Enclosure 1

FINAL REPORT

ON

METHODOLOGY AND RESOLUTION

OF

INCREASED ENVIRONMENTAL TEMPERATURES IN THE MAIN STEAM VALVE ROOMS

(TAC 63632)

WATTS BAR NUCLEAR PLANT
UNITS 1 AND 2
TENNESSEE VALLEY AUTHORITY

NOVEMBER 25, 1992

Watts Bar Nuclear Plant
Increased Environmental Temperature in the Main Steam Valve Rooms

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Watts Bar Nuclear Plant
Increased Environmental Temperature in the Main Steam Valve Rooms

I. BACKGROUND

In accordance with 10 CFR 50.49, the Watts Bar Nuclear (WBN) Units 1 and 2 are being designed to ensure that the appropriate equipment will remain functional during and following a design basis event, as required for mitigation of the event. The worst-case temperature environment for the Main Steam Valve Vault (MSVV) rooms is due to a postulated Main Steamline Break (MSLB) in the room. Accordingly, the equipment located in the North and South MSVV rooms at WBN was initially qualified for the expected worst-case environmental conditions based on the mass and energy release data provided by Westinghouse for the MSLB.

A deficiency in the original mass and energy data provided by Westinghouse was identified and reported to NRC in 1984 (Reference 1). This deficiency existed because the Westinghouse analysis did not consider the effects of superheated steam following steam generator tube uncovery which would occur during this event. The inclusion of superheated steam would result in a higher peak MSVV room temperature than originally predicted. The higher temperature could affect the environmental qualification of Class 1E electrical equipment and valve vault structural steel.

Several interim reports were submitted by TVA regarding this deficiency with a "final" report for Unit 1 being submitted to J. Nelson Grace, NRC Region II, by letter dated January 13, 1986 (Reference 2). This January 13, 1986 report provided the conclusions of a safety evaluation performed by TVA which demonstrated the acceptability of a revised environmental profile which accounted for the superheated steam. This conclusion was premised on some minor plant modifications and some different assumptions regarding the functional requirements of affected equipment. This safety analysis also concluded that the structural steel and the valve vault concrete would retain their structural integrity. Additional information on the basis of this position and supporting calculations were provided to NRC's Director of Nuclear Reactor Regulation by TVA letter dated April 10, 1986 (Reference 3). Since the resolution provided in the January 13, 1986 and April 10, 1986 letters deviated from the existing design basis regarding the functional requirements of the affected equipment, NRC was requested to review and approve the resolution.

Concurrent with WBN's effort to resolve this issue, TVA's Sequoyah Nuclear (SQN) Plant was pursuing an alternate solution that did not alter the plant's design basis. In May 1988, NRC issued a Safety Evaluation Report (SER), Reference 4, which documented the Staff's approval of SQN's methodology. Based on NRC's acceptance of SQN's methodology and the additional burden that would be imposed on both WBN and NRC resources to review and approve the original WBN solution, TVA opted to withdraw the original WBN methodology and apply the staff-approved SQN methodology to WBN. This change of position was documented by TVA's letter to NRC headquarters dated September 26, 1989 (Reference 5) and to Region II by letter dated September 28, 1989 (Reference 6).

II. METHODOLOGY

Sequoyah's Methodology

The SQN methodology involved the complete reanalysis of the effects of an MSLB with superheat, following a postulated break in the valve vault rooms. SQN's reanalysis was performed by Westinghouse using the computer code COMPACT which had the capability to model the buoyancy effects of heated air inside the valve vaults which reduced both the magnitude and duration of temperatures associated with the MSLB superheat. TVA independently performed a confirmatory analysis using the RELAP5/MOD2 computer code and NRC contracted Battelle Pacific Northwest Laboratory (PNL) to perform an additional confirmatory analysis. PNL confirmatory analysis used the COBRA computer code. The results of each independent analysis showed good agreement with the shape and timing of the temperature profiles as documented in the NRC's SER on the SQN methodology (Reference 4).

Thermal lag analyses were then performed by SQN to show that the internal temperatures of critical components in required electrical equipment would not exceed their qualification temperature. These analyses were performed using two-dimensional HEATING5 models. A detailed technical review of these evaluations were performed by Franklin Research and Consultants under contract to NRC. NRC's technical reviewers concluded that there was reasonable assurance that the heat transfer modeling accurately reflected component temperatures during a MSLB. NRC staff further concluded that this methodology would be generically acceptable (with proper application) for demonstrating the qualification of other equipment in the valve vaults (see Reference 4).

This methodology utilizes condensate heat transfer coefficients which were assumed to be four times the maximum Uchida heat transfer coefficient. These condensate heat transfer coefficients were used initially when the valve vault temperature was below or equal to the saturated steam temperature. The forced convective heat transfer correlation was then used when the superheated temperature occurred in the MSVV. This method maximizes the total heat transfer to the devices during the scenario.

Given NRC's documented acceptance of SQN's methodology and commonality between the designs of SQN and WBN, WBN is utilizing the same methodology to resolve this issue. WBN specific analyses have been performed to assess the environmental conditions in the MSVV rooms during a MSLB using the SQN methodology (References 7 and 8). These analyses are discussed below. Additionally and similarly to SQN, component specific thermal lag analyses (References 9 through 17) have been performed to demonstrate qualification of the critical WBN components. These thermal lag analyses for specific components are discussed in Section III of this report.

Watts Bar's Application

Reference 7 is the WBN specific analysis which calculated the temperature profiles in the North and South MSVV rooms for a spectrum of MSLBs based on the WBN plant-specific MSLB mass and energy blowdowns generated by Westinghouse (Reference 18) for the original design (i.e., pre-Eagle-21). By Reference 19, TVA notified NRC of two design changes, the installation of new steamline break protection features in conjunction with the Eagle-21 process protection system and a reduction in the minimum required auxiliary feed water (AFW) flow rate, that would impact the mass and energy blowdowns. Reference 8 is the WBN specific analysis which calculates the temperature profiles in the North and South MSVV rooms for a spectrum of MSLBs based on the WBN plant-specific MSLB mass and energy blowdowns generated by Westinghouse (Reference 20) for the current design (i.e., Eagle-21 and reduced AFW flow). The geometry information utilized to model the MSVV structures was based on TVA calculation WBN-OSG4-147 (Reference 21). The computer code RELAP5/MOD3 was used to calculate the temperature profiles.

a) RELAP5 Model

The modeling of the geometric characteristics of the North and South MSVV rooms was performed in a similar fashion to that performed by TVA for SQN. The configuration and structural design of these rooms at WBN is very similar to SQN. The RELAP5 model consists of components representing the volumes and junctions (i.e. flow paths between volumes) which model the physical characteristics of the areas that are pertinent to the propagation (including natural circulation effects) and dissipation of the released mass and energy. These models provide the volumes, flow paths, heat sinks, vent areas, and restrictions of flow in each vault necessary to determine the temperature response of each vault.

The initial environmental conditions for the WBN analysis are identical to the assumptions utilized for the SQN analysis. Ambient outside temperature was assumed to be 95°F and the interior vault temperature was assumed to be 140°F.

Given the physical similarities of these structures between SQN and WBN, the similar modeling techniques and similar mass/energy release data, the WBN RELAP5 results are similar to the SQN results, as expected.

b) MSLB Scenario Cases

A spectrum of MSLB scenarios were setup and evaluated to determine the worst-case scenario(s) for environmental conditions. Twelve cases were identified which provided coverage for postulated MSLB scenarios of various break sizes and reactor power levels. The twelve cases analyzed in Reference 7 are:

Case Number	Reactor Power Level	Break Area
1	100%	1.40 ft^2
2	70%	1.40 ft^2
3	30%	1.40 ft^2
4	100%	0.80 ft^2
5	70%	0.80 ft^2
6	30%	0.80 ft^2
7	100%	0.60 ft^2
8	70%	0.60 ft^2
9	30%	0.60 ft^2
10	100%	0.40 ft^2
11	70%	0.40 ft^2
12	30%	0.40 ft^2

These same 12 scenarios were analyzed in Reference 8 with one exception. The break size utilized in cases 5 and 6 was 0.75 ft^2. This difference was necessitated due to Westinghouse's selection of the revised mass and energy data that was provided in Reference 20 (see Item c below).

Also note that a design difference exists between WBN and SQN in that WBN does not have a main steam check valve. As a consequence there is no need to consider upstream or downstream breaks, as was done at SQN. This design difference is insignificant with regards to identifying the enveloping environmental profile that must be determined for equipment qualification purposes.

c) Mass and Energy Data

The mass and energy data for both WBN and SQN were taken from the appropriate Westinghouse WCAP. These WCAPs analyze a spectrum of break sizes at various power levels. A parametric analysis was required to ensure that the worst case is identified. For example, larger break sizes generally result in earlier tube bundle uncovery, earlier initiation of superheat and earlier initiation of the reactor protection systems. Smaller break sizes result in later tube bundle uncovery; however, the initiation of the reactor protection systems is also delayed. Therefore, large break sizes generally result in earlier and higher peak temperatures but the duration of the transient is shorter. The data for both plants is similar and both include the additional heat due to the superheating phenomena. As stated above, the WBN-specific MSLB mass and energy blowdowns for the original design were provided in Reference 18 by Westinghouse. Two design changes are being implemented at WBN which impact this data. These design changes are the installation of the Eagle-21 process protection system and a reduction in the minimum required auxiliary feed water flow rate. The net impact of these two design changes is a reduction in the mass and energy releases for these MSLB scenarios. The revised mass/energy release data for the current design is provided in Reference 20. Given that the earlier mass/energy data (Reference 18) envelopes the mass/energy data for the current design (Reference 20), the use of either data is acceptable for the thermal lag analyses discussed in Section III. This conclusion is documented in Reference 8 and is easily verified by observation of the resulting worst case temperature profiles. A comparison of the worst case temperature profiles is provided as Figure 1.

III. WATTS BAR COMPONENTS

The qualification of numerous devices in the WBN MSVV rooms was challenged by the increased energy release associated with the superheated steam phenomena. Like SQN, in some cases the bulk maximum air temperature in the MSVV rooms at WBN exceeded the original qualification temperature. Similar to the methodology used at SQN and as provided for in NUREG-0588 (Reference 22), equipment-specific thermal lag calculations or tests have been performed to determine the maximum temperatures that could potentially be attained at the heat sensitive components within these devices. These analyses and tests demonstrate that safety-related equipment located in the MSVV rooms at WBN can perform their design basis safety functions during the worst-case MSLB.

The types of devices analyzed and the conclusions of the analyses are provided below. Based on these evaluation results and the qualification test reports for these devices, the environmental qualification of this equipment for the worst-case MSLB is assured.

Reference 9 documents a thermal lag analysis performed on a Barton model 763-LOT-7 transmitter. A two-dimensional HEATING6 model of the Barton model 763-LOT-7 transmitter, which is encased in insulation at WBN, was developed. The environmental conditions for this analysis were taken from Reference 7. The calculated peak housing temperature is well below the maximum temperature seen in the vendor's environmental qualification test.

Reference 10 documents a thermal lag analysis performed on a NAMCO limit switch. The NAMCO limit switch models used in the MSVV rooms are models EA-740 and

EA-180. A two-dimensional HEATING6 model was developed for the EA-740 version. The modeling of the EA-740 version provides results that envelope the EA-180 version since the thermal resistance path from the surface to its internal critical components is less. The results indicate that the peak temperatures seen at the critical components are well within the qualification temperature.

Reference 11 documents a thermal lag analysis performed on a CONAX connector. Similar to the NAMCO limit switch, several CONAX models are used and the most limiting version was modeled. This analysis provided assurance that the peak temperatures seen at the critical components are well within the qualification temperature.

Reference 12 documents a thermal lag analysis performed on a Limitorque SMB-00. Of the Limitorque models in the MSVVs, this model is the smallest and the thermal lag analysis will envelope the larger models. The calculated temperature for the critical components, such as the geared limit switch, terminal block, torque switch and cable insulation, were all bounded by the qualification temperatures.

Reference 13 documents a thermal lag analysis performed on an ASCO solenoid. Two cases were developed to evaluate the thermal responses of an energized and an unenergized condition. For these solenoids, the coil is the critical component. The peak temperatures seen at the coil for both cases were within the qualification test temperatures.

Similarly, References 14 and 15 provide thermal lag analyses for junction boxes and Gould Allied solenoid valves, respectively, that are required to function following a MSLB in the MSVV rooms. The results of each of these calculations provide assurance of their capability to perform as designed under these conditions.

Reference 16 contains the environmental qualification test profile for Target Rock solenoid valves. This test profile envelopes the calculated profile in Reference 8 for a MSLB in the MSVV rooms except for the short-duration peak after a MSLB event that initiates main steamline isolation. This short-duration peak does not affect the qualification of the valves.

Reference 17 documents a number of tests that were performed to determine the internal temperature of various conduit systems during a MSLB scenario with superheat. These tests were performed to verify the qualification of various types of safety-related electrical cables installed in the conduit systems. The tests achieved acceptable results provided that flexible conduits are wrapped with 2-inch Kaowool insulation. The flexible conduit in the MSVV rooms will conform with this requirement.

To ensure the qualification of the motor operators on the Main Feedwater Isolation Valves located in these rooms, Wyle Laboratories, under contract to TVA, determined the internal temperatures at critical components in the motors using an environmental test profile that enveloped the calculated worst-case profiles for this event at WBN. The resulting internal temperatures were determined by a thermocouple which was installed in the air gap between the stator and rotor and by measuring motor winding resistance. The recorded winding resistance was used to calculate the winding temperature directly. This test demonstrated that the thermal transient for the worst-case environmental profile does not result in critical component temperatures that exceed the thermal rating of the insulation system (e.g., 250°F).

Finally, the structural steel and concrete calculations were reviewed to ensure that there would be no adverse effect on structural integrity. Reference 23 documents the temperature transient analysis that was performed for the structural steel. Reference 24 documents the thermal analysis that was performed for the structural concrete. The maximum temperature for the steel was approximately 322°F. The maximum temperature for the concrete was approximately 212°F. The maximum temperatures and temperature gradients that are used in the existing structural calculations (References 25 and 26) are greater than these revised maximum temperatures and temperature gradients.

IV. SUMMARY

NRC has issued a favorable SER on the methodology utilized at SQN for addressing the impact of superheated steam that could result following a design basis MSLB. Using this approved methodology, SQN has provided assurance that the equipment required following a design basis MSLB will function as designed. This assurance was provided by performing internal heat transfer (a.k.a., thermal lag) analyses to demonstrate that the peak temperatures seen at critical components within a device was within the bounds of a device's environmental qualification test. The SER further concluded that this methodology would be acceptable for demonstrating the qualification of other equipment not specifically addressed in the SER.

Given NRC's acceptance of this methodology and the similarity of the design at WBN and SQN, WBN is utilizing this same methodology to demonstrate the qualification of the safety-related equipment located in the WBN MSVV rooms. This report demonstrates that the approach to resolve this issue at WBN is identical to that taken at SQN. Both WBN and SQN have utilized the mass/energy blowdown data provided by Westinghouse. Both WBN and SQN have used industry-accepted computer codes which effectively model the buoyancy effect of heated air to calculate the worst-case temperature profiles for these areas following a MSLB. And finally, both WBN and SQN have used the HEATING computer codes for performing thermal lag analyses for temperature sensitive components.

WBN is in the now in the process of updating the appropriate EQ binders for Unit 1 to reflect the results of these analyses and test. TVA plans to extend this methodology to address the Unit 2 devices and to update the Unit 2 EQ binders prior to Unit 2 fuel load.

V. CONCLUSION

This report summarizes the actions taken by WBN to demonstrate compliance with 10CFR50.49 for the equipment located in the MSVV rooms. The actions described in this report completely address and resolve the deficiency and corrective actions initially identified due to the omission of superheated steam in the vendor's MSLB mass/energy release calculations. WBN has directly applied the methodology utilized at SQN and accepted by NRC. This report should provide an adequate basis for NRC to issue a favorable SER for WBN's resolution of this deficiency.

REFERENCES

1) TVA letter to NRC - Region II, "Watts Bar Nuclear Plant Units 1 and 2 - Increased Environmental Temperatures in the Main Steam Valve Rooms - WBRD-50-390/84-29, WBRD-50-391/84-26 - First Interim Report," dated June 21, 1984 (TVA RIMS No. A27840621003).

2) TVA letter to NRC - Region II, "Watts Bar Nuclear Plant (WBN) Units 1 and 2 - Increased Environmental Temperatures in the Main Steam Valve Rooms - WBRD-50-390/84-29, WBRD-50-391/84-26 - Final Report for Unit 1 and Seventh Interim Report for Unit 2," dated January 13, 1986 (TVA RIMS No. L44860113806).

3) TVA letter to Director of Nuclear Reactor Regulation (NRC) regarding recalculation of the maximum temperature in the Main Steamline Valve Vault rooms, dated April 10, 1986 (TVA RIMS No. L44860410807).

4) NUREG-1232 Volume 2, "Safety Evaluation Report on Tennessee Valley Authority: Sequoyah Nuclear Performance Plan," dated May 1988.

5) TVA letter to NRC, "Watts Bar Nuclear Plant (WBN) Units 1 and 2 - Increased Environmental Temperature in the Main Steam Valve Vault Rooms," dated September 26, 1989 (TVA RIMS No. L44890926803).

6) TVA letter to NRC, "Watts Bar Nuclear Plant (WBN) Units 1 and 2 - Increased Environmental Temperatures in the Main Steam Valve Vault Rooms - WBRD-50-390/84-29 and WBRD-50-391/84-26 - Revised Final Report," dated September 28, 1989 (TVA RIMS No. L44890928802).

7) TVA Calculation WBN-OSG4-148, R0, "Environmental Conditions of MSVV during a MSLB," dated May 1, 1991 (TVA RIMS No. B18910506251).

8) TVA Calculation WBN-OSG4-148, R1, "Environmental Conditions of MSVV during a MSLB," dated August 8, 1992 (TVA RIMS No. B18920826273).

9) TVA Calculation WBN-OSG4-151, R0, "The Temperature Transient of the Barton Transmitter Inside MSVV during a MSLB," dated June 15, 1992 (TVA RIMS No. B18920617253).

10) TVA Calculation WBN-OSG4-152, R1, "Thermal Transient of Namco Limit Switch Located in the Valve Vaults during a MSLB," dated May 12, 1992 (TVA RIMS No. B18920526251).

11) TVA Calculation WBN-OSG4-155, R2, "Thermal Transient of Conax Connectors Located in Valve Vaults during a MSLB," dated June 18, 1992 (TVA RIMS No. B18920618269).

REFERENCES (continued)

12) TVA Calculation WBN-OSG4-156, R1, "Thermal Transient of Limitorque SMB-00 Located in the Valve Vaults during a 0.8 ft^2 MSLB," dated August 19, 1992 (TVA RIMS No. B18920817242).

13) TVA Calculation WBN-OSG4-157, R0, "Thermal Transient of ASCO Solenoid Located in the Valve Vaults during a MSLB," dated March 24, 1992 (TVA RIMS No. B18920326251).

14) TVA Calculation WBN-OSG4-158, R0, "Thermal Transient of Safety Related Junction Boxes Location in MSVV during a MSLB," dated October 10, 1992 (TVA RIMS No. B18921015257).

15) TVA Calculation WBN-OSG4-160, R0, "Thermal Transient Analysis of Gould Allied MSIV Solenoid Located in the Valve Vaults during a 0.8 ft^2 MSLB," dated August 13, 1992 (TVA RIMS No. B26920817242).

16) TVA Environmental Qualification Binder WBNEQ-SOL-002, R4, "Target Rock Solenoid Valves," dated May 12, 1992.

17) TVA Calculation WBN-OSG4-171, R0, "Effect of Superheat on 10CFR50.49 Cables in the Main Steam Valve Vaults (MSVVs)," dated February 12, 1992 (TVA RIMS No. B26920213202).

18) Westinghouse Topical Report WCAP-11053, "Steamline Break Outside Containment Mass Energy Release Analysis; TVA - Watts Bar," dated March 29, 1985.

19) TVA letter to NRC, "Watts Bar Nuclear Plant (WBN) - Increased Environmental Temperature in the Main Steam Valve Vault Rooms - Outstanding Issue 24 (TAC 63632)," dated January 23, 1992 (TVA RIMS No. T04920123898).

20) Westinghouse Topical Report WCAP-13274, "Steamline Break Outside Containment Mass/Energy Releases for the EAGLE 21/Reduced Auxiliary Feedwater Flow Programs TVA-Watts Bar," dated April 1992 (TVA RIMS No. T33920522920).

21) TVA Calculation WBN-OSG4-147, R1, "Subcompartment Model of Main Steam Valve Vaults," dated June 24, 1992, (TVA RIMS No. B18920629253).

22) NUREG-0588, R1, "Interim Staff Position on Environmental Qualification of Safety Related Electrical Equipment," dated July 1981.

REFERENCES (continued)

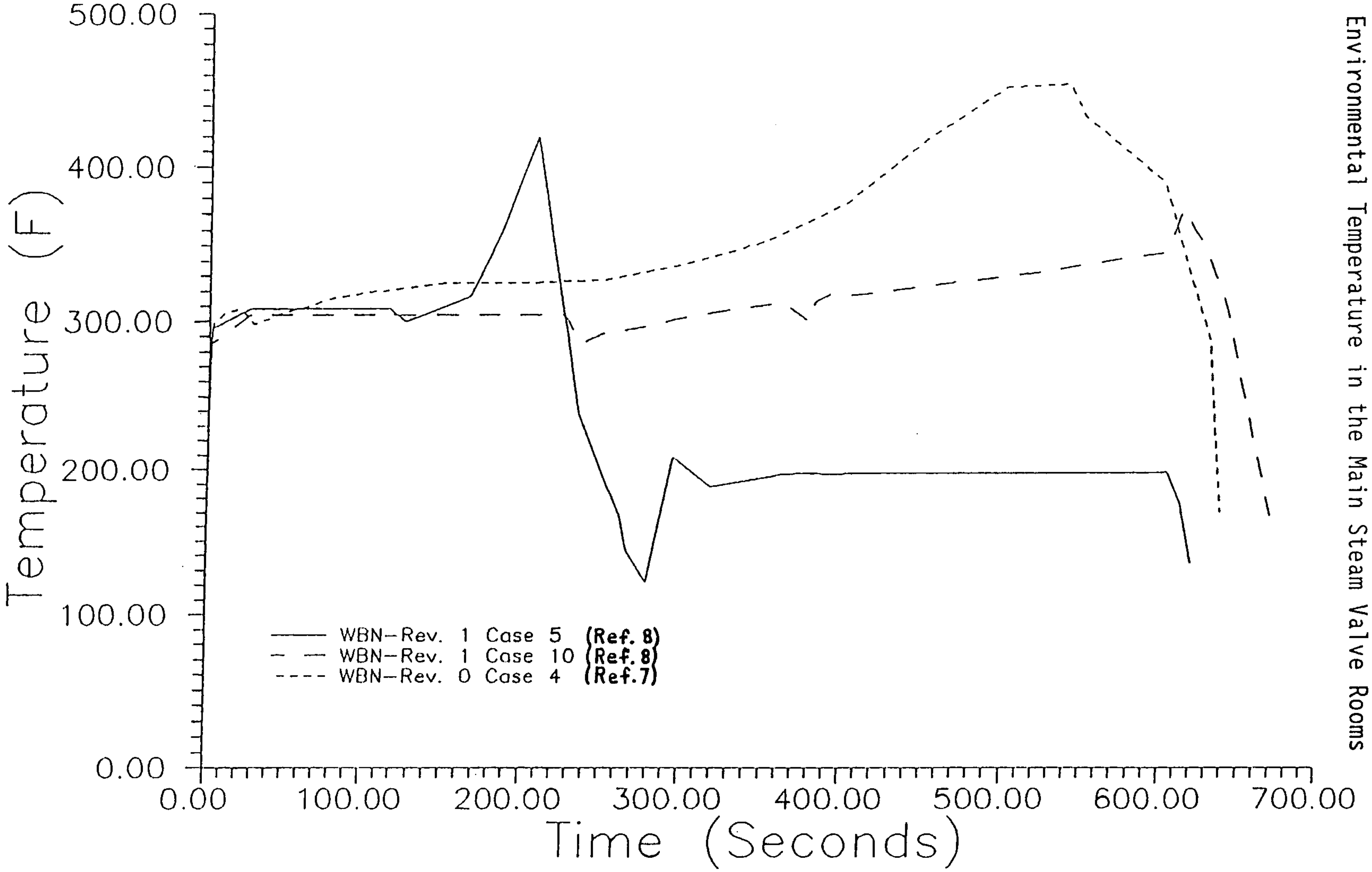
23) TVA Calculation WBN-OSG4-150, R0, "The Temperature Transient of Structural Steel Inside MSVV during a MSLB," dated April 21, 1992 (TVA RIMS No. B18920422251).

24) TVA Calculation TI-ANL-197, R1, "Valve Vault Structural Concrete Temperature Gradients Due to a Main Steam Line Break," dated March 25, 1992 (TVA RIMS No. B18920326253).

25) TVA Calculation WCG-1-220, R0, "Valve Room Steel Structures Temperature Evaluation," dated September 18, 1984 (TVA MEDS No. WBP840918019).

26) TVA Calculation CSG-86-011, R0, "MSLB Temperature on Valve Room Concrete," dated July 21, 1986 (TVA RIMS No. B41860709011).

Figure 1 Comparison of Temperature Profiles during MSLB
WBN South MSVV Cases 5 & 10



Enclosure 2

LIST OF COMMITMENTS

- The flexible conduit in the main steam valve vault rooms will be wrapped with 2-inch Kaowool insulation.