

1 UNITED STATES

2 NUCLEAR REGULATORY COMMISSION

3 BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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5 In re: Docket Nos. 50-247-LR; 50-286-LR  
6 License Renewal Application Submitted by ASLBP No. 07-858-03-LR-BD01  
7 Entergy Nuclear Indian Point 2, LLC, DPR-26, DPR-64  
8 Entergy Nuclear Indian Point 3, LLC, and  
9 Entergy Nuclear Operations, Inc. June 28, 2012

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11 REBUTTAL TESTIMONY OF

12 DR. ROBERT C. DEGENEFF, D. ENG.

13 REGARDING CONTENTION NYS-8

14 On behalf of the State of New York ("NYS" or "the State"),  
15 the Office of the Attorney General hereby submits the following  
16 testimony by Dr. Robert C. Degeneff, D. Eng., regarding  
17 Contention NYS-8.

18 Q. Please state your full name.

19 A. Dr. Robert C. Degeneff, D. Eng.

20 Q. Dr. Degeneff, could you briefly summarize the  
21 testimony you provided on December 9, 2011?

22 A. I was retained by the State of New York to provide  
23 expert testimony in connection with the State's Contention 8,

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1 which asserts that Entergy's license renewal application ("LRA")  
2 should be denied because it improperly excludes transformers  
3 from aging management review ("AMR") in violation of 10 C.F.R. §  
4 54.21 and does not include an aging management plan ("AMP") for  
5 transformers in violation of 10 C.F.R. § 54.29. In my  
6 testimony, as well as my expert report, I explained that  
7 transformers are passive devices, which are more similar to  
8 components for which AMR is required than those components for  
9 which AMR is not required. I also explained that age-related  
10 functional degradation in transformers is not readily monitored  
11 and so an AMP is needed to assure continued transformer  
12 functionality.

13 Q. What is the purpose of this rebuttal testimony you are  
14 now providing?

15 A. The State of New York has asked me to respond to  
16 Entergy's March 30, 2012 and NRC Staff's March 29, 2012  
17 testimony on Contention 8.

18 Q. Have you reviewed any additional documents since your  
19 December 9, 2011 testimony in preparation for this rebuttal  
20 testimony?

21 A. Yes. I have reviewed the following documents filed by  
22 Entergy on March 30, 2012: Applicant's Statement of Position  
23 Regarding Contention NYS-8 (Electrical Transformers) (ENT000090)

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1 ("Entergy SOP"); Testimony of Applicant Witnesses Roger Rucker,  
2 Steven Dobbs, John Craig, and Thomas McCaffrey Regarding  
3 Contention NYS-8 (Electrical Transformers) (ENTR00091) ("Entergy  
4 Test."); and the supporting exhibits (ENT000092-ENT00130B).

5 Additionally, I have reviewed the following documents filed  
6 by NRC Staff on March 29, 2012: NRC Staff's Initial Statement of  
7 Position on Contention NYS-8 (Transformers) (NRC000030) ("Staff  
8 SOP"); NRC Staff's Testimony of Roy Mathew and Shelia Ray  
9 Concerning Contention NYS-8 (Transformers) (NRC000031) ("Staff  
10 Test."); and the supporting exhibits (NRC000032-NRC000038).

11 Q. Do any of these documents change your opinion that  
12 transformers are passive components that require AMR?

13 A. No. I maintain that transformers qualify as  
14 components for which AMR is required under 10 C.F.R. § 54.21.  
15 See Pre-Filed Written Testimony of Dr. Robert C. Degeneff  
16 Regarding Contention NYS-8 (NYSR00003) ("Degeneff Pre-Filed  
17 Test.") at 6. Furthermore, in order to maintain transformer  
18 functionality, under 10 C.F.R. § 54.29, an aging management  
19 program ("AMP") is required to provide a reasonable assurance  
20 that the effects of transformer aging will be managed during the  
21 relicensing period. The failure to properly manage transformer  
22 aging may compromise: the integrity of the reactor coolant  
23 pressure boundary; the capability to shut down the reactor and

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1 maintain it in safe shutdown condition; or the capability to  
2 prevent or mitigate the consequences of accidents which could  
3 result in offsite exposures. See Report of Dr. Robert C.  
4 Degeneff In Support of Contention NYS-8(NYSR00005) (Dec. 12,  
5 2011) ("Degeneff Report") at 17-22.

6 Q. Are there any significant points of agreement between  
7 your testimony and that of Entergy's and NRC's experts?

8 A. Yes. In order to qualify for AMR under 10 C.F.R. §  
9 54.21 a component must: (1) have an intended function as set out  
10 in 10 C.F.R. § 54.4; (2) perform that intended function without  
11 moving parts; (3) perform that intended function without a  
12 change in configuration or properties; and (4) not be subject to  
13 replacement based on a qualified life or specified time period.  
14 In their testimony, Entergy's and NRC's experts admit that  
15 transformers: (1) perform an intended function as set out in 10  
16 C.F.R. § 54.4 (Entergy Test. at 98, A109; Staff Test. at 11,  
17 A17); (2) perform that intended function without moving parts  
18 (Entergy Test. at 40-41, A58; Staff Test. at 12, A20); and (3)  
19 are not subject to replacement based on qualified life or  
20 specified time period (Entergy Test. at 14, A24; Staff Test. at  
21 8, A.13). Neither set of experts asserts that transformers  
22 experience a change in configuration when functioning.  
23 Therefore, the only criteria on which their experts and I

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1 disagree is whether transformers function without a change in  
2 properties (or state).

3 Q. Dr. Degeneff, Entergy asserts that you have no  
4 experience specific to the nuclear power industry or nuclear  
5 regulation (Entergy SOP at 9). Do you have any experience with  
6 transformers that are used at nuclear plants similar to Indian  
7 Point?

8 A. Yes. I own a small manufacturing company that  
9 assembles systems of equipment containing transformers, which  
10 have been applied in several nuclear facilities. These  
11 transformers function no differently than transformers that my  
12 company supplies for other industries. This is because a  
13 transformer's characteristics are exactly the same whether they  
14 are applied in a nuclear facility, utility, industrial site,  
15 factory, or residential setting. As I explained in my December  
16 9, 2011 testimony, my education and professional experience  
17 provide me with in-depth knowledge of how transformers work and  
18 what is required to maintain their functionality. See Degeneff  
19 Pre-Filed Test. at 1-2.

20 Additionally, I have been a member of the Institute of  
21 Electrical and Electronics Engineers ("IEEE") Transformers  
22 Committee for approximately forty years. I currently serve as a  
23 fellow on the committee—a position that requires nomination and

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1 election, and is held by only 2% of members. As a committee  
2 member, I have served on subcommittees and working groups that  
3 have written numerous standards providing guidance on the  
4 necessary specifications for transformers applied in nuclear  
5 plants. For example, I was involved in the creation of IEEE  
6 C57.12.00, which provides the general requirements for liquid  
7 immersed, distribution power and regulating transformers. I  
8 have also worked on guides for the installation of transformers  
9 (IEEE C57.12.11) and the testing of transformers' insulation  
10 capabilities (IEEE C57.12.14), among others. These IEEE guides  
11 are used by nuclear plants across the country.

12 Unlike Entergy's experts, this is the first time I have  
13 consulted for anyone in the nuclear industry— as such I have no  
14 longer term agenda other than to report the characteristics of a  
15 transformer properly.

16 Q. Entergy's expert Dr. Dobbs takes issue with your use  
17 of the terms "static" and "passive" in your December 9, 2011  
18 report and testimony (Entergy Test. at 49-54). Can you please  
19 explain your use of these terms?

20 A. In my report and testimony, I have used the terms  
21 "static" and "passive" interchangeably to describe a component  
22 that has no moving parts and that performs its function without  
23 a change in configuration or properties. 10 C.F.R. § 54.21 does

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1 not use the terms "static" or "passive" to refer to AMR-included  
2 components. In fact, the term "passive" is only used for  
3 convenience in the 1995 License Renewal Statement of  
4 Consideration ("SOC"), (NYS000016) at 22477, to refer to  
5 components that perform an intended function without moving  
6 parts or without a change in configuration or properties. Thus,  
7 Dr. Dobbs's argument that I incorrectly conflate the terms  
8 "static" and "passive," is irrelevant to 10 C.F.R. § 54.21,  
9 which uses neither term. As the Commission used the term  
10 "passive" for convenience in the SOC, so too have I used the  
11 terms "passive" and "static" interchangeably in my testimony to  
12 succinctly refer to a device that has no moving parts and that  
13 functions without a change in configuration or properties.

14 Q. Do the electrical engineering materials cited in your  
15 expert report also use the terms "static" and "passive"  
16 interchangeably?

17 A. No, the electrical engineering materials refer to  
18 components that do not have moving parts or are fixed in one  
19 place as "static" and components that do not experience a change  
20 in configuration or properties as "passive." The electrical  
21 engineering materials frequently describe passive devices as  
22 those that cannot be controlled externally. This is because an  
23 external control is used to change a device's properties, state,

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1 or configuration. A device that the electrical engineering  
2 community considers to be both *static and passive* would require  
3 AMR under 10 C.F.R. § 54.21.

4 The electrical engineering community considers a  
5 transformer to be both static and passive (see NYS000006 and  
6 NYS000007). A transistor, on the other hand, is considered  
7 static and *active* because it does not have moving parts but it  
8 undergoes a change in properties and state during its normal  
9 intended use. The second edition of the IEEE dictionary defines  
10 a transistor as "An *active* semiconductor device with three or  
11 more terminals." NYS000415 (emphasis added). And so, a  
12 component can be both static and active under the electrical  
13 engineering community's definitions, but such a component would  
14 not be subject to AMR under 10 C.F.R. § 54.21.

15 Q. Dr. Dobbs argues that the electrical engineering  
16 materials cited in your expert report are not relevant to  
17 determining if AMR is required under 10 C.F.R. § 54.21 (Entergy  
18 Test. at 49-52). Do you agree?

19 A. No. The materials from the electrical engineering  
20 community that I cite are applicable to the Commission's Part 54  
21 concept of a passive component because they describe how a  
22 transformer functions. Since transformers function the same way  
23 in every context, the materials from the engineering community

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1 are relevant to understanding how transformers function at  
2 Indian Point. Only with an understanding of transformer  
3 functionality can one determine if a transformer is the type of  
4 component that requires AMR under 10 C.F.R. § 54.21. The  
5 materials I cite reflect the consensus in the engineering  
6 community that transformers function without moving parts and  
7 without a change in configuration or properties.

8 Additionally, in their testimony, Entergy's experts  
9 acknowledge that Entergy relies on materials from the electrical  
10 engineering community in its transformer management plan.  
11 Entergy Test. at 104 ("The 'Indian Point Energy Center Large  
12 Power Transformer Life Cycle Management Plan' (ENT000125) is  
13 based on guidance provided by EPRI and the IEEE."). Therefore,  
14 such materials are certainly relevant to this proceeding.

#### 15 **Properties of a Transformer**

16 Q. Now let's turn to Dr. Dobbs's discussion of  
17 transformer properties (Entergy Test. at 30-37). Does 10 C.F.R.  
18 Part 54 or the 1995 Statement of Consideration define the term  
19 "property" as it is used in 10 C.F.R. § 54.21(a)(1)(i)?

20 A. No. Although the term "property" is not defined in 10  
21 C.F.R. § 54.21(a)(1)(i), the Statement of Consideration does  
22 mention that "a battery changes its electrolyte *properties* when  
23 discharging." SOC at 22477. This example illustrates what is

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1 considered a property for the purposes of the regulation. A  
2 battery is composed of chemicals that undergo physical changes  
3 (chemical reactions) in order to produce the desired electrical  
4 energy. As the battery discharges electrical energy, the  
5 electrolytic properties (such as the conductivity, viscosity,  
6 acidity, and density) of the chemicals change. Thus, the traits  
7 of the constituent parts of a battery change during its  
8 operation. This example shows that in 10 C.F.R. §  
9 54.21(a)(1)(i) the term "property" refers to the qualities or  
10 traits of an object.

11 Q. Is Dr. Dobbs's definition of "property" consistent  
12 with the definition of property as it is used in 10 C.F.R. §  
13 54.21(a)(1)(i)?

14 A. No. Dr. Dobbs expands the definition of property to  
15 include not only the traits of an object, but also the traits of  
16 other materials with which an object interacts during its  
17 operation. Dr. Dobbs's definition is incorrect. An object does  
18 not inherit the properties of another object or material simply  
19 by interacting with it. If this were a valid concept of  
20 property, then the pressure and flow rate (in gallons per  
21 second) of the fluid in a pipe would be considered properties of  
22 the pipe containing the fluid. The pipe then would be  
23 considered an active component because the pressure and flow

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1 rate of the fluid in the pipe may change. However, a pipe is  
2 specifically listed in 10 C.F.R. § 54.21 as an object requiring  
3 AMR because pressure and flow are *not* properties of the pipe;  
4 they are properties of the fluid itself. This shows that Dr.  
5 Dobbs's concept of property does not match that of 10 C.F.R.  
6 Part 54.

7 Q. What effect does Dr. Dobbs's definition of property  
8 have on his testimony regarding transformers?

9 A. According to Dr. Dobbs's logic, since one must refer  
10 to electricity, current, voltage, and magnetic field in  
11 describing the operation of a transformer, these are the  
12 properties of a transformer. Dr. Dobbs's entire argument that  
13 transformers are active components hinges on his conflation of  
14 the properties of the electricity running through the  
15 transformer and the properties of the transformer itself. He  
16 argues that a transformer is an active component because the  
17 current, voltage, and magnetic field travelling through the  
18 transformer undergo a change during transformer operation.

19 Q. Do you agree with Dr. Dobbs that voltage and current  
20 are properties of a transformer (Entergy Test. at 33-34, A53)?

21 A. No. Dr. Dobbs argues that voltage and current cannot  
22 be properties of electricity because they are created by an  
23 external force. However, this is fundamentally incorrect. The

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1 laws of physics dictate that voltage and current are properties  
2 of the electrical power flowing through the transformer, not  
3 properties of the transformer itself. Current is the flow rate  
4 of electric charge. Voltage is the electromagnetic force that  
5 causes charge to flow through a conductor. The voltage that  
6 pushes charge through a conductor is akin to the pressure that  
7 pushes water through a pipe. It is commonly accepted that  
8 voltage and current are properties of electricity. Dr. Dobbs  
9 himself recognizes this fact. He states, "In simple terms,  
10 electrical power is defined by the equation:  $\text{Power} = (\text{Voltage}) \times$   
11  $(\text{Current})$ ." Entergy Test. at 62, A74. It is immaterial how  
12 current and voltage are created because the electricity is the  
13 same regardless of whether it is created by a generator or a  
14 battery. Electricity cannot exist without voltage and current—  
15 these are its properties.

16 Dr. Dobbs also makes the erroneous argument that since  
17 current and voltage are not "peculiar to" electricity they  
18 cannot be properties of it. Contrary to his assertion, there is  
19 no requirement that an object's properties be unique to that  
20 object. Moreover, a property does not cease to be a property of  
21 one object simply because another object also possesses that  
22 property. For example, one property of a transformer is its  
23 conductor dimensions. This same conductor size could be used

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1 for a cable or in a breaker. Since this conductor size is not  
2 "peculiar" to the transformer, application of Dr. Dobbs's  
3 argument would mean that the conductor size is not a property of  
4 the transformer (or cable or breaker). This is obviously not  
5 the case.

6 Q. Do you agree with Dr. Dobbs that magnetic field is a  
7 property of a transformer (Entergy Test. at 33-34, A53)?

8 A. No. Magnetic field is a property of electricity caused  
9 by the movement of electric current. Dr. Dobbs acknowledges  
10 this: "[B]oth positive and negative electric charges are  
11 surrounded by an electric field, and movement of those charges  
12 produces a magnetic field." Entergy Test. at 33, A51. When  
13 there is no electric current flowing into the transformer, there  
14 is no magnetic field because the transformer's coils and core  
15 are incapable of producing one. A magnetic field is also  
16 created when electric current passes through a cable, but this  
17 component is still considered to be passive under 10 C.F.R. §  
18 54.21. This is because the magnetic field created by the  
19 electric current does not change the properties of the component  
20 through which the current is traveling, be it a cable or a  
21 transformer.

22 Dr. Dobbs's statements regarding magnetic field illustrate  
23 the fundamental inconsistency in his argument. First, he argues

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1 that something cannot be a property of an object if it is  
2 created by an external force. According to this reasoning,  
3 since voltage and current are created by external forces, they  
4 cannot be properties of electricity. *Entergy Test.* at 13 and  
5 33. For the same reason, he concludes that pressure and flow  
6 are not properties of water. *Entergy Test.* at 69, A78.  
7 However, he then argues that a magnetic field is a property of a  
8 transformer, despite acknowledging that it is created by an  
9 external force. Dr. Dobbs states, "The change in magnetism that  
10 occurs in a transformer's core occurs automatically through  
11 *external electric stimuli* supplied by changes in the source and  
12 load." *Entergy Test.* at 35, A54 (emphasis added). He also  
13 states, "[T]ransformers respond to *external* voltages, currents,  
14 and changes in load." *Id.* at 78, A87 (emphasis added). Under  
15 Dr. Dobbs's own reasoning, magnetic field cannot be a property  
16 of a transformer because it is created by an external force.

17 Q. What are a transformer's properties?

18 A. As I stated in my December 9, 2011 testimony,  
19 transformer properties include turns ratios, winding conductor  
20 dimensions, insulation type and thickness, core dimensions, and  
21 cooling capability. See *Degeneff Pre-Filed Test.* at 9. These  
22 are the constituent parts of the transformer whose traits define  
23 the transformer's function. They remain the same before,

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1 during, and after a transformer's operation.

2 Q. Is the transformation ratio of the input and output  
3 voltage a property of the transformer? If so, does this make  
4 voltage a property of the transformer as Dr. Dobbs asserts  
5 (Enterger Test. at 59-60, A71)?

6 A. The transformation ratio is a property of the  
7 transformer. It is equivalent to the transformer's turns ratio.  
8 Both are determined by the number of turns on a transformer's  
9 primary winding divided by the number of turns on its secondary  
10 winding. This ratio never changes because the number of turns  
11 on a transformer's primary and secondary windings never changes.  
12 The ratio is described by the equation  $V_p/V_s = N_p/N_s = N$ , where  $v$   
13 = voltage,  $N$  = turns,  $s$  = secondary, and  $p$  = primary. As  
14 described by this ratio, the voltage of electricity moving  
15 through the transformer will be stepped up or down in proportion  
16 to the number of turns in the transformer's windings. For  
17 example, if there are twenty turns on the primary and two turns  
18 on the secondary, the turns ratio is 10. The voltage  
19 transformation ratio is also 10. So if the input voltage is  
20 1000 volts, the output voltage will be 100 volts. This does not  
21 make voltage a property of the transformer; it simply describes  
22 the change voltage will undergo as it moves through the  
23 transformer. Voltage is a property of electricity, not a

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1 property of the transformer itself.

2 Q. Do you agree with Dr. Dobbs that transformers are  
3 electrical sources and loads (Entergy Test. at 60, A73)?

4 A. No, Dr. Dobbs is incorrect. A transformer cannot  
5 generate power. It is not a source of power any more than a  
6 transmission cable is a source of power. The power must be  
7 supplied from some other source— a generator or battery, for  
8 example. The transformer passively transmits power in exactly  
9 the same way a cable transmits power.

10 Q. When the State's former consultant, Mr. Blanch,  
11 stated, "Transformers have design properties such as turns  
12 ratios, current, voltage, and power," (See 2009 Blanch  
13 Declaration, ENT000096, at 6) did he mean that current and  
14 voltage are properties of a transformer, as Dr. Dobbs argues  
15 (Entergy Test. at 56, A69)?

16 A. No. Mr. Blanch was referring to the fact that each  
17 transformer is built to withstand the flow of a certain amount  
18 of current at a specified voltage magnitude. A transformer's  
19 properties, such as its insulation, must be designed to  
20 withstand the anticipated maximum voltage of the system in which  
21 it is installed. In like manner, the winding conductors are  
22 sized to carry the anticipated transformer current. Each  
23 transformer is built to withstand a certain range of voltage and

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1 current. This does not make voltage and current properties of  
2 the transformer.

3 Q. When you stated that both the input voltage and the  
4 load served are completely independent of the design and  
5 characteristics of the transformer, did you mean, as Dr. Dobbs  
6 asserts, that any transformer will work in any application  
7 (Entergy Test. at 64, A76)?

8 A. No. My statement was that a transformer with certain  
9 design characteristics can be inserted into multiple systems and  
10 perform satisfactorily. For example, let's assume we have a 60  
11 hertz ("Hz") 10 megavolt ampere ("MVA") transformer designed to  
12 accept 230 kilovolts ("kV") input voltage and output 69kV  
13 voltage. One would expect to apply this transformer with the  
14 input power delivered at 230kV and the load receiving the power  
15 at 69kV. However, this transformer could be applied equally  
16 well serving a 5MVA load receiving power at 115kV and deliver  
17 that power at 34.5kV. This may not be an economical  
18 arrangement, but it is perfectly acceptable technically. In  
19 short, a transformer's fixed design properties can work with  
20 multiple input and output voltages. In other words, a  
21 transformer's terminal voltages and currents are subject to  
22 change based on how the transformer is being applied or used.  
23 Under Dr. Dobbs's own reasoning, terminal voltages and currents

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1 cannot be properties of a transformer because they are not  
2 inherent to the transformer.

3 Q. Does your description of transformer operation  
4 resemble that contained in EPRI's License Renewal Electrical  
5 Handbook, as Dr. Dobbs argues (Entergy Test. at 56, A69)?

6 A. No. The description of transformer operation contained  
7 in the EPRI handbook was written by representatives from Duke  
8 Power (now Duke Energy) as part of a prior, unrelated license  
9 renewal application. The change in the "physical properties of  
10 the transformer" that these representatives refer to is a change  
11 in the voltage and current traveling through the transformer.  
12 As I have stated, current and voltage are properties of  
13 electricity, not properties of a transformer. Thus, the  
14 description of transformer operation contained in the EPRI  
15 handbook conflates the properties of electricity and the  
16 properties of a transformer.

17 Q. Is your paper, "A Method for Constructing Reduced  
18 Order Transformer Models for System Studies from Detailed Lumped  
19 Parameter Models," at odds with your testimony, as Dr. Dobbs  
20 asserts (Entergy Test. at 56-57, A69)?

21 A. No. Dr. Dobbs has fundamentally misunderstood the  
22 paper, which discusses a method for creating a computer model  
23 that utility engineers can use to perform system studies

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1 involving transformers. The paper states that a transformer's  
2 terminal impedance (the transformer's impedance to the flow of  
3 electricity at its input at a specific frequency) is influenced  
4 by the frequency of the electric current (the number of times  
5 the current alternates per second) flowing through it. During  
6 normal operations the frequency is unchanging (e.g., it remains  
7 at 60 Hz); however, an external event (such as lightening  
8 striking the transformer or a breaker opening the circuit) can  
9 change the frequency and subject the transformer to transient  
10 voltages. The structure of a transformer's insulation must be  
11 engineered to withstand differing transient voltages. In order  
12 to design the insulation, transformer manufacturers maintain  
13 complex computer programs that compute the internal transient  
14 voltage distribution when the transformer is subjected to  
15 transient voltages. My paper suggests a method for creating a  
16 simpler model that can be used by utility engineers to perform  
17 system studies. This paper in no way conflicts with my  
18 testimony. In fact, it supports my argument that under normal  
19 operations, a transformer's properties do not change. The  
20 frequency characteristic of the transformer, like the turns  
21 ratio, is a property of the transformer, and unless there is a  
22 problem with the transformer (an internal failure or fault), it  
23 will be invariant. This is one measure to determine if there is

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1 a problem with a transformer.

2 Q. Dr. Dobbs asserts that a transformer experiences a  
3 change of state when it is put into service (Entergy Test. at  
4 11, A24). NRC's experts argue that a "transformer changes its  
5 state by transforming electrical energy into magnetic energy,  
6 then back into electrical energy again." Staff Test. at 6, A8.  
7 Do you agree with either of these assertions?

8 A. No. "State" refers to the condition of matter with  
9 respect to structure, form, constitution, phase, or the like.  
10 For example, water can change state from a liquid to a gas.  
11 During its operation, a transformer does not experience a change  
12 in state—its constituent parts are exactly the same before the  
13 transformer is placed in service and during the period it is in  
14 service. For example, unlike a transistor which changes state  
15 from a conductor to an insulator during operation, a transformer  
16 remains a conductor throughout its operation. NRC's experts  
17 incorrectly conflate the properties of electricity and the  
18 properties of the transformer. Although the current and voltage  
19 in the transformer change, the transformer itself does not.

20 Q. Does a transformer change configuration during its  
21 operation?

22 A. No. Configuration refers to the arrangement of an  
23 object's physical parts. A change in configuration is a

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1 physical change in the object's arrangement that affects how  
2 that object functions. For example, a valve, which is on the  
3 AMR-excluded list, changes configuration by physically opening  
4 and closing. None of the transformer's physical parts change  
5 arrangement during operation, and therefore, a transformer does  
6 not change configuration. Neither Entergy nor NRC Staff  
7 contends that a transformer experiences a change in  
8 configuration during operation.

9 **Comparisons of Transformers to AMR-Included**  
10 **and AMR-Excluded Components**

11 Q. Dr. Degeneff, now let's discuss Entergy's and Staff's  
12 experts' arguments concerning the differences and similarities  
13 between transformers and the components listed in 10 C.F.R. §  
14 54.21(a)(1)(i). Does Dr. Dobbs present an accurate analysis of  
15 your comparison between cables (AMR-included) and transformers  
16 (Entergy Test. at 65-68)?

17 A. No. Dr. Dobbs's statements regarding cables are  
18 technically misleading and misrepresent the physical reality of  
19 the situation. Dr. Dobbs presents three cable arrangements when  
20 only the third is relevant to my comments. This third  
21 arrangement can be represented with the same basic electrical  
22 equation that represents a simple two winding transformer. My  
23 point was that since a transformer's function can be represented

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1 by the same equation as a cable's function, a transformer should  
2 also be considered a passive component.

3 A transformer in its simplest arrangement consists of two  
4 conductors, one supplied with power and the other delivering  
5 power to a load. As such, the equations and characteristics of  
6 the simple two cable arrangement and a more complex transformer  
7 are exactly the same. This is basic to the understanding of  
8 cable and transformer operation. It is discussed in Chapters 3  
9 and 4 of N. Hancock's book "Matrix Analysis of Electrical  
10 Machinery," 2<sup>nd</sup> Edition, excerpted in NYS000416. Moreover, NRC  
11 Staff's experts agree that two cables can function as a simple  
12 transformer. Staff Test. at 23, A30 ("Dr. Degeneff is correct,  
13 in a theoretical sense, that two cables in close proximity to  
14 each other can function as a simple transformer. . .").

15 Q. NRC Staff's experts argue that the similarities  
16 between cables and transformers are not relevant to the question  
17 of whether a transformer is an active or passive component.  
18 Staff Test. at 23, A30. Do you agree?

19 A. No, the similarities are very relevant for this  
20 inquiry. Because cables and transformers are both passive  
21 devices involved in the transportation of electricity, the same  
22 elements that make it difficult to detect functional degradation  
23 in cables also make it difficult to detect functional

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1 degradation in transformers. Responding to a commenter who  
2 argued that the aging effects of cables would be "immediately  
3 detected during normal operation or functional testing," the  
4 1995 Statement of Consideration states:

5       The Commission disagrees with the commenter's  
6       assertion that the aging effects of cable make it  
7       easy to monitor functional degradation. Although  
8       there have been significant advances in this area,  
9       there is no single method or combination of methods  
10      that can provide the necessary information about the  
11      condition of electrical cable currently in service  
12      regarding the extent of aging degradation or  
13      remaining qualified life. Degradation due to aging  
14      of electrical cables caused by elevated temperature  
15      and radiation can cause embrittlement in the form of  
16      cracking of insulation and jacket materials. The  
17      cracks degrade the electrical properties of the  
18      insulation materials. The major concern is that  
19      failures of deteriorated cable systems (cables,  
20      connections, and penetrations) might be induced  
21      during accident conditions. Because these components  
22      are relied on to remain functional during and  
23      following design-basis events (including conditions  
24      of normal operations) and there are currently no  
25      known effective methods for continuous monitoring of  
26      cable systems, these examples of passive electrical  
27      components subject to an aging management review  
28      will remain in 10 C.F.R. § 54.21(a)(1)(i) and  
29      Section III(f)(i)(a) of the SOC.

30  
31 SOC at 22477-78.

32       Just as aging degradation can cause embrittlement in cables  
33      that is difficult to detect, it can also cause embrittlement  
34      (reducing the degree of polymerization) in transformer  
35      insulation structures that cannot be detected simply by  
36      monitoring the voltage and current moving through the

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1 transformer. The concern with both is exactly the same—as the  
2 insulation embrittles and degrades, the component's ability to  
3 withstand electrical stress decreases. This decrease cannot be  
4 observed in the electrical performance of the transformer or the  
5 cable, and left undetected will lead to catastrophic insulation  
6 failures.

7 Q. Do you agree with Dr. Dobbs's analysis of the  
8 differences between pipes and transformers (Entergy Test. at 69-  
9 72)?

10 A. No. First, as I mentioned above, Dr. Dobbs presents an  
11 inconsistent argument on what constitutes a property of an  
12 object. He argues that pressure and flow are not properties of  
13 fluid because they result from outside forces acting on the  
14 fluid. Entergy Test. at 69, A78. However, on page 35, A54, he  
15 argues that magnetic field is a property of the transformer,  
16 despite admitting that the magnetic field is caused by an  
17 external force acting on the transformer. As discussed  
18 previously, this characterization of property is incorrect.  
19 Pressure and flow are properties of fluid, not properties of a  
20 pipe. Furthermore, if these were properties of the pipe, the  
21 pipe would be considered an active component, which it is not.

22 Second, Dr. Dobbs misrepresents the analogy between a pipe  
23 and a transformer, and fails to properly relate Bernoulli's

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equation. The analogy between a transformer and a pipe with a changing diameter is as follows:

- The power delivered into the transformer ("S-in", e.g., MVA or electrical power) is the same as the power flowing out ("S-out") of the transformer (the transformer may induce a change in voltage, yet the power remains unchanged). In other words  $S_{in} = S_{out}$ . The analogy with the pipe is that the volume of fluid per unit time in ("Q-in" e.g., cubic feet/sec) is equal to the volume of fluid per unit time flowing out ("Q-out") or  $Q_{in} = Q_{out}$ .
- The voltage into the transformer ("V-in") is analogous to the area of the pipe at its start ("A-in"). The voltage out of the transformer ("V-out") is analogous to the area of the pipe at its termination ("A-out").
- The current flowing into the primary winding of the transformer is analogous to the velocity of the flow into the pipe. The current flowing out of the transformer's secondary winding is analogous to the velocity of the fluid flowing out of the pipe.
- The turns ratio of the transformer (which is invariant) dictates the relationship between the voltage in and the voltage out of the transformer, e.g.,  $N = V_{in}/V_{out}$ . In

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1       like manner, the relationship between the area of the pipe  
2       in to that of the area of the pipe out (which is also  
3       invariant) is  $N = A_{\text{in}}/A_{\text{out}}$ .

- 4       • The current into the transformer divided by the current out  
5       of the transformer is inversely proportional to  $N$ , the  
6       turns ratio or  $(V_{\text{in}}/V_{\text{out}})$ . In an analogous manner, the  
7       velocity of the fluid flowing into the pipe divided by the  
8       velocity of fluid flowing out of the pipe is inversely  
9       proportional to  $N$ , the area of the pipe in divided by the  
10      area of the pipe out ( $A_{\text{in}}/A_{\text{out}}$ ).

11      The pipe with a change in diameter is considered a passive  
12      device. Since the transformer is performing an analogous  
13      transformation it must also be considered a passive device. In  
14      both cases, the transformer and the pipe with a changing  
15      diameter, the fact that electric power or a fluid flows through  
16      each device does not change the properties of either device.  
17      Just as the unchanging properties of a pipe cause the change in  
18      the fluid, the unchanging properties of the transformer cause  
19      the change in the electricity moving through it.

20      Q. NRC Staff's experts argue that transformers are not  
21      like pipes because pipes can transport fluid without changing  
22      its properties, but transformers cannot transport power without  
23      changing current or voltage (Staff Test. at 22, A29). Do you

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1 agree?

2       A.   No. The electricity flowing through the transformer  
3 need not undergo a change during transformer operation.  
4 Normally, the transformer is used to adjust the voltage of the  
5 power flowing through the transformer, but if the turns ratio is  
6 1 to 1 then the power transmitted through the transformer will  
7 remain at the same voltage. This type of transformation is  
8 often used in power quality applications. By providing  
9 isolation, a transformer with a turns ration of 1 to 1 reduces  
10 electrical noise. In such a situation, the current and voltage  
11 of the electricity flowing through the transformer would not  
12 undergo any change. I have supplied this type of transformer to  
13 the nuclear industry.

14       Q.   Dr. Dobbs argues that the only aspect relevant to  
15 classifying a pipe, heat exchanger, steam generator, and reactor  
16 vessel as passive is that they all serve as pressure retaining  
17 boundaries (Entergy Test. at 72-73). Do you agree?

18       A.   No. As stated in 10 C.F.R. § 54.21, the relevant  
19 inquiry is whether a component undergoes changes in  
20 configuration, properties, or state during operation. These  
21 objects are considered passive because they do not experience a  
22 change in configuration, properties, or state. The comparison I  
23 made between the pipe, heat exchanger, steam generator, reactor

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1 vessel, and the transformer is that during operation, all of  
2 these components contain external materials (fluid or nuclear  
3 fuel) that undergo a change in properties or state; however, the  
4 components themselves does not change properties, configuration  
5 or state. For example, as a steam generator converts liquid to  
6 steam, the liquid undergoes a change in state and properties,  
7 but the steam generator is still considered passive. Similarly,  
8 the nuclear fuel within the reactor vessel changes properties or  
9 state, but the component itself does not change. My point is  
10 that a component is not considered active merely because the  
11 external materials moving through that component change  
12 configuration, properties, or state. This is also true of the  
13 transformer, where the electricity traveling through the  
14 transformer may change magnitude, but the component itself does  
15 not change.

16 Q. Do you agree with Dr. Dobbs that the change in  
17 resistivity in a transistor is directly analogous to the change  
18 in magnetic field inside a transformer (Enterger Test. at 74,  
19 A82)?

20 A. No, these changes are not analogous. Resistance is a  
21 property of a transistor. During operation, a transistor's  
22 resistance is changed, causing a change in the transistor's  
23 properties. Furthermore, the change in resistance can cause a

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1 change in the transistor's state from a conductor to an  
2 insulator. The Statement of Consideration specifically cites  
3 this change in state as the reason for excluding transistors  
4 from AMR:

5         Further, the Commission has concluded that "a  
6         change in configuration or properties" should  
7         be interpreted to include "a change in state" .  
8         . . For example, a transistor can "change its  
9         state" and therefore would not be screened in  
10        under this description.

11  
12 SOC at 22477.

13        As I discussed earlier, magnetic field is not a property of  
14 a transformer. It is created by the electric current flowing  
15 through the transformer. The magnetic field does not cause a  
16 change in the transformer's properties or state. Unlike the  
17 transistor, the transformer always remains a conductor. In  
18 comparison, a magnetic field is also created by the electric  
19 current traveling through a cable, but this does not make a  
20 cable an active component under the regulations.

21        The similarities between transformers and transistors  
22 discussed by Dr. Dobbs in his testimony and in ENT000111 are not  
23 relevant for the purpose of determining whether a transformer is  
24 an active or passive device under 10 C.F.R. § 54.21. The  
25 relevant criterion here is whether the device undergoes a change  
26 in configuration or properties (including state). The

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1 transistor undergoes a change in properties and state; the  
2 transformer does not. Dr. Dobbs attempts to complicate the  
3 matter in order to obscure this basic fact.

4 Q. Do you agree with Dr. Dobbs that the differences  
5 between batteries and transformers are the same as the  
6 differences between batteries and transistors?

7 A. No. Again, Dr. Dobbs attempts to confuse the matter  
8 to distract from the relevant distinction between the  
9 components. During operation, batteries and transistors undergo  
10 a change in properties. The chemical properties of the battery  
11 change, and the resistance of the transistor changes. A  
12 transistor may also experience a change in state from a  
13 conductor to an insulator. A transformer experiences neither a  
14 change in properties nor a change in state. This is the  
15 relevant difference for purposes of determining whether AMR is  
16 required under 10 C.F.R. § 54.21.

17 Q. As with transistors, Entergy's expert argues that the  
18 fact that power inverters and power supplies require external  
19 control in order to perform their intended functions is  
20 irrelevant because this is not a valid basis for including them  
21 in AMR (Entergy Test. at 81-82). Staff's expert makes a similar  
22 argument and notes that transformers can have external control  
23 mechanisms that dynamically control the relationship between

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1 input and output voltages (Staff Test. at 24). What is your  
2 response?

3 A. First, the transformers to which NRC's expert refers  
4 contain on-load tap changers, which have the ability to  
5 automatically change the transformer ratio. Such devices are  
6 not necessary for transformer functionality and do not change  
7 the basic function of the transformer. A tap changer can be  
8 compared to a valve on a pipe.

9 Second, like the transistor, the external controls on power  
10 inverters and power supplies cause those devices to change  
11 state. If the device has an external control then, depending  
12 upon the signal from the outside source, the device will perform  
13 some activity and change state or configuration, making it an  
14 active device. A transformer never changes state, even if it  
15 has a tap changer.

16 Q. Is Dr. Dobbs correct in asserting that you apply a  
17 "theory of inherited exclusion" when classifying power  
18 inverters, circuit boards, battery chargers, and power supplies  
19 as active components (Entergy Test. at 83, A95)?

20 A. No. Dr. Dobbs provides a flawed analysis of the  
21 classifications in the chart entitled "Comparison of Various  
22 Structures and Components" on pages 36-38 of my report  
23 (NYS000005). He mischaracterizes my argument saying that I

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1 present the idea that power inverters, power supplies, and  
2 circuit boards are all excluded from AMR merely because they  
3 have solid state devices. My actual statement was that since  
4 these components have solid state devices they can change state  
5 from a conductor to an insulator (or vice versa), and as such  
6 would be considered active devices. Contrary to Dr. Dobbs's  
7 statement, this is not true for transformers, which cannot  
8 change state.

9 Q. Staff's experts distinguish active and passive  
10 components arguing that "failure of active equipment is usually  
11 readily apparent" while "[f]ailure of a passive structure or  
12 component may not be readily apparent." Staff Test. at 8, A11  
13 and A12. Do you agree with this characterization?

14 A. No. First, the 10 C.F.R. § 54.21 characterizes AMR-  
15 included, or passive, components as those that do not have  
16 moving parts, do not function with a change in configuration or  
17 properties, and are not subject to replacement based on a  
18 qualified life or specified time period. The license renewal  
19 rule does not say that AMR-included components are those for  
20 which failure is not readily apparent.

21 Moreover, the detectability of failure is not a valid  
22 criteria for distinguishing active and passive devices.  
23 Contrary to Staff's experts' assertion, the failure of passive

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1 components may be immediately obvious. For example, the failure  
2 of a cable would be readily detected by protective relaying on  
3 the system. If a pipe failed it would also be obvious because  
4 there would be a drastic change in pressure on the system, an  
5 increase in temperature on the system, or liquid would be  
6 visually spilling from the pipe. Furthermore, the failure of an  
7 active device may not be readily apparent. For example, if a  
8 circuit breaker or a transistor failed, it would not be obvious  
9 until a signal was sent to one of those devices and it did not  
10 respond.

#### 11 **Monitoring of Age-Related Degradation in Transformers**

12 Q. Dr. Degeneff, now let's discuss the monitoring of  
13 aging degradation in transformers. Do you agree with Entergy's  
14 and Staff's experts that an AMP is not necessary for  
15 transformers because aging management is addressed through the  
16 requirements of 10 C.F.R. § 50.65 (the "maintenance rule")  
17 (Entergy Test. at 87, A96, Staff Test. at 20, A26)?

18 A. No, I do not agree. The regulations do not state that  
19 those components that would otherwise qualify for AMR under 10  
20 C.F.R. § 54.21, are excluded from AMR because they are covered  
21 by the maintenance rule. Therefore, the sufficiency of the  
22 maintenance rule is not relevant to determining whether a  
23 component qualifies for AMR.

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1       Moreover, the high incidence of transformer failures at  
2 nuclear facilities in the last few years is indisputable  
3 evidence that the Part 50 regulatory framework is inadequate for  
4 monitoring aging degradation and preserving the functionality of  
5 transformers.     NRC's 2009-2010 Information Notice found: "A  
6 relatively high incidence of transformer failures has occurred  
7 in the last few years, the majority of which could have been  
8 avoided had the licensee fully evaluated and effectively  
9 implemented corrective actions and recommendations identified in  
10 industry operating experience."     NRC Information Notice 2009-10,  
11 Transformer Failures-Recent Operating Experience (July 7,  
12 2009)(NYS000019) at OAG 10000526\_ 000002.     In other words, if  
13 the licensees had taken additional actions, the transformer  
14 failures could have been prevented. However, the corrective  
15 actions and recommendations identified in industry operating  
16 experience, such as in the IEEE Guide for the Evaluation and  
17 Reconditioning of Liquid Immersed Power Transformers, have not  
18 been endorsed by NRC and are not NRC requirements. Therefore,  
19 the Information Notice states that the majority of transformer  
20 failures could have been prevented if licensees had taken  
21 voluntary steps.     The problem is not that failures aren't  
22 preventable, but that such preventative measures are not  
23 requirements under the Part 50 regulations.     Mandating an AMP

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1 for transformers would force licensees to take such additional  
2 steps. As the numerous failures show, the Part 50 requirements  
3 alone are not effective at preventing transformer failure.

4 Q. Do you agree with Entergy's experts that NUREG/CR-5753  
5 provides support for the argument that AMR is not needed for  
6 transformers (Entergy Test. at 93, A103)?

7 A. No. Although NUREG/CR-5753 found that "there is no  
8 *presently identified* transformer aging mechanism that would  
9 cause a safety concern," this study is outdated (NYS000012 at  
10 ix-x, emphasis added). It was published 16 years ago, prior to  
11 the eighteen instances since 2007 in which catastrophic failures  
12 have occurred in transformers at nuclear power reactors. See  
13 Degeneff Report at 18-22. The study itself noted that  
14 transformers were relatively young at the time of the study and  
15 recommended additional review every *five* years.

16 Entergy's experts cite an industry guidance document, EPRI  
17 1002913, *Power Transformer Maintenance and Application Guide*, to  
18 support their argument that significant changes have been made  
19 in surveillance and maintenance practices and programs since  
20 NUREG/CR-5753 was written. Entergy Test. at 93, A103. This  
21 document itself is ten years old, and like NUREG/CR-5753, does  
22 not take into account the recent wave of large transformer  
23 failures.

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1 Q. Entergy's experts also argue that AMR is not required  
2 for transformers because Generic Safety Issue ("GSI") 107 "found  
3 that the safety significance of identified transformer  
4 performance issues was not sufficient to justify new  
5 requirements, and that maintenance rule requirements provide a  
6 sufficient means by which to address transformer performance  
7 issues . . ." Entergy Test. at 94, A105. What is your response?

8 A. Again, I do not agree that the maintenance rule must  
9 be found insufficient for the license renewal rule to apply to  
10 transformers.

11 Like the other studies cited by Entergy's experts, GSI 107  
12 was issued 12 years ago, in 2000, before the recent wave of  
13 transformer failures. Since GSI 107 compared the risk of  
14 transformer failure to the cost of regulatory development, the  
15 recent increase in transformer failure could change the outcome  
16 of the evaluation. Therefore, GSI 107 does not present an  
17 accurate assessment of the current situation.

18 Q. Are you arguing, as Entergy's experts assert, that  
19 Entergy is required "to detect, in advance of failure, all of  
20 the aging defects and degradation phenomena in components,  
21 including transformers" (Entergy Test. at 96, A107)?

22 A. No, I am not arguing that an AMP is required to detect  
23 all aging degradation in transformers. I am arguing that an AMP

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1 is necessary to detect degradation that can cause the loss of  
2 transformer functionality. The SOC specifically states, "The  
3 Commission believes that regardless of the specific aging  
4 mechanism, only aging degradation that leads to degraded  
5 performance or condition (i.e. detrimental effects) during the  
6 period of extended operation is of principal concern for license  
7 renewal." SOC at 22469. Clearly transformer degradation that  
8 causes transformer failure is the type of degradation this rule  
9 aims to prevent. On pages 14-17 of my December 2011 report, I  
10 listed types of aging degradation that can cause loss of  
11 transformer functionality. I also explained how these types of  
12 degradation can go undetected without an AMP. Entergy's experts  
13 mischaracterize my argument when they assert that I am concerned  
14 with detecting "all" of the aging effects and degradation  
15 phenomena in transformers. I do not believe an AMP is needed to  
16 detect "all" aging effects, but to detect degradation that can  
17 lead to failure of the transformer and related systems. While  
18 there can never be a guarantee that no failures will occur, the  
19 purpose of the license renewal rule is to provide a reasonable  
20 assurance that transformers will not fail. The recent history  
21 of transformer failure shows that the maintenance rule is  
22 insufficient, on its own, to provide this reasonable assurance.

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1 Q. Do you agree with Entergy's and NRC Staff's experts  
2 that a transformer's performance can be readily monitored as it  
3 performs its intended function (Entergy Test. at 42, A60; Staff  
4 Test. at 12, A20)?

5 A. No. Entergy's and NRC Staff's experts are incorrect  
6 when they contend that transformer degradation results in a  
7 change in the electrical performance of the transformer and the  
8 associated circuit. Due to the transformer's passive nature,  
9 electricity can continue to pass through a degraded transformer  
10 up until the moment of transformer failure. For example,  
11 degradation to a transformer's insulation will not result in any  
12 noticeable change to the current and voltage, but over time this  
13 can lead to transformer failure. This is explained in more  
14 detail on pages 38-40 of my report (NYS000005).

15 Q. Do you agree with Staff's and Entergy's experts that  
16 the relevant consideration for purposes of determining whether  
17 AMR is required, is whether gross failure of transformers is  
18 readily detectable (Staff Test. at 8, 15, 23-24; Entergy Test.  
19 at 107, A116)?

20 A. No, the purpose of the license renewal rule is to  
21 prevent gross failure, not to detect it. Entergy and NRC Staff  
22 argue that as long as electricity is flowing correctly through  
23 the transformer, its performance is not degraded, and when the

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1 transformer fails it is obvious. But it is the failure that is  
2 readily apparent, not the degradation. Transformer failure is  
3 the effect of unnoticed degradation, which is what an AMP is  
4 meant to prevent. This is why the Statement of Consideration  
5 says that the Commission is concerned with "aging degradation  
6 that leads to degraded performance or condition (i.e.  
7 detrimental effects) . . ." A transformer that appears to be  
8 functioning properly can nonetheless be in a degraded condition  
9 that will lead to failure. The presence of certain age-related  
10 degradation that can cause failure and is undetectable by  
11 performance monitoring is the very reason why an AMP is  
12 necessary for transformers.

13 I have participated in numerous transformer failure post  
14 mortems, which have found that the transformer failure could  
15 have been prevented if the transformer owners had had an  
16 effective aging management program.

17 Q. Can the age-related degradation of transformers be  
18 monitored online (i.e., while the transformer is operating)?

19 A. No. Many of the tests to determine transformer  
20 degradation must be conducted while the transformer is offline.  
21 For example, the aging of cellulose insulation cannot be  
22 monitored with the transformer operating. Nor can all the  
23 dissolved gas in the transformer's oil be determined with the

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1 transformer operating. Additionally, the mechanical integrity  
2 of the core and coils can not be determined with the unit  
3 operating. This requires physical inspection of the  
4 transformer, where the transformer is taken offline and drained  
5 of oil. It is unrealistic to represent that the aging condition  
6 of a transformer can be ascertained while the transformer is in  
7 operation.

8 This is significant because Entergy states that for all  
9 electrical components without moving parts indentified in the  
10 AMR-excluded lists, the functional degradation resulting from  
11 the effects of aging can be monitored online (*i.e.*, while  
12 operating). Entergy Test. at 40, A57. In contrast, the AMR-  
13 included components have aging-related degradation of their  
14 passive intended functions that cannot be monitored online.  
15 This is true of the transformer.

16 Q. Are Entergy's experts correct that some of the  
17 procedures you suggest for monitoring age-related degradation in  
18 transformers may be detrimental to transformer operation because  
19 they can introduce moisture and contaminants into the  
20 transformer internals and oil?

21 A. No, Entergy's experts' representation of my comments  
22 about monitoring the condition of the transformer takes an  
23 extreme and unrealistic position. Monitoring the health of the

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1 transformer does not place the transformer in danger. All of  
2 the monitoring activities I suggested have been applied safely  
3 in the utility industry. A program for inspecting a transformer  
4 must be tailored to each unique transformer and its performance  
5 history. This is alluded to in the EPRI Copper Book when it  
6 discusses the draining of oil from the unit. See ENT000129. A  
7 transformer monitoring program must meet the prudent guidance of  
8 the electrical industry.

9 On page 101 of Entergy's testimony a section of EPRI's  
10 Copper Book is reproduced. A careful reading shows that there  
11 are instances when internal inspection is warranted and this can  
12 be accomplished safely. Furthermore, Entergy's *Large Power*  
13 *Transformer Inspection Guidelines* (ENT000121) contains  
14 guidelines on conducting internal inspections of transformers.  
15 Entergy's experts state in their testimony: "If transformer  
16 degradation was detected through the current monitoring that  
17 Entergy performs on the transformers, then Entergy would, if  
18 warranted, perform an internal inspection of the transformer to  
19 determine and correct the cause. See generally, EN-EE-G-001  
20 (ENT000121)." ENTR00091 at 104.

21 Q. In a chart on pages 103-104 of their testimony,  
22 Entergy's experts explain the means by which they claim to  
23 address your concerns regarding the monitoring of aging

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1 degradation in transformers. Does this chart alleviate your  
2 concern that aging degradation will go unnoticed in transformers  
3 at Indian Point?

4           A. No. The rate of transformer failure at nuclear  
5 plants across the country shows that performance monitoring is  
6 insufficient to provide a reasonable assurance that transformer  
7 functionality will be maintained. This is because there are  
8 significant transformer failure modes that involve aging  
9 degradation of transformer components that do not affect  
10 transformer operating performance until the transformer fails.  
11 Therefore, the performance monitoring outlined in Table 4, which  
12 is in accordance with Part 50, is insufficient to maintain the  
13 functionality of aging transformers. For example, Entergy's  
14 experts assert that "[m]echanical changes in the transformer can  
15 be detected through capacitance testing as is performed at  
16 IPEC." Entergy Test. at 103. Capacitance testing, however, is  
17 inadequate for monitoring the mechanical and structural  
18 integrity of the coil assembly. Visual inspection of the coil  
19 assembly is the only way to properly assess its integrity. As  
20 this requires draining the oil from the transformer, such  
21 degradation is not observed through performance monitoring.  
22 Similarly, Entergy's experts assert that furanic compound  
23 analysis of the oil is Entergy's method of detecting

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1 polymerization. *Id.* However, as I explain on page 14 of my  
2 December report, visual inspection is necessary to determine  
3 whether the polymerization is occurring to a small degree and  
4 without significant risk throughout the insulation, or whether  
5 it is occurring intensely and with significant risk at a small  
6 number of locations.

7           Importantly, this chart refutes Entergy's and Staff's  
8 claim that age-related degradation in transformers is readily  
9 monitored, since Entergy's experts admit that there are  
10 conditions that may require the transformer oil to be drained so  
11 that a physical inspection of the transformer's internal  
12 structure can be conducted. This shows that the transformer's  
13 ability to perform its intended function is not monitored solely  
14 by a change in the electrical performance of the transformer and  
15 associated circuits.

16           Q. Your December 9, 2011 report cited a number of  
17 recent transformer failures. NYS000005 at 18-22. Have you come  
18 across any additional transformer failures that were not  
19 prevented by performance monitoring but could have been  
20 prevented with an AMP?

21           A. Yes. I have found two additional licensee event  
22 reports involving transformer failures that were not prevented  
23 by current monitoring but could possibly have been prevented by

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1 an AMP:

- 2 • On June 27, 2011, the off-site AC power sources to Unit 2  
3 Prairie Island Nuclear Generating Plant were declared  
4 inoperable as a result of Transformer 2RY lockout and  
5 less than the required minimum voltage on the  
6 transmission system. The overcurrent ground detection  
7 relay actuated due to a bus phase to ground fault  
8 resulting from failed gasket material, causing the  
9 transformer lockout. It was determined that a less than  
10 adequate review of the Preventive Maintenance Deferral  
11 Process delayed bus inspection that would likely have  
12 identified and corrected the problem (a hole in the bus  
13 duct due to exposure to moisture and rain). See  
14 NYS000417. This problem could have been prevented with  
15 more frequent inspection of the bus duct. The bus duct's  
16 degradation did not result in a change to the  
17 transformer's electrical performance until the moment of  
18 lockout.
- 19 • On January 30, 2012, Byron Station Unit 2 experienced a  
20 loss of normal offsite power and a reactor trip. On  
21 February 28, 2012, Byron Station Unit 1 experienced a  
22 loss of normal offsite power. Both events were caused by  
23 the failure of system auxiliary transformer inverted

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1 insulators (bushings). The insulator failures were  
2 caused by service propagation of a large manufacturing  
3 material defect. See NYS000418. It is possible that  
4 these bushing defects could have been found through  
5 visual inspection, but not performance monitoring.  
6 Several of the recent transformer failures have been  
7 caused by bushing failures. For example, the main  
8 transformer failures at Indian Point Units 3 and 2 in  
9 2007 and 2010, respectively, were caused by bushing  
10 failures. Entergy Test. at 105-06, A115. The bushing is  
11 an integral part of the high voltage power transformer.  
12 A high voltage power transformer cannot function reliably  
13 without bushings. The bushing is the point of electrical  
14 connection between the electrical system and the  
15 transformer. The purpose of the electrical  
16 characteristics of the bushing are the same as those of  
17 the high voltage cable, *i.e.*, to provide a low impedance  
18 path over which the power can flow and concomitantly to  
19 provide insulation between the conductor and ground (or  
20 other phase conductors). The degradation of the ability  
21 of either to perform its intended task cannot be  
22 consistently determined by measuring the change in the  
23 transformer's electrical performance.

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1 Q. Do you have any concluding remarks?

2 A. Transformers are a critical component in  
3 maintaining the safety and reliability of the Indian Point  
4 facility. Entergy claims that the program they have in place  
5 can maintain the safety and reliability of the system without an  
6 AMP for transformers. This is simply not the case, as  
7 demonstrated by the transformer failure rate in recent years.  
8 Without an AMP, there cannot be reasonable assurance that the  
9 effects of aging will be adequately managed so that transformer  
10 functionality will be maintained consistent with the CLB for the  
11 period of extended operation.

12 Q. Does this conclude your testimony?

13 A. Yes.

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1 UNITED STATES

2 NUCLEAR REGULATORY COMMISSION

3 BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

4 -----x

5 In re: Docket Nos. 50-247-LR; 50-286-LR

6 License Renewal Application Submitted by ASLBP No. 07-858-03-LR-BD01

7 Entergy Nuclear Indian Point 2, LLC, DPR-26, DPR-64

8 Entergy Nuclear Indian Point 3, LLC, and

9 Entergy Nuclear Operations, Inc. June 28, 2012

10 -----x

11 DECLARATION OF ROBERT C. DEGENEFF

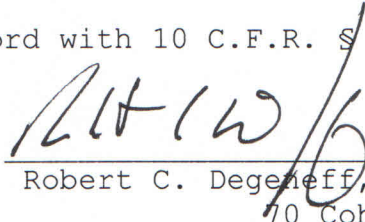
12 I, Robert C. Degeneff, do hereby declare under penalty of

13 perjury that my statements in the foregoing testimony and my

14 statement of professional qualifications are true and correct to

15 the best of my knowledge and belief.

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

  
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June 28, 2012

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