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Record of Revisions

Rev	Date	Revision Description
0	8/11	Initial Issue.
1	See EDMS	Closed all four open items in Section 4.2. This involved the following: Added references 21 through 25. Changed Author, Verifier, and Reviewer on Title Page. Text changes on pages 5, 9, 15, 16, 17, 18, 20, 22, 23, 24, 25. Modified Section 2.1 Assumptions to reflect closure of open items. Minor editorial and formatting changes were made.

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1.0 Background and Purpose

1.1 Purpose

This evaluation addresses the immunity of the Watts Bar 2 Class 1E Core Exit Thermocouple (CET) system from faults originating in, or by means of, the non-1E Incore Instrumentation System (IIS) Signal Processing System Cabinets (SPS).

This evaluation also addresses incore detector signal conductor charge-up issues caused by disconnection of the incore detector signal cable from its normal termination at the SPS cabinet.

This evaluation is necessary to ensure compliance with the isolation requirements of IEEE 384 for independence of Class 1E equipment and circuits. Though compliance with IEEE 384-1981 is required, the latest revisions of this standard, IEEE 384-1992 and IEEE 384-2008, include additional clarification on the requirements established in the 1981 revision, without relaxing any applicable requirements. For this reason, this document quotes the 2008 revision to IEEE 384, with the understanding that the requirements of the 1981 and 1992 revision are also met.

This calculation note was prepared according to Westinghouse Procedure NSNP 3.2.6.

1.2 Background

Watts Bar 2 includes 58 Incore Instrumentation Thimble Assemblies (IITAs) each of which contains five axial levels of Vanadium Incore Self Powered Neutron Detectors (SPNDs) used for power distribution monitoring (a non-1E function), and a single Core Exit Thermocouple used in the Post Accident Monitoring System (a 1E function). These separate functions share the same IITA to minimize the number of reactor vessel penetrations and routing complexities that would be required if they were installed in separate assemblies. Other than sharing the same IITA, the CETs and SPNDs are completely separate physically and electrically. The SPND signals are processed in two separate Incore Instrumentation System (IIS) Signal Processing System (SPS) cabinets (29 IITAs Incore detector assemblies per SPS cabinet). The CETs are also processed in two separate PAMS cabinets (29 CETs per cabinet). The CETs and SPNDs are routed such that all of the CETs associated with a single PAMS train will have its associated IITA SPNDs routed to one SPS cabinet. Those CETs associated with the other PAMS train will have the IITA SPND signals in their respective IITAs routed to the other SPS cabinet, (Reference 1). This arrangement complies with IEEE 384-2008 Section 4.6 d), as addressed in Section 1.3 of this evaluation.

[

]a,c

[

]a,c Note that the Watts Bar 2 IITA enters the reactor vessel through the Reactor Vessel bottom, via guide tubes which serve as the RCS pressure boundary. The guide tubes entering the reactor vessel bottom and enclosing the IITA assembly are terminated at the far end at a seal table assembly, where the IITA connector mates with a mineral insulated cable assembly, and where IITA disconnection during refueling may be effected. [

]a,c

The Watts Bar IITA Engineering Specification, 418A28 (Reference 10), provides additional detail on dimensions and composition of the IITA. [

]a,c

a,c

Figure 1. [ ][a,c]

a,c

[ ]

Figure 2. [ ][a,c]

[ ]a,c It should be noted that because of the compact nature of the IITA assembly the physical separation between the SPNDs and CETs within the IITA assembly and seal table connector does not meet the preferred minimum 1 inch separation requirement between the Class 1E CETs and non-1E Incore detectors as defined in IEEE-384.

[ ]a,c

This evaluation therefore addresses the following two issues:

1) Ensure that no fault originating either within the Incore signal processing system (SPS) cabinet or electrical surges on the input power lines or output [ ]a,c communications link can result in fault voltages at the Seal Table connector of greater than [ ]a,c between the connector pins.

2) Ensure that inadvertent disconnection or failures of any IITA emitter wire or wires either at the SPS cabinet, or anywhere in the cabling between the IITA seal table connector and the SPS cabinet will not cause voltage charge-up on the emitter wire exceeding [ ]^{a,c} during worst case (full power) plant operation, thus preventing the fault voltage from affecting the associated CET.

1.3 Requirements for 1E/non-1E Independence

Reference 5, "IEEE Standard 384-2008, IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits", addresses issues associated with separation between 1E and non-1E systems.

Note that the italicized text in subsections sections c. and d. of IEEE 384 Section 4.6, quoted below, represent additions to the IEEE 384-1992 text in the 2008 issue of this standard. Though the section numbers between revisions are changed, the technical changes are restricted to those in the italicized text. These do not change the fundamental requirements, but clarify that consideration of the energy available during faulting must be made, and that non-1E cabling may not be run with the associated cabling from a redundant division.

Section 4.5.1 of IEEE-384 (Reference 5) states the following:

"4.5.1 General

Non-Class 1E power, control, and instrumentation circuits become associated in one or more of the following ways, except as noted in items c), d), and e) in 4.6:

1) Electrical connection to a Class 1E power supply without the use of an isolation device.
2) Electrical connection to an associated power supply without the use of an isolation device.
3) Proximity to Class 1E circuits and equipment without the required physical separation or barriers.
4) Proximity to associated circuits and equipment without the required physical separation or barriers.
5) Sharing a Class 1E or associated signal source without the use of an isolation device. "

In accordance with the criteria set forth in Item 3 listed above, the Incore cables and their attached connectors are treated as Associated Circuits.

Section 4.5.2 of IEEE-384 (Reference 5) states the following:

"4.5.2 Criteria

Associated circuits shall comply with one of the following requirements:

c) They shall be analyzed or tested to demonstrate that Class 1E circuits are not degraded below an acceptable level. These associated circuits can then be considered non Class 1E circuits per the requirements in c), d), and e) in 4.6."

Section 4.6 of IEEE-384 addresses the independence of non-Class 1E circuits from Class 1E circuits as follows:

"4.6 Non-Class 1E Circuits; General Criteria

The independence of non-class 1E circuits from Class 1E circuits or associated circuits shall be achieved by complying with the following requirements:

c) The effects of less than minimum separation or the absence of electrical isolation between the non Class 1E circuits and the Class 1E circuits or associated circuits shall be analyzed to demonstrate that that Class 1E circuits are not degraded below an acceptable level or the non Class 1E circuits shall be associated circuits. *As part of the analysis, consideration shall be given to potential energy and identification of the circuits involved. Also, the non Class 1E circuits shall not be routed with associated cables from a redundant division.*

d) Non-Class 1E instrumentation signal and control circuits (see IEEE Std 690) are not required to be physically separated or electrically isolated from associated circuits provided that (1) the non-Class 1E circuits are not routed with associated cables of a redundant division and (2) the non-Class 1E circuits are analyzed to demonstrate that Class 1E circuits are not degraded below an acceptable level. *As part of the analysis, consideration shall be given to potential energy and identification of the circuits involved.*

e) Non Class 1E fiber optic circuits are not required to be physically separated from Class 1E and associated circuits. Electrical isolation is an inherent characteristic of fiber-optic circuits. Since fiber-optic circuits have no potential to degrade Class 1E circuits, they can be considered non Class 1E circuits versus associated circuits".

The Incore cable design does not meet the required minimum separation distance between the non-Class 1E SPNDs and Class 1E CETs. Based upon the above statements from IEEE-384, the purpose of this evaluation is to provide assurances that no credible fault within or by means of the non-Class 1E Incore SPS cabinet can adversely impact the Class 1E CETs by way of fault propagation over the Associated Incore cables.

Figure 3 is a block diagram defining the 1E/Associated/non-1E interface between the Class 1E Core Exit Thermocouples and the non-1E Incore SPS cabinets.

Note that:

- The 1E portion of the circuitry includes the IITA and connecting MI cabling housing the CET wiring.
- Interconnecting cabling from the Seal Table to the SPS cabinet does not perform a 1E function, but is not isolated from the 1E CETs per IEEE 384. Therefore, it is Associated.
- The Associated to non-1E interface is at the Incore SPS connector panel at the IIS SPS cabinet.
- The only electrical interfaces with the SPS are the Incore SPND output signals, the two [ ]^{a,c} input power feeds, and the two output [ ]^{a,c} links. [ ]^{a,c} links are fiber optic.

a,c

Figure 3: [ ]a,c

2.0 Summary of Results and Conclusions

Conclusions

No credible source of faulting within the SPS, the IITA, or the interconnecting cabling can negatively impact either PAMS train. Thus, both trains will remain operable.

For large input over-voltage conditions on the [ ]^{a,c} input instrument bus used in both the SPS cabinet and associated PAMS train, the SPS will not cause any failure within the PAMS train that would not otherwise occur as a direct result of the over-voltage condition within the PAMS power supply.

SPS Fault Evaluation

For the normal situation in which the 1E power input is maintained below [ ]^{a,c}, there are three possible sources of faulting within or by means of the non-1E Incore SPS. Each of these was evaluated for fault potential against the acceptance criteria of a [ ]^{a,c} limit on potential faulting.

The conclusion is that there is no credible fault originating within the non-1E Incore SPS that can exceed this limit

The three faults evaluated are

- Electrical surges [ ]^{a,c} on the [ ]^{a,c} communications link
- Electrical surges [ ]^{a,c} on the [ ]^{a,c} input power feed
- [ ]^{a,c} Power Supply failure during normal or harsh environmental conditions

Additionally, it was assumed that the input [ ]^{a,c} power feed could bypass (or short through) the [ ]^{a,c} power supply unattenuated directly to the SPND input signal leads.

The worst case fault is [ ]^{a,c} assuming complete power supply failure and a dead short through the SPS cabinet to the signal input cables. The incore instrument input cables are tested to a voltage of greater than [ ]^{a,c}, The lowest permissible cable insulation resistance is that of the IITA due to its elevated temperature during operation. This is [ ]^{a,c}. Therefore, conservatively assuming this minimum leakage resistance (maximum leakage current) is concentrated at a single point in the IITA, the energy available to cause further damage during the worst case power supply fault is restricted to [ ]^{a,c}, which is negligible.

1E bus Faults above [ ]a,c

[

]a,c

Failure of a single PAMS train is acceptable under such circumstances, and leaves the other train operable.

Cable Voltage Build Up Evaluation

The worst case voltage buildup due to disconnection or opening of the emitter wire at the Seal Table connector or any of the downstream signal processing will be less than the [ ]a,c for which the connectors will be qualified. [

]a,c The design maximum emitter current of [ ]a,c is sufficiently low that any short within the IITA will so restrict the energy available that further damage is precluded.

2.1 Assumptions and Interface Requirements

This evaluation is based on the interfaces to the SPS meeting the following requirements:

1. The maximum normal voltage on the AC input power to the SPS shall be limited to [ ]a,c. This requirement is met with the implementation of References 22 and 23.
2. The IITA and interfacing mineral insulated cabling up to the SPS cabinet interface shall have a dielectric voltage rating of at least [ ]a,c. This requirement is met per References 16 and 21.
3. The IITA and interfacing mineral insulated cabling shall be tested to confirm the ability to withstand a [ ]a,c application on the emitter wire without a reduction in insulation resistance such that the fault voltage could propagate to the IITA sheath, the interfacing MI cable sheath or adjacent connector pins. This requirement has been met and the results of the testing are documented in Reference 21.
4. The AC power cable to the SPS cabinet shall be routed in metal conduit such that the normal maximum voltage that can be impressed upon the AC power input is restricted to the [ ]a,c assumed in this evaluation. This routing requirement is defined in

Reference 22, and is confirmed by TVA as a requirement in Reference 23.

5. Watts Bar has confirmed that the [ ]a,c input power to the SPS cabinets are from isolated 1E sources, and are channelized such that the same source used in PAMS train A is used in SPS cabinet 1, and the same AC source used in PAMS train B is used in SPS cabinet 2. This requirement is defined in Reference 22, and confirmed by TVA in Reference 23.

3.0 References

1. WINCISE System Wiring Diagram, E-WBN2-155-006, Revision 1.
2. Standard Safety Line Filter Panel Assembly, Drawing 10042D05, Revision 6, sheets 1 through 4.
3. Standard Safety Power Supply Panels Assembly, Drawing 10043D28, Revision 7, sheets 1 through 23.
4. [ ]a,c
5. IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits, IEEE Std 384-1992, IEEE 384-1981, and IEEE 384-2008.
6. [ ]a,c
7. Watts Bar Unit 2 WINCISE Signal Processing System Design Requirements, WNA-DS-01811-WBT, Revision 0.
8. [ ]a,c
9. Drawing 6657E27, Revision 5, OPARSSEL Incore Instrumentation Thimble Assembly.
10. Engineering Specification for Incore Instrumentation Thimble Assembly, Specification number 418A28, Revision 2.
11. Design Specification, 00000-FEA-6102, Revision 8, Design and Fabrication Specification or Mineral Insulated Cable Assemblies Without Integral Reference Junctions.
12. WINCISE 1 to 2 Transition Cable Assemblies, E-WBN2-155-002, Revision 1.
13. [ ]a,c
14. Deleted.
15. Standard Specification for Thermocouples, Sheathed, Type K and Type N, for Nuclear or for Other High Reliability Applications, ASTM Standard E 235-06.

16. [

]a,c

17. WINCISE 6 to 1 Transition Cable Assemblies, drawing E-WBN2-155-003, Revision 1.

18. [

]a,c

19. Repair, Replacement, and Automation Services (RRAS) Common Q Power Supply Technical Manual, 00000-ICE-3453, Revision 2.

20. Watts Bar Unit 2 WINCISE Power Supply Panel Assembly, 10004D05, Revision 1, sheets 1 through 3.

21. "WINCISE Watts Bar IITA Dielectric Report" Report Number 021-8559, Rev. 00, Mirion Technologies Sensing Systems Division (IST Canada) Inc. November 2011.

22. Letter from G. A. Gisoni (Westinghouse) to Mr. Larry Bond (TVA) "Tennessee Valley Authority Watts Bar Nuclear Plant Unit 2 WINCISE SPS Power Requirements" WBT-D-1575, dated February 8, 2010.

23. Letter from Larry Bond (TVA) to Greg A Gisoni (Westinghouse) "Response to WINCISE SPS Cabinet Power Requirements", WBT-TVA-1060 dated March 15, 2010.

24. Letter from Daniel P. Kistler to D. N. Menard, "Incore Instrument Thimble Assembly (IITA) Insulation Resistance" LTR-NO-11-109, dated October 11, 2011.

25. Watts Bar 2 NSSS Completion Program, "Equipment Qualification Summary report for WINCISE Signal Processing System" EQ-QR-39-WBT-P, Revision 1, dated September 2011.

4.0 Calculations

4.1 Limits of Applicability

This analysis is applicable to the Watts Bar 2 Incore Nuclear Instrumentation system. The analysis is applicable for either [ ]a,c input power feeds to the Incore SPS. Though Watts Bar employs [ ]a,c from an isolated 1E source, this analysis conservatively assumes a [ ]a,c input power feed, with a maximum input fault voltage of [ ]a,c

4.2 Open Items

There are no open items in this calculation note.

Previous open items in Rev. 0 closed by this revision include:

(1) This Calc Note requires that the Incore detector assembly (IITA) and interfacing [ ]a,c to the SPS cabinet interface have a dielectric voltage rating of at least [ ]a,c, and that testing be performed to verify this value. [ ]a,c Reference 21 documents successful testing on the IITA required to close out this item.

(2) The [ ]a,c power supply must undergo successful EMC surge qualification testing to [ ]a,c to validate the assumptions regarding potential faults during normal operation. Successful surge testing is documented in Table 3.2.1 of Reference 25, closing out this item.

(3) The AC power cabling and voltage source external to the SPS cabinet shall be routed and the power source limited such that the maximum normal AC input voltage is [ ]a,c. These requirements are transmitted to TVA in Reference 22, and found acceptable in Reference 23. This closes out this item.

(4) The maximum IITA cable leakage resistance at the minimum temperature for criticality (551 degrees F) is limited to [ ]a,c. Since cable leakage resistance decreases with increased temperature, and normal reactor operating temperature is above this value, this is a conservative reference temperature. Cable leakage resistance must be verified by test or a combination of test (at one reference temperature) and analysis providing extrapolation to the performance at 551 degrees. This specification is required to minimize cable voltage charge-up during at-power IITA disconnection. Reference 24 confirms that the predicted resistance at the minimum temperature for criticality (551 degrees F) is less than 1.2E8 ohms. This closes out this item.

4.3 Method Discussion

This evaluation treats the non-1E Incore cabinet assembly in containment as an envelope. There are two points of electrical connection to the rest of the plant. These are the [ ]a,c communications connection and the AC power feed to the cabinet. The effects of

electrical surges on both of these interfaces were evaluated, and suitable isolation devices to prevent unacceptable fault propagation were specified. This evaluation of surges was restricted to normal (non harsh) operating environment.

Since the CET may be required during a LOCA, the cabinet is analyzed to determine what potential faults could be injected on the Incore cables from the SPS cabinets during such an event.

The cable charge build up issue evaluates the maximum possible voltage build up on an unterminated IITA detector at the seal table connector, which is the only point of vulnerability on the IITA assembly due to the double barrier design of the SPND and CET within the IITA. Maximum expected leakage resistance at elevated temperatures is assumed, and resulting voltage is calculated per Ohm's Law using the maximum permissible full power input current of [ ]^{a,c}.

4.4 Discussion of Significant Assumptions

[

]^{a,c} Surges are not assumed to occur during a harsh environment condition, when the Incore system will be experiencing environmental conditions well beyond the qualified ratings of the equipment.

Reference 7 requires that Power Supplies shall be equipped with a loss of voltage detection circuit, integral current limiting, and over-voltage protection circuit. Though this circuitry will provide protection during normal operation, during harsh conditions it must be assumed that the protective circuitry does not function.

The maximum normal AC voltage on the [ ]^{a,c} input is limited to [ ]^{a,c}. This is consistent with References 4, and 8, the [ ]^{a,c} DC Power Supply data sheets, and is greater than the specified [ ]^{a,c} Power interface Requirements specified for the SPS in Reference 7. All input power cabling between the isolated AC power input and SPS cabinet is routed in metal conduit.

It should be noted that the AC power input feed to the SPS is an isolated (per IEEE 384) 1E power source, and that this power source is the same source used to supply the CET circuitry in the associated Post Accident Monitoring System (PAMS) train. Thus, any extreme over voltage condition on the 1E input bus beyond the [ ]^{a,c} required in this analysis that may compromise the SPS will also independently compromise the associated PAMS channel used to monitor the affected CETs regardless of the status of the SPS.

By assigning each SPS cabinet and its corresponding PAMS division to the same Class 1E power bus, it is ensured that extreme fault voltages on a single 1E bus that [ ]^{a,c} can only disable one of the

two PAMS trains. This single failure of the 1E bus will still leave the other PAMS train intact and operable. The [ ]a,c Power Supply used in the PAMS (Reference 19) has a maximum input voltage rating of [ ]a,c, which is lower than that of the SPS [ ]a,c power supply. It can therefore be assumed that the PAMS power supply will be inoperable for input fault voltages approaching [ ]a,c and that the associated PAMS train will become inoperable.

Detailed cable routing of the SPS signal input cabling is not addressed in this evaluation. That is, IEEE 384 Section 4.6, item d, addressed in Section 1 of this Calc Note, (this is section 5.6 item 4 in the 1992 revision of IEEE 384) requires that there be no compromising of the class 1E cable routing by misrouting of the associated Incore cabling to the improper SPS cabinet. Reference 1 depicts the PAMS train/SPS signal routing assignments in accordance with IEEE 384 compliance. However, though physical details of this routing are within customer scope, Reference 22 does define routing requirements. Reference 23 acknowledges the acceptability of these requirements by TVA.

4.5 Acceptance Criteria

Faults originating in or by means of the normal electrical interfaces, [ ]a,c, cannot result in a voltage on the Incore input cables of [ ]a,c or more. Similarly, maximum cable charge-up voltage at the IITA connector shall not exceed [ ]a,c in the event of IITA disconnection while at power. Under these conditions, there is no failure in the SPS, IITA, or 1 to 2 transition cabling, either during normal or harsh environmental conditions, that can negatively impact wither PAMS train.

4.6 Input

[ ]a,c

5.0 Evaluations, Analysis, Detailed Calculations and Results

The Class 1E core exit thermocouples are most likely to be required during accident conditions: that is, during those events that could lead to a harsh containment environment (e.g. LOCA). The non-1E Incore Processing System Signal Processing System (SPS) cabinets used to mount the Incore system SPS are mounted in containment. As such, it may be expected that the SPS cabinets will experience a harsh environment well beyond the design capabilities of the system at the precise moment when the 1E thermocouples are most likely needed. It must be assumed that such an environment will lead to the failure of the Incore signal processing electronics.

The signal processing electronics are not post accident qualified; therefore it is not possible to perform a detailed circuit analysis of the SPS to assure that the maximum acceptable voltage on the IITA and its associated connectors is not exceeded. Note that there are numerous internal design features that limit the possibility of faulting during normal operation. These are not credited during harsh conditions.

However, the Incore SPS cabinets may be regarded as an envelope, and the sources of credible voltage transients evaluated individually, without the need for detailed analysis.

5.1 Faults under Normal Operating Conditions

The normal operating environment for the SPS is [ ]a,c. The Incore SPS cabinets have three external interfaces – AC input power, Ethernet communications to the Non-1E system, and Incore SPND input signals. For normal operating conditions, there are three faults that have the potential to provide faults to the SPND cables – surges on the AC power, surges on the Ethernet, and a power supply failure. These faults are analyzed herein.

5.1.1 AC Power Surges

[

]a,c

[ ]a,c The [ ]a,c power supply and associated protection devices have been qualified as defined in reference 25, including [ ]a,c surge testing. Thus, [ ]a,c input surges shall not result in unacceptable voltages on the [ ]a,c incore power distribution.

Surges must be assumed possible at any time during normal operation.

If, due to obsolescence or other concerns, other suppression devices are employed rather than those specified above, these devices will be evaluated to the same criteria described in this evaluation.

Based on the successful completion of the surge testing, the [ ]a,c surge on the AC input does not result in the output of the [ ]a,c power supply exceeding the maximum dielectric rating of the Incore cabling and connectors.

5.1.2 Surges on the Ethernet

Surges on the [ ]a,c output communications cable are not a credible threat. The SPS communicates with remote equipment by means of redundant [ ]a,c links. These will be fiber optic. Therefore, there is no credible surge that can be injected into the SPS cabinet from this interface.

5.1.3 [ ]a,c Power Supply Failure

[ ]a,c However the concern with the [ ]a,c power supply is that it could fail in such a manner as to produce a voltage greater than the dielectric rating of the Incore cables and connectors.

The most limiting internal source of unacceptable faulting was evaluated: [ ]a,c The power supply manufacturer [ ]a,c was asked to provide an assessment of the maximum credible voltage that could be produced under such conditions (Reference 6). The manufacturer responded that the power supply includes independent over-voltage protection that limits output voltage [ ]a,c will significantly limit the possible fault. However, the maximum voltage at the power supply input capacitors can be as high as the input RMS voltage X 1.414. Assuming a

maximum input voltage of [ ]^{a,c} on the nominal [ ]^{a,c} input, this can result in a maximum voltage of:

[ ]^{a,c}.

This is less than the required dielectric rating of the Incore cabling and connectors.

5.2 Faults under LOCA Conditions

The environmental conditions seen during a LOCA could exceed the values for which the equipment is qualified. Under these conditions, the electronics would be damaged beyond repair and any protection devices could not be credited for protection.

The most limiting internal source of unacceptable faulting was evaluated: this is faulting in the [ ]^{a,c} power supplies. [ ]^{a,c} The worst case fault voltage that could be generated is the peak voltage value at the power supply input capacitors, as evaluated in Section 5.1.2, above. [ ]^{a,c}

This is considerably less than the required dielectric rating of the Incore cabling and connectors.

There is no physical mechanism by which the power supply can generate more voltage than the input voltage multiplied by the ratio of peak to average for a sinusoidal input voltage (Vrms X SQRT(2)). This fault is the same limiting condition that will exist should the AC power input leads become shorted directly to the incore input cables.

It is assumed that this is the maximum credible voltage that can propagate to the Incore SPND MI cabling input. The [ ]^{a,c} output over voltage maximum in normal operation is not credited, since during a harsh environment, it is assumed that over voltage protection will not function.

The only other possible sources of fault voltages in the Incore signal processing electronics are the many point-of-load low voltage DC power supply ICs mounted on the individual circuit cards. These are all small, low voltage [ ]^{a,c} low wattage, solid state ICs, and their fault potential is restricted by design. Their failure in a mode capable of creating fault voltages of several hundred volts is not considered credible.

The minimum rated and tested dielectric strength of the incore cables is [ ]^{a,c}. Since the maximum input fault voltage is limited to much less than this voltage, the current leakage across any of the connector pins will be negligible, and the fault voltage can not generate sufficient energy to degrade the CET signals as required for IEEE-384 compliance. With the minimum permissible cable leakage resistance of [ ]^{a,c}, assumed to be located at a single point in the IITA, the maximum power that could be generated in the event of a [ ]^{a,c} power supply fault would be:

[ ]a,c. This is negligible, and will not cause any energy-related damage to the incore cabling or IITA.

5.3 Incore Cable Charge-up issue

This section addresses disconnection of the SPND detector signal cable while at power, and the resulting voltage build-up on the signal lead. The purpose is to demonstrate that the maximum voltage is always less than the [ ]a,c dielectric rating of the IITA seal table connector. Note that this is only an issue while at power, since detector current is negligible when shut down.

[

]a,c

The maximum detector current for which the SPS is designed is [ ]a,c. Actual current will be less [ ]a,c, and will be even lower for the progressively shorter SPNDs in each IITA. However, for conservatism it is assumed that all detectors are sourcing the design maximum current of [ ]a,c.

It is also conservatively assumed that the cable is disconnected at the seal table, so that any parallel resistance paths to Common in downstream MI cabling or the SPS are excluded. These would further reduce the voltage build up, since V = I X R, where V is the voltage build up on the emitter wire, I is the detector current (assumed to be [ ]a,c), and R is the maximum cable leakage resistance.

[

]a,c

Using the IST maximum measured leakage resistance of [ ]a,c, the maximum cable voltage build up assuming head area cable disconnection with a [ ]a,c input current would be:

[ ]a,c This is significantly below the [ ]a,c rating of the reactor head area connectors and is negligible.

However, the IR 400 readings defined above are taken at a temperature of [ ]a,c, which is significantly higher than the Watts Bar reactor operating temperature. In addition, cable leakage resistance decreases as temperature increases in a non linear fashion. For these reasons, cable leakage resistance at the minimum expected temperature for criticality has been derived. For Watts Bar the minimum temperature for criticality is 551 degrees F.

Reference 24 defines the maximum leakage resistance at the minimum temperature for criticality as being lower than [ ]^{a,c} which restricts the maximum possible cable charge-up to under [ ]^{a,c},, even assuming the maximum full power detector input current [ ]^{a,c}.

This limit is calculated as:

[ ]^{a,c}.

[This is a very conservative evaluation. In fact, the Vanadium SPND emitter wires within the IITA reactor core are all of different lengths, the longest being 144 inches, and the shortest being 28 inches (Reference 10, Section 4.2.3.6) . It can be expected that the longest in-vessel emitter lengths may also have the lowest cable leakage resistance (highest leakage current). These detectors would also have the highest detector current, due to their increased length. Since V = IR the higher current may be offset by the higher leakage. Conversely, the shortest detectors may have the highest leakage resistance, but this is offset by a lower current, so that the fault voltage may be limited by the lower current. None of this is credited in the preceding evaluation in which a maximum design input current is multiplied by the maximum detector leakage resistance.]^{a,c}

5.4 Defense In Depth

Disconnection of the IITA at power with Connector Failure

This section addresses the hypothetical case in which, for whatever reason, the barrier between CET and SPND is breached during normal operation. This could be due to excessively high IITA cable resistance when the IITA is disconnected, producing a voltage high enough to force a current through the connector pins to the CET.

[

]^{a,c}

[

]^{a,c}

If the fault occurs at this point, it is possible to calculate the resulting voltage on the Thermocouple leads. [

]a,c This represents approximately a worst case [ ]a,c error in temperature reading and will not cause any equipment damage. For most of the SPND detectors in the IITA, the current will be much lower, perhaps, on average, [ ]a,c. This will produce a proportionally smaller error [ ]a,c. This error could be detected both as an anomalous reading in the PAMS channel and would be immediately flagged to the SPS by the loss of normal SPND signal, so it is a detectable error. Loss of one CET while at power would not affect the PAMS function, which only requires two CETs per core quadrant per train to be operable. In addition, in a post accident environment, power (and SPND current), would be negligible, so the CET would be completely unaffected.

[

]a,c

Finally, if it is assumed that, for whatever reason, the grounded junction connection of the CET is disconnected, simultaneous with a shorting of the SPND current to the CET lead to the PAMS, then the [ ]a,c worst case fault current will be processed by the PAMS CET-reading analog input modules. These have an input impedance of approximately [ ]a,c. This impedance with a [ ]a,c input current would produce only [ ]a,c at the CET temperature measurement circuitry, which is within the acceptable range of inputs to the input module.

Therefore, this portion of the evaluation demonstrates that even if the CET/SPND barrier at the Seal Table connector were to be breached for any reason, while the normally available SPND signal path to the SPS was open circuited while at power, the resulting temperature error during any post-trip situation would be negligible, and that even at power and assuming a direct short to the CET temperature processing circuitry, there will be no equipment damage.

Checklist A: Proprietary Class Statement Checklist

Directions (this section is to be completed by authors): Authors are to determine the appropriate proprietary classification of their document. Start with the Westinghouse Proprietary Class 1 category and review for applicability, proceeding to Westinghouse Proprietary Class 2 – Non-Releasable and finally to Westinghouse Proprietary Class 2 – Releasable. The proprietary classification is established when the first criterion is satisfied.

Westinghouse Proprietary Class 1

☐ If the document contains highly sensitive information such as commercial documents, pricing information, legal privilege, strategic documents, including business strategic and financial plans and certain documents of the utmost strategic importance, it is Proprietary Class 1. Check the box to the left and see Appendix B of Procedure 1.0 in WCAP-7211, Revision 5, for guidance on the use of Form 36 and the distribution of this document. This document can be found at

http://worldwide.westinghouse.com/pdf/e3_wcap-7211.pdf.

Westinghouse Proprietary Class 2 – Non-Releasable

Review the questions below for applicability to this calculation, checking the box to the left of each question that is applicable. If one or more boxes are checked, the calculation is considered a Westinghouse Proprietary Class 2 – Non-Releasable document. See Appendix B of Procedure 1.0 in WCAP-7211, Revision 5, for guidance on the use of Form 36 and the distribution of this document.

☐ Does the document contain one or more of the following: detailed manufacturing information or technology, computer source codes, design manuals, priced procurement documents or design reviews?

☐ Does the document contain sufficient detail of explanation of computer codes to allow their recreation?

☐ Does the document contain special methodology or calculation techniques developed by or for Westinghouse using a knowledge base that is not available in the open literature?

☐ Does the document contain any cost information or commercially or legally sensitive data?

☐ Does the document contain negotiating strategy or commercial position justification?

☐ Does the document contain Westinghouse management business direction or commercial strategic directions?

☐ Does the document contain third party proprietary information?

☐ Does the document contain information that supports Westinghouse patented technologies, including specialized test data?

☐ Does the document contain patentable ideas for which patent protection may be desirable?

Westinghouse Proprietary Class 2 – Releasable

☒ If the calculation note is determined to be neither Westinghouse Proprietary Class 1 nor Westinghouse Proprietary Class 2 – Non-Releasable, it is considered Westinghouse Proprietary Class 2 – Releasable. Check the box to the left and refer to Appendix B of Procedure 1.0 in WCAP-7211, Revision 5, for guidance on use of Form 36 and the distribution of the document.

Checklist B: Calculation Note Methodology Checklist

(Completed By Author)

No.	Self Review Topic	Yes	No	N/A
1	Was the latest version of the calculation note template used?	X		
2	Is all information in the cover page header block provided appropriately?	X		
3	Are all the pages sequentially numbered, and are the calculation note number, revision number, and appropriate proprietary classification listed on each page? Are the page numbers in the Table of Contents provided and correct?	X		
4	Does this calculation note fulfill the customer requirements?	X		
5	Is the Summary of Results and Conclusions provided in Section 2.0 consistent with the purpose stated in Section 1.0 and calculations contained in Section 5.0?	X		
6	Is sufficient information provided for all References in Section 3.0 to facilitate their retrieval (e.g., from EDMS, SAP, CAPs, NRC's ADAMS system, open literature, etc.), or has a copy been provided in Appendix A?	X		
7	Are Section 4.2 and the open items box on the calculation note cover sheet consistent?	X		
8	Are all computer outputs documented in Table 6-2 and consistent with Table 6-1?			X
9	Are all computer codes used under Configuration Control and released for use?			X
10	Are the computer codes used applicable for modeling the physical and/or computational problem contained in this calculation note?			X
11	Have the latest and/or most appropriate versions of all computer codes been used?			X
12	Have all open computer code errors identified in Software Error Reports been addressed?			X
13	Are the units of measure clearly identified?	X		
14	Are approved design control practices (e.g., Level 3 procedures, guidebooks, etc.) followed without exception? If Level 3 procedures are used, please list those used, either in the body of the calculation note or here:	X		
15	Are all hand-annotated changes to the calculation note initialed and dated by author and verifier? Has a single line been drawn through any changes with the original information remaining legible?			X
16	Was a Pre-Job Brief held prior to beginning the analysis?	X		
17	Was a Self Check performed prior to submitting the analysis for Peer Checks and/or final verification?	X		
18	Was a Peer Check performed to review inputs documented in Section 4.6 prior to performing analyses?	X		
19	Was a Peer Check performed to review results before documenting them in Section 5.0?	X		
20	If required, have computer files been transferred to archive storage? Provide page number for list of files if not included in Table 6-2. Page			X
21	If applicable, have the results of any previous assessments on the analysis of record been incorporated in this calculation note?			X
22	If this calculation note requires a change to a safety analysis database (e.g., SAIK), has the change been submitted such that the database will be updated?			X
23	If this calculation note used FEA methods, were the guidelines discussed in WCAP-16904-P used?			X

If 'NO' to any of the above, provide page number of justification or provide additional explanation here or on subsequent pages.

Checklist C: Verification Method Checklist

(Completed By Verifier(s))

Verification Method (One or more must be completed by each verifier)		Initial If Performed
1	Independent review of document. (Briefly explain method of review below or attach.)	ACD
2	Verification performed by alternative calculations as indicated below.(1)	
	a. Comparison to a sufficient number of simplified calculations which give persuasive support to the original analysis.	
	b. Comparison to an analysis by an alternate verified method.	
	c. Comparison to a similar verified design or calculation.	
	d. Comparison to test results.	
	e. Comparison to measured and documented plant data for a comparable design.	
	f. Comparison to published data and correlations confirmed by experience in the industry.	
3	Completed Group-Specific Verification Checklist. (Optional, attach if used.)	
4	Other (Describe)	

(1) For independent verification accomplished by comparisons with results of one or more alternate calculations or processes, the comparison should be referenced, shown below, or attached to the checklist.

Verification: The verifier's signature (or Electronic Approval) on the cover sheet indicates that all comments or necessary corrections identified during the review of this document have been incorporated as required and that this document has been verified using the method(s) described above. For multiple verifiers, appropriate methods are indicated by initials. If necessary, technical comments and responses (if required) have been made on the "Additional Verifier's Comments" page.

Additional Details of Verifier's Review

Reviewed design input. Reviewed IEEE-384, and IEEE-603 to determine if approach was acceptable. Reviewed calculations for accuracy and checked with cable and probe designers to verify accurate information is presented herein. Reviewed the content of the analysis and its conclusions and agreed with results.

Checklist D: 3-Pass Verification Methodology Checklist

(Completed by Verifier(s))

No.	3-Pass Verification Review Topic	Yes	No	N/A
	First Pass			
1	Were the general theme, scope of document, and scope of review clear?	X		
	Second Pass			
2	Do the references appear to be documented correctly? Is there enough information present to ensure the referenced document is retrievable?	X		
3	Do the acceptance criteria seem appropriate?	X		
4	Does the technical content of the calculation note make sense from a qualitative standpoint and are appropriate methods used?	X		
	Third Pass			
5	Do the results and conclusions meet the acceptance criteria? Do the results and conclusions make sense and support the purpose of the calculation note?	X		
6	Has the technical content of the document been verified in adequate detail? Examples of technical content include inputs, models, techniques, output, hand calculations, results, tables, plots, units of measure, etc.	X		
7	Does the calculation note provide sufficient detail in a concise manner? Note that sufficient detail is enough information such that a qualified person could understand the analysis and replicate the results without consultation with the author.	X		
8	Is the calculation note acceptable with respect to spelling, punctuation, and grammar?	X		
9	Are the references accurate? Do the references to other documents point to the latest revision? If not, are the reasons documented? Are the references retrievable?	X		
10	Are computer code names spelled correctly? If applicable, are numerals included in the official code name as appropriate?			X
11	Has the calculation note been read word-for-word, cover-to-cover?	X		

If 'NO' to any of the above, provide page number of justification or provide additional explanation here or on subsequent pages.

Additional Verifier's Comments

The signatures of the Author(s) and Verifier(s) on the cover page (or Electronic Approval) indicate acceptance of the comments and responses.

No.	Verifier's Comments	Author's Response (If Required)
	N/A	

Appendix A: Supporting Documentation

A.1 [ ][a,c] Power Supply Fault Voltage Assessment Letter (Reference 6)

(The following page contains this letter.)

a,c

[ ]

A.2 [ ]a,c

[ ]a,c

A.3 [ ]a,c

[ ]a,c

A.4 Vendor Letter on [ ][a,c] (Reference 13)

(The following page contains this letter)

a,c

Attachment 8

Westinghouse Electric Company document CAW-11-3316, "Application For Withholding Proprietary Information From Public Disclosure WNA-CN-00157-WBT-P, "Watts Bar 2 Incore Instrument System (IIS) Signal Processing System (SPS) Isolation Requirements," Revision 1," (proprietary)," dated November 17, 2011
(Letter Item 2, SSER 24 Appendix HH Item Number 121)

Westinghouse

Westinghouse Electric Company
Nuclear Services
1000 Westinghouse Drive
Cranberry Township, Pennsylvania 16066
USA

U.S. Nuclear Regulatory Commission
Document Control Desk
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Rockville, MD 20852

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e-mail: greshaja@westinghouse.com
Proj letter: WBT-D-3635

CAW-11-3316

November 17, 2011

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: WNA-CN-00157-WBT-P, Revision 1, "Watts Bar 2 Incore Instrument System (IIS) Signal Processing System (SPS) Isolation Requirements" (Proprietary)

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-11-3316 signed by the owner of the proprietary information, Westinghouse Electric Company LLC. The affidavit, which accompanies this letter, sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR Section 2.390 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying affidavit by Tennessee Valley Authority.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse affidavit should reference this letter, CAW-11-3316, and should be addressed to J. A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company LLC, Suite 428, 1000 Westinghouse Drive, Cranberry Township, Pennsylvania 16066.

Very truly yours,

J. A. Gresham, Manager
Regulatory Compliance

Enclosures

CAW-11-3316

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF BUTLER:

Before me, the undersigned authority, personally appeared J. A. Gresham, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

J. A. Gresham, Manager
Regulatory Compliance

Sworn to and subscribed before me
this 17th day of November 2011

Cynthia Olesky
Notary Public

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Cynthia Olesky, Notary Public
Manor Boro, Westmoreland County
My Commission Expires July 16, 2014
Member, Pennsylvania Association of Notaries

(1) I am Manager, Regulatory Compliance, in Nuclear Services, Westinghouse Electric Company LLC (Westinghouse), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rule making proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse Application for Withholding Proprietary Information from Public Disclosure accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of

Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information that is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390; it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in WNA-CN-00157-WBT-P, Revision 1, "Watts Bar 2 Incore Instrument System (IIS) Signal Processing System (SPS) Isolation Requirements" (Proprietary) for submittal to the Commission, being transmitted by Tennessee Valley Authority letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse is that associated with the Incore Instrument System (IIS) Signal Processing System (SPS) and may be used only for that purpose.

This information is part of that which will enable Westinghouse to:

(a) Assist the customer in providing technical licensing information to the NRC that is required for approval of the Watts Bar Nuclear Unit 2 IIS and SPS System.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of similar information to its customers for the purpose of licensing in-core instrumentation systems.

(b) Its use by a competitor would improve his competitive position in the development and licensing of a similar product.

(c) The information requested to be withheld reveals the distinguishing aspects of a design developed by Westinghouse.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar calculations, analysis and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

COPYRIGHT NOTICE

The reports transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies of the information contained in these reports which are necessary for its internal use in connection with generic and plant-specific reviews and approvals as well as the issuance, denial, amendment, transfer, renewal, modification, suspension, revocation, or violation of a license, permit, order, or regulation subject to the requirements of 10 CFR 2.390 regarding restrictions on public disclosure to the extent such information has been identified as proprietary by Westinghouse, copyright protection notwithstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond those necessary for its internal use which are necessary in order to have one copy available for public viewing in the appropriate docket files in the public document room in Washington, DC and in local public document rooms as may be required by NRC regulations if the number of copies submitted is insufficient for this purpose. Copies made by the NRC must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.

Tennessee Valley Authority
Letter for Transmittal to the NRC

The following paragraphs should be included in your letter to the NRC:

Enclosed are:

1. __ copies of WNA-CN-00157-WBT-P, Revision 1, "Watts Bar 2 Incore Instrument System (IIS) Signal Processing System (SPS) Isolation Requirements" (Proprietary)

2. __ copies of WNA-CN-00157-WBT-NP, Revision 1, "Watts Bar 2 Incore Instrument System (IIS) Signal Processing System (SPS) Isolation Requirements" (Non-Proprietary)

Also enclosed is the Westinghouse Application for Withholding Proprietary Information from Public Disclosure CAW-11-3316, accompanying Affidavit, Proprietary Information Notice, and Copyright Notice.

As Item 1 contains information proprietary to Westinghouse Electric Company LLC, it is supported by an affidavit signed by Westinghouse, the owner of the information. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b) (4) of Section 2.390 of the Commission's regulations.

Accordingly, it is respectfully requested that the information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to the copyright or proprietary aspects of the items listed above or the supporting Westinghouse affidavit should reference CAW-11-3316 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company LLC, Suite 428, 1000 Westinghouse Drive, Cranberry Township, Pennsylvania 16066.

Attachment 9

Westinghouse Electric Company non-proprietary document WBT-D-3566 NP-Enclosure, "Summary of IITA Equipment Qualification Watts Bar 2," dated October 2011 (Letter Item 2, SSER 24 Appendix HH Item Number 126)

Summary of IITA Equipment Qualification

Watts Bar 2

October 2011

Westinghouse Electric Company LLC
1000 Westinghouse Drive
Cranberry Township, PA 16066

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Purpose

This document provides an overview of the analysis of the environmental and seismic/structural qualification methodology and results contained in the report CE-NPSD-240-P, "Summary Report: Class 1E Qualification of the Incore Instrument (Core Exit Thermocouple Portion) and Mineral Insulated Cable Assembly", published in June of 1983. CE-NSPD-240-P describes the environmental testing methodology and testing results obtained for the standard Combustion Engineering-style In-Core Instrument (ICI) assembly design used to periodically measure the core power distribution and provide core exit temperature measurements during and following Loss of Coolant Accident (LOCA) / Main Steam Line Break (MSLB) conditions.

Qualification Program Summary

The Class 1E Qualification Program applies to only-the ex-vessel portion of the ICI assembly. The ex-vessel portion of the ICI assembly is defined as the part of the ICI between the seal plug up to and including the electrical connector assembly. Only the core exit thermocouple is considered to be a class 1E component. The self-powered neutron detectors and the background detectors are not safety related and thus are not considered to be class IE components, and thereby are not part of this qualification program. This summary focuses on the seismic qualification testing done on the core exit thermocouple portion of the ICI assembly.

The ICI and associated Mineral Insulated (MI) cables were qualified in accordance with IEEE 323-1974, IEEE 344-1975, and NUREG 0588, Rev. 1. The testing was performed at C-E Laboratories in Windsor Connecticut. The ICI and MI cable were subjected to a sequence of accelerated irradiation, thermal and mechanical aging, seismic tests, accident condition irradiation, and thirty days exposure in a composite LOCA/MSLB steam and chemical spray environment. The Qualification Test Program was conducted by the Engineering and Development Department of Combustion Engineering, Windsor, Connecticut. Radiation aging of the ICI/MI cable system was conducted by Isometix, Inc., Parsippany, New Jersey.

The tests performed on the ICI and MI cable specimens were visual inspection, electrical continuity, insulation resistance, loop resistance and monitoring of the thermocouple signal prior to, during, and after the completion of the test sequence. The results from this program prove the ability of the ICI's and MI cables to meet the functional requirements for transmitting thermocouple signals in an accident environment, after aging to conditions equivalent to a 6-year service life for the ICI and a 40-year service life for the MI cable.

Qualification Acceptance Criteria

The Qualification Acceptance Criteria, as defined for the ICI and MI cable assemblies (Reference 1), states that:

1. The seismic and LOCA/MSLB test events shall not introduce a signal error of more than ±0.5 millivolts (±22 °F for a type K thermocouple) within the ICI/MI cable system; and
2. The test events shall not result in a long term or permanent signal decalibration greater than ±5 °F.

Qualification Testing Sequence

The ICI/MI cable system was tested in the following sequence:

1. Lifetime irradiation in air, 55.09 megarads from a cobalt-60 gamma source (0.52 megarads/hr for 105.9 hours).
2. Accelerated thermal aging, based on Arrhenius methodology equivalent to 40 years service for the MI cable and 6 years service for the ICI when subjected to a normal operating temperature of 140°F and a 24 hr/yr excursion to 250°F. Equivalent time/temperature aging conditions were 134°C for 114 hours for the MI cable and 121°C for 436 hours for the mated MI cable and ICI assembly.
3. Mechanical aging of electrical connectors was simulated by mating and demating the connectors 50 times.
4. Seismic testing on one orthogonal axis (due to the symmetrical configuration of the test sample), five OBE and one SSE events, to the required response spectra as shown in Figure 1. The ICI configuration tested is provided on Figure 2.
5. Accident irradiation in air, 152.52 megarads, from a cobalt-60 gamma source (0.73 megarads/hr for 208.6 hours). The ICI assembly connector backshell was shielded during accident irradiation, reducing the accident irradiation dose by 27.83%. This yielded the following total integrated doses:
    a. A total integrated dose of 207.61 megarads for the MI cable assembly (40 year lifetime dose plus the accident dose).
    b. A total integrated dose of 165.16 megarads for the ICI assembly (6~year lifetime dose plus the accident dose).
6. Steam and chemical spray exposure (30 days composite LOCA/MSLB profile, NaOH and boric acid chemical spray).

Qualification Hardware

The ICI and MI cable used in the qualification program were fabricated with an inventory of components generic to all CET systems. Specifically, the test hardware consisted of the following:

1. In-Core Instrument Assembly - This instrument was fabricated by Reuter-Stokes, Canada, Ltd., Cambridge, Ontario, Canada. The ICI assembly consists of one type K thermocouple, six copper wires (used to simulate the self powered and background detectors) and an axial strength member. These are enclosed in a flexible strip wound stainless steel sheath which is attached to a production seal plug to multi-pin electrical connector assembly.
2. MI Cable Assembly - The assembly was fabricated by Electronic Resources, Inc., Burbank, California. The MI Cable Assembly consists of a nine wire (7 copper, 1 chromel and 1 alumel) mineral-insulated cable terminated with a multi-pin electrical connector.
3. Multi-pin Electrical Connectors – The connectors mentioned above are "Litton CIR-Series Connectors" and are fabricated by Veam Division of Litton Systems Incorporated, Watertown, Connecticut.

Seismic Test Set Up

The ICI and MI cable assemblies were mounted and arranged on the seismic shaker table. A heater mounted to the test fixture on the seismic table was used for heating the thermocouples and was adjusted to maintain a steady state temperature of approximately 400°F throughout the test. The ICI assembly thermocouple was monitored during the seismic test and compared to a reference T/C to verify that the structural and functional integrity of the ICI/MI cable system was not impaired during a seismic event.

Seismic Test Response Spectra

The specified response spectra curves are shown in Figure 1. These curves are based on a composite of data obtained for several operating plants and plants that were under construction. See Reference 5.

Seismic Response Survey

A sine-survey test of the ICI/MI cable system was performed covering a frequency range of 1 to 40 hertz to determine if resonant frequencies existed. The test was performed at a vibration intensity of 0.1 and 0.2 g's in the vertical and one horizontal axis.

Seismic Test

The ICI/MI cable system was subjected to biaxial (vertical and horizontal) random multi-frequency excitations with a duration of 32 seconds. See Reference 4. Test table motions were spectrum analyzed at 1% of critical damping to yield test response spectra. The ICI/MI cable system was subjected to five OBE events followed by one SSE event. Testing was done on one axis due to the symmetrical configuration of the test sample. Output signals from the control accelerometers were displayed with respect to frequency. The test response spectrum is considered to be a conservative representation of the specified response spectrum.

Seismic Test Results

The specified agreement (±22 °F) of the ICI assembly thermocouple and the reference thermocouple could not be achieved. This, however, did not compromise the validity of the seismic acceptance criteria. Difficulties were encountered because of the following reasons:
The test fixture configuration placed the heater and the reference thermocouple at the tip of the ICI assembly. The CET is twelve (12) inches above the tip of the ICI assembly. The heater was set to maintain a temperature of 400°F. The reference thermocouple indicated a temperature range of 401°F to 412°F which substantiates its position relative to the heater. The CET, by virtue of being positioned twelve (12) inches above the heater and reference thermocouple indicated a temperature range of 339°F to 344°F. While this large temperature difference is outside the acceptance criteria, it is attributed to the test fixture configuration explained above as well as air turbulence (inside the test fixture) and movement of the test specimen and fixture parts relative to the heater and reference thermocouple during the test events.

After completion of the seismic test, a special temperature correlation test was performed. The ICI assembly had a heater and a reference thermocouple attached to the flexible portion of ICI in the area of the CET. The CET and the reference thermocouple output agreed within 1°F of each other (The CET read 396 °F while the reference thermocouple read 397 °F). The seismic test demonstrated that the ICI/MI cable system can maintain its physical and electrical integrity when subjected to the loadings defined by the Required Response Spectrum shown in Figure 1. The test specimen's output showed no signal discontinuities in any phase of the seismic testing. Oscillations of the T/C signals were noted during the simulated seismic event, however, they were well within the specified acceptance criteria of ±0.5 millivolts.

Conclusions

The qualification test program on the Mineral Insulated Thermocouple Cable Assembly was conducted in accordance with the methodology and guidelines outlined in IEEE Standard 323-1974, IEEE Standard 344-1975 and NUREG 0588 Rev. 01, for the normal service and accident conditions specified for this system. The following conclusions are drawn from the results of this test.

1. The In-Core Instrument/Mineral Insulated Cables System meets the acceptance criteria of a signal transmission accuracy of ±5 °F for steady state normal operating conditions and ±22 °F for transient accident conditions.
2. Irradiation of the multi-pin electrical connector to a total integrated dose of 200 megarads severely degraded the connector elastomer seals and socket inserts. The silicon elastomers used in the subject multi-pin connector, when irradiated to the aforementioned doses, did not maintain an effective moisture seal.
3. The ICI/MI cable system did not maintain the design insulation resistance test values. However, it was demonstrated that the reduced insulation resistance did not significantly affect the cable signal transmission accuracy, unless the system is perturbed by a large external voltage source. Removal of the voltage source returns the system to its former state.
4. The In-Core Instrument/Mineral Insulated Cable System is considered qualified for its intended application. The ICI/MI cable system tested and the qualification program test parameters are representative of the operating plant hardware and the plant service and accident conditions.

References

1. 00000-CCE-IR80-02, "Requirements for a Core Exit Class 1E Thermocouple Cable System".
2. IEEE Standard 323-1974, "General Guide for Qualifying Class IE Equipment for Nuclear Power Generating Stations".
3. IEEE Standard 344-1975, "General Guide for Seismic Qualification of Class IE Equipment for Nuclear Power Generating Stations".
4. TR-ESE-507, Rev. 01, "Seismic Qualification of the Northeast Utilities Millstone II CET and MI Cable Assemblies".
5. CENPS-182, "Seismic Qualification of C-E Instrumentation Equipment".
6. CE-NPSD-240-P, June 1983, "Summary Report: Class 1E Qualification of the Incore Instrument (Core Exit Thermocouple Portion) and Mineral Insulated Cable Assembly".

FIGURE 1

Seismic Horizontal and Vertical
Required Response Spectrum (RRS)
1% of Critical Damping

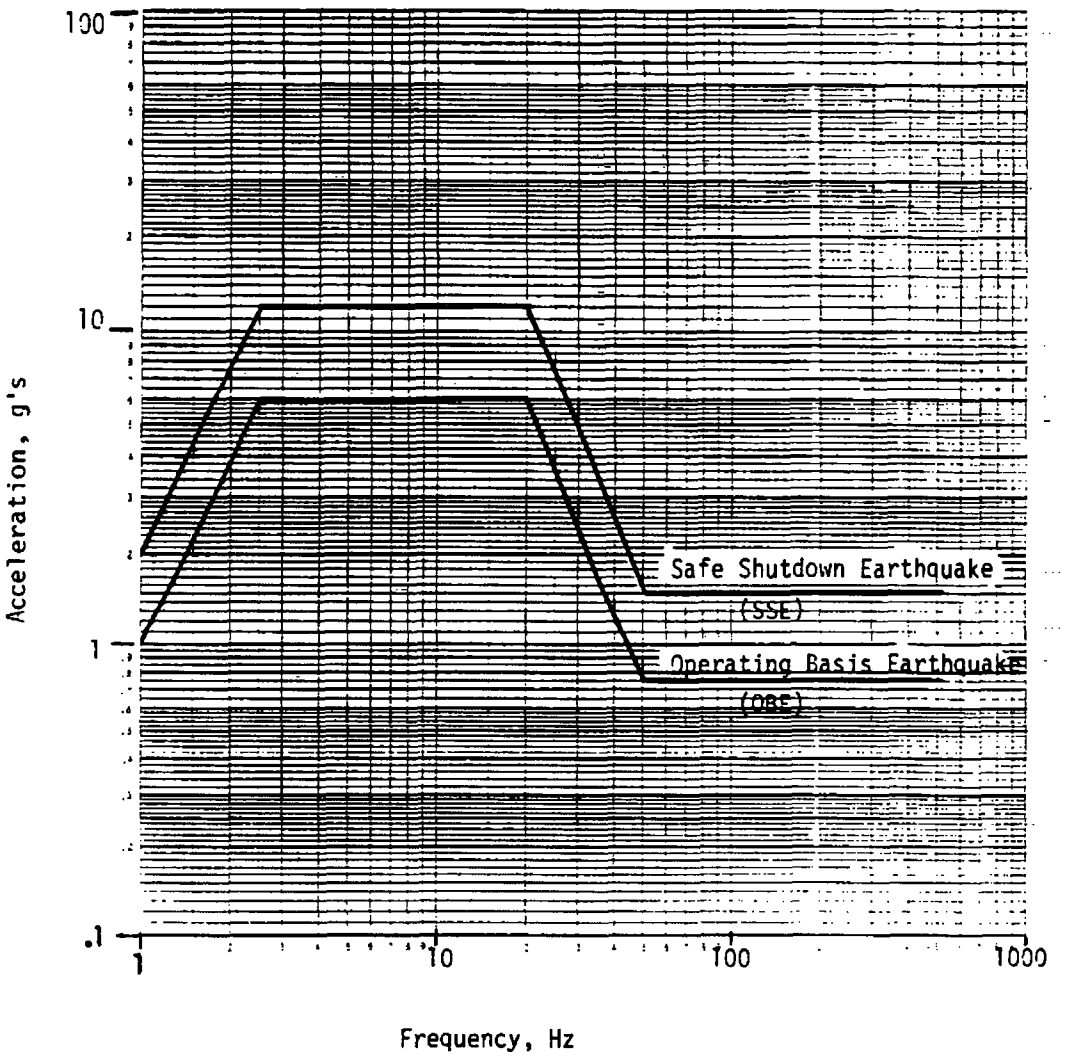
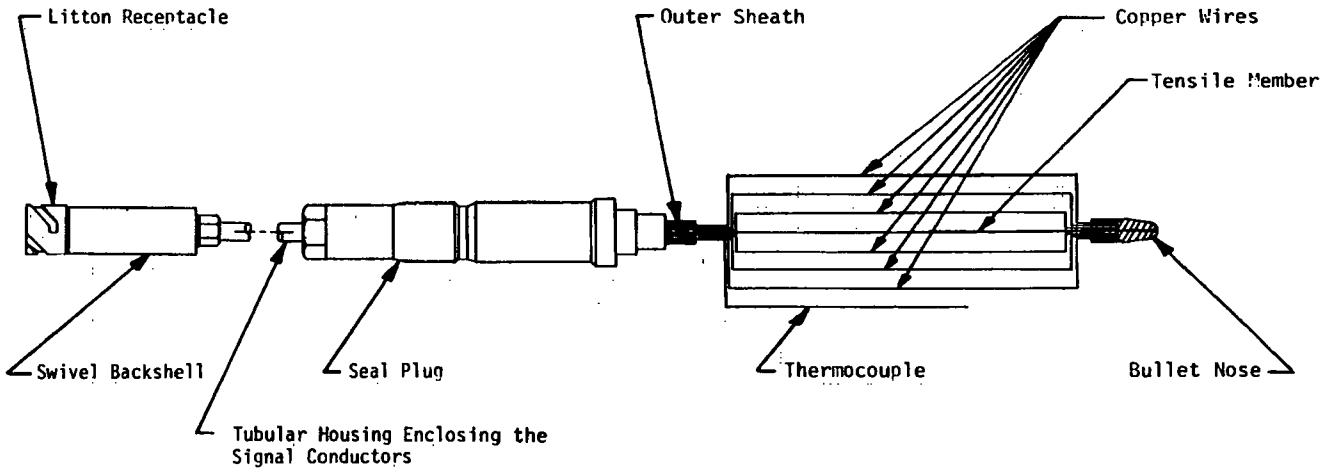


FIGURE 2

ICI Configuration