UNITED STATES
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

In re:	Docket Nos. 50-247-LR; 50-286-LR
License Renewal Application Submitted by	ASLBP No. 07-858-03-LR-BD01
Entergy Nuclear Indian Point 2, LLC, Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations, Inc.	DPR-26, DPR-64
	December 12, 2011

STATE OF NEW YORK
INITIAL STATEMENT OF POSITION
CONTENTION NYS-8

Office of the Attorney General
for the State of New York
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PRELIMINARY STATEMENT

In accordance with 10 C.F.R. Section 2.107(a)(1) and the Atomic Safety and Licensing Board's ("Board") July 1, 2010 Memorandum and Order, the State of New York ("New York") hereby submits its Initial Statement of Position on New York's admitted Contention 8 ("NYS-8") concerning electrical transformers, which "have the critically important function of providing power to equipment that is necessary for accident prevention, accident management, and accident mitigation" at nuclear power plants. *Aging of Safety Class 1E Transformers in Safety Systems of Nuclear Power Plants*, NUREG/CR-5753 at 50 (Feb. 1996) (Exhibit ("Exh.") NYS000012) ("NUREG/CR-5753").

In this proceeding, the State of New York has satisfied the standards contained in 10 C.F.R. § 2.309 governing contention admissibility – standards that NRC and Entergy have described as "strict by design." The State now submits this testimony to show that Entergy's license renewal application ("LRA") should be denied because the application improperly excludes transformers from aging management review in violation of 10 C.F.R. § 54.21. Moreover, should the Board grant the relief sought by New York, any subsequent attempt by Entergy to remedy this deficiency in its license renewal application by conducting an aging management review of transformers and implementing an aging management program for transformers should be filed with the Board and all parties should be given a reasonable opportunity to file, with the Board, new contentions based on Entergy's submittals.

SUMMARY OF ARGUMENT AND SUPPORTING EVIDENCE

This Statement is supported by the testimony of Dr. Robert C. Degeneff ("Degeneff PFT") and exhibits thereto; and the Report of Dr. Robert C. Degeneff ("2011 Degeneff Report") (Exhs. NYS000003, NYS000006-NYS000038, NYS000005, respectively). In his testimony and

accompanying report, Dr. Degeneff explains the uncontroversial consensus of the technical community that transformers are: (1) static components, which do not experience changes in configuration or state during their operation; (2) components that are more similar to components for which aging management review is required than to components for which aging management review is not required; (3) components in which age related degradation is not readily monitored; and (4) components whose useful life may exceed 60 years and for which periodic replacement is not generally scheduled. Each of these findings supports the conclusion that transformers require aging management review and an aging management program. Dr. Degeneff also examines recent examples of unanticipated transformer failures that illustrate (1) the inherent danger in relying solely on remote monitoring of transformer performance and (2) the need for an effective aging management program, similar to programs recommended by independent experts, including industry consultants.

As demonstrated in Point I, *infra*, transformers satisfy the first prong of the test for aging management review in 10 C.F.R. § 54.21(a), in that: (1) they perform their intended function "without moving parts or without a change in configuration or properties;" (2) the intended function of transformers is to change the voltage of electrical power without themselves experiencing any change in state; (3) transformers are similar to "included" components listed in 10 C.F.R. § 54.21(a)(i), because they perform their intended function passively, just as electric cables and water carrying pipes do; (4) unlike "excluded" components, transformers will always have precisely the same degree of effect on the electricity which flows through them, because transformers' properties never change; (5) not only do transformers' clear physical properties demonstrate that they require aging management review under the clear language of the regulations, but the Commission's comments in the Statement of Consideration in the license

renewal rule confirm that transformers are precisely the type of component for which the Commission intended to require aging management review because age related degradation in passive components like the transformer is not "readily monitored;" and (6) the Commission has a long history of concern about the inability to monitor transformers as demonstrated in NRC accident reports, NUREG's, and information notices, Entergy's own maintenance records, and reports from the technical community, all demonstrating that age related degradation is difficult to detect in transformers, and that if not detected can lead to catastrophic failure of the transformer.

As discussed in Point II, *infra*, transformers are not replaced at regular intervals, but are long-lived components whose service life can exceed even the licensing period of nuclear power plants, and thus, routine monitoring and maintenance through an effective aging management program is essential.

In sum, transformers meet both of the prongs of 10 C.F.R. § 54.21(a) and, thus, require aging management review.

PROPOSED FINDINGS OF FACT

This Statement of Position and its supporting evidence merit a finding by the Board of the following facts regarding NYS-8:

1. Transformers perform their intended function without moving parts or without a change in configuration or properties;

    1.1. Transformers perform their intended function without experiencing a change in state;

    1.2. Transformers are more similar to components for which aging management review is required than to components for which aging management review is not required;

    1.3. Age related degradation in transformers is not readily monitored;

2. Transformers are not subject to replacement based on a qualified life or specified time period; and

3. Entergy has failed to provide an aging management program for transformers.

PROCEDURAL HISTORY

On November 30, 2007, the State of New York submitted a Petition to Intervene, which Petition included proposed contentions regarding critical deficiencies in Entergy's Indian Point relicensing application with respect to public safety, health and the environment. Among those proposed contentions was Contention 8, which reads in its entirety:

> 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.

New York State Notice of Intention to Participate and Petition to Intervene, Contention 8, at pp. 103 (Nov. 30, 2007) ("NYS Petition"). The State asserted that transformers require an Aging Management Plan ("AMP"), because they function without moving parts or without a change in configuration or properties, as provided for in 10 C.F.R. §§ 54.21(a)(1)(i), 54.4(a)(1), (2) and (3). The State alleged, *inter alia*, that failure to effectively manage the aging of electrical transformers could compromise the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor and maintain a safe shutdown condition, or the capability to prevent or mitigate the consequences of accidents. *See* NYS Petition at 103-104.

On January 22, 2008, Entergy filed an Answer opposing the admission of Contention 8. *Answer of Entergy Nuclear Operations, Inc. Opposing New York State Notice of Intention to Participate and Petition to Intervene*, at pp. 69-72 (Jan. 22, 2008) ("Entergy Answer"). Entergy alleged that transformers do not require an AMP because an industry guidance document lists transformers as active components, which are subject to a licensee's routine maintenance

program. *Id.* at 70. Also on January 22, 2008, NRC Staff opposed the admission of Contention 8. *NRC Staff's Response to Petitions for Leave to Intervene,* at pp. 44-46 (Jan. 22, 2008) ("Staff Response"). Staff opposed Contention 8 based on a Staff guidance document in which Staff took the position that transformers do not require an AMP. On February 22, 2008, the State responded to Entergy and Staff's opposition, by asserting that neither industry nor Staff guidance is binding upon the Board. *State of New York's Reply in Support of Petition to Intervene,* Contention 8, at 59 (Feb. 22, 2008) ("NYS Reply").

On July 31, 2008 and following oral argument, the Board admitted Contention 8 with respect to "safety-related electrical transformers that are required for compliance with 10 C.F.R. §§ 50.48 and 50.63," finding that neither Entergy nor Staff provided any "legally binding justification to exclude transformers from" an aging management review. *Entergy Nuclear Operations, Inc.* (Indian Point Nuclear Generating Units 2 and 3) LBP-08-13, slip op. at 45, 48 N.R.C. 43 (July 31, 2008). The Board required that in addressing Contention 8, the parties should make representations as to "whether transformers are more similar to the included, or to the excluded, component examples" in 10 C.F.R. § 54.21(a)(1)(i).[1]

On August 14, 2009, Entergy filed a motion for summary disposition of Contention 8, supported by expert declarations. *Applicant's Motion for Summary Disposition of New York*

[1] According to a NUREG contractor report, nuclear power plants in the United States generally have between 4 and 12 transformers supplying safety systems. *Aging of Safety Class 1E Transformers in Safety Systems of Nuclear Power Plants,* NUREG/CR-5753 at 1 (Feb. 1996) (Exh. NYS000012) ("NUREG/CR-5753"). Aside from transformers specifically designated as safety-related transformers (Class 1E), aging management review includes within its scope non safety-related transformers "that support the function of a safety related system, structure, or component or whose failure could prevent a safety-related system, structure, or component from satisfactorily fulfilling its intended function(s)." *Nuclear Power Plant License Renewal; Revisions,* 60 Fed. Reg. 22,461 at 22,477, 22,465 (May 8, 1995) (Exh. NYS000016) ("SOC, 60 Fed. Reg. 22,461").

State Contention 8 (Electrical Transformers) (August 14, 2009) (including the August 12, 2009 declarations of Dr. Dobbs ("Dr. Dobbs Decl."), Mr. Craig and Mr. Rucker) ("Entergy's SD Motion"). Entergy renewed its previously unsuccessful argument that transformers do not require an AMP because transformers undergo a "change in state" (or a "change in configuration") when voltage travels through the transformer.

On September 14, 2009, NRC Staff filed an Answer supporting Entergy's motion for summary disposition of Contention 8. *See NRC Staff's Answer to Applicant's Motion for Summary Disposition of New York Contention 8* (Sep. 14, 2009) ("Staff Answer to SD Motion"). Staff concluded, based on its own expert reports, that Entergy had properly characterized transformers as undergoing a "change in state" when voltage is applied to the transformer.

On September 23, 2009, the State filed its reply to Entergy's motion for summary disposition of Contention 8. *See Response of the State of New York to Entergy's Summary Disposition Motion and NRC Staff's Supporting Answer* (Sep. 23, 2009) ("NYS Response to SD Motion"). The State alleged, *inter alia,* that Contention 8 had become the "law of the case" to be resolved in a full hearing; that Entergy conflated the changing properties of the power passing through transformers with a change in the transformer itself; and that transformers are the type of component for which the Commission intended an AMP to be required, because transformers are passive, degrade in ways not easily monitorable, and are long-lived.

On November 3, 2009, the Board denied Entergy's motion for summary disposition of Contention 8, concluding that summary disposition is inappropriate when, as with Contention 8, a genuine issue of material fact exists. *See Entergy Nuclear Operations, Inc.* (Indian Point Nuclear Generating Units 2 and 3), slip op. at 6 (Nov. 3, 2009).

LEGAL FRAMEWORK

NRC's regulations require an applicant for license renewal to prepare an Integrated Plant Analysis which includes a list of those structures and components subject to an aging management review ("AMR"). 10 C.F.R. § 54.21(a)(1). The structures and components subject to an AMR include those "that perform an intended function, as described in § 54.4, without moving parts or without a change in configuration or properties" and "that are not subject to replacement based on a qualified life or specified time period." 10 C.F.R. §§ 54.21(a)(1)(i), (ii). The regulation offers a non-exclusive list of components which require an AMR and a non-exclusive list of components which do not require an AMR; transformers are not included on either list. *See id*. The Commission also concluded in its Statement of Considerations for its 1995 revisions to the license renewal regulations, of which the current regulatory text is a product, that "structures and components that perform active functions can be generically excluded from an aging management review on the basis of performance or condition-monitoring programs" and that a "change in configuration or properties" should include a "change in state." *Nuclear Power Plant License Renewal; Revisions*, 60 Fed. Reg. 22,461 at 22,477 (May 8, 1995) ("SOC, 60 Fed. Reg. 22,461") (Exh. NYS000016). Entergy improperly seeks to fit transformers into this category of excluded components on the basis that transformers are 'active' devices. Entergy has not argued that transformers are devices that are replaced based on a "qualified life or specified time period."

The ultimate burden of proof in any adjudicatory proceeding remains with the applicant throughout the proceeding. *See, e.g.*, *Duke Power Co.* (Catawba Nuclear station, Units 1 and 2), CLI-83-19, 17 N.R.C. 1041, 1048 (1983), *citing Consumers Power Co.* (Midland Plant, Units 1 and 2), ALAB-283, 2 N.R.C. 11, 17 (1975); *AmerGen Energy Co., LLC* (Oyster Creek Nuclear

Generating Station), CLI-09-07, 69 N.R.C. 235, 263 (2009) (the applicant must demonstrate that it satisfies the "reasonable assurance standard" by a preponderance of the evidence); *Virginia Electric & Power Company* (North Anna Power Station, Units 1, 2, 3 & 4), ALAB-256, 1 N.R.C. 10, 17, n.18 (1975).

ARGUMENT

AGING MANAGEMENT REVIEW IS REQUIRED FOR TRANSFORMERS UNDER 10 C.F.R. § 54.21

When the current license renewal regulations were adopted in 1995, the Commission asserted that "mitigation of the detrimental effects of aging resulting from operation beyond the initial license term should be the focus for license renewal." SOC, 60 Fed. Reg. at 22,464 (Exh. NYS000016). The Commission emphasized that in interpreting the scope of issues to be considered during a license renewal review, absent clear and convincing evidence that a system or component was to be excluded from such review, it should be considered as subject to review:

> As the commenter suggested, the Commission did consider further limiting the scope of license renewal to certain issues in a plant's design that were specifically based on a time period bounded by the current license term (40 years). As a result, the Commission explicitly identified the need to review time-limited aging analyses and incorporated this requirement into the final rule. However, as discussed in Section III.d and III.f of this SOC, *the Commission determined that, at this time, there was not an adequate basis to generically exclude passive, long-lived structures and components from an aging management review*. Therefore, the Commission believes it is inappropriate to further reduce the systems, structures, and components within the scope of license renewal.

SOC, 60 Fed. Reg. at 22,468 (Exh. NYS000016) (emphasis added). Transformers are such "passive, long-lived" components which experience age related degradation, and, consequently, require aging management review and an aging management program.

POINT I

TRANSFORMERS DO NOT CHANGE CONFIGURATION, PROPERTIES, OR STATE

1. Transformers Are Passive Devices.

The transformer is an essentially perfect device for the transformation of electrical power, *i.e.*, the input volt-amperes will equal the output volt-amperes. The transformer is a static device, which has no moving parts or control mechanism and which undergoes no change in configuration or state during its operation. Rather, it is the power flowing through the transformer which undergoes a change in state, while the transformer performs precisely the same designed operation to whatever amount of power is passed through it, because its transformation characteristic is fixed by its unchanging properties. *See* Summary of Findings, 2011 Degeneff Report (Exh. NYS000005) at 2, 32.

If Staff and Entergy's interpretation of "changing state" carried the day, pipes, containment domes, electrical cables (which become heated when energized and can cause some energy loss as electricity is passed through them), to name only a few, would be considered active systems because things inside them change. *See* Degeneff Report, at 8-10 (analyzing similarities between transformers and components listed as included within § 54.21(a)(1)(i)); and Degeneff PFT (Exh. NYS000003) at 14-29. Taken to its logical conclusion, Entergy and Staff's position would eliminate most, if not all, of Part 54. New York submits that the Commission did not intend such a reading of § 54.21. Entergy and Staff's legally insufficient justification for the exclusion of transformers from aging management review ultimately rests on a misunderstanding of the nature of transformers and on industry guidance, which is not binding.[2] *Entergy Nuclear*

[2] NRC is not compelled to grant a license because a licensee purports to comply with guidance,

Operations, Inc. (Indian Point, Units 1 and 2), Transcript at 198-200 (Mar. 10, 2009) ("Tr.").

Each of a transformer's key properties demonstrates that it is a passive device, which is long-lived if properly maintained and monitored. Degeneff Report at 2-3, 23. In his Report, Dr. Degeneff establishes the fundamental nature of the transformer as a passive device – facts which Entergy has not actually contradicted in its filings regarding NYS-8. First, transformers have no moving parts. Degeneff Report at 2. Second, transformers typically contain two insulated wires that are wrapped or coiled around a core that is frequently made of iron or metal alloys. *Id*. Third, a transformer itself does not change when it is in operation, nor does a transformer contain any moving parts for its basic function. *Id*. Fourth, the power flowing through the transformer does change as a result of the operation of the transformer. *Id*. at 2. Fifth, this change occurs because a magnetic field, created by an alternating current flowing through the primary coil in the transformer causes a current to be generated in the second coil. *Id*. Sixth, leading authorities on electrical components, including IEEE, define a transformer as a "passive" or "static" component. Degeneff Report at 2-3; *see also*, Harlow, Electric Power Transformer Engineering, page 2-1 (2d Edition) CRC Press (2007) ISBN 0-8493-9186-5 (referencing ANSI/IEEE) (Exh. NYS000009) ("2007 Harlow"); Harlow, Electric Power Transformer Engineering, page 2-1, CRC Press (2004) ISBN 0-8493-1704-5 (Exh. NYS000008) ("2004 Harlow"); IEEE Standard Dictionary of Electrical and Electronic Terms, IEEE Std 100-1996 (6th Edition), page 1131,

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and, as is the case here, an intervenor may challenge the regulatory sufficiency of guidance. *State of New Jersey v. NRC*, 526 F.3d 98, 102 (3d Cir. 2008). In this contested proceeding on this contested issue, the regulatory sufficiency of Entergy's exclusion of transformers must be demonstrated with the same reasoning and evidence that would have been employed if the Staff guidance on which Entergy relies had never been issued. *See Pacific Gas & Electric Co. v. Federal Power Comm'n*, 506 F. 2d 33, 38-39 (D.C. Cir. 1974); *see also Guardian Federal Savings & Loan Association v. Federal Savings & Loan Insurance Corp.*, 589 F.2d 658, 666 (D.C. Cir. 1978) (an agency must be prepared to defend its position and "cannot claim that the matter is foreclosed by the prior policy statement.").

ISBN 1-55937-833-6 (1996) (Exh. NYS000010) ("IEEE Dictionary"); Flanagan, Handbook of Transformer Design and Application (2nd Edition), page 1.1, McGraw Hill (1993)("Flanagan"); Blume, Transformer Engineering, page 1, General Electric (1951), Exh. NYS000006 ("Blume"). Finally, NRC acknowledges that "transformers perform their primary function without the use of moving parts." NUREG/CR-5753 at 50. This statement by NRC Staff, while not binding on Entergy, is an admission by Staff (*see* Rule 801(d)(2) of the Federal Rules of Evidence) and thus should be the basis for rejection of any contrary position now being taken by Staff, absent a rational explanation by Staff of why its previous position was wrong and why it failed to withdraw the identified guidance as erroneous.

Contrary to the technical consensus that transformers are passive devices, Entergy and Staff instead concludes that transformers are active devices. Entergy and Staff implausibly argue that the current which flows through a transformer, and the magnetic field produced by that flow, are components of the transformer and, because they change, the transformer changes. Entergy and Staff's conflation of the properties of the transformer with the properties of the power that flows through the transformer is the heart of the factual dispute in Contention 8. As Dr. Degeneff explains in his report, the electric current is no more a part of the transformer than is the water in a hose a part of the hose, or the water in a steam generator a part of the steam generator, or the electricity flowing in a cable a part of the cable. Degeneff Report at 6-8. In the March 10, 2008 oral argument, Judge Wardwell summarized the nature of transformers: "The transformer doesn't change its state . . . It's the electricity that changes state. And isn't it here that it's the device which we're considering, the component that we're considering, and it's a change in state of that component, not a change in state of some material coming in and out of it, like water into and out of a pump, because you change the state of water coming into and out of a

pump, moving it faster." Tr. 213:23-24, 214:1-8 (Mar. 10, 2008).[3]

The property of a transformer which is determinative of its function – the transformation of electrical power – is its turns ratio. If a transformer has a turns ratio of 10 to 1, *i.e.*,, a step down transformer, then an input voltage of 1,000 volts would be transformed to an output voltage of 100 volts; if the input voltage were 500 volts, the output voltage would be 50 volts. While the input and output voltages are different in each example, the ratio between input and output voltages remains constant, because the ratio is a non-changing property of the transformer. Other design properties determine the amount of power which a transformer can handle, although they do not determine the transformer ratio. These properties, which include the conductor size, insulation type and thickness, and cooling capability, do not change while a transformer performs its intended function, but are the subject of age related degradation during the lifetime of a given transformer. Degeneff Report at 14-16.

Voltage, current, and magnetic flux, on the other hand, are established by the voltage that is applied to the primary winding of the transformer and the load that the transformer serves. Both the applied (input) voltage and the load served are completely independent of the transformer of interest. Degeneff Report at 2-4. In fact, as Entergy's expert acknowledges, the changes in the properties of the power flowing through a transformer are a consequence of the power's being an alternating current instead of direct current, which, in turn, is determined by the source of that power, not the transformer through which that power flows. *See*, Degeneff Report

[3] The Commission, in the text of the regulation and in the SOC to the final rule, emphasized that the component itself is the focus of the inquiry into whether that component operates "without a change in configuration or properties" and not the material that may flow through the component, such as steam, water or electricity. Thus, for example, 10 C.F.R. § 54.21(a)(i) requires aging management review for the passive pump casing, but not the active pump and the passive valve body. *See also* SOC, 60 Fed. Reg. at 22,477.

at 24-26; Declaration of Dr. Dobbs at ¶ 20 ("Dobbs Decl."). It is meaningless for Entergy to assert that "without voltage and current, there is no transformer operation." Dobbs Decl. at ¶ 16. This tautology is true of any component whose function is to receive an input, *e.g.*, without water flowing through a pipe, there is no pipe operation and without electricity flowing through a cable, there is no cable operation.

2. Transformers Are More Similar To The Included Components Than To The Excluded Components Listed In 10 C.F.R. § 54.21(a)(i).

A comparison with the components listed in 10 C.F.R. § 54.21(a)(i) illustrates that transformers are more similar to "included" components than to "excluded" components. The nonexhaustive list of components which "perform an intended function . . . without moving parts or without a change in configuration or properties [or state]" includes:

> 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 . . . .

but excludes:

> 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.

10 C.F.R. § 54.21(a)(i). In general, transformers are similar to many of the "included" structures and components and distinct from "excluded" structures and components, because, like the "included" components, transformers have no moving parts, do not change configuration, and do not experience a change in state. *See* Degeneff Report at 6. In fact, if two cables, with cables

being an "included" component, are placed in proximity, they will act as a transformer in that a varying current in one cable will induce voltages and currents in the adjacent cable. Because the physical laws that describe how the magnetic field is developed around a cable are exactly the same physical laws that describe how a magnetic field is developed in a transformer, the simplest form of transformer merely consists of two cables placed in close proximity. *See* Degeneff Report at 6-7. Thus, if Entergy and Staff were correct, any two cables located in proximity to each other would be classified as "active" components and not subject to aging management. Entergy's Application, and Staff's SER and SSER, belie this conclusion and expose their argument about transformers for what it is: an assertion that is contrary to accepted scientific knowledge, lacks supporting facts and defies logic.

With respect to other "included" components, transformers share common characteristics and perform analogously, as Dr. Degeneff explains in his Report in the section entitled *Comparison of Various Structures and Component*. *See* Degeneff Report at 6-8. For example, different amounts of power may be applied to a transformer, but the voltage will always change at the same ratio, because the unchanging properties of the transformer dictate only one ratio. This is exactly the same situation one has when a fluid passes through a pipe with a constriction; when the amount of fluid that passes through the pipe is constant, the pressure of the fluid will change at the constriction, but the pipe remains invariant, its properties and characteristics unchanged. Degeneff Report at 7. Like the fixed rate of transformation determined by a transformer's turns ratio, the dimension of the constriction will alter the flows of different quantities of fluid in a uniform manner. Moreover, a pipe with walls thinned by corrosion will continue to carry whatever fluid is passed through it without detectable performance degradation, just as a transformer may seem to be operating normally even though its insulation may be

seriously degraded. *Id* at 14-15.

In contrast, the transformer's key properties clearly distinguish it from the "excluded" components. Each of the "excluded" electrical components has a mechanism to dynamically control the relationship between the input and output and as such each of these is truly an active device. This control mechanism generally requires its own source of power in addition to the bulk source of power which supplies the large amount of power used by the device to perform its intended function. The transformer, in contrast, receives only one source of power and is not capable of varying the relationship between the input and output power, because the transformer performs its intended function according to a fixed ratio designed into the transformer at the time it was built. Degeneff Report at 8-13. For example, the control circuit in a power supply causes the power supply to deliver power with a certain voltage and current, while, in a transformer, the supplied voltage and current are wholly dependent on the power source and the load being supplied. *Id.* at 9-10.

Entergy focuses primarily on the alleged similarity between transformers and transistors to argue that transformers change state in performing their intended function, but the comparison is inapt. In contrast with the transformer whose properties remain invariant, the key property of a transistor that allows it to perform its intended function – its resistivity – is designed to change when an electric current is applied. Transistors function by changing state from an insulator to a conductor. Transistors are able to perform this function because they are made out of a material called a semiconductor stacked together in three layers. Because of its chemical properties, a stack of three layers of semiconductor can either function as an insulator (high resistance to impede the flow of electricity) or a conductor (low resistance to promote the flow of electricity). If a transistor is hooked up to a power source and a load in the way that a transformer is, the

transistor functions as an insulator. While the transformer performs its intended function with no further input, a transistor requires an additional control mechanism to perform its intended function of acting as a switch that stops or starts the flow of power. That separate control current, when applied to the transistor, will induce the transistor to change state to a conductor so that power can flow through it. Once the control power is removed, the transistor reverts state to an insulator. Thus, without the application of an external control power, the transistor cannot perform its intended function of starting or stopping the flow of power. *See* Degeneff Report at 12-13.

For a transformer to behave analogously to the transistor's change in resistivity, the transformer's turns ratio would have to change with the applied voltage, but this does not happen. A transformer with a ratio of 2:1 will forever have that transformation ratio, irrespective of the applied power. In contrast, a transistor's resistivity intentionally varies as the power applied to it varies. Moreover, the transformer performs its function once power is passed through it from the source to the load; it does not require a separate electrical control signal to begin transforming the power that flows through it. *See* Degeneff Report at 9-10.

3. Age Related Degradation In Transformers Is Not "Readily Monitored."

"Environmental conditions inherent with transformer operation cause components to degrade with time in service." NUREG/CR-5753 at 15 (Exh. NYS000012). Because aging degradation in transformers does not affect the transformer's performance, "transformers tend to appear as a two state device; it operates or it fails." NUREG/CR-5753 at 21. The insufficiency of current monitoring programs has been proven in at least 18 instances since 2007 in which catastrophic failures have occurred in large transformers at nuclear power reactors (including one each at Indian Point, Units 2 & 3), which failures were not prevented by the monitoring methods

in use at the reactors. *See* Degeneff Report at 18-22. Moreover, these failures occurred despite NRC's awareness of a trend of transformer failure. In one study, NRC found that 88 nuclear power plants had experienced a transformer failure in the period from January 1983 through April 1991, with 33 of those failures occurring in Safety Class 1E transformers. NUREG/CR-5753 at 26. Staff expressed its concern about the trend of transformer failure in a 2009 information notice – its third relating to transformer failure since 1982.[4] July 7, 2009 NRC Information Notice 2009-10: Transformer Failures—Recent Operating Experience, at 1 (ML090540218) (Exh. NYS000019) ("NRC IN 2009-10"). While the failed transformers involved in the latter report were not all safety related, the failures prompted the NRC Staff to observe:

> For several years, available industry operating experience has indicated an increasing trend in transformer failures, and has provided recommendations to reduce the chances of failure. Improved preventive maintenance and monitoring practices have helped to identify some problems before they developed to the point of failure, but the number of large transformers events has not decreased and in fact continues to rise.

NRC IN 2009-10. The NRC Staff further concluded, after its investigation, that:

> A relatively high incidence of transformer failures has occurred in the last few years, the majority of which could have been avoided had the licensee fully evaluated and effectively implemented corrective actions and recommendations identified in industry operating experience. These corrective actions included a more effective maintenance program and a more proactive approach to addressing abnormal indications.

Id. at 2. NRC IN 2009-10 provides a substantial basis for the proposition that transformers

[4] NRC has also published IE Information Notice 82-53, Main Transformer Failures at the North Anna Nuclear Power Station in 1982, regarding seven transformer failures, the causes of which were indicators of the effects of aging; and IE Information Notice 83-37, Transformer Failure Resulting from Degraded Internal Connection Cables, which noted that "Detailed transformer inspections, necessary to detect [long term, heat-induced degradation initially caused by a poor connection] prior to complete failure, were not included in the licensee preventive maintenance program." NUREG/CR-5753 at 27.

require an aging management review as part of the consideration of the license renewal application for Indian Point Units 2 and 3. The Commission expressed similar concerns in its final rule regarding plant relicensing, noting that "

> . . . it cannot generically determine that all licensees have processes, programs, or procedures in place for the timely detection of degraded conditions as a result of aging during the period of extended operation for passive, long-lived structures and components, that the potential exists for reduced reliability and failure of redundant, long-lived, passive structures and components.

SOC at 22486. Indeed, a broad survey of transformer failure at nuclear power plants concluded that "weakness in the maintenance and monitoring programmes" is the root cause for many transformer failures, a trend which continued despite a "concerted effort to identify and correct leading causes of the failures." OECD, Nuclear Energy Agency, *Operating Experience Report: Recent Failures of Large Oil-Filled Transformers*, NEA/CRNA/R(2011)6, at 11 (Mar. 14, 2011) (Exh. NYS000021) ("NEA Report"). Recent EPRI and IEEE reports also reflect recognition of the significance of transformer failures. *See* Degeneff Report at 22.

As is true of many passive components, transformer failure follows a bathtub curve: the failure rate is relatively high early on as transformers fail due to design or manufacturing defects, but then regresses to a relatively low rate for a significant portion of the transformer's operating lifetime. But, as transformers age, the failure rate returns to a relatively high level. *See* NUREG/CR-5753 at 21. The most significant cause of this age related failure is degradation of the transformer's insulation.[5] NUREG/CR-5753, at 50; *see also* Degeneff Report at 14-16. In his report and testimony, Dr. Degeneff provides examples of several kinds of age related degradation mechanisms for transformers that will not affect transformer performance, and

[5] Failures in transformers are generally classified as one of four types: magnetic circuit, winding, insulation, or structural failures. NUREG/CR-5753 at 21.

which, in most cases, can only be discovered through invasive inspections, wherein the transformer is taken offline and emptied of cooling oil. These include:

- polymerization of the insulation, which occurs when the molecules of the cellulose insulation in transformers break apart into smaller molecules, leading to reduced mechanical strength and increased susceptibility to electrical shorts. Because the degree of polymerization can vary within a single transformer, effective evaluation of the degree of polymerization requires multiple samples of the insulation material, taken throughout the transformer when the transformer has been emptied of liquid;

- diminishment in the mechanical and structural integrity of the core and coil assembly, due to thermal stresses and the torque created by the flow of strong electric currents. Diminished integrity can lead a transformer to fail when exposed to short circuits that it would normally be able to survive. A detailed internal inspection is the preferred method to analyze this broad category of degradation, because it doesn't produce symptoms that show up on electrical or chemical tests;

- internal arcing in the insulation structure due to the movement of windings, which can occur because the strong electric currents flowing through the windings create severe mechanical stresses. Movement of the windings decreases the integrity of the transformer's insulation. Frequency Response Analysis (FRA) is most commonly used to detect winding movement, but proper testing depends on proper calibration of complicated parameters such as test frequency range, test set-up, external circuits; accounting for the different physical structures of different transformers; and trending results over time, so such testing can be inaccurate, and is best done in combination with a visual inspection;

- A corona or radio interference voltage ("RIV") generated by the transformer will have no effect on the operating characteristics of the transformer but is a sure indication of a problem with the transformer. Although an acoustical test could identify the existence of a corona, a visual inspection is required to identify the actual flaw in the transformer that is causing the corona or RIV; and

- the accumulation of oil, dirt, or salt spray, or corrosion of the bushings, which increases the possibility of a flashover that can lead to catastrophic failure. Visual inspection is the best way to observe this increased contamination.

Degeneff Report at 14-15. Moreover, the longer the transformer has been in operation, the more susceptible it is to failures caused by transients such as lightning or switching, making inspection even more important during the relicensing period. NUREG/CR-5753 at 15. These aging effects can occur without noticeably affecting the transformer's performance. *Id.*; *see also* Degeneff

Report at 15-16. For example, the insulation capability of the oil and paper structure and the ability of the transformer to withstand a short circuit cannot be determined through routine monitoring, but, rather, require internal inspection or an impedance versus frequency scan of the winding structure. *Id.* at 16.. Simply measuring the changes in the electrical performance of the transformer and/or its associated circuits will not reveal these types of degradation as the consistent trend of transformer failure demonstrates. *Id.*. While most of these forms of aging degradation can be detected with at least one inspection method, no single inspection method can detect all forms of aging degradation. In many cases, such as dissolved gas analysis and frequency vs. impedance scans, the tests only reveal symptoms of the problem and not the actual cause; determining the actual type of age related degradation that produces the observed symptoms requires invasive visual inspections made while the transformer is offline and emptied of oil. *Id.* at 16-17 These factors demonstrate how age related degradation in transformers is not "readily monitorable."

Entergy has acknowledged that its routine inspection program cannot evaluate the effects of every type of age related degradation in transformers. For example, internal inspection is required to identify age related degradation in a certain type of clamp, which is used to hold together the internal winding structure, because "other current predictive technology" can not identify the degradation in that clamp. *See* Email string dated June 26, 2007 (Exh. NYS000038) ("Jun. 26, 2007 Email String"). As described above, the clamp's failure reduces the mechanical integrity of the winding structure with the consequence that "a severe through fault condition could have resulted in catastrophic failure" of the transformer. *Id.* Entergy, however, only performs internal inspections "when a transformer is drained for another purpose." *Id.* Such opportunistic inspection is inadequate, because even identifying which transformers contain the

susceptible clamps requires internal inspection.[6] Another transformer failure at an Entergy owned plant led Entergy staff to conclude "that dissolved gas analysis and other PM maintenance tasks are not sufficient to identify all non-random degradation mechanisms internal to the transformer since no indication of this degradation mechanism was observable with existing maintenance." *See* EN Large Power Transformer Status, undated (disclosed by Entergy on Jan. 30, 2009 monthly mandatory disclosure log) at 2-3 (Exh. NYS00040) ("Transformer Status"). Clearly, Entergy staff responsible for ensuring the operability of transformers at the company's nuclear power plants have not found age related degradation in transformers to be "readily monitorable."

Even as Entergy resists implementing an aging management program, it has implemented extended power uprates at Indian Point which have intensified the effects of age related degradation at Indian Point because the uprate led to transformers being operated at temperatures higher than their rated temperature, which results in "accelerated thermal aging of the transformer insulation." *See* Email dated July 18, 2005 (Exh. NYS000041) ("Jul. 18, 2005 Email").

4. An Aging Management Program Is Required To Mitigate The Aging Degradation Effects In Transformers That Are Not "Easily Monitored."

Just as in the case of other passive components, such as electric cables, for which the Nuclear Utility Group on Equipment Qualification sought special status, safety-related transformers must be subjected to an aging management review because "there is no single method or combination of methods that can provide the necessary information about the

[6] Although the memorandum containing this description of transformer failure called for internal inspections to be scheduled to address this aging issue, the actions taken by Entergy in response to this memorandum were not disclosed. *See* Jun. 26, 2007 Email String.

condition of [transformers] currently in service regarding the extent of aging degradation or remaining qualified life." SOC, 60 Fed. Reg. at 22,477 (bracket added). As described above, and as Dr. Degeneff explains in his Report, and reiterates in his testimony, performance monitoring will miss most common forms of age related degradation and condition monitoring programs largely reveal symptoms which can be produced by several different kinds of age related degradation such that pinpointing the specific form of age related degradation often requires a visual inspection of its components made while the transformer is offline. Degeneff Report at 16-17; Degeneff Testimony at 28-38, 42.

Thus, to effectively address age related degradation in transformers, a robust inspection and maintenance program is required, as NRC has acknowledged:

> A continual program of inspection, surveillance, monitoring, and maintenance will help ensure transformer reliability. Such a program will detect and reduce stressors that shorten transformer life, prevent stressors before they cause degradation, and detect degradation in the early stages so that preventive and corrective action can be taken prior to transformer failure to reduce the rate of aging. An effective program of inspection, surveillance, monitoring, and maintenance consists of periodic cleaning and inspections; testing of dielectric strength; and testing of oil in liquid-filled transformers; testing to verify that electrical characteristics such as winding resistance, insulation resistance, turns ratio, excitation current, and resistance to ground are maintained. Regular measurement of temperature is an important element of a transformer monitoring program.

NUREG/CR-5753 at 50-51. EPRI also accepts the proposition that transformers are subject to aging management programs which, if properly implemented, can substantially improve the operating life of the transformer as well as improve plant safety. *See* Life Cycle Management Planning Sourcebooks, Volume 4: Large Power Transformers 1007422 Final Report at 7-2 (Mar. 2003) (Exh. NYS000034) ("Transformers Final Report"), where in discussing the option of operating a plant for 60 years under license renewal EPRI offers aging management of

transformers as part of one of the alternatives: "LCM Plan Alternative 2A: A rigorous preparation for license renewal with an aggressive aging management program, system performance enhancements, and timely component replacements or upgrades."[7]

NRC, EPRI, and IEEE's concern with the aging problems of transformers, the growing evidence of transformer failures since at least 1995, and the existence of condition monitoring aging management techniques and programs that can provide considerable enhancement to the integrity and reliability of transformers require that Entergy subject its transformers to an aging management review and implement special programs to address aging problems in its transformers before its reactors be allowed to continue to operate for an additional twenty years. Addressing precisely the kinds of problems presented by passive components like transformers is why the NRC requires that such components be subjected to an aging management review. It is apparent from Entergy's actions in this proceeding that absent action by this Board, Entergy will not implement aging management programs, like those recommended by EPRI and NUREG/CR-5753, to assure the reliability of its safety related transformers during extended operation because its experts opine that aging management is not necessary and that transformers are exempted from aging management review because they are purportedly active components.[8]

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[7] In a 2006 EPRI document, EPRI again describes the causes of transformer failures and advocates the use of condition monitoring – not just performance monitoring – to detect failure potential before failures occur. Plant Support Engineering: Large Transformer End-of-Expected-Life Considerations and the Need for Planning – 1013566 - Final Report (Dec. 2006), at 2-3 to 2-10, 3-1 to 3-5 (Exh. NYS000019) ("NRC IN 2009-10"). *See also* SAND93-7068, May 1994, Aging Management Guideline For Commercial Nuclear Power Plants – Power And Distribution Transformers at 1-3 to 1-7, 4-7 to 4-21 and 5-22 (Exh. NYS000018) ("1994 Sandia Report") (identifying failure modes and monitoring programs needed to prevent such failures); IEEE Guide for the Evaluation and Reconditioning of Liquid Immersed Power Transformers (IEEE Std C57.140-2006) (Exh. NYS000017) ("2007 IEEE Report") at 11-15 (listing failure modes of transformers and methods for detecting these failures before they occur).

[8] Indeed, in an email exchange, Entergy employees remarked that although implementing an

5. The Commission Required Aging Management Review For Passive Components Because The Effects Of Age Related Degradation Are Not "Readily Monitored."

The plain reading of the regulations in light of the well-accepted understanding of the nature of transformers and how they operate is consistent with the Commission's Statement of Considerations regarding its license renewal regulations. Moreover, Entergy and Staff's exclusion of transformers from aging management review is contrary to the Commission's stated concern for detecting age related degradation in components in which the effects of that degradation are not "readily monitored." *See* SOC, 60 Fed. Reg. at 22,477. The Commission further found that components should be considered "passive" when they are components in which the effects of age related degradation are not readily monitored:

> passive structures and components for which aging degradation is not readily monitored are those that perform an intended function without moving parts or without a change in configuration or properties. For example, a pump or valve has moving parts, an electrical relay can change its configuration, and a battery changes its electrolyte properties when discharging. Therefore, the performance or condition of these components is readily monitored and would not be captured by this description.

SOC, 60 Fed. Reg. at 22,477.

Previously, the Nuclear Utility Group on Equipment Qualification sought to have electrical cables excluded from the blanket definition of passive components because, it asserted, means to monitor the performance of cables were being developed and might obviate the need for aging management review (*see* Letter from Malcolm Philips and William Horin to the Secretary of the Commission dated December 8, 1994 at 2-4 (PDR fiche 9412130158) (Exh.

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aging management program for transformers at Indian Point would be "the path of least resistance," they were determined not to do so, because Indian Point would then be the only facility in the country to require an aging management program for transformers. *See* Email String dated August 7, 2008 and August 11, 2008 (Exh. NYS000042) ("August 2008 Email String").

NYS000043) ("NUGEQ Letter").[9] The Commission rightly rejected the Group's request, emphasizing that the focus of its aging management concerns was not operational monitoring but rather monitoring of the degradation of the condition of the equipment to function in the future:

> The commenter stated that the only aging effects of cables are shorting and loss of continuity, and for cables not in a harsh environment, these effects would be immediately detected during normal operation or functional testing. The Commission considers the examples of electrical components (e.g., electrical cables, connections, and electrical penetrations) listed in 10 CFR 54.21(a)(1)(i) and Section III.f(i)(a) of the SOC to be properly categorized as "passive" because they perform their intended function without moving parts or without a change in configuration or properties and the effects of aging degradation for these components are not readily monitorable. The Commission also believes that this categorization is not premature as stated by the commenter. The Commission disagrees with the commenter's assertion that the aging effects of cable make it easy to monitor functional degradation. Although there have been significant advances in this area, there is no single method or combination of methods that can provide the necessary information about the condition of electrical cable currently in service regarding the extent of aging degradation or remaining qualified life. Degradation due to aging of electrical cables caused by elevated temperature and radiation can cause embrittlement in the form of cracking of insulation and jacket materials. The cracks degrade the electrical properties of the insulation materials. The major concern is that failures of deteriorated cable systems (cables, connections, and penetrations) might be induced during accident conditions. Because these components are relied on to remain functional during and following design-basis events (including conditions of normal operation) and there are currently no known effective methods for continuous monitoring of cable systems, these examples of passive electrical components subject to an aging management review will remain in 10 CFR 54.21(a)(1)(i) and Section III f(i)(a) of the SOC.

SOC, 60 Fed. Reg. at 22477-78. Thus, the Commission made clear that passive components must be subjected to aging management review because they may have constituent parts that can degrade without affecting the current performance of the component but which can make the

[9] A copy of this document is provided as Exh. NYS000043 attached to the declaration of Assistant Attorney General Lisa M. Burianek that accompanies this response (Exh. NYS000044) ("PFT Burianek Decl. NYS-8").

component vulnerable to failure in the future -- as do transformers. Indeed, the Commission's concern about age related degradation in cables is wholly translatable to transformers, the life of which "depends mostly on the life of the insulation." NUREG/CR-5753 at 21. Like the cable, age related degradation of the insulation on the transformer's internal windings can occur without any noticeable effect on transformer performance, but can make the transformer more "susceptible to failure caused by transients" such as occur in accident conditions. *See* NUREG/CR-5753 at 15, 21. For passive functions, such as that performed by the cable or the transformer, "the relationship between the measurable parameters and the required function is less directly verified." SOC, 60 Fed. Reg. at 22,471. Thus, despite the fact that a licensee may have condition and performance monitoring programs in place for passive components, "present limitations," described in detail, above, preclude passive components from generic exclusion from aging management review. *See* SOC, 60 Fed. Reg. at 22,471. This license renewal proceeding is not the forum for Entergy to alter this generic determination on the basis that its own maintenance program is sufficient to adequately detect age related degradation in transformers at Indian Point. Entergy's performance-based program is neither sufficient nor adequate. Entergy must conduct an aging management review of its transformers, regardless of how comprehensive a maintenance and inspection program Entergy follows under the NRC's Maintenance Rule (10 C.F.R. §§ 50.48 and 50.63).

Entergy has not submitted an aging management program for transformers. Thus, no voluntary inspection program, even if robust – which Entergy's is not – can replace the aging management review required under 10 C.F.R. § 54.21(a) for passive and long-lived components like transformers. *See* Degeneff Report at 17-18. When one commenter on the license renewal rule suggested that the Commission divide "long-lived passive structures and components into

two categories: those that have a less rigorous approach to oversight and maintenance and those that have a sufficiently high level of licensee programs and regulatory oversight" the Commission rejected that approach, noting:

> The Commission believes it would be too difficult to further divide the structures and components required for an aging management review into those passive, long-lived structures and components "rigorously" managed and those "not as rigorously" managed.

SOC, 60 Fed. Reg. at 22,478. Nor can Entergy credit existing, voluntary maintenance and inspection programs relative to a full-fledged aging management review; Entergy must conduct a comprehensive aging management review to determine the proper aging management program to manage the inevitable effects of transformer aging during Entergy's license renewal period.

POINT II

TRANSFORMERS ARE NOT SUBJECT TO REPLACEMENT BASED ON A QUALIFIED LIFE OR SPECIFIED TIME PERIOD

The effects of aging on a component are "cumulative throughout its service life." *See* SOC, 60 Fed. Reg. at 22,478. Those aging effects can be mitigated either by replacing that component before the aging effects have become too severe, or by implementing an aging management program. *Id.* Transformers are normally considered to be a "long life item," which can remain in service for 40 years or greater.[10] NUREG/CR-5753 at 50. Entergy has not disputed that properly maintained transformers can remain in service for a period of time

[10] NUREG/CR-5753 was published in 1996. Of the transformers studied, 95% had been in service less than 20 years old and 75% less than 15 years. *Id.* at 50-51. The authors concluded that the young average age of transformers at nuclear power plants made it "difficult, if not impossible, to determine the effects of aging using plant operating experience." *Id.* at 28. The authors recommended that the study be updated every 5 years; however, it appears that the study has never been updated. More recent reports establish that aging effects in transformers are a cause for concern. *See, e.g.* NRC IN 2009-10 (Exh. NYS000019) and the NEA Report (Exh. NYS000021).

exceeding the original licensing period of Indian Point. Nor has Entergy indicated in its application any program to replace transformers based on a predetermined service life. Rather, Entergy appears to retire and replace transformers based on several factors, including age, condition, and the availability of spares.[11] *See* Entergy Nuclear Northeast, Power Transformer Spare Purchase Recommendations (Jan. 4, 2006) (Exh. NYS000039) ("Spare Purchase"). The Commission decided that "passive structures and components that are replaced based on performance or condition" should not be generically excluded from an aging management review. SOC, 60 Fed. Reg. at 22,478. Consequently, transformers are a component "not subject to replacement based on a qualified life or specified time period" per the meaning of 10 C.F.R. § 50.21(a)(ii).

This fact, together with the fact that transformers perform their intended function "without moving parts or without a change in configuration or properties," require that Entergy perform an aging management review and implement an aging management program for those transformers at Indian Point which perform an intended function described in 10 C.F.R. § 54.21(a).

[11] The range of assessment factors include: transformer age, whether the transformer is normally loaded, the transformer normal loading and percentage of loading with respect to the transformer rating; dissolved gas analysis testing results; the physical condition of the transformer; the impact on the station if the transformer were to be removed from service; availability of a replacement unit; existing spare units; off-site power considerations; and flexibility of spare unit to support multiple site or applications. *See* Entergy Nuclear Northeast, Power Transformer Spare Purchase Recommendations (Jan. 4, 2006) (Exh. NYS000039) ("Spare Purchase").

CONCLUSION

For all the reasons stated, Entergy's license renewal application ("LRA") should be denied because the application improperly excludes transformers from aging management review and from an aging management program.

Respectfully submitted,

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