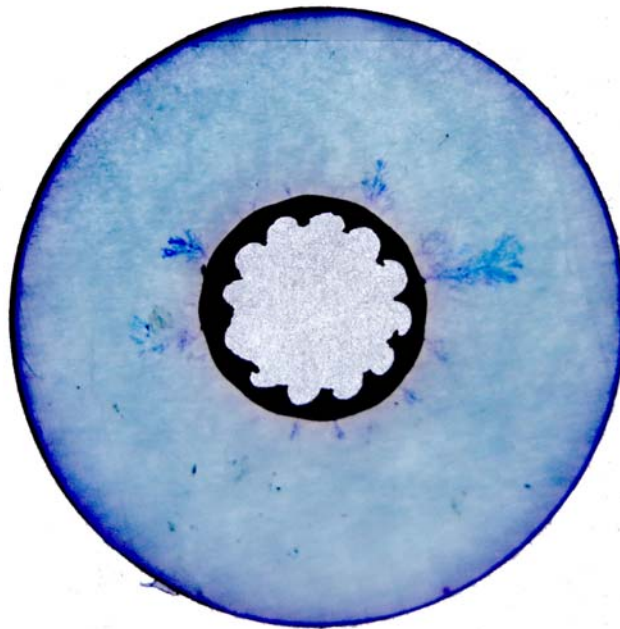
5 A. Many cable failures occur from mechanical damage
6 during dig-ins, or as a result of workmanship errors in the
7 field during the installation of cables to accessories, such as
8 joints or terminations, or from the slow degradation of the
9 cable insulation due to moisture intrusion or exposure to
10 excessive heat. If the insulation is degraded, the cable may no
11 longer be able to support the line-to-ground voltage, resulting
12 in a breakdown or failure between the cable and ground or
13 shield. Electricity from the conductor will then discharge into
14 the surrounding environment, thus causing a drop in voltage and
15 the inability of the current to complete the circuit.

16 Q. What is the major cause of insulation degradation in
17 non-EQ cables constructed in the 1960s and 1970s with XLPE or
18 EPR insulation that are exposed to significant moisture?

19 A. A type of electrochemical degradation, known as "water
20 treeing" is the primary cause of the premature degradation of
21 the insulation leading to development of electrical trees. Water
22 treeing occurs in energized cables that are not constructed to
23 resist water intrusion but are nevertheless wetted or submerged

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1 in water for periods of time. Water permeates the cable
2 insulation over time and forms channels that resemble trees.
3 Water trees are shown below in a photograph I took of a cross-
4 section of cable insulation in which the conductor has been
5 removed. The insulation has been dyed so that the channels of
6 the water trees are revealed.



7
8 **Example of water trees in cable insulation**
9

10 Cables with extruded XLPE insulation manufactured in the
11 1960s and 1970s have experienced high failure rates when
12 subjected to conditions that form water trees leading to
13 electrical trees.

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1 Q. In your testimony, when you refer to cable insulation,
2 will you be referring to extruded XLPE and EPR insulation
3 manufactured in the 1960s and 1970s?

4 A. Yes

5 Q. Do water trees themselves necessarily cause the
6 failure of the insulation to support line to ground voltage?

7 A. No. A water tree does not significantly break down the
8 dielectric (electrical) strength of the insulation and will
9 continue to support rated voltage, although a degree of partial
10 discharge of the electricity may occur at the locations within
11 the water trees that have carbonized. Over time, the partial
12 discharges (or electrical breakdown) will carbonize further, or
13 burn, the water tree channels to form electrical trees. When
14 sufficient electrical trees have formed through the insulation,
15 the insulation will break down, the cable will not be able to
16 support voltage and will therefore not be able to carry current.
17 Water trees usually form in areas of high electrical stress
18 within the insulation. For this reason, they usually form in the
19 insulation nearest the cable conductor.

20 Q. Does XLPE and EPR cable manufactured today have the
21 same propensity to water treeing in wet environments.

22 A. Generally, no. There have been technical developments
23 in the manufacture of XLPE and EPR cables, such as dry curing of

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1 the cable, applying semi-conductive shields with substantially
2 reduced ionic content, and incorporating tree retardant
3 compounds in cross-linked polyethylene insulation which reduce
4 the propensity toward water treeing.

5 Q. Can electrical trees form in the absence of water
6 trees?

7 A. Yes. Occasionally, an electrical tree can form after
8 prolonged operation of a cable with something protruding into
9 the cable insulation, such as a portion of the conductor or the
10 insulation shield, but electrical trees formed by this mechanism
11 are manufacturing defects.

12 Q. Are there tests that can assess the condition of
13 cable insulation on inaccessible cables?

14 A. Yes there are. The staff of the Nuclear Regulatory
15 Commission in its guidance "Generic Aging Lessons Learned Report
16 ("GALL") issued in December 2010 lists six maintenance or
17 diagnostic tests that the NRC determined are proven tests for
18 detecting deterioration of the insulation system in inaccessible
19 power cables due to wetting or submergence. NUREG-1801, Rev. 2,
20 *Generic Aging Lessons Learned, Final Report* (December 2010) at
21 XI E3-2 ("New GALL"), Exh. NYS00147D. The list in the New GALL
22 is not exclusive, and I will describe several tests that are not
23 explicitly listed in the New GALL but are relevant to the issues

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1 in this proceeding. Maintenance and diagnostic tests are used
2 to assess the condition of inaccessible cables. All of these
3 tests require taking the cable out of service to fit test
4 equipment or sensors and each has advantages and disadvantages.
5 Some of the tests are destructive -- that is, the cable that is
6 tested will need to be replaced if it fails the test. Moreover,
7 the insulation on some cables may be weakened by destructive
8 tests even though they pass the test. Other tests are non-
9 destructive -- that is, they assess the condition of the cable
10 insulation without necessarily harming or weakening it.

11 Q. Please describe the destructive tests.

12 A. Destructive tests can be considered "pass/fail" tests.
13 They can all be performed on both shielded and unshielded
14 cables. For example, the AC Voltage Withstand test subjects a
15 cable to a voltage at or above the voltage that the cable was
16 designed to withstand. Either the cable will withstand the
17 increased voltage or it will fail due to a defect in the
18 insulation, joint or termination. If there is a failure, it will
19 occur during controlled conditions rather than failing when the
20 cable is in service and expected to perform. If the cable fails,
21 then it must be replaced.

22 The step voltage test is a variation of the AC Voltage
23 Withstand test. DC instead of AC current is used, the voltage is

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1 raised in stages, and the leakage current is monitored during
2 the test to determine if there are problems.

3 A voltage withstand test not listed in the New GALL is Very
4 Low Frequency ("VLF") testing. If a cable contains water trees,
5 VLF testing is more likely to convert them to electrical trees
6 during the test than the AC Voltage Withstand test. This is a
7 benefit of VLF testing because water trees will not necessarily
8 cause a breakdown in the dielectric strength of the cable
9 insulation but electrical trees will. Thus, a cable with water
10 trees may pass the AC Voltage Withstand test even though it
11 contains water trees that may eventually convert to electrical
12 trees and cause a cable failure in the future. Because VLF
13 testing converts existing water trees into electrical trees more
14 effectively than a simple AC voltage withstand test, it will
15 better force weakened insulation to fail during the testing
16 outage when the cable is not expected to perform and when it can
17 be repaired without disrupting operations or compromising safety
18 features. If a cable fails the VLF test, as with any withstand
19 test, it must be replaced.

20 Q. Please describe the non-destructive tests listed in
21 the New GALL.

22 A. The Insulation (dielectric) dissipation factor
23 compares the characteristics of the cable insulation

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1 (dielectric) material to that of a near-perfect dielectric using
2 a standard capacitor and a capacitive bridge. The capacitive
3 bridge is used to determine the dissipation factor through the
4 known capacitance of a standard capacitor with that of the
5 unknown capacitance of the cable. It is generally non-
6 destructive. This test only detects "gross" effects of the cable
7 -- that is, characteristics that affect the bulk of the cable
8 insulation, but does not detect localized problems. It is best
9 used on paper insulated cables that have appreciable dielectric
10 loss.

11 Partial Discharge Detection detects the minute electrical
12 "noise" (partial discharge or "PD") that is generated where
13 localized breakdowns are occurring in electrical equipment,
14 including in the insulation of cables and accessories, when
15 voltage is applied. As the voltage is raised, localized
16 breakdowns in the insulation - called "partial discharge" -
17 generate a signal that can be detected from the end of the
18 cable. The test takes advantage of the propagation velocity of
19 the signal through the cable to determine the location within a
20 cable that the PD is occurring- i.e., in a specific location
21 within the cable, or in a joint or termination. The magnitude of
22 the signal detected reflects the extent of the partial
23 discharge.

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1 In Time Domain Reflectometry, sometimes called "cable
2 RADAR", a signal is sent through the cable from one accessible
3 cable end; the magnitude and timing of reflections returned to
4 the test equipment gives a measure of the insulation impedance
5 characteristics; the cable propagation velocity is used by the
6 test equipment to determine the location of the impedance.

7 Q. In the New GALL, the AMP for inaccessible non-EQ low
8 and medium voltage cables states that "trending actions are
9 included as part of this AMP." Please explain what "trending
10 actions" are.

11 A. The results of cable condition monitoring tests are
12 "trendable" if the performance of the cable on a later test can
13 be compared with the performance of the same cable on an earlier
14 test so that its relative performance over time can be assessed.
15 Trendable results are important because they provide information
16 about the rate of cable insulation degradation.

17 Q. Are the results of the tests you have described all
18 trendable?

19 A. No. The results of the destructive or pass/fail
20 tests, such as AC Voltage Withstand, Step Voltage and VLF, are
21 not trendable because they only tell you whether the cable
22 withstood the voltage on a particular occasion but do not reveal
23 anything specific about the relative condition of the cable

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1 insulation on that occasion. Therefore, the results of two
2 tests at different times cannot be compared other than whether
3 the cable passed the second test.

4 The results of non-destructive tests such as Insulation
5 Dissipation Factor, PD and TDR can be trended. For example, a
6 comparison of PD test results might show partial discharge
7 occurring in a section of the cable that previously had shown no
8 discharge which could indicate increased cable insulation
9 degradation. Similarly, comparing test results of the
10 Insulation Dissipation factor test might reveal an increase in
11 the dissipation factor as the insulation ages. A comparison of
12 TDR tests may show variations in cable impedance along a tested
13 cable section from earlier tests, perhaps indicating a localized
14 change in the cable condition or environment.

15 Q. Are all the tests listed in the New GALL equally
16 effective on different types of cable?

17 A. No. The condition of cables without an intact
18 metallic shield around the insulation cannot be effectively
19 tested with PD or TDR. The signals evidencing the partial
20 discharges in the PD test or TDR test are minute and are much
21 more likely to be lost - a process called attenuation - in
22 unshielded than shielded cables, or even in taped shields that
23 have experienced some degree of corrosion, particularly in

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1 longer cable circuits. PD and TDR are therefore much less
2 effective in low-voltage cables, most of which are unshielded.
3 Also, the test equipment is sensitive to electrical interference
4 in the vicinity. In addition, PD and TDR tests may be
5 ineffective in cables with helical tape shields that have
6 experienced some degree of corrosion, particularly in longer
7 cable circuits.

8 The pass/fail tests such as AC Voltage Withstand, Step
9 Voltage and VLF are effective on both shielded and unshielded
10 cables. However, their results cannot be trended so they give
11 almost no information about the actual condition of the cable
12 insulation short of breakdown. In sum, there is no one ideal
13 test to monitor the condition of a cable's insulation.

14 Q. Please summarize Entergy's Aging Management Plan
15 ("AMP") for non-EQ inaccessible low and medium voltage cables
16 exposed to significant moisture which was revised in response to
17 Staff's Request for Additional Information and follow-up
18 questions.

19 A. Entergy revised its initial AMP for non-EQ low and
20 medium voltage power cables after the New GALL was issued.
21 Entergy's revised AMP was expanded to apply to low voltage power
22 cables from 400V to 2 kV as well as medium voltage power cables
23 from 2kV to 35kV which are exposed to significant moisture.

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1 *Entergy Response (NL-11-032) to Request for Additional*
2 *Information, Aging Management Programs, Indian Point Nuclear*
3 *Generating Unit Nos. 2 & 3 (Mar.28, 2011) ("Entergy March 28*
4 *Response") Attachment 1 at 12-13, Exh. NYS000151. Significant*
5 *moisture is defined in the New GALL as periodic exposures to*
6 *moisture that last more than a few days- for example, cable*
7 *wetting or submergence in water. New GALL at XI E3-1, Exh.*
8 *NYS00147D. Entergy has indicated it will inspect for water*
9 *accumulation in manholes at least once every year. In addition*
10 *to the annual manhole inspections, Entergy will inspect manholes*
11 *after events such as heavy rain or flooding. The manhole*
12 *inspection frequency will be increased as necessary based on*
13 *evaluation of inspection results. Entergy March 28 Response,*
14 *Attachment 1 at 12-13, Exh. NYS000151.*

15 Entergy has indicated that cables that are exposed to
16 significant moisture will be tested at least once every six
17 years to provide an indication of the condition of the conductor
18 insulation. Test frequencies will be adjusted based on test
19 results and operating experience. Entergy also states that its
20 AMP will be implemented consistent with the corresponding
21 program described in the New GALL and that it will be
22 implemented prior to the period of extended operation. Entergy
23 March 28 Response, Attachment 1 at 12, Exh. NYS000151.

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1 Q. Does Entergy's revised AMP contain any more detail?

2 A. No.

3 Q. In your opinion, does Entergy's revised AMP
4 demonstrate that the effects of aging on the intended
5 function(s) of non-environmentally qualified inaccessible low
6 and medium voltage cables that are exposed to adverse localized
7 environments will be adequately managed during the period of
8 extended operation?

9 A. No it does not.

10 Q. Please explain your conclusion that the AMP is
11 insufficient as it relates to the manhole inspection program.

12 Q. Preventing cable insulation degradation in the first
13 instance is a more effective aging management program than
14 testing the condition of cables to determine whether its
15 insulation has already degraded. Because water trees cannot
16 form in a cable in the absence of water, and almost all
17 electrical trees result from water trees, a robust program for
18 preventing water accumulation in manholes and conduits is
19 essential. Entergy's AMP does not describe the specifics of
20 such a program. Entergy simply provides a schedule of manhole
21 inspections but does not mention or commit to any of the
22 corrective measures listed in the New GALL if water is found,
23 such as the installation of permanent drainage systems, or sump

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1 pumps and alarms. Entergy does not identify actions it will
2 take in the event water intrusion is a chronic problem not
3 sufficiently managed by the proposed schedule of maintenance
4 listed in the GALL.

5 Q. In your opinion, is the AMP sufficient as it relates
6 to cable condition monitoring and testing.?

7 A. No it is not. Entergy has provided so little specific
8 information, that it cannot demonstrate that its cable condition
9 monitoring program will reasonably assure the cables' continued
10 operation during the license renewal period.

11 Q. What information is missing?

12 A. As an example, Entergy has not given any information
13 about the number of non-EQ inaccessible power cables exposed to
14 adverse localized environments.

15 Q, Why is the number of cables important?

16 A. In its License Renewal Application, Entergy has
17 committed to implement its AMP for non-EQ inaccessible power
18 cables prior to the period of extended operation at IP 2 and
19 IP3. The license for IP 2 expires in September 28, 2013, and its
20 period of extended operation begins after that date. To fulfill
21 its commitment, Entergy will have to test all the relevant
22 cables at IP 2 within the next 20 months and will have to be
23 able to schedule enough planned outage time to accomplish all

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1 the testing.

2 Q. Can you estimate the number of cables that can be
3 tested in a normal work shift.

4 A. It depends on the type of test, the testing
5 equipment, time required to obtain switching outages, and the
6 technicians performing the test. Partial discharge testing can
7 be performed at a rate of 3-5 cables per normal work shift of
8 10-12 hours; a voltage withstand test can be performed at a rate
9 of 6-12 cables per normal work shift.

10 Q. Can you assess whether Entergy will be able to test all
11 the relevant cables at IP2 before the period of extended
12 operation.

13 A. I cannot because Entergy has provided no information
14 about the number of relevant cables at either IP 2 or IP3.

15 Q. What other information is missing from Entergy's
16 revised AMP?

17 A. The revised AMP does not identify anything about the
18 characteristics of the non-EQ inaccessible cables that are
19 exposed to significant moisture or identify testing methods that
20 are appropriate for the types of cable the AMP will manage. It
21 does not identify their location, their number, their function,
22 or their physical characteristics. However, as the Brookhaven
23 National Laboratory in a report prepared for the NRC in 2010

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1 explained, the selection of an appropriate testing technique
2 depends on cable characteristics such as voltage rating, cable
3 insulation or jacket material, cable shielding and cable
4 location. NUREG/CR-7000, BNL-NUREG-90318-2009, *Essential*
5 *Elements of an Electric Cable Condition Monitoring Program*,
6 Office of Nuclear Regulatory Research (January 2010) ("NUREG/CR-
7 7000") at 3-20, Exh. NYS000148.

8 For example, I have assumed that the relevant cables are
9 extruded construction for which certain tests would generally be
10 inappropriate, such as DC Step Voltage or Insulation Dissipation
11 Factor. Those same tests, however, would be effective for
12 paper-lead cables, another cable type that utilities frequently
13 used in the 1960s and 1970s.

14 Similarly, whether or not a cable has a metallic shield
15 over the insulation will determine whether certain test methods
16 such as PD or TDR will be effective. If an unshielded cable more
17 than a few hundred feet long is tested with the PD method, then
18 the test results may show that partial discharge is not
19 occurring when it is - i.e. a false negative. That is because
20 the signal that establishes whether or not partial discharges
21 are occurring due to insulation degradation becomes attenuated
22 in an unshielded cable or is disrupted by neighboring electrical
23 equipment.

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1 Because Entergy has failed to provide any information about
2 the characteristics of the relevant cables or selected test
3 methods appropriate for those characteristics, it has not
4 explained what the acceptance criteria are for the tests it will
5 conduct. For example, a voltage withstand test must apply
6 voltage to the cable that is at or above the cable's rating to
7 see if the cable can withstand the stress of normal operation.
8 If a lower voltage is applied, the cable may "pass" the test
9 when it would have failed a test with higher voltage. Similarly,
10 in the Partial Discharge Test, the partial discharges that occur
11 at the location of degraded insulation are measured in
12 picocoulombs. If Entergy applies the PD test to certain cables,
13 it must describe the level of picocoulomb discharge that is
14 acceptable and the level that is not. Moreover, its acceptance
15 criteria must be consistent with industry practice. The
16 industry acceptance criterion for PD testing is no more than 5pC
17 discharge. Otherwise, the Board cannot know whether degraded
18 cables that should be repaired or replaced are allowed to remain
19 in place because the test was insufficiently rigorous.

20 Q. Does the revised AMP include trending actions?

21 A. No. The revised AMP does not mention trending and
22 because it does not select any particular tests, it is not
23 possible to know whether test results will be trendable or if

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1 Entergy intends to use trending in its AMP. The ability to trend
2 test results is extremely significant because it provides
3 information about the rate of cable insulation degradation and
4 that information can be used preventively to repair or replace
5 cables before they fail. Thus, if Entergy chooses a non-
6 trendable voltage withstand test on shielded medium voltage
7 cable over trendable tests such as PD or TDR, it will not obtain
8 information that could be used proactively to repair or replace
9 cables before they are on the verge of failure.

10 Q. Are there adverse environmental conditions, other than
11 moisture intrusion, that can cause the degradation of power
12 cable insulation?

13 A. Yes. For example, thermally induced cable degradation
14 occurs when a power cable is operated above its rated
15 temperature, and the insulation melts or burns causing the
16 insulation's dielectric strength, that is, its voltage
17 insulating properties, to degrade to the point of an electrical
18 breakdown.

19 Q. Is thermal degradation a problem that must be
20 considered in the aging management of inaccessible low and
21 medium voltage power cables?

22 A. Yes. As I discuss below, there may be uncertainty
23 about the installation environment of inaccessible power cables

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1 such as the thermal resistance of the soil in which the cables
2 are buried. Moreover, underground power cables may be in close
3 proximity to each other, either directly buried underground or
4 in cable conduits which may cause the mutual heating effect,
5 discussed below.

6 Q. What causes thermal degradation of cables?

7 A. Thermal degradation can occur in essentially three
8 situations. First, the thermal resistance of the environment
9 through which an underground cable passes may be too high for the
10 heat generated by the current to pass out of the cable and into
11 the surrounding soil. For accessible cables in air, there may be
12 inadequate thermal convection and radiation to dissipate the
13 heat. Second, the ambient temperature around the cables may be
14 greater than the cable was designed to withstand because of an
15 external heat source, such as a steam line, hot water pipe or
16 inadequate ventilation. External heat sources can affect cable
17 temperatures when in parallel or crossing cable circuits or when
18 occupying the same conduits or trench areas. And third, heat
19 from other cables in close proximity, particularly in
20 underground conduits, will cause the temperature to rise in the
21 vicinity of the subject cable and cause a mutual heating effect.

22 Q. Has Entergy prepared an AMP for non-EQ inaccessible
23 power cables that are exposed to adverse localized environments,

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1 such as excessive heat.

2 A. Entergy has not prepared such a plan. Nor has Entergy
3 shown that no plan is necessary by demonstrating that none of
4 its inaccessible cables are ever operated above their rated
5 temperatures.

6 Q. Does insulation degrade faster when exposed to
7 excessive heat than excessive moisture?

8 A. This depends on the extent of the heating. Problems
9 in cables caused by moisture intrusion generally develop over
10 months or years. Low or moderate excessive heating can
11 accelerate cable aging over months or years, while high
12 excessive heating can seriously degrade a cable's condition
13 quickly, within weeks to months. In extreme cases, serious
14 degradation can occur even more quickly.

15 Q. Have any studies been done on the effect of excessive
16 heat on low-voltage cables.

17 A. Yes. The Sandia National Laboratory commissioned a
18 study entitled Aging Management Guideline for Commercial Nuclear
19 Power Plants - Electrical Cable and Terminations, SAND96-0344.
20 The study report was issued in 1996 and concluded that "thermal
21 embrittlement of insulation is one of the most significant aging
22 mechanisms for low-voltage cable." SAND96-0344, *Aging Management*
23 *Guideline for Commercial Nuclear Power Plants - Electrical Cable*

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1 *and Terminations* (September 1996) at 1-3. Exh. NYS00156A.

2 Because all the safety-related power cables at IP 2 and 3
3 are low-voltage, Entergy's failure to explain how it will manage
4 the effects of excessive heat on the insulation of non-EQ
5 inaccessible low-voltage cables is a critical omission from its
6 License Renewal Application. Without such a plan, Entergy has
7 failed to demonstrate that its safety-related low-voltage power
8 cables will continue to perform their critical function during
9 the period of extended license operations.

10 Q. Are there tests that can determine whether
11 inaccessible cables are operating in excessively hot
12 environments?

13 A. Yes. The inaccessible cables could be retrofitted with
14 a fiber optic sensor that provides temperature readings along
15 the length of the cable every meter (3.3 feet). The results of
16 this test method, known as Distributed Temperature Sensing
17 (DTS), can be compared over time and can reveal whether a hot
18 spot in a cable is getting worse.

19 Alternatively, discrete thermocouple temperature monitoring
20 at known hot spots at inaccessible locations, perhaps by
21 inserting a thermocouple up to a few hundred feet into a conduit
22 occupied by low or medium voltage cable, can be used as an
23 alternative to DTS or (on accessible cables) thermographic

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1 testing on accessible cables. Entergy can identify the critical
2 locations to be monitored through the use of an integrated
3 approach that may include (a) the review of Environmental
4 Qualification (EQ) zone maps that show radiation levels and
5 temperatures for various plant areas, (b) consultations with
6 plant staff that are cognizant of plant conditions, (c)
7 performing soil thermal resistivity tests for buried cables, and
8 (d) the review of relevant plant-specific and industry operating
9 experience. The results of the temperature monitoring can be
10 trended, and continuous monitoring may be possible. Fire
11 protection systems in some buildings utilize DTS-based systems
12 to check the temperature of zones within a building.

13 Q. Under what circumstances are corrective actions
14 required for cable overheating?

15 A. Power cables have "emergency" operating temperature
16 limits intended to address short incursions above rated
17 temperature and load. If DTS or discrete temperature tests
18 indicate that cables are consistently operating at temperatures
19 above their "normal" operating limits for longer than
20 permissible emergency durations, or more frequently than
21 periodic emergencies are allowed, or above "emergency" operating
22 limits at any time, then corrective actions must be taken. Those
23 actions include, but are not limited to, removing additional

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1 thermal insulation that may be placed around the cables,
2 reducing the number of cables installed in close proximity (to
3 mitigate mutual heating), replacing existing cables with larger
4 conductor cables to decrease heat losses, lowering the ambient
5 temperature in which the cables are installed, and replacing
6 high thermal resistivity soils around the cable conduits or
7 direct buried cables with a lower thermal resistivity thermal
8 backfill.

9 Q. Please summarize your conclusions about whether
10 Entergy has demonstrated that it will manage the aging affects
11 of non-environmentally qualified inaccessible power cables
12 exposed to adverse localized conditions.

13 A. Entergy's AMP is lacking in substantive detail, and
14 thus Entergy has failed to demonstrate that it will manage the
15 effects of aging of non-EQ inaccessible cables exposed to
16 significant moisture or excessive heat so that they will be able
17 to perform their intended function for another 20 years during
18 the extended licensing period of operation.

19 The following specific critical details about the non-EQ
20 inaccessible power cables are missing from Entergy's LRA

- 21 • Age of the cable circuits
- 22 • The number of cable circuits

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- The lengths of cable circuits
- The voltage class of the cables
- The types of cables, including insulation type
- The types of testing that will be performed
- The acceptance criteria for each of the tests
- The corrective actions
- The management of the effects of aging due to thermal stress
- Justification for failing to consider aging due to thermal stress

Because of this absence of substantive detail, the licensing board cannot adequately assess if Entergy's LRA should be approved for the continued operation of IP2 and IP3.

Q. Does this conclude your testimony?

A. Yes.

I have reviewed all the exhibits referenced herein. True and accurate copies are attached.

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1 UNITED STATES

2 NUCLEAR REGULATORY COMMISSION

3 BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

4 -----X
5 In re: Docket Nos. 50-247-LR; 50-286-LR
6 License Renewal Application Submitted by ASLBP No. 07-858-03-LR-BD01
7 Entergy Nuclear Indian Point 2, LLC, DPR-26, DPR-64
8 Entergy Nuclear Indian Point 3, LLC, and
9 Entergy Nuclear Operations, Inc. December 14, 2011

10 -----X
11 DECLARATION OF EARLE C. BASCOM, III

12 I, Earle C. Bascom, III do hereby declare under penalty of
13 perjury that my statements in the foregoing testimony and my
14 statement of professional qualifications are true and correct to
15 the best of my knowledge and belief.

16 Executed in Accord with 10 C.F.R. § 2.304(d)

17 
18

Earle C. Bascom III, P.E.
President/Principal Engineer
Electrical Consulting Engineers P.C.
4037 Ryan Place
Schenectady, New York 12303
(518) 357-4550
r.bascom@ec-engineers.com

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