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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

NRC STAFF'S TESTIMONY OF ROY MATHEW AND SHEILA RAY
<u>CONCERNING CONTENTION NYS-8 (TRANSFORMERS)</u>

Q.1. Please state your names, occupations, and by whom you are employed.

A.1. My name is Roy K. Mathew (RKM).[1] I am employed as a Team Leader in the Electrical Engineering Branch, Division of Engineering, Office of Nuclear Reactor Regulation (NRR), U.S. Nuclear Regulatory Commission, in Rockville, Maryland. A statement of my professional qualifications is attached hereto. (NRC000032)

My name is Sheila Ray (SR). I am employed as an Electrical Engineer in the Division of Engineering, Office of Nuclear Regulatory Research (RES), U.S. Nuclear Regulatory Commission, in Rockville, Maryland. A statement of my professional qualifications is attached hereto. Staff Transf. Exh. 2. (NRC000033)

Q.2. Please describe the nature of your current responsibilities.

A.2. (RKM) I am currently a Team Leader in the Electrical Engineering Branch ("EEEB") in the Division of Engineering in NRR. As a Team Leader, I am involved in the review of license amendment requests pertaining to electrical areas. I have participated in international

[1] In this testimony, answers provided by specific witnesses are identified by denoting those witnesses' initials at the beginning of the answer. Where an answer is provided by all witnesses, the witnesses' initials are not provided.

collaborations on grid and electrical power systems, reviewed large power transformer failures in the industry for the last several years, and assisted EEEB staff with the issuance of Information Notice 2009-010, "Transformer Failures - Recent Operating Experience". Previously, I worked as a Team Leader in the Division of License Renewal. As a Team Leader in the Division of License Renewal, I conducted several safety review audits for license renewal and developed interim staff guidance for certain aging management programs. Previously, I was an Operations Engineer, and in that role, I developed and monitored implementation of Reactor Safety Strategic Performance Area inspection procedures for Surveillance Testing, Maintenance Effectiveness, Inservice Testing, Heat Sink Operability, and Equipment Alignment. In addition, I have been a Reactor Engineer in Region 1, where I performed Electrical Distribution System Function Inspections (EDFSI), and Safety System Functional Inspections (SSFI).

Through my educational experience, training, and 29 years of experience in the nuclear power industry, I have acquired extensive knowledge in electrical engineering and nuclear engineering topics.

A.2. (SR) I am currently an Electrical Engineer in the Office of Nuclear Regulatory Research, Division of Engineering, Mechanical and Electrical Engineering Branch. My responsibilities include project management for the "Confirmatory Research on Equipment Qualification," international collaboration on cable aging, and participation in IEEE and IEC standards committees. Previously, I was an Electrical Engineer in the Electrical Engineering Branch in the Division of Engineering in NRR. In this role, I conducted safety reviews for license renewal applications, specifically focusing on electrical systems and components, performed reviews of power uprate applications, and worked on station blackout rulemaking.

Q.3. Please explain what your duties have been in connection with the NRC Staff's review of the license renewal application (LRA) submitted by Entergy Nuclear Operations, Inc.

(Entergy or Applicant) for Indian Point Nuclear Generating Units 2 and 3 (IP2 and IP3, or Indian Point).

A.3. (RKM) As part of my official responsibilities, I provided input to portions of the NRC Staff's (Staff) "Safety Evaluation Report Related to the License Renewal of Indian Point Nuclear Generating Units 2 and 3," NUREG-1930, published in November 2009 (SER), regarding electrical components. Specifically, I provided input in the following areas: Section 2.5, "Scoping and Screening Results: Electrical and Instrumentation and Controls System," and Section 3.6, "Aging Management of Electrical and Instrumentation and Controls System." I also reviewed the SER's incorporation of my inputs, and I reviewed SER Section 2.1, "Scoping and Screening Methodology." I have served as the Staff's principal reviewer of the Staff's treatment of electrical transformers in connection with the license renewal of IP2/IP3. As part of my responsibilities, I submitted an affidavit on behalf of the Staff in response to the Applicant's motion for summary disposition of Contention NYS 8 (NYS 8), filed in this proceeding by the State of New York (State or New York), which the Staff filed on September 14, 2009, and I assisted in preparing the Staff's Statement of Position concerning Contention NYS 8, which the Staff is filing simultaneously herewith.

A.3. (SR) As part of my official responsibilities, I provided input to portions of the NRC Staff's SER for IP2 and IP3 regarding electrical components. Specifically, I provided input in the following areas: Section 2.5, "Scoping and Screening Results: Electrical and Instrumentation and Controls System." I also reviewed the SER's incorporation of my inputs, and I reviewed SER Section 2.1, "Scoping and Screening Methodology." I assisted in preparing the Staff's Statement of Position concerning Contention NYS 8, which the Staff is filing simultaneously herewith.

Q.4. What is the purpose of your testimony?

A.4. The purpose of our testimony is to present the Staff's views with respect to Contention NYS-8. That contention generally challenges the Staff's determination that electrical transformers are active components and, therefore, are not subject to an aging management review and do not require an aging management plan or program. The Staff's position is consistent with Entergy's position as set forth in the Indian Point LRA, filed on April 30, 2007.

Q.5. Please identify documents that you reviewed or relied on for purposes of preparing your testimony.

A.5. I reviewed the Statement of Position filed by the State of New York (NYS), Initial Statement of Position, Contention NYS-8 (NYS000002), the testimony of Dr. Robert C. Degeneff (NYS000003), the Report of Robert C. Degeneff (NYS000005), and NYS Exhibits 6 through 44. I also relied on the following documents in the testimony that follows: IEEE Standard C57.12.80 2010, "IEEE Standard Terminology for Power and Distribution Transformers" (NYS000011); IEEE 100, The Authoritative Dictionary of IEEE Standards Terms, Seventh Edition (NRC000034); Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants (NUREG-1800) (NYS000161); Letter from C. Grimes (NRC/NRR) to D. Walters (NEI), dated September 19, 1997, re Determination of Aging Management Review for Electrical Components (Agencywide Document Access and Management System ("ADAMS") Accession No. ML993610300) (ENT000097); Regulatory Guide 1.188, "Standard Format and Content for Applications to Renew Nuclear Power Plant Operating Licenses" (Rev. 1, Sept. 2005) (ADAMS Accession No. ML051920430) (ENT000099); National Fire Protection Recommended Practice 70B, "Recommended Practice for Electrical Equipment Maintenance" (NRC000035)); IEEE C57.106, "IEEE Guide for Maintenance and Acceptance of Insulating Oil in Equipment" (NRC000036); N.Y. Utami, et al., "Evaluation Condition of Transformer Based on Infrared Thermography Results," *Properties and Application of Dielectic Materials*, IEEE 2009 (NRC000037); and IEEE Std 62-1995, "IEEE Guide for Diagnostic Field Testing of Electric Power Apparatus -Part 1: Oil Filled Power Transformers, Regulators, and Reactors" (NRC000038).

Q.6. Are you familiar with Contention NYS-?

A.6. Yes. Contention NYS-8 states as follows:

> The LRA for IP2 and IP3 violates 10 C.F.R. §§ 54.21(a) and 54.29 because it fails to include an aging management plan for each electrical transformer whose proper function is important for plant safety.

The bases for this issue were set forth in the contentions filed by the State of New York (New York) on November 30, 2007. As set forth therein, New York generally asserts that electrical transformers are passive components that perform their safety function without moving parts or a change in configuration or properties. Because the regulations at 10 C.F.R. §§ 54.21(a) and 54.29 require aging management programs for long-lived passive components, New York asserts that the Indian Point License Renewal Application (LRA) should include an aging management program (AMP) for electrical transformers. Because the Indian Point LRA does not include an AMP for electrical transformers, New York asserts that the LRA is in violation of the regulations.

Q.7. Do you agree with Contention NYS 8?

A.7. No. The Staff has determined that electrical transformers, including transformers at IP2/IP3, are active components; their performance and degradation are readily monitorable and thus they are not subject to aging management review and do not require an aging management program pursuant to 10 C.F.R. §§ 54.21(a)(1)(i) and 54.29. Accordingly, the Staff has determined that the LRA's treatment of electrical transformers is correct, and that the treatment of electrical transformers at IP2/IP3 in the Staff's Safety Evaluation Report ("SER") is also correct.

Q.8. What are electrical transformers?

A.8. An electrical transformer is a device that converts variations of current in a primary circuit to variations of voltage and current in a secondary circuit via induction. A transformer consists of two electrically-isolated circuits, connected by a magnetic field. Steel in the core carries the magnetic flux that links the two electric circuits.

IEEE Standard C57.12.80 2010, "IEEE Standard Terminology for Power and Distribution Transformers" (NYS000011) defines a transformer as a "static electric device consisting of a winding, or two or more coupled windings, with or without a magnetic core, for introducing mutual coupling between electric circuits. Transformers are extensively used in electric power systems to transfer power by electromagnetic induction between circuits at the same frequency, usually with changed values of voltage and current."

A transformer changes its state by transforming electrical energy into magnetic energy, then back into electrical energy again. Because its operation depends on electromagnetic induction between two stationary coils and a magnetic flux of changing magnitude and "polarity," transformers are necessarily active AC devices.

Transformers range in size, depending on the application. For example, the transformers connecting the main generator in a power plant to the transmission system are large-sized, oil-filled power transformers with forced cooling system (pumps, fans, blowers, etc.). Other smaller transformers are used in low-voltage power system and instrumentation and control applications. Both large-sized and smaller transformers are used at IP.

In addition, some of the transformers at IP are liquid-filled transformers and others are dry-type transformers. In liquid-filled transformers, the transformer cores are immersed in an insulating oil. The oil serves three functions. First, it provides insulation. Second, it transfers heat away from the windings so that that heat can be dissipated by the heat exchanger, cooling fins, tank surface, or radiator. Third, oil testing serves as a diagnostic tool to monitor the condition of the transformer. Dry-type transformers are transformers that operate in air or gas rather than being oil-filled. The two general types of construction for dry-type transformers are the open or ventilated dry-type and the sealed or closed tank type. Dry transformer windings are usually impregnated with varnish or are of cast coil construction. Sealed transformers are cooled and insulated by a high-dielectric inert gas, such as nitrogen, sulfur hexafluoride, or perfluoropropane.

There are several common cooling methods used in transformers. There are self-cooled transformers [identified as “OA” (oil to air cooled) or “ONAN” (oil natural convection air natural convection)], where heat is dissipated by the tank surface and cooling fins or tubes. There are forced-air cooled transformers [identified as “FA” (forced air) or “ONAF” (oil natural convection air fan)], where fans are employed to force air over the cooling surfaces to augment the self-cooled rating. There are forced-air cooled/forced-oil cooled transformers [identified as “FA/FOA” or “OFAF” (oil forced air forced)], where an oil pump circulates oil through a fan-blown oil-to-air heat exchanger. And there are water cooled transformers [identified as “FOW” or “OFWF” (oil forced water forced)], where heat exchange is obtained by means of water pumped through a pipe coil installed inside or outside the transformer tank.

Q.9. How do transformers operate?

A.9. Transformers operate on the principle of electromagnetic induction or varying magnetic flux. They transfer energy from one or more circuits to other circuits at the same frequency, usually with changed values of voltage and current.

Specifically, transformers consist of two or more windings linked by a mutual magnetic field. When one of the windings (primary) is connected to an alternating voltage source, an alternating flux is produced. The amplitude of the flux depends on the primary voltage and number of turns in the windings. A varying current in the primary winding creates a varying magnetic flux in the transformer's core (the iron core on which both windings are wound) and thus a varying magnetic field through the secondary winding. This varying magnetic field induces a varying electromotive force (EMF), or "voltage", in the secondary winding. The value of the induced voltage depends on the number of secondary turns.

To regulate the output voltage, a tap changer can be used. A tap changer is a device fitted to power transformers for regulation of the output voltage to required levels. This is normally achieved by changing the ratios of the transformers on the system by altering the number of turns in one winding of the appropriate transformer. A tap changer is defined as “a selector switch device used to change transformer taps with the transformer de-energized." IEEE 100, The Authoritative Dictionary of IEEE Standards Terms, Seventh Edition, C57.12.80-1978r (NRC000034). It is also described as "an available connection that permits changing the active portion of the device in the circuit." *Id*.

Q.10. Are transformers active or passive components?

A.10. Transformers are active components.

Q.11. What are the characteristics of active components?

A.11. Active components generally have moving parts or undergo a change in configuration, properties or state in order to perform their intended functions. Age-related degradation of active components is usually readily monitorable and failure of active equipment is usually readily apparent. Examples of active components are pumps, motors, switchgears, transistors, batteries, power inverters, and battery chargers.

Q.12. What are the characteristics of passive structures or components?

A.12. Passive structures or components generally perform their intended functions without moving parts or changes in state, configuration or properties. Age-related degradation in passive structures or components is not readily monitorable. Failure of a passive structure or component may not be readily apparent. Examples of passive components are the containment, the reactor vessel, the reactor coolant system pressure boundary, steam generators, pipes, and electrical cables.

Q.13. Are transformers long-lived components?

A.13. Yes. Transformers are long-lived components and not subject to replacement based on a qualified life or specified time period.

Q.14. Please describe the Commission's requirements pertaining to the treatment of passive and active components in the context of license renewal.

A.14. The Commission requires that long-lived passive components be subject to aging management review (AMR) and requires that age-related degradation be managed. Licensees can use aging management programs (AMP), consistent with Commission guidance in NUREG-1801, "Generic Aging Lessons Learned (GALL) Report," to demonstrate management of age-related degradation. In contrast, the Commission does not require AMR for active components.

The difference in treatment is based on the observation that performance and functionality can be readily monitored in active components, but not so readily monitored for passive components and that detrimental aging effects that may affect active equipment can be readily identified and addressed through routine surveillance, performance monitoring, and maintenance. Detrimental aging effects on passive components, on the other hand, are not readily identifiable or addressable through routine surveillance, performance monitoring, and maintenance. Because surveillance and maintenance programs for active equipment, as well as other maintenance aspects of plant design and licensing basis that are required throughout the period of extended operation, will identify and correct detrimental aging effects on active components, AMRs and AMPs are not required for active components.

The Commission's requirements governing the treatment of passive and active components are set forth in 10 C.F.R. § 54.21, which states, in pertinent part, as follows:

> Each application must contain the following information:
>
> (a) an integrated plant assessment (IPA). The IPA must –
>
> (1) For those systems, structures, and components within the scope of this part, as delineated in § 54.4, identify and list those structures and components subject to an aging management review. Structures and components subject to an aging management review shall encompass those structures and components ---
>
> (i) that perform an intended function, as described in § 54.4, without moving parts or without a change in configuration or properties. These structures and components include, but are not limited to, the reactor vessel, the reactor coolant system pressure boundary, steam generators, the pressurizer, piping, pump casings, valve bodies, the core shroud, component supports, pressure retaining boundaries, heat exchangers, ventilation ducts, the containment, the containment liner, electrical and mechanical penetrations, equipment hatches, seismic Category I structures, electrical cables and connections, cable trays, and electrical cabinets, excluding, but not limited to, pumps (except casing), valves (except body), motors, diesel generators, air compressors, snubbers, the

> control rod drive, ventilation dampers, pressure transmitters, pressure indicators, water level indicators, switchgears, cooling fans, transistors, batteries, breakers, relays, switches, power inverters, circuit boards, battery chargers, and power supplies; and
>
> (ii) That are not subject to replacement based on a qualified life or specified time period.

It should be noted that the regulation states that active structures and components "include . . . but are not limited to" the listed structures and components. Thus, the list is not exclusive, i.e., the fact that a component is not on the list does not mean that it is not an active component.

Structures and components that are subject to AMR under 10 C.F.R. § 54.21 must be age-managed pursuant to 10 C.F.R. § 54.29(a)(1), which states:

> A renewed license may be issued by the Commission up to the full term authorized by § 54.31 if the Commission finds that:
>
> (a) Actions have been identified and have been or will be taken with respect to the matters identified in paragraphs (a)(1) and (a)(2) of this section, such that there is reasonable assurance that the activities authorized by the renewed license will continue to be conducted in accordance with the CLB [current licensing basis] and that any changes made to the plant's CLB in order to comply with this paragraph are in accord with the Act and the Commission's regulations. These matters are:
>
> (1) managing the effects of aging during the period of extended operation on the functionality of structures and components that have been identified to require review under § 54.21(a)(1)[.]

Structures and components that are not subject to an AMR are not required to have AMPs.

Q.15. What is an Aging Management Review (AMR)?

A.15. An AMR is a review that identifies (for any particular system, structure, or component within the scope of license renewal as defined in 10 CFR 54.4) the material, environment, aging effects, and aging management programs that are credited for managing these aging effects. The AMR helps to establish that the effects of aging are adequately managed so that the intended function of each system, structure, or component is maintained in a manner consistent with the current licensing basis for the period of extended operation.

Q.16. What is an Aging Management Program (AMP)?

A.16. An AMP is a program used to manage certain aging effects on particular structures and components within the scope of license renewal. An AMP typically has 10 elements, as described in the GALL Report. These elements are: scope of program, preventive actions, parameters monitored or inspected, detection of aging effects, monitoring and trending, acceptance criteria, corrective actions, confirmation process, administrative controls, and operating experience. NUREG-1801 describes the information that should be included in each AMP element.

Q.17. Are transformers within the scope of license renewal?

A.17. Yes.

Q.18. How does the applicant treat transformers in the LRA?

A.18. The LRA does not include an AMR for electrical transformers and therefore does not propose an AMP for electrical transformers.

Q.19. Do you agree with Contention NYS-8's assertion that electrical transformers are passive components that are subject to AMR pursuant to 10 C.F.R § 54.21 and require an AMP pursuant to 10 C.F.R § 54.29?

A.19. No. Transformers perform their intended functions through a change in state (i.e,. a change in voltage, current, and magnetic flux). In other words, a transformer changes its state by transforming electrical energy into magnetic energy, then back into electrical energy again. Because its operation depends on electromagnetic induction between two stationary coils and a magnetic flux of changing magnitude and "polarity," transformers are necessarily active AC devices. Because transformers perform their intended functions through a change in state, transformers are active components, not passive components. In addition, transformers are readily monitorable. They are subject to surveillance, monitoring, and maintenance pursuant to 10 CFR 50.65, "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," and other Part 50 regulatory requirements. Age-related degradation can be readily identified and addressed through existing regulatory programs, and there is no need for an AMR or AMP to address age-related degradation. Therefore, the AMR and aging management requirements in 10 CFR §§ 54.21 and 54.29 that apply to long-lived passive components do not apply to transformers.

Q.20. What is the basis for your statement that electrical transformers are active components for purposes of 10 C.F.R. § 54.21?

A.20. Active components have moving parts or they undergo a change in configuration, properties, or state in order to perform their intended function. Transformers operate without moving parts, but in order to perform their intended function, they undergo a change in state by stepping down voltage from a higher to a lower value, stepping up voltage to a higher value, or providing isolation to a load and thereby perform their intended function. Transformers perform their intended function through a change in state similar to the change in state or configuration that occurs in switchgear, power supplies, battery chargers, and power inverters, all of which the regulations explicitly identify as active components. Like other active components, degradation of a transformer's ability to perform its intended function is readily monitorable and degradation will result in a change in the electrical performance of the transformers and associated circuits.

In addition, transformers are similar to a number of other active components that are identified in the regulations as active components. Transformers are similar to circuit breakers, relays, and switches because they are all monitored in a similar way. The monitoring techniques for all of these components include performance or condition monitoring by testing and maintenance/surveillance programs. Maintenance/surveillance programs include instrument checks, functional tests, calibration functional tests, and response time verification tests. The results of these tests and performance monitoring programs can be analyzed and trended to provide an indication of aging degradation for transformers and circuit breakers, relays, and switches.

In Staff guidance, provided in the Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants (NUREG-1800) (NYS000161), transformers are considered active components. The Standard Review Plan instructs Staff, who are reviewing license renewal applications, on how to determine whether components are subject to aging management review. It explains what "passive" components are and states that Table 2.1-5 identifies a number of typical components and identifies whether they are "passive."

> In this step, the reviewer determines whether the applicant has properly identified the components subject to an AMR from among those which are WSLR [within the scope of license renewal] (i.e., those identified in Subsection 2.5.3.1). The reviewer should review selected components that the applicant has identified as being WSLR to verify that the applicant has identified these components as being subject to an AMR if they perform intended functions without moving parts or without a change in configuration or properties and are not subject to replacement on the basis of a qualified life or specified time period. The description of "passive" may also be interpreted to include structures and components that do not display a "change in state."
>
> Only components that are "passive" and "long-lived" are subject to an AMR. Table 2.1-5 lists many typical components and structures, and their associated intended functions, and identifies whether they are "passive."

NUREG-1800, Section 2.5.3.2, p. 2.5-5. Table 2.1-5 identifies transformers as components that do not meet the passive component definition at 10 CFR § 54.21(a)(1)(i). See NUREG-1800, Rev. 2 at p. 2.1-26.

In 1997, during the course of its review of NEI guidelines for license renewal, the Staff identified a need for guidance regarding whether certain electrical components should be subject to aging management review. Letter from C. Grimes (NRC/NRR) to D. Walters (NEI), dated September 19, 1997, re Determination of Aging Management Review for Electrical Components (ADAMS Accession No. ML993610300) (ENT000097). The Staff noted that, while the regulation at 10 C.F.R. § 54.21(a)(1)(i) identified many electrical components as active and not requiring aging management review, the list was not exclusive and did not cover a number of components, e.g., transformers, fuses, indicating lights, heat tracing, electric heaters, and recombiners. *Id.* at 2. The Staff compared these components with the components specifically identified in the regulation as active and considered how the performance of intended functions would be achieved and whether age-related degradation would be readily monitored. *Id*. The Staff determined that transformers should be considered active components, which did not require aging management review, because performance and degradation were readily monitorable. *Id*. The Staff explained:

> Based on the consideration discussion provided in the rule and [Statement of Consideration], the staff compared the electrical components identified above with the examples explicitly provided in the rule in terms of how the performance of their intended functions would be achieved and whether aging degradation of these components would be readily monitored using currently available techniques, in a similar way by which the examples in the rule (circuit breakers, relays, switches, etc.) would be monitored. These techniques include performance or condition monitoring by testing and maintenance/surveillance programs that include instrument checks, functional tests, calibration functional tests, and response time verification tests.

Id. The Staff concluded that transformers did not require an aging management review because they performed their intended function through a change in state similar to that in switchgear, power supplies, battery chargers and power inverters and that degradation in transformers' ability to perform their intended function was readily monitorable.

> Transformer perform their intended function through a change in state by stepping down voltage from a higher to a lower value, stepping up voltage to a higher value, or providing isolation to a load. Transformers perform their intended function through a change in state similar to switchgear, power supplies, battery chargers, and power inverters, which have been excluded in § 54.21(a)(1)(i) from an aging management review. Any degradation of the transformer's ability to perform its intended function is readily monitorable by a change in the electrical performance of the transformer and the associated circuits. Trending electrical parameters measured during transformer surveillance and maintenance such as Doble test results, and advanced monitoring methods such as infrared thermography, and electrical circuit characterization and diagnosis provide a direct indication of the performance of the transformer. Therefore, transformers are not subject to an aging management review.

Id. See also, Regulatory Guide 1.188, "Standard Format and Content for Applications to Renew Nuclear Power Plant Operating Licenses" (Rev. 1, Sept. 2005) (ADAMS Accession No. ML051920430) (ENT000099).

Q.21. Why don't active components require an AMR or AMP?

A.21. Active components do not require an AMR or AMP because they are considered to be adequately monitored and maintained by existing plant programs and procedures. In other words, detrimental aging effects that may affect active equipment can be readily identified and corrected through routine surveillance, performance monitoring, and maintenance. Surveillance and maintenance programs for active equipment, as well as other maintenance aspects of plant design and licensing basis, are required throughout the period of extended operation in accordance with the plant's current licensing basis. Gross failure of a power transformer is typically monitored by various indications and alarms in the control room.

Q.22. Are electrical transformers subject to performance monitoring to identify and correct detrimental aging effects?

A.22. Yes, both the input and output voltage and current as well as power output and the temperature of oil can be monitored. Trending electrical parameters measured during transformer surveillance and maintenance provides a direct indication of the performance of the transformer. For example, overvoltages and undervoltages can be detrimental to the transformer and the load it serves. In addition, temperature gauges on the transformer can give a direct indication of performance. National Fire Protection Recommended Practice 70B, "Recommended Practice for Electrical Equipment Maintenance" (NRC000035), "states that excessive temperature indicates an overload or some interference with the normal means of cooling."

National Fire Protection Association's Recommended Practices 70B also has a discussion on pressure/vacuum gauges for sealed tanks on transformers and states the following in Section 21.2.5.2:

> Pressure/vacuum gauges are often found on sealed tank and automatic pressure transformers and indicate the integrity of the sealed construction. Most transformers have provisions for adding a pressure/vacuum gauge, and, if feasible, the gauge should be added. The readings should be compared to the recommendations of the manufacturer for normal operating ranges. High pressures indicate an overload or internal defect and should be investigated immediately. A sustained zero pressure reading indicates a gas leak or a defective gauge.

In addition, trending electrical parameters measured during transformer surveillance and maintenance such as Doble test results, and advanced monitoring methods such as infrared thermography, and electrical circuit characterization and diagnosis provide a direct indication of the performance of the transformer. Furthermore, IEEE C57.106, "IEEE Guide for Maintenance and Acceptance of Insulating Oil in Equipment" (NRC000036), states that "certain properties of mineral insulating oil have been determined as important for proper electrical equipment performance" and that "oil in service may contain dissolved gases that are useful in assessing the continued serviceability of certain types of transformers." Table 4 of IEEE C57.106 provides a list of pertinent standards for mineral insulating oil. For testing in-service oil, IEEE C57.106 provides suggested limits for continued use of service-aged insulating oil in Table 5.

An IEEE Paper by N.Y. Utami, et al., describes thermography as non-contact measurements of an object's temperature. N.Y. Utami, et al., "Evaluation Condition of Transformer Based on Infrared Thermography Results" at 1056, *Properties and Application of Dielectic Materials*, IEEE 2009 (NRC000037). Infrared thermography is the use of infrared radiation to depict thermal variations. The IEEE paper states that unusually high external temperatures or unusual thermal patterns of transformer tanks indicate problems inside the transformer. Abnormally high temperatures can damage or destroy transformer insulation and, thus, reduce life expectancy. The applicant is required to perform the required maintenance to systems and components important to safety to ensure that they will perform its intended functions in accordance with 10 CFR Part 50 requirements.

Q.23. Are electrical transformers subject to maintenance that corrects the detrimental effects of aging?

A.23. Yes, for example, the following maintenance procedures are used to correct the detrimental effects of aging on electrical transformers: visual inspections, operational checks on auxiliary devices, examination and testing for oil and nitrogen leaks, insulation resistance tests, turns ratio tests (to confirm a difference in voltage between phases and detect shorts), insulating liquid testing, oil analysis, insulating power factor tests (i.e., Doble tests), insulation oil filtration tests, load tap changer tests, and low voltage excitation tests. National Fire Protection Recommended Practice 70B, "Recommended Practice for Electrical Equipment Maintenance" (NRC000035); IEEE Std 62-1995, "IEEE Guide for Diagnostic Field Testing of Electric Power Apparatus - Part 1: Oil Filled Power Transformers, Regulators, and Reactors" (NRC000038).

Q.24. Will degradation in electrical transformers result in detectable losses?

A.24. Degradation of a transformer's ability to perform its intended function is readily monitorable by a change in the electrical performance of the transformer and the associated circuits. Trending electrical parameters measured during transformer surveillance and maintenance such as Doble test results, and advanced monitoring methods such as infrared thermography, and electrical circuit characterization and diagnosis, provide a direct indication of the performance of the transformer.

Q.25. Is it possible to monitor electrical transformers for degradation?

A.25. Yes. Electrical transformers can be monitored for degradation. Samples of transformer oil can tell service engineers a great deal about the condition of a transformer. Because oil is used to cool the transformer and to insulate internal components and because it bathes every internal component, it contains a great deal of diagnostic information. Trending of laboratory analyses of a sample of transformer oil can provide advance warning of aging. Typical tests carried out during the laboratory analysis of an oil sample include: breakdown voltage (dielectric strength), moisture content, dissolved gas analysis, and oxygen inhibitor. For testing in-service oil, IEEE C57.106 (NRC000036) provides suggested limits for continued use of service-aged insulating oil in Table 5.

The best information about a transformer's condition is obtained by viewing trends. So it is useful to take a benchmark sample when a transformer is first energized, or when an oil treatment is performed, and to take further samples at regular intervals so that any variation in quality can be identified to indicate developing faults.

Q.26. Are electrical transformers subject to the Maintenance Rule requirements?

A.26. Yes, electrical transformers are subject to the Maintenance Rule requirements. Transformers fall into the scope of the maintenance rule per 10 CFR 50.65(b)(2)(i), (ii), and (iii), since they are needed for offsite power and to provide power to the safety buses during normal operation and to mitigate an accident. The offsite power system is considered the preferred power source and the startup and/or unit auxiliary transformers provide power to equipment used to mitigate an accident. Because electrical transformers are subject to the Maintenance Rule requirements, licensees must monitor the performance or condition of transformers so they perform their intended function.

The Maintenance Rule, 10 C.F.R. § 50.65, states:

> The requirements of this section are applicable during all conditions of plant operation, including normal shutdown operations.
>
> (a)(1) Each holder of an operating license for a nuclear power plant under this part and each holder of a combined license under part 52 of this chapter after the Commission makes the finding under § 52.103(g) of this chapter, shall monitor the performance or condition of structures, systems, or components, against licensee-established goals, in a manner sufficient to provide reasonable assurance that these structures, systems, and components, as defined in paragraph (b) of this section, are capable of fulfilling their intended functions. These goals shall be established commensurate with safety and, where practical, take into account industrywide operating experience. When the performance or condition of a structure, system, or component does not meet established goals, appropriate corrective action shall be taken. For a nuclear power plant for which the licensee has submitted the certifications specified in § 50.82(a)(1) or 52.110(a)(1) of this chapter, as applicable, this section shall only apply to the extent that the licensee shall monitor the performance or condition of all structures, systems, or components

associated with the storage, control, and maintenance of spent fuel in a safe condition, in a manner sufficient to provide reasonable assurance that these structures, systems, and components are capable of fulfilling their intended functions.

(2) Monitoring as specified in paragraph (a)(1) of this section is not required where it has been demonstrated that the performance or condition of a structure, system, or component is being effectively controlled through the performance of appropriate preventive maintenance, such that the structure, system, or component remains capable of performing its intended function.

(3) Performance and condition monitoring activities and associated goals and preventive maintenance activities shall be evaluated at least every refueling cycle provided the interval between evaluations does not exceed 24 months. The evaluations shall take into account, where practical, industry-wide operating experience. Adjustments shall be made where necessary to ensure that the objective of preventing failures of structures, systems, and components through maintenance is appropriately balanced against the objective of minimizing unavailability of structures, systems, and components due to monitoring or preventive maintenance.

(4) Before performing maintenance activities (including but not limited to surveillance, post-maintenance testing, and corrective and preventive maintenance), the licensee shall assess and manage the increase in risk that may result from the proposed maintenance activities. The scope of the assessment may be limited to structures, systems, and components that a risk-informed evaluation process has shown to be significant to public health and safety.

(b) The scope of the monitoring program specified in paragraph (a)(1) of this section shall include safety related and nonsafety related structures, systems, and components, as follows:

(1) Safety-related structures, systems and components that are 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 that could result in potential offsite exposure comparable to the guidelines in Sec. 50.34(a)(1), Sec. 50.67(b)(2), or Sec. 100.11 of this chapter, as applicable.

(2) Nonsafety related structures, systems, or components:

(i) That are relied upon to mitigate accidents or transients or are used in plant emergency operating procedures (EOPs); or

(ii) Whose failure could prevent safety-related structures, systems, and components from fulfilling their safety-related function; or

> (iii) Whose failure could cause a reactor scram or actuation of a safety-related system.
>
> (c) The requirements of this section shall be implemented by each licensee no later than July 10, 1996.

Because electrical transformers are subject to the Maintenance Rule, they are monitored and maintained so that degradation due to aging can be identified and corrected. The Maintenance Rule, along with existing monitoring, surveillance, inspection and testing programs, serves the purpose for electrical transformers that an AMP would serve for a passive component. Since a transformer is an active component and its performance is monitored under the Maintenance Rule, and other existing regulatory programs, applicants are not required to address aging management through an AMP.

Q.27. Are electrical transformers more like the active components or the passive components identified in 10 C.F.R. § 54.21(a)(1)(i)?

A.27. Electrical transformers are more like the active components identified in 10 C.F.R. § 54.21(a)(1)(i). Specifically, transformers are like the following active components:

Batteries: Transformers are similar to batteries because, like batteries, they operate without moving parts. When a battery is working, the electrolyte properties change during discharge but the change cannot be seen. When transformers are working, the magnetic flux changes, but cannot be seen. When a battery is operating, a chemical reaction is taking place and output voltage and current can be measured. Similarly, when a transformer is working, a change in the magnetic flux is taking place and as a result, output voltage and current can be measured. Both batteries and transformers can be readily monitored. They are not subject to periodic replacement based on a qualified life or specified time period (i.e., they are long-lived components).

Transistors: Transformers are similar to transistors, which are explicitly identified in 10 C.F.R. § 54.21(a)(1)(i) as active components, or components that are not subject to an aging management review. To operate, both of them undergo a change of state but do so with no moving parts and without a chemical change. In addition, transistors' output is easily monitored and in this way, transistors are similar to transformers. Both transistors and transformers are long-lived components and they perform their intended function through a change in state. Degradation of the ability of both transistors and transformers to perform their intended functions is readily detectable and in many instances will trigger plant alarms.

Battery Chargers: Transformers are similar to battery chargers. Battery chargers do not have moving parts and function without a chemical change, yet they are identified in 10 C.F.R. § 54 .21(a)(1)(i) as active components. Battery chargers supply constant direct current power to batteries being charged. Generally the input source is alternating current power and the charger converts the electricity to direct current power in order to charge the battery. Like battery chargers, transformers perform an electrical conversion that cannot be seen, only measured. Battery chargers are long-lived components and their performance is readily monitored. Similarly, transformers are long-lived components and their performance is readily monitored.

All of these components, batteries, transistors, battery chargers and transformers, are electrical components that are considered active components, because they undergo a change of state, configuration or properties in the course of performing their intended function.

Q.28. Are transformers different than the passive components identified in 10 C.F.R. § 54.21(a)(1)(i)?

A.28. Yes.

Cables: Transformers are different than passive components like electrical cables because cables perform their intended function (transmit power or signals) without a change in state, configuration, or properties and the effects of aging degradation for cables are not readily monitorable. In contrast, the effects of aging degradation on transformers are readily monitorable.

Reactor vessel, containment, and piping: Transformers are different than the reactor vessel, containment, and piping because the reactor vessel, containment, and piping perform their intended function without a change in state, configuration or property. Transformers, in contrast, perform their intended function through a change in state. In addition, age-related degradation in the reactor vessel, containment, and piping is not readily monitorable and failure to perform their intended functions may not be readily monitorable, while failure of a transformer to perform its intended function and degradation are both readily monitorable.

Q.29. Dr. Degeneff asserts that transformers are like pipes because pipes can change the properties of the fluid or power that they contain but they themselves undergo no change in properties. Do you agree?

A.29. No, transformers are not like pipes. The function of a pipe is to transport fluid from one point to another without acting upon that fluid to change its properties. While it is possible that a pipe can change the property of the fluid that travels through it, that is not a pipe's primary function. In contrast, transformers cannot transport power (voltage and current) from input to output without changing the power, either changing current or voltage or both. In addition, age-related degradation in piping is not readily or directly monitorable. As explained earlier, a transformer changes its state by transforming electrical energy into magnetic energy, then back into electrical energy again. Because its operation depends on electromagnetic induction between two stationary coils and a magnetic flux of changing magnitude and "polarity," transformers are necessarily active AC devices. Therefore, power transformers are active devices which do not require aging management review or an aging management program in accordance with 10 C.F.R. § 54.21(a)(1) (i).

Q.30. Dr. Degeneff asserts that transformers are like electrical cables because a transformer is, essentially, two cables in close proximity to each other. Do you agree?

A.30. No. Cables are passive devices and they transport power from point A to point B without moving parts or any change in configuration, property or state and the effects of aging are not readily monitorable. While Dr. Degeneff is correct, in a theoretical sense, that two cables in close proximity to each other can function as a simple transformer, that observation is not relevant to the question whether a transformer is an active or a passive component. Transformers perform their intended function through a change in state similar to batteries, transistors, battery chargers, switchgear, power supplies, and power inverters, which have been excluded in 10 C.F.R. § 54.21(a)(1)(i) from an aging management review.

Q.31. Dr. Degeneff asserts that a transformer is like a reactor pressure vessel, containment, and steam generator, all of which are passive components. Do you agree?

A.31. No. As we stated earlier, the reactor pressure vessel, containment, and steam generator are long-lived passive components that require an aging management review because functionality is measured indirectly and age-related degradation in them cannot be easily monitored. Because transformers are active devices that can be readily monitored and maintained pursuant to the Maintenance Rule and other regulatory programs, they do not require an aging management program.

Q.32. Dr. Degeneff asserts that transformers are not like transistors, power inverters, power supplies, circuit breakers, and battery chargers, which are all considered active components, because these components have mechanisms to dynamically control the relationship between input and output and transformers do not have these external control mechanisms. Do you agree?

A.32. No. First, this is not a relevant consideration. Whether or not a component has an external control or not does not determine whether it is a long-lived passive component that requires aging management. Transistors, power inverters, power supplies, circuit breakers, and battery chargers do not require external controls, but they are all active components. Like transformers, they can be easily monitored for performance. Gross failure of these components is readily detectable during plant operation. They are all covered by existing monitoring and maintenance procedures and thus they do not require an AMP to manage age-related degradation.

Second, the premise of the statement is incorrect. Transformers can have external control mechanisms that dynamically control the relationship between input and output voltages. Indian Point's IP-2/IP-3 13.8 kV feeders are connected to the 6.9 kV buses through autotransformers. These autotransformers have load tap changers that automatically adjust output voltages when input voltages falls to certain values. They have control mechanisms that dynamically control the relationship between input and output voltages.

Q.33. Dr. Degeneff lists 18 instances of transformer failures in the Report he filed with his testimony (NYS00005, pp. 18-21). Were these failures readily apparent?

A.33. Yes, in each instance the failure was readily apparent. In some instances, the failure was accompanied by an explosion and/or fire, both of which were readily apparent. These instances include the failures of the Indian Point, Unit 3 main transformer on April 6, 2007; the Diablo Canyon, Unit 2 main transformer on August 16, 2008; the Salem Unit 1 main power transformer on July 7, 2010; the Sequoyah Nuclear Plant intertie transformer on September 22, 2010; and the Indian Point, Unit 2 main transformer on November 7, 2010. In some instances, the failure resulted in activation of alarms or reactor or turbine trips or reactor scrams. These instances include the failure of the Limerick Generating Station, Unit 2 main transformer on February 1, 2008; the North Anna, Unit 2 main transformer on October 29, 2008; the Oyster Creek main transformer on November 28, 2008; and the Comanche Peak Unit 1 main generator output transformer on January 9, 2010. The failure of the Oyster Creek M1A transformer on February 1, 2009 resulted in both a fire and a reactor scram. The fact that these failures were readily apparent shows that transformers are active components, i.e., components whose performance or functionality is readily apparent, readily observable, readily monitored and directly verified. They are thus different from passive components, such as containment, where functionality is indirectly verified and where a performance failure may not be readily apparent.

Q.34. Has the Staff of the NRC reached a conclusion with respect to Contention NYS-8?

A.34. Yes. Based on a review of the 10 CFR Part 54 requirements, NRC staff guidance provided in NUREG-1800 (NYS000161), the IP2 and IP3 License Renewal Application, the Staff's Safety Evaluation Report Related to the License Renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3 (NUREG-1930 and Supplement 1) and the documents identified in our foregoing testimony on pages 4-5, the Staff of the NRC concludes that electrical transformers are <u>active</u> components and are not subject to aging management review and do not require an aging management program in accordance with 10 CFR §§ 54.21(a)(1)(i) and 54.29. Consistent with the Staff's views, Entergy's license renewal application for Indian Point treats electrical components as active components and does not include an aging management review or an aging management program for electrical transformers at Indian Point. The Staff has, therefore, concluded that Entergy's Indian Point license renewal application is acceptable and that there is no merit in the contention's assertion that electrical transformers should be subject to an aging management review or an aging management program.

Q.35. Does this conclude your testimony?

A.35. Yes.

March 22, 2012

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

AFFIDAVIT OF ROY K. MATHEW

I, Roy K. Mathew, do hereby declare under penalty of perjury that my statements in the foregoing testimony and my statement of professional qualifications are true and correct to the best of my knowledge and belief.

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Dated at Rockville, Maryland
This 22nd day of March, 2012

March 22, 2012

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

AFFIDAVIT OF SHEILA RAY

I, Sheila Ray, do hereby declare under penalty of perjury that my statements in the foregoing testimony and my statement of professional qualifications are true and correct to the best of my knowledge and belief.

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Dated at Rockville, Maryland
This 22nd day of March, 2012