XCEL ENERGY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT

SEISMIC FRAGILITIES FOR UNIT #1 AND UNIT #2 TURBINE BUILDING PIPING AND EQUIPMENT (REV. 2)

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TABLE OF CONTENTS

1 INTRODUCTION 3

2 TECHNICAL BACKGROUND 6

2.1 SEISMIC DEMAND 6
2.1.1 Structural Model 6
2.1.2 Soil Properties 6
2.1.3 Ground Input Motion Seismic Demand 7
2.1.4 Soil-structure interaction analysis 9
2.1.5 Generating Amplified floor response spectra 9
2.2 ESTABLISHING MEDIAN SEISMIC FRAGILITIES 9
2.2.1 EPRI NP-6041 Screening Lanes and the Surrogate Element 9
2.2.2 Calculating HCLPF capacities using CDFM Approach 10
2.2.3 Directly calculating median fragilities 10

3 EVALUATION CRITERIA 11

3.1 DUCTILE PIPING 11
3.1.1 Material Properties 11
3.1.2 Strength and Load Combinations 11
3.1.3 Stress Indices and SIFs 12
3.2 NON DUCTILE PIPING 12
3.3 DUCTILE PIPING WITH NON DUCTILE INLINE COMPONENTS (CAST IRON VALVES) 13
3.4 DUCTILE PIPING WITH BRASS OR BRONZE THREADED INLINE COMPONENTS: 13
3.5 DUCTILE PIPING WITH INLINE VICTAULIC COUPLINGS 14
3.5.1 Victaulic Couplings 14
3.5.2 Victaulic Properties 14
3.5.3 Evaluation Criteria 15
3.6 PIPE SUPPORTS 16
3.6.1 Pipe Supports - Structural Steel 16
3.6.2 Pipe Supports - Component Standards 17
3.6.3 Pipe Supports - Concrete Anchorages 17
3.6.4 Pipe Supports - Welds 17
3.7 DETERMINATION OF THE COEFFICIENT OF UNCERTAINTY, β_C 17
3.8 EQUIPMENT 22
3.9 BLOCK WALLS 22
3.10 RMST 23

4 EVALUATION RESULTS 24

4.1 SCOPE 24
4.2 CAST IRON VALVE FRAGILITY FOR CL-67 LINE 24
4.3 EQUIPMENT MEDIAN FRAGILITIES 25
4.4 CIRCULATING WATER PIPING SEISMIC CAPACITY 26
4.5 BLOCK WALL MEDIAN FRAGILITIES 27
4.6 PIPING MEDIAN FRAGILITIES 27

5 REFERENCES 80

APPENDIX 1 – WALKDOWN PACKAGE SUMMARY A1.1

APPENDIX 2 – LIST OF IN-SCOPE EQUIPMENT A2.1

APPENDIX 3 – MARKED-UP P&ID'S A3.1

1 INTRODUCTION

The objective of this scope of work is to develop median seismic fragility values for the identified flooding sources in the Unit #1 and Unit #2 Turbine Building at the Prairie Island Nuclear Generating Plant (PINGP), for use in a probabilistic risk assessment (PRA).

The majority of the piping reviewed was in the following systems:

- Cooling Water (CL) - including Turbine Building Cooling
- Fire Protection - Water System (FP)

Plant areas assessed are essentially all of the power block in the Turbine Building.

The seismic fragility values are developed as follows:

1. Xcel Energy identified the major equipment components whose failure would result in significant flooding in the turbine building. In addition, a few branch piping systems and components that are not part of the cooling water (CL) system were also identified. Using this as input, the interconnecting piping that, if it failed, could result in significant flooding, was determined. These components and systems are identified diagrammatically on the color coded P&ID's shown in Appendix 1.

   NF-39216-2
   NF-39217-1
   NF-39220
   NF-39221
   NF-39222
   NF-39223
   NF-39224
   NF-39242
   NF-39244
   NF-39253-1
   NF-39253-3
   NF-39603-2
   NF-39603-3
   NF-39605-1
   NF-86172-1

2. From the PINGP flow diagrams, determine the portion of a subject system that is supplied water to and from the identified equipment.

3. Organize the non-seismically qualified piping on the P&ID (flow diagrams) into segments. A typical segment is a larger diameter run pipe between major pieces of equipment, or a smaller diameter branch from a run pipe to another piece of equipment. Each pipe segment is identified using the number of the first valve on the segment.

4. An engineer experienced in the seismic evaluation of piping at nuclear power plants walks down each pipe segment and identifies any conditions that would result in a reduced seismic capacity, such as:

   - An unusual geometry that would concentrate large inertial loads in a local area,
   - Branch pipes with stiff lateral supports connected to run pipes with flexible lateral supports,
   - Dead weight supports that are vulnerable to lateral loads, such as short threaded rods with fixed end conditions, beam clamps, vertical stanchions where the pipe could move laterally and fall off, and poorly detailed or poorly constructed supports,
   - Non-ductile components such as cast iron valves or fittings, threaded fittings, or Victaulic couplings,
   - Field-fabricated fittings that could result in high stress concentrations,
   - Potential seismic interaction hazards such as unanchored equipment or masonry block walls.

Based on the walk-down, either assign the piping segment a seismic fragility based on pre-calculated screening values (Ref. [56]) or identify it as requiring further analysis.

5. An engineer experienced in the seismic analysis of equipment at nuclear power plants walks down each item of equipment and either screens it - i.e., concludes that it has a seismic capacity at least as high as the surrogate element (Reference [15], [18]), or identifies the equipment as requiring further evaluation. The evaluation includes consideration of any seismic interaction hazards such as masonry block walls. For example, a well anchored horizontal pump with no significant nozzle loads due to the attached piping would be screened, while an unanchored vertical tank would be identified as requiring further evaluation.

6. Where required, perform further evaluations of piping and equipment. The seismic demand for these evaluations are the seismic hazard floor response spectra described in Section 2.1. The criteria for the evaluations are described in Section 3.

7. Assign each piping segment a seismic fragility based on the above evaluations. The final fragility value is the lowest value based on consideration of the pipe fragility, the fragility of attached equipment, and the fragility of any seismic interaction hazards.

The piping and equipment that is part of this program is shown diagrammatically on the P&ID's in Appendix 1. In addition, the P&ID's show the boundaries and assign numbers to the individual piping walkdown packages. A summary of the walkdown packages is given in Appendix 2. A summary of the in-scope equipment is given in Appendix 3. The following color coding is used on the P&ID's of Appendix 1.

Pink = In-scope equipment
Yellow = Supply piping to screened by walkdown
Blue = Return piping to be screened by walkdown
Green = Piping that will be analyzed for fragilities by S&A
Orange = Piping previously analyzed by Xcel Energy; previous analyses will be scaled to establish fragilities

The equipment nomenclature used in Appendix 1, 2, and 3 is as follows:

AFWP = Auxiliary Feedwater Pump
TOROC = Turbine Oil Reserve Oil Cooler
FWPOC = Feedwater Pump Oil Cooler
T(E.H.)FROC = Turbine (E.H.) Fluid Reservoir Oil Cooler
FWOSPC = Feedwater Oxygen Sensor Panel Cooler
CPOC = Condensate Pump Oil Cooler
HDPOC = Heater Drain Pump Oil Cooler
GBDC = Generator Bus Duct Coolers
RMHX = Radiation Monitor Heat Exchanger
GHC = Generator Hydrogen Cooler
HSOUC = Hydrogen Seal Oil Unit Coolers
GEC = Generator Exciter Coolers
HVAC = Heating, Ventilating, and Air Conditioner
LSAC = Lab and Service Area Chiller
CD Pump = Condensate Pump
HDR = Header
FWPMUC = Feedwater Pump Motor Unit Cooler
HDTPMUC = Heater Drain Tank Pump Motor Unit Cooler
CPMUC = Condensate Pump Motor Unit Cooler
ACMUC = Air Compressor Motor Unit Cooler
AFWPMUC = Auxiliary Feedwater Pump Motor Unit Cooler
RCDSR = Refrigerator CDSR Unit

BW = Backwash
BWSP = Backwash Water Supply Pump
BWTP = Backwash Waste Transfer Pump
BWST = Backwash Water Storage Tank
BWRT = Backwash Waste Receiving Tank
RMUWST = Reactor Make-Up Water Storage Tank
RMUWP = Reactor Make-Up Water Pump
SAC = Station Air Compressor
SAAC = Station Air Compressor After Coolers

In some cases, it was important to determine if a piping system had cast iron or welded steel valves. Cast iron inline valves can result in low median fragility values. Appendix 4 provides a determination of the valve materials for selected packages.

2 TECHNICAL BACKGROUND

2.1 SEISMIC DEMAND

The Prairie Island Nuclear Generating Plant model [20] is utilized to perform a new soil-structure interaction analysis in order to develop the seismic response to the uniform hazard mean ground motion response spectrum (GMRS) developed by the Electric Power Research Institute (EPRI) [22]. The mean ground motion estimate is closer to the 84th percentile shape normally employed in the using Conservative Deterministic Failure Margin (CDFM) Approach. Thus the mean uniform hazard spectrum (UHS) was used for the seismic demand in the development of equipment fragilities using the CDFM methodology. The uniform hazard median GMRS is essentially the same as the mean GMRS above about 5 Hz but the two spectra differ (median spectra is less) below 5 Hz. Since the piping fragilities (median capacities) are calculated directly using the separation of variable approach given in Reference 10, and a number of piping systems have fundamental frequencies less than 5 Hz, it was decided to use the median GMRS for the development of the piping fragilities. The mean GMRS amplified floor response spectra are provided in S&A calculation 10C3877-BOS-CAL-002 [52]. The median GMRS amplified floor response spectra are provided in S&A calculation 10C3877-BOS-CAL-006 [56].

A GT STRUDL [21] structural model of the power plant is developed based on the original design-basis structural model from Blume [20]. An Eigen-solution analysis is performed and the fixed-base frequencies and mode shapes are then used with the EKSSI [23] software package in order to conduct a soil-structure interaction (SSI) seismic response analysis. The resulting amplified acceleration time histories are used to generate the floor response spectra for various damping values.

2.1.1 STRUCTURAL MODEL

A GT STRUDL model of the PINGP is developed, comprising two reactor buildings, the auxiliary building (with the spent fuel pool), the turbine building, and two turbine supports, all as one interconnected structure. Since the Eigen-solution analysis results matched those from Blume [20], the model was divided into three different fixed-base structures: a reactor building (Unit 1), the turbine + auxiliary building, a turbine support (the West Unit), and each part is analyzed separately for the SSI response analysis. The GTSTRUDL model is provided in Calculation 10C3877-BOS-CAL-001 [51].

The development of structural models is documented in S&A Calculation 10C3877-BOS-CAL-001 [51].

2.1.1.1 Turbine Pedestal

The turbine pedestal is modeled as a 4-node system with one node attached to the fixed base. The fixed base structural model yields 4 modal frequencies and shapes which are used for the combined soil-structure analysis.

2.1.1.2 Turbine Building

The turbine building is integrally connected to the auxiliary building and cannot be modeled as an independent component. The combined auxiliary and turbine buildings are modeled as a 28-node system with 2 nodes attached to the fixed base. The fixed base model yields 15 modal frequencies and shapes which are used for the combined soil-structure analysis.

2.1.2 SOIL PROPERTIES

Low strain soil properties are based on those used in EQE Calculation 250800-C-03 [28] after adjusting for the actual foundation depth. Once elevations are adjusted, the profile is consistent with the limited set of modulus of rigidity values presented in Prairie Island NGP USAR, Appendix E [93].

2.1.3 GROUND INPUT MOTION SEISMIC DEMAND

The mean ground motion response spectrum (GMRS) is from the client [22] and was identified as being derived from EPRI Seismic Hazard Curves for Prairie Island NGS following the procedure described in Regulatory Guide 1.208 [29]. (The client stated that this information was taken from EPRI Report 1016736, “”Assessment of Seismic Hazard at 34 U.S. Nuclear Plant Sites”, August 2008. This report is not available to S&A and the S&A work is based on the data supplied in reference [22]). Resulting values are shown in Table 2.1 and plotted in Figure 2.1. Data is based on 5% damping.

Table 2.1 - Data for Prairie Island NGS Ground Motion Response Spectrum
(Based on Client Input [22])

Frequency (Hz)	S_a (g)
100	0.169942
25	0.364251
10	0.339111
5	0.397295
2.5	0.193567
1	0.099222
0.5	0.07596

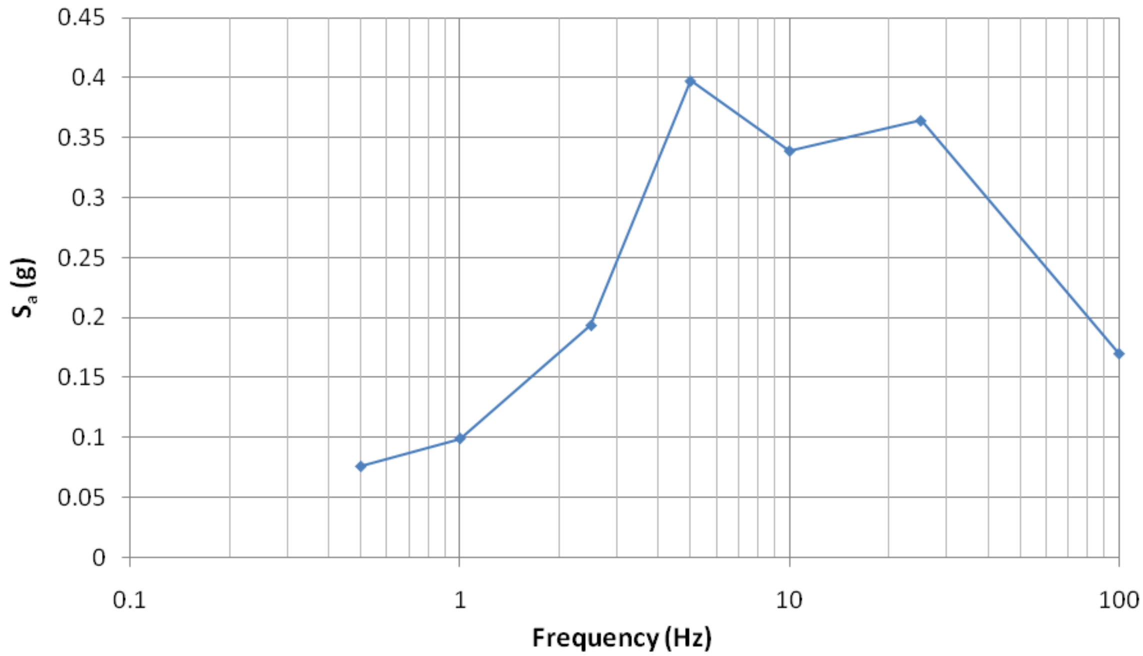

Figure 2.1 - Initial Prairie Island NGS GMRS
(Based on Client Input [22])

Time histories were developed based on the GMRS data given above, scaled to an appropriate PGA. . To improve this process, it is necessary to interpolate more data points. In most sections, a constant linear-log slope is assumed as shown in Figure 2.1. For the higher frequencies, it is necessary to modify the data somewhat. 100

Hz is considered unreasonably high for the analysis, and the PGA of 0.169942 is instead anchored at 50Hz. Data points are then interpolated between 25 and 50 Hz. The final set of frequencies is extended on the upper end to 50 Hz. The resulting data is shown in Figure **2.**2.2.

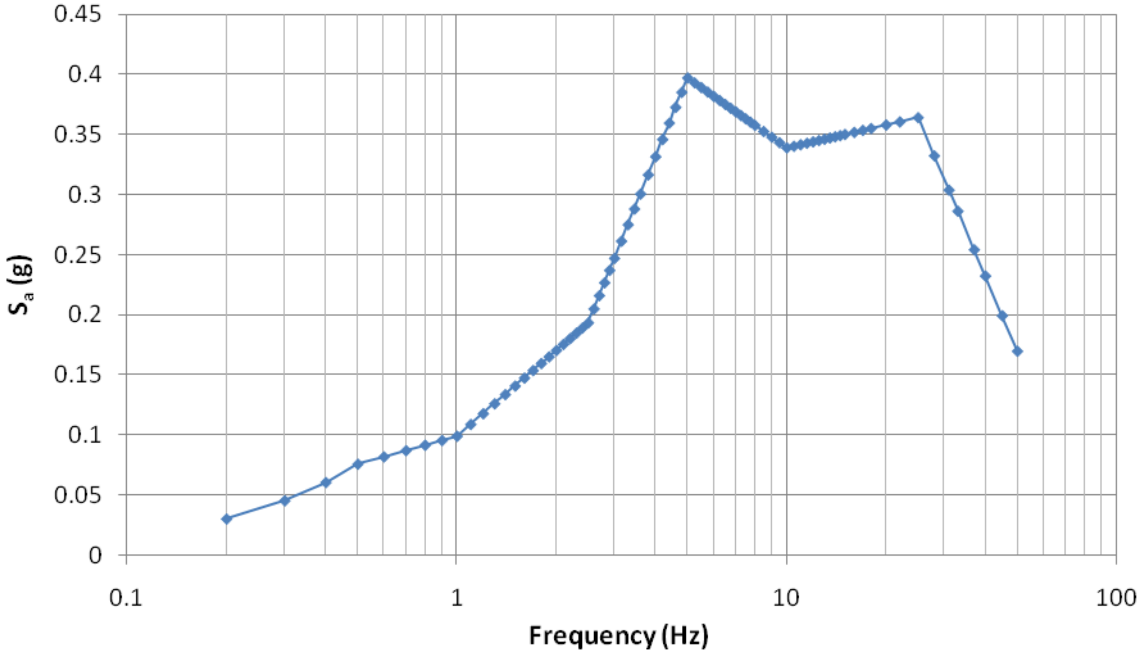

Figure 2.2 - Final Prairie Island NGS GMRS
(Based on client input [22], interpolated as discussed above)

The methodology consists of the steps outlined below. The detailed calculations, organized according to these steps, are provided in Section 7. The coordinate system used in the calculations is X=EW, Y=NS, Z=Vertical.

1. Fixed-base modal properties are calculated for the Turbine Pedestal and the combined Turbine and Auxiliary Buildings using the structural models described in Section 2.1.1.

2. Horizontal time histories are generated from the mean GMRS hazard spectrum scaled to a PGA of 0.3g. Since horizontal and vertical response is considered to be uncoupled, vertical time history is determined as 2/3 of the first horizontal time history.

3. Lower-bound (LB) and upper-bound (UB) low strain soil properties are calculated based on the best estimate (BE) low strain soil properties given in Reference 25. The resulting range allows for an assessment of uncertainty in the analysis results. LB and UB values are taken as 2/3 and 3/2 times the initial BE shear modulus values, respectively, as suggested in ASCE 4-98 30 for the lowest level of uncertainty of soil properties.

4. Large strain soil properties are determined for the LB, BE, and UB cases. Poisson's ratio is adjusted for vertical analysis to maintain an unchanged compression wave velocity at large strains.

5. Soil impedance functions are calculated for each of the components of the structure using each of the best estimate, lower bound, and upper bound high strain soil properties.

6. Soil impedance functions are selectively combined to develop soil impedance matrices for the Turbine Pedestal and the combined Turbine and Auxiliary Buildings. Translation and rotation in the horizontal plane

are controlled by the impedances of the overall structure while rocking, coupled translation-and-rocking, and vertical motion are controlled by the impedances of the particular component being analyzed.

7. The structural models and the soil impedance functions are combined to form the soil-structure models. The models are analyzed in EKSSI [23] using the input time histories, and response time histories are calculated separately for the X and Y direction for all levels in the Turbine Pedestal and Turbine Building and for the Z direction for the foundation of the Turbine Building. These calculations are performed for each of the LB, BE, and UB soil impedance matrices.

8. Amplified floor response spectra are generated from the time histories in SpectraSA for both X (E-W) and Y (N-S) directions in all levels in the Turbine Pedestal and Turbine Building and for the Z (Vertical) direction for the Turbine Building foundation.

The results of these analyses are found in S&A calculation 10C3877-BOS-CAL-002 [52]

2.1.4 Soil-structure interaction analysis

Soil and structure models are combined using the software package EKSSI [23]. From the structural model, magnitudes and locations of nodal masses are inputted along with modal frequencies and shapes. From the preceding soil analysis, frequency-dependent soil impedance matrices are inputted. Finally, seismic excitation is applied using the time histories developed found in S&A calculation 10C3877-BOS-CAL-002 [52].

The desired output of the analyses is response spectra for all levels in the turbine support and turbine building.

2.1.5 Generating Amplified floor response spectra

Outputted time histories based on best estimate soil properties are converted into amplified floor response spectra. The same set of frequencies used to develop the time histories are used to develop the response spectra for damping 0.5%, 1%, 2%, 3%, 4%, 5%, and 7% of critical, as well as N-411 variable damping. Envelopes are also developed for the Turbine Building in both the E-W and N-S directions over its full height (elev. 693’ to 790.5’) and from foundation up to the operating floor (693’ to 735’). Final best estimate amplified floor response spectra plots and envelopes are given in Appendix A with the associated data tabulated in Appendix B of S&A calculation 10C3877-BOS-CAL-002 [52].

2.2 ESTABLISHING MEDIAN SEISMIC FRAGILITIES

2.2.1 EPRI NP-6041 Screening Lanes and the Surrogate Element

EPRI NP-6041, Tables 2-3 and 2-4 present three screening lanes that can be used to assign so-called High Confidence of Low Probability of Failure (HCLPF) capacities to structures and equipment. The three lanes denote a seismic capacity in terms of spectral acceleration or peak ground acceleration (PGA). The capacities of the three lanes are 0.8g, 0.8g to 1.2g and > 1.2g, or in terms of PGA, 0.3g, 0.5g and >0.5g. These EPRI NP-6041 screening levels define a HCLPF capacity. The HCLPF of a component meeting the screening criteria for a lane is determined by comparing the screening level spectral acceleration to the 84th percentile ground motion spectrum. It is implied that the ground motion spectral shape is broad banded such as a NUREG/CR-0098 spectral shape used in NP-6041 and named the Review Level Earthquake (RLE). The EPRI UHS has a much different spectral shape and in the frequency range where the dominant structural response occurs, the spectral acceleration is somewhat low compared to the RLE whereas the peak of the EPRI UHS occurs at 10 Hz where there are often few significant structural response modes.

For Prairie Island (PI) the equipment screening level is >0.5g. For all equipment and piping that cannot be screened at this level explicit fragility calculations are performed. As a Class III* structure, the TB is designed to the greater of the static, lateral seismic load factor, 0.05g, or the design wind speed, 100-MPH, according to the USAR, Section 12.2.1.4 [93]. The TB seismic shears and moments are found in the “Blume” report [20] for the

0.06g “design” earthquake. They are doubled to be representative of the 0.12g Safe Shutdown Earthquake (SSE) and shown below. The base shear and moments for the 100-MPH wind are calculated (shown below) based on the wind pressure Equation 7 given in ASCE 3269 [25] where the projected areas of the north and east faces are based on a nominal TB height of 108 ft. and base widths of 440 ft. and 219 ft., respectively. The equivalent pressure for the 100-mph wind values is 33.3 psf (1.3 x 25.6 psf). The values for base shear and moment are considered comparable for the two external events.

Dir.	Seismic Base Shear (Kips)	Seismic Base Moment (Ft-Kips)	Wind Base Shear (Kips)	Wind Base Moment (Ft-Kips)
EW	940	52000	780	42148
NS	1600	66000	1568	84681

The tornado evaluation for the TB performed by Stevenson & Associates [26],[27] qualifies the building for 63 psf, which is nearly a doubling of the forces associated with the 100-mph wind event. This clearly infers that the seismic capacity is nearly double the 0.12g SSE site event. As such, the seismic capacity of the TB well exceeds the design basis SSE level earthquake and is, thus, screened out at 0.3g.

2.2.2 CALCULATING HCLPF CAPACITIES USING CDFM APPROACH

For equipment that cannot be screened, and for masonry block walls, HCLPF capacities are computed using CDFM. The CDFM capacities are then converted to median fragilities. CDFM calculations consist of standard engineering calculations using DBE acceptance criteria. The criteria are described in Sections 3.8 and 3.9.

Per References [10] and [13], a HCLPF capacity is approximately equal to the 1% probability of failure for a lognormal distribution with β = 0.4. This establishes the relationship between a median capacity and a HCLPF as:

$$\text{MEDIAN} = \text{HCLPF} \times e^{2.326\beta} = \text{HCLPF} \times e^{2.326(0.4)} = 2.54 \times \text{HCLPF}$$

2.2.3 DIRECTLY CALCULATING MEDIAN FRAGILITIES

Piping capacities are established by directly calculating median fragilities and the associated uncertainty factors as given in Reference [10]. The methodology used is described in Section 3.1.

3 EVALUATION CRITERIA

3.1 DUCTILE PIPING

3.1.1 MATERIAL PROPERTIES

The piping was originally designed to the B31.1 Power Piping Code [4]. Per Ref. [8], code allowable stresses are mean plus 1 σ or 2 σ values. This represents a 95% to 98% confidence level. Median allowable stresses are typically 20% higher than the Code values. Therefore, 1.2 times the B31.1 Code allowable stresses will be used.

3.1.2 STRENGTH AND LOAD COMBINATIONS

Reference [8] recommends the use of ASME BPVC Level D allowable stresses and the possible use of ductility factors. Since this is a median analysis versus a design basis analysis, ASME BPVC Class 3 acceptance criteria are used. Further, the later versions of the Code incorporate seismic design rules that reflect the extensive testing conducted by EPRI in the late 1980s and implemented in the Code by several ASME Special Working Groups. Therefore this criteria provides the most current and realistic Code seismic design basis. This approach uses the B_2' Stress indices for a pseudo primary stress evaluation and C_2 stress indices for secondary stresses. The S_h value used in the ASME Code is essentially the same as the S_h used by the B31.1 Code. Therefore, actual material capacities (S_h values) should be based on the B31.1 Code of record values. This is considered appropriate since the piping was design and constructed to the 1967 B31.1 Code. The BPVC specifies a primary stress limit to be the lesser of $3S_h$ for seismic design.

$$B_1 \frac{PD_o}{2t} + B_2^{'} \left(\frac{M_{Dwt} + M_{SSE_I}}{Z}\right) \leq 3.0 S_H$$

$$2C_2 \frac{M_{SSE_D}}{Z} < 6.0 S_H$$

$$S_H = 1.2 * \left(S_h = S\right)$$

P = Best estimate operating pressure (psi)
D_o = Pipe outside diameter (in)
t = Pipe wall thickness (in)
Z = Pipe section modules (in^3)
B_1 = Primary pressure stress Index per the Code
B_2' = Seismic inertial bending stress index per the Code
C_2 = Secondary bending stress Index per the Code
M_{DWT} = Moment due to deadweight (in-lbs)
M_{SSE-I} = Moment due to seismic inertial (in-lbs) (amplitude)
M_{SSE-D} = Moment due to seismic displacement (in-lbs) (amplitude)
S_h, S = B31.1 Code allowable stress at operating temperature (psi)

The ASME Level D limits have requirements to evaluate SAMs or any secondary stresses as SAMs are a major cause of piping failures resulting from strong motion earthquake; therefore some limit on the SAM stresses is considered. The allowable stress values in the 1967 B31.1 Code were based on the lesser of 5/8 S_y or ¼ S_u. The above equations as put forth and the consideration of the 1.2 increase for material properties limit the piping stresses to about the lesser of 2.25 S_y or .9 S_u for Primary Stresses and to about 4.5 S_y or 1.8 S_u for secondary stresses.

The above limits are still conservative versus mean or median values. Based on the extensive EPRI [12] test program conducted in the late 1980s and early 1990s, ductile piping systems, configured as the systems under review in this program, can withstand elastically predicted seismic stress levels to 5 to 10 times the material yield stress. Ductility factors are applied to the elastically predicted stresses to account for these ductility and non-linear response effects. Ref. [31], [17] Table 4 suggests a ductility factor of 2 to 3 for "……..distribution systems that can deform in-elastically to a moderate extent without any loss of function……". This ductility factor is then used to reduce the seismic loads by an amount of:

$$\text{2Hz and} \le: \ \frac{1}{\mu} = .33 \text{ to } .5$$

$$\text{2Hz to 8Hz}: \ \frac{1}{\sqrt{2\mu - 1}} = .44 \text{ to } .57$$

For our work here, a ductility factor of 2 or a knockdown factor of ½ = .5 is applied to the seismic inertial demand. The Code secondary stress limits are set to allow local deformation. Therefore, they have some localized ductility allowance in them. In addition the Code limits assume that elastic follow-up will not occur. Therefore, for secondary anchor motions effects (SAMs) a lower ductility factor of 1.5 is used. This factor is applied to the piping stresses and support loads on ductile support members. It is removed for the evaluation of any brittle concrete anchorages and for components having limited ductility such as cast iron valves.

The resulting piping evaluation criteria are:

$$B_1 \frac{PD_o}{2t} + B_2^{'} \left(\frac{M_{Dwt} + .5 * M_{SSE_I}}{Z} \right) \le 3.0 S_H$$

$$2C_2 \frac{.67 * M_{SSE_D}}{Z} < 6.0 S_H$$

$$S_H = 1.2 * \left(S_h = S \right)$$

The above equations limit the piping stresses to about the lesser of 4.5 S_y or 1.8 S_u for primary stresses and to about 6.75 S_y or 2.7 S_u for secondary stresses. A primary stress limit of $6S_h$ has been proposed by ARC Technical Care Group (TCG) [33] after an in-depth review of the EPRI piping seismic test program [12]. This limit is based on the use of B indices and represents a factor of safety of about 1.5 to 2.0. For critical components (elbows and tees), the ASME B_2 index is about 1.5 times the B_2' index. Therefore the use of B_2' and the ductility factor of 2 in the above primary stress equation is equivalent to using a capacity of $9S_h$ in the ARC TCG criteria. As the ARC TCG capacity of $6S_h$ is based on a factor of safety of 1.5 to 2, the equivalent capacity of $9S_h$ used here provides a good estimate of the median capacity.

3.1.3 STRESS INDICES AND SIFS

The B_2' indices were developed by the ASME BPVC Section III, Special Working Group on Seismic Rules. They were extracted from the EPRI test data [12] and were further correlated to detailed FEA conducted by the Japanese Team members of the SWG-SR. The resulting values were essentially based on mean data and do not have a conservative bias [34, 35]

The original SIF's (i factors that will be discussed later) developed by "Markl & George" for the B31 series piping codes were based on mean data. In recent years, the trend has been to develop SIF's that have a conservative bias. The code, however, contains SIF's based on the original "Markl & George" data. It would take extensive investigation of the SIF's to quantify the margin above median capacity that may exist in these SIF's. Such an investigation is beyond the scope of the current effort. It was mentioned for information and possible future consideration.

3.2 NON DUCTILE PIPING

The equations given in the previous section only apply to ASME material P grades number P1 thru P9. This is plain carbon steel or austenitic stainless steel. The equations are not applicable to non ductile materials such as cast iron. For non ductile piping the Code provides a modified set of level D stress equations. In addition, the Level D secondary stress limit on SAMs is applied as no explicit limit on secondary stresses is conducted for the OBE earthquake level. The equations are as given below with the allowable stress value reduced to S_u. For non-ductile materials the failure point is more clearly defined. Brittle materials such as cast iron fail abruptly when the ultimate stress capacity is reached. Therefore, S_u is judged to be a good estimate of the medium capacity. In addition, the ductility factor of μ= 2.0 no longer applies.

$$B_1 \frac{PD_0}{2t} + B_2 \left(\frac{M_{DWT} + M_{SSE_1}}{Z} \right) \leq S_U$$

$$\therefore 2C_2 \frac{M_{SSE_D}}{Z} < S_U$$

Where S_u = Code or ASTM Standard ultimate material capacity.

3.3 DUCTILE PIPING WITH NON DUCTILE INLINE COMPONENTS (CAST IRON VALVES)

For the piping, the same criteria as in section 3.1 are applied. The cast iron valves are evaluated against capacities developed in reference [62]. The resulting relationships are:

$$B_1 \frac{PD_o}{2t} + B_2^{'} \left(\frac{M_{Dwt} + .5 * M_{SSE_I}}{Z} \right) \leq 3.0 S_H$$

$$2C_2 \frac{.67 * M_{SSE_D}}{Z} < 6.0 S_H$$

$$S_H = 1.2 * (S_h = S)$$

At the valves:

$$\left(\frac{M_{DWT} + M_{SSE_1}}{Z} \right) \leq S_1$$

$$2i \frac{M_{SSE_D}}{Z} < S_1$$

S_1 is developed specifically for cast iron valves in Reference [62].

3.4 DUCTILE PIPING WITH BRASS OR BRONZE THREADED INLINE COMPONENTS:

For the piping, the same criteria as in Section 3.1 are applied. As brass and bronze are ductile materials, the same criteria is applied with (1) the Code allowable stress for brass or bronze, as applicable, and (2) B_2' = 2.3, which is the Code specified index for threaded joints.
For the piping:

$$B_1 \frac{PD_o}{2t} + B_2^{'} \left(\frac{M_{Dwt} + .5 * M_{SSE_I}}{Z} \right) \leq 3.0 S_H$$

$$2C_2 \frac{.67 * M_{SSE_D}}{Z} < 6.0 S_H$$

$$S_H = 1.2 * (S_h = S)$$

At the valves:

$$\left[B_1 = .5\right] * \frac{PD_0}{2t} + \left[B_2' = .75(2.3)\right] * \left(\frac{M_{DWT} + .5M_{SSE_1}}{Z}\right) \leq 3.0S_2$$

$$2(2.3)\frac{.67 * M_{SSE_D}}{Z} < 6.0S_2$$

$$S_2 = 1.2 * (S_h = S)$$

S_2 is 1.2 times the Code allowable stress, S_h or S, for bronze or brass as applicable.

3.5 DUCTILE PIPING WITH INLINE VICTAULIC COUPLINGS

Median capacities for Victaulic couplings are to be determined in accordance with the guidance provided in reference [64].

3.5.1 VICTAULIC COUPLINGS

The Victaulic coupling criterion was based on developing a capacity equivalent to an ASME BPVC Level D. Such a criterion would insure Leak tight Structural integrity with a margin of about 2.0. Some additional conservatism was built into the capacities developed in the reference calculation [36]. This basis and a more in-depth review of the SQURTS [37] seismic test data to determine a median capacity criterion for use in the determination of median fragilities of Victaulic couplings.

The Victaulic Catalog [38] provides two controlling parameters for the design of the joint: the pull out load and the rotation of the joint. These two controlling capacities will be extracted from the catalog and median fragilities developed are based on the application of the seismic testing results.

3.5.2 VICTAULIC PROPERTIES

2” and 4” Victaulic Model 77 – Flexible Couplings were seismically tested. The 4” Model 77 coupling will govern the median fragility criterion due to data from the test results

Allowable pullout axial loads for 2”, 4”, 6”, and 12” Model 77 joints:[38]

2”:	4,430 lbs
4”:	15,900 lbs
6”:	34,740 lbs
12:	102,000 lbs

Allowable rotations for 2”, 4”, 6”, and 12” Model 77 joints: [38]

2”:	≈ 1.5º
4”:	≈ 1.5º
6”:	≈ 1.2º
12”:	≈ 0.5º

It is noted take per the Victaulic Catalog these values can be c doubled for cut grooved pipe. However this is provided for information only as the allowable rotations were based on actual test data.

3.5.3 EVALUATION CRITERIA

The allowable rotations for Victaulic couplings: (Allowable Rotation in equation η_1)

Pipe size	Allowable Rotation at the Joint
2"	4.2 degrees
4"	4.2 degrees
6"	3.4 degrees
12"	1.4 degrees

The allowable axial loads are based on an assumed Amplified Floor Response Spectra ZPA of 3.25 g.

The allowable axial forces for Victaulic couplings if a detailed analysis is not conducted on the piping system: : (Allowable Axial Force in equation η_2)

Pipe size	Allowable Axial Forces at the Joint
2"	100 lbs
4"	318 lbs
6"	418 lbs
12"	2035 lbs

The allowable axial forces at Victaulic couplings if a detailed analysis is not conducted on the piping system: (Allowable Axial Load (AL) in equation η_3)

Pipe size	Allowable Axial Load (AL) at the Joint
2"	4,430 lbs
4"	15,900 lbs
6"	34,470 lbs
12"	102,000 lbs

The following relationships shall be used to determine the fragility of Victaulic Style 77 couplings:

Rotation:

$$\eta_1 = \frac{\text{Allowable Rotation}}{\text{Developed Rotation}} * ZPA_1$$

<u>Axial Loads:</u>

$$\eta_2 = \frac{\text{Allowable Axial Force}}{\text{Developed Axial Force}} * ZPA_1$$

$$\eta_3 = \frac{SL}{APL} * ZPA_1$$

Where:

ZPA_1 =	ZPA associated with the <u>Amplified Floor Response Spectra</u> used in the piping analysis is .3g.
Allowable Rotation =	allowable degrees (º) from the testing
Developed Rotation =	rotation across the joint (not the total rotation of the piping system at the joint) from analysis. Total rotation in the piping system may be used as long as the resulting fragility is in excess of 1.25g
SL =	AL-PL-WL
SL =	Seismic axial capacity
AL =	allowable axial load from the Victaulic catalog
PL =	pressure load ($P*A_P$)
A_P =	pipe inside cross section area
WL =	actual pipe weight load on the coupling from the analysis
APL =	developed axial load

η_2 is applicable to detailed or simplified analysis, but η_3 is only applicable to detailed analysis.

η or the median fragility is the lesser of η_1, (η_2 or η_3 as applicable)

3.6 PIPE SUPPORTS

3.6.1 PIPE SUPPORTS - STRUCTURAL STEEL

The pipe support structural steel is evaluated using AISC 6th Edition Part 2 [1] capacities. The ductility factor of 2.0 for inertial loads and 1.5 for SAM loads is maintained to account for the reduction in the applied load from the piping due to piping inelastic behavior and energy absorption, and to also account for the energy absorption of the support elements themselves. The ductility factor is incorporated by reducing the seismic loads based on the following load combination:

$$|D| + \left| \left[(.5 * SSE_I)^2 + (.67 * SSE_D)^2 \right]^{1/2} \right|$$

Per Ref. [8], the code allowable stresses are at mean plus 1σ or 2σ. Mean or median properties for structural steel materials are typically 20% higher than the ASTM allowable stress values. This 1.2 factor is applied to the code allowable stress.

3.6.2 PIPE SUPPORTS - COMPONENT STANDARDS

The MSS-SP-58 allowable loads on component standard supports are multiplied by 2, as put forth for level D loads in ASME BPVC, Section III, Division 1 Code Case N500 [3]. In addition, the ductility factor of 2.0 for inertial loads and 1.5 for SAM loads applies. The resulting load combination is:

$$|D| + \left| \left[(.5 * SSE_I)^2 + (.67 * SSE_D)^2 \right]^{1/2} \right|$$

The majority of the MSS-SP-58 [14] components in this system are fabricated from hot rolled steel products. Per Ref. [10], mean or median properties for structural steel materials are typically 20% higher than the tabulated ASTM or MSS-SP-58 allowable stress values. Therefore, the capacities can be increased by an additional factor of 1.2 or a total increase of 1.2*2.0 = 2.4.

Per Ref. [11], tests on snubbers and struts indicated that they have a failure margin against ASME Level D limits (2 times Level A) of between 1 to 4. The average is approximately 2.0. The approach taken here is to reduce the applied load by 2.0 and compare them to failure Level D limits (2 Times Level A).

3.6.3 PIPE SUPPORTS - CONCRETE ANCHORAGES

For pipe support anchors the mean capabilities from testing due for the GIP Program [18] and as given in EPRI Report NP-5228-SL [7] are used and no ductility factors are applied.

Per Ref. [7], pg. 2-58, the following tension / shear interaction equation is used:

$$\left\{ \left(\frac{TL}{ATL} \right)^2 + \left(\frac{VL}{AVL} \right)^2 \right\}^{\frac{1}{2}} \prec 1.0$$

TL=applied Tensile load
VL=applied Shear load
ATL=mean capacity in tension from the GIP tests [7]
AVL=mean capacity in shear from the GIP tests [7]

3.6.4 PIPE SUPPORTS - WELDS

All the welds on the piping system supports are fillet welds. The median allowable weld shear stress is computed as 1.7*.3*f_u, where fu is the ultimate strength of the weld material. . This is a typical allowable stress for DBE loads and is a conservative estimate of median capacity. Based on the quality of welding observed at PINGP, weld stresses are not expected to control support fragilities. The ductility factor of 2 on inertial loads and 1.5 on SAM loads is applied in calculating weld stresses.

3.7 DETERMINATION OF THE COEFFICIENT OF UNCERTAINTY, β_C

Per reference [10], page 2-34 and 2-35

$HCLPF_{50} = A_m e^{-1.65(\beta r + \beta u)}$

Where A_m is the median capacity based on the pga and the β_r is the variance associated with randomness and β_u is the variance associated with the uncertainty. The values are determined in the table that follows this discussion. The uncertainty, β_C, as associated with this fragility is $\beta_C = \sqrt{\beta r^2 + \beta_U^2}$. This value is required in the PRA if the fragilities a being developed and supplied are Median fragilities verses HCLPF50 or HCLP84. The values developed using the criteria of this calculation are judged to be median values and there a β_C value is required.

Table 3.1 lists the demand variable and associated variances associated with each of the factors. Table 3.2 lists the capacity variables and associated variances associated with each of the factors. These factors were arrived at by review and use of Ref. [59] and the documents referenced in Ref. [59]. Detailed discussion of the basis of all the factors is not provided. The notes provide general insight and in some cases specific reference to the basis of the values selected. These tables are provided for information only.

Table 3.1 - Fragility Analysis Demand Variables

Item	**Median Demand Factor**	**β_r Randomness Std Dev.**	**β_u Uncertainty Std Dev**	**Notes**
Structure				
Ground Motion				
Spectral Shape	1	.14	0	Ref [10] Table 3-2 anchored at PGA of 33 Hz average of high and low values
Vertical Component Response	1	.15	.18	Ref [10] Table 3-2 Lower bound values reduced .07 for detailed site specific analysis based on engineering judgment for β_r ; β_u is based on the average of the generic values reduce by .05 per notes in Table 3-2.
Horizontal Direction Peak Response		.09	0	Ref [10] Table 3-2 Lower bound augmented by the guidance for average of anchor bolt tension and shear given in Ref [10], Table 3-3.
Damping	.07	----	.05	Ref [10] Table 3-4 for Concrete Structures, S&A used 7% building damping in CB [18]. It was not specified for RB but assume it was similar and 7% was used.
Modeling				
Frequency	1	----	.05	Ref [10], Page 3-15 to 3-18 based on the consideration that the frequency prediction is highly accurate due to the details of the analysis
Mode Shape	1	----	.05	Ref [10], Page 3-18 as Turbine building is a simple structure dominated by a one or two modes of response
Torsional Coupling	N/A	----	----	Three dimensional Models used by S&A
Mode Combinations		.07	---	Ref [10]; page 3-19 average of simple and complex structure would be .07 with the simple structure being at .05. Since the Turbine building and Pedestal is a relatively simple structure a value of .07 was chose.
Time History Simulation	1		.1	Per Boston Calculation 10C3877-BOS-CAL-002 (Ref [29])
Foundation-Structure				

Table 3.1 - Fragility Analysis Demand Variables

Item	**Median Demand Factor**	**β_r Randomness Std Dev.**	**β_u Uncertainty Std Dev**	**Notes**
Interaction				
Ground Motion Incoherence	1	----	----	No reduction or effect.
Vertical Spatial Variation	1	.08	.02	Uncertainty taken at 3 std dev per ref [10] page 3-23 and Randomness per ref [12] Page 3-24
SSI Analysis	1	----	----	All uncertainty was accounted for and addressed in the detailed SSI done by S&A
Earthquake Component Combination		.10	----	Earthquake direction combination was via SRSS. Value per Ref [10] page 3-27.
Subtotal	-----	.27	.22	
Equipment				
Qualification Method	1	---	---	Median Centered Reanalysis Conducted
Damping	.05	----	.02	Ref [10] page 3-48 suggests a value between .02 to .035. The work by PVRC [8] and more recent studies conducted by Jack Ware at EGG Idaho and information presented to the Appendix N Working Group of the ASME BPVC, Section III, Division 1 supports the lower value therefore, it is the author's opinion that .02 should be used.
Modeling				
Frequency	1	---	.05	Ref [10] page 3-49 (also the discussion on pages 3-15 to 3-18)analysis estimate of Frequency should be fairly close.(based on author's judgment)
Mode Shape	1	---	.05	Ref [10], page 3-45 and the above considerations (based on author's judgment)
Mode Combination	1	.07	---	Ref [10], page 3-45. this has partially been accounted for in the variances associated with the structure, (based on author's judgment)
Earthquake Component Combination	1	.10	----	SRSS used; Value per Ref [10] page 3-27. This has partially been accounted for in the Variances associated with the structure, (based on author's judgment)
Subtotal		.12	.16	
Total		.29	.27	

Table 3.2 - Fragility Analysis Capacity Variables

Item	**Median Demand Factor**	**β_r Randomness Std Dev.**	**β_u Uncertainty Std Dev**	**Notes**
Piping				

Table 3.2 - Fragility Analysis Capacity Variables				
Item	**Median Demand Factor**	**β_r Randomness Std Dev.**	**β_u Uncertainty Std Dev**	**Notes**
Material Properties	1		.07	Reference [10], Table 3-9 S the piping allowable capacity is a function ultimate stress for A-106 Gr. B
Strength Factor (Allowable Capacities)	N/R	---	---	Not required accounted for in the material properties
Load Combinations	1	0.00	----	SRSS used for Inertial loads and SAM loads, Value per Ref [10] page 3-27. However, this was already accounted for in the equipment demand variances above.
Inelastic Response (Ductility)	1	----	.07	Since ductility is a function of material properties its uncertainty shown be on the order of the that for material properties. This based on the author's judgment.
Total	-----	0.00	.10	
Supports (Ductile Members - No expansion anchors)				
Material Properties	1		.12	Reference [10], Table 3-9, the AISC-SCM [Ref 1] is allowable stress design and is controlled by yield stress
Strength Factor (Allowable Capacities)	N/R	---	---	Not required accounted for in the material properties
Load Combinations	1	0.00	----	SRSS used for Inertial loads and SAM loads, Value per Ref [10] page 3-27. However, this was already accounted for in the equipment demand variances above.
Inelastic Response (Ductility)	1	----	.12	Since ductility is a function of material properties its uncertainty shown be on the order of the that for material properties.. This based on the author's judgment.
Total	----	.0	.17	
Anchor Bolts				
Strength Factor (Allowable Capacities)				
Tension	1	---	.28	Reference [8], Table, pg. O-3. Per field review there were not cracks observed in the vicinity of the concrete anchorages.
Shear	1	---	.24	Reference [8], Table, pg. O-3 Per field review there were not cracks observed in the vicinity of the concrete anchorages.
Load Combinations		.0	----	SRSS used for Inertial loads and SAM loads, Value per Ref [10] page 3-27. However, this was already accounted for

Table 3.2 - Fragility Analysis Capacity Variables				
Item	**Median Demand Factor**	**β_r Randomness Std Dev.**	**β_u Uncertainty Std Dev**	**Notes**
				in the equipment demand variances above. Interaction effects accounted for in strength factors.
Total	----	0	.28	Used the Higher of the Tension or Shear Variance
Limited Ductility Components				
Material Properties	1		.07	Taken the same as ductile materials above based on ultimate capacity failure.
Strength Factor (Allowable Capacities)	---	---	---	Not required accounted for in the material properties
Load Combinations		0	----	SRSS used for Inertial loads and SAM loads, Value per Ref [10] page 3-27. However, this was already accounted for in the equipment demand variances above. Interaction effects accounted for in strength factors.
Ductility	1	-----	.07	Since ductility is a function of material properties its uncertainty shown be on the order of the that for material properties
Total		.0	.10	

The following is a summary of the combined β_r and β_u values:

Piping (Ductile and non ductile)

$$\beta_r = \sqrt{.29^2 + 0^2} = .29$$
$$\beta_U = \sqrt{.27^2 + .10^2} = .28$$

Support Steel:

$$\beta_r = \sqrt{.29^2 + 0^2} = .29$$
$$\beta_U = \sqrt{.27^2 + .17^2} = .28$$

Support Anchor Bolts:

$$\beta_r = \sqrt{.29^2 + 0^2} = .29$$
$$\beta_U = \sqrt{.27^2 + .28^2} = .39$$

Support Limited Ductility Components

$$\beta_r = \sqrt{.29^2 + 0^2} = .29$$

$$\beta_U = \sqrt{.27^2 + .10^2} = .28$$

The resulting uncertainty associated with each item is:

Piping: $\beta_C = \sqrt{.29^2 + .28^2} = .41$

Support Steel: $\beta_C = \sqrt{.29^2 + .31^2} = .42$

Anchor Bolts: $\beta_C = \sqrt{.29^2 + .39^2} = .48$

Limit Ductility Component: $\beta_C = \sqrt{.29^2 + .28^2} = .40$

It was decided to use a β_C = 0.4 for piping by consensus of XCEL Energy and S&A staff members.

3.8 EQUIPMENT

As discussed in Section 2.2, equipment that is either screened by the walk down engineer (it is therefore covered by the surrogate element) or HCLPF capacity is computed using CDFM. The HCLPF capacity is then converted to a median fragilities by multiplying by a factor of 2.54. The associated composite mean β_c = 0.4. The CDFM acceptance criteria are based on the recommendations in EPRI NP-6041, and are summarized below:

Equipment damping:	3% pumps, 5% other equipment
Allowable stresses, steel & welds:	1.7 x AISC 9th [1] normal allowable stresses
Allowable stress, concrete anchors:	GIP [18] Appendix C

Some equipment is unanchored. Where appropriate, friction is credited. Static friction coefficients were established based on a review of engineering manuals:

Friction, steel concrete:	0.35
Friction, rubber pad:	1.00

Unanchored, vertical, atmospheric storage tanks (in particular, the Reactor Make-Up Water Storage Tanks) are evaluated based on the methodology given in Reference [5].

3.9 BLOCK WALLS

As discussed in Section 2.2, a block wall HCLPF capacity is computed using CDFM. The HCLPF capacity is then converted to a median fragilities by multiplying by a factor of 2.54. The associated β_c = 0.4.

The CDFM values were first computed using the fairly conservative acceptance criteria are summarized below:

Reinforced Block Walls

Damping: 5%

Fundamental frequency: Based on cracked section properties; if the frequency is below the peak of the floor response spectrum, the peak is used.

Moment capacity: $M_u = 0.9 * \left[A_s * f_y * \left(d - \frac{a}{2} \right) \right]$ Where, $a = \frac{A_s * f_y}{0.85 * f'_m * b}$, b = 12”

A_s = area of reinforcing steel per foot of wall
f_y = reinforcing steel yield strength
d = depth of reinforcing steel
f'_m = compressive strength of concrete block.

3.10 RMST

The Reactor Make-Up Water Storage Tanks (RMST) are vertical water storage tanks located on the Turbine Building ground floor (el. 695’), founded on a thick grade slab. It is a freestanding, flat-bottom, vertical cylindrical tank containing water at atmospheric pressure. The tank is unanchored.

This evaluation uses the unanchored tank seismic analysis procedure developed for DOE High-Level Waste Storage tanks in BNL 52361[5]. The procedure addresses high-importance unanchored tanks subject to high earthquake load and is appropriate for this application.

Applied ground floor response spectra are taken as developed in S&A Calculation 10C3877-BOS-CAL-002 [55] for the foundation level of the Turbine Building. Details of the tank evaluations can be found in Reference [58].

4 EVALUATION RESULTS

4.1 SCOPE

The following table, Table 4.1, lists the systems, flow diagrams and piping specifications that define the scope of this evaluation.

Table 4.1

System	Flow Diagram	Piping Specifications
Cooling Water Turbine Bldg	**NF-39216-2**	**M-362, MZX1**
Cooling Water Turbine Bldg	**NF-39217-1**	**M-362**
Chilled Water System	**NF-86172-1**	**MZX1 or M-359 (as applicable)**
Condensate System Unit 1	**NF-39220**	**M-354, M-359**
Instrument Air Piping	**NF-39244**	**M-362**
Condensate Polishing System	**NF-39253-1**	**M-380**
Reactor Made Up & Demineralized Water Systems	**NF-39242**	**M-380**
Condensate System Unit 2	**NF-39221**	**M-354, M-359**
Equipment Heat Removal System	**NF-39603-2**	**M-362**
Station Air/Condensate Polishing	**NF-39253-3**	**M-362**
Feedwater & Aux Feedwater Unit 1	**NF-39222**	**M-362**
Feedwater & Aux Feedwater Unit 2	**NF-39223**	**M-362**
Steam Heating System	**NF-39605-1**	**M-362**
Lab & Service Area A/C & Chilled Water Safeguard System	**NF-39603-3**	**M-369**
Bleed Steam & Heater Vents	**NF-39224**	**M-362**

4.2 CAST IRON VALVE FRAGILITY FOR CL-67 LINE

Shown below is Table 4.2 with Cast Iron valve fragilities for valves near the following equipment: Hydrogen Seal Oil Unit Cooler (HSOUC), Generator Exciter Cooler (GEC), and Generator Hydrogen Cooler (GHC).

Table 4.2

Table with valve fragilities in relationship to the equipment they support			
Valve Number	Valve Diameter	Equipment it is attached associated with	Fragility number
CW-2-3	3”	Hydrogen Seal Oil Unit Cooler	0.221g
CW-10-1	2-1/2”	Generator Exciter Cooler	0.364g
CW-10-2	2-1/2”	Generator Exciter Cooler	0.372g
CW-10-3	2-1/2”	Generator Exciter Cooler	0.397g
CW-10-4	2-1/2”	Generator Exciter Cooler	0.318g
CW-28-1	6”	Generator Hydrogen Cooler	0.430g
CW-28-2	6”	Generator Hydrogen Cooler	0.587g
CW-28-3	6”	Generator Hydrogen Cooler	0.516g
CW-28-4	6”	Generator Hydrogen Cooler	0.528g
CW-28-5	6”	Generator Hydrogen Cooler	0.400g
CW-28-6	6”	Generator Hydrogen Cooler	0.522g
CW-28-7	6”	Generator Hydrogen Cooler	0.491g
CW-28-8	6”	Generator Hydrogen Cooler	0.585g
CW-32-1	14”	Generator Hydrogen Cooler	0.613g

4.3 EQUIPMENT MEDIAN FRAGILITIES

The equipment HCLPFs or, in some case, median capacities, A_m, are presented in Table 4.3 below. In general, the conservative, deterministic failure margin (CDFM) criteria of EPRI NP-6041 are followed; however, in the case of the unit coolers the median capacity was calculated directly since it's based on the attached supply and return line capacities. If an equipment item is shown as "screened" then its capacity is greater than or equal to 0.5g by virtue of being screened in accordance with Table 2-3 of EPRI Report NP-6041 [8]. Detailed calculations for the equipment capacities are given in S&A Calculation 10C3877-BOS-CAL-004 [57].

A Seismic Review Team (SRT) inspected equipment in the field (walkdown) and identified vulnerabilities. The evaluated equipment is listed in Table 1 with the screening results. When the calculations did not show excessive capacity of the equipment, an estimate of the HCLPF (High-Confidence-Low-Probability-Failure) capacity was determined. The HCLPFs and median capacities are reported in terms of peak ground acceleration.

The applied floor response spectra are taken from S&A Calculation 10C3877-BOS-CAL-002 [55]. Several pieces of equipment are located at elevation 679' in the Turbine Pedestal (TP), which is considered to have the same response spectrum as elevation 695' in the Turbine Building due to the connection of a rigid foundation.

Table 4.3 - Equipment List and Results Summary

Equipment	**Building**	**Elevation**	**HCLPF (pga)**	**Median (pga)**
253-281 (11BWST), (21BWST) Backwash Water Storage Tank	TB	695'	0.60 g	
11, 21 Backwash Waste Receiving Tank	TB	695'	Screened	
11/12 Heater Drain Tanks	TB	695'	Screened	
21&22 and 11&12 Hydrogen Seal Oil Unit Coolers	TB	695'	Screened	
21&22 Turbine Oil Reservoir Oil Coolers	TB	695'	0.66 g	
11&12 Turbine Oil Reservoir Oil Coolers	TB	695'	0.55 g	
11/12 & 21/22 Generator Bus Duct Coolers	TB	715'	0.39 g	
121 Lab & Service Area Water Chiller	TB	755'	0.25 g	
11, 12, 21 and 22 FW Pump Oil Coolers	TB	695'	Screened	
11 Heater Drain Tank Pump Motor Unit Cooler	TP	679'	0.14 g	
23 Heater Drain Tank Pump Motor Unit Cooler	TP	679'	0.34 g	
11/21 ZX Chiller	TB	715'	Screened	
Heater Boiler	TB	715'	0.50 g	
U1 Condensate Pump Motor Unit Coolers	TB	695'		0.19 g
U1 Feedwater Pump Motor Unit Coolers	TB	715'		0.37 g
U1 Heater Drain Tank Pump Motor Unit Coolers (12,13)	TB	695'		0.37 g
21 U2 Condensate Pump Motor Unit Coolers (3/4" Valve)	TB	695'		0.05 g
22, 23 U2 Condensate Pump Motor Unit Coolers	TB	695'		0.29 g
U2 Feedwater Pump Motor Unit Coolers	TB	715'		0.39 g
U2 Heater Drain Tank Pump Motor Unit Coolers (21,22)	TB	695'		0.39 g
11/ 12 & 21/22 Reactor Make-Up Water Storage Tank[1]	TB	695'	100% full: 0.40g 75% full : 0.55g	
11/12 & 21/22 Generator Exciter Coolers	TB	735'	Internal to Turbine Screened	
11/12 & 21/22 Generator Hydrogen Coolers	TB	735'	Internal to Turbine Screened	

Equipment	Building	Elevation	HCLPF (pga)	Median (pga)
11/12 & 21/22 Turbine EH Fluid Reservoir Oil Coolers	TB	715'	Screened	
11/12 & 21/22 Turbine Room Sump Pumps	TB	679'	Screened	
Rad Monitor Heat Exchanger	TB	695'	Screened	
Refrigerator CDSR	TB	695'	Screened	
FW Oxygen Sample Cooler	TB	715'	Screened	
121,122,123, 124, 125 Station Air Compressors	TB	695'	Screened	
121,122,123, 124, 125 Station Air After coolers	TB	695'	Screened	
121,122 Bag Filters	TB	715'	Screened	
121,122 Media Filters	TB	715'	Screened	
11, 12, 13, 21, 22, 23 Condensate Pump Oil Coolers	TB	679'	Internal to pump Screened	
11, 12, 13, 21, 22, 23 Heater Drain Pump Oil Coolers	TB	679'	Internal to pump Screened	
12/21 Aux Feedwater Pump Motor Unit Coolers	TB	715'	39603-2 Screened	
121, 122, 123 Air Compressor Motor Unit Coolers	TB	715'	39603-2 Screened	

Note 1 : Calculation presented in S&A 10C3877-BOS-CAL-005 [55]

4.4 CIRCULATING WATER PIPING SEISMIC CAPACITY

During the CL piping and equipment walkdowns, the Cooling Water (CW) main and branch piping was also assessed. However, based on the walkdown, the piping could be screened, and fragility calculations were not required. The main conclusions from the walkdown were:

a) The large CW supply and discharge headers have high seismic capacity, especially when compared to the CL and FP piping included in the seismic flooding assessment.
b) The large expansion joints between the piping and the condenser waterboxes have high seismic capacity, and provide for some flexibility if needed.
c) The condenser tube cleaning system (Amertap) connected to the CW piping has high seismic capacity. The ball catching units and small recirculation pumps are well anchored, the valves and fittings are flanged stainless steel, and the welded steel piping is well-supported.
d) The ¾" corrosion monitoring piping and socket welded steel valves have high capacity through the first valve. This valve is closed during normal operation, isolating the remainder of the piping. Therefore, these lines have high capacity.
e) While the condenser waterbox vent and drain piping has some cast iron valves, their failure would not impact the seismic flooding analysis. If the vent piping lines failed, there would not be any water flow through these lines, so the flooding scenarios would not be affected. The drain lines are isolated during power operation. Although the waterbox inventory could drain out if these drain lines failed, as the condenser pit filled with water from other flooding sources, the water would backflow into the waterbox, and fill it higher than the original level. Thus, more volume would be available in the condenser pit if the waterbox drain lines failed. Therefore, there is no impact on the flooding scenarios.

Therefore, the CW piping and equipment is screened from the flooding assessment.

4.5 BLOCK WALL MEDIAN FRAGILITIES

The masonry block wall HCLPFs are presented in Table 4.4 below. The conservative, deterministic failure margin (CDFM) criteria of EPRI NP-6041 [8] are followed. The HCLPFs are reported in terms of peak ground acceleration.

The applied floor response spectra are taken from S&A Calculation 10C3877-BOS-CAL-002 [55].

Table 4.4 - Equipment List and Results Summary

Equipment	Building	Elevation	HCLPF (pga)
Block Wall behind Demineralizer Tank	TB	708' – 732'	0.40 g
Block Wall adjacent to Elevator	TB	715' – 735'	0.35 g
Safety Related Masonry Block Walls #3 and #8	TB	695'-715'	0.29 g
Block Wall on south wall el. 735'	TB	735-755-	1.80 g

4.6 PIPING MEDIAN FRAGILITIES

An engineer experienced in the seismic evaluation of piping at nuclear power plants walked down each pipe segment identified as being in-scope and identified any conditions that would result in a reduced seismic capacity, such as:

- An unusual geometry that would concentrate large inertial loads in a local area,
- Branch pipes with stiff lateral supports connected to run pipes with flexible lateral supports,
- Dead weight supports that are vulnerable to lateral loads, such as short threaded rods with fixed end conditions, beam clamps, vertical stanchions where the pipe could move laterally and fall off, and poorly detailed or poorly constructed supports,
- Non-ductile components such as cast iron valves or fittings, threaded fittings, or Victaulic couplings,
- Field-fabricated fittings that could result in high stress concentrations,
- Potential seismic interaction hazards such as unanchored equipment or masonry block walls.

Based on the walk-down, either the piping segment was assigned a seismic fragility based on pre-calculated screening values, or identified as requiring further analysis. The evaluations were performed in accordance with the criteria specified in Section 3.1, and are documented in References [68], [70] thru [78], and [94]. The results are summarized in the following tables.

There is one table for each PINGP flow diagram drawing identified in Section 4.1. Within each table, the piping is organized into segments. Each segment is identified by a description and a valve number. For each segment, up to three median fragilities are provided: piping inertia, piping seismic anchor, and other. For piping inertia and piping seismic anchor motion median fragilities, the associated uncertainty $\beta = 0.4$. The "other" median fragility is that of any equipment attached to the piping segment, or any block wall that has the potential to fall on the piping segment. The associated uncertainty is $\beta = 0.4$. These are the median fragilities previously tabulated in Sections 4.3 and 4.4, now associated with specific piping segments (The table notes specify the particular equipment or wall.)

As discussed in Section, 2.2, all piping has another fragility, the median fragility of the Turbine Building itself and all other items which were "screened" using EPRI NP-6041 screening lane 1. These items are lumped into the so-called surrogate element, which has a median fragility of 2.08g and uncertainty of $\beta = 0.4$.

A portion of the Main Steam Lines in Unit #1 and Unit#2 are being reanalyzed by the S&A Chicago office. The analysis for earthquake is primarily Response Spectra Modal Analysis (RSMA). The Unit #1 analysis has been completed Ref. [101] for the load cases involving Safe Shutdown Earthquake (SSE). The piping was demonstrated to meet the equivalent of somewhere between a Level C and Level D ASME Section III limit. The input spectra used was the PINGP Design Basis Earthquake (DBE) for most of the piping, while some of the piping was evaluated to a Uniform Building Code (UBC) Zone 1 Seismic load. The piping evaluated for the UBC Zone 1 Seismic load was qualified essentially to ASME BPVC Level B limits. Based on the discussions in References [8], [10], and [16], piping analyzed to the level of detain with the capacity limits used, results in a HCLPF50 of greater than 0.5g. Therefore both the Unit #1 and Unit #2 Main Steam Line piping is judged to have a median fragility of 1.25g.

The Fire Protection piping in the Turbine Building was analyzed for seismic fragility. The enveloped worst case analysis yielded a fragility of 0.15g Ref. 69].

Another consideration for the response of the plant to a seismic induced flood is the “Loss of Off Site Power”. Reviews conducted by during the IPEEE program indicated that ”Loss of Off Site Power” has a significant probability of occurrence and in most cases is controlled by the failure of ceramic insulators that support the offsite power supply lines. Considering this, the fragility value assign to the “Loss of Off Site Power Event” is as follows:

Median fragility: 0.30g
$\beta_r = .27$
$\beta_\mu = .40$

Table for NF-39216-2, NF-39222, NF-39605-1, and NF-39223

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-1	4-CL-89	4"	24" Supply Header (U1)	#11 AFWP	M-362	H1	4": 1/1 3": 1/1	4": 2/1 3": 2/1	2.53	NC	EQ:AFWP#11 Screened at 0.5g HCLPF per NP-6041 Table 2-3. Median Valve is 1.25	1.25	.4	(1) Piping is all welded construction, including valves and has had obvious seismic design. (2) Part of the pipe is SS but screened on the basis that it is all CS
CL-2	4-CL-68	4"	24" Supply HDR	12" TOROC Supply Line	M-362	H1	1.5/1	4/1	> 1.25	N/C	None	> 1.25g	.4	Contains CI Valves. Based on comparison of U1 to U2 plant dwgs., the median fragility is > 1.25g.
CL-3	2-CL-96	2"	24" Supply HDR	Station Air Branches	M-362	H1	1/1	1/1 & 5/1	2": .99	NC	Safety Related Block Wall #8: HCLPF capacity is 0.29 g and median capacity = 0.73g	0.73	.4	2" valves are THRD brass valves and welded steel.
CL-4		2"/1"	12" TOROC Supply Line	T(EH)FROC	M-362	H1	1.5/1	5/1	(1.25*.99) = 1.24 (Freq <2.5 HZ)	NC	EQ:T(EH)FROC: Screened at 0.5g HCPLF per NP-6041 Table 2-3. Median Value is 1.25	1.24	.4	(1) Portion of the piping on the 715' Level is 1" SS tubing (2) Contains THRD brass valves, THRD unions and compression fittings
CL-5	3-CL-69	3"/2"	12" TOROC Supply Line	FWPOC	M-362	H1	1/1	16/1	3": .34*1.25 =.43 2": .99*1.25 = 1.24 (Freq < 2.5 HZ)	N/C	EQ: FWPOC #11: EQ: FWPOC #12: Screened at .5 g HCLPF Median value is 1.25g	3": 0.43 2": 1.24	.4 .4	(1) Contains CI valves (3" pipe) and THRD brass valves (2" pipe) and THRD unions

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-6	¾ –CL- 69	¾"	3-CL-69	FWOSPC	M-362	H1	1/1	1/1	>1.0	N/C	EQ: FWOSPC: Screened at 0.5g HCLPF per NP-6041 Table 2-3. which is a median value of 1.25g Controlling issue is spatial interaction which results in a median capacity of 0.10	0.10	.4	(1) Line is ¾" SS tubing with compression fittings (2) **OUTLIER** – has major Spatial interaction problem with conduit and with piping system
CL-7	2-CL-68	2"	12-CL-68	12-CL-68	M-362	H1	1/1	1/1	.99	N/C	None	0.99	.4	(1) Contains THRD brass valves and THRD unions
CL-8	1½ -CL-72	1½"	16-CL-67	CPOC #11/#12/#13	M-362	H1	1-½: 1.5/1 ¾: 1.5/1	1-½: 4/1 ¾: 2/1	¾": 1.07 1-1/2": 1.03	> 1.0	EQ: CPOC #11: EQ: CPOC #12: EQ: CPOC #13: Condensate pumps are adequately anchored. Screened at .5 g HCLPF. Median value is 1.25	1.03	.4	(1) Most of the pipe is welded SS and ¾" valves are welded. 1-1/2" pipe is CS and has THRD brass valves (2) The piping is attached to the 16" Pipe that was analyzed in CL-57. Actual SAM from that analysis used for SAM review (The analysis included the appropriate spectral adjustment factors)

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-9	1-CL-74	1"	3-CL-69	HDPOC #11/#12/#13	M-362	H1	2": 1.5/1 1": 1.5/1 ¾": 1/1	2": 6/1 1": 1.5/1 ¾": 2/1	>1.0	N/C	EQ: HDPOC #11: EQ: HDPOC #12: EQ: HDPOC #13: The HDPOC are attached to the heater drain pumps which screen at .5 g HCLPF median value is .1.25	1.00	.4	(1) piping is all welded carbon steel, valves are all weld carbon steel, does contain THRD unions
CL-10	2-CL-67	2"	16-CL-67	GBDC #11/#12	M-362	H1	1.2/1	7/1	.99*1.25 = 1.24 (Freq < 2.5 HZ)	1.10	EQ: GBDC #11: EQ: GBDC #12: The GBDC screens at ..39 g HCLPF. Median capacity is 0.98g . Block wall capacity is 0.39g HCPLF. Median capacity .98	.98	.4	(1) All valves are THRD brass valves (2) The piping is attached to the 16" Pipe that was analyzed in CL-57. Actual SAM from that analysis used for SAM review (The analysis included the appropriate spectral adjustment factors) (3) Block wall SI evaluated.
CL-11		1½"	16-CL-67	RMHX	M-362	H1	1.5/1	8/1	1.03*1.25 = 1.29 (Freq < 2.5 HZ)	NC	EQ: RMHX: Screened at 0.5g HCLPF per NP-6041 Table 2-3 Block wall: .39g HCLPF. Median capacity is .98 (Same as CL-17)	0.98	.4	(1) Contains both welded steel and THRD brass valves. (2) There is a block wall above the piping and equipment.

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-12	24-CL-12	24"	Aux. Bldg. Wall	Cooling Water Exit of TB	M-362	H2	1/1	3/1	.>0.75 g	NC	None	>0.75	.4	This piping is welded steel piping with no valves and which has obvious seismic design. Based on the analysis conducted for CL-57 and the results of the evaluation of existing plant analyses for large bore in the CL system. This line is assigned g level of >.75g based on judgment. If questioned detailed analysis would bear out this number.
CL-13	10-CL-04 14-CL-110	5"/6"/ 10"/14"	GHC #11/#12	Cooling Water Exit Header	M-362	H2	1/1	6/1	5": 1.15 6": 0.597 10": 1.15 14": 1.15	NC	EQ: GHC #11: EQ: GHC #12: Screened at 0.5g HCLPF per NP-6041 Table 2-3. Median capacity is 1.25	0.597	.4	(1) Analysis was conducted for this piping system. (2) Fragility is controlled by 6" cast iron valves
CL-14		1½	RMHX	Cooling Water Exit Header	M-362	H1	1/1	3/1	>1.0	NC	EQ: RMHX: Screened at 0.5g HCLPF per NP-6041 Table 2-3 Block wall: .39g HCLPF (same as CL-17). Median capacity is .98g	0.98	.4	(1) All valves are welded but it does contain THRD unions (2) There is a block wall above the piping and equipment.

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-15	2-CL-275	¾"/2"	CPOC #11/#12/#13	24" Return Header	M-362	H1	2" SS 1/1 2" CS 1.5/1 ¾" CS1/1	2" SS 1/1 2" CS 3/1 ¾" CS1/1	2": 0.99	NC	EQ: CPOC #11: EQ: CPOC #12: EQ: CPOC #13: The condensate pumps are adequately anchored. Screened at .5g HCLPF. Median capacity 1.25g	0.99	.4	(1) All ¾' valves are welded steel and all 2" valves are THRD brass valves. (2) Also contains "glass" sight-glass in steel case. Judged as not controlling.
CL-16	1-CL-276	¾"/1/ 1-1/2"	HDPOC #11/12/13	24" Return Header	M362	H1	¾": 1.5/1 1": 1.5/1 1-½": 1.5/1	¾": 6/1 1": 6/1 1-½": 6/1	¾": 1.07 *1.25 = 1.33 1": 1.04*1.25 = 1.3 1-1/2" : 1.03*1.25 = 1.28	NC	EQ: HDPOC#11: EQ: HDPOC#12: EQ: HDPOC#13: The Heater Drain Pumps and the HDPOC are Screened at .5g HCLPF which is median value of 1.25 Median capacity for the spatial interaction with the cable tray is 0.20 g	0.20 g	.4	(1) all ¾" valves are welded and 1" and 1-1/2" valves are THRD brass valves (2) 1" and 1-1/2" pipe contains THRD unions (3) 1-1/2" pipe also contains "glass" sight-glass in steel case, judged as strong as a threaded brass valve. (4) This is a spatial interaction between the 1-1/2" Pipe and a cable tray bank that requires further review

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-17	2-CL-77	2"	GBDC #11/#12	24" Return Header	M-362	H1	1/1	1/1	.99	NC	EQ: GBDC #11: EQ: GBDC #12: Screened at .39g HCLPF. Median capacity is 0.98g Adjacent block walls pose interaction hazard – capacity =0.39g HCLPF. Median capacity is .98g	0.98	.4	All valves are THRD brass valves Governed by block wall capacity.
CL-18	3-CL-81	3"/2"	HSOUC #11/#12	24" Return Header	M-362	H1	1/1	2/1	3": .34 2": .99	NC	EQ: HSOUC#11: EQ: HSOUC#12: Screened at 0.5g HCLPF per NP-6041 Table 2-3. Median capacity is 1.25.	3": .34 2": .99	.4 .4	All 3" valves are CI and all 2" valves are THRD brass valves
CL-19	4-CL-86	4"/ 2-1/2""	GEC #11/#12	24" Return Header	M-362	H2	4": 1/1 2-1/2": 1.5/1	4": 3/1 2-1/2": 3/1	2-1/2": 0.606 4" : 2.53*1.54 = 3.9 (Freq < 2.5 HZ)	NC	EQ: GEC#11: EQ: GEC#12: Screening of GEC based on drawing review. Screened at .5 g. HCLPF. Median capacity is 1.25.	0.606	.4	(1) Screening of GEC based on drawing review. (2) All 2-1/2" valves are CI
CL-20	10-CL-68	10"/12"	TOROC #11/#12	24" Return Header	M362	H1	1/1	1/1	>1.25g	NC	EQ: TOROC#11: EQ: TOROC#12: Screened at 0.55g HCLPF. Median capacity is 1.38	>1.25	.4	Piping contains CI valves. Capacity based on comparison to unit 2 line which is essentially identical and was analyzed by PI (package 03P-XI-1)

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-21	2-CL-271	2"/1"	T(EH)FROC #11/#12	24" Return Header	M362	H1	1/1	5/1	.99*1.25 = 1.24 (Freq < 2.5 HZ)	NC	EQ: T(EH)FROC#11: EQ: T(EH)FROC#12: Screened at 0.5g HCLPF per NP-6041 Table 2-3. Medina capacity is 1.25	1.24	.4	(1) Portion of the piping on the 715' Level is 1" SS tubing (2) Contains THRD brass valves, THRD unions and compression fittings
CL-22	2-CL-110	2"	FWPOC #12	24" Return Header	M-362	H1	1/1	2/1	.99	0.75	EQ: FWPOC#12: Coolers are adequately anchored. Screened at .5g HCLPF. Median capacity is 1.25	0.75	.4	(1) Piping contains THRD brass valves and THRD unions
CL-23	¾ -CL-262	¾"	FWOSPC	3"-CL-110	M-362	H1	1/1	1/1	>1.0	0.6	EQ: FWOSPC: Coolers are adequately anchored. Screened at .5g HCLPF. Median capacity is 1.25. Controlling issue is spatial interaction which results in a median capacity of 0.10	0.10	.4	(1) Line is ¾" SS tubing with compression fittings (2) **OUTLIER** – has major Spatial interaction problem with conduit and other items.
CL-24	2-CL-110	2"	FWPOC #11	24" Return HDR	M-362	H1	1/1	2/1	.99	0.75	EQ: FWPOC#11: Coolers are adequately anchored and screened at 0.5g HCLPF. Median capacity is 1.25	0.75	.4	All valves are THRD brass valves and the pipe contains THRD unions

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-25	6-CL-111 3-CL-111 2-CL-111	2”	Station Air Branches	24” Return HDR	M-362	H1	6”: 1.1/1 3”: 1/1 3”: 1.5/1 2”: 1.5/1	6”: 3/1 3”: 3/1 3”: 5/1 2”: 5/1	6”: > 1.92 3”: > 1.92	NC	None	1.92	.4 .4 .4	(1) All 6” valves are CI, all 3” valves are welded steel
CL-26	4-2CL-137	4”	24” Supply HDR	#21 AFWP	M-362	H1	4”: 1.5/1 3”: 1.5/1	4”: 2/1 3”: 2/1	2.53	NC	EQ:AFWP#21: Screened at 0.5g HCLPF per NP-6041 Table 2-3. Median capacity is 1.25	1.25	.4	(1) Piping is all welded construction, including valves and has had obvious seismic design. (2) Part of the pipe is SS but screen on the basis that it is all CS
CL-27		4”	24” Supply HDR	Sprinkler System	M-362	H1	1/1	1/1	2.53	NC	None	2.53	.4	(1) Valve CW-15-5 is a welded steel valve. The remaining values are CI but are down stream of CW-15-5 which is normally closed. Therefore screen as welded steel pipe with weld steel valves (2) Pipe is full anchored past Check valve at the Turbine Bldg wall
CL-28	2-CL-111	2”	AFWP #11/#12	24” Return Header	M-362	H1	1/1	2/1	2.53	NC	EQ: AFWP#11: EQ: AFWP#12: Screened at 0.5g HCLPF per NP-6041 Table 2-3. Median capacity 1.25	1.25	.4	1) Piping is all welded construction, including valves and has had obvious seismic design. (2) Part of the pipe is SS but screen on the basis that it is all CS

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-55	6-CL-78	4"/6"	#11/#12 TRSP	24" Return Header	M-362	H1	6": 1.5/1	6": 6/1	6": 0.561	NC	EQ: TRSP #11: 0.5g HCLPF EQ: TRSP #12: 0.5g HCLPF Screened at 0.5g HCLPF per NP-6041 Table 2-3. Median capacity 1.25	0.561	.4	(1) Very small amount of 4" pipe line is basically all 6" pipe (2) All 6" valves are CI (3) There are 3 attached lines to the Steam Generator Blowdown system that are out of scope. The only in scope branch is evaluated in CL-55a
CL-55a		2"/3"	6-CL-78	#11 TBSCS/RM (162-081)	M-362	H1	1/1	2/1	>1.00	NC	None	>1.00	.4	(1) 2" Piping is not shown on PID but was found in the field. (2) Valve CV-39085 normally closed therefore the piping integrity is only required to this valve (per PRA guys) (3) Pipe is all threaded fittings and valves are all THRD brass valves.

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-57	16-CL-67		24” Supply HDR	#11/#12 GHC, #11/#12 GEC, #11 HSOCU	M362	H2	N/A	N/A	16”: >1.5 14”: 0.613 6”: 0.40 5”: >0.8 4”: >1.5 3”:0.221 2-1/2”:0.318 2”: 1.00	NC	EQ: GHC#11: EQ: GHC#12: EQ: GEC#11: EQ: GEC#12: EQ: HSOCU#11: Screened at 0.5g HCLPF per NP-6041 Table 2-3. Median capacity 1.25	16”: 1.26 14”: 0.613 6”: 0.40 5”: >0.8 4”: >1.26 3”:0.221 2-1/2”:0.318 2”: 1.0	.4 .4 .4 .4 .4 .4	(1) Fragilities for 2-1/2”, 3”, 6” and 14” pipe are controlled by cast iron valves. (2) Fragilities for 2” pipe are controlled by threaded brass valves (3) The fragilities of the 4” and 16” pipe are controlled by steel pipe. (4) Results are based on detailed linear elastic analysis
ZX-7	16-ZX-127	16”	18-CL-67	Pipe Cap	MZX1	H1	695’: 1/1 715’: 1/1	695’: 3/1 715’: 10/1	.99* 1.25 = 1.24 (Freq < 2.5 Hz)	NC	(1) Block Wall (A10): (2) Block Wall (A12): Both block walls have a capacity of 0.29g HCLPF. Median capacity .73	0.73	.4	(1) Pipe is assume to be CS (2) Pipe runs next to two block walls on the 715 Elevation; one at CL A-10 and one from CL A-12 to A-14

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
ZL-1		1"	Svc Bldg Lunch Room /AC	6-CL-98	M362	H1	1.5/1	5/1	1.04*1.25 = 1.30 (Freq < 2.5 HZ)	NC	(1) Elev. Block Wall: .35g HCLPF (2) Men's LR Block Wall: .35g HCLPF Median capacity is .875. (Block wall is remote from isolation valve therefore does not control.)	1.30	.4	(1) Pipe first appears between 735' and 715' in the men's locker room. (near column line G3) It then runs thru the floor on 715' and ties into the 6" pipe at about elevation 708' (2) Pipe runs beside block wall that is the elevator shaft from 708' to 715' (near column line G3) and then the block wall that is the men's locker room from 715'+ (3) Pipe is all THRD steel fittings and THRD brass valves

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
ZL-2	6-CL-98	6”	HVAC Return Line	24” Return HDR	unknown	H1		10/1	0.85	NC	(1) Elev. Block Wall: .35g HCLPF and a median value of .875g (2) Men’s LR Block Wall: .35g HCLPF and a median value of .875g	0.85	N/A	(1) This is a 6” roof drain line that runs thru the floor on 715’ and ties into the 24” Header pipe at about elevation 708’ (near column line G3) (2) Pipe runs beside block wall that is the elevator shaft from 708’ to 715’ and then the block wall that is the men’s locker room from 715’ to 735’ (near column line G3) (3) Pipe is all Victaulic Fittings .

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
ZL-3		1”	2-CL-74	SVC Building Lunch Room AC	M362	H1	1.5/1 to 2/1	8/1	N/A	NC	(1) Elev. Block Wall: .35g HCLPF (2) Men’s LR Block Wall: .35g HCLPF Block wall capacity is 0.35g HCLPF. Median capacity .875	N/A	N/A	(1) Pipe first appears between 735’ and 715’ in the men’s locker room. (near column line G3) It then runs thru the floor on 715’ and ties into the 6” pipe at about elevation 708’ (2) Pipe runs beside block wall that is the elevator shaft from 708’ to 715’ (near column line G3) and then the block wall that is the men’s locker room from 715+ (3) pipe eventually ties into line 2-CL-74 (4) Pipe welded construction with THRD unions and THRD brass valves (5) Actual Cooling Unit cannot be found. Based on discussions of Plant personal this unit was removed from service in the past. Pipe is valved off at the header. Since this is the return line it does not contribute as there is not flow.

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
HS-1	HS-15-2	1-1/2"/3/4"	121 Heating Boiler	30" Return Stanchion (U1)	M-362	H1	1/1	5/1	2.53*1.25 = 3.1	NC	EQ: 121 Heating Boiler: 0.5g HCLPF. Median capacity is 1.25	1.25	0.4	(1) The piping is all welded construction and all the valves are welded steel. (2) HCLPF of boiler is set equal to commencement of sliding.
01P-III-1	24-CL-20	20	NP 292	NP-252	M362		N/A	N/A	> 1.25	NC	None	>1.25	0.4	Taken from existing PI Analysis
01P-VIII-1	30-CL-20	30	Turbine Bldg Wall	NP 452	M362		N/A	N/A	> 1.25	NC	None	>1.25	0.4	Determined using the existing PI Analysis
01P-VIII-2	24-CL-67	24	NP 452	CWH-93	M362		N/A	N/A	> 1.25	NC	None	>1.25	0.4	Determined using the existing PI Analysis
01P-VIII-4	18-CL-67	18	NP 410	NP 3025	M362		N/A	N/A	> 1.25	NC	Safety-related block wall #3 at 0.29g HCLPF. Median capacity is 0.73	0.73	0.4	(1) Determined using the existing PI Analysis (2) Piping runs thru Safety Related Block Wall #3 which controls capacity
01P-VIII-3	12-CL-12	12	NP 410	NP 2072 & 2059	M362		N/A	N/A	> 1.25	NC	EQ: #11TOROC: EQ: #12TOROC: Anchorage capacity governs at 0.55g HCLPF with a median capacity of 1.38g	>1.25	0.4	Taken from existing PI Analysis
CL-58	8-CL-97	8	Roof Drain	24" Return HDR (U1)	Unknown	H1/H3	1/1	1/1 and 3/1	.7g	NC	None	0.7	0.4	Pipe contains Victaulic fittings but is well support and screening based on the consideration of Victaulic fittings

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	

Notes:
NC = Not controlling
NA = Not Applicable to Determination

Table for NF-39217-1, NF-39222, and NF-39223

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-32	4-CL-90	4”	24” Supply HDR	AFWP #12	M362	H1	1.5/1	1.5/1	2.53	NC	EQ:AFWP#12 Screened at 0.5g HCLPF per NP-6041 Table 2-3. Median Valve is 1.25	1.25	.4	(1) Piping is all welded construction, including valves and has had obvious seismic design. (2) Part of the pipe is SS but screened on the basis that it is all CS
CL-33	4-2AF-1	4”	24” Supply HDR	AFWP #22	M362	H1	1.5/1	1.5/1	2.53	NC	EQ:AFWP#22 Screened at 0.5g HCLPF per NP-6041 Table 2-3. Median Valve is 1.25	1.25	.4	(1) Piping is all welded construction, including valves and has had obvious seismic design. (2) Part of the pipe is SS but screened on the basis that it is all CS
CL-34	4-2CL-11	4”	24” Supply HDR	TOROC Supply Line	M362	H1	1/1	2/1	3.04	N/C	None	3.04	.4	(1) piping contains CI valves which controls fragility
CL-35	2-2CL-211	2”	TOROC Supply Line	TOROC Supply Line	M362	H1	1/1	1/1	0.99	N/C	None	0.99	.4	(1) Pipe is welded steel and contains threaded brass valves which controls fragility
CL-36	3-2CL-14	3”/2”	TOROC Supply Line	FWPOC #21/#22	M362	H1	1/1	10/1	2”:0.99 *1.25 = 1.24 3”:0.34*1.25 = .43 (Freq <2.5 HZ)	N/C	EQ: FWPOC #21: EQ: FWPOC #22: Screened at .5 g HCLPF Median value is 1.25g	2”: 1.24 3”: 0.43	.4	(1) 3” pipe contains Cast Iron valves (2) 2: “ pipe contains threaded brass valves and threaded unions, the valves control.

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-37	¾ -2CL-144	¾”	3-2CL-14	FWOSPC	M362	H1	1/1	1/1	>1.0	0.1	EQ: FWOSPC: Screened at 0.5g per NP-6041 Table 2-3. Median Valve is 1.25	0.1	.4	(1) This is ¾” SS Tubing with Swagelok fittings. (2) Rides on a 3” pipe with spans of 10/1 to 14/1 and has a short run from last pipe attachment to panel. This is the controlling fragility and was assigned a value of .1g
CL-38	1½-2CL-18	1½”/1”/¾”	2-2CL-14	HDPOC #21/#22/#23	M362	H1	¾”: 1/1 1”: 1/1 1-1/2”: 1/1	¾”: 3/1 1”: 4/1 1-1/2”: 2/1	¾”: 1.07*1.25 = 1.34 1”: 1.06*1.25 = 1.32 1-1/2”: 1.03	N/C	EQ: HDPOC #21: EQ: HDPOC #22: EQ: HDPOC #23: The HDPOC are attached to the heater drain pumps which screen at .5 g HCLPF median value is 1.25	¾”: 1.25 1”: 1.25 1-1/2”: 1.03	.4	(1) 1-1/2” pipe contains brass threaded valves and threaded unions valves will control (2) 1” and ¾” pipe is all welded steel including valves and fittings does have some threaded unions
CL-39	2-2CL-15	2”/¾”	18-2CL-9	T(EH)FROC #21	M362	H1	¾: 1/1 2”: 1/1	¾: 1/1 2”: 4/1	¾: 1.07 2”: .99*1.25 = 1.24 (Freq <2.5 HZ)	N/C	EQ:T(EH)FROC: Screened at 0.5g HCPLF per NP-6041 Table 2-3. Median Value is 1.25	¾”: 1.07 1”: 1.24	.4	Pipe contains threaded brass valves and threaded unions
CL-40	1½-2CL-17	1½”	16-2CL-9	CPOC #21/#22/#23	M362	H1	¾”: 1.5/1 1”: 1.5/1 1-1/2”: 1.5/1	¾”: 3/1 1”: 3/1 1-1/2”: 3/1	¾: 1.07*1.25 = 1.33 1”: 1.04*1.25 = 1.3 1-1/2”: 1.03*1.25 = 1.29 (Freq < 2.5 Hz)	>1.0	EQ: CPOC #21: EQ: CPOC #22: EQ: CPOC #23: Condensate pumps are adequately anchored. Screened at .5 g HCLPF. Median value is 1.25	>1.00	.4	(1) All sizes of pipe contain threaded brass valves and threaded unions (2) SAMs based on using CL-57 results as input

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-41	2-2CL-9	2"	16-2CL-9	GBDC #21/#22	M362	H1	1/1	1/1 and 5/1	0.99	>1.0	EQ: GBDC #21: EQ: GBDC #22: The GBDC screens at .39 g HCLPF therefore the median value is 0.98 g . Block wall capacity is 0.39g HCPLF. Median capacity .98	0.98	.4	(1) there are flexible joints at the equipment but both ends of the joints are well supported and the equipment is well support therefore not a concern based on judgment (2) Pipe contains threaded brass valves (3) Adjacent block wall governs capacity. (4) SAMs based on using CL-57 results as input
CL-42	24-2CL-56	24"/30"	Aux Bldg Wall	Cooling Water Discharge	M362	H2	1/1	2/1	.>0.75	NC	Block Wall: Block wall is short (10' High) and the block wall is prevented from interacting with the standpipe by a structural bracing member. Therefore, the block wall is screened out and is not a concern	> 0.75	.4	This piping is welded steel piping with no valves and which has obvious seismic II/I design. Based on the analysis conducted for CL-57 and the result of the evaluation of existing plant analyses for large bore in the CL system. This line is assigned g level of >..75g based on judgment. Detailed analysis would bear out this number. (2) There is a block wall above the Standpipe that is reviewed

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-43	4-2CL-56	4”/2½”	GEC #21; #22	24” Return HDR (U2)	M362	H2	1/1	2/1	0.606	0.606	EQ: GEC#21: EQ: GEC#22: Screening of GHC based on drawing review. Screened at .5 g. HCLPF. Median capacity is 1.25.	0.67	.4	(1) 2-1/2” Pipe contains cast iron valves (2) Header pipe displacement controls SAM value and was evaluated and shown to be 0.606 g
CL-44	14-2CL-56	5”/6”/10”/14”	GHC #22; #21	24” Return HDR (U2)	M362	H2	1/1	2/1 & 3/1	5”: 1.15 6”: .597 10”: 1.15 14”: 1.15	NC	EQ: GHC#21: EQ: GHC#22: Screening of GHC based on drawing review. Screened at .5 g. HCLPF. Median capacity is 1.25	5”: 1.15 6”: .597 10”: 1.15 14”: 1.15	.4	(1) 6” pipe contains cast iron valves and S type Victaulic couplings (2) Valves on 10” and 14” pipes are steel and welded (3) Fragility is controlled by cast iron valves (4) Similar to CL-13 and results from that analysis are applied here.

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-45	2-2CL-54	2"	GBDC #21/#22	24" Return HDR (U2)	M362	H1	1/1	1/1 & 3/1	.99	N/C	EQ: GBDC #21: EQ: GBDC #22: The GBDC screens at .39 g HCLPF, therefore the median value is 0.98 g . Block wall capacity is 0.39g HCPLF. Median capacity .98g	0.98	.4	(1) there are flexible joints at the equipment but both ends of the joints are well supported and the equipment as well support therefore not a concern based on judgment (2) Pipe contains threaded brass valves and threaded unions. (4) Pipe has threaded connections to the unit (3) Adjacent block wall was evaluated.
CL-46	2-2CL-130	2"/ 1½" / ¾"	CPOC #21/#22/#23	24" Return HDR (U2)	M362	H	¾: 1/1 1": 1/1 2": 1/1	3/4": 1/1 1": 3/1 2": 1/1 & 5/1	¾": 1.07 1": 1.04 2": .99	N/C	EQ: CPOC #21: EQ: CPOC #22: EQ: CPOC #23: Condensate pumps are adequately anchored. Screened at .5 g HCLPF. Median value is 1.25 Worst Case Support > 1.25	¾": 1.07 1": 1.04 2": .99	.4	(1) ¾" and 1" pipe is all welded construction but does contain threaded unions. (2) 2" pipe contains threaded brass valves (3) Also contains "glass" sight-glass in steel case. Judged as not controlling. (4) Poor designed support was reviewed and found to have more than adequate capacity and would not control the fragility.

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-47	1½-2CL-131	¾" /1"/ 1½"	HDPOC #21/#22/#23	24" Return HDR (U2)	M362	H1	¾": 1/1 1": 1/1 1-1/2": 1/1	¾": 2/1 1": 3/1 1-1/2": 4/1	¾: 1.07 1": 1.04 1-1/2: 1.03	PP: .05 HDR: 0.9	EQ: HDPOC #21: EQ: HDPOC #22: EQ: HDPOC #23: The HDPOC are attached to the heater drain pumps which screen at .5 g HCLPF median value is 1.25	.05	.4	(1) In the pump pit the 1" piping is cross supported to pipe that are cross support to other pipes that in some cases are rigidly support and in some cases are not. Pipe will receive multiple conflicting SAM inputs. Therefore, use and initial SAM fragility of .05g. Higher vale may be possible if in depth review is conducted. (2) ¾" and 1" pipe in pump pit is all welded steel construction but does contain threaded unions (3) 1-1/2" pipe contains threaded brass valves and unions (4) Also possible SAM issue at the header pipe (5) Also contains "glass" sight-glass in steel case. Judged as not controlling.
CL-48	2-2CL-56	2"	FWPOC #22	24" Return HDR (U2)	M362	H1	1/1	2/1	.99	N/C	EQ: FWPOC #22: Screened at .5 g HCLPF Median value is 1.25g	0.99	.4	Pipe contains threaded brass valves and unions

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-49	2-2CL-56	2"	FWPOC #21	24" Return HDR (U2)	M362	H1	1/1	2/1	.99	N/C	EQ: FWPOC #21: Screened at .5 g HCLPF Median value is 1.25g	0.99	.4	Pipe contains threaded brass valves and unions
CL-50	2-2CL-50	2" /1"/ ¾"	T(EH) FROC #21	24" Return HDR (U2)	M362	H1	1/1	1/1 & 15/1	¾: 1.07 1": 1.04 2": .99	N/C	EQ:T(EH)FROC: Screened at 0.5g HCPLF per NP-6041 Table 2-3. Median Value is 1.25	.99	.4	(1) ¾" and 1" pipe has threaded valves and unions by the equipment (2) the 2" valve in this piping system is flanged steel. Conservatively use Threaded brass to account for flanges
CL-51	¾ -2CL-145	¾"	FWOSPC	24" Return HDR (U2)	M362	H1	1/1	1/1	N/C	N/C	EQ: FWOSPC: Screened at 0.5g per NP-6041 Table 2-3. Median Valve is 1.25 Fire Protection System SI: 0.35	.35	.4	(1) This is ¾" tubing that is well support on Unistrut supports directly to the in place steel. (2) Header SAMs would be small and the tubing has adequate flexibility to accept the SAMs (3) There is a 1-1/2" Fire Protection sprinkler system that runs above the tubing. It is threaded construction with cast iron fittings and the piping is poorly supported.

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-52	3-2CL-56	3"/2"	HSOUC #21	24" Return HDR (U2)	M362	H1	1/1	2/1	3": 0.34 2": .99	.35	EQ: HSOCU#21: Screened at 0.5g HCLPF per NP-6041 Table 2-3. Median capacity 1.25	0.34	.4	(1) 3" pipe contains cast Iron valves (2) 2" pipe has threaded brass valves (3) simplified SAM screening was conducted.
CL-53	2-CL-112	2"	AFWP #21	24" Return HDR (U2)	M362	H1	1.5/1	1.5/1	2.53	NC	EQ:AFWP#21 Screened at 0.5g HCLPF per NP-6041 Table 2-3. Median Valve is 1.25	1.25	.4	(1) Piping is all welded construction, including valves and has had obvious seismic design. (2) Part of the pipe is SS but screened on the basis that it is all CS
CL-54	16-2CL-09	16"/10"/ 6"/3"/2"	Anchor at 3110	GHC #21/#22 GEC #21/#22 HSOUC #21	M362	H2	N/A	N/A	16": >1.5 14": 0.613 6": 0.40 5": >0.8 4": >1.5 3":0.221 2-1/2":0.318 2": 1.0	N/C	EQ: GHC#21: EQ: GHC#22: EQ: GEC#21: EQ: GEC#22: EQ: HSOCU#21: Screened at 0.5g HCLPF per NP-6041 Table 2-3. Median capacity 1.25	16": 1.25 14": 0.613 6": 0.40 5": >0.8 4": >1.25 3":0.221 2-1/2":0.318 2": 1.0	.4	(1) This line is very similar in routing to CL-57. The fragilities for this line are based on the fragilities for CL-57 (2) CL-57 was evaluated by analysis.
CL-56	6-2CL-51	4"/6"	TRSP #21/#22	24" Return HDR (U2)	M362	H1	4: 1/1 6: 1/1	4": 1/1 6": 7/1	0.561 g	N/C	EQ: TRSP #21: 0.66g HCLPF EQ: TRSP #22: 0.66g HCLPF therefore the median capacity is 1.65	0.561 g	.4	(1) 4" pipe contains Cast Iron valves by the Sump Pumps (2) 6" pipe contains Cast Iron Valves (3) Attaches to 24" return header by lateral strut support and therefore, no SAM concerns

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-56a	N/A	2”	6-2CL-51	Thru CV 39080	M362	H1	N/A	N/A	1.0	N/C	None	1.0	.4	1) 2” Piping is not shown on PID but was found in the field. (2) Valve CV-39085 normally closed therefore the piping integrity is only required to this valve (per PRA guys) (3) Pipe is all threaded fittings and valves are all THRD brass valves.
01P-II-1	24-CL-23	24”/30”	Turbine Bldg Wall	NP 80	M362	H1	N/A	N/A	> 1.25	NC	None	>1.25	0.4	Determined using the existing PI Analysis
01P-VIII-4	18-2CL-9	18”	NP 3025	Unit #1 (NP 410)	M362	H1	N/A	N/A	> 1.25	NC	None	>1.25	0.4	Determined using the existing PI Analysis
01P-VIII-5	12-2CL-9	12”	NP 3025	NP 3380 & NP 3425	M362	H1	N/A	N/A	> 1.25	NC	EQ: #21TOROC: EQ: #22TOROC: Anchorage capacity governs at 0.66g HCLPF with a median capacity of 1.6 g	>1.25	0.4	Determined using the existing PI Analysis
01P-VIII-7	30-CL-23	30”	NP 80	NP 2	M362	H1	N/A	N/A	> 1.25	NC	None	>1.25	0.4	Determined using the existing PI Analysis
01P-VIII-6	16-2CL-9	16”	NP-32	NP-3110	M362	H1	N/A	N/A	> 1.25	NC	None	>1.25	0.4	Determined using the existing PI Analysis
03P-XI-1	24-2CL-56 12-2CL-56	24” 12”	Aux Bldg Wall TOROC	IIB/III Boundary 24-2CL-24	M362	H1	N/A	N/A	> 0.75g	NC	EQ: #21TOROC: EQ: #22TOROC: Anchorage capacity governs at 0.66g HCLPF with a median capacity of 1.6 g	>1.25	.4	Determined using the existing PI Analysis

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-59	6-2CL-56	8"	Roof Drain	24" Return Header (U2)	Unknown	H1/H3	1/1	1/1 and 3/1	0.70	NC	None	0.70	0.4	This line is essentially identical to the Unit 1 line and capacities are based on the Unit 1 review.
CL-60	6-2CL-57	6"	Roof Drain	24" Return Header	Unknown	H1	1/1	1/1 and 3/1	0.80	NC	None	0.80	.4	

Notes:
NC = Not controlling
NA = Not Applicable to Determination

Table for NF-39220

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CD-1	6”-CD-12 4”-CD-42 2”-CD-34	6”/4”/2”	CD Pump Discharge Pipe 18-CD-2	24” Service Water HDR (U2)	M-354	H2	6”: 1/1 2”: 1/1	6” :6 /1 2”: 6/1	.74*1.54 =1.14 (Freq < 2.5 HZ)	6”: .35 4”: NC 2”: NC	none	6”: 0.35 4”: 1.14 2”: 1.14	.4 .4 .4	(1) pipe and valves are all weld CS (2) piping has had a Seismic II/I design (3) 2” pipe branches from 6” pipe at lateral & vertical support , therefore, no SAM concerns (4) 6” line branches from RH 18” pipe. Simplified span review used to get SAMs.

Notes:
NC = Not controlling

Table for NF-39221

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CD-2	6-2CD-12	6”	18-2CD-2	24” Return HDR (U2)	M-354	H2	1/1	12/1	.74*1.54 =1.14 (Freq < 2.5 HZ)	6”: 0.45 4”: NC	None	6”: 0.45 4”: 1.14	.4 .4	(1) pipe and valves are all weld CS (2) piping has had limited Seismic II/I design (3) 6” line branches from RH 18”. Simplified review used to get SAM capacity.
CD-3	2-2CD-40	2”	6-2CD-12	Valve 2CD-74-1	M-354	H1	1/1	3/1	.91*1.25 =1.14 (Freq < 2.5 HZ)	0.48	None	0.48	.4	(1) pipe and valves are all weld CS (2) 2” line branches from CD-2 pipe. Simplified review used to get SAM capacity.

Notes:
NC = Not controlling

Table for NF-39242

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
RM-1	3-2RM-10	3	21/22 RMUWST	Demineralizer Tank	M380	H1	1/1	(1) BT: 8/1 (2) 715': 1/1	1.30	2-1/2": > 2.65 2": > 2.65 3": 0.79	EQ: #21RMUWST: EQ: #22 RMUWST: Tank Capacities: 100% full: 0.40g HCLPF. Median Value is 1.0 75% full: 0.55g HCLPF. Median value is 1.38	0.79	.4	(1) Piping runs a long distance; review was conducted to above the 715' elevation so that the pipe could not Siphon the RMUSTs. Therefore, it was not reviewed to the Demineralizer. Tank. (2) Piping is all welded construction and is SS (3) Four Branch Lines that were reviewed for possible SAM issues using simplified SAM Review. (4) Piping near unanchored tank has flex leg of 8' check against anticipated Tank movements. Tank slip is defined as failure therefore not a concern.

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
RM-2	6-2RM-2	6	21/22 RMUWST	RMUP (U2)	M380	H1	1/1	1/1	.59	NC	EQ: #21RMUWST: EQ: #22 RMUWST: EQ: #21 RMUP: EQ: #22 RMUP: Tank Capacities: 100% full: 0.40g HCLPF. Median value is 1.0 75% full: 0.55g HCLPF. Median value is 1.38 Pumps screened at 0.5g HCLPF per EPRI Table 2-3 Median value is 1.25	.59	.4	(1) Pipe is all welded construction and is SS (2) Very short stiff run to tanks, therefore when tank moves nozzle will pull out the tank wall. Therefore, Tank controls Fragility. Tank slip is defined as failure therefore not a concern.
RM-3	3-RM-10	3	11/12 RMUWST	Demineralizer Tank	M380	H1	1/1	(1) BT: 4/1 (2) 715' EL: 1/1	1.30	>1.0	EQ: #11RMUWST: EQ: #12 RMUWST: Tank Capacities: 100% full: 0.40g HCLPF. Median value 1 is 1.0 75% full: 0.55g HCLPF. Median value is 1.38	1.00	.4	(1) Piping runs a long distance; review was conducted to above the 715' elevation so that the pipe could not Siphon the RMUSTs. Therefore, it was not reviewed to the Demineralizer. Tank. (2) Piping is all welded construction and is SS (3) two Branch Lines that were review for possible SAM issues. (4) Piping near unanchored tank has flex leg of 8' check against anticipated Tank movements. Tank slip is defined as failure therefore not a concern.

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
RM-4	4-RM-2	4	21/22 RMUWST	RWMP (U1)	M380	H1	1/1	1/1	.59	NC	EQ: #11RMUWST: EQ: #12 RMUWST: EQ: #11 RMUP: EQ: #12 RMUP: Tank Capacities: 100% full: 0.40g HCLPF median value is 1.0. 75% full: 0.55g HCLPF. Median value is 1.38 Pumps screened at 0.5g HCLPF per EPRI Table 2-3. median values is 1.25	.59	.4	(1) Pipe is all welded construction and is SS (2) Very short stiff run to tanks, therefore when tank moves nozzle will pull out the tank wall. Therefore, Tank controls HCLPF. Tank slip is defined as failure therefore not a concern.

Notes:
NC = Not controlling

Table for NF-39244

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-29(a)	1½-CL-96	1-1/2", 1", ¾"	Station Air Supply Line	Station Air Return Line	M-362	H1	1.5/1	3/1	1.03	NC	EQ: (#121) SAAC: EQ: (#121) SAC: Screened at 0.5g HCLPF per EPRI Table 2-3. Median Value is 1.25.	1.03	.4	(1) All valves, all sizes are THRD brass valves (2) 1-1/2" pipe contains THRD brass "glass" flow indicator. Judged to have as much capacity as a brass valve. (3) 3/4" pipe contains THRD brass "glass" flow indicator. Judged to have as much capacity as a brass valve. (4) ¾" pipe is all THRD fittings and includes CI fittings at some locations (5) 1-1/2" piping is welded construction but contains THRD unions

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-29(b)	1½-CL-111	1-1/2", 1", ¾"	Station Air Supply Line	Station Air Return Line	M-362	H1	1.5/1	3/1	1.03	NC	EQ: (#121) SAAC EQ: (#121) SAC: Screened at 0.5g HCLPF per EPRI Table 2-3. Median Value is 1.25.	1.03	.4	(1) All valves, all sizes are THRD brass valves (2) 1-1/2" pipe contains THRD brass "glass" flow indicator. Judged to have as much capacity as a brass valve. (3) 3/4" pipe contains THRD brass "glass" flow indicator. . Judged to have as much capacity as a brass valve. (4) ¾" pipe is all THRD fittings and includes CI fittings at some locations (5) 1-1/2" piping is welded construction but contains THRD unions

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-30(a)	1½-CL-96	1-1/2", 1", ¾"	Station Air Supply Line	Station Air Return Line	M-362	H1	1.5/1	4/1	1.03	NC	EQ: (#122) SAAC: EQ: (#122) SAC: Block Wall #8 capacity is 0.29g HCLPF. Median value is .73g Pumps and compressors screened at 0.5g HCLPF per EPRI Table 2-3. Median Value is 1.25.	0.73	0.4	(1) All valves, all sizes are THRD brass valves (2) 1-1/2" pipe contains THRD brass "glass" flow indicator. Judged to have as much capacity as a brass valve. (3) 3/4" pipe contains THRD brass "glass" flow indicator. . Judged to have as much capacity as a brass valve. (4) ¾" pipe is all THRD fittings and includes CI fittings at some locations (5) 1-1/2" piping is welded construction but contains THRD unions (6) Block wall by compressor and piping, called "Safety Related Block Wall #8"

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-30(b)	1½-CL-111	1-1/2", 1", ¾"	Station Air Supply Line	Station Air Return Line	M-362	H1	1.5/1	4/1	1.03	NC	EQ: (#122) SAAC EQ: (#122) SAC Block Wall #8 capacity is 0.29g HCLPF. Median value is .73g. Pumps and compressors screened at 0.5g HCLPF per EPRI Table 2-3. Median Value is 1.25.	0.73	0.4	(1) All valves, all sizes are THRD brass valves (2) 1-1/2" pipe contains THRD brass "glass" flow indicator (3) 3/4" pipe contains THRD brass "glass" flow indicator. Judged to have as much capacity as a brass valve. Judged to have as much capacity as a brass valve. (4) ¾" pipe is all THRD fittings and includes CI fittings at some locations (5) 1-1/2" piping is welded construction but contains THRD unions (6) Block wall by compressor and piping, called "Safety Related Block Wall #8"

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-31(a)	1½-CL-96	1-1/2”, 1”, ¾”	Station Air Supply Line	Station Air Return Line	M-362	H1	1.5/1	3/1	1.03	NC	EQ: (#123) SAAC EQ: (#123) SAC Block Wall #8 capacity is 0.29g. Median value is .73g Pumps and compressors screened at 0.5g HCLPF per EPRI Table 2-3. Median Value is 1.25.	0.73	.4	(1) All valves, all sizes are THRD brass valves (2) 1-1/2” pipe contains THRD brass “glass” flow indicator (2) 3/4” pipe contains THRD brass “glass” flow indicator. . Judged to have as much capacity as a brass valve. (3) ¾” pipe is all THRD fittings and includes CI fittings at some locations (4) 1-1/2” piping is welded construction but contains THRD unions (5) Block wall by compressor and piping, called “Safety Related Block Wall #8”

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CL-31(b)	1½-CL-111	1-1/2", 1", ¾"	Station Air Supply Line	Station Air Return Line	M-362	H1	1.5/1	4/1	1.03	NC	EQ: (#123) SAAC EQ: (#123) SAC Block Wall #8 capacity is 0.29g HCLPF median value is .73g. Pumps and compressors screened at 0.5g HCLPF per EPRI Table 2-3. Median Value is 1.25.	0.73	0.4	(1) All valves, all sizes are THRD brass valves (2) 1-1/2" pipe contains THRD brass "glass" flow indicator (2) 3/4" pipe contains THRD brass "glass" flow indicator. . Judged to have as much capacity as a brass valve. (3) ¾" pipe is all THRD fittings and includes CI fittings at some locations (4) 1-1/2" piping is welded construction but contains THRD unions (5) Block wall by compressor and piping, called "Safety Related Block Wall #8"

Notes:
NC = Not controlling

Table for NF-39253-1

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CP-1	4-2CP-20	4"	Valve 2CP-52-1	#21 BWST (U2)	M380	H2	1/1	NT: 2/1 RT: 6/1	.34	NC	EQ: (#21)BWST Tank capacity = 0.60g HCLPF. Median capacity is 1.5	.34	.4	(1) This is a very long run of piping to get to CHK valve 2CP-52-1
CP-2	6-2CP-6	6"	#21 BWST (U2)	BWSP (U2)	M380	H1	1/1	2/1	>1.0	NC	EQ: (#21)BWST: EQ: (#21)BWSP: EQ: (#21)BWSP: Tank capacity = 0.6g HCLPF. Median capacity is 1.5 Pumps are screened at 0.5g HCLPF per EPRI NP-6041 screening tables. Median capacity is 1.26	>1.0	.4	(1) Piping is all welded steel construction.
CP-3	4-CP-20	4"	Valve CP-52-1	#11 BWST(U1)	M380	H2	1/1	NT: 2/1 RT: 3/1	.34	NC	EQ: (#11)BWST SI: FP Pipe Tank capacity = 0.6g HCLPF. Median capacity is 1.5 Fire protection Spatial interaction: .11g (Freq < 2.0 Hz double the value .22)	.22	.4	(1) This is a very short run of piping to get to CHK valve CP-52-1 (2) There is an 8" THRD and Victaulic FP Protection Header that is directly above this piping. Screened based on the fire protection system capacity in this location.

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CP-4	6-CP-5	6”	#11 BWST	BWSP (U1)	M380	H1	1/1	2/1	>1.0	NC	EQ: (#11)BWST: EQ: (#11)BWSP: EQ: (#11)BWSP: Tank capacity = 0.6g HCLPF Median capacity is 1.5. Pumps are screened at 0.5g HCLPF per EPRI NP-6041 screening tables. Median capacity is 1.25	>1.0	.4	(1) Piping is all welded steel construction.
CP-5	4-CP-11	4”	#11 BWRT	BWTP (U1)	M380	H1	1/1	3/1	.95*1.25 =1.19 (Freq < 2.5 HZ)	NC	EQ: (#11)BWRT: EQ: (#11)BWTP: EQ: (#11)BWTP: Tank capacity >> 0.5g HCLPF Median capacity is >1.25 Pumps are screened at 0.5g HCLPF per EPRI NP-6041 screening tables. Median capacity is 1.25	1.19	.4	(1) Pipe and valves are all welded steel

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CP-6	4-2CP-12	4”	#21 BWRT	BWTP (U2)	M380	H1	1/1	3/1	.95*1.25 =1.19 (Freq < 2.5 HZ)	NC	EQ: (#21)BWRT: EQ: (#21)BWTP: EQ: (#21)BWTP: Tank capacity >> 0.5g HCLPF Median capacity is greater than 1.25 Pumps are screened at 0.5g HCLPF per EPRI NP-6041 screening tables. Median capacity is 1.25	1.19	.4	(1) Pipe and valves are all welded steel

Notes:
NC = Not controlling

Table NF-39353-3

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
CP-7	2-CP-81	¾”, 1-1/4”, 1-1/2”, 2”	24” Supply HDR (U2)	#124/#125 SAAC	M362	H1	1/1	1/1 & 4/1	¾”: 1.09 1-1/4”: 1.03 1-1/2”: 1.03 2”: .99	NC	SAAC #124/#125 screen at .5g HCLPF which is 1.25 median	0.99	.4	1. All piping is welded or threaded fittings. 2. Valves are threaded brass. 3. Supports are well constructed.
CP-8	1-CP-45	¾”, 1”	2-CP-81	#124 SAC	M362	H1	1/1	1/1 & 3/1	¾”: 1.09 1”: 1.04	NC	SAC #124 screen at .5g HCLPF which is 1.25 median	1.04	.4	1. All piping is welded or threaded fittings. 2. Valves are threaded brass. 3. Supports are well constructed.
CP-9	1-CP-45	¾”, 1”	2-CP-81	#125 SAC	M362	H1	1/1	1/1 & 3/1	¾”: 1.09 1”: 1.04	NC	SAC #125 screen at .5g HCLPF which is 1.25 median	1.04	.4	1. All piping is welded or threaded fittings. 2. Valves are threaded brass. 3. Supports are well constructed.
CP-10	1-1/2-CP-82	1”, 1-1/4”, 1-1/2”, 2”	#124/#125 SAAC	24” Return HDR (U2)	M362	H1	1/1	1/1, 4/1, 8/1	1”: 1.04 1-1/4”: 1.03 1-1/2”: 1.03 2”: .99	NC	SAAC #124/#125 screen at .5g HCLPF which is 1.25 median	.99	.4	1. All piping is welded or threaded fittings. 2. Valves are threaded brass. 3. Supports are well constructed.

Package No.	**Line No.**	**Pipe Size**	**From**	**To**	**Matl Spec**	**Spect.**	**Span Ratio**		**Fragilities – Median Capacity (g-PGA)**					**Notes**
							Vert.	**Lat.**	**Inert.**	**SAM**	**Other**	**Control**	**β_C**	
CP-11	3-CP-55	¾”,1”, 3”	#124 SAC	2”-CP-55	M362	H1	1/1	1/1 & 2/1	¾”: 1.09 1”: 1.04 3”: 2.93	NC	SAAC #124/#125 screen at .5g HCLPF which is 1.25 median	¾”: 1.09 1”: 1.04 3”: 2.93	.4	1. All piping is welded or threaded fittings. 2. Valves are threaded brass. 3. Supports are well constructed. 4. Small SAM < ½”. Header pipe displacement limited by branch to valve station. No concerns per engineer judgment
CP-12	3-CP-55	¾”, 1”, 3”	#125 SAC	1-1/2”-CP-82	M362	H1	1/1	1/1 & 2/1	¾”: 1.09 1”: 1.04 3”: 2.93	NC	SAC #125 screen at .5g HCLPF which is 1.25 median	1.04	.4	1. All piping is welded or threaded fittings. 2. Valves are threaded brass. 3. Supports are well constructed.

Notes:
NC = Not Controlling

Table NF-39603-2

Package No.	**Line No.**	**Pipe Size**	**From**	**To**	**Matl Spec**	**Spect.**	**Span Ratio(1)**		**Fragilities – Median Capacity (g-PGA)**					**Notes**
							Vert.	**Lat.**	**Inert.**	**SAM (2)**	**Other (2)**	**Control**	**β_C**	
ZE-1	4-ZE-3	4"/3"/2"/ 1-1/2"	24" Supply HDR (U1) (12-CL-67)	#11A/#11B/#12 A/#12B FWPMUC; #11/#12/#13 HDTPMUC	M-359	H1	15 ft	30 ft	2.53	0.14g HCLPF for HDTPMUC # 11: HDTPMUC 12&13 and FWPMUC 11A/B and 12A/B Median is 1.4 *.37 = 0.52 (Freq < 2.5 HZ)	(1) EQ: (#11A) FWPMUC: (2) EQ: (#11B) FWPMUC (3) EQ: (#12A) FWPMUC (4) EQ: (#12B) FWPMUC (5)EQ: (#11) HDTPMUC: (6)EQ: (#12) HDTPMUC: (7)EQ: (#13) HDTPMUC: Governed by #11 Heater Drain Cooler frame	0.35 (#11 only) (#12 & #13 are 0.52g) (#11A/B & #12A/B =0.52g)	.4	Governed by #11 Heater Drain Tank Pump Motor Unit
ZE-2	3-ZE-2	3"/2"	24 Supply HDR (U1) (12-CL-67)	#11/#12/#13 CPMUC	M-359	H1	10 ft	40 ft	2.57	0.19 *1.4 = .27 (Freq < 2.5 HZ)	(1) EQ: (#11)CPMUC: (2) EQ: (#12)CPMUC: (3) EQ: (#13)CPMUC:	0.27 (=1.4*0. 19g)	.4	Governed by Condensate Pump Motor Unit Cooler SAMs

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio[1]		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM [2]	Other [2]	Control	β_C	
ZE-3	2-ZE-14	2"/1½"	24" Supply HDR (U1)	#121/#123 ACMUC #21 AFWPMUC	M-359	H1	11ft	18 ft	2.57		(1) EQ: (#121)ACMUC: (1) EQ: (#123)ACMUC: (1) EQ: (#21)AFWPMUC: Screened at 0.5g HCLPF by EPRI NP-6041 screening tables. Median capacity is 1.25g	1.25	.4	All components seismically designed
ZE-4	4-ZE-5	4"/3"/2"/ 1-1/2"	#11A/#11B/#12A/ #12B FWPMUC	24" Return HDR (U1)	M-359	H1	12 ft	56 ft	2.53	0.37G for FWPMUC #11A/B & #12A/B: Median is 1.4 * .37 = 0.52 (Freq < 2.5 Hz)	(1) EQ: (#11A)FWPMUC: (2) EQ: (#11B)FWPMUC (3) EQ: (#12A)FWPMUC (4) EQ: (#12B)FWPMUC	0.52g	.4	All components seismically designed
ZE-5	4-ZE-4	2/1½ /3/4	#11/#12/#13 HDTPMUC	24" Return HDR (U1)	M-359	H1	17 ft	17 ft	2.57	0.37g for HDTPMUC # 12 & 13: Median is 1.4 *.37 = 0.52 (Freq < 2.5 HZ)	(1)EQ: (#11)HDTPMUC: (2)EQ: (#12)HDTPMUC: (3)EQ: (#13)HDTPMUC:	0.35 (#11 only) (#12 & #13 are 0.52g)	.4	Governed by #11 Heater Drain Tank Pump Motor Unit Cooler
ZE-6	3-ZE-2	2/1½	#11/#12/#13 CPMUC (10-CL-110)	24" Return HDR (U1)	M-359	H1	13 ft	20 ft	2.57	0.19 *1.4 = .27 (Freq < 2.5 HZ)	(1) EQ: (#11)CPMUC: (2) EQ: (#12)CPMUC: (3) EQ: (#13)CPMUC	0.27 (=1.4*0. 19g)	.4	Governed by Condensate Pump Motor Unit C

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio[1]		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM [2]	Other [2]	Control	β_C	
ZE-7	4-ZE-15	4"/2"/1-1/2"	#121/#123 ACMUC #21 AFWPMUC	24" Return HDR (U1)	M-359	H1	11ft	18 ft	2.53	NC	(1) EQ: (#121)ACMUC: (2) EQ: (#123)ACMUC: (3) EQ: (#21)AFWPMUC: Screened at 0.5g HCLPF by EPRI NP-6041 screening tables. Median capacity is 1.25	1.25	.4	
ZE-8	2-ZE-12	2/1½	24" Supply HDR (U2)	#12AFWPMUC #122 ACMUC	M-359	H1	11 ft	18 ft	2.57	NC	(1) EQ: (#12)AFWPMUC: (2) EQ: (#122)ACMUC: Screened at 0.5g HCLPF by EPRI NP-6041 screening tables. Median capacity is 1.25g	1.25	.4	
ZE-9	4-ZE-13	4"/2"/1-1/2"/1"	#12 AFWPMUC #122 ACMUC	24" Return HDR (U2)	M-359	H1	11 ft	18 ft	2.53	NC	(1) EQ: (#12)AFWPMUC: (2) EQ: (#122)ACMUC: Screened at 0.5g HCLPF by EPRI NP-6041 screening tables. Median capacity is 1.25g	1.25	.4	

Package No.	**Line No.**	**Pipe Size**	**From**	**To**	**Matl Spec**	**Spect.**	**Span Ratio**(1)		**Fragilities – Median Capacity (g-PGA)**					**Notes**
							Vert.	**Lat.**	**Inert.**	**SAM** (2)	**Other** (2)	**Control**	β_C	
ZE-10	4-2ZE-3	4"/3"/2"	24" Supply HDR (U2)	#21A/#21B/ #22A/#22B FWPMUC; #21/#22/#23 HDTPMUC	M-359	H1	14 ft	24 ft	2.53	0.34 HCLPF for #23 HDTPMUC FWPMUC & #21A/B & #22A/B HDPTMUC #21 &#22 median is 0.39* 1.4=0.55	(1) EQ: (#21A)FWPMUC: (2) EQ: (#21B)FWPMUC (3) EQ: (#22A)FWPMUC (4) EQ: (#22B)FWPMUC (5)EQ: (#21)HDTPMUC: (6)EQ: (#22)HDTPMUC: (7)EQ: (#23)HDTPMUC:	0. (0.86 for #23 only) (#22& 23 HDT are 0.55g) (#22A/B & #21A/B are 0.55g)	.4	Governed by FWPMUC & HDTPMUC #21 & # 22
ZE-11	3-ZE-18	3"/2"	4-2ZE-5	#121/#122 RCDSR	M-359	H1	12 ft	40 ft	2.57	NC	(1) EQ: (#121)RCDSR: (2) EQ: (#122)RCDSR Screened by EPRI NP-6041 at 0.5g HCLPF per Tables 2-3. Median capacity is 1.25g	1.25	.4	
ZE-12	3-2ZE-1	3"/2"	24" Supply HDR (U2)	#21/#22/#23 CPMUC	M-359	H1	14 ft	24 ft	2.57	0.05*1.4=0.07 for ¾" hole for #21 CPMUC #22&23 median is= 0.29*1.4=0.41	(1) EQ: (#21)CPMUC: (2) EQ: (#22)CPMUC: (3) EQ: (#23)CPMUC:	-.07 for #21 (3/4" hole) 0.41 for #22&23	.4	Governed by Condensate Pump Motor Unit Cooler SAMs

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio[1]		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM [2]	Other [2]	Control	β_C	
ZE-13	4-2ZE-5	4/3/2/1 ½	#21A/#21B/ #22A/#22B FWPMUC	24" Return HDR (U2)	M-359	H1	12 ft	28 ft	2.53	0.39g for FWPMUC 21A/B & 22A/B Median is 1.4 * .39 = 0.55g	(1) EQ: (#21A)FWPMUC: (2) EQ: (#21B)FWPMUC (3) EQ: (#22A)FWPMUC (4) EQ: (#22B)FWPMUC	0.55g	.4	Seismically designed
ZE-14	3-ZE-19	3"/2"	#121/#122 RCDSR	4-2ZE-5	M-359	H1	12 ft	40 ft	2.57	NC	(1) EQ: (#121)RCDSR: (2) EQ: (#122)RCDSR Screened by EPRI NP-6041 at 0.5g HCLPF per Tables 2-3. Median capacity is 1.25g	1.25	.4	Seismically designed
ZE-15	3-2ZE-4	3"/2"/1 ½"/3/4"	#22/#23/#21 HDTPMUC	24" Return HDR (U2)	M-359	H1	10 ft	20 ft	2.57	0.39g for HDTPMUC #21 & #22 Median is 1.4 * .39 = 0.55g	(1)EQ: (#21)HDTPMUC: (2)EQ: (#22)HDTPMUC: (3)EQ: (#23)HDTPMUC: Governed by #11	(0.85 for #23 only) (#22& 23 HDT are 0.55g)	.4	Governed by Heater Drain Tank Pump Motor Unit Cooler
ZE-16	3-2ZE-2	3"/2"/1-1/2"	#21/#22/#23 CPMUC	24" Return HDR (U2)	M-359	H1	14 ft	24 ft	2.57	CPMUC #22 & #23 Median = 0.29 *14 = .41 (Freq < 2.5 HZ) 0.05*1.4=0.07 for ¾" hole for #21	(1) EQ: (#21)CPMUC: (2) EQ: (#22)CPMUC: (3) EQ: (#23)CPMUC .	-.07 for #21 (3/4" hole) 0.41 for #22&23	.4	

Package No.	**Line No.**	**Pipe Size**	**From**	**To**	**Matl Spec**	**Spect.**	**Span Ratio[1]**		**Fragilities – Median Capacity (g-PGA)**					**Notes**
							Vert.	**Lat.**	**Inert.**	**SAM [2]**	**Other [2]**	**Control**	**β_C**	

Notes:
NC = Not controlling
(1) values given are maximum unsupported Spans versus span ratio
(2) For equipment at the 695' or lower elevation if the original fragility was based on a mean versus median spectra. In the low frequency range (<2.5 Hz) the mean spectra is significantly higher than the median spectra. The 1.4 factor is used to reflect this difference. This is documented in S&A calculation 10C3877-CLE-CAL-036.

Table NF-39603-3

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
ZW-1	4-ZW-1	4”	24” Supply Header	121 Lab and Svc Area Chiller	M359	H3, H1	1/1	1/1	695’ Elev.: 0.40 Other Elev.: .7	NC	EQ: 121 Lab and SVC Area Chiller: Chiller has a median capacity based on the onset of sliding of 0.63 g Block wall: 735 Elev.: Block wall median capacity is not less than 4.5 g	0.40	.4	(1) Pipe is attached to the Chiller on top of Block wall offices in TB at 735’. Runs from chiller, thru roof, above suspended ceiling and exists block wall on south side (Unit #1 Side) and runs directly down to the 695’ Elevation (2) Valves by Chiller are welded steel. (3) Valves on 695’ Elevation are 3” cast iron valves. (4) There is a missing support at the bottom of the riser on this line.
ZW-2	4-ZW-2	4”	121 Lab and Svc Area Chiller	24” Return Header	M359	H3, H1	1/1	1/1	0.8	NC	EQ: 121 Lab and SVC Area Chiller: Chiller has a median capacity based on the onset of sliding of 0.63 g Block wall: 735 Elev.: Block wall median capacity is not less than 4.5gg	0.63 g	.4	(1) Pipe is attached to the Chiller on top of Block wall offices in TB at 735’. Runs from chiller, thru roof, above suspended ceiling and exists block wall on south side (Unit #1 Side) and runs directly down to the 695’ Elevation (2) Valves and on 695’ by Chiller are steel.

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	

Notes:
NC = Not controlling

Table NF-86172-1

Package No.	Line No.	Pipe Size	From	To	Matl Spec	Spect.	Span Ratio		Fragilities – Median Capacity (g-PGA)					Notes
							Vert.	Lat.	Inert.	SAM	Other	Control	β_C	
ZX-1	12-ZX-144	12"	Aux Building Wall	#11/#21 ZX Chiller	MZX1	H1	1/1	4/1	>1.25	NC	EQ: (#11)ZX Chiller EQ: (#21)ZX Chiller Anchorage capacity exceeds 0.5g HCLPF Median capacity is 1.25 Chiller screened at 0.5g HCLPF per EPRI NP-6041 Tables median capacity is 1.25	>1.25	.4	(1) Pipe is all welded steel construction mostly CS with small amounts of SS (2) all valves are welded or bolted steel valves (3) Pipe is attached to Coolers with 12" #77 Victaulic connections (4) Analysis conducted to determine fragilities
ZX-2	12-ZX-155	12"	#11/#21 ZX Chiller	24" Return Header (U2)	MZX1	H1	1/1	4/1	>1.25	NC	EQ: (#11)ZX Chiller EQ: (#21)ZX Chiller Anchorage capacity exceeds 0.5g HCLPF. Median capacity is 1.25 Chiller screened at 0.5g HCLPF per EPRI NP-6041 Tables. Median capacity 1.25	>1.25	.4	(1) Pipe is all welded steel construction mostly CS with small amounts of SS (2) all valves are welded or bolted steel valves (3) Pipe is attached to Coolers with 12" #77 Victaulic connections
ZX-3	2-Zx-153	2"	12-ZX-144	2" Tee	MZX1	H1	1/1	3/1	3.92 *1.25 = 4.9 (Freq < 2.5 HZ)	>1.25	None	>1.25	.4	(1) Piping is all welded SS construction (2) Branches from 12" Header; Header is1/1 Vertical and 4/1 lateral; flex leg is 3'6".

ZX-4	2-Zx-?	2"	2-ZX-154	12-ZX-3	MZX1	H1	1/1	3/1	3.92* 1.25=4.94 (Freq < 2.5 HZ)	0.98	None	0.98	.4	(1) Piping is all welded SS construction (2) Branches from 12" Header; Header is1/1 Vertical and 4/1 lateral; flex leg is 3'
ZX-5	Mech. Pack Pipe	2"			MZX1	H1	1/1	3/1	1.86* 1.25 =2.32 (Freq < 2.5 HZ)	NC	EQ: (#121N)MF: EQ: (#121S)MF EQ: (#122W)BF EQ: (#121E)BF Screened at 0.5g HCLPF per EPRI NP-6041 Tables. Median capacity 1.25.	1.25	.4	(1) Piping is all welded SS construction, short runs very stiff. (2) Flanged "glass" sight-glass. Glass is contained in large rigid stainless steel component judged to have the less capacity than the pipe, the pipe capacity is reduced by 50% to account for this component
ZX-6	2-ZX-155	2"	Mech. Pack Pipe	24" Return HDR	MZX1	H1	1.5/1	8/1	>1.25	NC	None	>1.25	.4	(1) Piping is a combination of CS and SS (2) pipe contains THRD steel valve and THRD unions (3) There are 5 very short rod hangers mid-span in the system. (4) Detailed Analysis conducted to determine Fragilities

Notes:
NC = Not controlling

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