ENCLOSURE 2

Browns Ferry Nuclear Plant
Units 1, 2, and 3

Browns Ferry (Units 1–3) Core Plate Bolt Analysis Stress Analysis Report, NEDO-33632
(GE Non-Proprietary)

HITACHI

GE Hitachi Nuclear Energy

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Browns Ferry (Units 1–3) Core Plate Bolt Analysis Stress Analysis Report

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IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT

Please Read Carefully

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ACRONYMS

Term	Definition
AC	Acoustic
ANSYS	Engineering simulation software based on finite element analysis
ASME	American Society of Mechanical Engineers
B&PVC	Boiler and Pressure Vessel Code
BFN	Browns Ferry Nuclear Plant
BWR	Boiling Water Reactor
BWRVIP	Boiling Water Reactor Vessel and Internals Project
dP	Pressure differential
DW	Deadweight
EFPY	Effective Full Power Years
EPRI	Electric Power Research Institute
FE	Finite Element
FEA	Finite Element Analysis
FSAR	Final Safety Analysis Report
GEH	GE-Hitachi Nuclear Energy
ICGT	In-Core Guide Tube
kips	Kilo-pounds (1000 x lb_f): a unit of force
ksi	Kilo-pounds-per-square-inch (1000 x psi): a unit of mechanical stress (or pressure)
LOCA	Loss of Coolant Accident
OBE	Operating Basis Earthquake
RIPD	Reactor Internal Pressure Difference
RSLB	Recirculation Suction Line Break
SRSS	Square Root Sum of Squares
SRV	Safety Relief Valve
SS	Stainless Steel
SSE	Safe Shutdown Earthquake
TLAA	Time Limiting Aging Analysis

1.0 INTRODUCTION AND BACKGROUND

Tennessee Valley Authority (TVA) is required to perform a plant-specific core plate[1] hold-down bolt stress analysis as part of the Time Limiting Aging Analysis (TLAA) for the Browns Ferry Nuclear Plant (BFN) license renewal. This plant-specific analysis performed by GE-Hitachi Nuclear Energy (GEH) is consistent with Electric Power Research Institute (EPRI) Boiling Water Reactor Vessel and Internals Project (BWRVIP)-25 Appendix A (Reference 1) and BFN's current licensing basis. This analysis shows that the core plate bolts in BFN Units 1–3 meet American Society of Mechanical Engineers (ASME) code allowable limits; this demonstrates that BFN core plate bolts can withstand normal, upset, emergency, and faulted loads considering the effects of stress relaxation on the bolts until the end of the 60-year period of extended operation.

[1] The proper component terminology is *core support*, but *core plate* has been used almost universally and will be used in this report

2.0 SCOPE

An analysis was conducted to determine the stress in the core plate bolts assuming the failure of the beam-to-rim weld. This analysis is based on a conservative structural analysis of the BFN core plate geometry. If the beam-to-rim welds fail or the beams separate from the core plate, the load distribution on the core plate bolts changes. Of special interest is the amount of bending induced in the bolts when the core plate bows upward or when load from the beams is no longer transferred to the rim. The tensile load on the bolts is the same in all cases.

The bolt arrangement for the core plate geometry was modeled with finite element analysis (FEA). Lateral restraint of the aligner pin hardware was also considered. Also, the case of failure of the core plate to rim weld was considered to determine if there was a significant effect on the core plate bolt loading.

The purpose of the stress calculations performed herein is to demonstrate the structural adequacy of the BFN core plate bolts and aligner pins if subjected to the three scenarios listed in BWRVIP-25 Appendix A (Reference 1). Plant-specific data are applied in the analysis and the ASME Boiler and Pressure Vessel Code (B&PVC), Section III (Reference 2) is used as guide for the allowable stress limits.

This analysis only reports whether or not the stresses in the core plate bolts remain under ASME allowable values for the three BWRVIP-25 Appendix A (Reference 1) scenarios and loading conditions; other issues, such as inspection, are not in the scope of this analysis.

3.0 SUMMARY OF ANALYSIS RESULTS

This analysis shows that the BFN core plate bolts meet the ASME Code allowable stresses for the loading conditions and assumptions made for all three scenarios analyzed in BWRVIP-25 Appendix A (Reference 1). A summary of these results can be found in Table 7-1 and details of the analysis results can be found in Section 7.0. The three scenarios are:

1. Load on the core plate bolts with no credit for aligner pins (the bolts take all of the horizontal and vertical loads).
2. Shear-only load on the aligner pins with no credit for horizontal bolt restraint (the bolts take the vertical loads and the aligner pins take all of the horizontal loads).
3. Load on the core plate bolts with no credit for aligner pin and also with the stiffener-beam-to-rim weld cracked (the core plate bolts take all of the horizontal and vertical loads).

4.0 STRUCTURAL ACCEPTANCE CRITERIA

The acceptance criteria are consistent with BFN Final Safety Analysis Report (FSAR) (Reference 3) as shown in Table 4-1. The material properties were taken from Section III of the ASME B&PVC (Reference 2). The limiting load combinations are in Service Level C (Emergency Condition), yet both the Emergency and Faulted Conditions results are reported in Section 7.0 and explained in Section 5.0.

4.1 Allowable Stress Limits

Table 4-1: Allowable Stress Limits

Stress	Stress Category	Service Level C Allowable Limit*	Service Level D Allowable Limit*
P_m	Membrane Stress	1.5 S_m	2.0 S_m
$P_m + P_b$	Membrane + Bending Stress	2.25 S_m	3.0 S_m
Shear	Shear Stress	0.9 S_m	1.2 S_m

Note: *The allowable stress limits are from Reference 3, Appendix C, Table C.4-1.

5.0 LOADS AND LOAD COMBINATIONS

Table 5-1 indicates the loads considered for this analysis. [[

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Table 5-1: Loads Considered for Analysis

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Table 5-2: Load Combinations

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All load combinations were considered in the evaluation, and the Emergency condition (Level C) is the most limiting. This can be understood by noting that the loads are nearly the same between the Emergency and Faulted conditions, yet the allowable stress is much lower for the Emergency condition than for the Faulted condition. The Normal/Upset condition is bounded by the Emergency condition because the applied operating basis earthquake (OBE) load is half of the safe shutdown earthquake (SSE) load, yet the allowable stress is more than half of the Emergency condition. To be conservative, faulted reactor internal pressure difference (RIPD) values were used with the Emergency condition allowable limits.

5.1 Load Combinations

The total horizontal direction load is effectively equal to the horizontal SSE load. The vertical loads on the core plate bolts are caused mainly by the pressure differential across the core plate. [[

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5.2 Acoustic Load

The AC load is a horizontal load acting on the shroud in a postulated Recirculation Suction Line Break (RSLB) event. Safety Communication SC09-03 (Reference 4) describes this load on the shroud and how its omission from shroud loads may be non-conservative. Although the BWRVIP-25 Appendix A (Reference 1) calculations did not include this load, the core plate is attached to the shroud and therefore, the load has been included.

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5.3 Horizontal Seismic Loads

Shear load values were converted to and applied as accelerations on each component. [[

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5.4 Vertical Seismic Loads

Vertical seismic loads were imparted to the model as accelerations. The BFN FSAR (Reference 3, Section 2.5.4) states, "vertical accelerations are 2/3 of the horizontal accelerations." [[

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5.5 Fluid Drag and Deadweight Loads

The fluid drag was applied as a pressure to the bottom surface of the core plate. [[

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5.6 Preload

Preload on the core plate bolts is accounted for after the FEA analysis run [[

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5.7 Friction

For this analysis, 304 SS is interacting with 304 SS on a wetted interface. [[

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A friction factor 0.2 is suggested in Section 5.5 of BWRVIP-51A (Reference 5) for modeling the friction restraint for the evaluation of retained flaws unless a higher value can be technically justified. Typical jet pump material is also SS, and the recommended friction factor of 0.2 should be applicable for the SS core plate and core plate bolts. [[

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5.8 Fluence

The core plate bolt preload relaxes with fluence. [[

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5.9 Thermal Relaxation

No thermal gradients act across the core plate. However, thermal reduction in the core plate preload is included in the analysis. [[

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6.0 STRUCTURAL ANALYSIS

6.1 Model Components

The following figure shows the components of the model (Reference 1). The zero of the azimuthal location, Θ, is located along the X-axis.

Figure 6-1: Core Plate Assembly Model Component Names

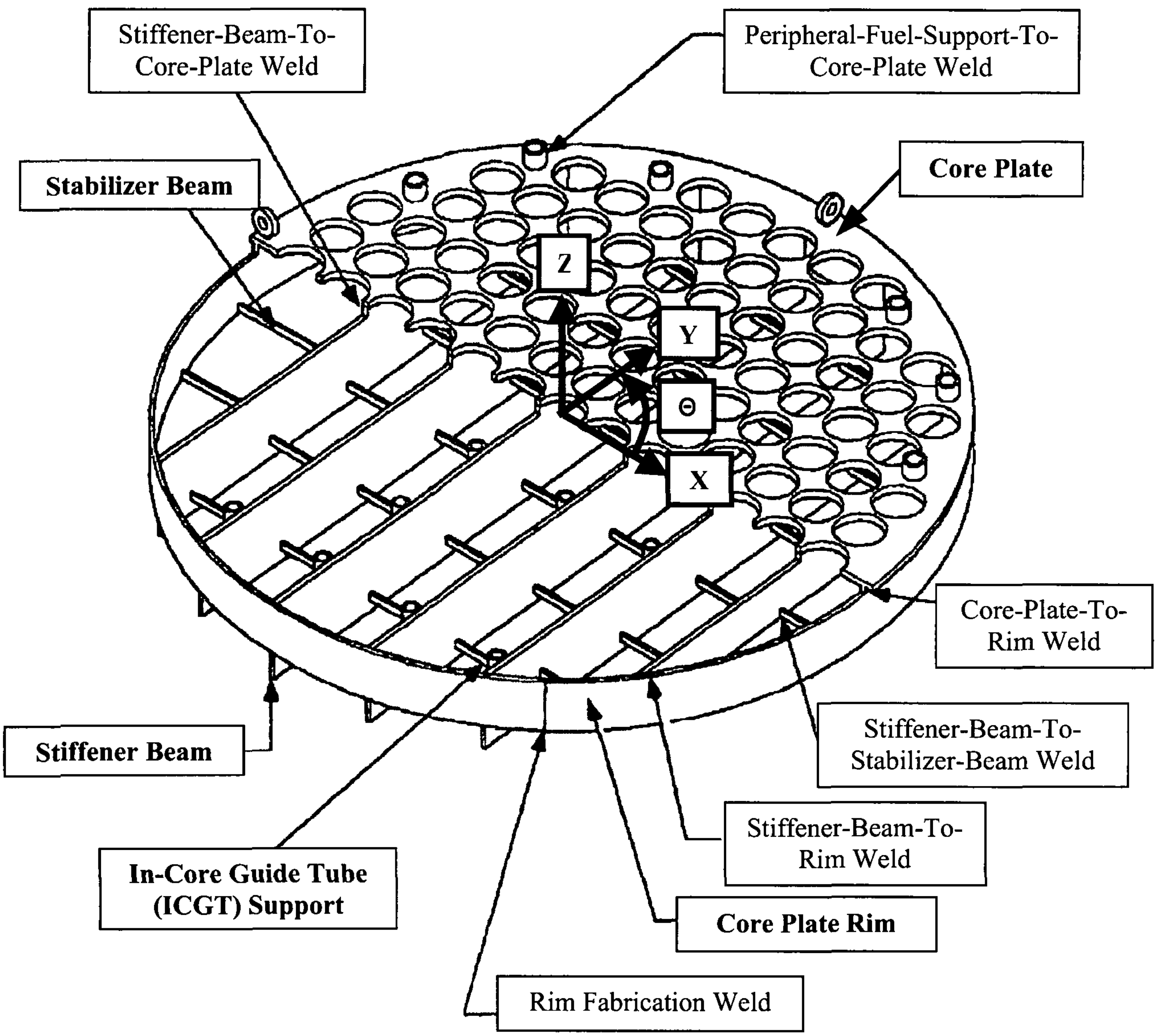
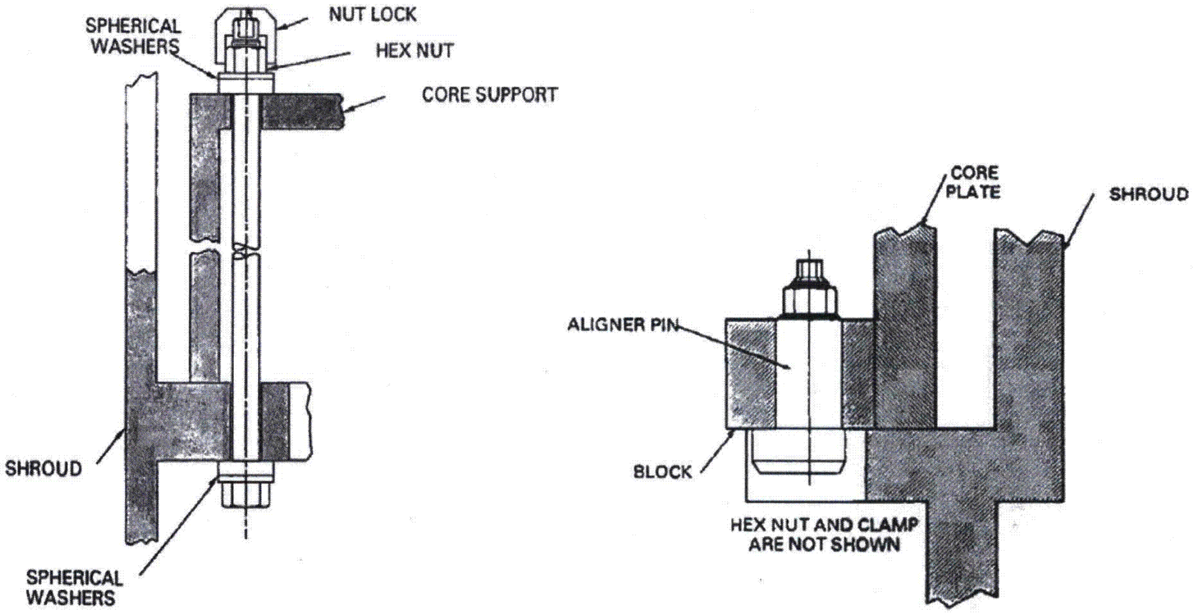


Figure 6-2 is a generic figure showing the configuration of the core plate bolts and aligner pins (Reference 1).

Figure 6-2: Core Plate Bolt and Aligner Pin Configuration



6.2 Finite Element Model and Analysis

This analysis was performed using ANSYS 11.0. [[

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6.3 Scenario Descriptions

6.3.1 Scenario 1

Aligner pins are not included in the model for this scenario. All of the horizontal loading and vertical loading is supported by the core plate bolts. The only connection between the core plate assembly and the ledge of the shroud is through the connection of the core plate bolts. Therefore, all of the horizontal loads imparted on the core plate are resisted by the bending of the core plate bolts, and all vertical loads are resisted by the axial stretching of the bolts.

6.3.2 Scenario 2

Aligner pins are included in the model for this scenario. All of the horizontal loading is taken by the aligner pins. The aligner pins cannot support a vertical load. Therefore, the core plate bolts were modeled to take only the vertical loads but not the lateral loads. The only connection between the core plate assembly and the ledge of the shroud is via the core plate bolts in the vertical direction and the aligner pins in the horizontal direction. Therefore, all of the horizontal loads imparted on the core plate are resisted by the shearing of the aligner pins, and all vertical loads are still resisted by the axial stretching of the core plate bolts.

BWRVIP-25 Appendix A (Reference 1) determines the maximum of the horizontal loads calculated on all four aligner pins. Then the stress on a single aligner pin is calculated by applying this maximum horizontal load. [[

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6.3.3 Scenario 3

The difference between this scenario and Scenario 1 is the postulated complete failure of the weld between the stiffener beams and the rim. Aligner pins are not included in the model for this scenario. All of the horizontal loading and vertical loading is supported by the core plate bolts. The only connection between the core plate assembly and the ledge of the shroud is through the connection of the core plate bolts. Therefore, all of the horizontal loads imparted on the core plate are resisted by the bending of the core plate bolts, and all vertical loads are resisted by the axial stretching of the core plate bolts.

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Figure 6-3: [[ ]]

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7.0 ANALYSIS RESULTS

7.1 Comparison of Core Plate Bolt Stresses to ASME Allowable Limits

As stated in Section 3.0, this analysis shows that the BFN core plate bolts meet the ASME allowable stresses for the loading conditions and assumptions made for all three scenarios analyzed in BWRVIP-25 Appendix A (Reference 1). This analysis follows the example analysis with three differences:

1. This analysis naturally uses plant-specific loading and geometry for BFN and ASME allowable limits consistent with the licensing basis.
2. This analysis takes credit for a conservative amount of friction.
3. The horizontal load imparted to the aligner pins is now calculated in the same fashion as for the bolts (see Section 6.3.2).

Results for the Emergency Condition are shown in Table 7-1, which is the most limiting condition. For comparison, the Faulted Condition has been included in Table 7-2. [[

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Table 7-1: Stresses Compared to ASME Allowable Limits (Emergency Condition)

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Table 7-2: Stresses Compared to ASME Allowable Limits (Faulted Condition)

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Notes for Tables 7-1 and 7-2:
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Figures 7-1 and 7-2 can be compared with Figures A-3 and A-4 of BWRVIP-25 Appendix A (Reference 1). Figures 7-1 and 7-2 serve as visual verification of the results and as a useful benchmark against the BWRVIP-25 analysis. The zero degree location corresponds to the reference X-axis in Figure 6-1. [[

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Figure 7-1: [[ ]]

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Figure 7-2: [[ ]]

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8.0 CONCLUSION

Taking into consideration the preload relaxation due to thermal effects and fluence for a 60 year plant life, this analysis shows that the BFN core plate bolts meet the ASME allowable stresses for the most limiting plant-specific load combinations and loads for all three scenarios analyzed in BWRVIP-25 Appendix A (Reference 1).

9.0 REFERENCES

1. BWRVIP-25, “BWR Core Plate Inspection and Flaw Evaluation Guidelines,” EPRI, 1996.
2. ASME B&PVC, Section III, 1965.
3. BFN Final Safety Analysis Report.
4. Safety Communication SC09-03, “Shroud Screening Criteria Reports,” August 3, 2009.
5. BWRVIP-51A, “BWR Vessel and Internals Project: Jet Pump Repair Design Criteria,” EPRI, 1996.

ENCLOSURE 3

Browns Ferry Nuclear Plants
Units 1, 2, and 3

Affidavit

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, Edward D. Schrull state as follows:

(1) I am the Vice President, Regulatory Affairs, Services Licensing, of GE-Hitachi Nuclear Energy Americas LLC (GEH), and have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in GEH proprietary report, NEDC-33632P, "Browns Ferry (Units 1-3) Core Plate Bolt Analysis Stress Analysis Report," Revision 0, dated December 2010. GEH proprietary information in NEDC-33632P is identified by a dotted underline inside double square brackets. [[This sentence is an example.{3}]] Figures and large equation objects containing GEH proprietary information are identified with double square brackets before and after the object. In each case, the superscript notation {3} refers to Paragraph (3) of this affidavit that provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner or licensee, GEH relies upon the exemption from disclosure set forth in the Freedom of Information Act (FOIA), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for trade secrets (Exemption 4). The material for which exemption from disclosure is here sought also qualifies under the narrower definition of trade secret, within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975 F2d 871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704 F2d 1280 (DC Cir. 1983).

(4) The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a. and (4)b. Some examples of categories of information that fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by GEH's competitors without license from GEH constitutes a competitive economic advantage over GEH and/or other companies.

b. Information that, if used by a competitor, would reduce their expenditure of resources or improve their competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.

c. Information that reveals aspects of past, present, or future GEH customer-funded development plans and programs, that may include potential products of GEH.

d. Information that discloses trade secret and/or potentially patentable subject matter for which it may be desirable to obtain patent protection.

(5) To address 10 CFR 2.390(b)(4), the information sought to be withheld is being submitted to the NRC in confidence. The information is of a sort customarily held in confidence by GEH, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GEH, not been disclosed publicly, and not been made available in public sources. All disclosures to third parties, including any required transmittals to the NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary and/or confidentiality agreements that provide for maintaining the information in confidence. The initial designation of this information as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure are as set forth in the following paragraphs (6) and (7).

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, who is the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge, or who is the person most likely to be subject to the terms under which it was licensed to GEH. Access to such documents within GEH is limited to a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist, or other equivalent authority for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GEH are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary and/or confidentiality agreements.

(8) The information identified in paragraph (2) above is classified as proprietary because it contains results and details of structural analysis methods and techniques developed by GEH for the stress analysis of the Browns Ferry core plate bolts. Development of these methods, techniques, and information and their application for the design, modification, and analyses methodologies and processes for the core plate bolt stress analysis was achieved at a significant cost to GEH. The development of the evaluation process along with the interpretation and application of the analytical results is derived from the extensive experience database that constitutes a major GEH asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GEH's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GEH's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GEH. The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial. GEH's competitive advantage will be lost if its competitors are able to use the results of the GEH experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GEH would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GEH of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing and obtaining these very valuable analytical tools.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 15th day of December 2010.

Edward D. Schrull
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