SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2

DYNAMIC QUALIFICATION

COMPONENT NAME: Recirculation Discharge Gate Valve

MPL OR EDL ITEM NO.: B31-F031

MPL REFERENCE: 238X114AE, Rev. 20

EQUIPMENT CLASSIFICATION: ☒ **ACTIVE** ☐ **PASSIVE**

THE SEISMIC QUALIFICATION REPORT(S) IDENTIFIED HEREIN HAVE BEEN EVALUATED AND REQUALIFIED WHERE NECESSARY TO SHOW THAT THE ABOVE-MENTIONED COMPONENT IS CAPABLE OF MEETING THE NUCLEAR REGULATORY COMMISSION SEISMIC QUALIFICATION REVIEW TEAM (SQRT) REQUIREMENTS.

PREPARED BY: Hung Le Hung Le DATE 1-20-83

ORGANIZATION General Electric Company - NEBO

REVIEWED BY: J. Hamstad Jr. DATE 1/24/83
SQRT PROGRAM MANAGER

APPROVED BY: Hung Le Hung Le DATE 1-21-83
RESPONSIBLE DESIGN ENGINEER

GENERAL ELECTRIC

QUALIFICATION SUMMARY

1. COMPONENT NAME: Recirculation Discharge Gate Valve

2. MPL OR EDL ITEM NO.: B31-F031

3. QUALIFICATION DOCUMENTATION (ENCLOSED WITH THIS REPORT)

A. QUALIFICATION SUMMARY OF EQUIPMENT (SQRT FORM), INCLUDING REQUIRED RESPONSE SPECTRA WITH TRS PLOTTED ON RRS GRAPH, AS APPROPRIATE.

Qualification summary is attached. RRS and TRS were not used because the test conducted was a RIM test.

B. SQRT EVALUATION FLOW CHARTS (MARKED TO SHOW DECISION PATH).

C. REFERENCE DOCUMENTS

REFERENCE NUMBER	DOCUMENT IDENTIFICATION	REVISION OR DATE	TITLE/SUBJECT
1	VPF #3174-162	Rev. 4	Recirculation Discharge Valve Outline & Assembly Drawing
2	FDDR KR1-380	Rev. 2	Field Deviation Disposition Request for Replacing SMB-3-100 by SB-3-100, 1/18/83
3	16511-9	12/3/81	Report of Test for Seismic Qualification of Two Actuators SMB-1-60 (DC) and SMB-2-60 (AC) for Limitorque Corporation
4	B0037	1/11/80	Seismic Qualification Envelope - Limitorque Valve Actuators
5	B-0115	6/24/82	Hydrodynamic Vibration Testing (New Loads)
6	DRF #206-B33-BLKV-KR0 pp. 701-782	8301	Recirculation Gate Valve Analysis - Susquehanna Discharge Valve with SB-3-100 Actuator
7	VPF #3174-159	Rev. 3	Vendor Stress Report
8	NEDE-24788-1	June, 1981	SQRT Technical Approach for Re-evaluation of BWR Equipment

D. ADDITIONAL SUPPORTING DOCUMENTS

DOCUMENT IDENTIFICATION	REVISION OR DATE	TITLE/SUBJECT
GE 21A1840	Rev. 2	Purchase Specification - Gate Valve
GE 385HA777	Rev. 0	Dynamic Loads Methods and Criteria - NSSS Equipment, Piping, RPV & Internal - BWR 4 & 5

QUALIFICATION SUMMARY (CONTINUED)

MPL ITEM NO.: B31-F031

4. REQUIREMENTS

The pressure retaining parts (valve body and bonnet) of the recirculation discharge valve (Reference 1) must maintain their pressure integrity during the applicable loading events. In addition, since the valve is classified as active, its structure including the actuator (Reference 2) must be capable of withstanding the maximum accelerations in these events and remain operable.

Functional Description: The valve is open during normal operation and is required to be closed during an LPCI injection to the reactor pressure vessel.

5. DEMONSTRATED CAPABILITY

A three-dimensional finite element model of the valve and actuator was developed and analyzed to determine the valve maximum capability for structural integrity. In addition, the valve was modelled as a single element and included in the piping system. Dynamic analysis using the response spectrum analysis method was performed on the piping system. Seismic and suppression pool hydrodynamic loads were considered. Critical location stresses were evaluated and compared with the allowable stress criteria. The operability of the actuator was demonstrated by a single-axis, single-frequency test on similar actuators.

Results of the structural integrity analysis and operability tests on the actuator demonstrated that the valve will maintain its structural integrity and the actuator will operate satisfactorily during and following the dynamic loading events.

6. RATIONALE FOR QUALIFICATION CERTIFICATION

(INCLUDE DECISION ANALYSIS WITH COMPARISON TO ACCEPTANCE CRITERIA, APPROACH FOR DEMONSTRATING OPERABILITY, AND CONSIDERATION OF HIGH-FREQUENCY RESPONSE.)

Qualification certification is justified because the methods used in the equipment analysis were based on requirements specified in the Reference 8 document.

A three-dimensional finite element model of the valve and its extended structure was prepared and used to perform a mode/frequency analysis using the SAP4G computer code. The valve fundamental frequency was determined by the frequency analysis to be less than the seismic cut-off frequency of 33 Hz. This required a dynamic analysis considering multimode response. However, since the valve is pipe-mounted and the required response spectra at the valve location were not available, it was necessary to perform a dynamic analysis on the entire piping system. A simple lumped-mass model of the valve and its actuator was developed based on the valve fundamental frequency, and was used to represent the valve dynamic characteristics in the piping analysis.

A dynamic analysis was performed on the recirculation piping system using the response spectrum analysis method. The analysis gave the maximum dynamic accelerations on the valve actuator and the maximum moment and force on the valve structure due to seismic and suppression pool hydrodynamic load combinations. Modes up to 60 Hz were considered and the effects of closely spaced modes were included using the double sum method. Dynamic responses were combined by SRSS.

QUALIFICATION SUMMARY (CONTINUED)

6. RATIONALE FOR QUALIFICATION CERTIFICATION (CONTINUED)

The maximum moment and force calculated by the piping dynamic analysis was applied to the three-dimensional finite element model of the valve to calculate the stress at critical locations. Static analysis was used for the stress evaluation.

Structural integrity was addressed by completing the dynamic and static analyses described above, calculating stress at critical locations, and comparing the resulting stresses to the ASME code allowables. The code stamped pressure boundary components of the recirculation valve are classified as ASME B&PV code Section III Class I equipment and must comply with the rules of this section. At locations where the ASME code does not specifically apply (e.g., valve yoke), methods employed by the vendor or methods based on stress analysis and mechanics principles were used.

Operability of the actuator was addressed by comparing the maximum actuator acceleration calculated by the piping dynamic analysis to the actuator performance test. The test conducted was a single-axis, single-frequency test (Reference 3). Single-frequency testing is justified because the actuator is rigid compared to the dynamic load cut-off frequency (lowest natural frequency is greater than 100 Hz, as shown in Reference 3). Single-axis testing is also justified because testing has shown that no cross-coupling exists on the actuator (Reference 4). The test was performed on the two Limitorque actuators, model SMB-1-60 and SMB-2-60 which were verified by the actuator manufacturer to be similar to the model SB-3-100 used on this recirculation discharge valve (Reference 5). The test followed the guideline of the IEEE 382-80 standard. An acceleration of 10g was applied to the test actuators at a frequency range from 2 Hz to 100 Hz. This test acceleration is sufficiently higher than the actuator maximum accelerations determined by the piping dynamic analysis (7.80g horizontally and 0.94g vertically, Reference 6) to assure the actuator operability.

The dimensional information required to develop the valve finite element model was primarily obtained from the valve vendor stress report (Reference 7). Additional information not available in the report was requested from the vendor and is contained in the design record file (Reference 6).

Seismic and hydrodynamic loads (including Phase III loads) were considered in the dynamic evaluation.

EQUIPMENT: Recirculation Discharge Gate Valve Actuator

MPL No.: B31-F031

DATE: 11/15/82

DECISION POINT	DECISION and/or BASIS FOR DECISION
1) Is equipment same or dynamically similar to equipment already, or soon to be qualified to SQRT requirements?	1) No
2) Original qualification by analysis or test?	2) Test - The actuator has electrical components, and can only be qualified by test.
3) Equipment fundamental frequency above hydrodynamic load high frequency assymtote?	3) Yes - The actuator natural frequency is above 100 Hz in all three orthogonal directions.
4) $TRS_{ZPA} > RRS_{ZPA}$?	4) Not applicable. The test performed was a RIM test on similar actuators (single axis, single-frequency sine-beat test) in accordance with IEEE 382-80 standard. RRS was not used.
5) Operability demonstrated?	5) Yes - The actuator operated properly during the test.
6) Qualified to SQRT?	6) Yes

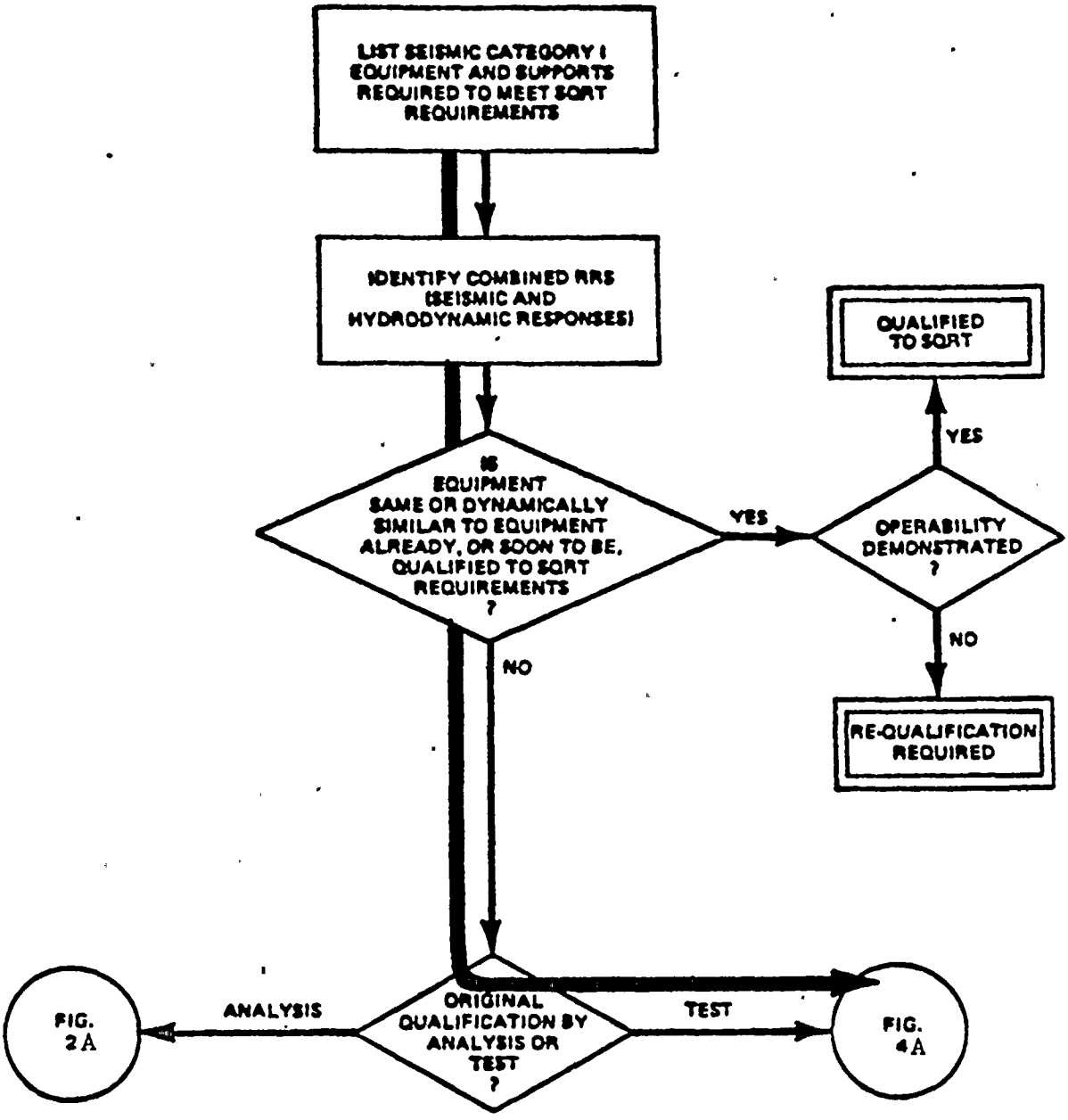

Figure 1A SQRT Re-Evaluation Flow Chart

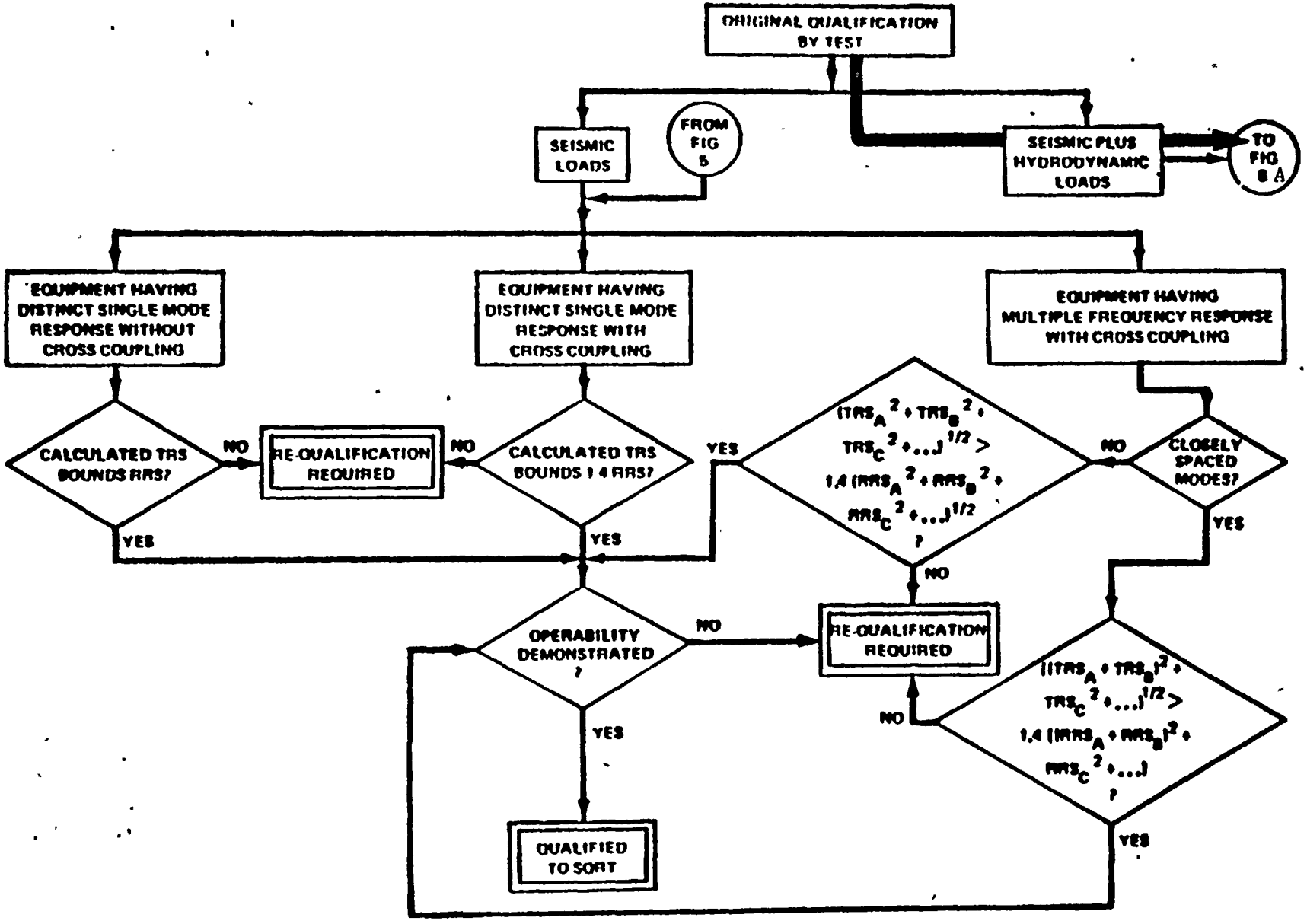

Figure 4A SQRT Re-Evaluation Flow Chart - Original Equipment Qualification by Test-Seismic Loads

FOR ACTUATOR ONLY

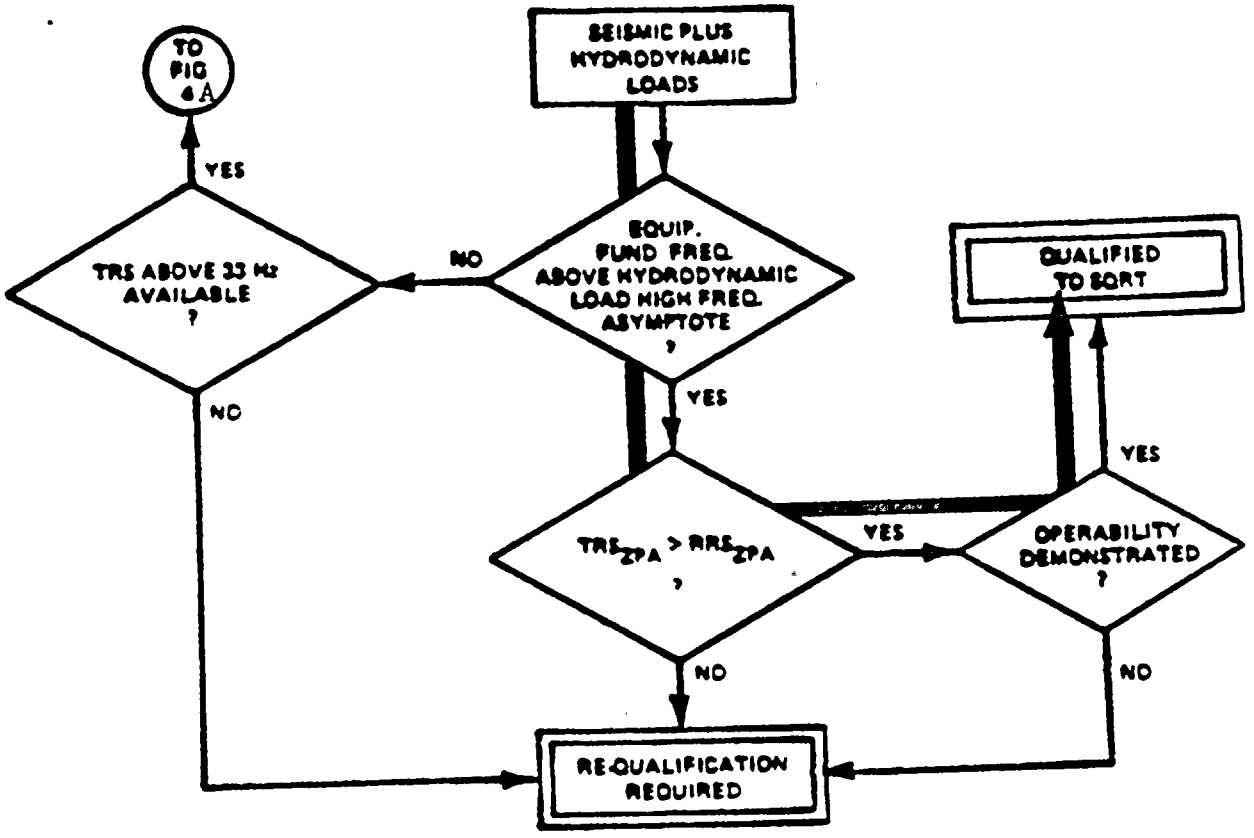

Figure 5A SQRT Re-Evaluation Flow Chart - Original Equipment Qualification by Test-Seismic Plus Hydrodynamic Loads

MPL: B31-F031

For Actuator Only

Qualification Summary of Equipment

I. Plant Name: Susquehanna — Type:

1. Utility: Pennsylvania Power & Light Company — PWR

2. NSSS: GE — 3. A/E: Bechtel — BWR 4, Mark II

II. Component Name: Recirculation Discharge Valve Actuator

1. Scope: [X] NSSS [ ] BOP

2. Model Number: SB-3-100 — Quantity: 2

3. Vendor: Limitorque Corporation

4. If the component is a cabinet or panel, name and model No. of the devices included: N/A

5. Physical Description a. Appearance Motor-Operated Actuator

b. Dimensions 24" x 27" x 34" (approximate)

c. Weight 1550 lbs

6. Location: Building: Primary Containment

Elevation: 720 ft

7. Field Mounting Conditions [X] Bolt (No. 8, Size 7/8")
[ ] Weld (Length ____)
[ ] ____

8. a. System in which located: Reactor Recirculation System

b. Functional Description: See Note A

c. Is the equipment required for [ ] Hot Standby [ ] Cold Shutdown
[ ] Both [X] Neither

9. Pertinent Reference Design Specifications:

Purchase Specification, GE 21A1840, Rev. 2

Note A: Actuates the recirculation discharge gate valve, open and closed with torque seating at fully closed position.

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III. Is Equipment Available for Inspection in the Plant: [X] Yes [ ] No

IV. Equipment Qualification Method:

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

Qualification Report*: Hydrodynamic Vibration Testing (New Loads)

(No., Title and Date) Report # B-0115, 6/24/82

Company that Prepared Report: Limitorque Corporation

Company that Reviewed Report: General Electric

V. Vibration Input:

1. Loads considered: a. [ ] Seismic only

b. [ ] Hydrodynamic only

c. [X] Combination of (a) and (b)

2. Method of Combining RRS: [ ] Absolute Sum [ ] SRSS [X] N/A (other, specify)

3. Required Response Spectra (attach the graphs): N/A

See Note B

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

5. Required Acceleration in Each Direction: [ ] ZPA [X] Other See Note B (specify)

OBE	S/S =		F/B =	V =	
SSE	S/S =	7.80g	F/B =	7.80g	V = 0.94g

6. Were fatigue effects or other vibration loads considered?

[ ] Yes [X] No

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

*NOTE: If more than one report complete items IV thru VII for each report.

NOTE B: A single-axis, single-frequency test was performed in accordance with the IEEE 382-80 standard. RRS and damping were not used in this test. The required accelerations are maximum accelerations on the actuator due to highest seismic and hydrodynamic load combination.

12/80

MPL: B31-F031

For actuator only

VI. If Qualification by Test, then Complete*:

1. [X] Single Frequency [ ] Multi-Frequency: [ ] random [X] sine beat [ ] _____
2. [X] Single Axis [ ] Multi-Axis
3. No. of Qualification Tests: OBE _____ SSE _____ Other See Note C (specify)
4. Frequency Range: 2Hz - 100 Hz
5. Natural Frequencies in Each Direction (Side/Side, Front/Back, Vertical):

   S/S = Above 100 Hz F/B = Above 100 Hz V = Above 100 Hz
6. Method of Determining Natural Frequencies

   [X] Lab Test [ ] In-Situ Test [ ] Analysis
7. TRS enveloping RRS using Multi-Frequency Test [ ] Yes (Attach TRS & RRS graphs See Note A [ ] No
8. Input g-level Test: OBE S/S = 10g F/B = 10g V = 10g

   SSE S/S = _____ F/B = _____ V = _____
9. Laboratory Mounting: same as field mounting (see Note C)

   1. [X] Bolt (No. _____, Size _____) [ ] Weld (Length _____) [ ] _____
10. Functional operability verified: [X] Yes [ ] No [ ] Not Applicable
11. Test Results including modifications made: N/A
12. Other test performed (such as aging or fragility test, including results):

    None

*Note: If qualification by a combination of test and analysis also complete Item VII.

'NOTE C: One sine-beat test was performed in each of the three orthogonal directions and on each of the two actuators SMB-1-60 and SMB-2-60. Frequency range: 2 Hz - 100 Hz. 12/80

The number and size of bolts used in lab mounting were the same as field mounting bolts recommended by the manufacturer for the two actuators tested.

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or Actuator Only
Not Applicable

VII. If Qualification by Analysis, then complete:

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

4. [ ] Computer Codes: _____

   Frequency Range and No. of modes considered: _____

   [ ] Hand Calculations

5. Method of Combining Dynamic Responses: [ ] 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

EQUIPMENT: Recirculation Discharge Gate Valve With Actuator

MPL No.: B31-F031

DATE: 11/15/82

DECISION POINT	DECISION and/or BASIS FOR DECISION
1) Is equipment same or dynamically similar to equipment already, or soon to be qualified to SQRT requirements?	1) No
2) Original qualification by analysis or test?	2) Analysis
3) Frame type structure?	3) Yes - The valve and its actuator were modeled as beam elements.
4) Qualification by static coefficient analysis?	4) No
5) Is equipment flexible?	5) Yes - Natural frequency is less than 33 Hz.
6) Response spectrum or time history analysis?	6) Response spectrum modal analysis. RS analysis was not performed on the valve, but on the entire recirculation piping system on which the valve is mounted.
7) Did original analysis account for closely spaced modes?	7) Yes
8) Did original analysis combine 3-D effects?	8) Yes
9) Does reevaluation meet design requirements?	9) Yes - All stresses due to the applicable loads were less than the allowable stresses as required to demonstrate structural integrity.
10) Operability demonstrated?	10) The actuator operability was demonstrated by test in accordance with IEEE 382-80 standard.
11) Qualified to SQRT?	11) Yes

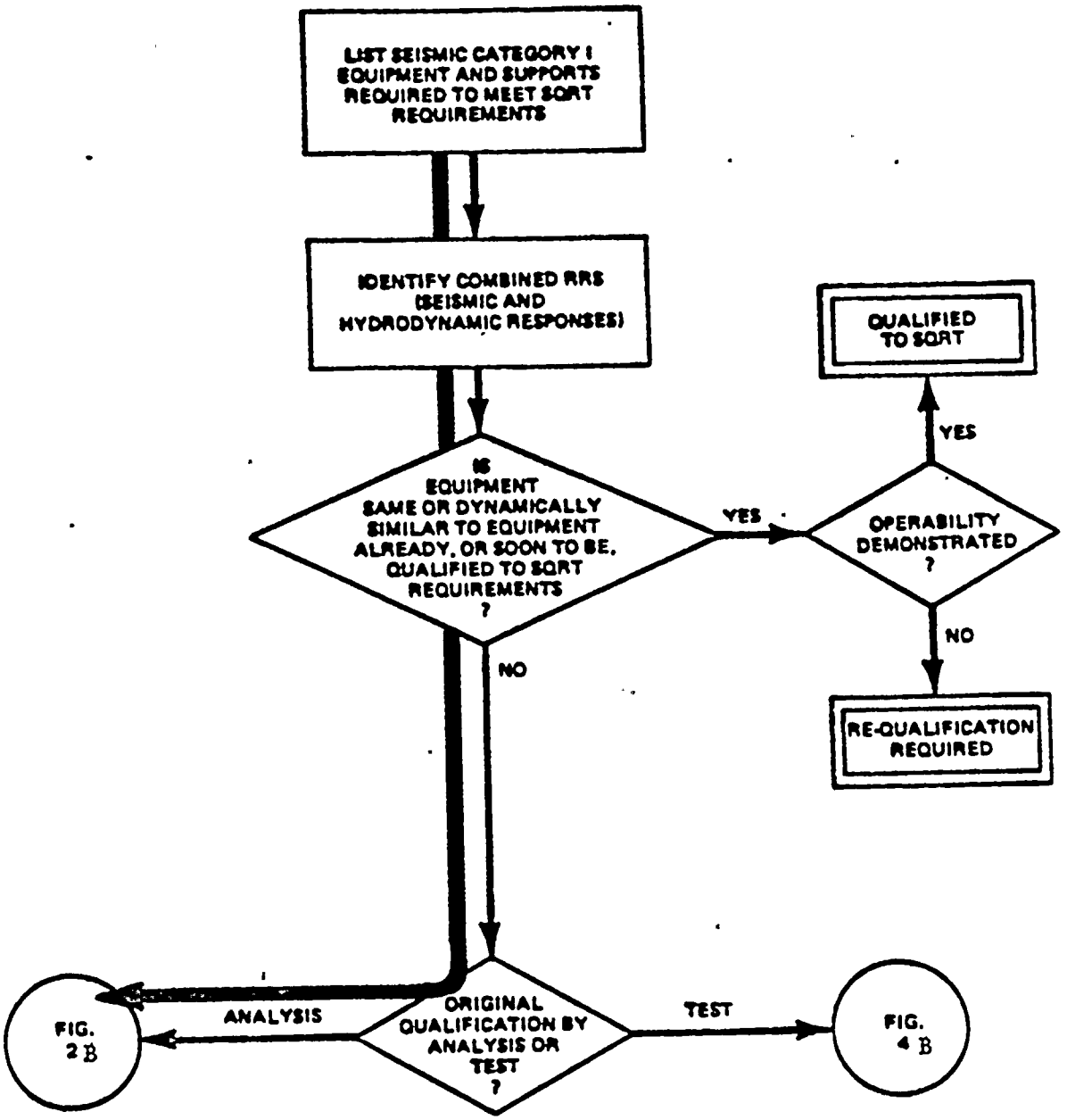

Figure 1B SQRT Re-Evaluation Flow Chart

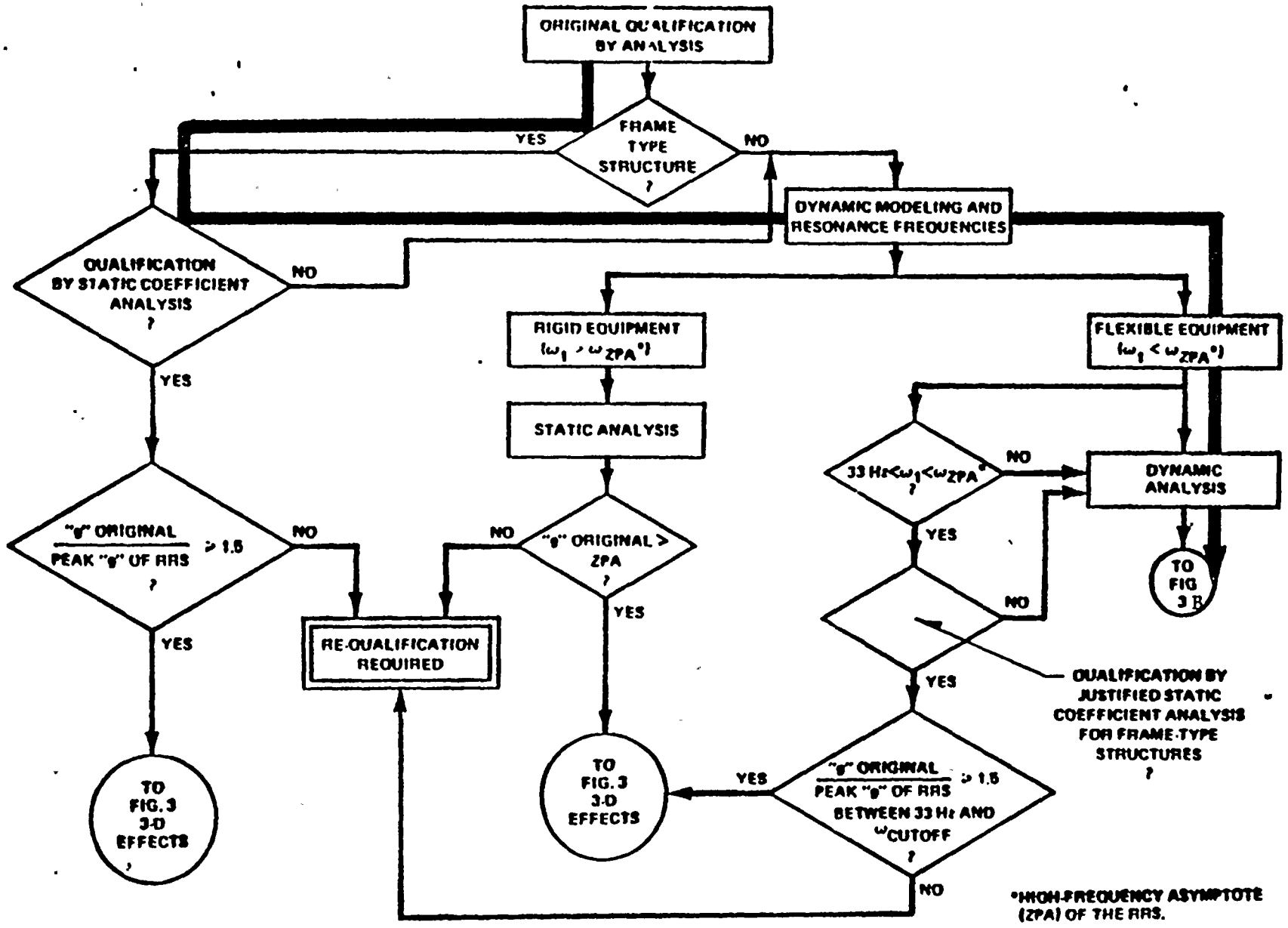

Figure 2B SQRT Re-Evaluation Flow Chart - Qualification by Analysis

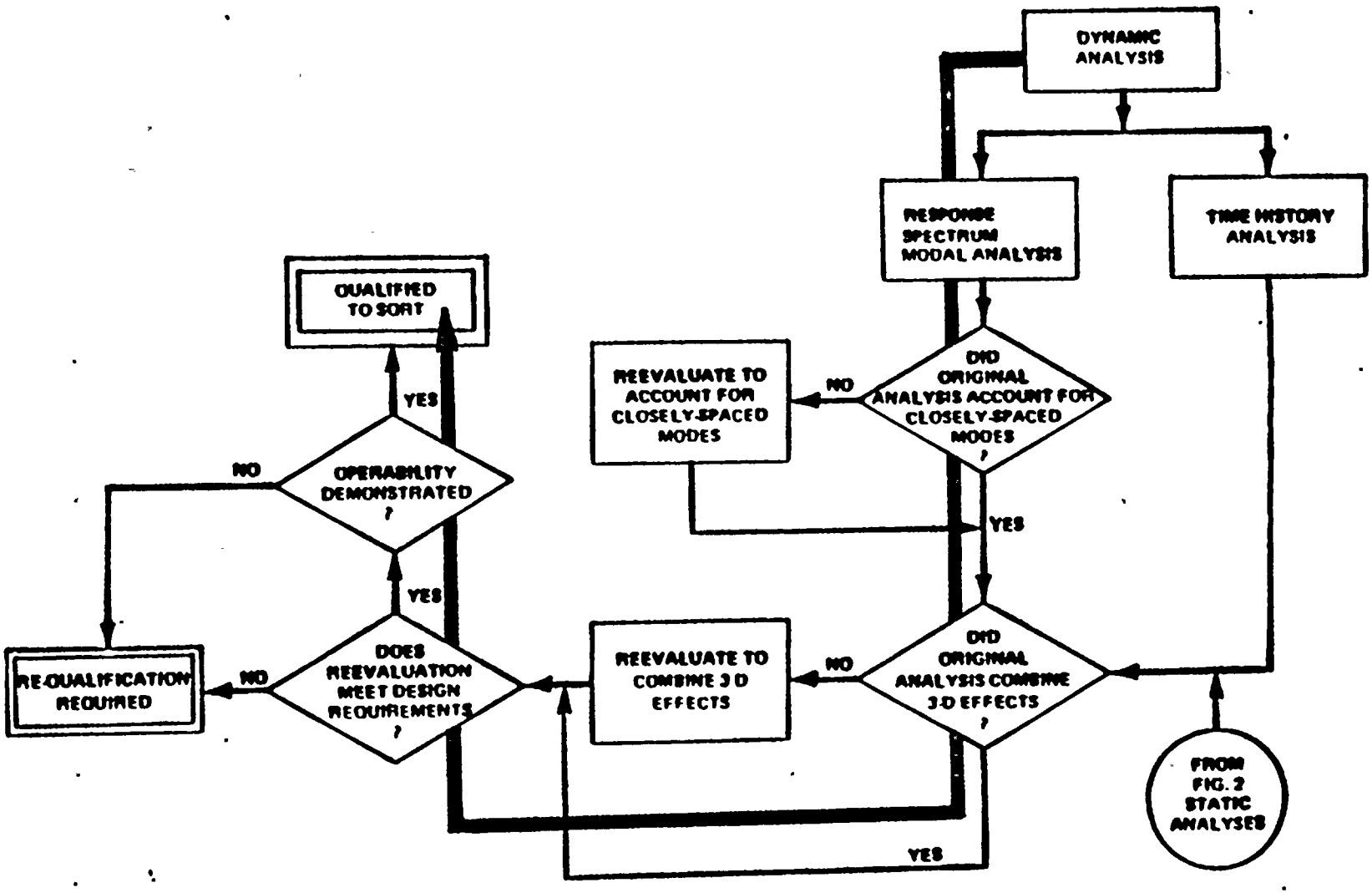

Figure 3B SQRT Re-Evaluation Flow Chart - Qualification by Dynamic Analysis

For Valve Assembly and Actuator

Qualification Summary of Equipment MPL: B31-F031

I. **Plant Name:** Susquehanna **Type:**

1. **Utility:** Pennsylvania Power & Light Company PWR

2. **NSSS:** GE 3. **A/E:** Bechtel BWR-4, Mark II

II. **Component Name** Recirculation Discharge Valve

1. **Scope:** [X] NSSS [ ] BOP
Valve Assembly drawing #D-13018

2. **Model Number:** VPF# 3174-162-4 **Quantity:** 2

3. **Vendor:** Valve: Lunkenheimer, Actuator: Limitorque Corp.

4. **If the component is a cabinet or panel, name and model No. of the devices included:** N/A

5. **Physical Description** a. **Appearance** Motor Operated Gate Valve

b. **Dimensions** 28" x 24" x 28"

c. **Weight** 11220 lb

6. **Location:** **Building:** Primary Containment

Elevation: 720 ft

7. **Field Mounting Conditions** [ ] Bolt (No.____, Size____)
[X] Weld (Length____) Welded on pipe
[ ] _____

8. a. **System in which located:** Reactor Recirculation System

b. **Functional Description:** Open during normal operation
Closed to allow LPCI injection into reactor

c. **Is the equipment required for** [ ] Hot Standby [ ] Cold Shutdown
[ ] Both [X] Neither

9. **Pertinent Reference Design Specifications:**

Purchase Specification, GE 21A1840, Rev. 2

MPL: B31-F031

For Valve Assembly and Actuator

III. Is Equipment Available for Inspection in the Plant: [X] Yes [ ] No

IV. Equipment Qualification Method:

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

Qualification Report*: Recirculation Gate Valve Analysis - Susquehanna Discharge Valve With SB-3-100 Actuator

(No., Title and Date) DRF #206-B33-BLKV-KRO, pp. 701-782, 8301

Company that Prepared Report: General Electric

Company that Reviewed Report: General Electric

V. Vibration Input:

1. Loads considered: a. [ ] Seismic only

b. [ ] Hydrodynamic only

c. [X] Combination of (a) and (b)

See Note D

2. Method of Combining RRS: [ ] Absolute Sum [X] SRSS [ ] (other, specify)

3. Required Response Spectra (attach the graphs): See Note D

4. Damping Corresponding to RRS: OBE 0.5% SSE 1.0%

5. Required Acceleration in Each Direction: [ ] ZPA [X] Other See Note E (specify)

OBE	S/S =	F/B =	V =
SSE	S/S = 7.80g	F/B = 7.80g	V = 0.94g

6. Were fatigue effects or other vibration loads considered?

[ ] Yes [X] No

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

*NOTE: If more than one report complete items IV thru VII for each report.

Note D: The valve is pipe-mounted. RRS and damping were not applied at the valve location; but at the piping-containment attachment points. RRS and damping were used in the piping analysis. RRS were combined by SRSS. 12/80

Note E: These are maximum accelerations at the actuator due to the highest load combination. The maximum accelerations were used to compare with the test acceleration on the limitorque actuator to determine its operability. To demonstrate the valve structural integrity, the stresses at critical locations were calculated using the maximum moments and forces from the piping dynamic analysis.

EMPL: B31-F031

For Valve Assembly and Actuator
Not Applicable

VI. If Qualification by Test, then Complete*:

1. [ ] Single Frequency [ ] Multi-Frequency: [ ] random [ ] sine beat [ ] _____
2. [ ] Single Axis [ ] Multi-Axis
3. No. of Qualification 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. Input g-level Test: OBE S/S = _____ F/B = _____ V = _____

   SSE S/S = _____ F/B = _____ V = _____
9. Laboratory Mounting:

   1. [ ] Bolt (No._____, Size_____) [ ] Weld (Length_____) [ ]_____
10. Functional operability verified: [ ] Yes [ ] No [ ] Not Applicable
11. Test Results including modifications made: _____

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

    _____

    _____

*Note: If qualification by a combination of test and analysis also complete Item VII.

EPL: B31-F031

For Valve Assembly and Actuator

VII. If Qualification by Analysis, then complete:

1. **Method of Analysis:**

   [X] Static Analysis [ ] Equivalent Static Analysis

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

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

   S/S = 23.4 Hz (parallel to pipe) F/B = 43.1 Hz (perpendicular to pipe) V = Above 100 Hz

   See Note F

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

   [X] Finite Element [X] Beam [ ] Closed Form Solution

4. [X] **Computer Codes:** SAP4G07, ANSI07

   Frequency Range and No. of modes considered: 0 - 60 Hz

   [X] Hand Calculations

5. **Method of Combining Dynamic Responses:** [ ] Absolute Sum [X] SRSS
   [ ] Other: (specify)

   See Note D

6. **Damping:** OBE 0.5% SSE 1% **Basis for the damping used:** GE 3B5HA777

7. **Support Considerations in the model:** Valve supported by piping

8. **Critical Structural Elements:**

A.

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

See Attached Table

B.

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

Note F: Both static and dynamic analyses were performed. The valve was first modelled as a 3-D, multi-degree of freedom system to determine its natural frequencies. Stress analysis was performed on this model to calculate the valve capability using static loading. Dynamic analysis was also performed on the entire piping system with the valve represented by one pipe element. The piping dynamic analysis gave the maximum accelerations on the actuator and the maximum moments and forces on the valve.

CRITICAL STRUCTURAL LOCATIONS

Critical Location	Load Combination	Calculated Stress (psi)	Allowable Stress (psi)	Stress Ratio
Body/Bonnet Flange				
S_H	SSE + AP	26515	28837	0.92
S_R	SSE + AP	7666	19225	0.40
S_T	SSE + AP	8098	19225	0.42
$(S_H + S_R)/2$	SSE + AP	17176	19225	0.89
$(S_H + S_T)/2$	SSE + AP	17393	19225	0.90
Flange Bolt	SSE + AP	22380	27975	0.80
Yoke	SSE + AP	21234	29100	0.73
Yoke Bolt	SSE + AP	34215	57600	0.59

Stresses were calculated based on the highest moment and force on the valve. These maximum loads were determined by piping dynamic analysis.

NOTE
S_H = HUB STRESS
S_R = RADIAL STRESS
S_T = TANGENTIAL STRESS