TENNESSEE VALLEY AUTHORITY
CHATTANOOGA, TENNESSEE 37401
400 Chestnut Street Tower II

December 1, 1982

Director of Nuclear Reactor Regulation
Attention: Ms. E. Adensam, Chief
Licensing Branch No. 4
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Ms. Adensam:

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

By letter dated September 23, 1982 from T. M. Novak to H. G. Parris, TVA was provided with a list of concerns resulting from an April 1982 audit of Watts Bar Nuclear Plant. Enclosed is additional information to resolve the concerns of the NRC Seismic Qualification Review Team.

If you have any questions concerning this matter, please get in touch with D. P. Ormsby at FTS 858-2682.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

L. M. Mills

L. M. Mills, Manager
Nuclear Licensing

Sworn to and subscribed before me
this 1st day of Dec. 1982

Bryant M. Lowery
Notary Public
My Commission Expires 4/8/86

Enclosure
cc: U.S. Nuclear Regulatory Commission
Region II
Attn: Mr. James P. O'Reilly, Regional Administrator
101 Marietta Street, Suite 3100
Atlanta, Georgia 30303

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ENCLOSURE

WATTS BAR NUCLEAR PLANT UNITS 1 AND 2
SEISMIC QUALIFICATION REVIEW TEAM AUDIT

CONTENTS

1. Ice Condenser Intermediate Deck Doors
2. Reactor Trip Switchgear
3. Reactor Protection System Cabinet
4. Engineering Safeguards Cabinet
5. Pressurizer Safety Valve
6. Charging/Safety Injection Pumps
7. Boric Acid Filter, Transfer Pump
8. Power Range Neutron Detector
9. Control Rod Drive Mechanism
10. Main Control Panel
11. Electrical Penetrations
12. 125 V DC Vital Batteries
13. Diesel Generator Control and Protection Relay Panel
14. Metal Clad Switchgear
15. Battery Rack
16. Duplex Alarm Relay/Sum and Difference Amplifier
17. Main Steam Isolation Valve
18. ERCW Pump
19. Diesel Combustion Air Intake Filter
20. Control Damper, Motor Operated
21. Emergency Generator Starting and Control System Contractor: Barksdale Pressure Switch/Square D Relays
22. Spent Fuel Pit Crane (Fuel Handling Machine)

Generic Concerns

GC.1 Single Axis, Single Frequency Testing
GC.2 Use of Damping Values
GC.3 Peak Broading in the Test Response Spectra or Required Response Spectra
GC.4 Field Installed Mounting Versus Qualification Test or Analysis
GC.5 Nozzle Load Exerted on Safety Related Equipment

WATTS BAR NUCLEAR PLANT UNITS 1 AND 2
SEISMIC QUALIFICATION REVIEW TEAM AUDIT

1. Ice Condenser Intermediate Deck Doors

No outstanding action items.

2. Reactor Trip Switchgear

2.1 Question:

The cabinet was mounted to the test table using 3/8 inch bolts, while the installed cabinet was mounted using continuous welds along the front and back edges. Demonstrate that the field mounting is at least as adequate as the test mounting (Generic consideration).

Response:

See response to Generic Concern 4.

2.2 Question:

A box-shaped cable support beam that extends downward from the floor above contacts the cabinet near its top. Explain whether the contact with this beam affects the qualification of the cabinet.

Response:

The observed contact between the cable tray support beam and the reactor trip switchgear is not consistent with the seismic qualification of either the switchgear or the cable tray/support configuration. TVA installation of such equipment typically provides a minimum of 1.0 inch clearance (lower with justification) for relative motion due to seismic excitation. This situation will be corrected, prior to fuel loading, to provide for adequate clearance for seismic response motion without impact between the equipment and cable tray support.

2.3 Question:

There is no peak broadening in the test response spectra (TRS) or required response spectra (RRS). Justify the acceptability of a narrow response spectrum peak. (Generic consideration)

Response:

In response to this item, Westinghouse has peak broadened the RRS provided by TVA in accordance with TVA requirements (10% broadening). The broadened RRS has been compared with TRS. Based on this comparison, the TRS envelopes the RRS with the exception of a small area between 4.8-5.2 Hz. This is acceptable since there are no natural frequencies in the 4.8-5.2 Hz range.

A copy of the broadened RRS and the comparison of the TRS and RRS is contained in the revised SQRT Form (Attachment 2.3-1). It should be noted that it is not considered appropriate to peak broaden the TRS.

2.4 Question:

Explain how damping was considered in this qualification for both OBE and SSE seismic input.

Response:

See the response to Generic Concern 2.

3. <u>Reactor Protection System Cabinet</u>

3.1 Question:

Demonstrate that field mounting is at least as adequate as test mounting. (Generic consideration)

Response:

See response to Generic Concern 4.

3.2 Question:

Evaluate how qualification is affected by the close mounting of cabinets.

Response:

NRC's site audit observation was that 'the cabinet is mounted approximately 1/4 inch to 3/8 inch from the adjacent safeguards test cabinet.' TVA concurs with the NRC concern regarding the possibility of impacting between adjacent items of equipment due to seismic response motion. For the subject cabinets this possibility would represent an unacceptable situation.

SSE repsonse motion calculations have been performed for both the reactor protection system cabinet and the safeguards test cabinet which show that a minimum clearance of 1/2 inch between the cabinets is required to ensure that impacting will not occur. TVA will recheck the cabinets installation to verify existing clearance, and will adjust the cabinets mounting as required to ensure that clearance between the cabinets is no less than the 1/2 inch minimum required.

3.3 Question:

Provide an evaluation of the degree of amplification in response incurred by the cabinet during tests to more clearly justify single frequency testing.

Response:

See the response to Generic Concern 1. The RRS provided by TVA has been peak broadened by Westinghouse by 10 percent. A comparison of the RRS and TRS demonstrates that the TRS envelopes the RRS. The broadened RRS and the subject comparison are included in the revised SQRT Forms (Attachment 3.3-1).

4. Engineered Safeguards Test Cabinet

4.1 Question:

Demonstrate that field mounting is at least as adequate as test mounting.

Response:

See response to Generic Concern 4.

4.2 Question:

Evaluate how qualification is affected by the close mounting of cabinets.

Response:

See response to Item 3.2.

4.3 Question:

Provide an evaluation of the degree of amplification in response incurred by the cabinet during tests to more clearly justify single frequency testing.

Response:

See the response to Generic Concern 1. The RRS provided by TVA has been peak broadened by Westinghouse by 10 percent. A comparison of the RRS and TRS demonstrates that the TRS envelopes the RRS. The broadened RRS and the subject comparison are included in the revised SQRT Forms (Attachment 4.3-1).

5. Pressurizer Safety Valve

No outstanding action items.

6. Charging/Safety Injection Pumps

6.1 Question:

Perform a detailed analysis on the suction nozzle connection using an approach appropriate for the nozzle geometry.

Response:

Based on the Pacific Pump and Westinghouse review of the design reports identified on the SQRT Form previously provided to the NRC, the Bijlaard technique was not used for the analysis of the pump suction nozzle. The pump suction nozzle was analyzed in accordance with the requirements of the ASME Code, Section III, Appendix A-2212. It should be noted that the Bijlaard technique was used to analyze the discharge nozzle. The geometry of the discharge nozzle does lend itself to analysis using Bijlaard techniques.

6.2 Question:

Provide a comparison between nozzle loads used in the pump analysis and those obtained from piping analysis. (Generic consideration)

Response:

The most recent CVCS piping system analysis results showed the piping loads imposed on the charging pumps exceeded the pump vendor's (Westinghouse) defined nozzle loads limit criteria. The piping analysis loads were transmitted to Westinghouse with the request to assess the impact, if any, upon the qualification of the pumps. TVA was subsequently advised by Westinghouse that the revised nozzle loads for the pumps are acceptable.

7. Boric Acid Filter, Transfer Pump

No outstanding action items.

8. Power Range Neutron Detector

No outstanding action items.

9. Control Rod Drive Mechanism

9.1 Question:

The qualification documentation did not identify load combinations used. Identify all load combinations, such as seismic plus Loss-of-Coolant-Accident (LOCA), and explain how responses were combined.

Response:

As identified in the Watts Bar FSAR, all appropriate loading combinations are considered for the CRDMs. Specifically, for the faulted condition Westinghouse includes LOCA, SSE, and dead weight loads in their analysis. The LOCA and SSE loads are combined by the square-root-sum-of-squares method and this resultant is added absolutely with the deadweight loads. The enclosed SQRT Form (Attachment 9.1-1) has been revised to reflect the above information.

9.2 Question:

Verify that the Westinghouse response spectra envelope the Watts Bar floor-level response spectra.

Response:

As described in Note 2 of the CRDM SQRT Form (Attachment 9.1-1), Westinghouse performed a generic stress analysis to determine allowable moments. Westinghouse then performed a specific plant analysis using specific Watts Bar response spectra (not generic spectra) to determine specific plant moments. As noted on the SQRT Form, the specific plant moments are enveloped by the allowable moments thus demonstrating qualification of the CRDM's for Watts Bar.

9.3 Question:

Compare natural frequencies identified during pluck test on the CRDM with calculated natural frequencies.

Response:

Vibration tests were performed on the Westinghouse Model L-105 full length CRDM as documented in References 1 and 2. Reported first mode frequencies for the L-105 ranged from 6.51 Hz to 10.08 Hz, depending on the head adaptor length (the lower frequency corresponding to the longer adaptors). A second mode at 27.5 Hz was also reported. These frequencies were higher than calculated for the L-106A since the L-105 is shorter by about two feet. Taking into account the differences between the L-105 and L-106 the correlation between available test results and calculations for the L-106 model are reasonable. As described below, potential differences in natural frequencies have been accounted for in the analysis.

To account for the differences in the frequencies between the test results and analytical results for the longest CRDM, the following procedure was used. (The longest CRDM is the CRDM with the greatest seismic loads.) The longest CRDM first test frequency is 6.66 Hz, while the analytical result was 4.26 Hz.

By examining the attached enveloping response spectra, all the CRDM's had the same input acceleration value at their first frequency, except for the longest CRDM. To account for this, the seismic loads on the longest CRDM were ratioed upward. The ratio used as the peak horizontal acceleration value divided by the acceleration value used in the original analysis at 4.26 Hz. Thus, the difference in the test frequencies and analytic frequencies is accounted for.

1. Obermeyer, F. D., 'Effective Structural Damping of the KEP L105 Control Rod Drive Mechanism,' WCAP-7427, January 1970. (Westinghouse Proprietary)

2. Obermeyer, F. D., WCAP-7427, Addendum 1 to reference (1) above, December 1970. (Westinghouse Proprietary).

10. Main Control Board

10.1 Question:

The analysis was performed assuming the panel to be fixed at its base. An inspection revealed that the panel is attached to the floor with spot welds along the inside edge only of an angle-shaped member at the base of the panel. The freedom of the outside edge of this member could introduce flexibility into the base-to-floor attachment. Evaluate by test or analysis whether the installed attachment is adequately fixed.

Response:

TVA has performed an analysis to evaluate the flexibility effects of the base mounting angle as installed upon the specified natural frequency of the control room panels as seismically qualified by Westinghouse. The demonstration analysis was based on panel test data provided in the Westinghouse prepared main control panel SQRT forms. The critical axis, relative to the panel is logically the front/back direction; the lowest natural frequency in this axis as 21.1 Hz.

The flexibility of the base angle (as installed with intermittent welds along the inside edge only) was computed and transformed into an equivalent torsional spring at the base of the panel. The additional flexibility of this base spring was considered to act in series with flexibility inherent in the 21.1 Hz panel natural frequency. The effect of adding the base angle flexibility was to reduce the panel natural frequency of 21.1 Hz to 19.7 Hz. This minor frequency shift is well within the accuracy of seismic qualification testing.

10.2 Question:

There is no peak broadening in the TRS or RRS. Justify the acceptability of a narrow response spectrum peak.

Response:

Westinghouse utilized the TVA response spectra to perform the dynamic seismic analysis of the Watts Bar Main Control Board. The spectra used by Westinghouse were not broadened. Westinghouse has evaluated the effect of the broadened spectra on the analysis and determined that there is no impact. Specifically, the natural frequency of the control board does not coincide with response spectra peaks, therefore, peak broadening would not impact the control board stresses. Additionally, as noted during the plant audit, there is considerable margin between the actual and allowable stresses.

11. Electrical Penetrations

11.1 Question:

A comparison of site specific RRS with the TRS showing adequate enveloping of the RRS by the TRS.

11.2 Question:

A satisfactory response as to which one of the SSE levels was used for comparison.

Response (11.1 and 11.2):

The electrical penetrations installed at Watts Bar Nuclear Plant were seismically qualified by Conax Corporation's generic program. The required response spectra from their generic program are shown on the attached graphs (Figure 11.2-1 and 11.2-2) together with the floor response spectra applicable to the Watts Bar installation. It is apparent that the Conax generic criteria adequately envelopes the Watts Bar installation requirements.

It might be noted that the Conax generic crtieria reflects a factor 1.5 between the OBE response spectrum and the SSE spectrum while the Watts Bar requirements reflect a factor of 2.0. Since each of the Conax spectra envelopes the corresponding Watts Bar installation required spectrum, the difference in factor between OBE and SSE has no particular significance other than margin of conservatism.

12. 125 V dc Vital Batteries

12.1 Question:

Explain what surveillance programs will be instituted to maintain the seismic capability of the vital batteries throughout plant life.

Response:

The attached field inspection procedure (Attachment 12.1-1) requires a detailed annual inspection. Any observed indication of degradation of any sort, functional or structural, will be noted, evaluated, and corrected as appropriate.

12.2 Question:

Verify that all batteries will have spacers installed as they did during qualification tests.

Response:

Spacers between battery units have not yet been installed in the 125V dc vital battery assemblies as required by installation drawings and as would be required for compatability with the qualification test configuration. Spacers will be installed prior to fuel loading.

During the seismic audit, this concern was expressed as a generic comment applicable to all similar battery assembly configurations. The only other similar battery is the emergency diesel generator battery assembly. It has been verified that the spacers between battery units are already in place in the DG battery assemblies.

12.3 Question:

The TVA specification for bid required positive anchorage of the battery cells which was accepted by the vendor. Explain whether the vendor was given a release from this requirement.

Response:

The WBN battery specification (reviewed during the plant audit) does not require that the battery cells have hold-down hardware. It does require in paragraph D.3.a(3) that 'all battery cells shall be anchored or fastened in such a way that they will remain in place when friction is assumed nonexistent. If side and end rails are used, they shall be arranged to prevent cells from jumping over or slipping between the restraining rails and bottom support rails.'

It was determined during previous seismic testing of similar vital battery assemblies that side and end rails were sufficient restraint if located above the center of gravity of the battery. This restraint design configuration was employed by the vendor for the WBN installation. The seismic test of the WBN configuration verified that this method of restraint is seismically acceptable.

13. <u>Diesel Generator Control and Protection Relay Panel</u>

13.1 Question:

Provide a comparison between a RRS and the TRS and justify adequacy of the single frequency input motion.

Response:

Seismic testing of the diesel generator control and protection relay panel was accomplished in January 1975 in accordance with TVA's criteria implementing the procedures of IEEE 344-1971.

Testing at SSE levels was conducted as a series of single frequency (sine beat, 10 cycles per beat) tests at frequencies throughout the 1-33 hertz range, specifically including tests at all equipment natural frequencies noted during the sine sweep resonance search tests. The required input acceleration level was the zero period acceleration (ZPA) of the applicable SSE floor response spectrum.

This test program can also be shown to satisfy the test procedures of IEEE 344-1975 with a considerable degree of conservatism. With regard to the consideration of multifrequency test input motion, the fundamental requirement is that the TRS must envelop the RRS or applicable portions thereof with a peak input acceleration no less than the ZPA. Depending on the dynamic characteristics of the equipment being qualified, the applicable portion (most critical portion) of the RRS may or may not include the frequency range of the response spectrum peak. The most critical portion of the response spectrum is that frequency range which includes the natural frequency or frequencies of the equipment. Test data from a number of equipment response accelerometers has established the relay panel natural frequencies as follows:

Longitudinal (side/side) -- 17.5 hertz
Lateral (front/back) -- 14, 25, and 30 hertz
Vertical -- rigid

The TRS/RRS comparison plots (Figure 13.1-1 and 13.1-2) illustrate that in the frequency range of equipment lowest natural frequency and above, the TRS envelopes the RRS with a large margin of conservatism. In its longitudinal (side/side) axis, the panel was found to have a single natural frequency at 17.5 hertz. At this most critical frequency, the TRS acceleration is 13.3 g compared with the RRS value of approximately 1.6 g; conservative by a factor of 8.3. The lateral (front/back) axis was found to have three natural frequencies 14, 25, and 30 hertz. The following table lists, for several test frequencies, the TRS and RRS acceleration values at the equipment natural frequencies. This data clearly shows the adequacy of the series of single frequency tests as satisfying the qualification requirements, including the consideration of multiple mode excitation and interaction.

Acceleration Ratios - TRS/RRS

Test Frequency	Panel Natural Frequency 14	25	30
14	13.3/3.2	1.7/1.3	1.4/1.15
16	6.0/3.2	2.1/1.3	1.7/1.15
25	---	13.3/1.3	4.0/1.15
30	---	3.7/1.3	14.5/1.15

In addition, to the consideration of test enveloping at observed natural frequencies, TVA's criteria for single frequency testing recognizes the possibility of there being other localized critical frequencies which are not detected during testing. (In view of the number and distribution of response accelerometers used in the relay panel test, the possibility of undetected critical frequencies is considered remote.) The SSE test series for the relay panel included test frequencies throughout the 1-33 hertz range at approximately 1/2-octave increments which adequately cover this possibility.

13.2 Question:

Explain the consequence of the observed relay chatter.

Response:

During seismic testing of the diesel generator relay board, each different type of relay was monitored for electrical continuity. Relay chatter was observed in only one circuit (#46). This anomoly was evaluated by both the equipment vendor and TVA as a part of the qualification test review and found to be of no concern to appropriate safety functionality of the equipment. The relay exhibiting the chatter is used only during testing phases of the diesel generator system and cannot prevent proper operation of the diesel generator system during or after a seismic event.

13.3 Question:

Demonstrate that all relays (including differential relays) will be functional in both the open and closed positions.

Response:

Seismic qualification testing of diesel generator relay board included an extensive program for the verification of appropriate electrical functionality in all possible modes of operation (i.e., relays in both the open and closed positions). Detailed functional test procedures were provided to TVA in separate correspondence which was referenced in the Wyle Laboratories test report. (The Wyle Laboratories test report was reviewed by the NRC at the time of the audit, however, the subject ocrrespondence was not available at the audit.) The subject correspondence is attached (Attachment 13.3-1) and paragraph 3.3 of the procedure defines the functional monitoring program which was performed during seismic testing. No functional anomalies critical to appropriate operation of the relay board were observed.

13.4 Question:

Demonstrate that field mounting of the panel is at least as structurally sound as lab mounting.

Response:

The DG relay panels are provided by the vendor with a removable channel base. The channel is attached, bolted, to an angle at the base of the panel and is considered an integral part of the relay panel assembly. For seismic qualification, the test report states: 'The test specimen (including base sill channel) was bolted to a steel plate which in turn was welded to the seismic test machine.'

TVA's installation is in accordance with vendor-supplied drawings. The base sill channel is welded to embedded plates and grouted in place. The relay board is in turn bolted to the channel. By inspection, the field mounting is at least as structurally adequate as the test mounting. For this installation, the assembly dynamic characteristics will be dictated by the flexibility inherent in the equipment panel, and its bolted attachment to the base sill channel. This area of the assembly installation mounting is identical to the tested configuration.

14. <u>Metalclad Switchgear (6900 V)</u>

14.1 Question:

To complete qualification of this item the applicant was requested to describe the mounting method used during testing and to show that field mounting is at least as structurally sound as test mounting.

Response:

Wyle Laboratories test procedure No. 541/3400/ES states that '. . . specimen will be attached using ten 1/2'-13 commercially available bolts, nuts, and washers.' Although this definition of the attachment configuration was not specifically related in the test report, No. 427868-1, (provided for review during SQRT audit) it has been confirmed through direct contact with Wyle personnel that this was indeed the test mounting configuration.

TVA drawing No. 45W247-1 R15, and GE drawing No. 0123D3645 illustrate the bolted attachment configuration. Field inspection of the installed configuration has verified installation per these drawings.

The equipment attachment configuration for qualification testing was in fact representative of the installed configuration.

During the seismic audit, TVA was asked (informal question) for any additional data which might exist relative to the definition of equipment assembly natural frequencies.

In an effort to respond to this informal question, the GE engineer involved in the switchgear test program was contacted. He was asked if there was any additional information (e.g., his own engineering notes) regarding equipment natural frequencies beyond that contained in the seismic test report. He was unable to provide additional information. The transmissibility plots included in the test report, pages 40 through 51, are the best indication of equipment dynamic characteristics, including natural frequencies.

Major assembly natural frequencies, as indicated by the transmissibility plots are:

side/side - 3.2 Hz
front/back - 10 Hz

15. Battery Rack

No outstanding action items.

16. Duplex Alarm Relay/Sum and Difference Amplifier

No outstanding action items.

17. Main Steam Isolation Valve (MSIV)

17.1 Question:

Provide nozzle loads and compare these to allowable values for the attached piping. (Generic consideration)

Response:

The Watts Bar MSIVs are seismically qualified based on the extensive generic program of testing and analysis performed by the valve manufacturer, Atwood and Morrill. This program included a series of tests to demonstrate valve operability while subjected to the combined effects of valve actuator seismic loads, attached piping nozzle loads, and internal pressure. Actuator seismic loads and nozzle loads were applied statically. This test qualified the valve for simultaneous application of:

Internal pressure	-- 1244 psig
Nozzle loads	-- Yield stress in attached piping.
Test values	-- $M = 1.967 \times 10^6$ ft lb $P = 1.0 \times 10^6$ lb
Actuator seismic loads	-- 3.0 G each direction (5.8 g resultant)
Test value	-- 29,900 lb applied at operator CG

TVA's piping analysis allowable loads criteria is such as to ensure that the MSIV nozzle loads qualification level is not exceeded. The stress in the attached piping is, by criteria, limited to less than 0.76 yield stress. From the piping analysis, the actual loads in the attached piping at the MSIV interface are found to be significantly less than that permitted by the piping stress allowable criteria.

The degree of margin between the imposed piping loads and the MSIV qualification limits is best indicated (qualitatively) by a comparison of interface bending moments. The maximum seismic bending moment imposed by the piping on any of the MSIV interfaces was found from analysis results to be 0.7292×10^6 ft-lb, as compared with the maximum MSIV qualification test bending moment of 1.967×10^6 ft-lb.

17.2 Question:

Provide maximum g levels at the valve location as obtained from piping analysis results.

Response:

As discussed in the response to Item 17.1, the MSIV generic qualification program included the consideration of 3.0 g seismic loading in each of three mutually perpendicular axes, 5.8 G resultant loading. TVA's main steam piping analysis criteria includes a seismic acceleration limit of 3.6 g resultant; the piping analysis model includes representation of the MSIVs. This criteria ensures that seismic qualification limits of the valves will not be exceeded in the installed configuration.

As in the case of nozzle loads, the maximum acceleration values from the piping system analysis are significantly less than the criteria allowable. The maximum seismic acceleration on any of the MSIVs was found from the analysis results to be 2.68 g resultant.

17.3 Question:

Describe tests performed on the 32-inch MSIV and explain how these assure operability of the valve under Watts Bar seismic conditions.

Response:

The Watts Bar MSIVs have been subjected to an extensive program of testing and analysis to ensure seismic qualification and operability under all required loading conditions. The following is a summary of, in TVA's view, the most significant aspects of A&M's program.

Seismic Test of MSIV Control Panel

Reference: Environmental Test Laboratory, 'Seismic Qualification Test Report - 32-In. MISV Control Panel for Atwood and Morrill Company, Incorporated' dated 5/19/77.

The control panel is rigidly attached to the valve actuator assembly. The panel was subjected to low level (0.3 g) sine sweep resonance search test in each principal axis. Testing was performed up to 50 hertz; the panel was found to be rigid (fn greater than 33 Hz). Seismic qualification to SSE levels was accomplished as a series of single frequency, 30-second, sine dwell tests with an input acceleration level of 3.0 g. Testing was performed at approximately 1/2 octave increments up to 36 hertz in each principal axis. A 12-stop valve operational procedure was performed with each test. No structural or functional degradation occurred as a result of the seismic test conditions.

Seismic Test of MSIV Actuator

Reference: American Environments Company Report STR-060578-1, 'Nuclear Qualification Test Report on MISV Air Spring Actuator for Atwood and Morrill Company, Incorporated' dated 10/23/78.

The referenced test program subjected the full scope of environmental and seismic conditions on a 26-in. MSIV actuator assembly. The seismic portion of the test program included:

Resonant Frequency Search - The actuator assembly was subjected to a low level (0.3 g) sine sweep resonant search test in each principal axis. Testing was performed up to 50 hertz; the actuator assembly was found to be rigid (fn greater than 33 Hz). The lowest significant resonance of the actuator was found to be approximately 36 Hz.

Dynamic Shake Table Test - Functional appurtenances, i.e., limit switch assemblies and air manifold assembly components, were subjected to dynamic seismic simulation testing. The components were subjected to 30-second sine dwell tests at each integer frequency in the range of 1 to 35 hertz. The input was applied to the horizontal and vertical axes simultaneously, in phase, at an angle of 34 degrees from the horizontal. The test series was repeated in each of four orientations, each time rotating the equipment 90 degrees about the vertical axis. Testing was performed with an input acceleration level of 14.4 g (12 g horizontal/8 g vertical) to the limits of the dynamic test equipment capability. Operability of the components was verified throughout the testing program.

Static Seismic Simulation Test - The actuator assembly was subjected to static seismic loading test. A load of 46,080 pounds (46,080 = 14.4 g times 3,200 pounds) was applied through the actuator center of gravity along an axis perpendicular to the valve actuator stem centerline. The actuator was operated a minimum of once per load application (five times total) from fully open to fully closed and returned to fully open.

No structural or functional degradation occurred as a result of any of the above testing.

Pipe End Load/Static Bend Test

Reference: Atwood and Morrill Company Report 44, 'Closure Testing of a 32-In. MSIV Under Pipe and Seismic Loading' dated 5/9/77.

The discussion of this test program, including test load parameters, and their significance to TVA's MSIV seismic qualification is provided in the response to questions 1 and 2. This test program was observed by A&M's MSIV customers from throughout the industry, both domestic and international. A TVA representative was present throughout the test program. Testing to levels significantly in excess of TVA's qualification requirements was accomplished with no evidence of structural or functional degradation.

Sonic Flow Test of a MSIV

Reference: Atwood and Morrill Company Test Report 43, 'Performance Testing of a 26-In. MSIV During Simulated Guillotine Break Conditions' dated 5/9/77.

A series of flow tests was performed on an MSIV to demonstrate its ability to close under flow conditions associated with a guillotine break in the connected steam flow lines. The program included testing in both the forward and reverse flow directions. Testing was performed on a 26-in. MSIV, modified to model a 32-in. MSIV. The tests were conducted at the U.S. Naval Ship Engineering Center at the Philadelphia Navy Base.

The blowdown type test consisted of the sudden release of a controlled pressurized volume of nitrogen to produce sonic flow conditions through the valve. Since the maximum flow velocity in the test system is controlled by the sonic velocity of the fluid, no adjustment could be made for differences between steam flow and nitrogen flow. Nitrogen has a lower sonic velocity than steam, but, since it is considerably more dense, the mass flow rate at sonic velocity is about twice that of steam.

The flow rates through the test valve were approximately 20 x 10^6 lbs/hour of nitrogen as compared to 12 x 10^6 lbs/hour steam flow. The thrust due to the jetting gas is also a factor; steam thrust has been calculated to be approximately 480,000 lbs and nitrogen 430,000 lbs (using thrust = V^2A/g). The behavior of both gases is approximately the same since both act as perfect gases at the temperature and pressure used during testing.

The method of gas supply, as mentioned was from a controlled volume of nitrogen, allowed to escape through the valve. For this reason, the system pressure decreased exponentially rather than maintaining a constant 900-1000 lb/in^{2}g pressure in the valve, expected in an actual power plant. This was compensated to some extent by starting with an initial pressure higher than the normal design pressures (up to 1300 lb/in^{2}g). In the final test runs, the system pressures after valve closure were 750 lb/in^{2}g for test 5 and 650 lb/in^{2}g for test 4, sufficiently high to adequately represent actual conditions.

The test program was accomplished with no evidence of structural or functional degradation of the valve. The test report concluded that:

> The most significant principle demonstrated by the series of reverse flow tests is that the motion of the poppet is independent of fluid flow . . . Based on the performance of the 26-inch MSIV, it can be concluded that closure of the 32-inch valve is defined by the set speed of the air cylinder metering valves.

18. <u>ERCW Pump</u>

18.1 Question:

To assist in completion of our review the applicant was requested to perform an evaluation of the effects of impact loads due to nonlinear supports along the pump column.

Response:

The matter of impact loading between the 'down-hole' portion of the pump and the pump supports has been the subject of considerable technical discussions among TVA, the questioning auditor, and the pump vendor consultant analyst. The following is a summary of those discussions.

The original seismic qualification analysis of the pump did not address the consideration of impact loading. It was the technical opinion of the analyst, with TVA concurrence, that although impacting would probably occur under seismic loading, it does not represent a concern to pump functionality. This decision was based primarily on two factors.

1. The maximum possible clearance between the pump outer casing and the 'down-hole' supports is 3/8 inch. This small amount of gap will prevent the pump from developing significant kinetic energy at impact.

2. The pump design configuration is such that impact at the outer casing will not jeopardize pump functionality. The pump design has, in effect, assumed the possibility of impacting between the pump impellar and the casing. To eliminate any concern in this regard, bronze wear rings are located on the pump casing at the point of potential contact.

These two factors alone have been judged by TVA to be a sufficient basis to eliminate the question of impacting from concern. In response to a specific request from TVA, the pump vendor has performed an evaluation of impact loading which has been provided to TVA. TVA concurs with this evaluation to the extent that even with an ultra-conservative analysis, impacting is shown to be no concern to pump operability.

A copy of the pump vendor's analysis is attached (Attachment 18.1-1).

19. <u>Diesel Combustion Air Intake Filter</u>

19.1 Question:

The qualification report for this item was not available at the plant audit. The applicant was requested to submit the qualification documents for review.

Response:

A copy of the American Air Filter Company Report No. PEP 574, 'Seismic Analysis of P01-54 Zycoil (Filter),' dated February 19, 1974, is attached (Attachment 19.1-1). In reviewing this analysis for qualification of the filter for Watts Bar installation, it will be noted that the applied static loads are not sufficiently high to envelope the applicable floor response spectrum (Figure 19.1-1) peak acceleration. In order for the analysis to be acceptable, the lowest natural frequency must be greater than the frequency range of response spectrum peak acceleration. In the original evaluation, the premise of equipment rigidity was accepted by TVA based on engineering judgment. The judgment was based on inspection of the filter assembly which incorporated the addition of 4 x 4 x 3/8 angle vertical stiffeners to the standard filter design.

This judgment is still considered valid. Supplementary calculations (Attachment 19.1-2) which include simplified, conservative, natural frequency computations are also attached.

The total calculation package provides clear demonstration of the equipment capability to withstand SSE loading conditions, with a considerable margin of safety.

21. Barksdale Pressure Switch/Square D Relay

21.1 Question:

Details of the biaxial tests and the items involved in them.

21.2 Question:

A satisfactory justification of the single axis, single frequency tests in the presence of the magnification frequencies.

Response (21.1 and 21.2):

Barksdale Pressure Switch--The Barksdale pressure switch (as reported in Wyle Laboratories report No. 42749) was subjected to the following test procedure:

Test Series 1

Resonant search - Low level, 1-33 Hz

Three individual axes - Sine beat tests at observed resonant frequencies, 3 g input in each horizontal and 1 g input in the vertical axes independently.

Biaxial tests - Sine beat tests at resonances, 1.5 g vertical/1.5 g horizontal simultaneously. Test specimen re-oriented and test repeated in the vertical and second horizontal axis simultaneously.

The following is a summary of data from the biaxial test results.

		Input Accel	
Test Axis	Freq	Horiz	Vert
Vert/S-S	5	2.40	3.20
	27	1.80	1.66
Vert/F-B	7	2.10	2.40
	12	1.70	1.84
	33	1.80	1.80

For installation in the diesel generator building, single frequency testing is within the guidelines of IEEE-344, 'Seismic ground motion has been filtered due to one predominant strucutral mode . . . short duration steady-state vibration can be a conserative input excitation.' The attached (Figure 21.1-1) applicable floor response spectrum (broadened) clearly exhibits the single mode filtering characteristics. Conservatism of the qualification test is ensured by:

1. The test input acceleration is significantly greater than the required input motion, i.e., applicable response spectra ZPA. The required SSE input levels are 1.1 g horizontal/.75 g vertical. The conservatism of the input acceleration level tabulated above is obvious.

2. Imposing the input motion to the equipment at this observed natural frequencies, by definition, represents testing at the most critical frequencies relative to the equipment. This test procedure represents a much more severe condition to the equipment than simply enveloping the broadened required response spectra.

Square D Relay--Wyle Laboratories report No. 42749 also included testing of the Square D relays. The relays, as separate devices, were included in the same sequence of testing as the Barksdale pressure switch (test series 1). The relays were further tested in their installed configuration in the engine control panel (test series 2). Test series 2 consisted of vertical axis testing only.

From further review of the equipment contract files, it has been found that testing of the relays included in this report was not intended to represent seismic qualification of the relays for Watts Bar installation. Seismic qualification of the engine control panel, including functional Square D relays, was established by earlier testing at Acton Laboratories. The following is a summary of pertinent data and discussion from the Acton test program.

Reference: Acton Environmental Testing Company
Test Report No. 9647
Dated October 23, 1972

The engine control panel was subjected to the following test program; all testing was perfomed as a series of single frequency (sine beat) tests in each of three mutally perpendicular axes independently.

Resonant search - Low level, 1-33 Hz

Low level beat frequency - Sine beat tests in each principal axis at an input acceleration level of 1.7 g's. Test frequencies were 1/2,2,5,8,11,14,17,21,24,27,30, and 33 Hz plus any observed equipment natural frequencies.

High level beat frequencies - Sine beat test in each horizontal axis at an input acceleration level of 3 g; same test frequencies. The vertical axis was not tested at this acceleration level.

Several representative relays were monitored for electrical continuity during testing.

Two problems were encountered during horizontal axis testing: (1) a number of relays fell loose from their installation in the panel, and (2) a crack developed in the cabinet structure. The problems were corrected by (1) incorporating a spring and bracket assembly around each relay to hold it in place, and (2) repairing the apparently defective weld in the cabinet structure. Portions of the horizontal axis test program were repeated to verify adequacy of the fixes. The qualification program was completed with no further evidence of physical damage, with the relays restrained in place there was no evidence of electrical misfunction. The installation has been rechecked to verify that the spring/bracket restraints for the relays are in place for the Watts Bar unit.

For this installation in the diesel generator building, the justification for single frequency testing is the same as that presented previously for the Barksdale pressure switch. Justification of single axis testing is based on two considerations.

1. Conservatism of test input acceleration values of 3 g horizontal/1.7 g vertical as compared with the required levels of 1.1 G horizontal/.75 g vertical.

2. Electrical relays inherently reflect a single axis critical failure mode, i.e., contact chatter due to excitation along the axis parallel to that of contractor motion. The single axis mode of failure characteristic, consistent with the intent of IEEE 344, 1975, represents an acceptable basis for single axis qualification tests.

In view of all the above considerations, the Square D relays were judged to be adequately seismically qualified for their Watts Bar installation in the engine control panel.

For information to further illustrate the margin of conservatism refected in this qualification test program, a representative comparison of test response spectra with the required response spectra is attached (Figure 21.1-2). At the most critical frequencies, equipment natural frequencies of 17 and 24 Hz, the single frequency test response spectra envelope the corresponding required spectral values by large margins as tabulated below.

Acceleration Ratios - TRS/RRS

Test Frequency	Panel Natural Frequency	
	17	24
17	22.5/1.6	7.2/1.3
21	9.5/1.6	17.0/1.3
24	4.1/1.6	22.5/1.3

22. Spent Fuel Pit Crane (Fuel Handling Machine)

22.1 Question:

The SQRT Forms for this item were not available at the plant audit. The applicant was requested to submit the SQRT Forms for review.

Response:

The SQRT Forms are attached (Attachment 22.1-1).

Generic Concerns

GC.1 Question:

Numerous NSSS equipment items were qualified using single frequency and/or single axis testing. Westinghouse claimed to have previously produced rationale for the acceptability of this form of testing for qualifying their equipment. Since members of the audit team were unfamiliar with the justification that Westinghouse had prepared, they requested references relative to this justification and other documentation supporting the use of single frequency, single axis tests in qualifying the NSSS equipment.

Response:

The NRC questioned the acceptability of single axis, single frequency testing performed by Westinghouse. As described below, the acceptability of this type of testing had previously been questioned by the staff and resolved by Westinghouse based on a supplemental demonstration testing program. Provided below is a brief history of this issue.

In 1969 Westinghouse began seismic qualification of electrical equipment by test for complex electrical equipment not amenable to seismic qualification by analysis. Components such as transmitters, process control equipment, solid state protection system, and static inverters were included in this program. The results of these tests were reported in WCAP-7817 and WCAP-7821 and submitted to the NRC for review in early 1972. The qualification methodology employed at that time was generally single axis, single frequency tests, as specified in IEEE-344-1971. The NRC formally accepted these WCAPs in January 1973 as a basis for the licensing of Westinghouse plants. WCAP-7817 (7821) was referenced for specific plant applications until December of 1974 when the NRC rescinded its previous approval and issued questions concerned with the justification of the test methods that were used. Finally, in June 1975, these WCAPs were declared unacceptable for further reference until more tests or analysis were performed to verify the conservatism of the original qualification methodology. The major concern identifed by the NRC was the use of single axis sine beat testing to conservatively expose the equipment to multi-mode excitation. This concern surfaced with the issuance of IEEE-344-1975.

In July 1975, Westinghouse proposed a supplemental seismic demonstration program. The first and most important objective was to demonstrate that the previous single axis sine beat testing conservatively tested the equipment's seismic capability. The accomplishment of this objective required some additional testing of certain equipment selected by the NRC using simulated multiple frequency inputs in more than one axis. The second and third objectives of this program were to demonstrate bistable operability during a seismic event and to address the potential for spurious operation resulting from high 'g' levels. Westinghouse completed the supplemental qualification program and submitted several qualification reports (e.g., WCAPs 8673, 8694, and 8624) to the NRC.

To review the results of the supplemental seismic demonstration program and to verify that adequate margin exists for equipment tested by Westinghouse prior to May 1974, the NRC performed a seismic audit of Westinghouse-supplied electrical equipment in 1975-76. The audit was led by the NRC's Mechanical Engineering Branch with the cooperation of the NRC's Electrical Instrumentation and Control Systems Branch. As part of the audit, tours of Westinghouse test facilities were held and specific pieces of equipment were inspected at plant sites. Determinations of the adequacy of test methods were made with references to actual equipment configuration. Seismic test parameters such as equipment frequency, test amplitude, and test duration were reviewed. The NRC's Mechanical Engineering Branch reported (Reference NRC memorandum from J. P. Knight to R. D. DeYoung dated August 26, 1976) that, based on their review, adequate assurance existed that the electrical equipment studied could withstand an SSE.

The above referenced Topical Reports specifically demonstrated the acceptability of single axis, single frequency testing by repeating multi-axis, multi-frequency testing on the same equipment. As a result of this supplemental testing program justification for the single frequency tests is based on the following:

a. The test amplification levels and frequencies used for the tests assume coincident occurrence of the building and equipment natural frequencies. In general, this condition will not exist and the equipment responses will be much smaller than those used for the tests.

b. To 10 cycle per beat input used by Westinghouse results in an equipment amplification that is sufficient to account for multi-mode and multi-directional effects.

c. The sine beat input is applied at the natural frequencies of the equipment this results in a resonance build-up of component responses that is very conservative in terms of equipment malfunction compared to the smaller resonance buildup.

d. In the frequency range of significant response, sine beat will provide some multi-mode response. However, the sine beat individual response spectra will not envelope the entire frequency range of the typical floor response spectra.

e. The sine beat input subjects the equipment to a fatigue environment that exceeds the fatigue input of an actual earthquake.

GC.2 Question:

Westinghouse was requested to provide a statement as to how damping values were used in qualifications for OBE and SSE input obtained from floor response spectra provided by TVA.

Response:

Westinghouse examines seismic test motion acceptability using 5% critical damping in the development of the TRS. The TRS is compared to a RRS of the same damping or less to show acceptability. Westinghouse employs this criteria for the following reasons:

1. Electrical cabinets are bolted/welded construction which exhibit damping values in the range of 4 to 7 percent which are representative of that found in Regulatory Guide 1.61. For this reason, Westinghouse uses 5% damping in generation of the TRS because it represents average damping experienced by equipment.

2. Examination of seismic test motion at low damping tends to cause large fluctuations in the TRS analysis which lends itself difficult to interpretation. Examination of seismic test motion at 5% damping tends to minimize the fluctuations in the TRS leading to a better representation.

3. The equipment will experience its inherent damping independent of that value used to analyze the equipment seismic test motion.

4. The rationale defined above is recognized by the industry and is reflected in the recommended industry practice identified in IEEE-344-1975.

GC.3 Question:

In numerous situations, there is no peak broadening in the TRS or RRS. Thus, the applicant was requested to justify acceptability of a narrow response spectrum peak.

Response:

BOP Scope Equipment

In the evaluation of the adequacy of seismic qualification reports for safety-related items of equipment, TVA ensures that the ± 10 percent broadening (with respect to frequency) of the applicable floor response spectra is appropriately taken into account. This requirement is reflected in TVA's Watts Bar seismic qualification design criteria, 'Seismic Qualification of Category 1 Fluid System Components and Electrical or Mechanical Equipment,' WB-DC-40.31.2 which is used as the basis for defining the seismic requirements in procurement specifications for TVA procured safety-related equipment.

The response spectrum broadening requirement is fundamentally implied in the design criteria's reference to IEEE Standard 344 which addresses spectrum broadening. The requirement is again specifically stated in the discussion of dynamic analysis--'the maximum spectral (acceleration) values within a ± 10 percent band of the calculated frequencies of the equipment will be used for computation of modal dynamic response inertial loading.'

The appropriate implementation of seismic qualification requirements, including spectra broadening, in ensured through TVA's program of detailed review of equipment qualification test procedures, required prior to testing, and qualification reports, tests and/or analysis. required prior to equipment delivery to the plant site.

NSSS Scope Equipment

For seismic qualification of equipment, Westinghouse utilizes the response spectra provided by TVA. For the equipment reviewed by the NRC, Westinghouse has peak broadened the TVA response spectra by 10% or has addressed the reasons for not broadening the spectra in response to specific items.

GC.4 Question:

The field installed mounting was frequently different from that used in the qualification test or analyses of safety-related equipment, especially for electrical cabinets. Can the applicant, in all cases, state that the equipment was mounted as adequately in the field as in the lab or as assumed in analysis.

Response:

The fundamental requirement for consistency between the equipment qualification mounting configuration and the corresponding installed configuration is well documented in seismic design criteria WB-DC-40-31.2. The discussion of test methods includes the requirement that 'the equipment being tested will be mounted on the vibration generator in a manner that simulates the intended service mounting.' Further, the discussion of equipment vendor supplied documentation includes the requirement that 'the equipment manufacturer will provide data regarding the support locations, reactions, dimensions, etc., required for proper operations and support of the equipment such that appropriate interface requirements can be established between his equipment and TVA structure.'

With few exceptions then, the safety-related equipment is installed in accordance with vendor directions. In the very few cases where compatible installation problems arise, alternative mounting configurations are evaluated by TVA and equipment vendor personnel as appropriate to ensure that seismic qualification is not invalidated.

During the site audit, several items of NSSS equipment were specifically questioned as to the consistency between qualification test mounting configuration and the installed configuration.

Following the audit, TVA rechecked its installation drawings for the NSSS items of equipment to verify that the installation was consistent with vendor (Westinghouse) instructions. TVA has also discussed with Westinghouse the comparison of the installed equipment anchorage configurations with the corresponding seismic qualification anchorage configuration.

With regard to installation details, there is one area of difference between qualification test and installed configurations which is typical of the questioned NSSS equipment. The NSSS equipment, typical of most electrical panels, is provided by the vendor with a base sill subassembly. There are, then, two mounting interfaces involved in anchorage considerations: (1) attachment interface of the equipment panel to the sill, and (2) attachment interface of the sill to TVA's building floor. In general, Westinghouse seismic qualification testing was accomplished with bolted attachment of both the panel-to-sill and sill-to-test table interfaces. For TVA's installation to embedded plates, the sills are first removed from the equipment panels and anchored by welding all around to the embedded plates. The equipment is then placed on the sill and reattached by bolting. For such configurations, the assembly dynamic characteristics will be dictated by the flexibility inherent in the equipment panel, bolting attachment of the panel to sill, and to a much lesser degree, the sill itself. Within the accuracy of simulation provided by seismic qualification testing, there is no significant difference in equipment assembly dynamic characteristics attributable to the difference between bolting and welding the sill base interface. By inspection and simple consideration of the respective metal areas involved, it is obvious that TVA's welded attachment of the sill to embedded plate installation is at least as adequate (strength and rigidity) as the bolted test configuration. It is TVA's position that this minor difference in mounting detail does not in any way violate the basic requirement that equipment qualification test mounting must simulate the intended service mounting.

The mounting configuration details for the main control room panels are slightly different from the situation discussed above. The discussion of control panel anchorage as a unique situation is provided in the response to Item 10.1.

GC.5 Question:

The nozzle loads exerted on safety-related equipment by attached piping were frequently not mentioned. Can the applicant, in all cases, state that the nozzle loads on the equipment were considered and that the attached piping was designed accordingly.

Response:

TVA has long recognized the basic requirement for ensuring interface (nozzle) load compatability between fluid system equipment and attached piping. In this regard, TVA has established nozzle loads criteria in terms of attached piping allowable stress. (Nozzle loads criteria for Watts Bar safety-related active equipment, floor mounted and in line mounted, is contained in Attachment GC.5-1.)

Nozzle loads criteria is imposed on equipment suppliers as an integral part of the seismic qualification requirements for compatability, this same criteria is imposed on the TVA piping system analysis as the definition of load limits at the equipment interface. Any problems arising from the application of the nozzle loads criteria are resolved on a case-by-case basis typically in one of two ways:

1. Where piping system interface loads exceed the criteria, the equipment nozzle loads may be increased to a level which envelopes the imposed piping system loads. The equipment suppliers' documentation of this increased nozzle load capability would, or course, become a supplement to his original qualification report.

2. Where the equipment cannot be shown capable of withstanding the nozzle loads criteria, modifications may be made to the piping system configuration which limit the imposed loading to levels no greater than the documented equipment nozzle load capability.

It is TVA's position that compatability between the demonstrated eqipment nozzle loads capability and the corresponding attached piping system loads will be maintained.

SQRT AUDIT

FIGURES

11.2-1

11.2-2

13.1-1

13.1-2

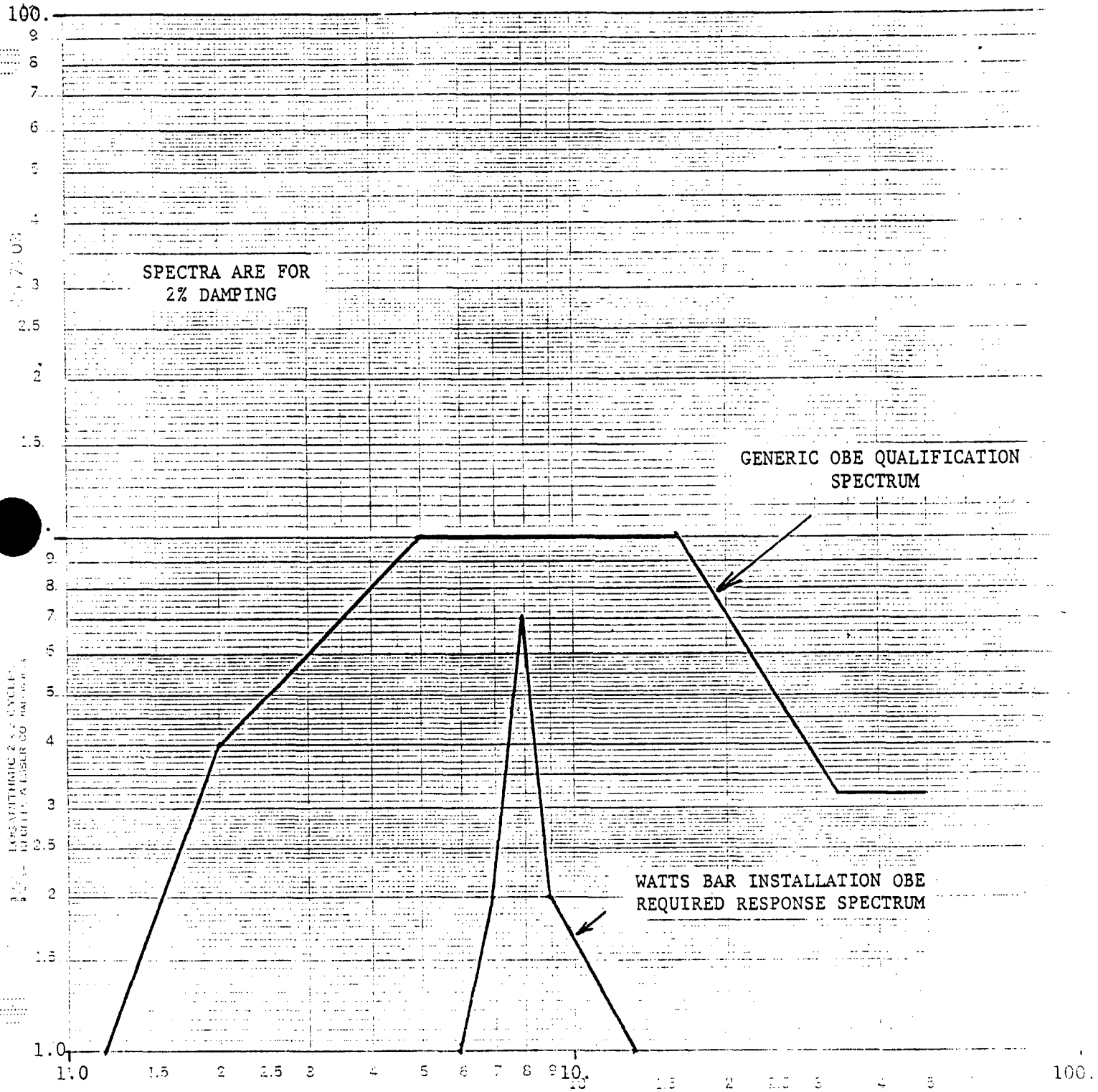
19.1-1

21.1-1

21.1-2

FIGURE 11.2-2

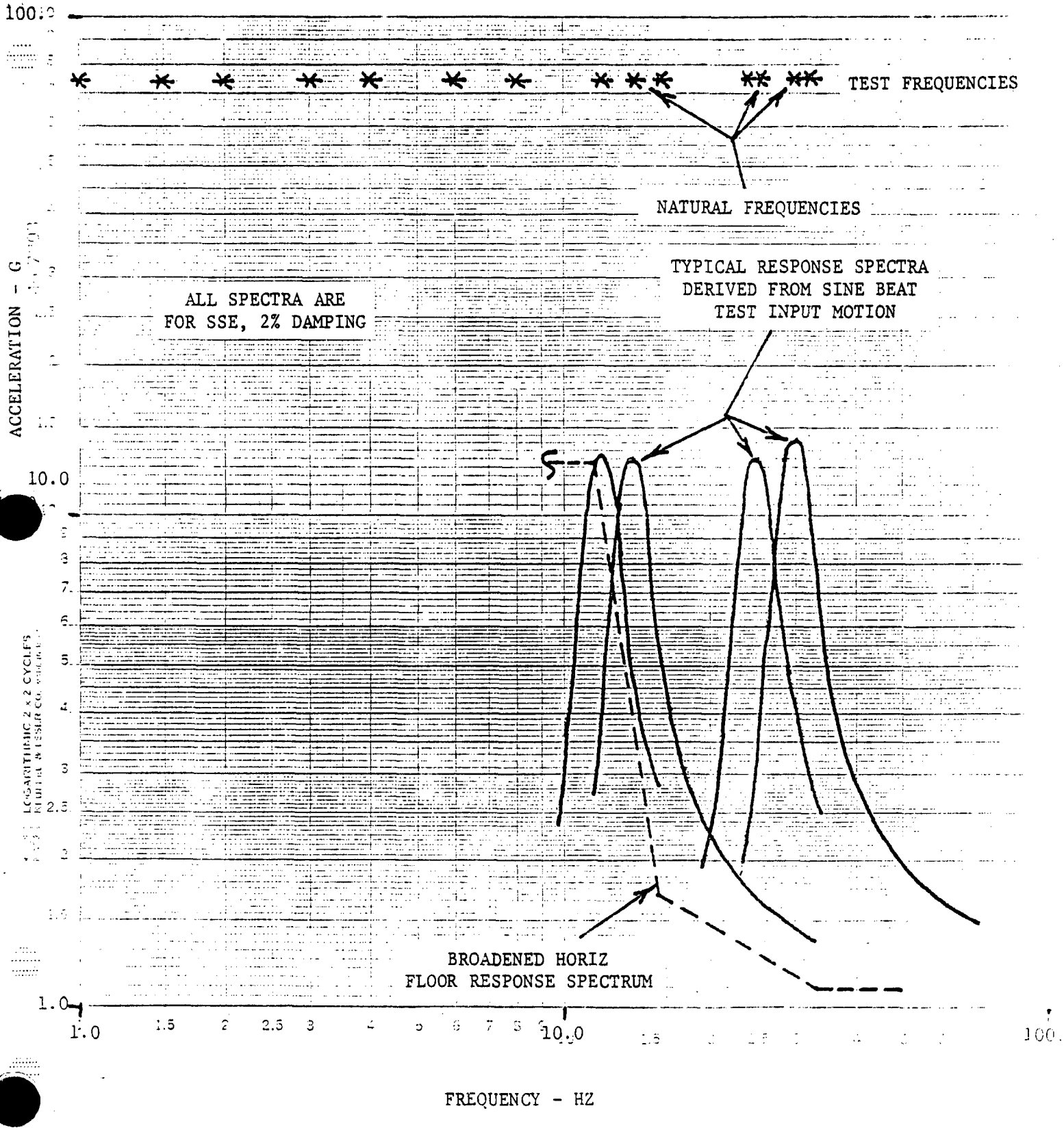
RESPONSE SPECTRA COMPARISON
ELECTRICAL PENETRATIONS
OPERATING BASIS EARTHQUAKE



FREQUENCY - HERTZ

FIGURE 13.1-1

TRS/RRS COMPARISON
DG CONTROL & PROTECTION RELAY PANEL
LATERAL (FRONT/BACK))AXIS



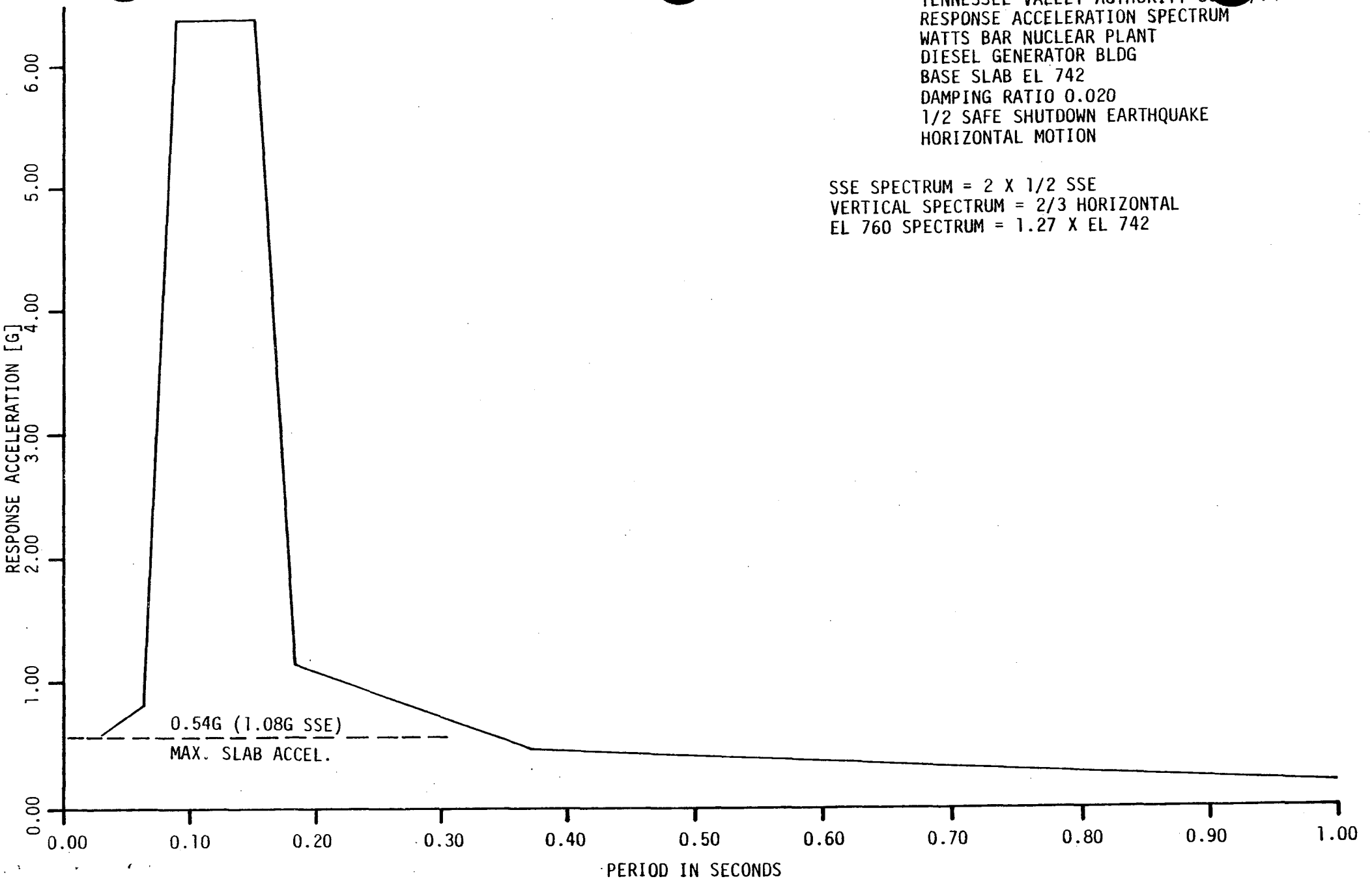

TENNESSEE VALLEY AUTHORITY
RESPONSE ACCELERATION SPECTRUM
WATTS BAR NUCLEAR PLANT
DIESEL GENERATOR BLDG
BASE SLAB EL 742
DAMPING RATIO 0.020
1/2 SAFE SHUTDOWN EARTHQUAKE
HORIZONTAL MOTION
SSE SPECTRUM = 2 X 1/2 SSE
VERTICAL SPECTRUM = 2/3 HORIZONTAL
EL 760 SPECTRUM = 1.27 X EL 742
RESPONSE ACCELERATION [G]
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0.54G (1.08G SSE)
MAX. SLAB ACCEL.
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
PERIOD IN SECONDS

FIGURE 19.1-1

FIGURE 33: TENNESSEE VALLEY AUTHORITY
WBNP AUXILIARY-CONTROL BUILDING
RESPONSE SPECTRA
FLOOR ELEVATION 711.5
DAMPING RATIOS 0.050, 0.100, 0.150
½ SSE, N-S HORIZONTAL

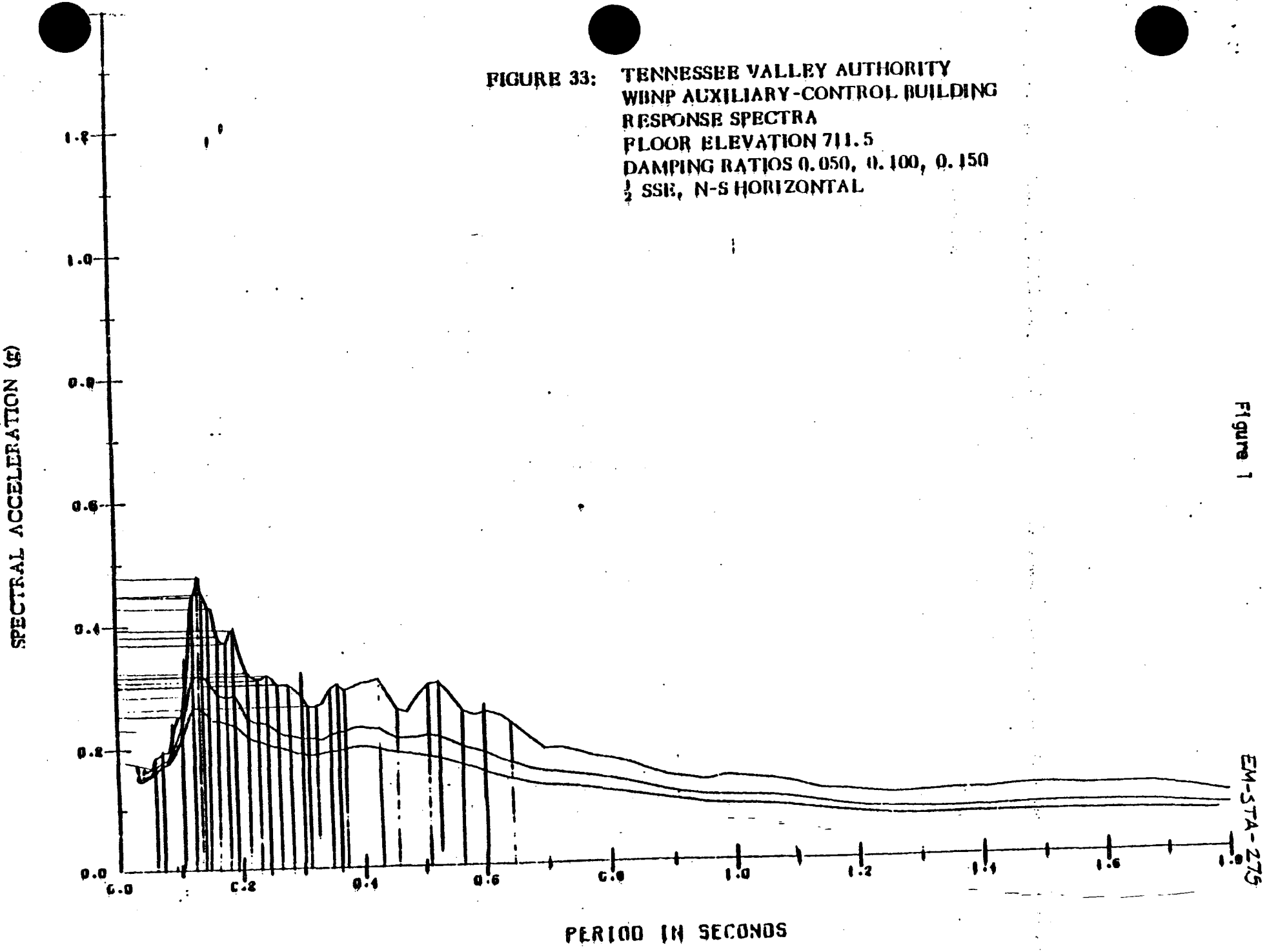


FIGURE 33

Figure 1

EM-STA-275

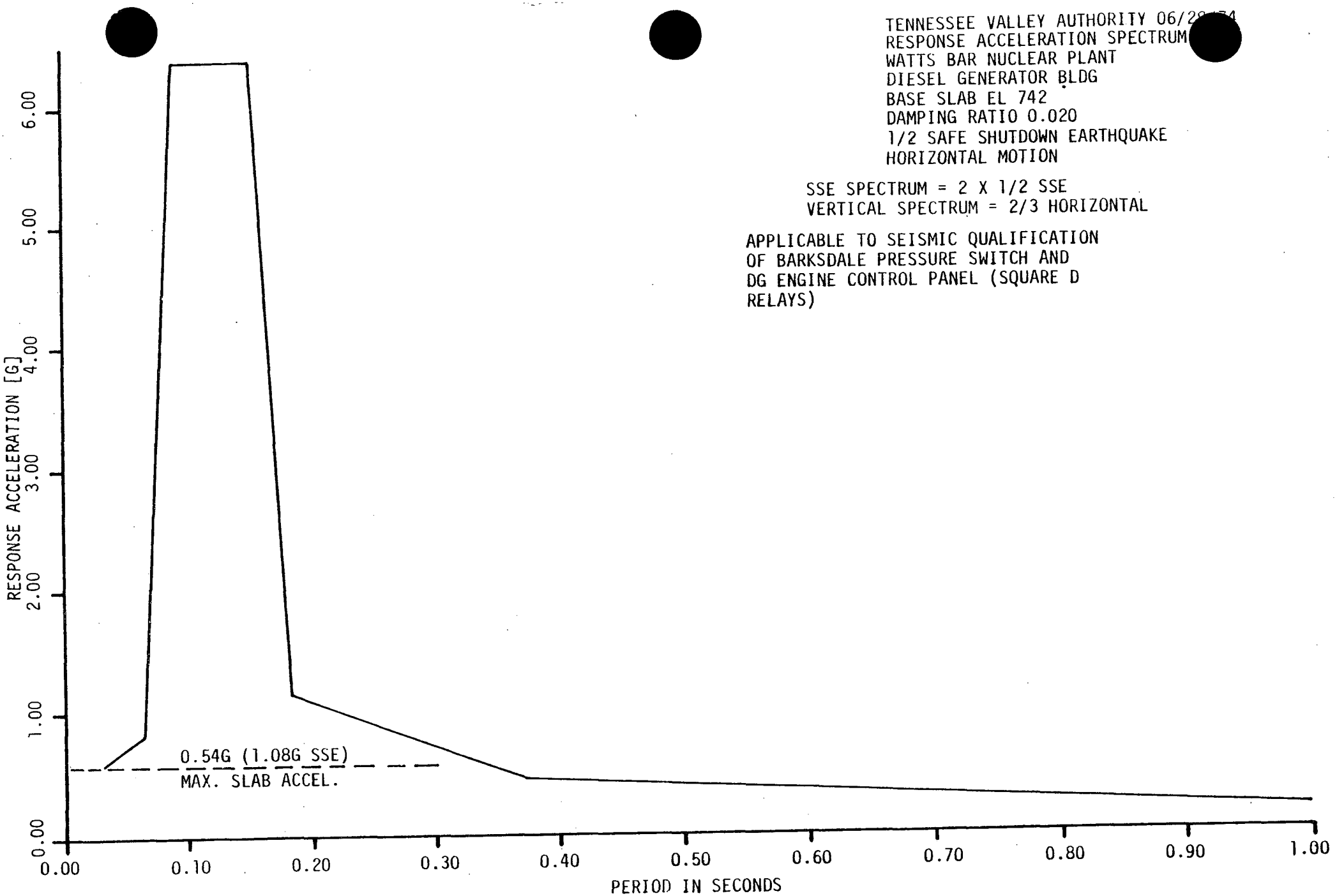
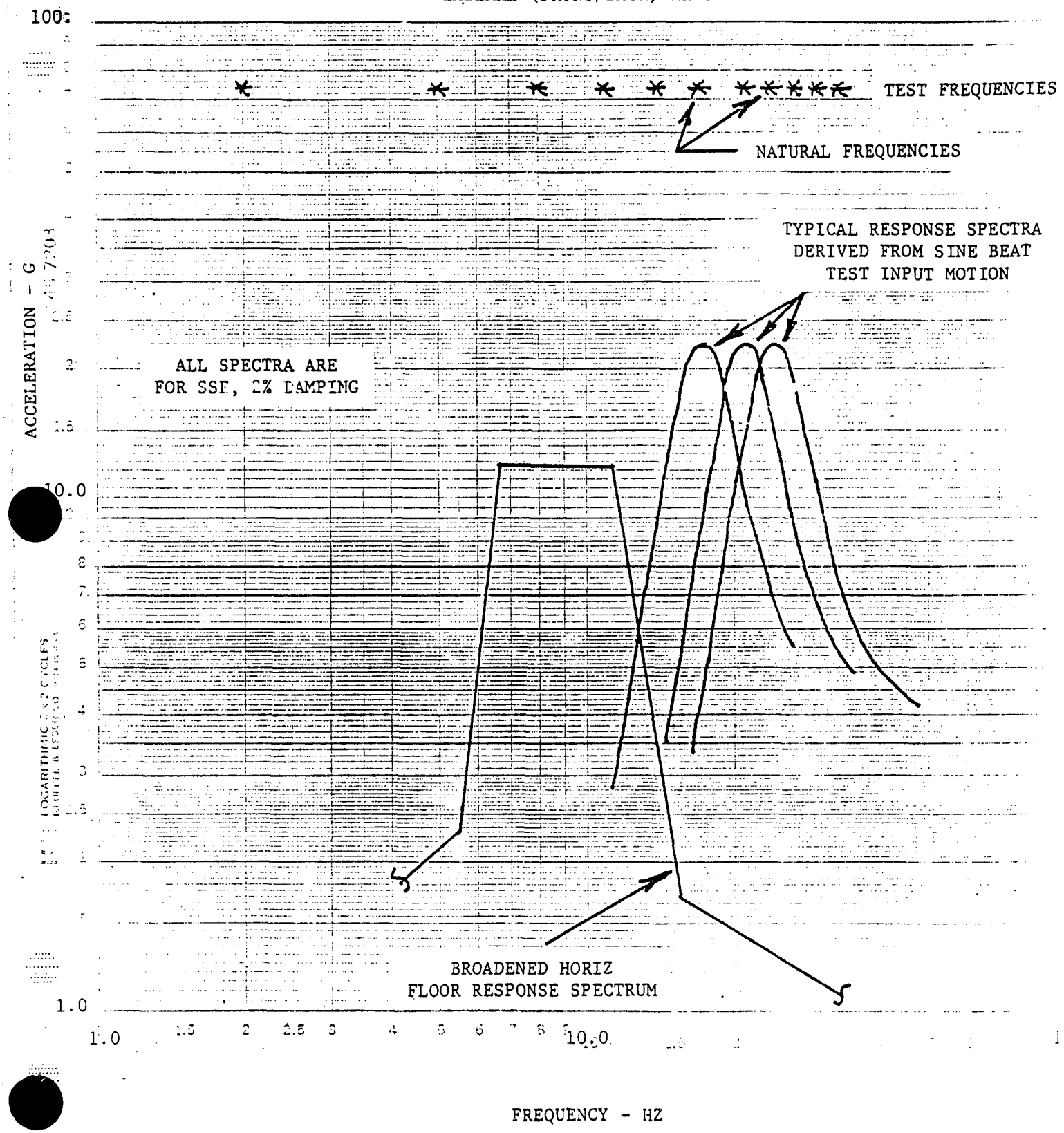

TENNESSEE VALLEY AUTHORITY 06/28/74
RESPONSE ACCELERATION SPECTRUM
WATTS BAR NUCLEAR PLANT
DIESEL GENERATOR BLDG
BASE SLAB EL 742
DAMPING RATIO 0.020
1/2 SAFE SHUTDOWN EARTHQUAKE
HORIZONTAL MOTION
SSE SPECTRUM = 2 X 1/2 SSE
VERTICAL SPECTRUM = 2/3 HORIZONTAL
APPLICABLE TO SEISMIC QUALIFICATION
OF BARKSDALE PRESSURE SWITCH AND
DG ENGINE CONTROL PANEL (SQUARE D
RELAYS)
RESPONSE ACCELERATION [G]
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0.54G (1.08G SSE)
MAX. SLAB ACCEL.
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
PERIOD IN SECONDS

FIGURE 21.1-1

FIGURE 21.1-2

TRS/RRS COMPARISON
DG ENGINE CONTROL PANEL
LATERAL (FRONT/BACK) AXIS



SQRT AUDIT

ATTACHMENT 2.3-1

Seismic and Dynamic Qualification Summary of Equipment

Attachment 2.3-1

I. Plant Name: Watts Bar

Type:

1. Utility: TVA — PWR X
2. NSSS: W NES — BWR
3. A/E: TVA — Other

II. Component Name: Reactor Trip Switchgear (Reactor trip and bypass breakers)

1. Scope: [XX] NSSS [ ] BOP [ ] Other
2. Model Number: 9125D23 Quantity: One
3. Size or Range:
4. Vendor: Westinghouse (Swgr. Div.)
5. If the component is a cabinet or panel, name and model Number of the devices included: Reference drawing 9125D23, Rev. 3
6. Physical Description:
   a. Appearance: Two-Bay Vertical Cabinet
   b. Dimensions: 42.18" X 73.25" X 92.00"
   c. Weight: Approximately 3400 lbs.
7. Location: Building: Auxiliary Building

   Elevation: 782 ft.
8. Field Mounting Conditions [ ] Bolt (No. ____, Size ____)
   [XX] Weld (Length ____)
   [ ]
9. Mounting Orientation [e.g., on floor, cantilevered, suspended, etc.]

   Floor mounted
10. a. System in which located: Reactor Protection System

    b. Functional Description: Provides Reactor Trip Function

    c. Is the equipment required for [XX] Hot Standby [XX] Cold Shutdown

    [XX] Both [ ] Neither [ ] Other

II. Pertinent Reference Design Specifications for Qualification Requirements: E-Spec 952080 Rev. 2

a. Seismic Input
See Section VI

b. Hydrodynamic Load Input
N/A

c. Fatigue Considerations
See Section V

d. Service Conditions
Controlled Environment

e. Qualified Life
40 yrs.

III. Is Equipment Available for Inspection in the Plant:

[XX] Yes [ ] No [ ] Partial or limited availability

IV. Equipment Qualification Method:

[XX] Test [ ] Analysis [ ] Combination of Test and Analysis

Qualification Report*: WCAP-8687 Supplement 2 - E20B Rev. 1

(No., Title and Date): Equipment Qualification Test Report Reactor Trip Switchgear, July 1981

Company that Prepared Report: Westinghouse

Company that Reviewed Report: Westinghouse

Where Report is filed or available: Westinghouse Monroeville Nuclear Center

Applicable Codes And/Or Standards: IEEE-344-1975, IEEE-323-1974

V. Vibration Input:

1. Loads considered:
a. [XX] Seismic only
b. [ ] Hydrodynamic only
c. [ ] Vibration from normal operation
d. [ ] Combination of (a), (b), and (c)

2. Method of Combining RRS:

[ ] Absolute Sum [ ] SRSS [ ] _____ (other, specify)

3. Required Response Spectra** (attach the graphs): See attached Figure 1-2

NOTE:
*If more than one report complete items IV thru VII for each report.
**If other than RRS is used, describe method.

4. Damping Corresponding to RRS: OBE 5% SSE 5%

5. Required Acceleration in Each Direction:

[ ] ZPA [ ] Other _____ (specify)

OBE S/S = N/A F/B = N/A V = N/A

SSE S/S = N/A F/B = N/A V = N/A

6. Were fatigue effects considered?

[XX] Yes [ ] No

If yes, describe how they were treated in overall qualification program: 5 OBE cycles for fatigue effects

OBE = 1/2 SSE

VI. If Qualification by Test, then Complete:

1. [ ] Single Frequency [XX] Multi-Frequency: [ ] random [XX] sine beat [ ] _____

2. [ ] Single Axis [XX] Multi-Axis
[ ] Independent axis [XX] In-phase motions

3. Number of Qualifications Tests:

OBE 5 SSE 4 Other _____ (specify)

4. Frequency Range: 1 Hz to 33 Hz

5. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

S/S = 5-7 Hz F/B = 10-12.5 Hz V = > 33 Hz

6. Method of Determing Natural Frequencies

[XX] Lab Test [ ] In-Situ Test [ ] Analysis

7. TRS enveloping RRS using Multi-Frequency Test

[XX] Yes (Attach TRS & RRS graphs) See attached Figure 3
[ ] No

8. Maximum Input g-level Test:

OBE S/S = N/A F/B = N/A V = N/A

SSE S/S = N/A F/B = N/A V = N/A

9. Laboratory Mounting:

A. [XX] Bolt (No. 12, Size 3/8")

[ ] Weld (Length _____) [ ] _____

B. Orientation and Fixturing: Floor mounted

10. Functional operability verified:

[XX] Yes [ ] No [ ] Not Applicable

11. Test Results including modifications made: Test results were acceptable and structural integrity demonstrated. No modifications to the equipment were made.

12. Other tests performed (such as aging or fragility test, including results):

None

13. Failure Modes (If appropriate: None)

14. Margins Available: [XX] Input Spectrum [ ] Fragility

VII. If Qualification by Analysis, then complete: N/A

1. Method of Analysis:

~~[ ] Static Analysis [ ] Equivalent Static Analysis~~

[ ] Dynamic Analysis: [ ] Time-History [ ] Response Spectrum

2. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

S/S = _____ F/B = _____ V = _____

3. Model Type: [ ] 3D [ ] 2D [ ] 1D

[ ] Finite Element [ ] Beam

[ ] Closed Form Solution [ ] Other _____

4. [ ] Computer Codes: _____

Frequency Range and No. of modes considered: _____

[ ] Hand Calculations

5. Method of Combining Dynamic Responses from Seismic and other Dynamic Loads:

[ ] Absolute Sum [ ] SRSS [ ] Other: _____ (specify)

6. Damping:

OBE _____ SSE _____ Basis for the damping used: _____

7. Support Considerations in the model: _____

8. Critical Structural Elements:

A. Identification Location	Governing Load or Response Combination	Seismic Stress	Total Stress	Stress Allowable

B.

Max. Critical Deflection	Location	Maximum Allowable Deflection to Assure Functional Operability

9. Failure Modes: _____

10. Margins Available: [ ] Input Spectrum [ ] Stress or Deflection

N/A

FIGURE 53: TENNESSEE VALLEY AUTHORITY
WBNP AUXILIARY-CONTROL BUILDING
RESPONSE SPECTRA
FLOOR ELEVATION 781.5
DAMPING RATIOS 0.050, 0.100, 0.150
½ SSE, N-S HORIZONTAL

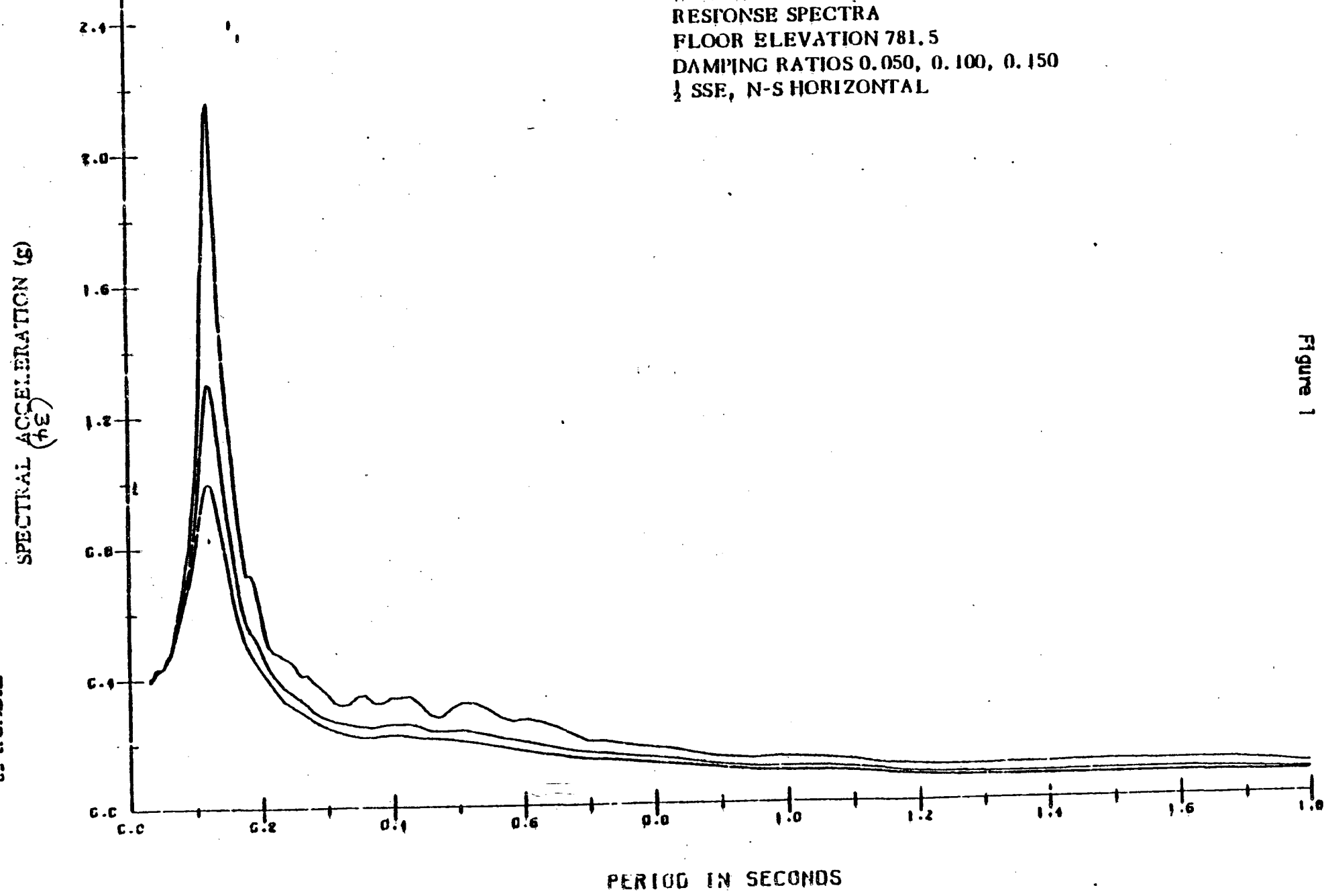


Figure 1

FIGURE 53

FIGURE 55: TENNESSEE VALLEY AUTHORITY
WBNP AUXILIARY-CONTROL BUILDING
RESPONSE SPECTRA
FLOOR ELEVATION 781.5
DAMPING RATIOS 0.050, 0.100, 0.150
½ SSE, E-W HORIZONTAL

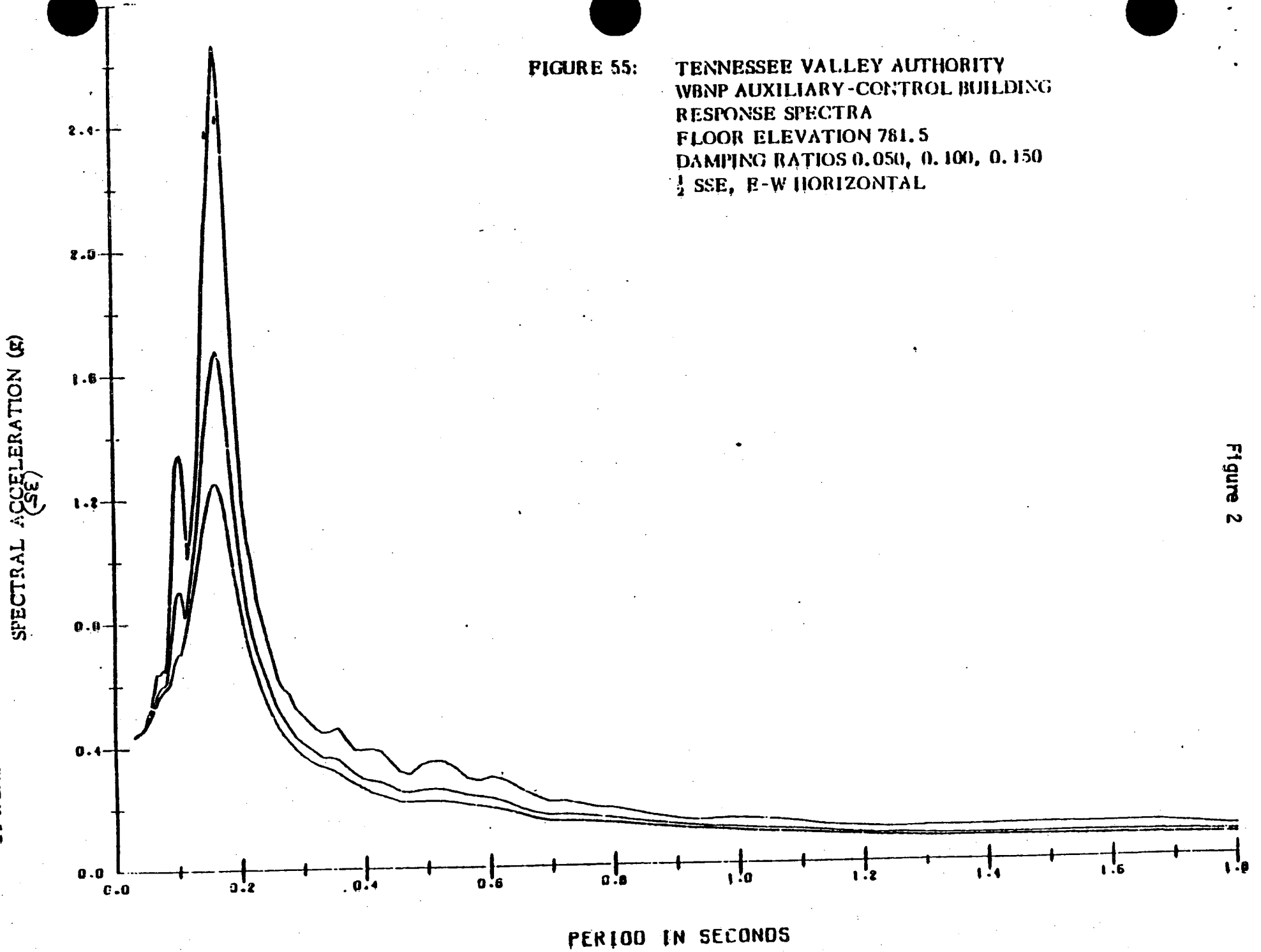
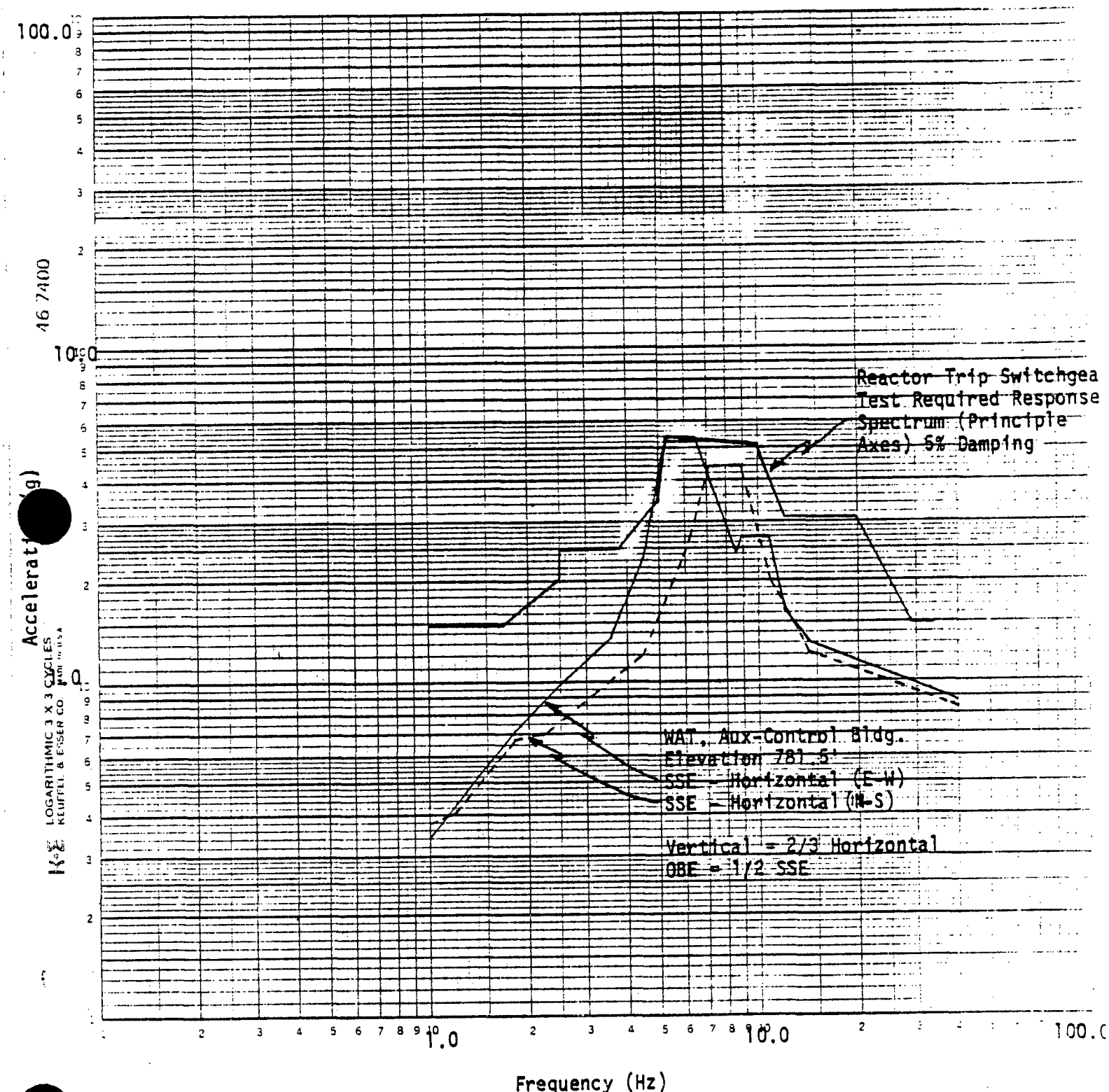


FIGURE 55

Figure 2

Figure 3

Equipment: Reactor Trip Switchgear



SQRT AUDIT

ATTACHMENT 3.3-1

Seismic and Dynamic Qualification Summary of Equipment

Attachment 3.3-1

I. Plant Name: Watts Bar

Type:

1. Utility: TVA

PWR XX

2. NSSS: W NES

BWR

3. A/E: TVA

Other

II. Component Name: Solid State Protection System

1. Scope: [X] NSSS [ ] BOP [ ] Other

2. Model Number: 1057E57 Quantity: 2 (Train A&B)

3. Size or Range:

4. Vendor: Westinghouse (W ID)

5. If the component is a cabinet or panel, name and model Number of the devices included: Reference drawing 1057E57, Rev. K

6. Physical Description:

a. Appearance: Three-Bay Vertical Cabinet

b. Dimensions: 90" x 30" x 91.31"

c. Weight: Approximately 2300 lbs.

7. Location: Building: Control

Elevation: 708 Ft.

8. Field Mounting Conditions [ ] Bolt (No. ____, Size ____)
[X] Weld (Length ____)
[ ] ____

9. Mounting Orientation [e.g., on floor, cantilevered, suspended, etc.]

Floor Mounted

10. a. System in which located: Reactor Protection System

b. Functional Description: Provides reactor trip and safeguards actuation

c. Is the equipment required for [X] Hot Standby [X] Cold Shutdown

[X] Both [ ] Neither [ ] Other ____

II. Pertinent Reference Design Specifications for Qualification Requirements: _____

a. Seismic Input
b. Hydrodynamic Load Input
c. Fatigue Considerations
d. Service Conditions
e. Qualified Life

III. Is Equipment Available for Inspection in the Plant:

[ ] Yes [ ] No [ ] Partial or limited availability

IV. Equipment Qualification Method:

[X] Test [ ] Analysis [ ] Combination of Test and Analysis

Qualification Report*: WCAP 7817 Seismic Testing of Electrical & Control Equipment

(No., Title and Date): WCAP 7817 Supplement 3 Seismic Testing of Electrical and Control Equipment (W SSPS) Low Seismic Plants

Company that Prepared Report: Westinghouse

Company that Reviewed Report: Westinghouse

Where Report is filed or available: W Monroeville Nuclear Center

Applicable Codes And/Or Standards: IEEE 344 1971

V. Vibration Input:

1. Loads considered:
   a. [X] Seismic only
   b. [ ] Hydrodynamic only
   c. [ ] Vibration from normal operation
   d. [ ] Combination of (a), (b), and (c)

2. Method of Combining RRS:

[ ] Absolute Sum [ ] SRSS [ ] _____ (other, specify)

3. Required Response Spectra** (attach the graphs): See Attached Figure T&2

NOTE:
*If more than one report complete items IV thru VII for each report.
**If other than RRS is used, describe method.

II. Pertinent Reference Design Specifications for Qualification Requirements: E-Spec 952152 Rev. 1

a. Seismic Input
See Section VI

b. Hydrodynamic Load Input
N/A

c. Fatigue Considerations
N/A

d. Service Conditions
Controlled Environment

e. Qualified Life
40 yrs.

III. Is Equipment Available for Inspection in the Plant:

[X] Yes [ ] No [ ] Partial or limited availability

IV. Equipment Qualification Method:

[XX] Test [ ] Analysis [ ] Combination of Test and Analysis

Qualification Report*: WCAP 7817 Seismic Testing of Electrical & Control Equipmen

(No., Title and Date): WCAP 7817 Seismic Testing of Electrical and Control Equipm Supplement 2 (low seismic plants)

Company that Prepared Report: Westinghouse

Company that Reviewed Report: Westinghouse

Where Report is filed or available: W Monroeville Nuclear Center NS Department

Applicable Codes And/Or Standards: IEEE 344-1971

V. Vibration Input:

1. Loads considered:
a. [X] Seismic only
b. [ ] Hydrodynamic only
c. [ ] Vibration from normal operation
d. [ ] Combination of (a), (b), and (c)

2. Method of Combining RRS:

[ ] Absolute Sum [ ] SRSS [ ] _____ (other, specify)

3. Required Response Spectra** (attach the graphs): See Attached Figure 1&2

NOTE:
*If more than one report complete items IV thru VII for each report.
**If other than RRS is used, describe method.

4. Damping Corresponding to RRS: OBE N/A SSE 5%

5. Required Acceleration in Each Direction:

[ ] ZPA [ ] Other _____ (specify)

OBE S/S = N/A F/B = N/A V = N/A

SSE S/S = N/A F/B = N/A V = N/A

6. Were fatigue effects considered? No

[ ] Yes [X] No

If yes, describe how they were treated in overall qualification program: _____

VI. If Qualification by Test, then Complete:

1. [X] Single Frequency [ ] Multi-Frequency: [ ] random [X] sine beat [ ] _____ 5 beats (10 cpb) @ each test frequen

2. [X] Single Axis [ ] Multi-Axis
[ ] Independent axis [ ] In-phase motions

3. Number of Qualifications Tests: Front-to-Back Side-to-Side Vertical

OBE _____ SSE 3 Other _____ (specify)

4. Frequency Range: 5-35 Hz

5. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

S/S = 8.0 Hz F/B = 15 - 25 Hz V = 33 Hz

6. Method of Determing Natural Frequencies

[X] Lab Test [ ] In-Situ Test [ ] Analysis

7. TRS enveloping RRS using Multi-Frequency Test

[ ] Yes (Attach TRS & RRS graphs)
[X] No TRS envelopes RRS for single-axis sine beat testing

4. Damping Corresponding to RRS: OBE N/A SSE 5%

5. Required Acceleration in Each Direction:

[ ] ZPA [ ] Other _____ (specify)

OBE S/S = N/A F/B = N/A V = NA

SSE S/S = N/A F/B = N/A V = N/A

6. Were fatigue effects considered?

[ ] Yes [X] No

If yes, describe how they were treated in overall qualification program: _____

VI. If Qualification by Test, then Complete:

1. [X] Single Frequency [ ] Multi-Frequency: [ ] random [X] sine beat [ ] _____ @ each test freq. 5 beats (10 cpb)

2. [X] Single Axis [ ] Multi-Axis
[ ] Independent axis [ ] In-phase motions

3. Number of Qualifications Tests: Front-to-Back, Side-to-Side, Vertical

OBE _____ SSE 3 Other _____ (specify)

4. Frequency Range: 1-5 Hz

5. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

S/S = 8.0 F/B = 15 - 25 V = 33 Hz

6. Method of Determing Natural Frequencies

[X] Lab Test [ ] In-Situ Test [ ] Analysis

7. TRS enveloping RRS using Multi-Frequency Test

[ ] Yes (Attach TRS & RRS graphs)
[X] No TRS envelopes RRS for single-axis sine beat testing

8. Maximum Input g-level Test: See Attached Figures 3&4

OBE S/S = _____ F/B = _____ V = _____

OBE S/S = _____ F/B = _____ V = _____

9. Laboratory Mounting:

A. [X] Bolt (No. 12, Size 3/4")

[ ] Weld (Length _____) [ ] _____

B. Orientation and Fixturing: _____

10. Functional operability verified:

[X] Yes [ ] No [ ] Not Applicable

11. Test Results including modifications made: Test results were acceptable. Number of bolts used to fasten the three-rack structure to the rack case was increased from 12 to 24.

12. Other tests performed (such as aging or fragility test, including results):

None

13. Failure Modes (If appropriate: None)

14. Margins Available: [X] Input Spectrum [ ] Fragility

VII. If Qualification by Analysis, then complete: N/A

1. Method of Analysis:

~~[ ] Static Analysis [ ] Equivalent Static Analysis~~

[ ] Dynamic Analysis: [ ] Time-History [ ] Response Spectrum

2. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

S/S = _____ F/B = _____ V = _____

3. Model Type: [ ] 3D [ ] 2D [ ] 1D

[ ] Finite Element [ ] Beam

[ ] Closed Form Solution [ ] Other _____

8. Maximum Input g-level Test: See Attached Figures 3&4

OBE S/S = _____ F/B = _____ V = _____

OBE S/S = _____ F/B = _____ V = _____

9. Laboratory Mounting:

A. [X] Bolt (No. 12, Size 3/4")

[ ] Weld (Length _____) [ ] _____

B. Orientation and Fixturing: Floor Mounted

10. Functional operability verified:

[X] Yes [ ] No [ ] Not Applicable

11. Test Results including modifications made: Test results were acceptable. Number of bolts used to fasten the three-rack structure to the rack base was increased from 12 to 24.

12. Other tests performed (such as aging or fragility test, including results):

None

13. Failure Modes (If appropriate: None)

14. Margins Available: [X] Input Spectrum [ ] Fragility

VII. If Qualification by Analysis, then complete: N/A

1. Method of Analysis:

[ ] Static Analysis [ ] Equivalent Static Analysis

[ ] Dynamic Analysis: [ ] Time-History [ ] Response Spectrum

2. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

S/S = _____ F/B = _____ V = _____

3. Model Type: [ ] 3D [ ] 2D [ ] 1D

[ ] Finite Element [ ] Beam

[ ] Closed Form Solution [ ] Other _____

4. [ ] Computer Codes: _____

Frequency Range and No. of modes considered: _____

[ ] Hand Calculations N/A

5. Method of Combining Dynamic Responses from Seismic and other Dynamic Loads:

[ ] Absolute Sum [ ] SRSS [ ] Other: _____ (specify)

6. Damping:

OBE _____ SSE _____ Basis for the damping used: _____

7. Support Considerations in the model: _____

8. Critical Structural Elements:

A.

Identification Location	Governing Load or Response Combination	Seismic Stress	Total Stress	Stress Allowable

B.

Max. Critical Deflection	Location	Maximum Allowable Deflection to Assure Functional Operability

9. Failure Modes: _____

10. Margins Available: [ ] Input Spectrum [ ] Stress or Deflection

FIGURE 33: TENNESSEE VALLEY AUTHORITY
WBNP AUXILIARY-CONTROL BUILDING
RESPONSE SPECTRA
FLOOR ELEVATION 711.5
DAMPING RATIOS 0.050, 0.100, 0.150
½ SSE, N-S HORIZONTAL

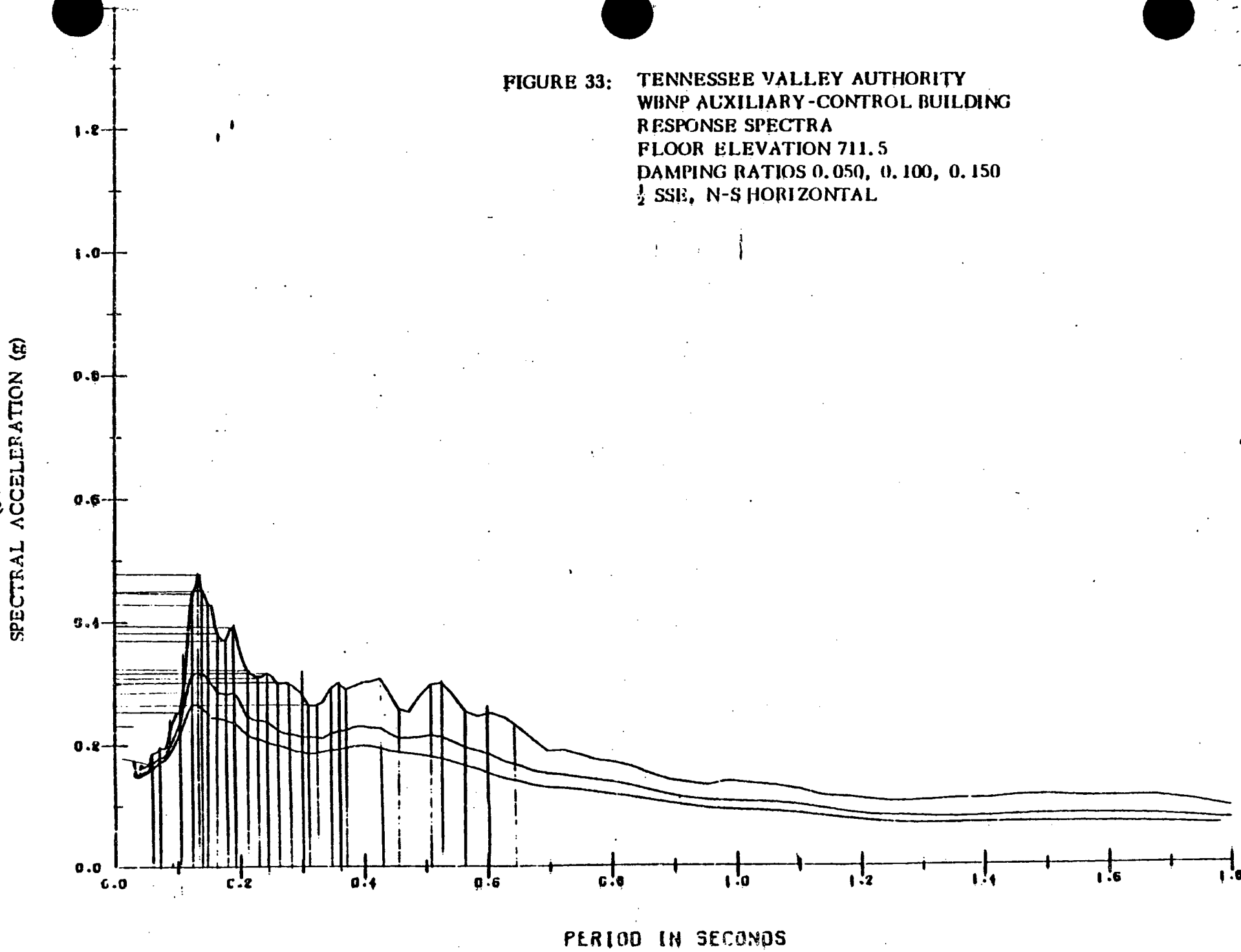


Figure 1

EM-STA-275

FIGURE 33

FIGURE 35: TENNESSEE VALLEY AUTHORITY
WBNP AUXILIARY-CONTROL BUILDING
RESPONSE SPECTRA
FLOOR ELEVATION 711.5
DAMPING RATIOS 0.050, 0.100, 0.150
½SSE, E-W HORIZONTAL

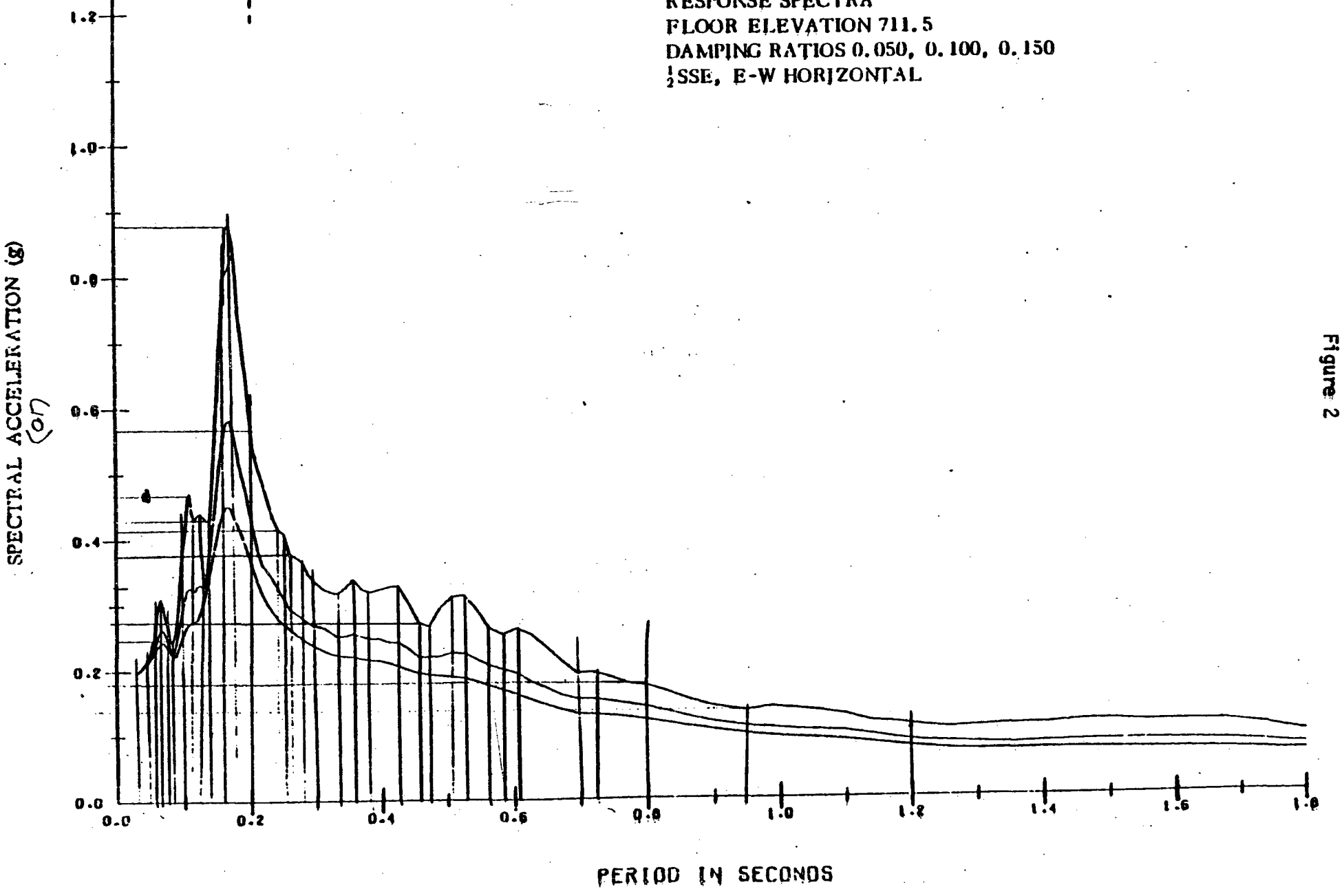


Figure 2

EM-STA - 275

Figure 3

Equipment: Solid State Protection System (3-Bay)

and Safeguards Test Cabinet (1-Bay)

Horizontal

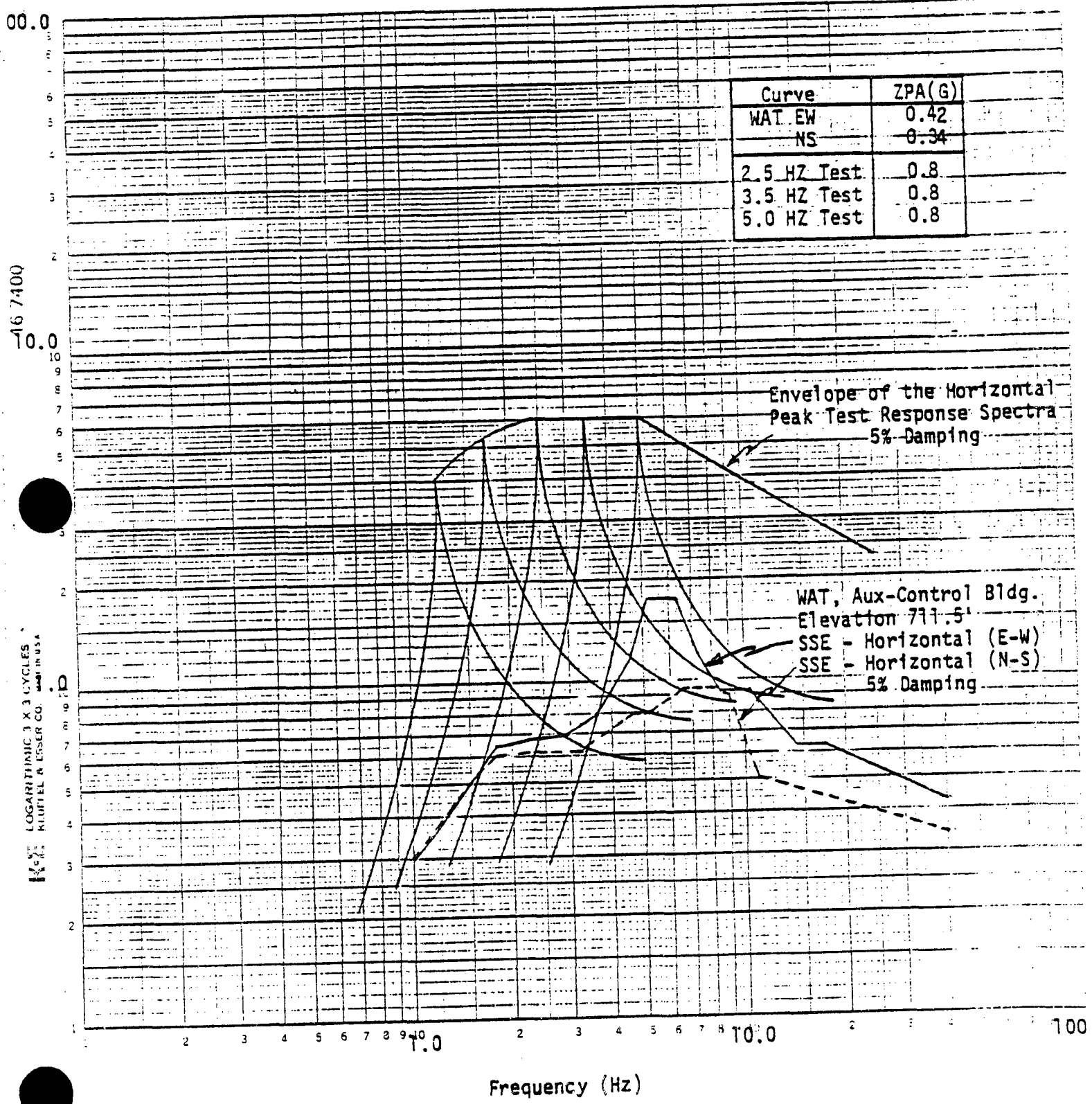
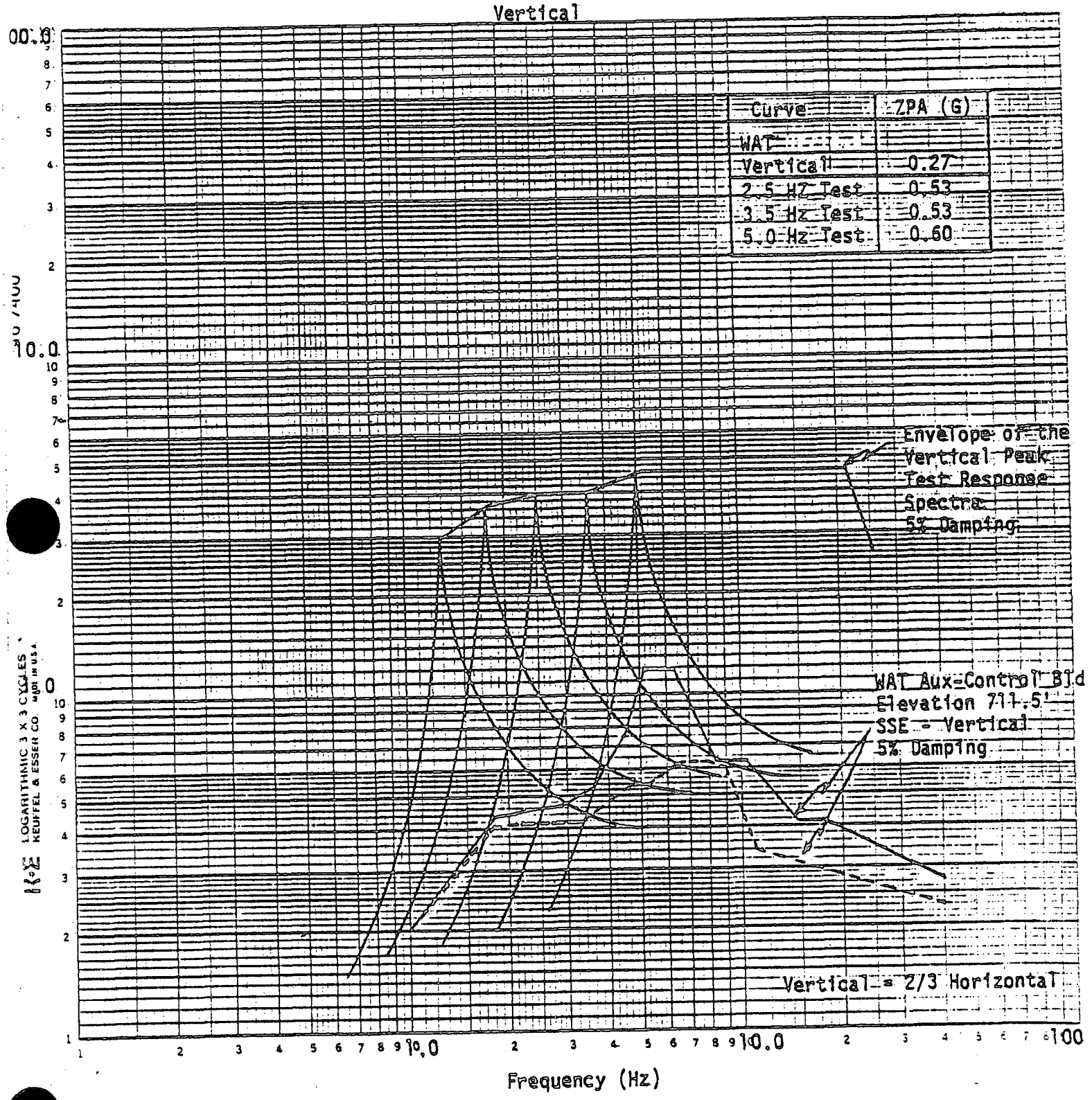


Figure 4

Equipment: Solid State Protection System (3-Bay)

and Safeguards Test Cabinet (1-Bay)



SQRT AUDIT

ATTACHMENT 4.3-1

Attachment 4.3-1

Seismic and Dynamic Qualification Summary of Equipment

Plant Name: Watts Bar

Type:

1. Utility: TVA

PWR XX

2. NSSS: W NES

BWR

3. A/E: TVA

Other

II. Component Name: Safeguards Test Cabinet

1. Scope: [X] NSSS [ ] BOP [ ] Other

2. Model Number: 1060D36 Quantity: two (Train A&B)

3. Size or Range:

4. Vendor: Westinghouse (W ID)

5. If the component is a cabinet or panel, name and model Number of the devices included: Reference drawing 1060E36, Rev. 0

6. Physical Description:

a. Appearance: One Bay Vertical Cabinet

b. Dimensions: 30" x 30" x 91.31"

c. Weight: Approximately 1500 lbs.

7. Location: Building: Control Building

Elevation: 708 Ft.

8. Field Mounting Conditions [ ] Bolt (No. ____, Size ____)
[X] Weld (Length ____)
[ ] ____

9. Mounting Orientation [e.g., on floor, cantilevered, suspended, etc.]

Floor mounted

10. a. System in which Located: Reactor Protection System

b. Functional Description: Provides at-power test capability

c. Is the equipment required for [X] Hot Standby [X] Cold Shutdown

[X] Both [ ] Neither [ ] Other ____

II. Pertinent Reference Design Specifications for Qualification Requirements: E-Spec 952152 Rev. 1

a. Seismic Input
See Section VI

b. Hydrodynamic Load Input
N/A

c. Fatigue Considerations
N/A

d. Service Conditions
Controlled Environment

e. Qualified Life
40 yrs.

III. Is Equipment Available for Inspection in the Plant:

[X] Yes [ ] No [ ] Partial or limited availability

IV. Equipment Qualification Method:

[X] Test [ ] Analysis [ ] Combination of Test and Analysis

Qualification Report*: WCAP 7817 Seismic Testing of Electrical & Control Equipment
Seismic Testing of Electrical & Control Equipment

(No., Title and Date): WCAP 7817 for Low Seismic Plants
Supplement 7

Company that Prepared Report: Westinghouse

Company that Reviewed Report: Westinghouse

Where Report is filed or available: W Monroeville Nuclear Center - NS Department

Applicable Codes And/Or Standards: IEEE-344-1971

V. Vibration Input:

1. Loads considered:
a. [X] Seismic only
b. [ ] Hydrodynamic only
c. [ ] Vibration from normal operation
d. [ ] Combination of (a), (b), and (c)

2. Method of Combining RRS:

[ ] Absolute Sum [ ] SRSS [ ] _____ (other, specify)

3. Required Response Spectra** (attach the graphs): See Attached Figures 1&2

NOTE:
*If more than one report complete items IV thru VII for each report.
**If other than RRS is used, describe method.

4. Damping Corresponding to RRS: OBE N/A SSE 5%

5. Required Acceleration in Each Direction:

[ ] ZPA [ ] Other _____ (specify)

OBE S/S = N/A F/B = N/A V = N/A

SSE S/S = N/A F/B = N/A V = N/A

6. Were fatigue effects considered? No

[ ] Yes [X] No

If yes, describe how they were treated in overall qualification program: _____

VI. If Qualification by Test, then Complete:

1. [X] Single Frequency [ ] Multi-Frequency: [ ] random 5 beats
[X] sine beat (10 cpb)
[ ] _____ @ each test frequency

2. [X] Single Axis [ ] Multi-Axis
[ ] Independent axis [ ] In-phase motions

3. Number of Qualifications Tests: Front-to-Back, Side-to-Side, Vertical

OBE _____ SSE 3 Other _____ (specify)

4. Frequency Range: 1 Hz to 35 Hz

5. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

S/S = 9.5 - 13 F/B = 19 - 20 V = 33 Hz

6. Method of Determing Natural Frequencies

[X] Lab Test [ ] In-Situ Test [ ] Analysis

7. TRS enveloping RRS using Multi-Frequency Test

[ ] Yes (Attach TRS & RRS graphs)
[X] No TRS envelopes RRS for single-axis sine beat testing

8. Maximum Input g-level Test: See Attached Figures 3&4

OBE S/S = _____ F/B = _____ V = _____

SSE S/S = _____ F/B = _____ V = _____

9. Laboratory Mounting:

A. [X] Bolt (No. 4, Size 3/4)

[ ] Weld (Length _____) [ ] _____

B. Orientation and Fixturing: Floor Mounted

10. Functional operability verified:

[X] Yes [ ] No [ ] Not Applicable

11. Test Results including modifications made: Test results were acceptable and structural integrity demonstrated. No modifications to the equipment were made.

12. Other tests performed (such as aging or fragility test, including results):

None

13. Failure Modes (If appropriate: None)

14. Margins Available: [X] Input Spectrum [ ] Fragility

VII. If Qualification by Analysis, then complete: N/A

1. Method of Analysis:

~~[ ] Static Analysis [ ] Equivalent Static Analysis~~

[ ] Dynamic Analysis: [ ] Time-History [ ] Response Spectrum

2. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

S/S = _____ F/B = _____ V = _____

3. Model Type: [ ] 3D [ ] 2D [ ] 1D

[ ] Finite Element [ ] Beam

[ ] Closed Form Solution [ ] Other _____

4. [ ] Computer Codes: _____

Frequency Range and No. of modes considered: _____

[ ] Hand Calculations

5. Method of Combining Dynamic Responses from Seismic and other Dynamic Loads:

[ ] Absolute Sum [ ] SRSS [ ] Other: _____ (specify)

6. Damping:

OBE _____ SSE _____ Basis for the damping used: _____

7. Support Considerations in the model: _____

8. Critical Structural Elements:

A.

Identification	Location	Governing Load or Response Combination	Seismic Stress	Total Stress	Stress Allowable

B.

Max. Critical Deflection	Location	Maximum Allowable Deflection to Assure Functional Operability

9. Failure Modes: _____

10. Margins Available: [ ] Input Spectrum [ ] Stress or Deflection

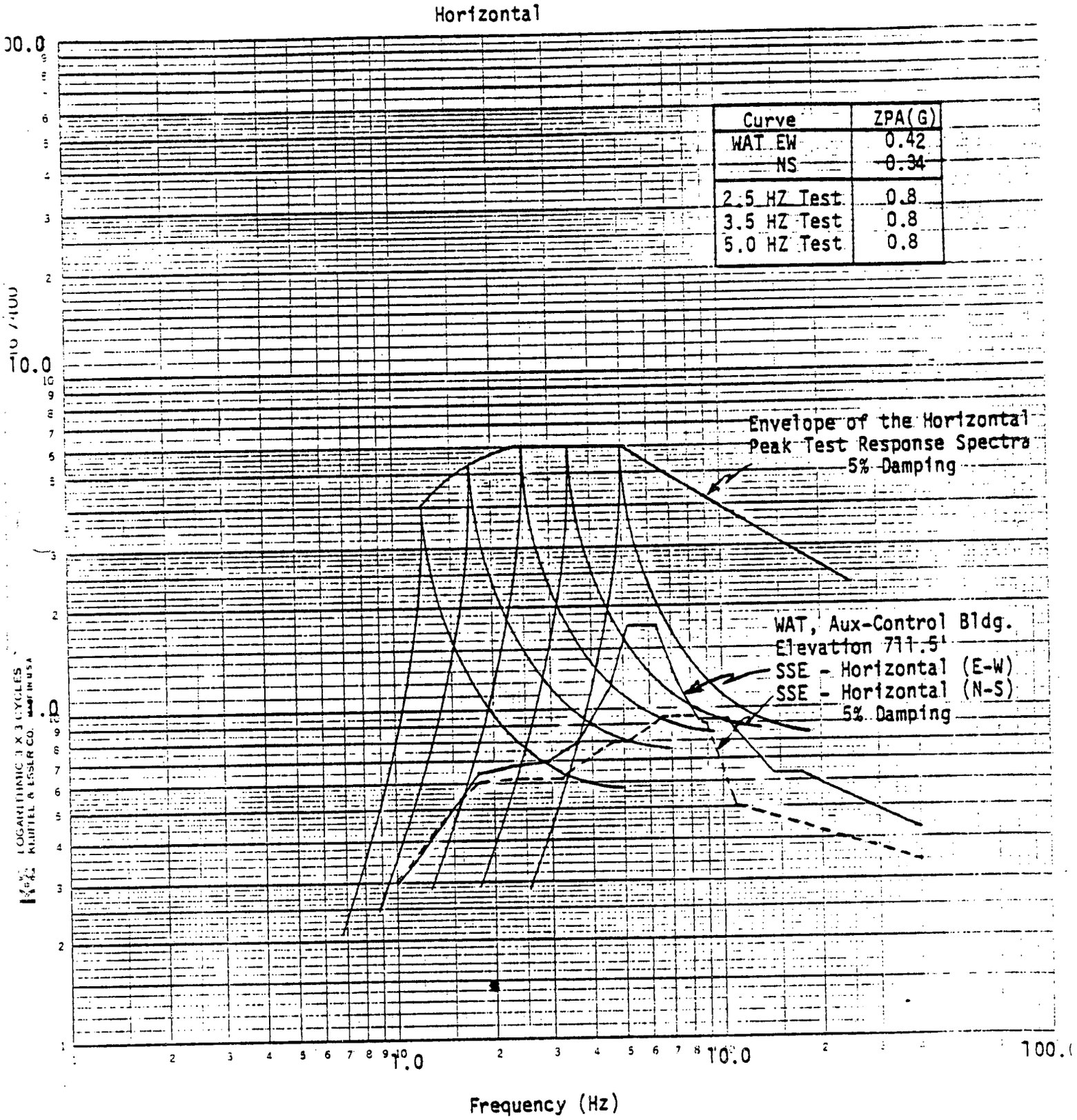
N/A

Figure 3

Equipment: Solid State Protection System (3-Bay)

and Safeguards Test Cabinet (1-Bay)

Horizontal



Attachment 9.1-1

Seismic and Dynamic Qualification Summary of Equipment

Plant Name: Watts Bar

Type:

1. Utility: TVA — PWR 4 Loop
2. NSSS: Westinghouse — BWR
3. A/E: TVA — Other

II. Component Name: CRDM

1. Scope: [X] NSSS [ ] BOP [ ] Other
2. Model Number: L106-A Quantity: 53
3. Size or Range: CRDM's for 12-foot core
4. Vendor: Westinghouse Electro-Mechanical Division
5. If the component is a cabinet or panel, name and model number of the devices included: Not applicable
6. Physical Description:
   a. Appearance: Cylindrical pressure housing with control rods (See W dwg. 1168E85, Rev. 3)
   b. Dimensions: 20' high x 3.8" diameter (see W dwg. 1168E85, Rev. 3)
   c. Weight: ~1800 lbs. (see W dwg. 1168E85, Rev. 3)
7. Location: Building: Containment
   Elevation: 755.63'
8. Field Mounting Conditions: [ ] Bolt (No. ____, Size ____)
   [X] Weld (Length 20.5 inches W Dwg. 184577E, Rev. 2)
   [ ] _____
9. Mounting Orientation [e.g., on floor, cantilevered, suspended, etc.]
   Mounted on reactor vessel head in vertical position and supported by CRDM seismic support system.
10. a. System in which located: Reactor Coolant System
    b. Functional Description: RCS pressure boundary and reactor trip/scram
    c. Is the equipment required for [X] Hot Standby, [ ] Cold Shutdown
    [ ] Both [ ] Neither [ ] Other _____

11. Pertinent Reference Design Specifications for Qualification Requirements:

E-Spec 677470, Rev. 1/952356, Rev. 1

a. Seismic Input
See Item V

b. Hydrodynamic Load Input
See Note 1

c. Fatigue Considerations
See Item V.6

d. Service Conditions
See Referenced E-Spec

e. Qualified Life
40 yrs.

III. Is Equipment Available for Inspection in the Plant:

[X] Yes [ ] No [ ] Partial or limited availability

IV. Equipment Qualification Method:

[ ] Test [X] Analysis [ ] Combination of Test and Analysis

Qualification Report:* EM 4531 inc. Revisions 1 and 2

(No., Title and Date): Stress and Thermal Report of Type L-106A and L-106B CRDM EM 4531 1/31/74 R/1 8/19/75 R/2 4/12/76.

Company that Prepared Report: Westinghouse Electro-Mechanical Division Manf. Cert. by EMD

Company that Reviewed Report: Owners Cert. by Westinghouse PWR Division

Where Report is filed or available: Westinghouse Electro-Mechanical Division

Applicable Codes and/or Standards: ASME Code/IEEE-344-71

V. Vibration Input:

1. Loads considered:
   a. [X] Seismic only
   b. [X] Hydrodynamic only
   c. [ ] Vibration from normal operation
   d. [ ] Combination of (a), (b), and (c)

2. Method of Combining RRS:

   [ ] Absolute Sum [X] SRSS [ ] _____ (other, specify)

3. Required Response Spectra** (attach the graphs): See attached

Note:

*If more than one report complete items IV thru VII for each report.
**If other than RRS is used, describe method.
Note 1 - LOCA loads are considered in combination with SSE loads under the faulted condition.

11. Pertinent Reference Design Specifications for Qualification Requirements: _____

a. Seismic Input
b. Hydrodynamic Load Input
c. Fatigue Considerations
d. Service Conditions
e. Qualified Life

III. Is Equipment Available for Inspection in the Plant:

[ ] Yes [ ] No [ ] Partial or limited availability

IV. Equipment Qualification Method:

[ ] Test [ ] Analysis [ ] Combination of Test and Analysis

Qualification Report:*	WAT Upset and Faulted Condition Loadings	WAT CRDM Seismic Review
(No., Title and Date):	WAT-117/13 2/19/81	RPVSA-82-087, 11/11/82
Company that Prepared Report:	W NTD	W NTD
Company that Reviewed Report:	W NTD	W NTD
Where Report is filed or available:	Westinghouse	Westinghouse

Applicable Codes and/or Standards: IEEE-344-1971

V. Vibration Input:

1. Loads considered:
   a. [ ] Seismic only
   b. [ ] Hydrodynamic only
   c. [ ] Vibration from normal operation
   d. [ ] Combination of (a), (b), and (c)

2. Method of Combining RRS:

   [ ] Absolute Sum [ ] SRSS [ ] _____ (other, specify)

3. Required Response Spectra** (attach the graphs): _____

Note:

*If more than one report complete items IV thru VII for each report.
**If other than RRS is used, describe method.

II. Pertinent Reference Design Specifications for Qualification Requirements:

a. Seismic Input

b. Hydrodynamic Load Input

c. Fatigue Considerations

d. Service Conditions

e. Qualified Life

III. Is Equipment Available for Inspection in the Plant:

[ ] Yes [ ] No [ ] Partial or limited availability

IV. Equipment Qualification Method:

[ ] Test [XX] Analysis [ ] Combination of Test and Analysis

Qualification Report:* EM 4941 and EM 4941 Addendum 1

(No., Title and Date): EM 4941 L-106A Full-Length Control Rod Drive Mechanism and Capped Latch Housing Assembly Pressure Boundary Component Summary Report.

Company that Prepared Report: EM4941 Add 1 Same Title as above plus capped catch housing replacement Westinghouse Electro-Mechanical

Company that Reviewed Report: Manf.-Cert. by EMD Owners Cert. by W PWR Division

Where Report is filed or available: Westinghouse Electro-Mechanical Division

Applicable Codes and/or Standards: ASME Code/IEEE 344-71

V. Vibration Input: Not applicable based upon paragraph 3.1.5 Seismic of E-Spec 677470 Rev. 1

1. Loads considered:
   a. [XX] Seismic only
   b. [XX] Hydrodynamic only
   c. [ ] Vibration from normal operation
   d. [ ] Combination of (a), (b), and (c)

2. Method of Combining RRS:

   [XX] Absolute Sum [ ] SRSS [ ] _____ (other, specify)

3. Required Response Spectra** (attach the graphs): _____

Note:

*If more than one report complete items IV thru VII for each report.
**If other than RRS is used, describe method.

4. Damping Corresponding to RRS: OBE 5%/1% SSE 5%/2%

5. Required Acceleration in Each Direction:

[ ] ZPA [ ] Other N/A (specify)

OBE S/S = N/A F/B = N/A V = N/A

SSE S/S = N/A F/B = N/A V = N/Z

6. Were fatigue effects considered?

[X] Yes [ ] No

If yes, describe how they were treated in overall qualification program:

Fatigue effects were considered as required by the ASME Code for Class 1 components.

VI. If Qualification by Test, then complete:

1. [ ] Single Frequency [ ] Multi-Frequency: [ ] random
[ ] sine beat
[ ] _____

2. [ ] Single Axis [ ] Multi-Axis
[ ] Independent Axis [ ] In-phase motions

3. Number of Qualifications Tests:

OBE _____ SSE _____ Other _____ (specify)

4. Frequency Range: _____

5. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

S/S = _____ F/B = _____ V = _____

6. Method of Determining Natural Frequencies:

[ ] Lab Test [ ] In-Situ Test [ ] Analysis

7. TRS enveloping RRS using Multi-Frequency Test

[ ] Yes (Attach TRS & RRS graphs)
[ ] No

8. Maximum Input g-level Test:

OBE S/S = _____ F/B = _____ V = _____

SSE S/S = _____ F/B = _____ V = _____

9. Laboratory Mounting:

A. [ ] Bolt (No. ____, Size ____)

[ ] Weld (Length ____) [ ] _____

B. Orientation and Fixturing: _____

10. Functional operability verified:

[ ] Yes [ ] No [ ] Not Applicable

11. Test Results including modifications made: _____

_____

12. Other tests performed (such as aging or fragility test, including results):

_____

_____

13. Failure Modes (if appropriate _____)

14. Margins Available: [ ] Input Spectrum [ ] Fragility

VII. <u>If Qualification by Analysis, then complete</u>: See Note 2

1. Method of Analysis:

[X] Static Analysis [ ] Equivalent Static Analysis

[X] Dynamic Analysis: [X] Time-History (LOCA) [X] Response Spectrum (Seismic)

2. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

S/S = ~~5.6~~ 5.0 4.3 5.9 6.8 hz F/B = Same as S/S V = Above 100 hz

3. Model Type: [X] 3D [X] 2D [ ] 1D

[X] Finite Element [X] Beam

[ ] Closed Form Solution [ ] Other _____

Note 2: The analysis of the CRDM's is performed in two parts. First, a generic stress and thermal analysis is performed to determine maximum allowable moment loadings on the CRDM's (see report EM 4531 referenced above). Secondly, a specific plant seismic response spectra analysis and a specific plant LOCA time history analysis are performed. The mements from this analysis are combined by the SRSS method as noted in Item 5 below and compared with the allowable moments (see Item 8.R). The results of the specific plant seismic and LOCA analysis are summarized in the referenced report. Note that the detailed calculation notes and computer runs for these specific plant LOCA and SSE analyses are maintained by Westinghouse in the Byron CRDM file. This information will be available for review during the audit at the site.

4. [X] Computer Codes: WECAN/EFASS-6

Frequency Range and No. of modes considered: 0-80 hz. 66 modes (these are total system modes)

[ ] Hand Calculations

5. Method of Combining Dynamic Responses from Seismic and other Dynamic Loads:

[ ] Absolute Sum [X] SRSS [ ] Other: _____ (specify)

(Faulted = $\sqrt{LOCA^2 + SSE^2}$ + DW)

6. Damping

OBE 5%/1% SSE 5%/2% Basis for damping used: Tests

7. Support Considerations in the model: System Supports (actual)

8. Critical Structural Elements:

A.

Identification	Location	Governing Load or Response Combination	Seismic Stress	Total Stress	Stress Allowable
Rod travel housing/latch housing joint canopy weld.		OBE Moment 80,700 in-lb	80.7 in-KIP	NA	85.95 in-KIP

B.

Max. Critical Deflection	Location	Maximum Allowable Deflection to Assure Functional Operability
NA		

9. Failure Modes: NA

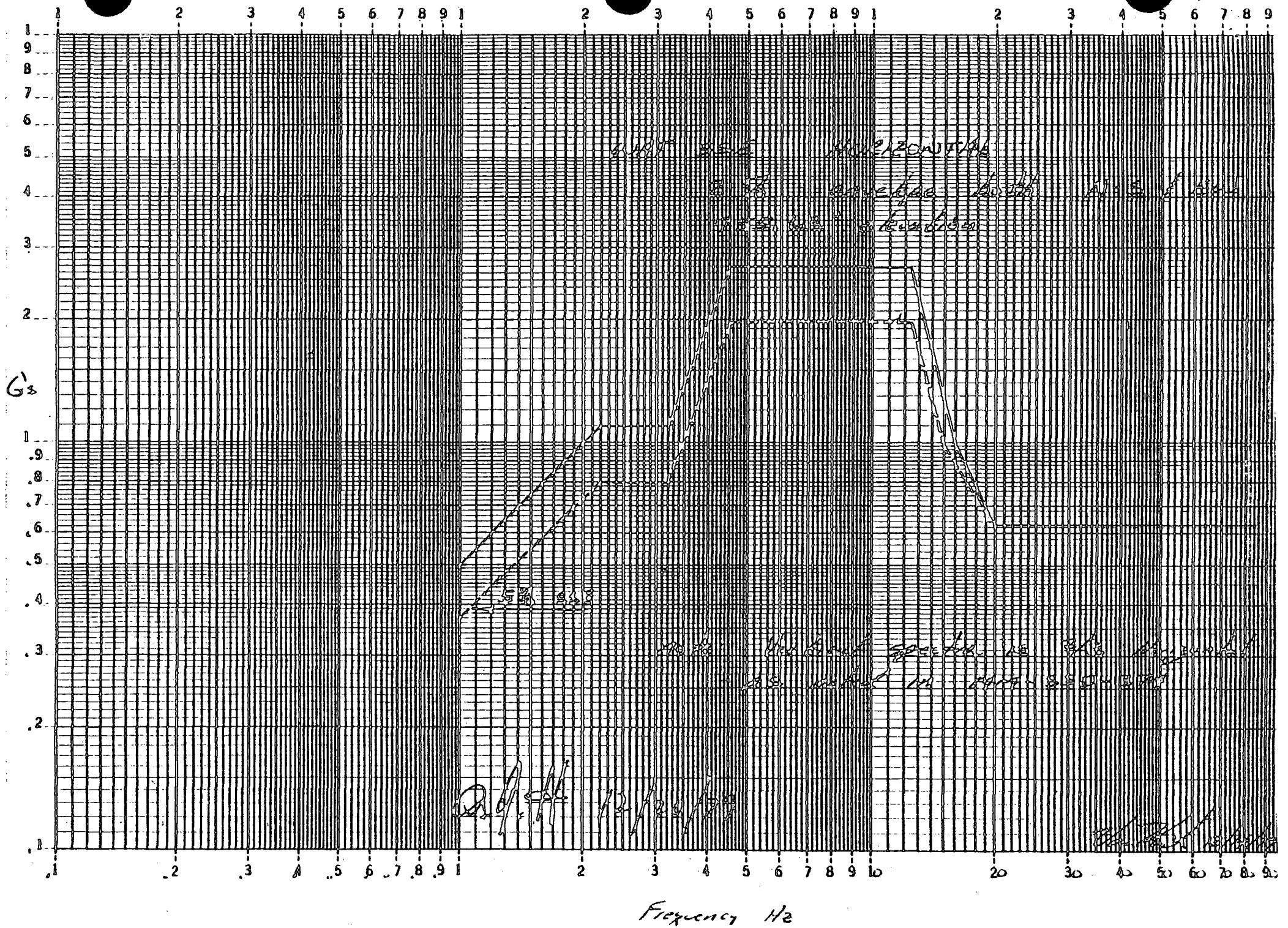
10. Margins Available: [ ] Input Spectrum [ ] Stress or Deflection

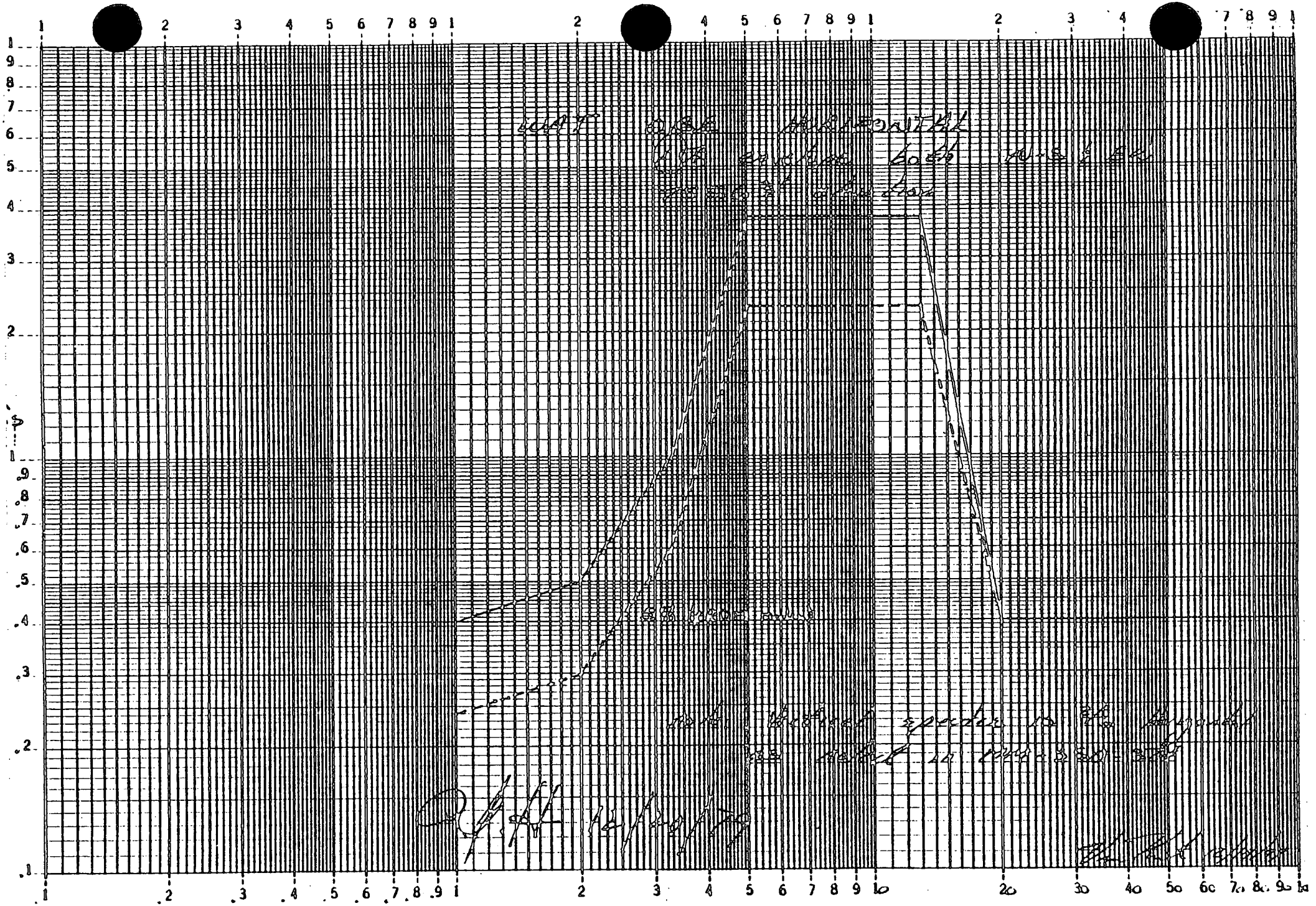
As noted in Item 8A above, there is considerable margin between the allowable and specific plant moment loadings.

References:

1. Obermeyer, F. D., "Effective Structural Damping of the KEP L105 Control Rod Drive Mechanism," WCAP-7427, January 1970. (Westinghouse Proprietary).

2. Obermeyer, F. D., WCAP-7427, Addendum 1 to reference (1) above, December, 1970. (Westinghouse Proprietary).


G's
Frequency Hz


A
Frequency Hz

SQRT AUDIT

ATTACHMENT 12.1-1

Attachment 12.1-1

WATTS BAR NUCLEAR PLANT

SAFETY-RELATED

MAINTENANCE INSTRUCTION

MI-57.7

ANNUAL SAFETY-RELATED 125-VOLT D.C. VITAL BATTERY INSPECTION

UNITS 1 & 2

Rev. By	Rev. No.	Date	Revised Pages
	0	8/8/78	All
CAR	1	3-11-80	All
JDS	2	3-24-81	1 & 2

1C	Plant Master File
	Superintendent
	Assistant Superintendent
1C	Mechanical Maintenance Supervisor
	Results Supervisor
1C	Operations Supervisor
2C	Quality Assurance Supervisor
1C	Health Physicist
	Administrative Supervisor
	Chemical Laboratory
	Instrument Shop
1C	Shift Engineer's Office
	Unit Control Room
	Health Physics Laboratory
	PSU Supervisor
	Mechanical Engineer
	Reactor Engineer
	Chemical Engineer
	Instrument Maintenance Supervisor
	Asst. Director of Nuc Power (Oper)
1U	Electrical Maintenance Supervisor
1C	Plant Industrial Engineer
1C	Outage Director
1U	NRC
1C	Nuclear Safety Review Staff
1U	Plant Maintenance Branch-C
1C	Assistant Maintenance Supervisor
1C	Nuc. Power Training Center

Prepared By Jimmy D. Hutson

Submitted By _____ Supervisor

PORC Review 3-11-80 Date

Approved By _____ Superintendent

Date Approved 3-11-80

The last page of this instruction is

1.0 PURPOSE

This instruction provides for an annual program of maintenance on the following listed safety-related station batteries:

125-volt d.c. battery bank No. I
125-volt d.c. battery bank No. II
125-volt d.c. battery bank No. III
125-volt d.c. battery bank No. IV

This instruction, in conjunction with other instructions, will be used to comply with the requirements of standard practice WB7.4.4 and ESL5.1 for establishing a station battery maintenance program.

This instruction will comply with the constraints imposed by Technical Specification 3.8.2.3 and 3.8.2.4. This instruction can be performed in all modes of operation.

NOTE: All steps preceded with a numeric symbol, #, require documentation in the data package.

2.0 REFERENCES

2.1 ESL 5.1, "Scheduled Battery Maintenance"

2.2 Technical Specification 3.8.2.3

2.3 Technical Specification 3.8.2.4

2.4 Standard Practice WB7.4.4

3.0 PREREQUISITES

3.1 If it is necessary to remove any terminal connections, notify operations to take the battery out of service by opening the battery breaker on the appropriate board. For a list of batteries and corresponding breaker numbers, see Appendix B. The appropriate breaker should be opened before any terminal removal work begins. (The tagging-procedure is attached as Appendix B.)

#3.2 Obtain approval of Shift Engineer or his designated representative to perform this instruction.

3.3 Breaker 109 an applicable 125-v vital battery board is open. (Applicable only when removing terminal connections)

3.4 Review ESL 5.1 before performing this instruction.

4.0 PRECAUTIONS

4.1 Personnel performing this instruction shall wear an approved faceshield, apron, and rubber gloves.

4.2 Personnel performing this instruction should be aware of the location of the eyewash station and ensure that the exhaust fan is operating in each
* battery room. If eyewash is found to be inoperable, notify foreman before
* proceeding with this instruction.

4.3 Smoking, open flames, or welding is prohibited in the immediate vicinity of the battery as a precaution against ignition of any hydrogen present.

4.4 Keep battery terminals and straps clear of all tools and other foreign objects except when checking or tightening the terminals and straps.

4.5 If connector bolt wrenches are used, use wrenches with insulated handles. All other hand tools used on battery terminals should have insulated handles.

4.6 Discharge all static electricity from the body before touching a cell or cell post by touching a grounded surface, such as grounded iron work.

#4.7 Efforts shall be made to maintain a clean work area.

5.0 PREPARATION FOR WORK

#5.1 Obtain a microhmeter with an accuracy of no less than ± 2 percent for checking terminal connections in this instruction.

#5.2 Obtain a torque wrench capable of handling torques from 5in/lbs to 150in/lbs.

5.3 Have baking soda available for neutralizing acid spills.

5.4 Obtain an approved faceshield, apron, and rubber gloves.

6.0 PERFORMANCE OF WORK

NOTE: The following steps are to be performed for each of the four batteries and the data recorded on the appropriate data sheets (Appendix A).

Two craftsmen will perform this instruction. Each craftsman will read the value on the microhmeter to assure the measurement is accurate. They shall then sign and date each data sheet to verify that each step was done properly.

For maintenance reasons, any one battery or combination of batteries may be checked by this procedure at times other than the routine annual inspection.

#6.1 Read the intercell connection resistance of each cell with a microhmeter and record each value on the appropriate data sheet.

#6.2 Compute the average of the connection resistances by using the readings taken in step 6.1 and record it on the appropriate data sheet.

#6.2.1 Compare all connection resistance readings against the average resistance reading. If reading is within 10% range check appropriate space on the appropriate data sheet.

NOTE: If reading is above 10%, space shall be checked only after one of the corrective actions has brought resistance reading within 10% of the average reading.

6.3 Torque the high reading connection(s) to 100 in/lbs (for stainless steel terminal connectors.)

#6.4 Reread and record the questionable connection resistance to see if torquing the connection has improved the microhmeter reading.

6.5 If torquing has not improved the reading, check the post and the connector for corrosion. If it is necessary to break a terminal connection, have operations remove the battery from service. See Appendix B for procedure.

6.5.1 If the terminal connector and the battery terminal are corroded, the connector should be removed and the terminal and the connector should be cleaned with a brass suede brush or fine sand paper.

6.5.2 Apply no-oxide grease to the clean battery terminal and connector and reinstall it.

6.5.3 Torque the bolted connection to 100 in/lbs.

#6.5.4 Reread the newly installed connector resistance and record the reading. If the connection is still above 10 percent of the average reading, notify the maintenance supervisor. Note the action to be taken under "Remarks" section of the Data Cover Sheet.

6.0 PERFORMANCE OF WORK (continued)

6.6 Visually inspect all battery terminals and connectors and apply no-oxide grease to the battery terminals and connectors if needed.

6.7 Clean batteries if needed with a solution of bicarbonate of soda (one pound of soda per gallon of water.) Wipe the water off with a clean dry rag.

7.0 POST MAINTENANCE TESTING

7.1 No post-maintenance testing will be required; all connections removed will be verified operable by terminal resistance check.

7.2 The performance of this instruction has been completed.

ANNUAL SAFETY-RELATED 125-VOLT D.C. VITAL BATTERY INSPECTION
UNITS 1 & 2

BATTERIES CHECKED (INDICATE)

/___/ 125-volt d.c. battery bank No. I

/___/ 125-volt d.c. battery bank No. II

/___/ 125-volt d.c. battery bank No. III

/___/ 125-volt d.c. battery bank No. IV

REASON FOR CHECK

/___/ Annual Readings

/___/ Other (Explain) _____

_____

Reference TR# (If Applicable) _____

Performed by _____ Date _____
Electrician

_____
Electrician

Reviewed by _____ Date _____
Electrical Engineer

Approved by _____ Date _____
Maintenance Supervisor - Electrical

QA Reviewed (If Nonroutine) _____ Date _____

Return to Electrical Maintenance Section

REMARKS: _____

_____

_____

_____

_____

SQRT AUDIT

ATTACHMENT 13.3-1

13. DIESEL CONTROL & PROTECTION RELAY PANELS
ATTACHMENT FOR QUESTION 13.3, ATTACHMENT 13.3-1

DELTA SWITCHBOARD COMPANY

705 N. CARLTON AVENUE • P.O. BOX 1995 • PHONE (209) 466-3621 • STOCKTON, CALIFORNIA • 95201

November 4, 1974

Ref: Tennessee Valley Authority
Contract 74C8 - 85329
Our S.O. 47495
Seismic Test

TEST PLAN

A. Purpose of Test.

To determine effects of seismic shock on the physical and operational characteristics of the submitted relay board.

B. Equipment under Test.

Item 1. Referenced contract, diesel generator relay board 1A-A, cubicle type, 3 sections.

C. Test Parameters.

Accelerations of 1.08G horizontal and .78G vertical are considered the maximum safe shutdown conditions.

D. Minimum acceptance criterion.

1. No loss of function or ability to function as class IE diesel generator relay board, before, during, or after test.

2. No structural/electrical failure (i.e., connections and and anchorages) which would compromise component integrity.

E. Test Facility.

Wyle Laboratories
Testing Division Norco Facility
1841 Hillside Avenue
Norco, CA. 91760

PROCEDURE

1.0 Mounting

1.1 Specimen Orientation

The Diesel Generator Relay Board, hereinafter called the specimen, will be placed on the Wyle multi-axis simulator table. The specimen will be oriented such that its longitudinal axis will be co-linear with the longitudinal axis of the table. For the second axis of test, the specimen will be rotated 90-degrees about its vertical centerline.

1.2 Specimen Mounting

The specimen will be secured to an interface fixture in its normal mounting manner. The fixture will be welded to the test machine.

2.0 Proof Testing

2.1 Accelerometer Locations

Accelerometers shall be mounted on the test table and throughout the board under test to monitor input and output accelerations. The accelerometers shall be located in accordance with the attached sketch, and they shall monitor the axes corresponding to the axes excited on the input.

2.2 Sinusoidal Testing

a. A frequency scan for resonance shall be conducted using a sinusoidal input level of around 0.2g. The frequency range shall be 1 Hz to 33 Hz, and the sweep rate shall be one octave per minute. The frequency scan shall be conducted with the horizontal and vertical axis in phase and then with one axis 180° from the original phase. When the testing is complete in this axis the board shall be rotated 90° horizontally, and the frequency scan shall be conducted with the horizontal and vertical axis in phase and then with one axis 180° from the original phase.

b. Four distinct seismic tests shall be made on the subject board for qualification. These four tests shall consist of first, with the inputs (horizontal, and vertical) in phase; next, with one input 180° out of phase, next, with the board rotates 90 degrees horizontally and the inputs (horizontal and vertical) in phase; and finally, with the same equipment orientation but with one input 180 degrees out of phase.

c. A sine beat test shall be the basis for seismic qualification of the subject boards. Each of the four tests described in paragraph "b" above, shall consist of the application of a sine beat motion with maximum peak acceleration corresponding to the safe shutdown earthquake (SSE)

c. (continued)

zero period acceleration (ZPA) which is 1.08g horizontal and 0.72g vertical over a frequency usuage of 1 to 33 Hz. Five beats with a pause between beats such that there results no significant superposition of motion shall be run at each natural frequency of the board as determined by the resonant search test and at each half octave over the frequency range 1 to 33 Hz. There shall be 10 cycles per beat for each sine beat.

3.0 Monitoring

3.1 Excitation Control

Control accelerometers to monitor input accelerations will be mounted on the test table at locations near the driving points for the horizontal and vertical axes.

3.2 Specimen Response

The required quantity of response accelerometers will be mounted on the specimen at locations shown on the attached sketch. Each accelerometer response will be recorded on magnetic tape and/or oscillograph recorder.

3.3 Functional Device Monitoring Criteria (Electrical Monitoring)

a. Each of the relays listed below shall be monitored with chatter detectors for contact chatter. Contact chatter is defined as false opening of normally-closed contacts and false closures of normally-open contacts which times are greater than one milli-second. Each relay shall be tested for chatter throughout all four test phases.

b. One each of the following protective relays shall be tested for contact chatter with the relays de-energized:

Device No.	Relay Type
51V	COV-8
32	CRN-1
64	DCF
59	CV-5
51	CO-8
46	CM
87	SA-1
50	SC

DE-ENERGIZED -- NOT CRITICAL TO RELAY PANEL OPERATION FOR ACTUATION OF D.G. SYSTEM.

c. The following lock-out relays shall be tested for contact chatter. One relay shall be tested in the reset position and the other in the tripped position. BOTH MODES

Device No.	Relay Type
86-3	Series 24
82-2	Series 24

d. Each of the following auxiliary relays shall be tested for contact chatter with one of each type relay energized and one of each type relay de-energized. BOTH MODES

Relay Type
MG-6
HGA

e. After the seismic test, each of the above relays shall be inspected for physical failure and tested for electrical failure.

4.0 In-Process Inspection

The records will be checked for quality of performance after each test. The specimen will be examined for possible damage following each phase of testing and at other appropriate times. All important vibration effects will be logged. Photographs will be taken of any noticeable physical damage that may occur.

5.0 Report

Test reports shall be in accordance with contract 74C8-85329, and consist of:

Wyle Laboratories Test Data.

Ten copies of a certification type report will be issued subsequent to the completion of testing, and this report will be signed by a registered professional engineer.

The subject test report is an official document which shall have unity, coherence, and emphasis. Any unsatisfactory portions of the test report may require retesting of the board and resubmitting a corrected test report.

The documentation shall include the following:

a. Description of the testing facilities (name and location)

b. List of equipment and supporting structure used during test and calibration data of instruments.

c. A sketch and written description of the physical installation of equipment on the testing machine showing test directions and accelerometer locations.

d. Provide a summary of test data consisting of test number, sweep rate, input acceleration level, time between beats, beat frequency, frequency content, axis tested, test

e. Discuss any failures which occurred during the testing.

f. Furnish a table of data taken from the oscillograph recordings of input accelerations, board accelerations, frequency, and time between beats.

g. Average damping co-efficients of board tested in each axis. Show equation used and give an example of calculation.

h. Data on the relays tested consisting of relay location, accelerations, frequency, test number, failures, and any pertinent information to prove their ability to withstand and function during and after the seismic tests.

i. Natural resonant frequencies obtained.

j. Certification that the boards not tested are of identical construction and could meet the same seismic and environmental requirements as the board that was tested.

k. Approved signature and date.

DELTA SWITCHBOARD COMPANY

John Hey
Project Engineer

JH:ph

SQRT AUDIT

ATTACHMENT 18.1-1

ATTACHMENT 18.1-1

McDONALD ENGINEERING ANALYSIS COMPANY
POST OFFICE BOX 9974
2245 1st Street N. W.
BIRMINGHAM, ALABAMA 35215
PHONE
(205) 854-0719

May 5, 1982

Tennessee Valley Authority
W9D183, 400 Summitt Hill Drive
Knoxville, Tennessee 37902

Attn: Mr. John Williamson

Subject: Watts Bar Essential Raw Cooling Water Pumps, our report ME-274 - .375" support gap

Dear Mr. Williamson:

As I discussed with you on the phone, I can not do a precise analysis of this gap unless I have the complete time-history data for this system. However, as we discussed, I am able to perform a conservative approximate analysis as follows:

Using the standard formula:

$$d = \tfrac{1}{2}at^2 \text{ where } d = .375", \ a = .2g \text{ or } 77 \text{ in./sec.}^2,$$

and t = time before impact

Therefore:

$$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(.375)}{77}} = .099 \text{ seconds}$$

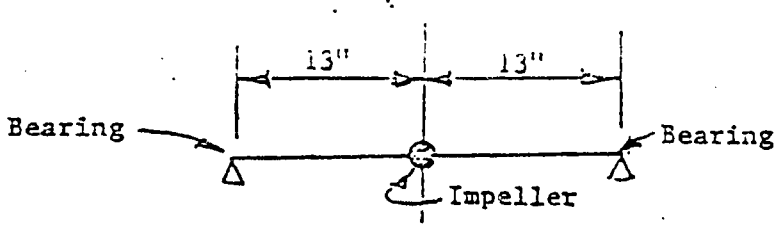
Also, $v = at$, where v is the velocity. Thus:

$$v = 77(.099) = 7.63 \text{ in./sec.}$$

The kinetic energy is: $U = \tfrac{1}{2}mv^2$, m = 12.2 for total bowl assembly

$$U = \tfrac{1}{2}(12.2)(7.63)^2 = 355 \text{ in-lbs.}$$

The impeller shaft has $K = \frac{48EI}{L^3} = \frac{48(29000000)(6.84)}{(26)^3} = 541{,}721$ lbs./in.



The kinetic energy is absorbed by the shaft, thus:

$$\tfrac{1}{2}K\Delta^2 = U = 355$$

$$\Delta = \sqrt{\frac{2(355)}{541721}} = .036'' \text{ , thus the wear rings contact}$$

This causes a load on the wear ring of:

$$P = K\Delta = 541721(.036) = 19{,}502 \text{ lbs.}$$

The wear ring is 12" diameter x 1" wide. Thus, the contact area is:

$$A = 12(1) = 12 \text{ in.}^2 \text{ projected}$$

The contact stress is:

$$S = 19502/12 = 1{,}625 \text{ psi}$$

The allowable is at least 5,000 psi for <u>short term</u> loads for bronze wear rings.

As shown above, even a very conservative analysis shows that the gap will be no problem. I think that the above is very conservative because once the impeller makes contact, the energy will probably be absorbed elsewhere in the bowl.

Very truly yours,

C K McDonald

C. K. McDonald

CKM/sds

SQRT AUDIT

ATTACHMENT 19.1-1

ATTACHMENT 19.1-1

PEP 574

Seismic Analysis of P01-54 Cycoil

Bruce GM Diesel, Inc.

C. Gary Hughes

19 February 1974

19 February 1974

Seismic Analysis

Equipment: P01-54 Cycoil

By: American Air Filter Co., Inc.

Engineer: C. Gary Hughes

For: Power Systems Division of
Bruce GM Diesel, Inc.

Job:

Purchase Order: 19093-336-379

Bruce Spec.: PSD QA010, Rev. 1, June, 1972

Seismic Spec.: 21A9236BZ, Rev. 0 Par. 4.8

Seismic Requirements:

The equipment must be designed to withstand and remain operable after the application of the worst of the seismic loadings:

(1) Horizontal 2.7 g, Vertical 1.8 g

(2) Horizontal 3.0 g, Vertical 0.5 g

The coefficients are to be applied to the center of mass of the equipment in the worst case manner concurrently with operating loads. Stresses resulting from this load combination are not to exceed 90% of the material yield stress.

Worst Case Seismic Load:

Bending stresses in the vertical columns are dominant. Therefore, the highest horizontal acceleration poses the most severe loading condition (loading 2 above).

Maximum Stresses:

The standard cycoil was modified by the addition of 6 equally spaced vertical stiffeners. These 4 x 4 x 3/8 rolled steel angles are designed to withstand all of the seismic forces without the need for using the available stiffness in the standard design.

Unit Dry Weight: 2440 Lb.

Weight of Oil: 300 Lb.

Total Wet Weight: 2740 Lb.

Even though the majority of the oil remains in the base reservoir, the weight of the unit will be analyzed as though the oil is evenly distributed over the height of the unit.

The bending moment at a stiffener base is:

$$M = \frac{wL^2}{3} \qquad \text{Where } L = \text{Column Length} = 91 \text{ in.}$$

$$w = \frac{a_H W}{6L} \quad \text{LB/IN}$$

$$W = 2740 \text{ Lb}$$

$$a_H = 3.0 \text{ g}$$

$$\therefore M = \frac{(3.0)(2740)(91)^2}{(6x91)(3)} = 4.16x10^4 \text{ IN-LB}$$

Section modulus(S), 4x4x3/8 angle = 1.52 IN^3

$$\therefore \text{Bending stress } \sigma_B = \frac{M}{S} = \frac{4.16x10^4}{1.52} = \underline{\underline{27,340 \text{ psi}}}$$

Assuming uniformly distributed vertical forces:

The axial compressive stress in a stiffener is:

$$\sigma_A = \frac{(1+a_v)(W)}{6A} = \frac{1.5(2740)}{6(2.86)} = \underline{\underline{240 \text{ psi}}} \quad \left(\begin{matrix} a_v = 0.5 \text{ g} \\ A = 2.86 \text{ in}^2 \end{matrix}\right)$$

The maximum combined stress is:

$$27{,}340 + 240 = 27{,}580 \text{ psi}$$

or 76.6% of the 36,000 psi material yield stress.

This stress level is less than the specified maximum of 90% of material yield stress.

Maximum Deflections:

The maximum deflection occurs at the top of the equipment under the 3.0 g horizontal load. Again considering one of the six 4x4x3/8 column stiffeners:

$$\Delta_{max} = \frac{wL^4}{24EI} \qquad \text{where} \quad w = \frac{a_H W}{6L} = 15 \text{ LB/IN}$$

$$L = 91 \text{ in}$$

$$E = 29\text{x}10^6 \text{ psi}$$

$$I = 4.36 \text{ in}^4$$

$$\therefore \quad \Delta_{max} = \frac{15(91)^4}{24(29\text{x}10^6)(4.36} = 0.34 \text{ in}$$

This deflection is not high enough to cause equipment malfunction during a seismic occurence. Filter pads, the oil lift assembly, and perforated plate will all remain in a stable position throughout the elastic motion. The equipment will return to its original operating configuration after the prescribed seismic disturbance.

Statement of Conformance:

The 54 P01 cycoil, as altered with additional stiffeners, is designed to withstand the prescribed seismic loads without loss of equipment function.

C. Gary Hughes

C. Gary Hughes,
Product Engineer

CGH/tw

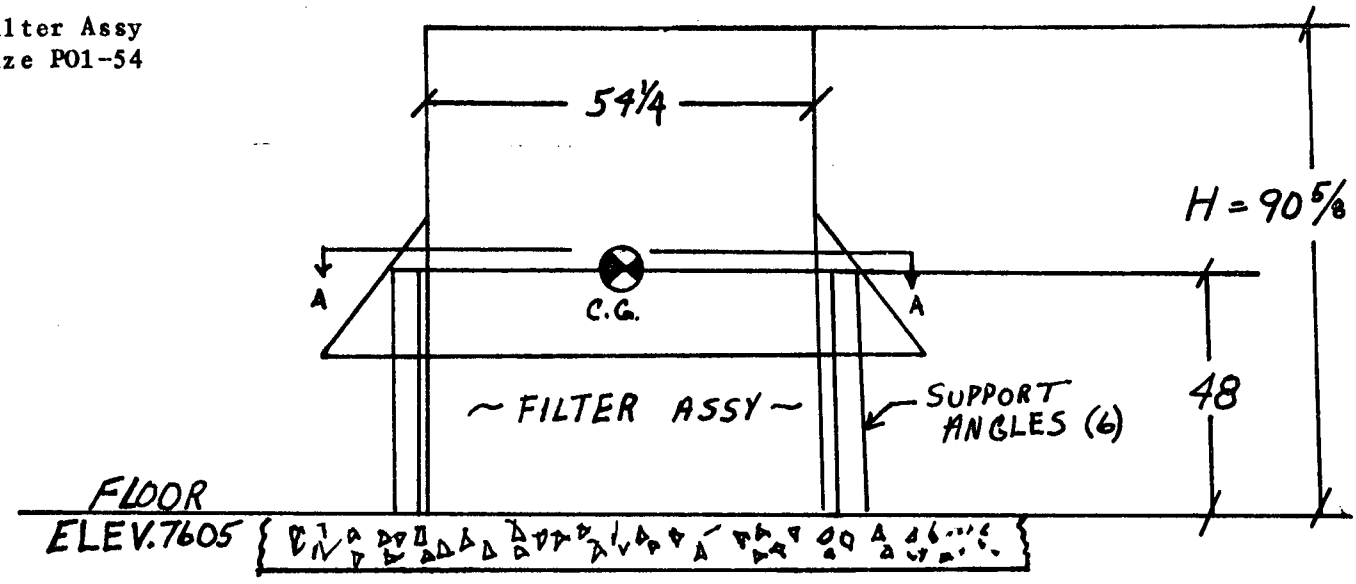
SQRT AUDIT

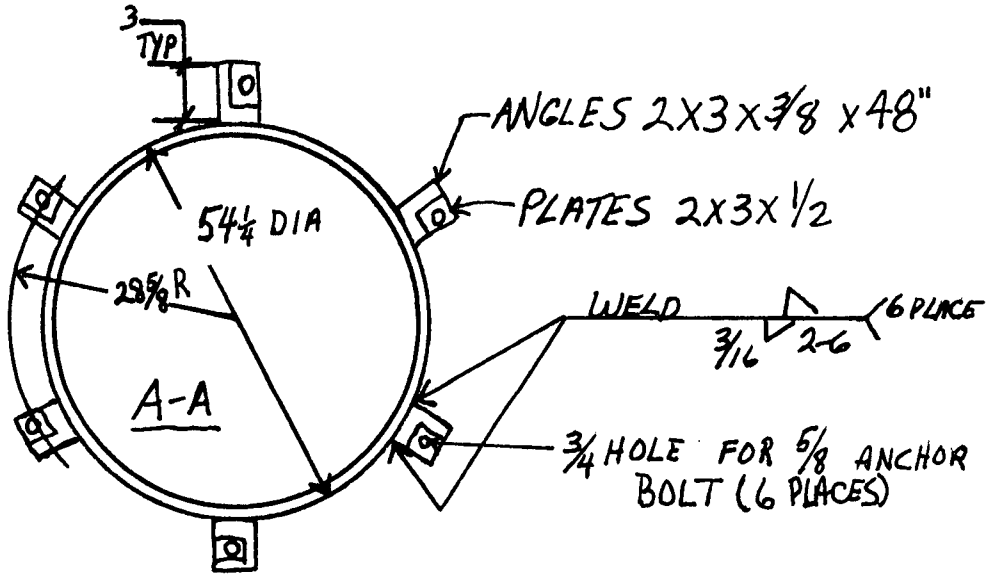
ATTACHMENT 19.1-2

ATTACHMENT 19.1-2

SEISMIC ANALYSIS OF SUPPORT FOR INTAKE AIR FILTER (CYCOIL)
FOR DIESEL GENERATORS
WATTS BAR NUCLEAR PLANT

Filter Assy
Size P01-54





References:

(1) Morrison-Knudsen Co., Inc., Drawing D379D08003, Rev. C
(2) American Air Filter Co., Inc., Drawing 63P-774505-A
(3) TVA Drawings 17W586-1R13 and 17W220-1R8

I. DETERMINE MAXIMUM ANCHOR BOLT LOAD ~ P_{max}

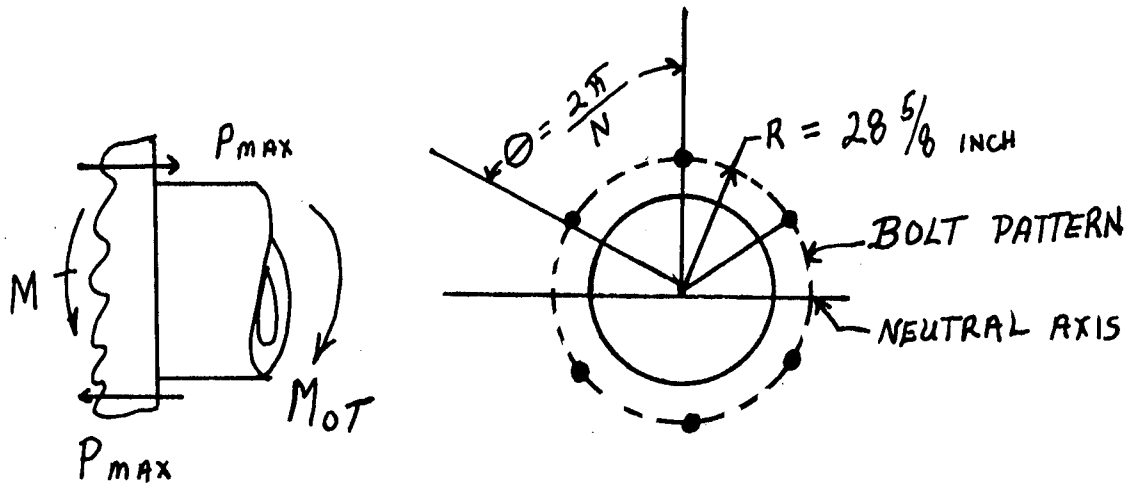
Do unit analysis, i.e., for 1g horiz. acceleration from reference (2):

Weight of Filter Assy Dry = 1,900 lbs
Weight of Oil (45 gal) = 300 lbs

Total Weight = 2,200 lbs

Assume Assy C.G is 48 inches above floor

Overturn Moment ~ M_{ot} = 2,200 lbs x 48 in
105,600 in-lbs for 1g



Pattern Symmetrical About Vertical Axis
Neutral Axis Along Diameter
N = Number of Bolts in Pattern = 6

$$P_{MAX} = \left(\frac{2}{NR}\right) M_{ot} = \frac{2}{6 \times 28\text{-}5/8} \times 105{,}600$$

$$= 1230 \text{ lbs per 'g'}$$

This filter assy is mounted on floor elevation 760.5 of Diesel Generator Building. In order to determine an appropriate response acceleration from the applicable response spectrum, the following natural frequency calculations for the support angle (2 x 3 x 3/8) and composite section are presented.

Properties of angle:

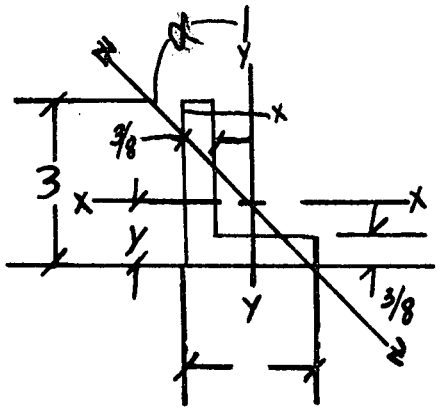
$A = 1.74\ in^2$

$I_{x-x} = 1.51\ in^4$, $Z_x = 0.76\ in^3$

$\gamma_x = 0.93\ in$

$I_{y-y} = 0.53\ in^4$, $Z_y = 0.36\ in^3$,

$\gamma_y = 0.55\ in$



$I_{z-z} = 0.31\ in^4$

$\gamma_z = 0.42\ in$

$\alpha = 23^\circ$

$X = 0.53\ in$

$Y = 1.03\ in$

<u>For Angle Acting Alowe</u>

Natural Freq. of Uniform Beam ~ W_n

$$W_n = \frac{a_n}{2\pi}\sqrt{\frac{EI}{\mu_1 l^4}}$$ For cantilever

where $a_n = 3.52$, $E = 30 \times 10^6$ PSI (Steel Angle)

$$\mu_1 = \text{Mass per unit length} = \frac{0.28\ \#/in^3 \times 1\ in \times 1.74\ in^2}{386}$$

$\mu_1 = .0013$

$l = 48\ in$

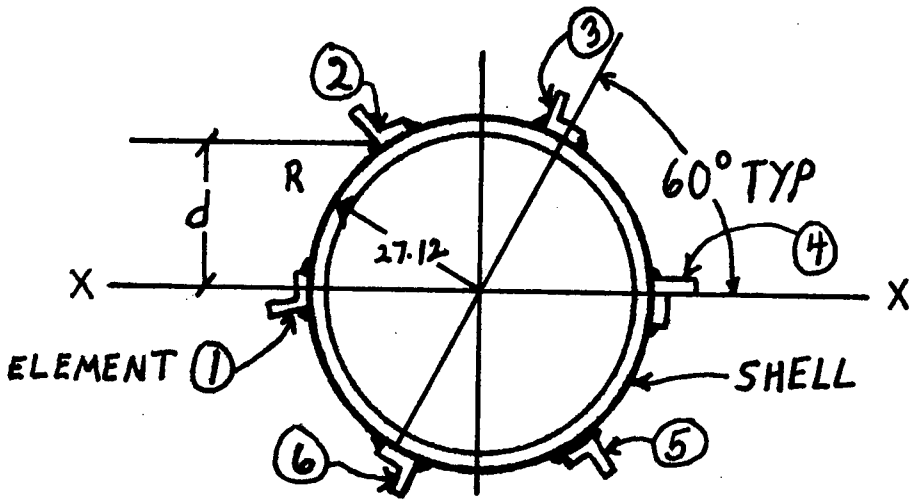
Calculate W_n about 3 axes, i.e., x-x, y-y, z-z

$$\text{About x-x} \sim W_n = \frac{3.52}{2\pi}\sqrt{\frac{30 \times 10^6 \times 1.51}{.0013 \times 48^4}} = 45.H_Z$$

About y-y ~ $W_n = \frac{3.52}{2\pi}\sqrt{\frac{30 \times 10^6 \times 0.53}{.0013 \times 48^4}} = 27.H_Z$

About z-z ~ $W_n = \frac{3.52}{2\pi}\sqrt{\frac{30 \times 10^6 \times 0.31}{.0013 \times 48^4}} = 21.H_Z$

The above W_n's are for information only since the angles do not act alone but as part of a composite cross section to resist bending. Therefore, the composite cross section properties are determined below for calculation of W_n.



Calculate I_{total} by General Eq. ~ $I_{total} = I_{cg} + Ad^2$

For Conservatism Neglect Shell Contribution to I_{total}

Elem	I_{cg} (in⁴)	A(in²)	d(in)	Ad²(in⁴)	Comments
1	0.53	1.74	0	0	
2	~0.31	1.74	24.38	1034	d = (R + 1.03) sin 60°
3	~0.31	1.74	24.38	1034	
4	0.53	1.74	0	0	
5	~0.31	1.74	24.38	1034	
6	~0.31	1.74	24.38	1034	
Total	2.30	10.44		4136	

Moment of Inertia of Composite Cross Section About Axis x-x (see page 4)

$$I_{total} = I_{xx} = \sum I_{cg} + \sum AD^2$$

$$\underline{I_{total}} = 2.30 + 4136 = \underline{4138\ in^4}$$

<u>Calculate Composite Section W_n</u>

$$W_n = \frac{a_n}{2\pi}\sqrt{\frac{EI_{total}}{\mu \ell\ 1^4}}$$

μ_1 = Mass per unit length ~ let weight (2200 lbs) of filter assy be distributed evenly over length (ℓ) of angles (48 inches).

$$\mu = \frac{2200\ lbs}{386 \times 48} = 0.1187$$

$$W_n = \frac{3.52}{2\pi}\sqrt{\frac{30 \times 10^6 \times 4138}{0.1187 \times 48^4}} = 249.H_z$$

From applicable response spectrum, the corresponding response accelerations are

Horizontal Acceleration ~ $A_H = 1.27 \times 2 \times 0.54 = 1.37g$

Vertical Acceleration ~ $A_V = 2/3\ A_H = 0.91g$

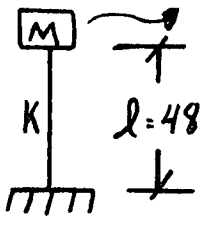
The above $W_n = 249\ H_z$ was based on uniform beam

Do additional W_n calculation based on the following model

$$K = \frac{3EI_{total}}{\ell^3}$$

$$K = \frac{3 \times 30 \times 10^6 \times 4138}{48^3}$$

$$K = 3.368 \times 10^6\ \frac{Lbs}{in}$$



$$M = \frac{\text{Assy weight } 2200\ lbs}{386}$$

$$W_n = \frac{1}{2\pi}\sqrt{\frac{3.368 \times 10^6 \times 386}{2200}} = 122\ H_z$$

Corres, Response Acceleration Are No Change From Above, i.e., $A_H = 1.37g$; $A_V = 0.91g$

See the following for components stress analyses!

Bolt Stress Analysis

From Unit Analysis, Page 2, Bolt Load = 1230 lbs/g

Total $P_{max} = A_H \times 1230 = 1.37 \times 1230 = 1{,}685$ lbs

Bolt Size = 5/8 inch diameter (steel)

$A_t = 0.22$ in² (root area) ~ Class 2A, 3A Threads

$A_s = 0.96 - 1.10 \ \frac{in^2}{inch}$ ~ Class 2A, 3A Threads

Tensile Stress in Bolt ~ S_t

$$S_t = \frac{1685 \text{ lbs}}{0.22} = 7{,}659 \text{ PSI}$$

Assume Bolt Material is A36, Sy = 36,000 PSI

Let Allowable Bolt Stress = 0.9 Sy = 32,400 PSI

Margin of Safety (M.S.) of Bolt

$$\text{(Bolt) M.S.} = \frac{32400}{7659} - 1 = +3.18$$

Composite Section or Support Angle Analysis

Bending Stress (S_b) at Angle Outer Fiber

$C = (R + 3) \text{ SIN } 60° = 26.08$ in

$$S_b = \frac{A_H M_{ot} \times C}{I_{total}} = \frac{1.37g \times 105{,}600 \ \frac{in\text{-}lb}{g} \times 26.08 \text{ in}}{4138 \text{ in}^4}$$

$S_b = 912$ PSI

Assume Angle Material is A36, Sy = 36,000 PSI
Let Allowable Stress = 0.9 Sy = 32,400 PSI

Margin of Safety (M.S.) of Angle

$$\text{(Angle) M.S.} = \frac{32{,}400}{912} - 1 = + \underline{\text{Very Large}}$$

SQRT AUDIT

ATTACHMENT 22.1-1

Attachment 22.1-1

Seismic and Dynamic Qualification Summary of Equipment

Plant Name: Watts Bar

Type:

1. Utility: Tennessee Valley Authority — PWR X
2. NSSS: Westinghouse — BWR
3. A/E: TVA — Other

II. Component Name: Fuel Handling Machine (spent fuel pit bridge crane)

1. Scope: [XX] NSSS [ ] BOP [ ] Other
2. Model Number: FHSCFB Quantity: One
3. Size or Range: 4000 lb Capacity
4. Vendor: Dwight Foote Inc.
5. If the component is a cabinet or panel, name and model number of the devices included: Not applicable
6. Physical Description:
   a. Appearance: Crane-type structure
   b. Dimensions: 25 ft. high - 46 ft. wide - 9'0" long
   c. Weight: 30,000 lbs.
7. Location: Building: Fuel Storage Building
   Elevation: 755 ft.-6 in.
8. Field Mounting Conditions: [ ] Bolt (No. ____, Size ____)
   [ ] Weld (Length ____)
   [XX] Rails connected to floor with anchor bolts
   Note: BOP designer provides size and type of bolts based on rail loads provided by Westinghouse.
9. Mounting Orientation [e.g., on floor, cantilevered, suspended, etc.]
   Sits on floor mounted rails
10. a. System in which located: Refueling System
    b. Functional Description: Used to transport new and spent fuel assemblies
    c. Is the equipment required for [ ] Hot Standby, [ ] Cold Shutdown
    [ ] Both [X] Neither [X] Other Refueling

11. Pertinent Reference Design Specifications for Qualification Requirements:
952570 Rev. 2
Equipment Specification - 676470 Rev. 3

a. Seismic Input See Section V
b. Hydrodynamic Load Input N/A
c. Fatigue Considerations N/A
d. Service Conditions See Referenced Spec.
e. Qualified Life 40 yrs.

III. Is Equipment Available for Inspection in the Plant:

[X] Yes [ ] No [ ] Partial or limited availability

IV. Equipment Qualification Method:

[ ] Test [X] Analysis [ ] Combination of Test and Analysis

Qualification Report:* RS-FHE-0470 (82)

(No., Title and Date): Fuel Handling Machine Static & Dynamic Analysis

Company that Prepared Report: Westinghouse NTD

Company that Reviewed Report: Westinghouse NTD

Where Report is filed or available: Westinghouse NTD

Applicable Codes and/or Standards: CMAA No. 70

V. Vibration Input:

1. Loads considered:
   a. [X] Seismic only
   b. [ ] Hydrodynamic only
   c. [ ] Vibration from normal operation
   d. [ ] Combination of (a), (b), and (c)

2. Method of Combining RRS:

   [ ] Absolute Sum [X] SRSS [ ] _____ (other, specify)

3. Required Response Spectra** (attach the graphs): See attached Figures 2-7

Note:

*If more than one report complete items IV thru VII for each report.
**If other than RRS is used, describe method.

4. Damping Corresponding to RRS: OBE 5% SSE 7%

5. Required Acceleration in Each Direction:

[ ] ZPA [ ] Other _____ (specify)

OBE* S/S = NA F/B = NA V = NA

SSE* S/S = NA F/B = NA V = NA

6. Were fatigue effects considered?

[ ] Yes [X] No

If yes, describe how they were treated in overall qualification program:

_____

_____

VI. <u>If Qualification by Test, then complete</u>: (not applicable)

1. [ ] Single Frequency [ ] Multi-Frequency: [ ] random
[ ] sine beat
[ ] _____

2. [ ] Single Axis [ ] Multi-Axis
[ ] Independent Axis [ ] In-phase motions

3. Number of Qualifications Tests:

OBE _____ SSE _____ Other _____ (specify)

4. Frequency Range: _____

5. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

S/S = _____ F/B = _____ V = _____

6. Method of Determining Natural Frequencies:

[ ] Lab Test [ ] In-Situ Test [ ] Analysis

7. TRS enveloping RRS using Multi-Frequency Test

[ ] Yes (Attach TRS & RRS graphs)
[ ] No

8. Maximum Input g-level Test:

OBE S/S = _____ F/B = _____ V = _____

SSE S/S = _____ F/B = _____ V = _____

9. Laboratory Mounting:

A. [ ] Bolt (No. ____, Size ____)

[ ] Weld (Length ____) [ ] _____

B. Orientation and Fixturing: _____

10. Functional operability verified:

[ ] Yes [ ] No [ ] Not Applicable

11. Test Results including modifications made: _____

_____

12. Other tests performed (such as aging or fragility test, including results):

_____

_____

13. Failure Modes (if appropriate _____)

14. Margins Available: [ ] Input Spectrum [ ] Fragility

VII. <u>If Qualification by Analysis, then complete</u>:

1. Method of Analysis:

[X] Static Analysis [ ] Equivalent Static Analysis

[X] Dynamic Analysis: [ ] Time-History [X] Response Spectrum
See Note 1

2. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

S/S = 3,4,7,8,12 F/B = 5,6,7,17 V = 3,4,5,6,8

3. Model Type: [X] 3D [ ] 2D [ ] 1D

[X] Finite Element [ ] Beam

[ ] Closed Form Solution [ ] Other _____

Note 1: Static analysis was performed to determine stresses from deadweight. A dynamic response spectra analysis was performed to determine seismic stresses. The seismic stresses and deadweight stress were combined absolutely.

4. [X] Computer Codes: WECAN (NRC is currently reviewing WECAN as part of WCAP 8829.)

   Frequency Range and No. of modes considered: 0.1 - 30 Hz - first four modes

   [ ] Hand Calculations

5. Method of Combining Dynamic Responses from Seismic and other Dynamic Loads:

   [X] Absolute Sum [ ] SRSS [ ] Other: _____ (specify)

   Seismic + DW

6. Damping

   OBE 5% SSE 7% Basis for damping used: *WCAP-7921

   *This report has been approved by the NRC.

7. Support Considerations in the model: Same as installed condition

8. Critical Structural Elements:

A.

Identification	Location	Governing Load or Response Combination	Seismic Stress	Total Stress	Stress Allowable
ELEM 5 (bridge truck)		F/B	3T161	35798	47,500

B.

Max. Critical Deflection	Location	Maximum Allowable Deflection to Assure Functional Operability
Not Applicable	Exceeding allowable stresses as defined in AISC manual of steel construction	

9. Failure Modes: None

10. Margins Available: [ ] Input Spectrum [X] Stress or Deflection

    As noted above, there is margin between allowable stresses and actual stresses.

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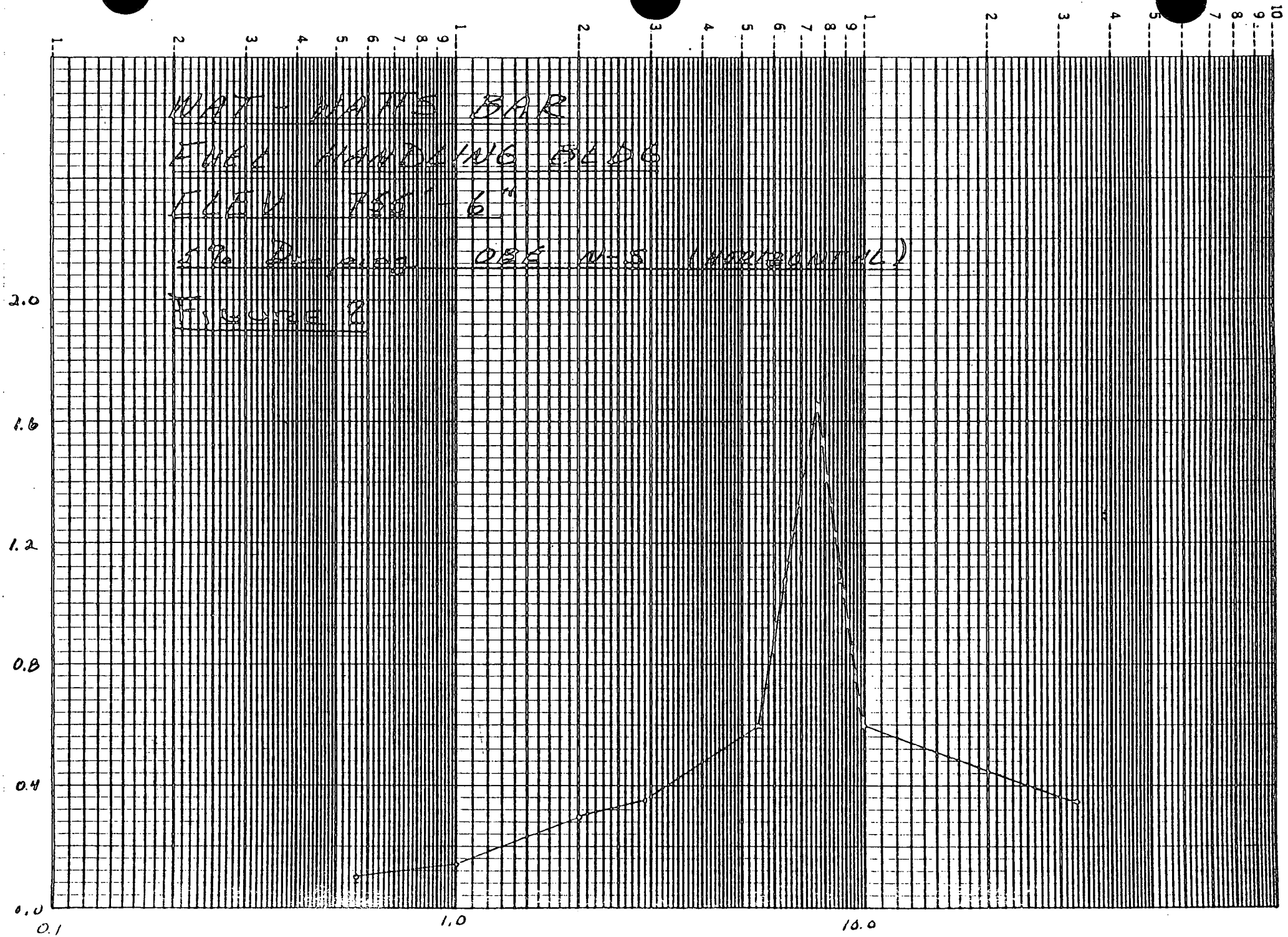
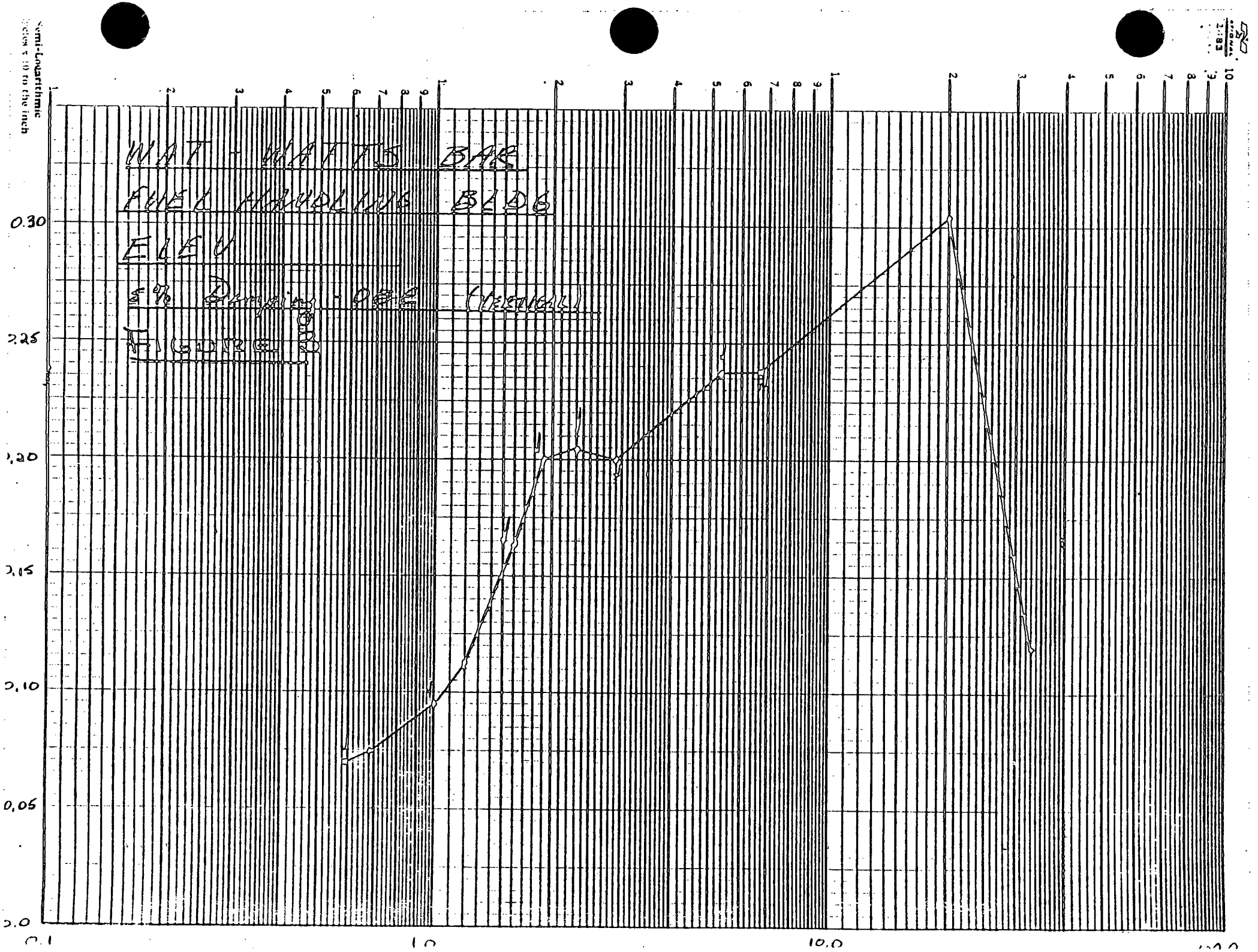
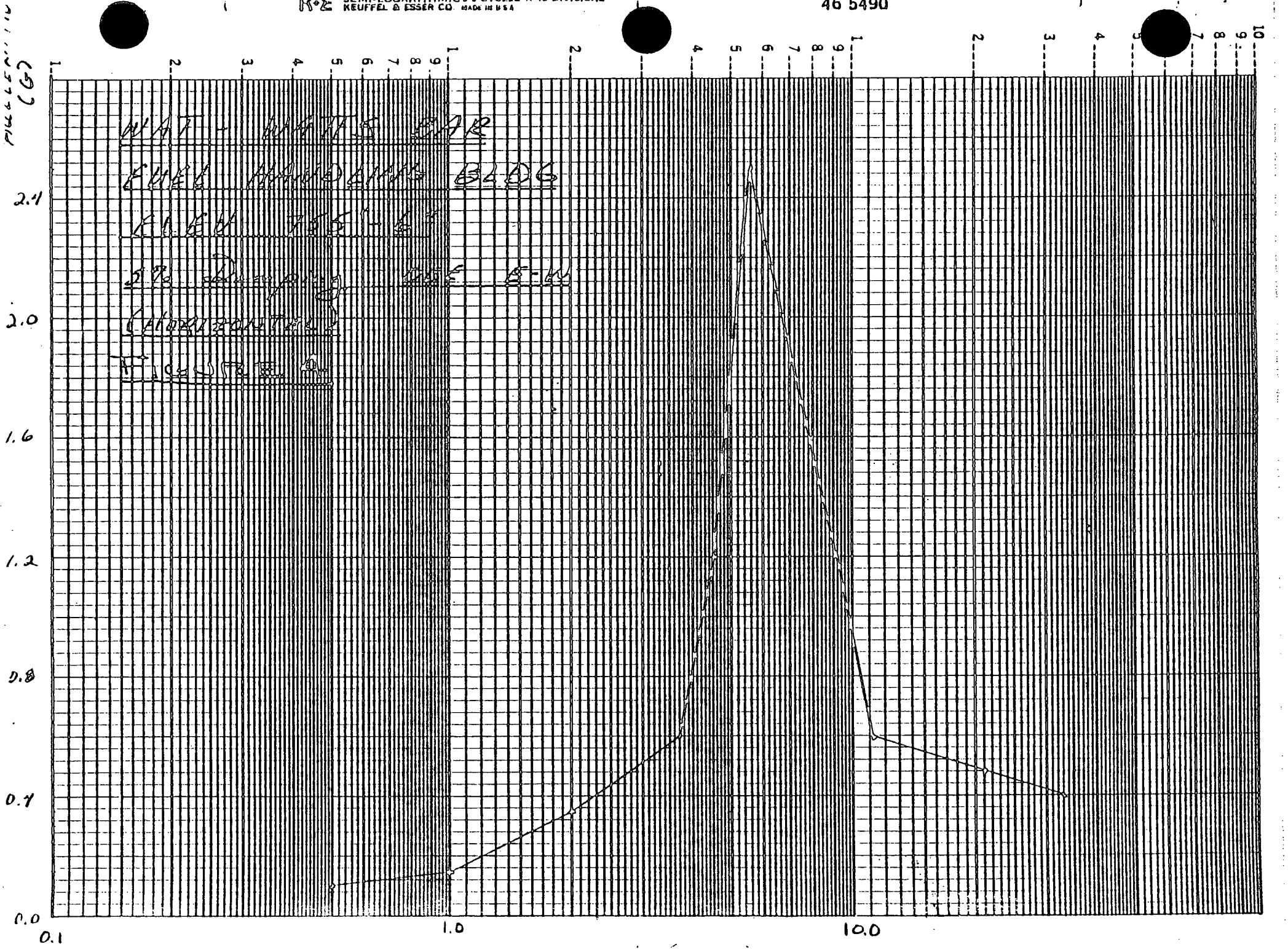
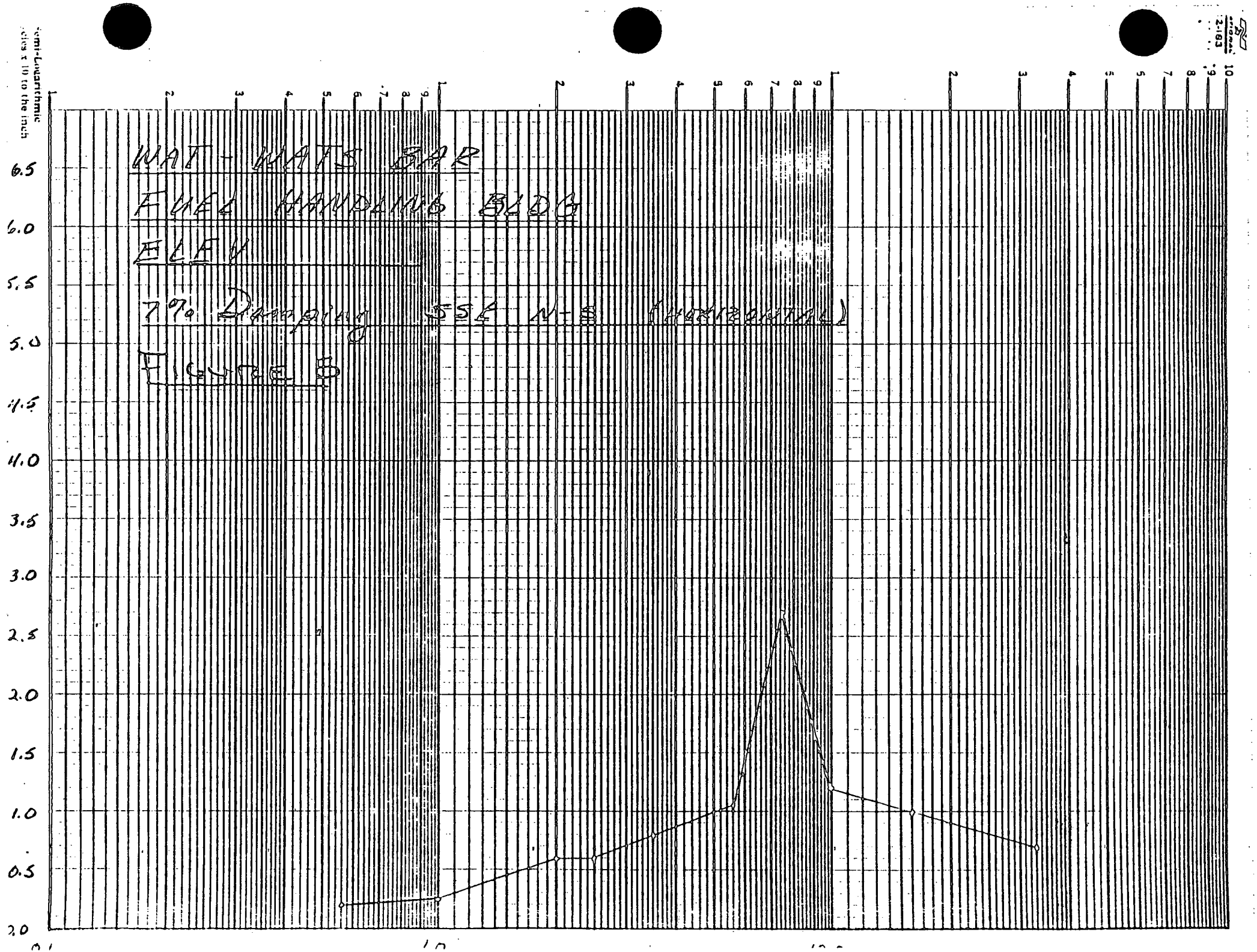
46 5490

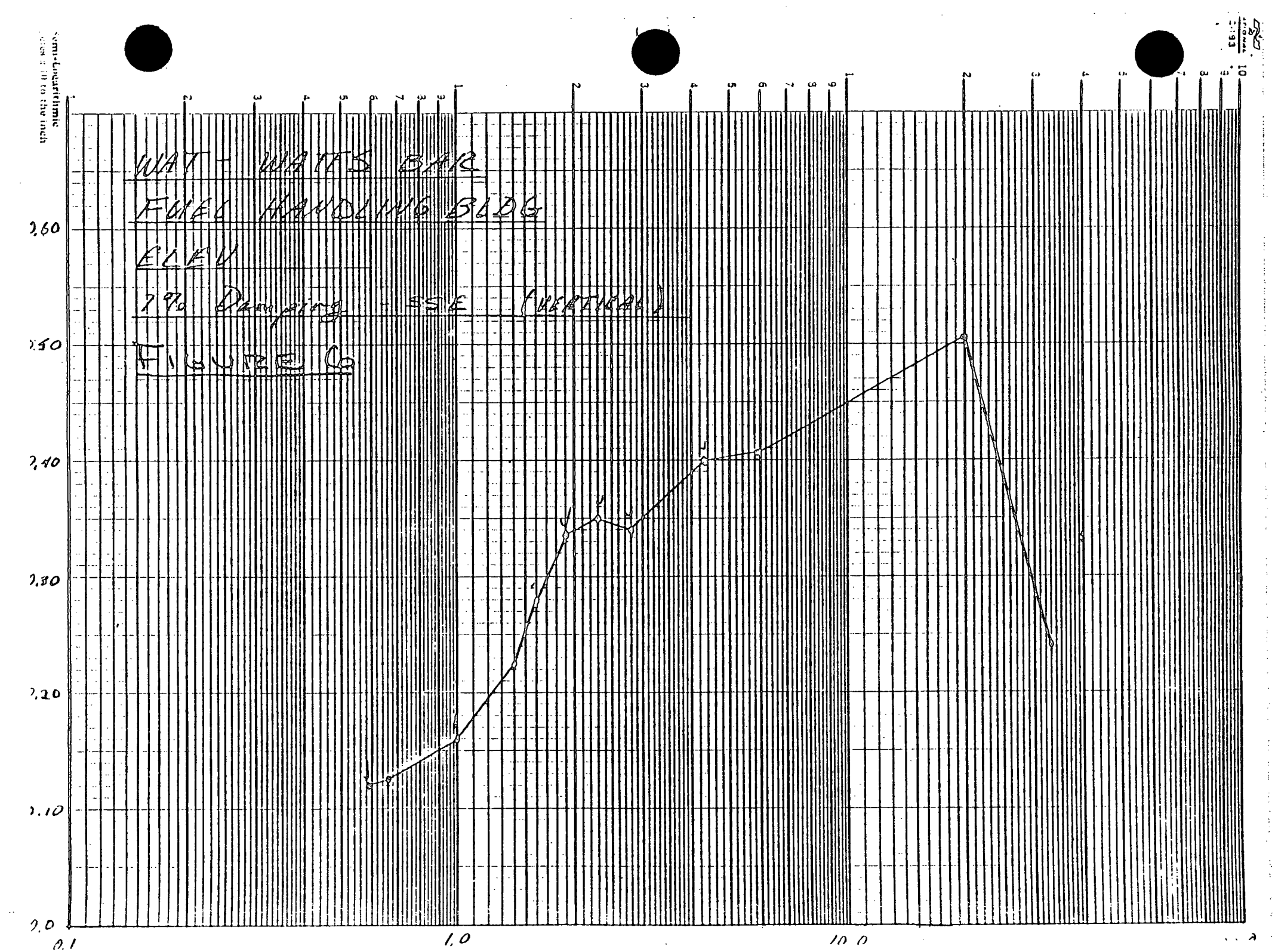


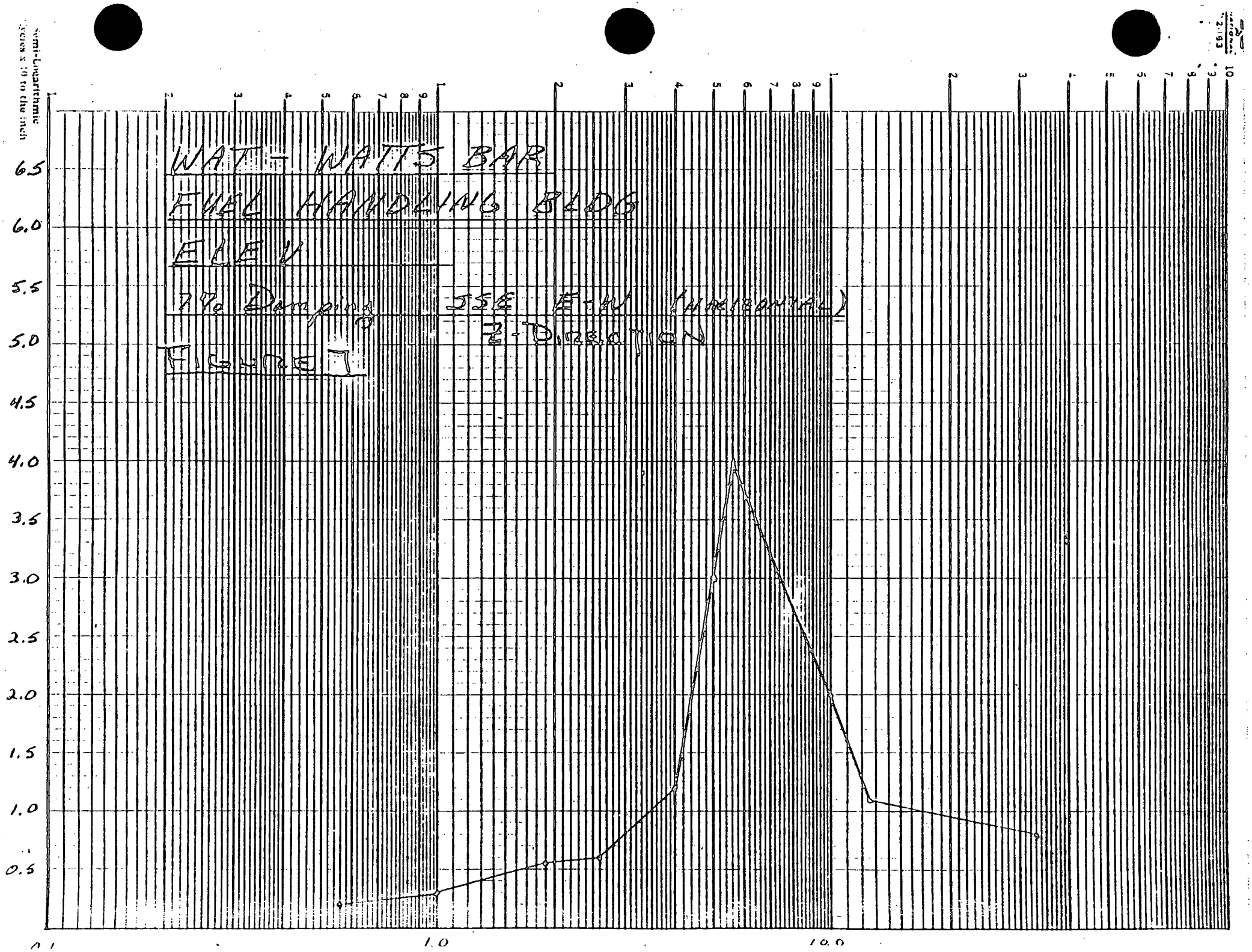

Semi-Logarithmic
Division x 10 to the inch
WAT - WATER BAR
FIXED HANDLING BLDG
ELEV
5% Damping - OBE (Design)
Figure 2
0.30
0.25
0.20
0.15
0.10
0.05
0.0
0.1
1.0
10.0

K+E SEMI-LOGARITHMIC 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 5490




Semi-Logarithmic
Cycles x 10 to the inch
WAT - WATS SAE
FUEL HANDLING BLDG
ELEV
7% Damping SSE N-S (Horizontal)
Figure 8
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0


WAT - WATTS BAR
FUEL HANDLING BLDG
ELEV
7% Damping - SSE (VERTICAL)
FIGURE 6
2.60
2.50
2.40
2.30
2.20
2.10
2.0
0.1
1.0
10.0
Semi-Logarithmic
Cycles 2 10 to the inch


Semi-Logarithmic
Cycles x 10 to the inch
WAT - WATTS BAR
FUEL HANDLING BLDG
ELEV
7% Damping SSE East (Horizontal)
Figure 7
Re-Direction
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.1
1.0
10.0

SQRT AUDIT

ATTACHMENT GC.5-1

ATTACHMENT GC.5-1

ATTACHMENT 2

NOZZLE LOADS CRITERIA

FOR SEISMIC CATEGORY I INLINE DEVICES

An extensive study of nozzle loading conditions for pipe supported equipment such as valves, strainers, etc., has been made by TVA.

This study revealed the following design loading conditions and combinations to be applicable to inline active devices (active valves). The loading conditions and load combinations are defined as follows:

Normal as pressure + deadweight + thermal.

Upset as pressure + deadweight + thermal + operating basis earthquake.

Emergency as pressure + deadweight + thermal + safe shutdown earthquake.

The following piping loads are to be transmitted to the nozzles:

Axial force equal to C_1 times the axial tensile of compressive force of the piping at yield when at room temperature.

Shear force equal to C_2 times the axial tensile or compressive force of the piping at yield when at room temperature.

Bending moment equal to C_3 times the bending moment of the piping at yield when at room temperature.

Torsional moment equal to C_4 times the bending moment of the piping at yield when at room temperature.

The nozzle loads are to be considered as being applied simultaneously.

The coefficient C_1, C_2, C_3, and C_4 given above are listed below for each loading condition.

Condition	Axial Force C_1	Shear Force C_2	Bending Moment C_3	Torsional Moment C_4
Normal	0.25	0.15	0.40	0.10
Upset	0.25	0.15	0.45	0.15
Emergency	0.30	0.15	0.50	0.20

Valve suppliers must certify in the stress report that active valves operability will be maintained when the system piping satisfies the requirement above for the nozzle end loads. A test of the active valves may be performed to demonstrate operational capability during and after the emergency condition loading.

Deflections of equipment resulting from seismic loads which may affect valve operation must be evaluated in the seismic analysis. Deflections must be held within minimum clearances between valve components or within manufacturing assembly tolerances. The natural frequency of overhanging or extended structures must be calculated to demonstrate that excessive deflections do not occur and interfere with valve operation. The minimum acceptable natural frequency is 33 Hz.

The pressure-containing parts of the valve assemblies shall be designed in accordance with the ASME B&PV Code, Section III.

For nonactive inline devices (nonactive valves, strainers, etc.), a nozzle stress analysis is not required when both the following conditions are satisfied by calculations: (1) section modulus and area of a plane, normal to the flow, through the region of minimum cross section, e.g., valve body crotch, are at least 10 percent greater than the piping connected to the valve body inlet and outlet nozzles, and (2) ASME Code allowable stress for the device body material is equal to or greater than the code allowable stress of the collected piping material. If unable to comply with this requirement, the design by analysis procedure of ASME Code, Section III (Subsection NB-3545.2 for valves) is an acceptable alternate method.

Unless otherwise specified, the yield stress of the piping material at room temperature shall be assumed to be 25,000 psi.

ATTACHMENT 4

NOZZLE LOADS CRITERIA

FOR SEISMIC CATEGORY I FLOOR-MOUNTED EQUIPMENT

The following criteria are standard design load requirement which all floor-mounted equipment nozzles and penetrations must meet (pumps, tanks, etc.).

The loads from attached piping exerted on the nozzles of the assembly may be classified by the following loading combinations:

a. Normal as deadweight + thermal + other applicable mechanical loads.
b. Upset (reference loading condition) as normal + operating basis earthquake.
c. Emergency as normal + safe shutdown earthquake (SSE).
d. Faulted as emergency + applicable design bases accident loading effects including SSE.

For the reference loading condition (upset), the maximum piping forces to be transmitted to the nozzles of the assembly are:

a. The direct forces (Px, Py, Pz) are, in addition to any internally induced pressure loads, a set of concentrated loads in three orthogonal directions each not less than 0.01 times the force of the attachment piping at yield when at room temperature.

b. The bending moments (My, Mz) in the two orthogonal directions are each not less than 0.0707 times the moment of the attachment piping at yield when at room temperature.

c. The torsional moment (Mx) is not less than 0.1 times the torsional moment of the attachment piping at yield when at room temperature.

Figure 1 illustrates the minimum nozzle/penetration design loads and the equations for calculating them. Note that the bending moment is not calculated as a resultant, but as a vector component which can be used as the allowable moment existing concurrently in two bending axes. The nozzle loads are to be considered as being applied simultaneously.

The loads to be transmitted to the nozzles of the assembly for each loading combination are defined as follows:

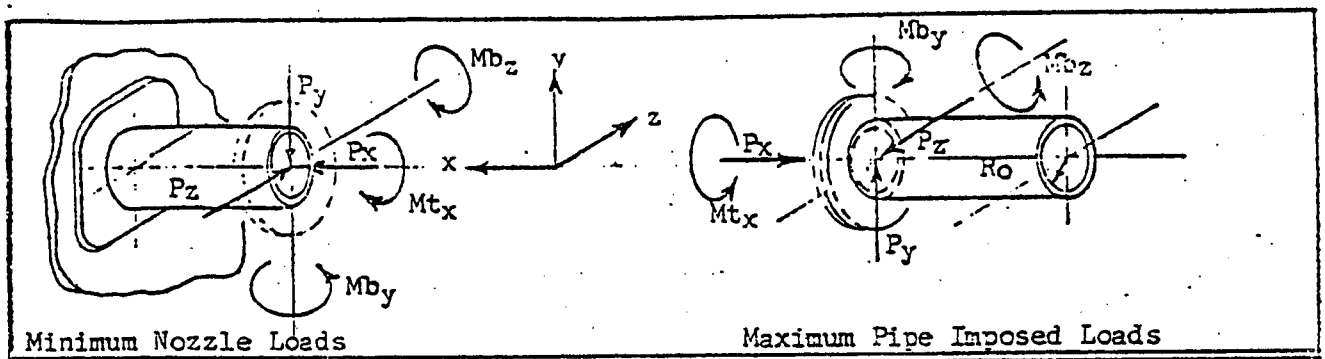
a. Normal - the loads shall not be less than 75 percent of the reference loading condition.

b. Upset - the loads shall not be less than 100 percent of the reference loading condition.

c. Emergency - the loads shall not be less than 125 percent of the reference loading condition.

d. Faulted - the loads shall not be less than 125 percent of the reference loading condition.

For nonactive equipment, it must be demonstrated that structural integrity is maintained under action of the above loading conditions. For active equipment it must be further demonstrated operability is not impaired by action of the above loads. Test data giving evidence of operability may be submitted in lieu of analysis.



The Axial or Lateral Forces P_x, y, z shall be .01 times the force at yield in the pipe.	$P^*_{x,y,z} = 0.01\ \sigma_y A$
The Bending Moment $M_{by,z}$ shall be 0.0707 times the moment at yield in the pipe.	$M_{by,z} = 0.0707\ \sigma_y Z$ $(M_r = 0.1\sigma_y Z)$
The Torsional Moment (Mt_x) shall be that required to produce a shear stress in the pipe wall of 0.1 times the yield stress of the pipe material.	$Mt_x = 0.1\ \frac{\sigma_y J}{R_o} = .2\ \sigma_y Z$

Definitions

$P_{x,y,z}$ = Minimum design force on nozzle*/penetration.

= Maximum allowable pipe imposed load.

Mby,z = Minimum design bending moment on nozzle*/penetration.

= Maximum allowable pipe imposed bending moment. (Note $Mby = Mbz$ are assumed to occur simultaneously.)

Mt_x = Minimum design torsional moment on nozzle/penetration.

= Maximum allowable pipe imposed torsional moment.

A = Metal cross sectional area of pipe.

Ao = Cross sectional area of pipe.

J = Polar moment of inertia of pipe cross section = $\frac{\pi}{32}(d_o^4 - d_i^4)$

P = Internal design pressure.

R_o = Outer pipe radius.

Z = Pipe section modulus = I/c

σ_y = Yield stress in pipe at operating temperature.

M_r = Resultant bending moment produced by Mby and Mbz.

*The load given for P_x shall be in addition to the internally induced pressure load PA_o, when evaluating the minimum design axial nozzle load.

FIGURE 1

MINIMUM NOZZLE/PENETRATION DESIGN LOADS