TVA

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AUG 22 1991

John H. Garrity
Vice President, Watts Bar Nuclear Plant

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Gentlemen:

In the Matter of the Application of	)	Docket Nos. 50-390
Tennessee Valley Authority	)	50-391

WATTS BAR NUCLEAR PLANT (WBN) - RESPONSES TO ADDITIONAL NRC QUESTIONS ON CABLE TRAY CLASSIFICATION, CONDUIT DAMPING, AND FEEDWATER CHECK VALVE SLAM ANALYSIS (TAC NOS. R00508, 79717)

NRC and TVA conducted a teleconference on August 8, 1991, to further discuss the following WBN Civil/Seismic open issues:

1. Feedwater Check Valve Slam Analysis
2. Conduit Damping
3. Cable Tray Qualification

Several additional questions or requests for further justification were presented during this discussion. The purpose of this submittal is to transmit responses to these items for staff review.

Because these items are still under discussion, no FSAR text changes are proposed at this time. As previously discussed with the staff, issue resolutions will be incorporated into a subsequent FSAR amendment as necessary.

No new commitments are contained in this submittal.

If you have any questions, please telephone P. L. Pace at (615) 365-1824.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

John H Garrity

John H. Garrity

Enclosure
cc: See page 2

A001
1/1

AUG 22 1991

cc (Enclosure):

NRC Resident Inspector
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Enclosure 1

Feedwater Check Valve Slam Analysis

Date:
Item No: HR0026

NRC FSAR MEETING
Seismic and Civil Issues Program

Program Element: HAAUP

NRC Reviewer(s): J. Fair

TVA Responsible Person: W. D. Carson

Issues Discussed/Information Presented:

Design criteria utilized for Feedwater Check Valve Slam transient evaluation:

The stated methodology used is still an open issue.

Open Issue(s)/Request(s):

TVA must present what was done for WBN on this subject.

TVA Planned Action/Position:

Attached is a summary describing analysis methodology for staff review.

Prepared By: Darlene Leong by WDC

Reviewed By: W.D. Carson / Jerry R Bitner

Approved By: Ruben O Hernandez 8/16/91

3027M

ANALYSIS OF FEEDWATER PIPING FOR CHECK VALVE SLAM TRANSIENT AND SEISMIC LOADS

Introduction

A description of the Watts Bar Nuclear Plant (WBN) evaluation of feedwater piping under water hammer transient loads due to pipe rupture was previously provided to the staff for review. The purpose of this document is to supplement the earlier submittal and to describe the methods of analysis currently being performed.

Analysis Methodology

A nonlinear time history analysis is being performed to demonstrate pressure boundary integrity of the feedwater system following a feedwater header break and check valve slam as described in Westinghouse Nuclear Services Division Technical Bulletin 79-9, simultaneously occurring with a seismic event. The analysis procedures were developed to accurately model the feedwater piping and support system and to apply appropriate loads for the check valve slam and seismic events.

Of the four feedwater lines at Watts Bar, the feedwater line associated with steam generator #4 was selected for analysis, having the maximum strains from initial transient analysis. The final analysis model includes the 16-inch feedwater line from the steam generator to the flued head anchor in the Auxiliary Building, the 2-inch bypass line around the check valve, and overlap portions of the 4-inch wet lay-up line to the isolation valve. (See Figures 1 and 2).

Modeling Description

The ANSYS computer program is used for the analysis. Both material and geometric nonlinearities exist in the model. Both static and dynamic loads are applied.

For the piping components, only material nonlinearity is applicable. Both elastic and plastic pipe and elbow elements are used in the model. Plastic piping properties are represented by bilinear stress-strain curves, based on ASME Code values of E, S_y, and S_u and values of ε_u from the ORNL Materials Handbook.

For the support components, both material and geometric nonlinearities are applicable. Basic support capacities are determined using ASME Appendix F allowables. The support models are developed considering the predicted behavior of the support after the capacities are reached. Most of the supports in the model are governed by weld stresses, shear or compression in structural steel, anchorage loads, or catalog component loads. These supports are modeled using linear load-deflection curves up to the Appendix F capacities. If the capacities are exceeded during the time history analysis, that direction of restraint is removed from the model. A few supports in the model are governed by tension or bending in structural steel. These supports are considered to be capable of undergoing deflection under continued loading and are therefore modeled using elastic-perfectly plastic load-deflection curves.

For the rupture restraints, only geometric nonlinearity is applicable. Gap elements are used to account for clearance between the pipe and shims of the rupture restraints. The rupture restraints are not active until the gaps are closed, after which the support has a linear load-deflection relationship.

Loading Conditions

Seismic inertia loads are characterized by displacement time histories of the support points; differential movements of support points in adjacent structures are characterized by constant relative displacements of support points superimposed over the inertial displacements. The seismic inertia displacement time histories were developed to correspond to the response spectra for the three structures to which the feedwater system is attached. The floor response spectra used correspond to the envelope of the OBE and SSE spectra for sets B and C, using Reg Guide 1.61 damping (2% OBE/3% SSE). The seismic time history is generated at 0.005 second time steps. SRP requirements are met for enveloping of the target response spectra and statistical independence for the three directions of motion.

The check valve slam loads are characterized by force-time histories applied to the piping elements. The force time histories correspond to a guillotine rupture of the 32-inch feedwater header and resulting slam of the check valve. The duration of the transient is 0.5 seconds in 0.001 second time steps.

Loads are applied to the feedwater model to simulate the actual stress state in the system during the postulated events. Initial conditions (deadweight, pressure, thermal expansion, and thermal anchor movements) are considered. The check valve force transients are applied concurrently with the seismic loads. The check valve slam event lasts 0.5 seconds, after which the seismic loads continue.

Acceptance Criteria

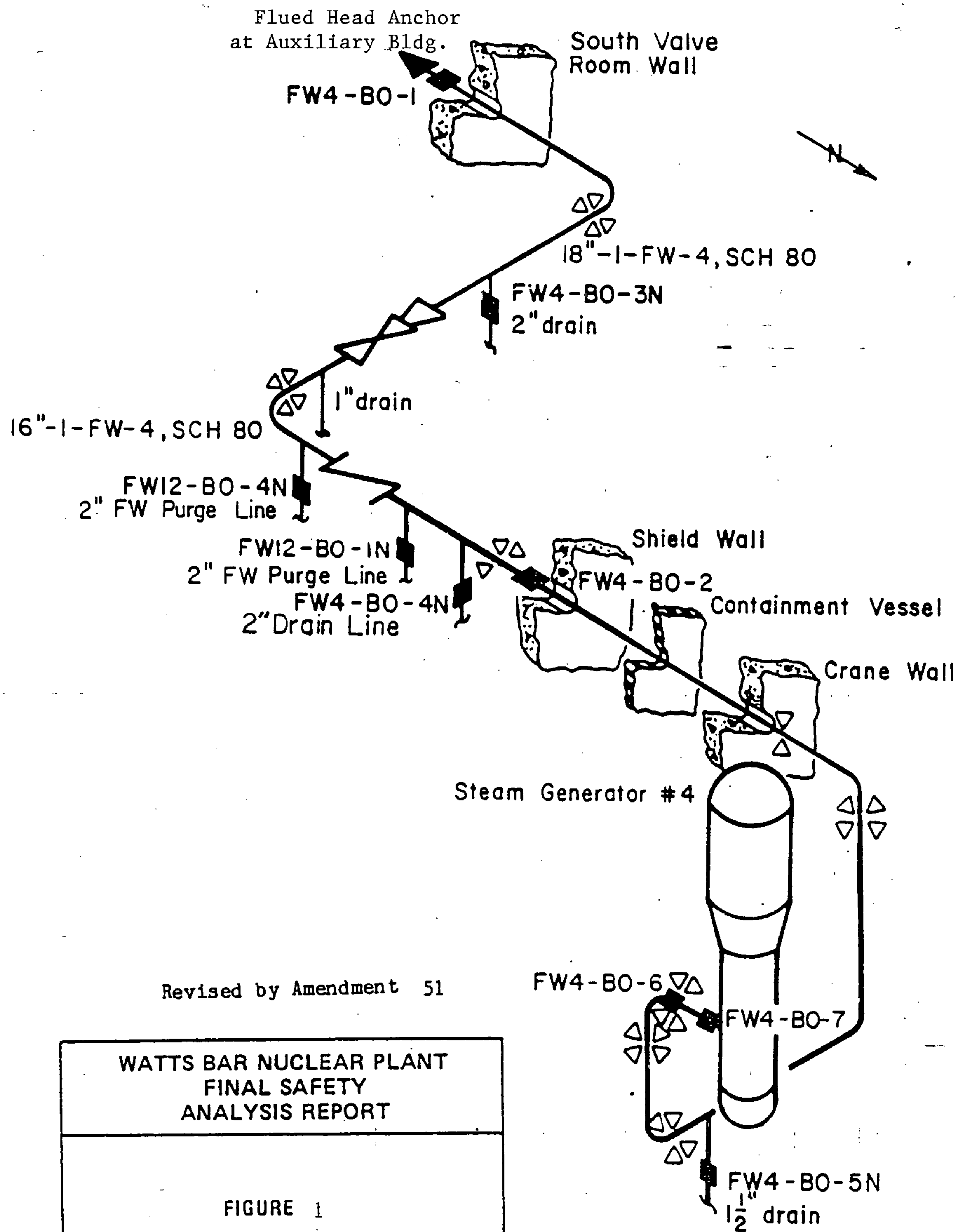
Response time histories are obtained for element stresses and forces, support loads and displacements, and rupture restraint gap size and loads. Calculated pipe stresses are compared to maximum allowable values per ASME Appendix F limits for plastic analysis:

$$P_m \leq 0.7\ S_u$$

where, P_m = primary membrane stress
S_u = ultimate tensile stress

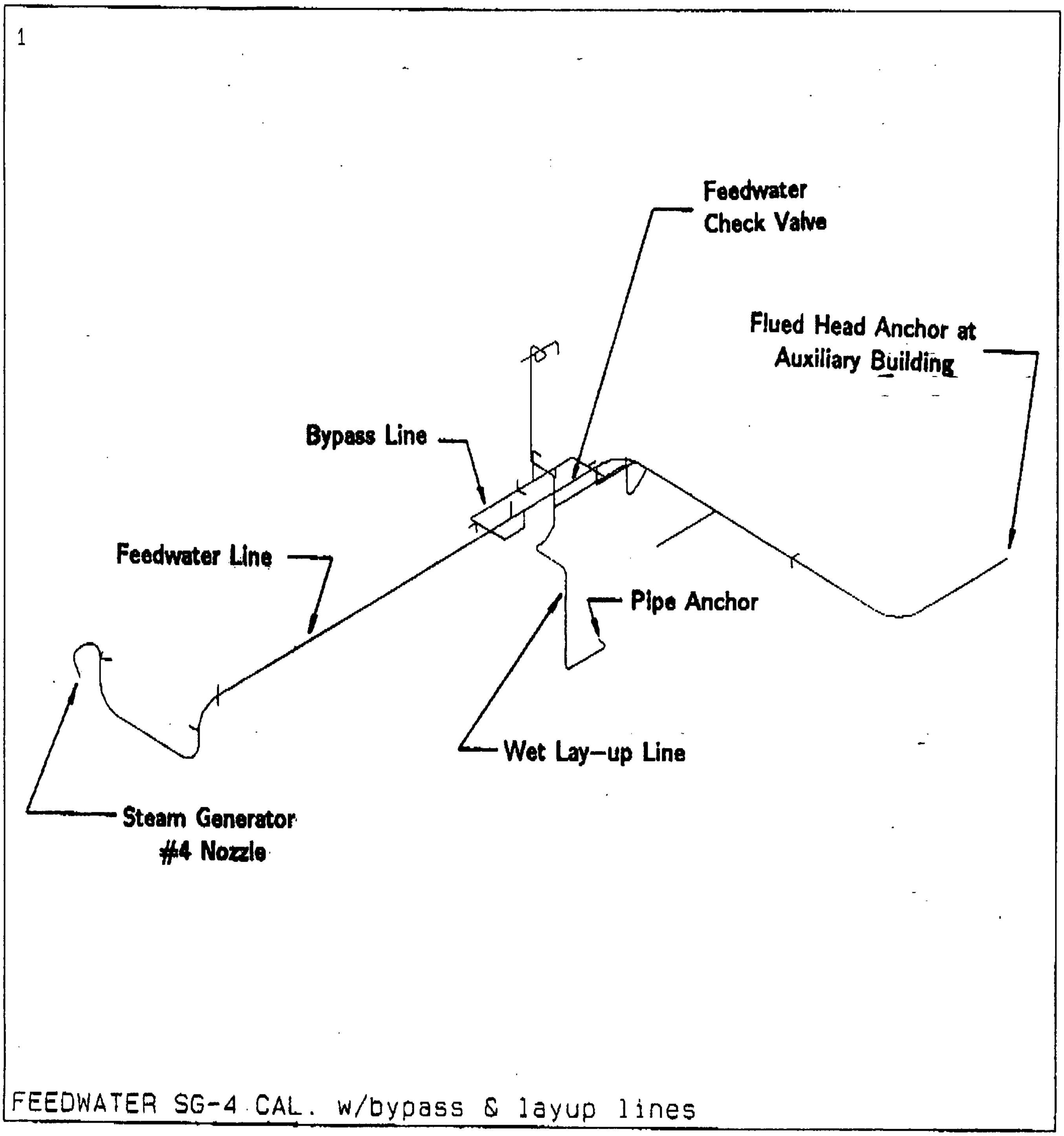
Displacement output time histories on the pipe at the support locations are reviewed to ensure that the dynamic responses are within the allowable deflections. Rupture restraint loads are reviewed to ensure that the loads are within the structural capacities; displacements are reviewed to ensure that they are consistent with the physical limitations of the restraints.

FEEDWATER LINE TO STEAM GENERATOR #4



Revised by Amendment 51

WATTS BAR NUCLEAR PLANT FINAL SAFETY ANALYSIS REPORT
FIGURE 1



Analysis Model
Figure 2

Enclosure 2

Conduit Damping Justification

Date: 8-14-91
Item No: CAS047B

NUCLEAR REGULATORY COMMISSION (NRC) FINAL
SAFETY ANALYSIS REPORT (FSAR) MEETING
SEISMIC AND CIVIL ISSUES PROGRAM

Program Element: Conduit

NRC Reviewer(s): Joe Braverman

TVA Responsible Person: Tom Cureton

Issues Discussed/Information Presented:

Page Number: 3.7-39 Paragraph/Line Number: 3.7.3.15 Category: B/C

Table 3.7-2 is referenced for damping values. These values have been revised from old FSAR.

Open Issue(s)/Request(s):

Numerous questions to be clarified by TVA. Basis for using average damping values needs justification. Tests by Wyle and ANCO correspond to lower values.

TVA Planned Action/Position:

(See Attachment which supercedes previous responses CAS047 and CAS047A)

Prepared by: Jerry L. Bitner 8/16/91

Reviewed by: Kevin B Westervelt 8/16/91 E Odar for CYC 8/16/91

Approved by: Ruben O Hernandez 8/16/91

1.0 SUMMARY

During the NRC FSAR Meeting in November, 1990, the NRC reviewer correctly noted in Item Number CAS047 that the damping values for conduit qualification have been revised by Amendment 64 to 4% OBE and 7% SSE as part of the total seismic validation program for WBN.

The purpose of this document is to address the justification for the 4% OBE and 7% SSE damping specified in Amendment 64 for conduit qualification.

TVA conducted a comprehensive test program using conduit specimens representative of the WBN conduit systems. The data from this program was analyzed using two evaluation methods. It was found that the data supports the use of over 6% OBE and 7% SSE damping at the strain levels allowed by the conduit design criteria for WBN.

The damping values, and other related parameters, from licensed plants were compared with those at WBN plants. The results show that the WBN conduit systems are comparable to five plants currently licensed to 4% OBE and 7% SSE.

The WBN conduits are considered as bolted steel structures. Reasons are given to support this statement. For bolted steel structures, Regulatory Guide 1.61 recommends 4% OBE and 7% SSE damping values.

Based upon these assessments, it is concluded that 4% OBE and 7% SSE damping values are appropriate for use in the qualification process for WBN conduit systems. Details of the assessment are provided in the subsequent sections of this report.

2.0 TEST DATA

To address conduit damping, TVA conducted a comprehensive test program (Reference 1) which addresses the major variables that affect system damping. The testing program included both steel and aluminum specimens of various sizes from 3/4-inch to 5-inch. Other test parameters addressed in the program are type of clamp, number of spans, span length, degree of fill, amplitude of excitation, type of excitation (snapback, impact and shaker) and effect of fire barrier mat.

The conduit spans were set according to the conduit size and fill to achieve conditions which are representative of those in the plant. The test conduits were bolted directly to the test apparatus; thus, the test results yield damping values which do not include conduit/support interactions, which is expected to increase the system damping. The test results for steel conduit are lower than those for aluminum; therefore, the steel conduit test data are used in this justification. Damping values for aluminum conduit are conservatively limited to the values for steel conduit.

The TVA tests were of generally low energy input, especially the snapback and impact tests. The input level of the tests is similar to the conduit response ranges expected for OBE seismic conditions. Therefore, the results are directly applicable to the OBE case. As expected, conclusions of the report show a large variation of damping values ranging from 2% to 17%. To determine a reasonable value for the population, the mean minus one standard deviation of damping values for the filled spans was calculated. This value is 5% which exceeds the proposed FSAR damping value of 4% of the OBE.

While the low level TVA tests are comparable to the OBE, it is conservative to use the mean from those tests to bound the SSE damping value. The mean damping level for all TVA tests, including the empty conduit spans, is 8.5%. This value is conservatively reduced to 7% for the WBN SSE validation effort to include a 15% factor of conservatism and to maintain a reasonable conformity with Regulatory Guide 1.61. For generic damping applications and for WBN in particular, the average value of all damping tests is considered to provide guidance in determining an appropriate damping value for use in the SSE case. The reasons for the applicability of this average value are listed below:

- For WBN, the site specific spectra were developed based on a mean plus one standard deviation excitation level, which includes appropriate design margins. Therefore, it is reasonable to use a mean damping value from tests to determine the applicable damping level for the SSE.

- Damping data are obtained from response measurements at discrete points on a system; in this case, one measurement per test was made. Since system damping is basically an average across the entire system and accounts for the gross summation of localized effects at discrete points, it is reasonable to obtain data with the scatter shown in the TVA tests, representing the localized effects of the chosen instrumentation point. It is also reasonable to use a mean value to define the effective damping of the entire system. In a similar manner, average damping values from tests were used to develop PVRC or Code Case N-411 damping.

Additional technical support for the WBN position of 4% OBE and 7% SSE for conduit qualification is based upon an approach endorsed by the Pressure Vessel Research Council (PVRC) in Reference 2 for piping systems.

In addition to the generic data-based conclusions that were used as the bases for Code Case N-411 damping, the PVRC Technical position on damping values established for piping (Reference 2) also allows system damping values to be determined experimentally. One of the two experimental options of the PVRC Technical Position is to perform a test on a similar (nearly identical) system to determine the damping for each mode. The damping allowed for each mode of the system in question is taken as 2/3 of the mean value of damping.

Applying this experimental option to the TVA Laboratory test data (Reference 1) gives 6.3% for OBE stress levels and 7.3% for SSE stress levels. The data evaluation procedure which supports these values is as follows:

1. Examine the steel conduit damping data when plotted as a function of frequency. This shows no frequency dependence (see Figure 11 of Reference 1).

2. Perform a least square linear fit to all steel conduit damping (y) data as a function of strain (x). This gives the equation $y = 0.00763x + 7.1$.

3. Define OBE and SSE levels at design allowable stresses of 8,700 psi and 14,500 psi respectively.

4. Divide these design allowable values by a typical value of modulus of elasticity of 29×10^6 psi to obtain OBE and SSE strain thresholds.

5. Substitute OBE and SSE strain thresholds from (4) into the damping vs strain equation from (2). This gives 9.4% for OBE and 10.9% for SSE.

6. Multiply the experimentally determined damping values from (5) by 2/3 to give the allowable damping value for analysis purposes. This gives 6.3% for OBE and 7.3% for SSE. These values are greater than the 4% for OBE and 7% for SSE specified for WBN conduit qualifications.

A plot of the least square linear fit curve in relation to all steel conduit data from the TVA test program is shown in Figure 1. Damping values that would be endorsed using the PVRC approach are also shown in relation to the values specified for WBN.

3.0 BOLTED STEEL STRUCTURES

For bolted steel structure, Regulatory Guide 1.61 recommends 4% OBE and 7% SSE. The conduit and supports used at WBN are considered bolted steel structures for the following reasons:

1. All conduit segments are joined together by threaded fitting connections. There are no welded conduit-to-conduit connections.

2. All of the conduit is attached to the support structure via unistrut members with one or two bolt clamps. There are no welded conduit-to-support connections.

3. A vast majority of the conduit supports are attached to the building structure with concrete expansion anchor bolts.

4.0 INDUSTRY PRECEDENCE

Several licensed plants use conduit damping values equivalent to those proposed for WBN. Design parameters for five of those plants (Byron, Braidwood, Clinton, Grand Gulf and Vogtle) were obtained and compared with those at WBN and summarized in the Table 1.

The five cited plants have input ground acceleration levels comparable to WBN. The conduits for those plants, like WBN, are of all-steel construction. Additionally, they are of comparable size ranges, fill level, span length, and clamp type. Further comparison of support types was also made; a summary is also provided in Table 1.

As shown in Table 1, WBN conduit systems are comparable to those five plants currently licensed to 4%/7% damping levels. The proposed damping for WBN is therefore justified and supported by these precedents.

5.0 CONCLUSIONS

TVA Conduit Test Program data, industry precedence and analogy to bolted steel structures all justify the use of 4% OBE and 7% SSE damping in the qualification process for WBN conduits. The salient points of the justification are reiterated below:

1. The TVA tests are representative of the conduit span population at WBN and are therefore directly applicable for the damping determination. Parameters are varied to obtain a good range of results which envelop the population at WBN.

2. The TVA tests yield lower bound damping values. Although they include the effects of the conduit clamps, the effects of conduit/support interaction are neglected.

3. The TVA tests are of predominately low energy input similar to the OBE event. The mean minus one standard deviation damping value of 5% is directly applicable to the OBE case and exceeds the proposed FSAR value of 4% for the OBE case.

4. The mean of all low energy tests is 8.5%. This mean value is substantially higher than the proposed FSAR value of 7% for the SSE case, which has been chosen to conform with the general damping trends in Regulatory Guide 1.61.

5. Due to the nature of damping test, and since the site specific spectrum is based on a mean plus one standard deviation excitation, a mean damping value determined from the testing is appropriate for use, especially for the SSE Case.

DAMPING RATIO vs. STRAIN

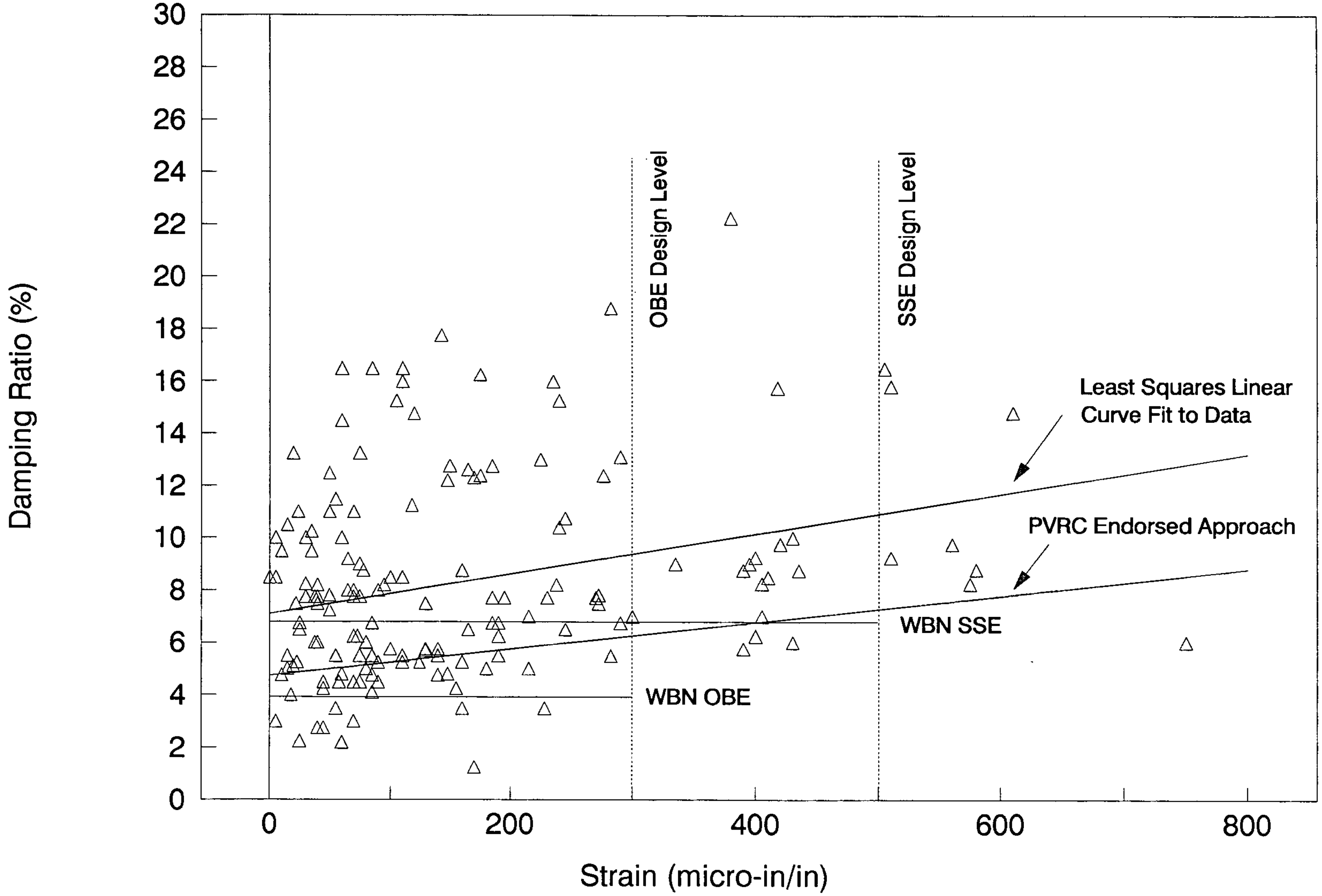


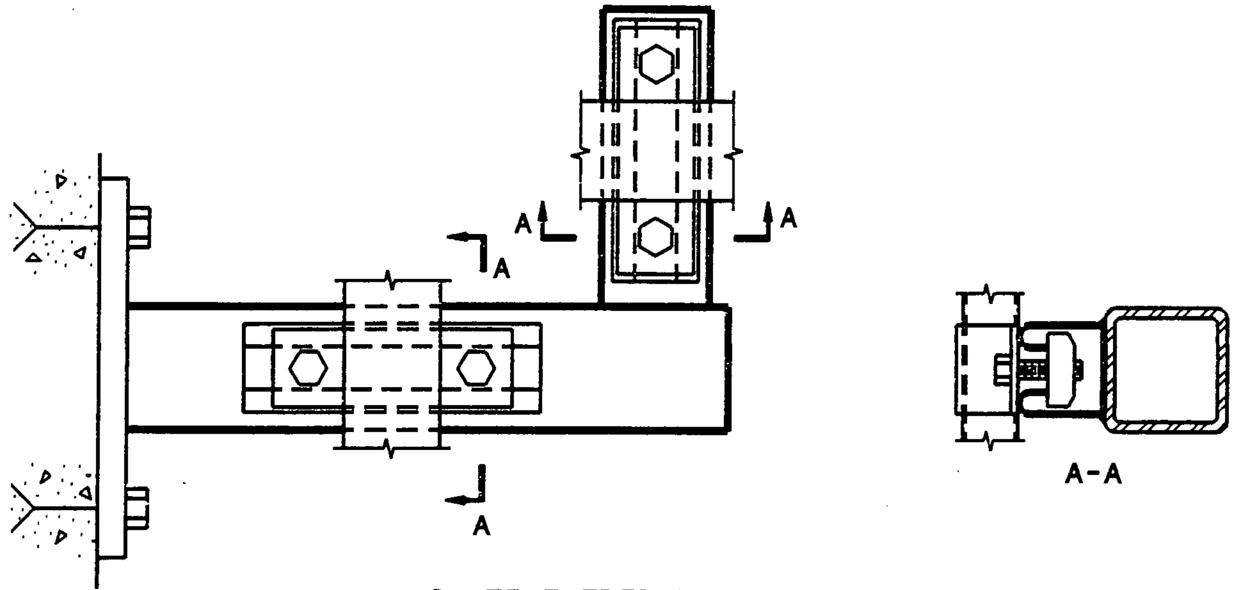
FIGURE 1

TABLE 1 - COMPARISON OF CONDUIT DAMPING VALUES FOR SELECTED NUCLEAR PLANT FACILITIES

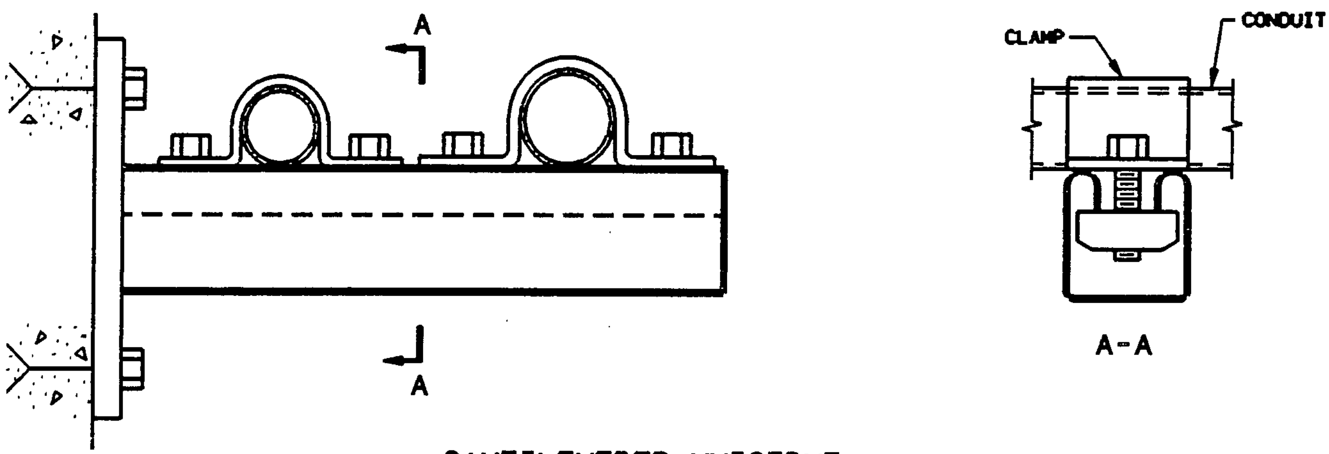
	BRYON	BRAIDWOOD	CLINTON	GRAND GULF	VOGTLE	WATTS BAR
DAMPING	4%/7%	4%/7%	7%	7%/7%	4%/7%	4%/7%
MULTI-MODE FACTOR	1.0 (8)	1.0 (8)	1.0 (8)	RSA (9)	1.0 (10)	1.2 (11)
INPUT GROUND ACCELERATION	0.2 g	0.2 g	0.25 g	0.15 g	0.2 g	0.215 g
SPECTRAL TYPE	RG 1.60	RG 1.60	RG 1.60	Modified Newmark	RG 1.60	Modified Newmark Site Specific
CONDUIT MATERIAL	steel	steel	steel	steel	steel	steel
CONDUIT FILL	40%	40%	40%	40%	40%	40%
CONDUIT SIZES	3/4" - 6"	3/4" - 6"	3/4" - 6"	1" - 4"	3/4" - 4"	3/4" - 5"
CONDUIT SPANS	10' - 15'	10' - 15'	10' - 15'	8' - 10'	8'	5' - 15'
CLAMP TYPE	2 bolt	2 bolt	2 bolt	1 & 2 bolt	2 bolt	2 bolt
SUPPORT TYPES (See Figures 2, 3 and 4 for Typical Conduit Support Details)	(1) (2) (7)	(1) (2) (7)	(1) (2) (7)	(1) (2),(6) (7)	(1),(3) (5) (7)	(1), (4) (5) (7)

NOTES:
- (1) Cantilever
- (2) Unistrut
- (3) Some steel frames
- (4) Some braced cantilevers
- (5) Combination tube steel/Unistrut
- (6) Cantilever frame, tube steel
- (7) Members welded to baseplate
- (8) This value is used at peak of response spectra
- (9) RSA - Response Spectra Analysis
- (10) A factor of 1.5 is specified in the FSAR and as permitted by the FSAR, the Vogtle project justified and used a value of 1.0 on peak.
- (11) This value is used at peak and, offpeak if the freq.> peak.

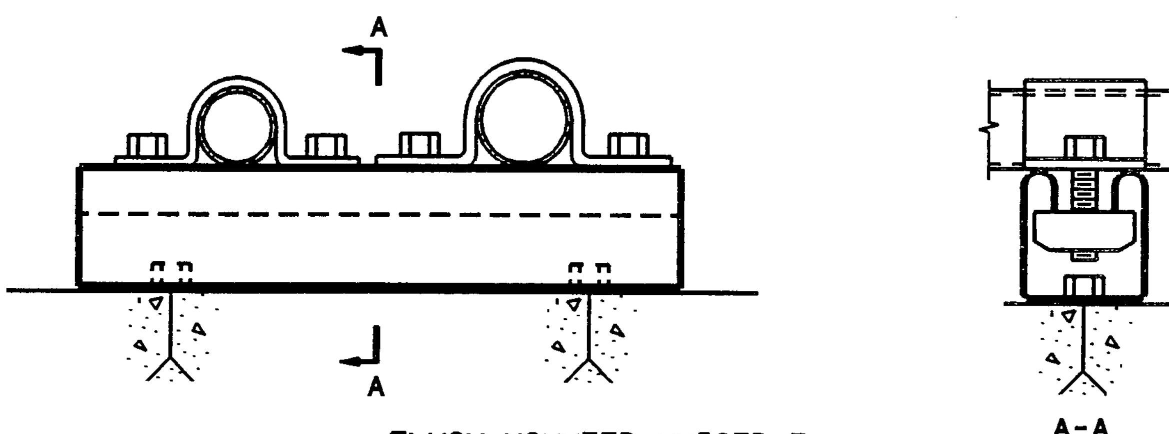
WATTS BAR - TYPICAL CONDUIT SUPPORT TYPES



CANTILEVERED TUBE STEEL



CANTILEVERED UNISTRUT

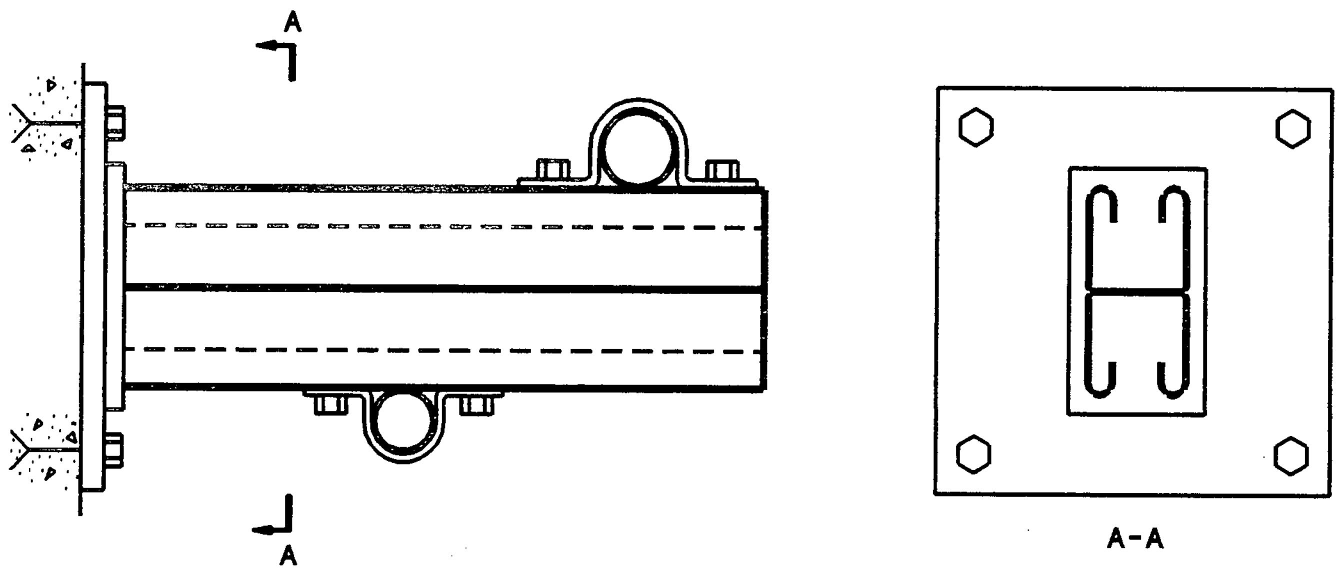


FLUSH MOUNTED UNISTRUT

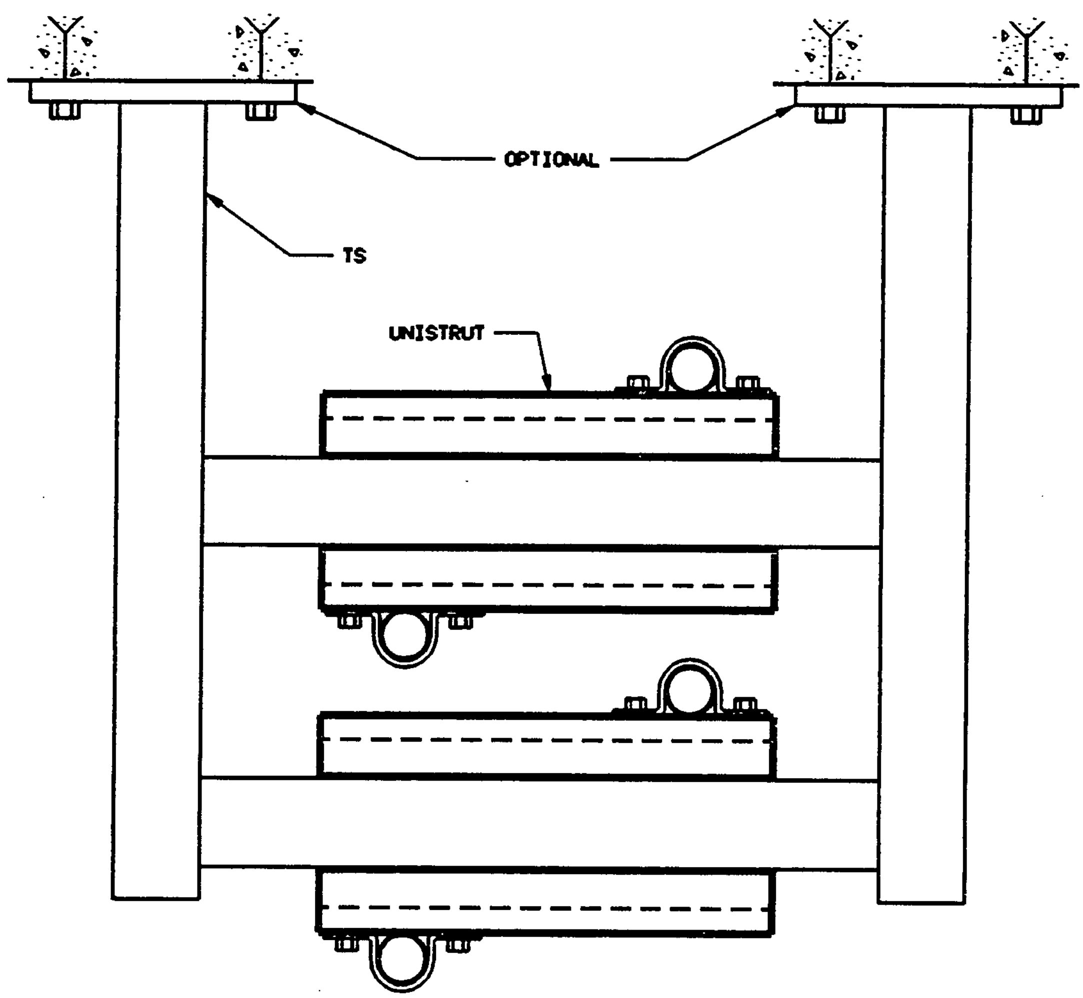
WBN MIS703 0.0.0 GWJ

FIGURE 2

GRAND GULF - TYPICAL CONDUIT SUPPORT TYPES



CANTILEVERED UNISTRUT

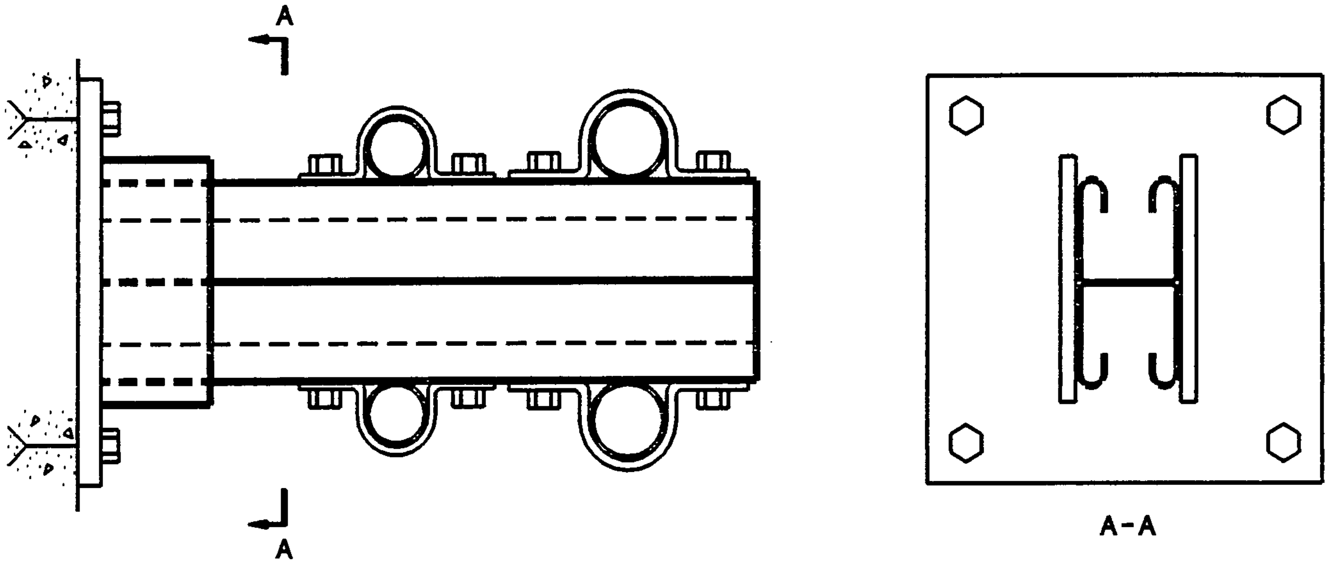


CANTILEVERED FRAME TUBE STEEL

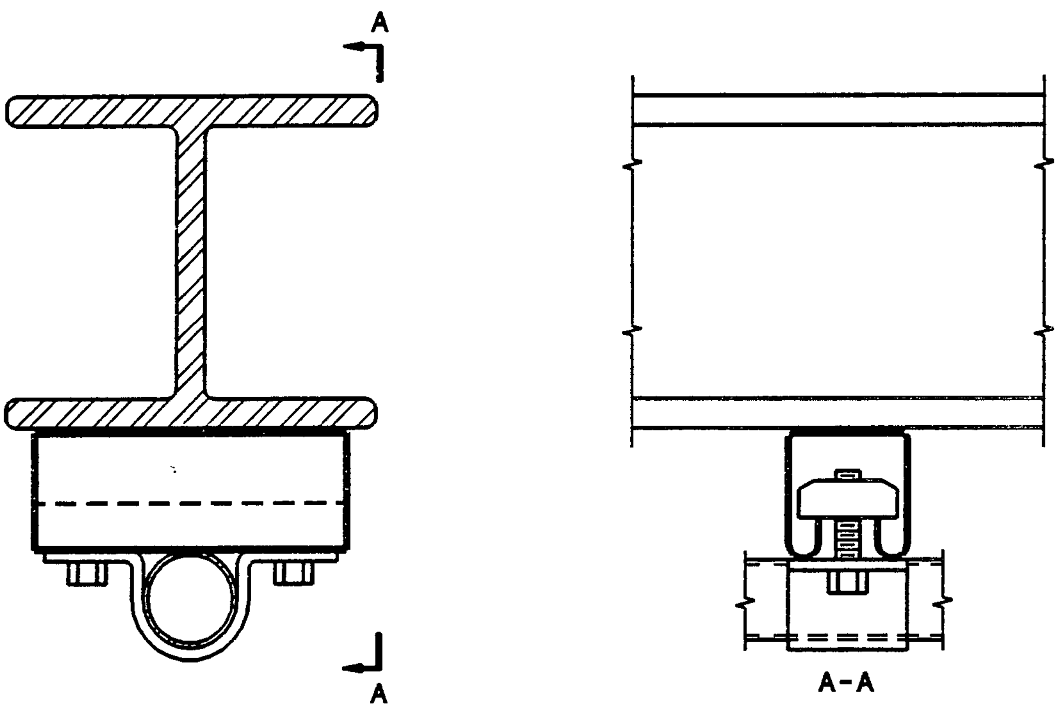
WBN MIS703 0.0.0 GWJ

FIGURE 3

BYRON, BRAIDWOOD, AND CLINTON - TYPICAL CONDUIT SUPPORT TYPES



CANTILEVERED UNISTRUT



FLUSH MOUNTED UNISTRUT

WBN MIS703 0.0.0 GWJ

FIGURE 4

Enclosure 3

Cable Tray Qualification
Response

Item No: WF0001B

RESPONSE TO NRC QUESTIONS

Program Element: Cable Tray

NRC Reviewer(s): Paul Besler

TVA Responsible Person: Bill C. Perkins

In the August 8, 1991 telephone call with the NRC, the NRC staff requested that TVA address the following issues:

1. What tests were utilized to derive the allowable horizontal (transverse) and vertical moments, Mha and Mva, respectively?
2. Basis for data points plotted in Figure 1?
3. How is the moment-interaction equation validated for bi-axial bending for cases with high vertical moment, cases for which test data is lacking?
4. FSAR update.
5. Consideration of shear and torsion in trays?
6. How are stresses in trays due to differential motion of flexible supports addressed?
7. How are DBA and thermal loads addressed?

TVA Responses:

Refer to the following sheets.

Prepared by: JORMA ARROS /BCP

Reviewed by: [signature] 8·16·91

Approved by: [signature] 8/16/91

1. What tests were utilized to derive the allowable horizontal (transverse) and vertical moments, Mha and Mva, respectively?

Mha was derived utilizing data from tests documented in References 1, 2, and 3. Tray hardware in these tests was of the type installed at Watts Bar Nuclear Plant (WBN). Tests in References 1 and 2 demonstrate that straight tray sections have inelastic transverse deformation capability far exceeding a ductility of three. The numeric value for Mha was derived utilizing data from the test of Reference 3 in which a simply supported 8-foot tray span was loaded in the transverse direction. In this test no vertical load was applied and the bending moment could be readily calculated for a simple span. The load was increased until, the tray hold down clips developed significant deformation and the test was halted. The tray showed no sign of failure or excessive deformation under this load. (The type of light gage hold-down clips that secured the tray in this test are no longer utilized for WBN cable tray to support connections. Stronger connection clips made of structural steel and welded to the support members have replaced the original arrangement.)

Mva was derived utilizing data from the test documented in Reference 4. In this test, a simply supported 8-foot span of tray of the type used at WBN was loaded in the vertical direction, with no transverse load applied.

See Figure A (sheet 2) for clarification and definition of the transverse and vertical moments.

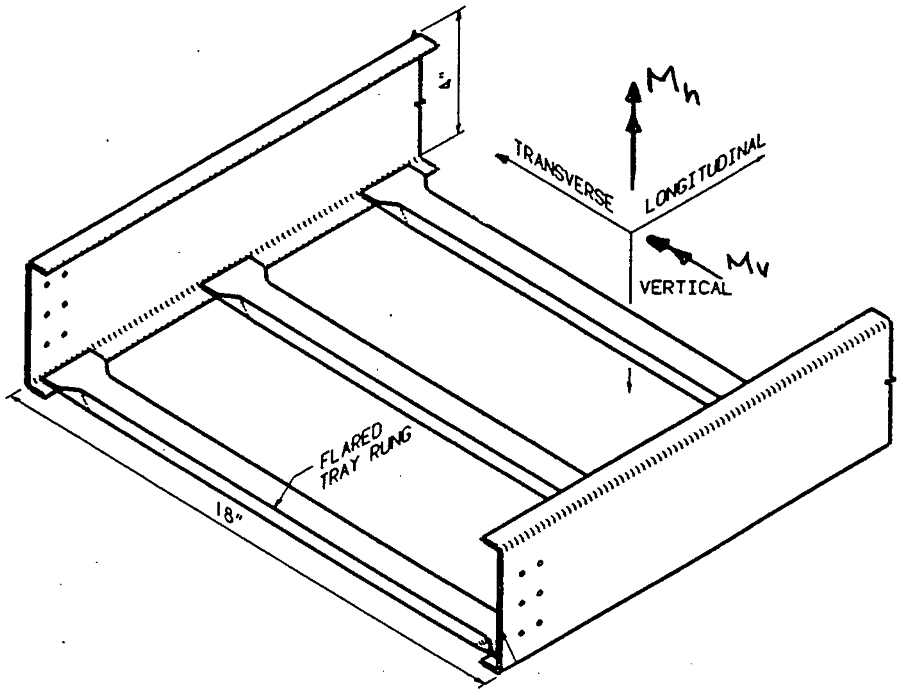


Figure A

M_h is the bending moment due to loads in the transverse direction.

M_v is the bending moment due to loads in the vertical direction (out of the plane of the tray).

2. Basis for data points plotted in Figure 1?

The following table provides references for each of the test data points shown in Figure 1.

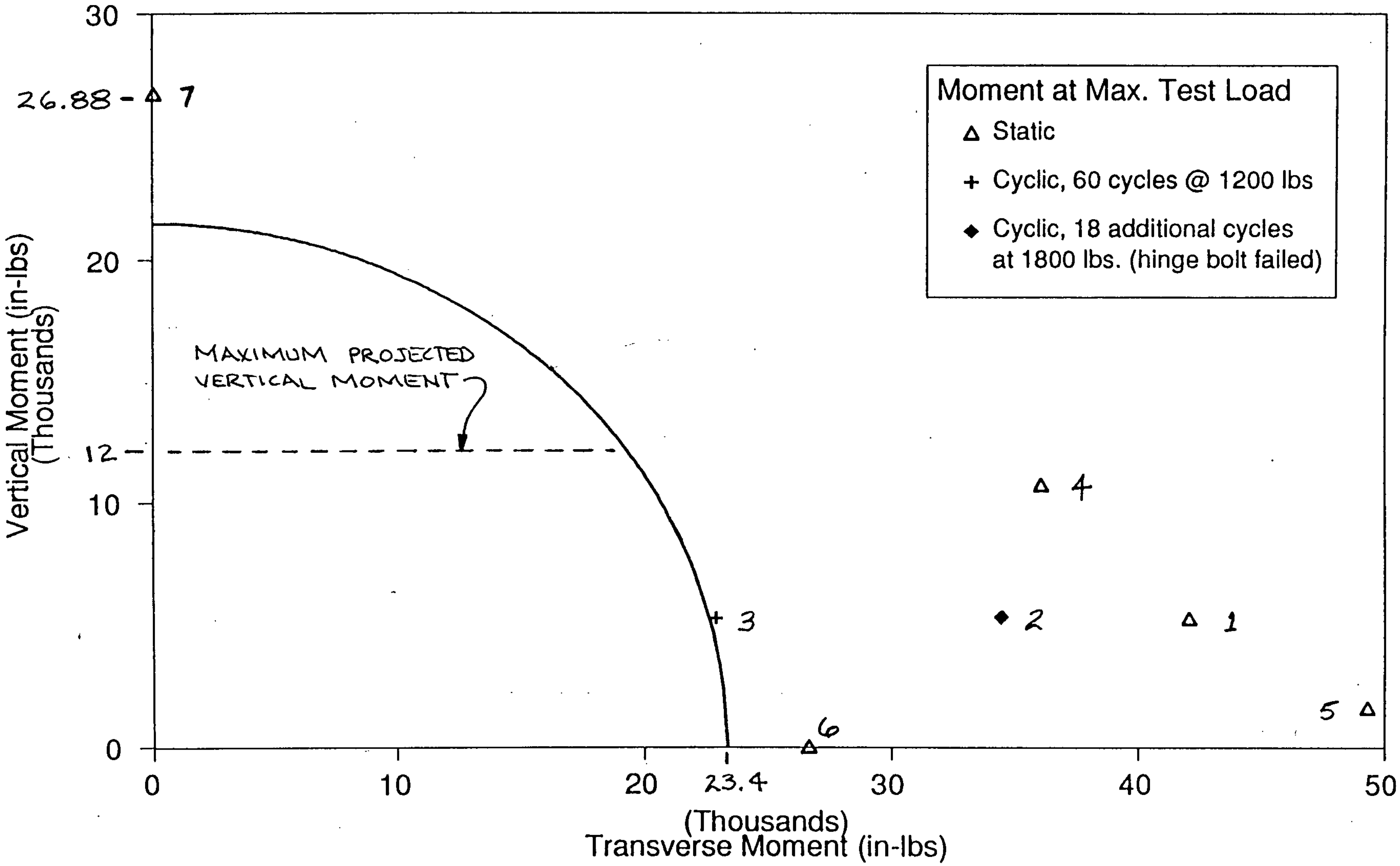
Point	Reference#	Load Transverse/Vertical (total lbs/ lbs/ft)	
1	1, Table 1	2199/70	static
2	1, Table 2	1800/70	cyclic transverse
3	1, Table 2	1200/70	cyclic transverse
4	2, Table 1	1885/140	static
5	2, Table 2	2827/70	static
6	3, Page 1	1470/0	static
7	4, Page 1	0/280	static

Remarks:

1. Point 3 corresponds to 60 cycles at 1200 pounds (push/pull) of transverse load (no failure), after which the load was increased to 1800 pounds, shown as point 2 and cycled for 18 additional times.

2. At points 1 and 2, riser connector hinge bolt failed. At points 4, 5, and 7 significant flexural deformations developed in the siderail at the loads given. At point 6, vendor-supplied tray hold-down clips yielded (new structural angle connector now implemented) and test was stopped; the tray did not fail.

FIGURE 1. **Allowable Transverse Moment and Vertical Moment Interaction**



MOMCRIT.DRW 50054-01 1/23/91

3. How is the moment-interaction equation validated for bi-axial bending for cases with high vertical moment, cases for which test data is lacking?

Based on a review and screening of cable tray routings in the plant, the highest vertical moment expected to occur in combination with horizontal moments is approximately 12,000-inch-pound (Figure 1).

Based on the margins available between this value of vertical moment (12,000-inch-pound) and the maximum value reached in the tests (26,880-inch-pound), and the demonstrated ductile behavior of tested cases with significant horizontal moment at similar vertical moment capacity (for example test point number 4), we concluded that the present interaction equation for the expected level of vertical moment is acceptable.

Evaluation of a vertical tray section does not involve the moment interaction formula as the two dimensional earthquake to be considered will only cause either the transverse or the vertical bending moment in the tray, but not both concurrently. In these cases, either of the bending moments is compared with the corresponding allowable moment. The same argument also applies to nonvertical riser sections.

4. FSAR update.

The FSAR will be updated to clarify the definition of the transverse and vertical moments as shown in response to question number 1.

5. Consideration of shear and torsion in trays?

The cable tray loading used in the tests caused bending moments and shear forces in both transverse and vertical directions in a fashion very similar to what would be caused by seismic loading. Consequently, the allowable moment interaction formula derived from the test results reflects both the bending and shear effects.

All tray supports at WBN are of structural steel construction and very stiff against rotation around the tray longitudinal axis (especially relative to the rotational stiffness of a tray). Consequently, trays are constrained against rotation at all support points and there is insignificant torsion due to support rotation.

The loads that generate major stresses in cable trays, i.e., the dead and seismic loads, cause only negligible torsional effects in typical cable tray configurations. In a configuration where a riser section connects to horizontal tray sections, the horizontal sections are subject to some torsion. Such configurations were tested in the test programs documented in Reference 1 and 2, and therefore, the torsional effects are covered by the moment interaction criteria developed based on the tests. Other configurations subject to some torsion include horizontal and vertical elbows. However, the torsional effects present are secondary in nature and have been shown to be insignificant.

6. How are stresses in trays due to differential motion of flexible supports addressed?

WBN cable tray supports are very stiff and every support provides three way support for the tray. Consequently, tray stresses due to differential support motion are insignificant.

The effects of the differential support point motion due to seismic differential building motion have been addressed in the Shakespace task of the Integrated Interaction Program to ensure sufficient flexibility exists in the tray and support arrangements.

7. How are DBA and thermal loads addressed?

Thermal expansion in cable trays is accommodated by expansion capability in the tray and support connection hardware without exceedance of allowable stresses.

DBA impulse loads to attachments to the steel containment are expressed in terms of response spectra similar to seismic response spectra, and accordingly, are evaluated similar to seismic loads.

REFERENCES

1. Watts Bar Nuclear Plant, Cable Tray Riser Qualification Program, Full-Scale Cable Tray Sections, CVB-86-1, March 18, 1986.

2. Sequoyah Nuclear Plant, Cable Tray Riser Qualification Program, Full-Scale Cable Tray Sections, CVB-85-4, December 20, 1985.

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