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Harold R Denton, Director
Office of Nuclear Reactor Regulation
US Nuclear Regulatory Commission
Washington, DC 20555

MIDLAND ENERGY CENTER
MIDLAND DOCKET NOS 50-329, 50-330
EQUIPMENT QUALIFICATION AND THE SEISMIC MARGIN REVIEW
FILE: B3.7.1/B3.10.4 SERIAL: 25647

REFERENCES:
(1) LETTER FROM NRC TO J W COOK, DATED 11/18/82
(2) LETTER FROM R W HERNAN TO J W COOK, DATED 5/19/83
(3) LETTER FROM J W COOK TO H R DENTON, DATED 2/4/83, SERIAL 21010
(4) LETTER FROM T M NOVAK TO J W COOK, DATED 6/21/83
(5) LETTER FROM J W COOK TO H R DENTON, DATED 9/25/81 SERIAL 13781

This letter was initiated in reply to the remarks received in Reference 4, pertaining to the Midland Seismic Qualification Program. On February 8, 1983, a meeting was held between CPCo and the Staff on the topic of the Seismic Margin Review (SMR) Program and to discuss CPCo's overall approach to the issue of seismic qualification of equipment including CPCo's response to Reference 1. This letter is provided to document our responses to Reference 1 pertaining to equipment qualification and the Seismic Margin Review Program as put forth at the February 8, 1983 meeting, and hence to provide our understanding of the situation. In addition, this letter also responds to the additional staff comments on equipment qualification in Reference 2.

The following discussion specifically responds to Staff concerns contained in References (1) and (2) documenting how we are conducting both our SQRT program and the SMR:

1. "demonstrate qualification of all safety related equipment using the 1982 FSAR spectra;" Reference (1)

   CPCo concurs with the Staff on this issue. As stated in Section 3.10 of the Midland FSAR, the design basis for seismic qualification of all safety-related equipment will be the in-structure response spectra generated in accordance with Section 3.7 of the Midland FSAR.

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2. "demonstrate that all equipment needed to shutdown the reactor and maintain it in a safe condition would remain functional following an SSRS earthquake by actual qualification to an adequate spectra (such as an envelope higher than or equal to the shape derived from SSRS) or by providing appropriate justification;" Reference (1)

In the February 8, 1983 meeting with the NRC, CPCo discussed the methodology and criteria being used in the SMR Program for selection and evalution of equipment. CPCo believes that a selected sample of equipment is adequate to demonstrate the ability to achieve and maintain safe shutdown of the reactors. Attachment A to this letter is a flowchart previously given to the Staff as a handout during the February 8, 1983 meeting. This attachment illustrates the process used to select equipment for evaluation. As can be seen in Attachment A, stresses, level of seismic response increases, functional importance and vulnerability are factored into the equipment selection process. The process of selecting equipment was originally presented to the Staff in a meeting in Bethesda on June 30, 1981 and subsequently modified in my telephone conversation with Mr J P Knight on July 17, 1981 to include a larger equipment selection. Based on the above discussions, it was our understanding that a systematic sampling plan would be appropriate for the SMR.

During the February 8, 1983 meeting, we presented the Staff with a listing of the equipment evaluated in the SMR. This listing also identified the respective margins of the equipment with the lowest margin conservatively estimated at 1.24. The equipment evaluated in the SMR included 100 percent of the 4160 Volt system including switchgear, 480 Volt motor control centers, station batteries, the diesel generator system, the major pumps, BOP logic cabinets, auxiliary shut down panel, the ESFAS cabinet, and the decay heat removal and component cooling water heat exchangers. The above equipment having been selected by the previously mentioned criteria.

As was stated in the February 8, 1983 meeting, approximately 35 percent of the essential equipment has been evaluated in the SMR. Based upon the methods used in the SMR for selecting the equipment for evaluation, we feel that what has been done is adequate to demonstrate functionality of the required equipment following an SSRS earthquake.

3. "document process used to demonstrate functionality (item #2 above) in the record of qualification to be maintained for each affected piece/type of equipment for historical purposes; and" Reference (1)

The SQRT program documents the qualification of all equipment and therefore the functionality of the equipment. Whenever the SMR seismic responses are shown to be less than or equal to what the equipment in the SQRT program was to be qualified to, functionality has been demonstrated. As was discussed in the February 8, 1983 meeting and further documented in Volume VII, of Reference 3, all of the equipment evaluated have positive margins to either code

allowables when qualified by analysis or to the Test Response Spectra (TRS) when qualified by testing.

4. "any new equipment would be purchased to the SSRS." Reference (1)

During the aforementioned February 8, 1983 meeting, CPCo agreed to purchase "new" equipment to the Seismic Margin Earthquake. After fuel load, new equipment for plant modifications will be procurred using the in-structure response spectra, generated with Seismic Margin Earthquake (SME) as input ground motion, and based upon the criteria described in Volume I of the Seismic Margin Review (SMR) program dated February 1983, Reference 3.

Replacement equipment for original equipment (equipment in place at time of fuel load) will be procured by using the same seismic criteria as the original equipment, providing the replacement equipment matches the original equipment in such a way that no seismic requalification is required. If seismic requalification is required, the replacement equipment will be procurred using the in-structure response spectra described above.

Spare parts required to maintain original equipment will be procurred to meet or exceed the seismic qualifications of the original equipment.

Line and panel mounted equipment such as valves, dampers and instruments that are generically qualified will be procurred to meet or exceed the seismic qualifications of the original equipment unless proposed modifications would result in seismic reanalysis of the line or panel, in which case the line or panel would be reanalyzed to meet the in-structure response spectra described above.

5. "It was questionable for the applicant to conclude that the system hydro tests will result in greater tensile stresses than a seismic event when calculating pump functionality margins." Reference (2)

See Attachment B to this letter titled, "Functionality of Active Components", for a discussion on pump stresses resulting from system hydrostatic testing and the Seismic Margin Earthquake.

6. "The Staff considers small lines and associated components to be an area of special concern. The Midland seismic qualification program does not appear to take this aspect into account." Reference (2)

Small lines and appurtenances are considered in the seismic qualification of equipment. As an example which was provided in the aforementioned February 8, 1983 meeting, small lines and appurtenances were considered in the diesel generator SSRS seismic margins. The diesel generator SSRS seismic margins are formally documented in Volume VII of the Seismic Margin Review Report, Reference 3.

7. "It was stated that valve selection was made on the basis of critical pipe stresses. The staff is particularly concerned that the eccentricity of valve operators be considered in the analyses." Reference (2)

   The eccentricity of all motor operators or valves and manual operated valve assemblies where significant, are considered in the piping analyses models.

This information summarizes our understanding of past discussions and agreements with the Staff and details how CPCo is presently proceeding to respond to the Staff's comments regarding equipment qualification and the Seismic Margin Review. The Staff is requested to contact us should any further questions or comments on this topic arise.

James W. Cook

JWC/MFC/dlm

CC RJCook, Midland Resident Inspector
JGKeppler, Administrator, NRC Region III
TMNovak, USNRC, Assistant Director of Licensing
EDAdensam, USNRC, Branch Chief
DSHood, USNRC, Licensing Branch No 4
MAMiller, USNRC, Licensing Branch No 4
GBagchi, USNRC
RBosnak, USNRC
JPKnight, USNRC

CONSUMERS POWER COMPANY
Midland Units 1 and 2
Docket No 50-329, 50-330

Letter Serial 25647 Dated September 30, 1983

At the request of the Commission and pursuant to the Atomic Energy Act of 1954, and the Energy Reorganization Act of 1974, as amended and the Commission's Rules and Regulations thereunder, Consumers Power Company submits a clarification on the use of the Seismic Margin Earthquake.

CONSUMERS POWER COMPANY

By J W Cook
J W Cook, Vice President
Projects, Engineering and Construction

Sworn and subscribed before me this 5 day of October, 1983

Barbara P Townsend
Notary Public
Jackson County, Michigan

My Commission Expires September 8, 1984

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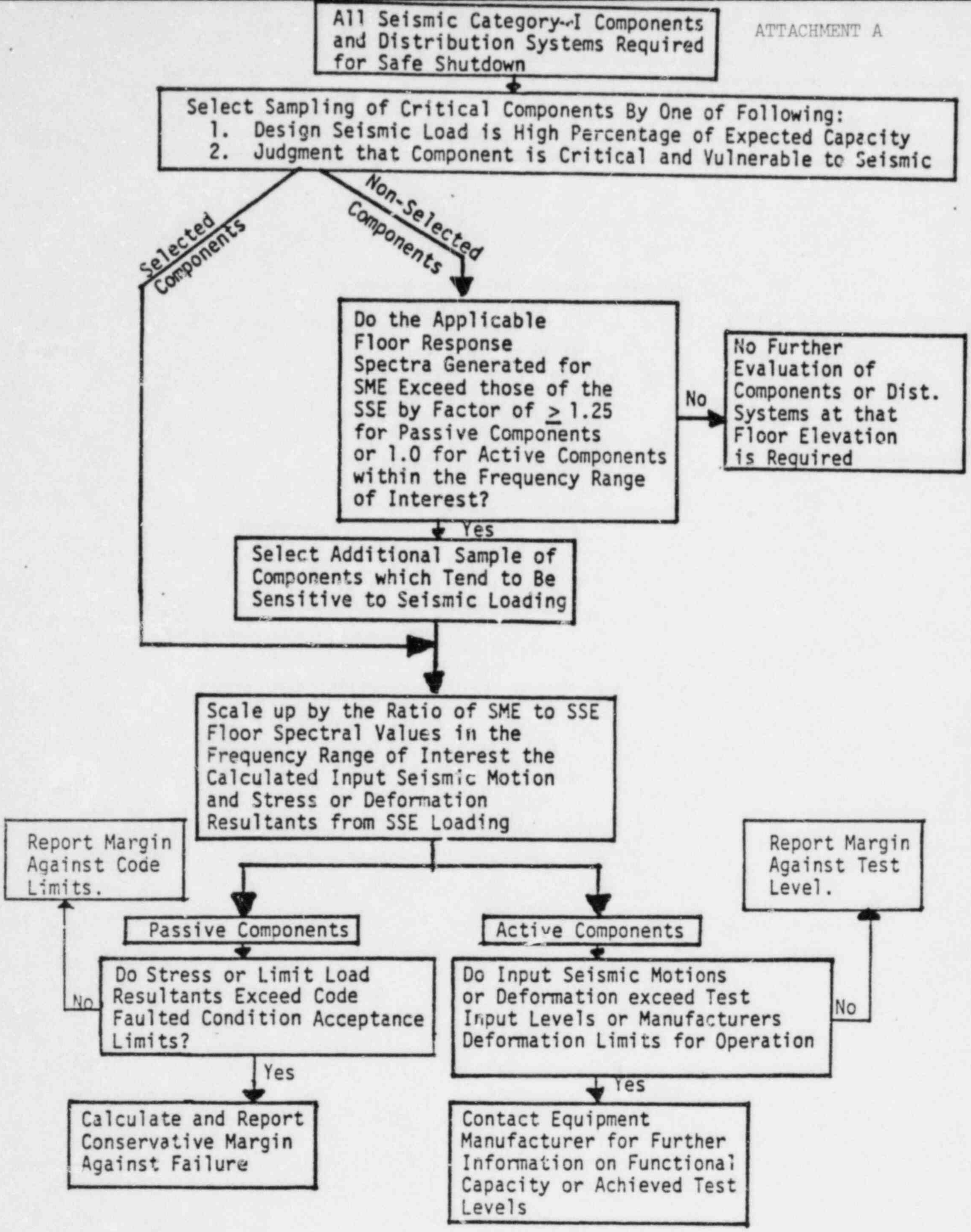

FIGURE I-9-1: PROCESS TO SELECT COMPONENTS AND DISTRIBUTION SYSTEMS FOR SEISMIC SAFETY MARGIN EVALUATION AND DEVELOP MARGINS

SMA 13701.05M394

FUNCTION OF ACTIVE COMPONENTS

Active components were generally qualified by testing. All Seismic Category 1 electrical switchgear, motor control centers, etc., were qualified by testing as were most active valves. Consequently, function has been demonstrated by shake table testing of the components while monitoring their function. Major pumps required for safe shutdown were qualified by analysis; thus, function of pumps under postulated SME loading must be demonstrated by analytical techniques.

Pump vendor reports were reviewed and analytical results were extrapolated to reflect stress and deflection conditions for the Seismic Margin Earthquake (SME) combined with normal operating loads (pressure, external piping loads, weight, motor torque, etc.).

Seismic margins for pumps presented are defined as:

$$F_{SME} = \frac{\sigma_A - \sigma_N}{\sigma_{SME}}$$

where:

σ_A = allowable stress (code or functional limit)

σ_N = stress due to normal operating loads

σ_{SME} = stress due to the SME

This form of displaying the seismic margin is a direct measure of the factor by which the earthquake may be increased before the allowable is reached. The above equation is also applicable for displacement limits, wherein, displacement is substituted for stress.

The allowable stress for meeting ASME code faulted condition limits may exceed the yield strength of the material and the resulting permanent deformation could cause loss of function, reduced function, leakage, etc. An allowable stress of 0.9 times the code specified yield strength was chosen as an alternate limit to assure that permanent deformation and possible loss of function would not occur.

Other limits were also used to demonstrate that permanent deformation would not occur from combined seismic and normal operating loads. A common design parameter calculated and evaluated for pump nozzles and flanges subjected to external piping loads as well as operating pressure is P_{FD}, where P_{FD} is the sum of the design pressure, P_D, plus an equivalent pressure, P_{EQ}, to represent the effects of piping reactions. The equivalent pressure is defined at that which would provide the same stress in a flange that would result from external bending moments and forces being applied to the flange.

The ASME Code, Subsections NC-3647 and ND-3647 provide equations for calculating equivalent pressure for moments arising from weight and thermal expansion. These same methods were used by the pump vendors to calculate equivalent pressures for externally applied moments arising from seismic events. Total flange, flange bolt and nozzle stresses may be calculated for the combined normal operating pressure, equivalent pressure for normal operating piping reactions (weight and thermal expansion) and equivalent pressure for seismic-induced piping reactions.

Alternate criteria to demonstrating that 0.9 times the code specified yield strength would not be exceeded are to demonstrate that the design plus equivalent pressure (P_{FD}) does not exceed either the rated pressure of the fitting or the hydrotest pressure. For standard flanges and fittings, pressure temperature ratings are specified in ANSI Standard B16.5. For instance, a 150-pound class flange constructed of carbon steel has a pressure rating of 275 psi at ambient temperature. This pressure rating is based on not exceeding a conservative working

stress level in the elastic material range; thus, if a calculated design plus equivalent pressure does not exceed the fitting rating, no permanent deformation would result.

The hydrotest pressure for ASME code pump cases and nozzles provided at Midland is based on 1.5 times the design pressure. A restriction on hydrotest pressure is that the component primary membrane stress intensity is limited to 0.9 times the code specified yield strength. Some small amounts of permanent deformation may result during a hydrotest where local membrane and bending stress exceed yield. However, once the inelastic deformation occurs, no further inelastic deformation would occur unless the combined operating pressure plus equivalent pressure exceeds the hydrotest pressure. Thus, the hydrotest pressure represents a threshold for which non-exceedance implies elastic response and no hindrance to function.

These alternate functionality acceptance criteria based on pressure ratings or hydrotest pressure obviously only apply to specific fittings and geometries and have only been used where clearly applicable.

It should be noted that a combined design plus equivalent pressure (P_{FD}) that exceeds the component hydrotest pressure or a fitting pressure rating does not necessarily mean that permanent deformation has occurred. In many instances the equivalent pressure at a flange exceeds the component hydrotest pressure but the flange stresses have been demonstrated to be well below 0.9 times yield.

There are six pump categories required for a safe shutdown of Midland. They are:

Service Water Pumps

Component Cooling Water Pumps

Auxiliary Feed Pumps (Electric Motor Driven)

Auxiliary Feed Pumps (Turbine Driven)

Decay Heat Removal Pumps

Makeup Pumps

All six pump categories were included in the SME study and the functional limits as stated previously as well as code stress limits have been demonstrated for all pumps.

SERVICE WATER PUMPS OP-75A-E

The sevice water pumps supply cooling water to safety-related equipment required for safe shutdown and to other non-safety-related equipment. The pumps are located in the Service Water Pump Structure at Elevation 634'-6". Qualification was by analysis (Reference 14). Refer to Appendix A, Section A-14 for details and results of the qualification report.

The horizontal design spectral acceleration values at the pump's fundamental frequencies exceeded the corresponding SME acceleration values at two percent damping and the vertical design acceleration value was less than the vertical SME acceleration value. Therefore, appropriate factors were computed from the ratios of spectral accelerations and the seismic loads and stresses from the qualification report were scaled to calculate seismic margins.

Stresses in the service water pump result from internal pressure, inertial effects of the pump case, pump motor and pump column, and external nozzle loads resulting from seismic inertial effects, restraint of thermal expansion and dead weight.

Service water pumps are connected to strainers by short rigid runs of pipe and the strainers serve as anchors for the attached service water discharge piping; thus, actual discharge nozzle loads resulting from inertial effects of the short pipe run between the pumps and strainers are very small. Very high piping reactions were, however, specified for design and these loads tend to dominate the total calculated stress at many locations.

The piping reaction loads specified for design were defined for faulted loading conditions with one-half of the specified load apportioned to normal loading (thermal expansion plus dead weight). Even though the geometry would preclude high seismic loading on the nozzles it was assumed that the loads did exist in determining margins against code stress allowables and margins against functional failure.

Another source of high loading, thus, high stress response in the pump anchor bolts, mounting flange, column flange and column, arises from a displacement limited condition in the pump column. Under a seismic loading event, the clearance between the pump column and its two supports is taken up. This results in a bending moment at the column to pump case interface. The inertial loads of the seismic event are much smaller in comparison. If the seismic event is scaled up, only the inertial portion of the load increases since the column displacement at its supports is fixed. Thus, a relatively high stress condition may result for a low level seismic event but will not increase appreciably for increased seismic levels.

Using the above conservative assumptions of nozzle loading, scaled stress response to seismic events and the seismic response features of the pump column, the governing margins calculated against code stress allowable and against function are:

Critical Area	Failure Mode	Governing Acceptance Criteria	F_{SME} Code	F_{SME} Function
Nozzle Flange	Leakage	ANSI B16.5 rated pressure	NA	1.86
Discharge Head Flange	Structural	ASME, App. XI	3.12	NA
Discharge Head Flange	Permanent Deformation	0.9 S_y	NA	2.19
Base Plate Flange	Structural	ASME, NF	3.35	NA
Base Plate Flange	Permanent Deformation	0.9 S_y	NA	2.57
Bolting to Base Plate	Structural	ASME, NF	2.42	NA
Nozzle (Elbow)	Structural	ASME, ND	2.40	NA
Nozzle (Elbow)	Permanent Deformation	0.9 S_y	NA	1.43
Column Support	Weld Stress	ASME, NF	1.93	NA
Column Support	Plate Stress	ASME, NF	1.83	NA
Shaft Deflection	Rubbing	Vendor Specified	NA	3.11
Column	Structural	ASME, ND	12.42	NA
Column	Permanent Deformation	0.9 S_y	NA	8.43

COMPONENT COOLING WATER PUMP

1P-73A, 2P-73A, 1P-73B, 2P-73B & OP-73

The component cooling water pumps are part of the component cooling water system and circulate cooling water in the closed loop system. The pumps are located in the Auxiliary Building at Elevations 584'-0" and 599'-0". Qualification of the pumps was by analysis (Reference 20). Refer to Appendix A, Section A-15 for a summary of the qualification report.

Seismic margins against code stress allowable and functional allowables were calculated using Equation 3-7. The suction nozzle flange was the most critically stressed element of the pump. The highest seismic loads from attached piping resulted on pump 1P-73A. The vendor's analysis of the flange was conducted using standard ASME code flange formula methods. The governing stress criterion was:

$$S_H \leq 2.4S$$

In the above equation, S_H is the longitudinal stress in the hub and S is the code allowable stress of 14,000 psi.

In the vendor's design analysis, stress components were computed for pressure loading. The pressure loading consisted of specified design pressure plus an equivalent pressure derived for external nozzle loads. A breakdown of load components for normal and SSE pipe reactions was provided by Bechtel. These loads were less than the design loads used by the vendor in his calculations. Pump 1P-73A had the greatest seismic nozzle loads. A comparison of SME spectra to the SSE spectra used in deriving the SSE nozzle loads revealed that the maximum ratio of SME/SSE spectral acceleration was 1.93 at about 11 Hz in the E-W direction at the 559-0" elevation. The SSE loadings were conservatively scaled upward by the 1.93 factor to upper bound possible SME piping reactions at nozzles. These scaled SME nozzle loads and the Bechtel derived normal loads were then used to calculate equivalent pressures for normal and SME loading. These equivalent pressures, along with the pump design pressure were used to recalculate flange stresses for normal and SME loading.

Pump hold down bolts and taper pins used for alignment were evaluated for loading resulting from pipe reactions at nozzles and inertial loading on the pump. The SME nozzle loads were upper bounded in the same manner as in the suction nozzle flange anlaysis. In this case, however, the most critical combination of loads for the bolting occurred at pump 1P-73B and at pump OP-73 for the taper pins. All shear was

assumed to be taken by the taper pins with only tension carried by the hold-down bolts. Margins for the pump pedestal hold-down bolts and taper pins were computed relative to the code faulted condition allowables.

Two stress related margins were computed for the suction nozzle flange, the margin against code and the margin relative to 0.9 of the code specified yield strength. The latter margin was computed to demonstrate that no permanent deformation would occur.

An additional comparison was made of the hydrotest pressure vs. the normal operating pressure plus the equivalent pressure for external nozzle loads. The hydrotest pressure of 262 psi is just slightly less than the combined normal operating plus equivalent pressure of 264 psi. Note, also, that the SME nozzle reactions were very conservatively scaled upward from calculated SSE loads by the worst ratio of the SME/SSE spectral accelerations from the applicable response spectra.

Shaft deflection, casing distortion and tolerance stackup were calculated by the pump vendor to demonstrate that rubbing would not occur at the wear rings. The dominant loading factor for shaft deflection was the hydraulic loading. Seismic-induced shaft deflections were very small. Casing distortion arises principally from external piping reactions which are dominantly seismic-induced. The vendor performed a tolerance study to derive a minimum radial clearance of 0.0085 inches. About one-half of this tolerance is used up by deflections due to normal operating loads and less than one-eighth of the minimum tolerance is used up by seismic loads appropriately scaled to define upper bound SME loading.

The controlling seismic margins relative to code allowables and functional acceptance criteria are:

Critical Area	Failure Mode	Governing Acceptance Criteria	F_{SME} Code	F_{SME} Function
Suction Nozzle Flange	Structural	ASME, App. XI	6.22	NA
Suction Nozzle Flange	Permanent Deformation	0.9 S_y	NA	5.93
Suction Nozzle Flange	Leakage	P_{FD} vs. Hydrotest Pressure	NA	1.0
Pump Hold-Down Bolts	Tension	ASME, NF	4.75	NA
Taper Pins	Shear	ASME, NF	1.69	NA
Shaft Deflection	Rubbing	Vendor Specified	NA	4.08

All other areas of the CCW pumps have greater margins relative to the SME. The component cooling water pumps have sufficient margin to withstand a significantly greater seismic event than the SME.

AUXILIARY FEEDWATER PUMP (ELECTRIC MOTOR DRIVEN)

1P-05A & 2P-05A

The auxiliary feedwater pumps provide a backup source of feedwater to remove decay heat transmitted to the steam generators by the primary coolant loops during a shutdown. The pumps are located in the Auxiliary Building at Elevation 584'-0". Qualification of the pumps was by analysis (Reference 22). Refer to Appendix A, Section A-17 for a summary of the qualifiction report.

The pumps were determined by analysis to be rigid. The SME zero period accelerations (ZPA's) were greater than the designed ZPA's applied to the pump-motor assembly in both horizontal directions but were less than the design ZPA in the vertical direction. The ZPA's applied to the pump and motor shaft models were greater than the SME ZPA's in both the horizontal and vertical directions.

The pumps were evaluated for compliance to the stress limits of the ASME code when subjected to pressure, SME inertial loading, pipe reactions arising from normal operating conditions (weight and thermal expansion loading) and pipe reactions resulting from the SME.

Vendor calculations were scaled to reflect the ratio of SME inertial loads to specified design loads and SME piping loads to specified design loads. Piping loads were calculated by Bechtel for dead weight, thermal expansion and SSE. The SSE loads were then scaled to reflect upper bound SME load by multiplying the Bechtel computed SSE reactions by the maximum ratio of the SME/SSE spectral accelerations taken from the applicable response spectra.

Governing stresses relative to code allowables are in the high pressure discharge flange. All other areas of the pump have lower combined SSE and normal loading stresses. The next most critical structural failure mode was the pump/motor bed plate anchor bolts.

Pump function was addressed by the vendor via analysis of shaft deflections, pump/motor coupling rotation and bearing loadings. The most restrictive limits for function were the coupling rotation and impeller deflection limits. Th vendor computed shaft and coupling displacements by means of a multinode beam computer model. The shaft was demonstrated to be rigid; thus, a static model was used. Nodal loading representing dead weight, hydraulic thrust and seismic were applied to the model and calculated displacements/rotations were compared to specified limits. The vendor computed displacements for seismic loading

were scaled by the maximum ratio of the SME to SSE spectral accelertion. In this case, the ratio of the SME ZPA to the static load used by the vendor was used as a scaling factor.

In order to assure that permanent deformation would not result in the pump flanges or body, stresses computed for combined normal operating conditions plus seismic loading were compared to 0.9 of the specified yield strength and margins were calculated. An additional margin relative to the hydrotest level was calculated. The pump hydrotest pressure of 3000 psig was compared to the discharge flange operating pressure of 1270 psi plus an equivalent pressure of 734 psi due to the SME and 185 psi due to normal loading reactions from connecting piping. Equivalent pressures due to external piping loads were calculated in accordance with the ASME Code, NC/ND 3647.

The seismic margins calculated in accordance with Equation 3-2 or its equivalent are:

Critical Area	Failure Mode	Governing Acceptance Criteria	F_{SME} Code	F_{SME} Function
Discharge Flange	Structural	ASME, App. XI	3.42	NA
Discharge Flange	Permanent Deformation	0.9 S_y	NA	4.83
Discharge Flange	Leakage	P_{FD} vs. Hydrotest Pressure	NA	2.10
Bed Plate Anchor Bolts	Tension	AISC, NUREG-0800	4.2	NA
Impeller	Rubbing	Vendor Specified	NA	15.7
Coupling	Rotation Misalignment	Vendor Specified	NA	30

AUXILIARY FEEDWATER PUMP (TURBINE DRIVEN)

1P-05B & 2P-05B

The auxiliary feedwater pumps provide a back-up source of feedwater to remove decay heat transmitted to the steam generators via the primary coolant loops during a plant shutdown. The pumps are located in the Auxiliary Building at Elevation 584'-0". Qualification of the pumps was by analysis (Reference 23). Refer to Appendix A, Section A-18 for a summary of the qualification report.

The pumps are identical to the motor driven units and seismic margins derived for the motor driven pumps are applicable to the turbine driven pumps. Piping reactions on the turbine driven pump units are less than on the motor driven units; thus, the assumption that the seismic margins are the same for both types of pumps is conservtive for the turbine driven units.

Bed plate anchor bolt margins are slightly greater for the turbine driven units. Piping reactions at the pump are less than for the motor driven pumps but the attached turbine steam piping adds to the overall bolt loading. The turbine drives were included in the vendor's analytical model to evaluate coupling rotations and misalignment; however, qualification of the turbine unit was the responsibility of the turbine supplier and is addressed in a separate report.

The only significant difference between qualification results of the motor driven and turbine driven pump units is at the coupling. The calculated coupling misalignment for the turbine driven unit is much less than the motor driven unit. The difference results from the drive units, not the pump. The turbine shaft rotation at the pump/drive unit coupling is much less than for the electric motor shaft. A very large margin was shown to exist for the motor driven unit (F_{SME} = 30) thus the margin for the turbine unit is very large (>30).

The seismic margins applicable to the turbine driven feedwater pumps are:

Critical Area	Failure Mode	Governing Acceptance Criteria	F_{SME} Code	F_{SME} Function
Discharge Flange	Structural	ASME, App. XI	>3.42	NA
Discharge Flange	Permanent Deformation	0.9 S_y	NA	>4.83
Discharge Flange	Leakage	P_{FD} vs. Hydrotest Pressure	NA	>2.1
Bed Plate Anchor Bolts	Tension	AISC, NUREG-0800	4.3	NA
Impeller	Rubbing	Vendor Specified	NA	15.7
Coupling	Rotation Misalignment	Vendor Specified	NA	>30

<u>MAKEUP PUMPS 1P-58A-C and 2P-58A-C</u>

The makeup pumps provide makeup water to the reactor coolant system and also act as high pressure injection pumps in the event of a small pipe break. The pumps are located in the Auxiliary Building (Main Auxiliary Area) at Elevation 599'-0". Qualification of the pumps was by analysis (References 27 and 28). Refer to Appendix A, Section A-21 for details and results of the qualification.

The pumps were demonstrated by analysis to be rigid. Inertial loading used in seismic design of the pump anchorage exceeded the SME inertial loading by factors of greater than five in each of the three directions. The pump vendor also applied design nozzle loadings greatly in excess of actual nozzle loadings predicted by Bechtel in their piping analysis. Calculations for the most critical areas identified by the design analysis were redone using predicted SME inertial loading and Bechtel nozzle loads scaled upward by the maximum ratio of the SME/SSE spectral acceleration in any possible frequency range of the attached piping.

Function was demonstrated by the pump vendor by analysis using inertial loadings greatly in excess of the SME accelerations at the pump mounting location. The vendor's results were scaled by the ratio of SME/vendor design accelerations to derive deflections of pump internals when subjected to the SME.

The suction and discharge flanges were not stress analyzed by the vendor. Design loadings at the nozzles were compared to a company engineering standard. The flanges are much heavier than required for the specified service; thus, a conservative SME margin was derived by comparing the design pressure plus equivalent pressure for external nozzle loads to the rated working pressure from the ANSI B16.5 Standard for Steel Pipe Flange and Flanged Fittings. A margin of greater than unity indicates that normal long term working stresses are not exceeded and no loss of function at the flanged joints would occur.

The gear drive was qualified separately by the drive vendor. The gear drive is rigid and was analyzed using equivalent static coefficient loadings of 3g horizontal and 1g vertical. Vendor results were scaled by the maximum ratio of the SME/vendor design accleration.

Since both the pump vendor and gear drive vendor used very conservative design loading, the margins relative to the SME are very high. Resulting margins of the governing components are:

Critical Area	Failure Mode	Governing Acceptance Criteria	F_{SME} Code	F_{SME} Function
Suction Flange	Leakage	Vendor's Engineering Standard	NA	25
Suction Flange	Leakage	ANSI B16.5 Rated Pressure	NA	4.2
Foundation Bolts	Tension & Shear	AISC, NUREG-0800	6.5	NA

Critical Area	Failure Mode	Governing Acceptance Criteria	F_{SME} Code	F_{SME} Function
Pump Mounting Bolts	Tension	ASME, NF	69.3	NA
Pump Alignment Pins	Shear	ASME, NF	7.5	NA
Shaft Deflection	Displacement	Vendor Specified	NA	>100
Coupling Deflection	Displacement	Vendor Specified	NA	>200
Gear Drive Hold Down Bolts	Tension	AISC, NUREG-0800	42.3	NA
Gear Drive Taper Pins	Shear	AISC, NUREG-0800	32.4	NA
Gear Drive Thrust Brg.	Force	Vendor Specified	NA	17.9
Gear Drive Lube Console Weld	Shear	AISC-NUREG-0800	52.2	NA

The makeup pump and their gear drives have sufficient margin to withstand earthquakes significantly greater than the SME.

DECAY HEAT REMOVAL PUMP, 1P-60A, 1P-60B, 2P-60A and 2P-60B

The decay heat removal pumps circulate water in the decay heat and core flooding system. The pumps are located in the Auxiliary Building (Main Auxiliary Area) at Elevation 568'-0".

Qualification of the pumps was by analysis (Reference 26). Refer to Appendix A, Section A-22 for details and results of the qualification.

Stresses in the decay heat removal pump result from internal pressure, pump inertial effects (pump case, pump motor, and supports) and attached piping (inertial effects, dead weight and restraint of thermal expansion). Reference 26 specifies that these pumps have fundamental

frequencies greater than 60 Hz; thus, can be treated as being rigid. Pump seismic inertial loading used in the design analysis exceeded the appropriate SME inertial loading by factors of greater than five in each of the three directions. Attached piping frequencies were unknown; thus, a worst case frequency was assumed which maximizes the ratio between the SME and the SSE. This is very conservative as all attached piping is assumed to respond 100 percent in a single mode at the frequency where the SME/SSE spectral acceleration ratio is the greatest. The maximum SME/SSE ratio for Elevation 568' spectra occurs at 14 Hz in the vertical direction and is equal to 2.29.

Pump sections which are not affected by nozzle load will all have factors of safety against the SME greater than 5 since the pump design inertial loads have been shown to be greater than 5 times those for the SME. Thus, the casing, casing bolts, gland plate bolts, motor attachment bolts and the pump shaft have sufficient margin to withstand a significantly greater seismic event than the SME.

Sections of the pump assembly, which are affected by the nozzle loads are the suction nozzle, discharge nozzle, overall pump assembly anchor bolts and the pump attachment bolts. The adequacy of each of these four items for both structural and functional consideration is addressed below. Safety factors relative to the SME are tabulated for each of these items as well as for pump rotating assemblies.

The vendor's analysis of the flange was conducted using standard ASME code flange formula methods. The governing stress criterion for the discharge flange was:

$$S_H \leq 2.4\ S$$

In the above equation, S_H is the longitudinal stress in the hub and S is the code allowable stress of 13,900 psi. The governing stress criterion for the suction flange was the combination of:

$$0.5\ (S_H + S_R) \leq 2.0\ S$$

where S_H and S are as defined previously and S_R is the radial stress in the flange.

In the vendor's design analysis, stress components were computed for design pressure plus an equivalent pressure derived for external nozzle loads. A breakdown of load components for normal and SSE pipe reactions was provided by Bechtel. The SSE pipe reactions were conservatively scaled up by 2.29 to provide an upper bound on the SME reactions. These scaled SME nozzle loads and the Bechtel derived normal loads were then used to calculate equivalent pressures for normal and SME loading. These equivalent pressures, along with the pump design pressure were used to recalculate flange stresses for normal and SME loading. Factors of safety were computed for both the suction and the discharge nozzles based on ASME Code faulted condition allowables (2.4 x S). In order to assure that permanent deformation would not occur in the pump flanges, the combination of equivalent pressures computed for combined normal and SME loding plus the design pressure were compared to both the pump hydrotest pressure (1038 psi) and the flange ANSI B16.5 rated pressure. The summary table below shows that both flanges can withstand, both functionally and structurally, seismic events greater than the SME.

Anchor bolts and pump attachment bolts are also affected by the SME nozzle loads. The anchor bolts secure the overall pump motor skid assembly to the concrete floor slab. The pump attachment bolts secure the pump to the skid. The anchor bolts themselves were assessed against AISC criteria, while pullout of the concrete embedment was assessed against the Prestressed Concrete Institute (PCI) Handbook. The pump attachment bolts were assessed against ASME Component Support Code criteria.

The vendors design analysis had indicated a small margin of safety for a combination of very conservative nozzle loading and inertial loading. Consequently, the bolt analyses were redone using SME inertial loading and Bechtel calculated nozzle reactions for normal and SSE loading with the SSE loading scaled upward to reflect an upper bound on SME. The more accurate evaluation of anchor bolt loading resulted in significantly larger margins relative to code allowable than calculated in the design analysis.

The resulting safety factors relative to the SME demonstrate both structural and functional cpacity for seismic events significantly larger than the SME.

Critical Section	Failure Mode	Basis for Allowable	F_{SME} Code	F_{SME} Code
Pump Attachment	Tension and Shear in Bolt	ASME, NF	6.7	NA
Anchor Bolts	Tension and Shear in Bolt	AISC, NUREG-0800	14.0	NA
Anchor Bolt Embedment	Concrete Pullout	PCI Design Handbook	19.5	NA
Shaft	Deflection at Impeller	Vendor Specified	NA	28.2
Coupling	Deflection	Vendor Specified	NA	33.3
Suction Flange	Structural	ASME, ND	4.02	NA
Suction Flange	Functional (Leakage)	P_{FD} vs Hydro-static Test Pressure	NA	2.56
Discharge Flange	Structural	ASME, ND	2.87	NA
Discharge Flange	Functional (Leakage)	P_{FD} vs Hydro-static Test Pressure	NA	1.76
Discharge Flange	Functional (Leakage)	ANSI B16.5 Rated Pressure	NA	2.93