Northern States Power Company

Monticello Nuclear Generating Plant
2807 West Hwy 75
Monticello, Minnesota 55362-9637

April 17, 1998

US Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

MONTICELLO NUCLEAR GENERATING PLANT
Docket No. 50-263 License No. DPR-22

Submittal of Information Regarding the Seismic Verification of the MSIV Leakage Path at Monticello (TAC No. 96238)

Ref. 1 Letter from M.H. Hammer, NSP, to NRC Document Control Desk, "NSP Response to Supplemental Request for Additional Information Concerning the Monticello Nuclear Generation Plant Power Rerate Program (TAC No. M96238)," March 26, 1998

By letter dated March 26, 1998 (Ref. 1), NSP informed the staff of its intent to take credit for fission product removal in the main steam lines and the condenser in certain Monticello accident scenarios under rerate operating conditions. In March 1998, a conference call was held between the staff and NSP regarding this issue. NSP stated that it would provide supplemental information on the seismic qualification of the MSIV leakage path to the condenser. This information is provided as Attachment 2 to this letter.

Please contact Joel Beres at (612) 295-1436 if additional information is required.

M Hammer

Michael F. Hammer
Plant Manager
Monticello Nuclear Generating Plant

c: Regional Administrator - III, NRC
NRR Project Manager, NRC
Sr. Resident Inspector, NRC
State of Minnesota, Attn: Kris Sanda
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Attachments
Attachment 1 NRC Affidavit
Attachment 2 Seismic Verification of MSIV Leakage Path

UNITED STATES NUCLEAR REGULATORY COMMISSION

NORTHERN STATES POWER COMPANY

MONTICELLO NUCLEAR GENERATING PLANT DOCKET NO. 50-263

Submittal of Information Regarding the Seismic Verification of the MSIV Leakage Path at Monticello (TAC No. 97781)

Northern States Power Company, a Minnesota corporation, by letter dated April 17, 1998 provides its response for the Monticello Nuclear Generating Plant to a US Nuclear Regulatory Commission (NRC) request for additional information pursuant to a conference call between the NRC staff and NSP in March 1998. This letter contains no restricted or other defense information.

NORTHERN STATES POWER COMPANY

By M F Hammer
Michael F. Hammer
Plant Manager
Monticello Nuclear Generating Plant

On this 17th day of April 1998 before me a notary public in and for said County, personally appeared Michael F. Hammer, Plant Manager, Monticello Nuclear Generating Plant, and being first duly sworn acknowledged that he is authorized to execute this document on behalf of Northern States Power Company, and that to the best of his knowledge, information, and belief the statements made in it are true.

Samuel I. Shirey
Samuel I. Shirey
Notary Public - Minnesota
Sherburne County

SAMUEL I. SHIREY
NOTARY PUBLIC - MINNESOTA
My Comm. Exp. Jan. 31, 2000

Attachment 2

Seismic Verification of MSIV Leakage Path

Report Outline

1.0 Introduction

The Monticello Nuclear Generating Plant (MNGP) power rerate radiological analysis has taken credit for deposition and holdup of radioactive iodine in the steam lines downstream of the MSIVs and in the main condenser. The main condenser and a pathway from the MSIVs were assessed to assure they would retain sufficient structural integrity following a safe shutdown earthquake (SSE) to transport the MSIV leakage.

The methodology suggested in NEDC-31858P (Reference 3) was used to seismically verify this pathway. This report will discuss the applicability of this methodology for Monticello and how this methodology was used for the seismic verification of the pathway. This report will summarize the seismic evaluation that was performed for the piping and equipment in the Main Steam Isolation Valve (MSIV) leakage path for Monticello. The evaluation demonstrates that a reliable pressure boundary can be maintained downstream of the MSIVs during and after a seismic event.

The method of seismic evaluation relies in part on the use of earthquake experience data and similarity principles. Plant specific analyses of piping and equipment were used in combination with the experience method. The evaluation method and results are described in this report.

The experience method for qualification of nuclear plant equipment is described in references 1, 2, 3, and 4 and also in the supporting documents cited within the references. References 1 and 2 provide guidance on the evaluation of piping. Reference 3 provides an evaluation of the MSIV leakage issue for General Electric boiling water reactors, including Monticello. The SQUG Generic Implementation Procedure (GIP) described in reference 4 is for qualification of certain existing equipment in older nuclear plants and has been reviewed extensively by the Nuclear Regulatory Commission (6).

2.0 Scope of Piping and Equipment

The MSIV leakage pathway utilizes the drain lines from each of the main steam lines. These drain lines are located downstream of the MSIVs and connect into a header which connects to the condenser. Figure 2-1 shows this leakage path from the main steam lines to the condenser. All of the branch lines are not shown on the figure for clarity.

The branch lines which interconnect with the main steam lines between the outboard MSIVs and the stop valves or with the drain lines were included in the scope of the piping that was reviewed. These branch lines were included such that their path was terminated at a piece of equipment that would assure that the MSIV leakage would be confined to the piping system and prevent leakage from going beyond it. This assured that leakage would be transferred to the condenser.

The leakage path piping, equipment and supports are located in the following areas.

Reactor Building	Turbine Building	Recombiner Building
- HPCI Room - RCIC Room - Torus Area - Main Steam Tunnel	- Condenser Bay - SJAE Room - MPV Room - Condenser Bay to SJAE Room Pipe Chase - Condensate Backwash Receiving Tank Room	All areas

To facilitate the walkdown and review, the piping was segmented into 30 walkdown packages. This segmentation was done according to system function, size considerations and, to a lesser extent, plant location. Table 2-1 identifies the piping packages. Table 2-2 presents a summary of the valves, in-line equipment, and attached equipment included in the scope.

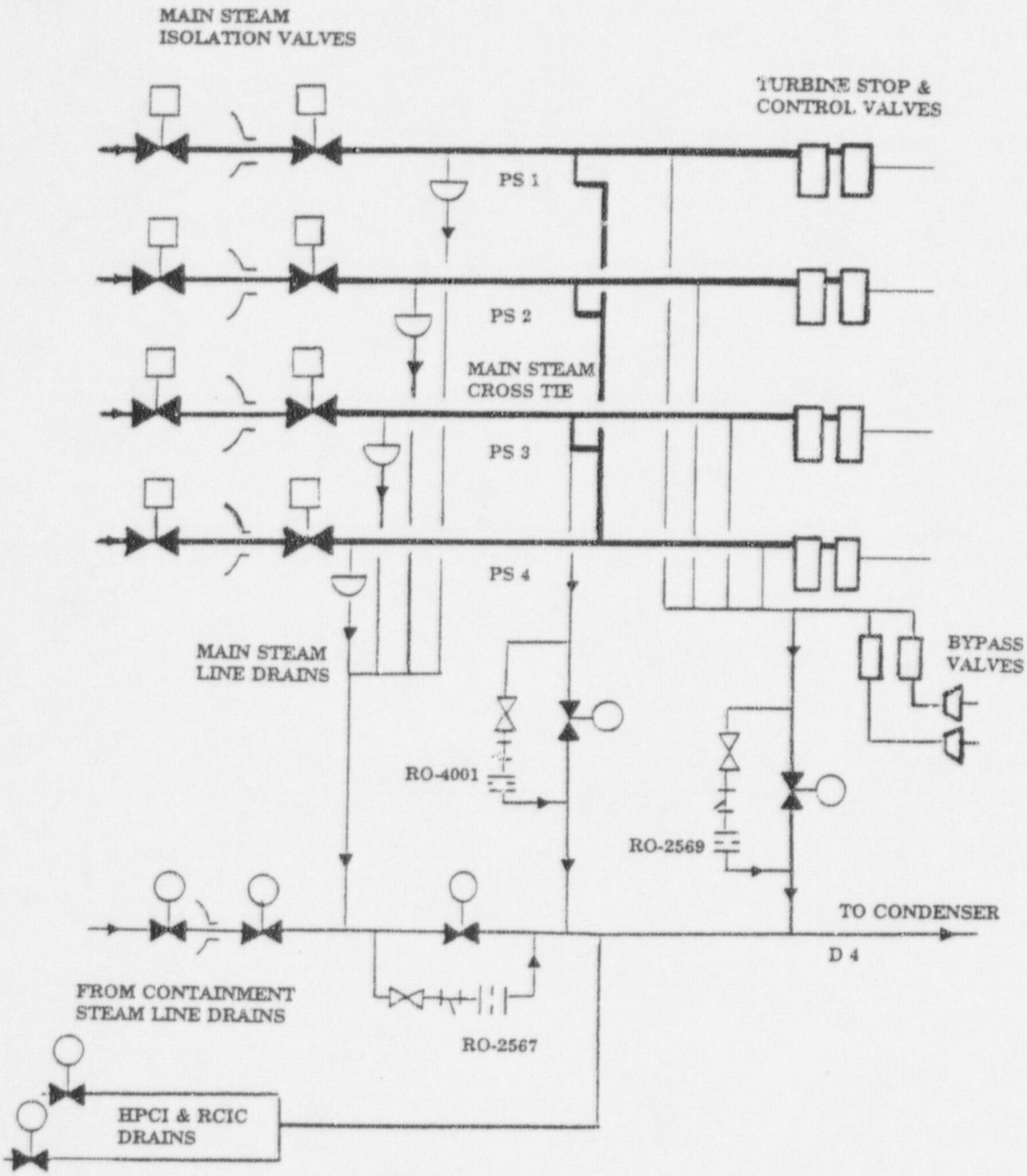


Figure 2-1

Monticello Main Steam Isolation Valve Leakage Pathways to the Main Condenser

Table 2-1: MSIV Piping Package List

Package	Piping System Description	Location
2913-1	Main Steam Drain	Condenser Bay/Steam Tunnel
2913-2	Main Steam Drains	Condenser Bay
2913-3	Pressure Equalizing Lines	Condenser Bay
2913-4	Piping from 10 P57-10-E to M 1617	Condenser Bay
2913-5	Pipe from Condenser Nozzle 8 to SJAE E-2B	SJAE/Pipe Tunnel/Cond. Bay
2913-6	Condenser Nozzle 8 to SJAE E-2B	SJAE/Pipe Tunnel/Cond. Bay
2913-7	RV33-6 -HB lines	SJAE/Pipe Tunnel/Cond. Bay
2913-8	RV34-6 -HB lines	SJAE/Pipe Tunnel/Cond. Bay
2913-9	MS to SJAE E-2A/E-2B	SJAE/Pipe Tunnel/Cond. Bay
2913-10	Air Injector Piping	SJAE Room
2913-11	T72 and T33 Tank Lines	SJAE/MPV/Hallway
2913-12	From SJAE to Tank T72 and Off Gas System	SJAE Room
2913-13	Off Gas Piping	Recombiner Bldg/Buried
2913-14	Off Gas Piping	Recombiner Bldg/Buried
2913-15	Drain Tank Feed and Discharge Lines	SJAE/MPV Rooms
2913-16	Off Gas Steam Tap Line	SJAE/Pipe Tunnel/Cond. Bay
2913-17	Off Gas Small Bore Piping	SJAE/MPV Rooms
2913-18	Off Gas Sample Line	Con. Bay/SJAE/MPV Rooms
2913-19	Off Gas Sample System	SJAE/MPV Rooms
2913-20	SHP System Steam Trap/Dryer	SJAE Room
2913-21	Recombiner Trains	Recombiner Bldg/Buried
2913-22	HPCI Pump Seal Lines	Reactor Building
2913-23	Gland Blower Discharge Line	Reactor Building
2913-24	MO-1739 Equalizing Line	Condenser Bay
2913-25	MO-4000 Equalizing Line	Condenser Bay
2913-26	Pressure Averaging System	Condenser Bay/Turbine Deck
2913-27-1	Steam Seal System, Section 1	Condenser Bay
2913-27-2	Steam Seal System, Section 2	Condenser Bay
2913-27-3	Steam Seal System, Section 3	Condenser Bay
2913-27-4	Steam Seal RV Drain Lines	Condenser Bay
2913-28	HPCI/RCIC Control Lines	Reactor Building
2913-29	Off Gas Blower Discharge	Buried/SJAE Room
2913-30	Hydrogen Water Chemistry System	Recombiner Bldg
2913-31	Main Steam Stop Valve Drains	Condenser Bay
2913-32	Bypass Valve Disharge Lines	Condenser Bay
2913-33	Backwash Tank Drain Line	Backwash Tank Room/Hallway
2913-34	Pump P-3 Feed/Discharge Pipe	MVP Room
2913-35	T72 Tank Drain/Control Lines	MPV Room
2913-36	SJAE Drain Lines	SJAE Room
2913-37	Various I&C Lines	SJAE Room/Condenser Bay
2913-38	V813 Tank Drain/Level Lines	Condenser Bay
2913-39	Feedwater Heater Steam Trap Drain Lines	Condenser Bay
2913-40	Misc Main Steam Drains and I&C Lines	Condenser Bay

Table 2-2: MSIV Leakage Path Equipment List

Equipment ID(s)	Description
17-104	SAMPLE CHAMBER
17-116	OFF GAS SAMPLE RACK
17-136	OFF GAS SAMPLE BOX
AO-1083A, AO-1083B	11 CDSR SUCT. ISOL.
AO-1084A, AO-1084B	12 CDSR SUCT ISOL
SV-1, SV-2, SV-3, SV-4	TURBINE HIGH PRESSURE STOP VALVES
CV-1242, CV-1243	SJAE STEAM SUPPLY
CV-2046A, CV-2046B	STEAM DRAIN TO MAIN CONDENSER
CV-2082A, CV-2082B	RCIC STEAM LINE DRAIN TO MAIN CONDENSER
CV-4164, CV-4165	HWC O_2 FLOW TO RECOMBINER CONTROL VALVE
E-1A, E-1B	HIGH PRESSURE, LOW PRESSURE CONDENSER
E-204	HPCI GLAND SEAL CONDENSER
E-2A, E-2B	AIR EJECTORS
E-4	STEAM PACKING EXHAUSTER
K-200	GLAND SEAL BLOWER
K-3A, K-3B	STEAM PACKING EXHAUSTER BLOWERS
LCV-7581	V-813 24" DELAY TANK VALVE
MO-1048, MO-1049	STM PACKING EXHAUSTER BLOWER DISCH VALVES
MO-2374	MAIN STEAM LINE DRAIN - OUTBOARD
MO-2564	STEAM LINE DRAIN DOWNSTREAM MSIVs
MO-2565	STEAM LINE DRAIN ORIFICE BYPASS
MO-1045	STEAM SEAL REG FEED VALVE
MO-4000	MAIN HEADER PRESSURE EQUALIZER DRAIN
MOIST-SEP	MOISTURE SEPARATOR
PCV-7489A, PCV-7489B	A RECMB TRAIN OG INLET VALVES
PCV-7496A PCV-7496B	OFFGAS BYPASS RETURN TO CONDENSER
PCV-7497A, PCV-7497B	OG STEAM SUPPLY VALVES
PCV-7498A, PCV-7498B	OG TRAIN STEAM SUPPLY VALVES
RV-1007, RV-1011	SAFETY/RELIEF VALVE
RV-1212, RV-1213	SAFETY/RELIEF VALVE
RV-1244, RV-1245	SJAE STEAM SUPPLY RELIEF VALVES
T-33	CONDENSATE BACKWASH RECOVERY TANK
T-72	SEPARATOR TANK
V-813	DRAIN COLLECTOR TANK
V-F-11	HIGH EFFICIENCY FILTER

3. Application of Experience Data

Recent work by the NRC and the US nuclear industry addressed systems interaction in nuclear power plants (NRC Unresolved Safety Issue A-17) and seismic qualification of equipment in operating nuclear power plants (NRC Unresolved Safety Issue A-46). This work has demonstrated that many non-seismically designed structures, systems, equipment and components have substantial inherent seismic ruggedness.

The Seismic Qualification Utility Group (SQUG) was formed in 1981 after an agreement with the NRC to develop alternative methods to resolve seismic safety issues for critical systems and components in operating nuclear stations. The primary method of evaluation developed by SQUG and the USNRC uses empirical data from past earthquakes and from shake table tests (seismic experience data).

Specific objectives of the seismic experience data approach include:

> Documentation of the most common causes of seismic damage or operational difficulties in facilities that contain structures, systems, equipment and components similar to those in nuclear stations.
>
> Credible definition of the threshold of seismic motion for various types of documented earthquake damage and shake table tests.
>
> Identification of structures, systems, equipment and components that typically are not damaged in earthquakes much larger than design basis earthquakes for nuclear stations and other facilities and in shake table tests. These data provide insights to actual seismic design margin.
>
> Development of seismic integrity criteria that can credibly predict the performance of structures, systems, equipment and components in future earthquakes.

It is important to note that the overall objective of seismic design is to provide assurance that nuclear safety functions will not be compromised in the event of the design basis earthquake and not necessarily to provide assurance that no damage will occur.

3.1. Experience-Based Piping Capacity

Experience from past strong motion earthquakes in conventional power plant and industrial facilities indicates that piping systems designed to industrial standards are rugged and can resist earthquakes of at least 0.5g PGA [1-3]. This includes piping systems which were not explicitly seismically designed. For all strong motion earthquakes affecting power stations in the United States since 1952, the amount of piping system failures observed was a very small percentage (much less than 0.01 percent) of the total piping at risk. This leads to the conclusion that failure of piping in earthquakes is caused primarily by local conditions of weakness in the piping systems rather than global conditions of piping design or construction. Primary concerns associated with potential local failures of the piping systems are identified as follows:

(a) Relatively low piping flexibility in regions of relatively large displacement resulting from attachment to building structures, massive equipment or other piping.

(b) Low piping ductility associated with the use of cast iron, PVC or other low-ductility materials.

(c) Threaded pipe joints or other regions of reduced cross section with sharp corners susceptible to fatigue, ratchet cracking, or rupture when subjected to cyclic seismic loads.

(d) Regions of degraded pipe caused by corrosion or erosion.

(e) Weak joints associated with friction type connections, or weak joints or repairs which result from poor welding.

(f) Failure of piping associated with loss of non-ductile pipe supports.

These conclusions have been documented by several organizations including Stevenson & Associates [1, 2], EPRI [27-29], EQE, Inc. [30, 31] and several other organizations [32-37]. Recent work conducted by the BWROG [3, 42] further validated, confirmed and supported these conclusions.

For this effort, walkdowns which compared the subject piping systems to piping systems which have actually experienced strong motion earthquakes (experience data) were used to verify the seismic adequacy of the main steam piping leakage path. The overall approach was developed from the suggested approaches and data put forth by Stevenson & Associates [1, 38] and the BWROG [3]. Similar procedures developed by the Department of Energy (DOE) for use in evaluation of the seismic capacity of piping systems at DOE defense nuclear facilities [12-13] were also considered. This process differs from the practice used historically in the nuclear power industry where the seismic adequacy of piping systems has been determined by analysis.

The spectra which was used in the establishment of the piping seismic capacity was based on the experience surveys and evaluations conducted in References [1], [2], and [3]. In Reference [1], Stevenson and Associates established a *bounding spectra* for the use in the evaluation of piping seismic capacity to resist strong motion earthquakes. This bounding spectra, as discussed in Reference 44, Appendix A, was developed from a reference spectra based on damage surveys at various industrial power facilities subjected to 4 strong motion earthquakes listed below.

(a) The 1971 San Fernando Earthquake
- Sylmer Converter Station and Rinaldi Receiving Station

(b) The 1979 Imperial Valley Earthquake
- El Centro Steam Plant

(c) The 1983 Coalinga Earthquake
- Pleasant Valley Pumping Station

(d) 1985 Chile Earthquake
- Llolleo Facilities
- San Pedro Facilities

Damage surveys at these facilities indicated a very low piping failure (<0.01%) and concluded this failure rate was a result of isolated local weakness in piping systems which could be best screened by an in-plant walkdown. Reference [1] established the *Reference Spectrum* as a spectrum which was the average of these four strong motion earthquakes. Considering the historical damage studies conducted (experience data reviews), Reference [1] established a piping bounding capacity spectrum for welded steel piping subjected to strong motion earthquake of 0.67 times the Reference Spectrum. Figure 3-1 shows the Reference Spectrum, the Bounding Spectrum, and the MNGP safe shutdown earthquake (SSE) ground spectrum (the SSE ground spectrum is discussed later).

Reference [1] established the bounding spectrum as applicable to the establishment of the seismic capacity, based on experience data, for welded steel piping located at an elevation up to 40 feet above grade. In addition, for piping at elevations higher than 40 feet above grade, reference [1] established the following capacity spectra:

(a) If the seismic demand prediction is based on a realistic median centered amplified floor response spectrum, the applicable experience-based capacity spectrum would be 1.5 times the bounding spectrum.

(b) If the seismic demand prediction is based on a conservative (Regulatory Guide 1.60) amplified floor response spectrum, the capacity spectrum would be 2.25 times the bounding spectrum.

The study further provided that for systems containing non-welded joints (e.g., threaded fittings) the applicable spectra (bounding spectra or factored bounding spectra) should be reduced by an additional factor of 0.67 to establish the seismic capacity of such joints.

Appendix D of Reference [3] describes the review and survey of piping experience data in relationship to main steam piping and condensers. The conclusions of this review are consistent with Reference [1] and [2] in that piping failures were found to be the result of isolated piping system weakness which are best identified by a walkdown screening evaluation. Figure 4.1 of Appendix D of Reference [3] presents ground spectra at several of the survey sites and also shows the MNGP Design Response Spectrum. Figure 3-2 presents a comparison of the piping bounding spectrum to the survey site ground spectra presented in Reference [3] and to the MNGP SSE ground spectrum.

Reference [2] provides the results of an extensive study and survey of piping systems subjected to strong motion earthquakes. This survey included compilation of earthquake experience performance data on over 1,000,000 feet of piping at 34 power facilities. The power stations investigated in these studies experienced ground accelerations and response which are consistent with the use of the bounding spectrum [1].

As can be seen in Figure 3-3, the piping bounding spectrum established in Reference [1] is enveloped by four very damaging earthquakes in which no significant damage to piping system occurred. Per Figure 3-2 the bounding spectrum is conservative with respect to the earthquakes presented in the Reference [3] investigations, with the notable exception that the 1989 Loma Prieta (Moss Landing) earthquake falls below the bounding spectra for fundamental piping system frequencies above 2.5 Hz. There is significant experience data available [1, 2] which demonstrates the acceptability of the bounding spectra as the experience based piping capacity spectra. This exception for the 1989 Loma Prieta (Mass Landing) earthquake is not of significance in the application of the bounding spectra. Therefore the following was established for the piping capacity spectra for use in the initial piping walk-down and screening evaluation.

(a) For piping less than 40 feet above grade the bounding spectrum will be the applicable capacity spectra.

(b) For piping higher than 40 feet above grade or piping systems for which amplified floor response spectra are available either 1.5 *[Bounding Spectrum], for a Realistic Median Centered Spectrum, or 2.25* [Bounding Spectrum] for a Conservative Design Spectrum will be the applicable capacity spectra. (The actual capacity spectrum used will be discussed in Section 4).

The application of this capacity spectra is closely linked to the requirement that the piping support spacing be consistent with the pipe support spacing observed in the piping experience data [1, 2, 3]. This is insured by conformance to Piping Caveat P1 which is discussed in Section 4.

The MNGP safe shutdown earthquake (SSE) ground response spectrum is shown in Figure 3-1 and Figure 3-2. The corresponding SSE horizontal peak ground acceleration (PGA) is 0.12g. The MNGP SSE ground spectrum is enveloped by the Bounding Spectrum and the spectra considered in the Reference [3] study.

3.2. Experience-Based Condenser Capacity

An evaluation of the seismic ruggedness of condensers and condenser anchorage for GE BWR plants is reported in Reference [3]. The configurations of the GE BWR condensers were compared to condensers in the earthquake experience data. Condensers in the earthquake experience data exhibited substantial seismic ruggedness even when they were not designed to resist earthquakes. Comparisons of condenser designs in GE Mark I, II, and III plants with those in the earthquake experience data revealed the GE plant designs are similar to those that exhibited good earthquake performance. The study concluded that for GE BWR sites including Monticello, a failure and significant breach of pressure boundary in the event of a design basis earthquake is highly unlikely and contrary to a large body of historical experience data. The conclusions of that study were verified by detailed comparison of the Monticello condenser configuration to the earthquake experience data. The comparison included a detailed evaluation of the Monticello condenser anchorage.

3.3. Experience-Based Capacity of Related Equipment

Other equipment in the scope of this review includes valves, instruments, and pressure vessels. This group of items is referred to as *Related Equipment* in this report. The SQUG Generic Implementation Procedure (GIP) methodology, documented in reference 4, is well suited to address the seismic adequacy of these items. The GIP provides a formal procedure for evaluating these classes of equipment against the earthquake experience data. The GIP has been extensively reviewed by the NRC [6] and has been widely used in the nuclear power industry for resolution of Unresolved Safety Issue A-46. The implementation of the GIP procedure for resolution of USI A-46 at Monticello is reported in Reference [26].

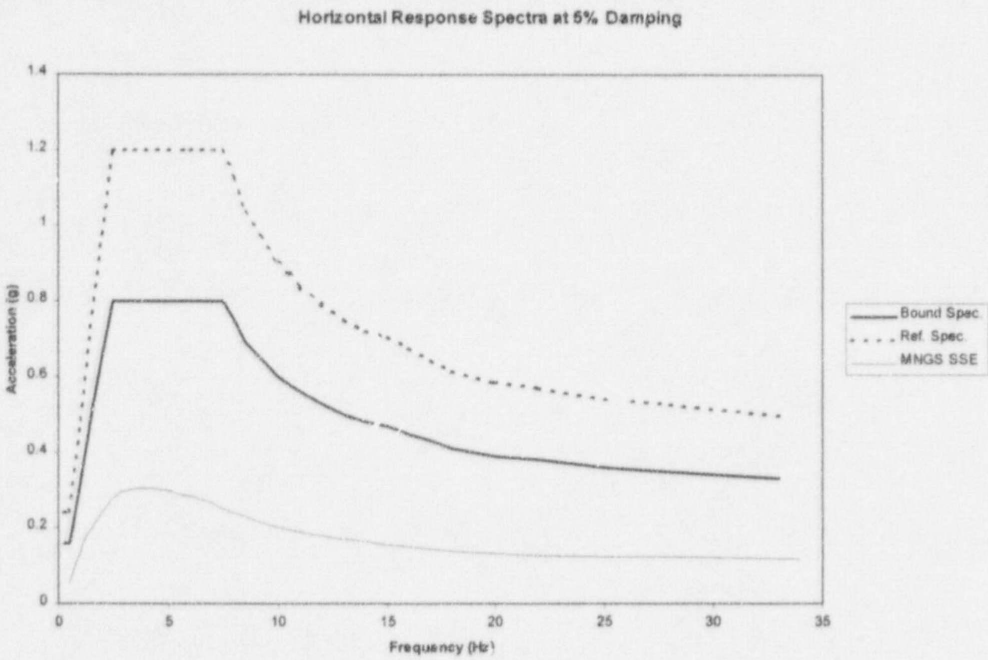


Figure 3-1: Bounding Spectrum, Reference Spectrum and MNGP SSE ground spectrum

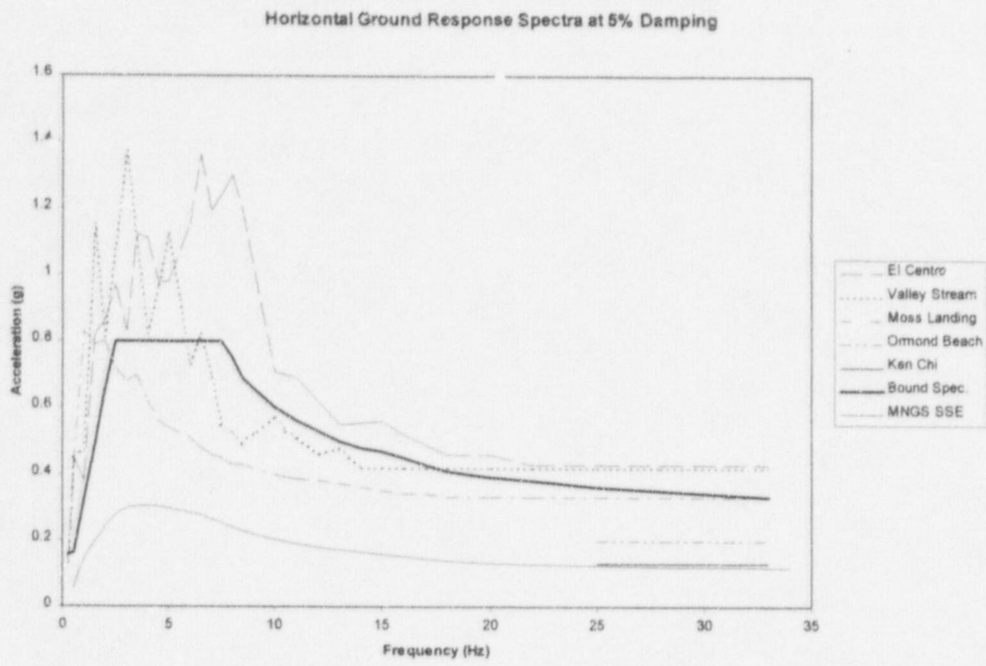


Figure 3-2: Spectra from Reference [3], Bounding Spectrum, and MNGP SSE ground spectrum

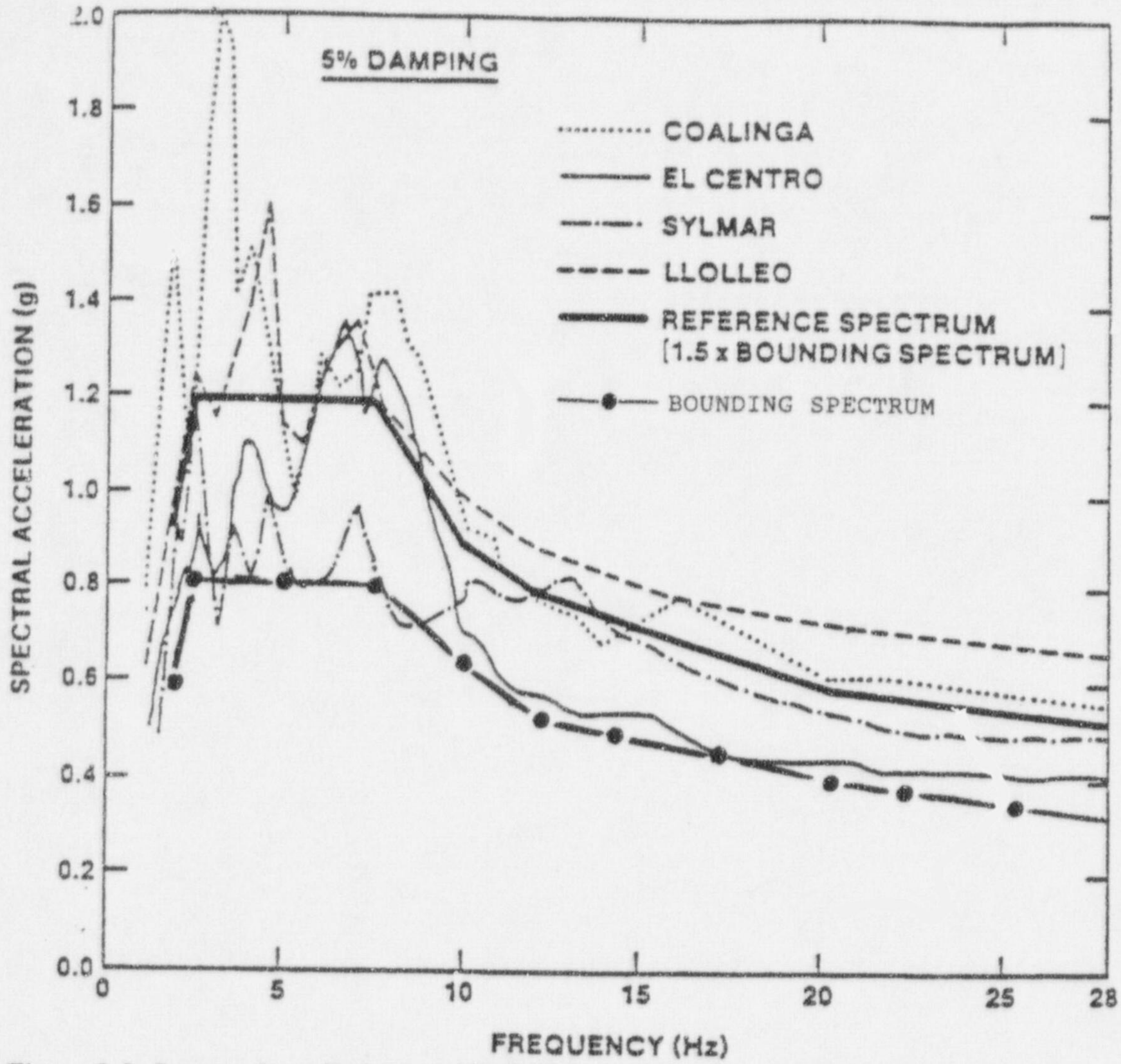


Figure 3-3: Spectra from Reference [1], Reference Spectrum and Bounding Spectrum

4. Seismic Evaluation Methodology

4.1. Piping and Supports

The evaluation of piping included of the following steps.

(a) Walkdowns of the piping systems and associated supports
(b) Piping System demand versus experience-based capacity comparison
(c) For each walkdown package, identification of any items judged to have inadequate seismic capacity, worst case supports, systems requiring limited analytical reviews and a worst case piping system for limited analytical review
(d) Limited analytical reviews for systems identified above
(e) Worst case pipe support evaluations
(f) Suggestions for the necessary piping system and component modifications
(g) Generation of Piping System Seismic Screening Work Sheet (PSSSWS) which documented the walkdown, the limited analytical reviews, the worst case support evaluations, and the final seismic capacity evaluation

The sections below provide details on the evaluation methodology for piping and supports. Included are caveats for comparison to experience data and criteria for supporting analyses.

4.1.1. Comparison to the Experience Data

The leakage path piping is compared to the piping in the experience data to insure the piping systems under review fall within the data base piping summarized in References [1], [2], [3] and [43]. Key parameters in the comparison are include the following.

(a) Piping is fabricated and designed to B31.1, B31.3 or ASME BPVC Section III.
(b) Piping sizes and materials fabrication fall within experience data.
(c) Piping support vertical and lateral span ratios fall within the data base assumed by verifying the following span criteria is met:

(1) For Welded Steel Pipe:
- Vertical Spans are less than (1.5) times the suggested B31.1 Deadweight Spans.
- Horizontal Spans are less than six times the suggested B31.1 Deadweight Spans.

(2) For Threaded Steel Pipe:
- Vertical Spans are less than (1.5) times the suggested B31.1 Deadweight Spans.
- Horizontal Spans are less than four times the suggested B31.1 Deadweight Spans.

These span criteria were based on a review of the data in reference [2] and the recommendations of reference [1].

(d) Piping operating pressures and temperatures fall within the experience data.
(e) Piping does not exhibit known failure modes or area of potential weakness as discussed below.
(f) Piping support system is adequate, consistent with the piping systems in the experience data, and would be expected to exhibit a ductile failure mode.

The review and comparison to the experience data was accomplished by walkdown of each piping system and completion of a PSSSWS. This checklist was developed to insure a systematic, consistent, and logical approach was applied to the verification of seismic adequacy of the piping systems. The caveats on the checklist were developed to insure that during the walkdown the system is adequately reviewed and to insure that the system does not exhibit the known failure modes that have been observed in the piping experience data.

Descriptions of the piping system caveats are given below. In addition, a summary comparison was performed for the Monticello leakage path piping as reported in Section 5. For that comparison, materials, sizes, spans and temperature ranges were compared to piping in the experience data to verify that the Monticello piping is adequately represented in the experience data.

Piping System Caveats

Caveat P1/P2 - Piping Maximum Span and Joint Types.
This caveat is related to the demand/capacity review and insures the piping span criteria established in the previous section is met.

Caveat P3 - Piping to Pipe Support Connection.
This caveat requires that the piping system shall be restrained by its supports so that it cannot fall off the supports when subjected to a lateral force associated with a design basis earthquake.

Caveat P4 - Beam Clamps.
This caveat requires that if beam clamps are used to attach piping supports to the building structure, they should not be orientated in such a way that gravity loads are resisted only by the clamping or frictional forces developed by the clamps. If beam clamps are oriented so the gravity load is resisted only by the clamping frictional force, they may loosen and slip off during an earthquake.

Caveat P5 - Corrosion and Erosion.
This caveat requires that excessive corrosion of piping supports, or anchorage should be identified when such corrosion or erosion exceeds 10 percent of the cross-sectional area of the support or anchor.

Caveats P6 - Broken or Missing Components.
This caveat requires that broken or missing piping system components should be identified for future repair or replacement.

Caveat P7 - Hard Spots.
This caveat requires the evaluation of stiff supports in long flexible runs of piping to determine if the seismic movement of the run could cause the stiff support to fail. The stiff support may thus be subjected to considerable load and fail due to loads from earthquake-induced, longitudinal movement of the piping run.

Caveat P8 - Flexible Joints Adequately Restrained.
This caveat deals with flexible hoses couplings, bellows, etc., and assures that they are restrained so as to limit their motion.

Caveat P9, P10 - Active Valves and Equipment.
These caveats stipulate that all motor, solenoid, or air operated valves which are required to be active during or following the SSE seismic event and all in line equipment meet the requirements of the SQUG-GIP.

Caveat P11, 12 - Run/Branch Displacements.
This caveat requires the Seismic Review Team (SRT) to review the branch piping in the vicinity of run/branch connections to insure the branch line has sufficient flexibility to absorb any expected significant SSE seismic run pipe displacements.

Caveat P13 - Seismic Anchor Motions at Building Joints.
Under this caveat, the SRT is required to review the piping in the area of the building joints to insure it has sufficient flexibility to withstand any significant anticipated relative SSE seismic motion of the building joints.

Caveat P14 - No Concerns with Piping Fabrication.
This caveat provides a mechanism for the SRT to identify any concerns with the piping fabrication and installation.

<u>Piping Support Caveats</u>

Caveat S1 - Ductile Pipe Support.
This caveat requires an assessment of the failure mode of the pipe supports. The SRT should look for items such as undersized welds, cast iron in the load path, etc. which could exhibit a non- ductile (brittle) failure mode.

Caveat S2 - Support Welded or Bolted Connections Meet AISC Specification. This caveat requires a review of bolted connects or welded connections to insure they are consistent with AISC requirements.

Caveat S3 - No Short Rod or Fixed End Rod Fatigue Concerns.
This caveat requires a screening of the rod hangers for potential fatigue failures or for short rods located among long rods.

Caveat S4 - Uni-directional Supports are Acceptable.
This caveat requires that uni-directional supports be evaluated for uplift issues, impact concerns, etc.

Caveat S5 - Corrosion Issues.
This caveat requires a review of the support and support anchorage for any potential corrosion issues.

Caveat S6 - No Concern with Lateral U-bolt Loads.
This requires the SRT to review U-bolts and make an assessment of potential lateral U-bolt loads - considering the significantly reduced capacity of U-bolts for applied lateral loads.

Caveat A1 - Cast-Iron and Lead Anchors.
The procedure requires that rod hangers or other types of supports using anchor embedments or inserts constructed of cast iron or lead be specially evaluated since there is a potential for a non-ductile failure mode. The earthquake experience data base includes examples of the failure of heavily-loaded rod hangers threaded into cast-iron inserts.

Caveat A2-Cracks in Concrete. The procedure stipulates that visible large cracks exceeding 1/32 of an inch in width, significantly spalled concrete, serious honeycomb or other gross defects in the concrete to which the pipe supports are attached creates a situation which should be evaluated for the potential effects on anchorage integrity during an earthquake.

Caveat A3 - Gaps Under Base plates.
The procedure requires that gaps larger than 1/4 inch under base plates for pipe supports should be noted and the base plate and anchorage analyzed for the installed condition to determine design adequacy.

Equipment Considerations.

In many instances, piping systems terminate at mechanical equipment, such as pumps, tanks, etc. There are three items of concern at these equipment piping interface locations.

(a) Anchorage of the equipment
(b) Nozzle loads applied to the equipment by the piping
(c) Equipment displacements applied to the piping system.

The walkdown procedure requires the SRT address these items by meeting Caveats E1 through E3 below. Note that if the piece of equipment under consideration has had its seismic adequacy verified in accordance with the SQUG-GIP then Caveat E1 and E2 are met and only Caveat E3 must be reviewed under this procedure.

Caveat E1 - Adequate Equipment Anchorage.
The unit should be anchored so as to limit its motion during an SSE seismic event.

Caveat E2 - Equipment Nozzle Loads.
The SRT must give consideration to possible situations where the equipment may be affected by excessive SSE seismic induced nozzle loads. The concern is that excessive

force on nozzles could potentially fail the nozzle or transmit loads through equipment nozzle to cause failure of the equipment anchorage.

Caveat E3 - Equipment Seismic Motions.
The SRT is required to review the attached piping to insure it has sufficient flexibility to withstand any significant anticipated SSE seismic displacements at piping/equipment nozzle interface.

<u>Spatial Interaction Caveats</u>

There are four caveats (SI-1 through SI-4) that should apply to evaluate piping spatial interactions which could adversely affect the piping systems being reviewed by this procedure. It must be insured that piping spatial interaction will not adversely affect the piping system or the adjacent systems, structures, or components.

SI-1: Soft Targets in Piping System Free From Impact.
The purpose of this caveat is to insure that during piping system seismic induced motion, items such as valve operators, pressure gauges, etc. will not impact adjacent structures and be damaged.

SI-2 Attached Lines Have Adequate Flexibility.
The purpose of this caveat is to insure that during piping system seismic induced motion, branch lines attached to the piping under review have adequate flexibility to absorb (without pressures, bounding rupture) any applied displacements. This is focused primarily on I/C piping and tubing.

SI-3 Overhead Components or Distribution Systems are not Likely to Collapse.
This caveat requires the SRT to review overhead systems to insure they have adequate seismic capacity such that they won't fall and damage the piping system.

SI-4 No Other Concerns Were Found.
This caveat provides the SRT a means to identify any other spatial interaction concerns.

4.1.2. Limited Analytical Review of Piping and Supports

This section defines the capacity criteria that was used in the limited analytical reviews of piping systems and in the evaluation of worst case supports. The capacity criteria was a stressed based criteria and demand criteria will be in terms of an applicable input seismic excitation level. For specific analytical reviews such as Rod Hanger Fatigue reviews, a different Demand/Capacity criteria was used and was defined in the applicable analytical review package.

For piping systems on which limited analytical reviews or analyses are conducted the capacity criteria was used:

$$P + .75i[(M_A/Z)] \leq 1.0\ S \qquad (4.1)$$

$$P + .75i[(M_A/Z)+(M_{BI}/Z)] \leq 2.4\ S \qquad (4.2)$$

$$i[\ M_C/Z + M_{Bsam}/Z\ ] \leq 2\ S_A \qquad (4.3)$$

P = Pressure Loadings
M_A = Applied Moments Due to Deadweight Loadings
M_{BI} = Applied Moments due to SSE seismic Inertial Loadings
M_{bsam} = Range of Applied SSE Moments due to Seismic Anchor Motion (SAM) Loadings
M_C = Range of Applied Moments due to Thermal Expansion and Thermal Anchor Motions
Z = Piping Section Modulus
S = Allowable Primary Stress limit per the B31.1 Code
S_A = Allowable Expansion Stress range per B31.1 Code
i = Stress intensification factor as defined in the B31.1 Code

Equation 4.1 is the standard deadweight allowable stress equation per the B31.1 Power Piping Code. In equation 4.2, S is the basic allowable material stress per the B31.1 Power piping Code which is the lesser of 5/8 Sy (2/3 Sy in later code editions) or Su/4. The majority of the piping under review is A-106B Carbon steel pipe, which has S=15000 psi, Sy=35000 psi and Su=60000 psi. Therefore Equation 4.2 limits the Pressure + Deadweight + Seismic Inertial Stresses to less than 1.03 Sy which insures elastic behavior. In equation 4.3, S_A for carbon steel pipe is approximately 1.5 S which is approximately 22,500 psi, and therefore 2.0 S_A is approximately 1.2 Sy. These stresses are secondary in nature, and therefore if they are limited to less than 2.0 Sy per reference [7], this will insure that elastic shakedown will occur, no significant membrane stress rupture will occur, and accumulated cyclic damage will be elastic. The 1.28 Sy limit used here is significantly less than the upper bound 2.0 Sy limit and is an acceptable secondary stress limit.

The piping support acceptance criteria used in the worst case support evaluation is as follows:

(a) Structural Steel

DWT+TH 1.0 ≤ AISC Allowable (4.4)
DWT+TH+SSE (Inertia and SAM) ≤ 1.7 AISC Allowable (4.5)

(b) Component Supports

DWT+TH ≤ 1.0 MSS-SP-58 Allowable (4.6)
DWT+TH+SSE (Inertia and SAM) ≤ 1.7 MSS-SP-58 Allowable (4.7)

Per the discussions in reference [8] this will insure that the maximum stresses in the support members are at or slightly less than the material yield stress. It should be noted that in many calculations a factor of 1.6 was used in lieu of 1.7. This adds additional conservatism to the calculations and support evaluations. The 1.7 is based on the Part II allowables of the AISC Steel Construction Manual [18]. Since the basic bending allowable is 0.6 Sy, the use of 1.7 limits the support member bending stress to approximately 1.02 Sy.

4.2. Condenser

The seismic adequacy of the Monticello condenser was verified by reference to the BWROG report on MSIV leakage (reference 3). In Appendix D of reference 3, the seismic demand at earthquake experience sites with condensers was compared to seismic demand at GE BWR sites including Monticello. Condensers of similar configuration to Monticello experienced strong motion in excess of the Monticello design basis earthquake without failure. Reference 3 concluded that a condenser failure from a design basis earthquake at any GE BWR site was highly unlikely. The adequacy of the Monticello condenser was further verified in this effort by a detailed comparison of the Monticello condenser configuration to the earthquake experience data and by a detailed evaluation of the Monticello condenser anchorage.

4.3. Related Equipment Capacity

The seismic adequacy of related equipment was verified using the GIP methodology as detailed in reference 4. Seismic capacity, caveat compliance, anchorage, and seismic spatial interaction concerns were addressed as specified in the GIP. The GIP Bounding Spectrum that was obtained from earthquake experience data was used to establish seismic capacity of all related equipment.

4.4. Seismic Demand

All items are evaluated for the safe shutdown earthquake (SSE) demand. The SSE ground response spectrum is identified in the MNGP Updated Safety Analysis Report. The MNGP SSE ground response spectrum is shown in Figure 3-1. The corresponding SSE horizontal peak ground acceleration (PGA) is 0.12g. The sections below describe SSE input for the equipment under review.

4.4.1. Piping Seismic Demand

Comparison to Experience-Based Capacity Spectrum

The majority of the piping under review is located in the Turbine Building, Recombiner Building, or is buried. A small amount of the piping is located in the Reactor Building including the Steam Tunnel. For the piping in the Turbine Building, Recombiner Building, or buried (all of which is less than 40 feet above grade), the demand spectrum will be the 5% damped MNGP SSE design basis ground Response Spectrum (Figure 3-1). For piping systems in the Reactor Building including the Steam Tunnel, the demand spectra will be the 5% damped design basis amplified floor response spectrum is taken at the applicable elevation and location.

(a) Turbine Building, Recombiner Building, Buried Piping (All < 40 feet above Grade)

The 5% damped Licensing Basis (Design Basis) Ground Response Spectrum will be compared to the Bounding Spectrum.

(b) Reactor Building (including the Steam Tunnels)

The applicable 5% damped amplified floor response Spectrum is compared to 1.5 * the Bounding Spectrum. (Note: Since the Monticello Spectrum is classified as Conservative Design, 2.25*Bounding Spectrum could have been used, however it was decided to use 1.5 to provide additional conservatism for the walk-down screening)

(c) Piping systems containing threaded joints

The bounding spectra (capacity spectra) used above are reduced by 0.67.

Limited Analytical Reviews of Above Ground Piping

For limited analytical reviews of piping in the Turbine Building and the Recombiner building (all of which is less than 40' above grade) when dynamic analysis is applied, the horizontal piping demand is based on the 5% damped ground response spectrum shown in Figure 3-1 multiplied by a factor of 1.5. The vertical demand is 2/3 of the horizontal demand. For piping in the reactor building the horizontal demand will be the applicable 5% damped amplified floor response spectrum and the vertical demand will be 2/3 of the horizontal demand. This spectra is judged to be acceptable for the following reasons.

(a) It is the licensing basis spectrum for the plant.

(b) The piping which is located at elevations less than 40' above grade is in a concrete shear wall building and a significant amount of this piping is below grade near the building foundation. Therefore no significant building amplification of the design basis ground response spectrum would be anticipated. Per the SQUG-GIP for plants with a conservative design basis spectrum, 1.5 times SSE ground response spectrum can be used to approximate in-structure response spectrum when such in-structure response spectrum is not available.

(c) The majority of the piping systems are rod hung systems and will have low fundamental frequencies (less than 10 Hz), and per the work of the PVRC [9,10] the percent system critical damping value applicable to such low frequency systems is at least 5%, and closer to 7% if the piping is insulated. A significant amount of the subject piping is insulated.

(d) The piping capacity criteria is very conservative. This criteria essentially limits the piping and piping support member stresses to less than yield. There is additional inelastic energy absorption of the ductile piping and piping support materials for which no credit is taken in the capacity criteria.

(e) The Monticello spectrum is classified as "Conservative Design," [26] and therefore the use of 5% damping provides a conservative yet more realistic estimate of the required earthquake demand.

For limited analytical reviews of piping systems when static analysis techniques are applied, applied demand was 1.5 times the peak of the ground response spectrum in the horizontal direction and 1.5 times two thirds of the peak of the ground response spectrum in the vertical direction.

Limited Analytical Review of Buried Piping System

For the evaluation of buried piping systems, the seismic demand is the design basis SSE ground response spectrum.

Worst Case Support Reviews

Seismic loads for use in worst case support reviews is determined as follows.

(a) Determine the a span length of piping which would be expected to be restrained by the support in question. This span length should include an additional equivalent length of piping for included valves, or other in-line components.

(b) Determine the total weight per unit length of piping considering pipe material weight, fluid weight, insulation weight, and any other weights in the piping system.

(c) Multiple the total unit weight of (2) times the total length of piping to be considered per (1).

(d) For determination of horizontal loads multiply value determine in (3) by the peak of the applicable horizontal response spectrum. For vertical loads use 2/3 of the horizontal value.

4.4.2. Condenser Demand Spectra

The Monticello condenser is located at the lowest level of the Turbine Building (Elevation 911). The applied seismic demand was the SSE ground spectrum shown in Figure 3-1.

4.4.3. Other Equipment Demand Spectra

Applied seismic demand for related equipment is based on the SSE ground spectrum shown in Figure 3-1 and the corresponding floor response spectra (FRS). Consistent with the Monticello USAR, the Reactor Building FRS at an equivalent elevation is used to define the FRS for equipment in buildings other than the EFT Building. No related equipment is located in the EFT building, therefore Reactor Building FRS can be applied in all cases. These FRS were also used for USI A-46 resolution and were judged to be "conservative design" spectra when used with the GIP [26]. Consistent with the GIP methodology, 1.5 times the ground spectrum was optionally used as "realistic, median centered" demand for items meeting the GIP 40-foot-above-grade elevation limitation and the 8 Hertz lower bound frequency limitation.

4.5. Seismic Review Team Members

An important consideration for the application of this method is the capabilities of the SRT. The Seismic Review Team for this effort consisted of two qualified Seismic Capacity Engineers both with greater than 15 years experience in the seismic design and analysis of piping systems, piping system supports, and mechanical and electrical equipment. The SRT team members possess extensive knowledge in the following.

(a) The performance of piping systems and piping system supports during strong motion earthquakes in industrial and nuclear power plants.

(b) Commercial piping and piping support design codes and standards.

(c) The valve qualification and anchorage evaluation procedures given in the SQUG-GIP.

(d) Seismic design and analysis practices for nuclear plant piping systems and piping system supports (including anchorage design).

The SRT for this program included Dennis Zercher of NSP and Timothy Adams and John O'Sullivan of Stevenson and Associates. Each of these team members has completed the SQUG-GIP training course.

5. Summary of Seismic Evaluation Results

5.1. Piping and Supports

5.1.1. Results Summary

The piping material data, size, and schedules were obtained from piping and instrument diagrams (P&IDs) and line specifications. The line specifications also provide the design pressure and temperature data. Exceptions to the above were the GE supplied Steam Seal System and Moisture Separator Systems. Material and pipe size data for this system was taken from GE documents.

The piping in all buildings but the Recombiner Building was designed to the B31.1 Code-1967 Edition. The piping in the Recombiner building was initially designed to the ASME BPVC Section III, Subsection ND, 1971 edition. This was done because the piping was originally specified as safety class. The piping classification was later changed to non-safety related, and the piping was installed to the requirements of the B31.1 Code 1973 edition. Insulation data was obtained by field observation; weight data was estimated using Reference [17] in conjunction with field data. Valve weight was taken from valve drawings if available or estimated from Reference [17].

Piping supports were either MSS-SP-58 standard supports, structural steel, Unistrut (cold formed steel) or some combination of these items. The structural steel was assumed to be A-36 steel specified by the 6th Edition AISC-SCM [18]. The MSS-SP-58 supports were assumed to be supplied by Bergen-Patterson (B-P) and the B-P load rating data was used [19]. It should be noted that the B-P ratings are industry typical and very similar to the load ratings provided by other pipe support vendors. The allowable Unistrut loadings were supplied taken from data supplied by the Unistrut Company [20].

The walkdowns were conducted over several intervals from April 1996 through June 1997. The walkdowns (using PSSSWS) evaluated the seismic capacity of the subject piping system. As part of the walkdown, pipe supports, equipment supports and other modifications to reduce the seismic vulnerability piping system being screened were specified. These modifications were then considered in the evaluation of the acceptability of the piping systems. As modifications were installed in the plant, as-built drawings were reviewed and considered in the generation of the final PSSSWS. If necessary a detailed evaluation and verification calculation was conducted for the as-built modifications.

Worst case supports were identified and a detailed evaluation was conducted for these supports. Rod hangers susceptible to fatigue failure, "hard spot" short rod hangers, and U-bolts subjected to significant lateral loads were identified. Detailed evaluations were conducted to evaluate both the fatigue capacity of the rod hangars and the lateral load capacity of the U-bolts.

Finally the discharge side of the steam seal system was determined to be the worst case piping system based on the size of the system and its support configuration. For this system a detailed analysis (using the criteria of ASME BPVC, Appendix N) was conducted. In addition, limited analytical reviews were conducted for portions of other piping systems which could be considered outside the screening criteria, which involved complex spatial interactions, or for which a highly accurate prediction of piping support loads was required. One unique analytical review was conducted for all buried piping systems.

5.1.2. Further Correlation with the Piping Experience Data

After completion of the piping system walkdowns, additional comparisons and reviews were conducted to insure that the Monticello piping systems fall within the range of the piping systems which constitute the experience data.

Piping Sizes

Table 5-1 presents a summary of the various piping, sizes, schedules and D/t ratios for each of the Walkdown Packages. Table 5-2 presents a general summary of the same data for the piping systems which constitute the experience data. More detailed summaries of the piping which constitutes the experience data are contained in Reference [2], [3] and [42]. Table 5-3 presents a comparison of the D/t ranges of the subject Monticello piping to the piping which constitutes the experience data. The subject Monticello piping systems are enveloped by the experience data with the following exceptions.

1. The experience data does not specifically identify the existence of 3-1/2" and 5" diameter piping.
2. The subject Monticello 1" piping has lower bound D/t of 4 versus 5 in the experience data.
3. The subject Monticello 24" piping has lower bound D/t ratio 20 versus 23 in the experience data.
4. The subject 18" Monticello piping has an upper bound D/t ratio 48 versus 43 in the experience data.

For items (2) and (3), these lower D/t ratios are due to the use of thicker wall piping which would be stronger and have higher capacity than the experience data piping and therefore are not of concern. For (4), the exceedance is only 12 percent which is less than typical piping system fabrication tolerances. Therefore, this piping is adequately represented in the experience data. The 3 1/2" diameter piping and the 5" diameter, although not explicitly in the database, are enveloped by larger and smaller sizes. Further, the 5" and 3 1/2" piping is in the steam seal system which was analyzed in detail. Therefore, this piping is adequately enveloped by the experience data and the supporting analysis.

Pressure Ranges

The experience data contained piping with operating pressures between 0 psig and greater than 3000 psig which envelopes the pressures of the subject Monticello piping which is 0 psig to 1250 psig.

Materials

Table 5.4(a) provides a summary of the allowable stress capacity of the predominant piping materials of the experience data piping. Table 5.4(b) provides a similar summary for the subject Monticello piping. As can be seen by reviewing the tables, the subject Monticello piping is adequately represented in the experience data piping.

Support Spans

Table 5.5 provides a summary for each walkdown package of minimum and maximum ratios of the actual vertical support spans to the suggested B31.1 deadweight spans and the actual lateral support spans to the suggested B31.1 spans. Table 5.6 provides the suggested B31.1 deadweight support spans. Figures 5-1 through 5-4 compare the subject Monticello piping maximum span ratios, Vertical Support Ratio (VSR) and Lateral to Vertical Support Span Ratio (LVSSR), to the experience piping span ratio data tabulated in Ref. [2]. As can be seen from these figures, the subject Monticello piping support spans are well represented and adequately enveloped by the piping experience data.

5.1.3. Conclusions

The results of the walkdown evaluations and correlation to experience data verify that the piping systems are seismically adequate if the outstanding items, identified as outliers, are resolved. All outliers and modifications are discussed in Section 5.4.

5.2. Condenser

Table 5-7 lists design data for the Monticello condenser and for the two experience data sites listed in Reference [3], Appendix D, Table 4-3 (Moss Landing 6 & 7, and Ormond Beach 1 & 2). The Monticello condenser design data is similar to or bounded by data for the two experience data sites. Per Figure 3-2, the Monticello SSE ground spectrum, which is the demand spectrum for the condenser, is enveloped by the Moss landing and Ormond Beach spectra. The Monticello condenser design data is also well represented by the data presented in Reference [3], Appendix D, Table 4-3. The comparison verifies that the results of the Reference [3] evaluation for structural integrity are applicable to the Monticello condenser.

The Monticello condenser anchorage consists of eight guided supports, one at each corner of the two condenser shells. At each support, the condenser base bears against a steel plate "shear lug" that is welded to an embedded sole plate. The shear lugs rigidly resist lateral loads but are arranged to allow thermal growth. Three 1.75 inch diameter cast-in-place anchor bolts are also located at each support (24 total). These bolts resist vacuum uplift loads. Companion bolt holes in the condenser base are 2.75 inches in diameter to allow for thermal growth. Figures 5-5 and 5-6 show guided support layout and details.

Reference 3, Appendix D evaluated lower and upper bound anchorage capacities of experience data and GE BWR condensers. For this evaluation, two capacity levels specific to the Monticello condenser were determined by detailed calculation (for rigid then ductile behavior). Capacities were derived from code based equations for capacities of anchorage elements (e.g., AISC Manual of Steel Construction, ACI-349). Capacities were defined in terms of allowed lateral acceleration. Considering oversized holes for bolts and potentially non-ductile failure of shear lugs, the calculations conservatively assume that cast-in-place bolts will not resist load in combination with the shear lugs.

For Monticello, a rigid-behavior anchorage capacity was obtained by crediting only the shear lug load path at a support. Based on detailed evaluation, the rigid-behavior capacity of the condenser anchorage was determined to be 0.15g. The capacity is controlled by the direction transverse to the turbine axis. The shear lug load path capacity parallel to the turbine axis is 0.16g.

A ductile-behavior anchorage capacity was obtained by crediting only the cast-in-place anchor bolts. The shear lug load path was assumed to fail in a brittle manner prior to bolt engagement and is given no credit in the ductile-behavior calculation. Based on detailed evaluation, the ductile-behavior capacity of the condenser anchorage transverse to the turbine axis was determined to be 0.24g. Parallel direction capacity is similar to transverse direction capacity.

The rigid-behavior capacity of 0.15g exceeds the SSE PGA of 0.12g. The condenser shells are squat steel plated box structures with substantial internal stiffening and the condenser is considered to be effectively rigid. Therefore rigid-behavior capacity exceeds SSE demand of 0.12g.

These Monticello anchorage parameters can be also compared to those plotted in Figures 4-10 and 4-11 of Appendix D, Reference [3], where

> Lower Bound Shear area of shear lugs considering linear load distribution and stiffer of potential load paths.
>
> Upper Bound Total shear area considering shear lugs and bolts with potential to act in the direction of the load.

The Monticello lower and upper bound shear areas for the transverse direction are 0.000078 and 0.00021 square inches per pound respectively. The values for the parallel direction are 0.00010 and 0.00023 square inches per pound. These values are above corresponding values for the experience data sites shown in Figures 4-10 and 4-11.

The comparison of condenser data and the anchorage capacity calculations verify for the Monticello condenser the conclusions presented in Reference [3], Appendix D. That is, a [illegible] significant breach of pressure boundary in the event of a design basis earthquake is highly unlikely and contrary to a large body of historical experience data.

The condenser was also subject to a walkdown inspection which was summarized in a Screening Evaluation Work Sheets (SEWS). Some surface cracking of embedment grout was observed at support locations. The condenser was declared an outlier pending repair of the grout.

5.3. Related Equipment

The condenser and the majority of related equipment were walked down during April 1996. Those walkdowns were conducted by J.J. O'Sullivan of Stevenson and Associates and D. Zercher of NSP. Follow up walkdowns were conducted as needed. A Screening Evaluation Work Sheet (SEWS) was completed for each item. Each SEWS contains a capacity versus demand comparison, a checklist of bounding spectrum caveats, an anchorage review checklist, a spatial interaction checklist, notes, and attached pictures (if available). The SEWS identify the determination of whether the item is acceptable or is an outlier and are signed by the SRT. The list of related equipment is provided in Section 2.

The majority of the related equipment is made up of valves. All valves were found to meet GIP screening criteria. Other items includes pressure vessels and instruments. The summaries below describe concerns and resolutions for items where seismic capacity issues were identified.

E-2A and E-2B The Air Ejectors are horizontal, cylindrical pressure vessels on saddles. Each ejector is bolted to a 4 foot high moment-resisting steel frame. The frames are anchored with cast-in-place bolts. An anchorage analysis indicated that diagonal bracing was required to reduce prying induced tension forces on anchors. The bracing was added and anchorage was found to be acceptable for SSE loading.

E-4 The Steam Packing Exhauster is a horizontal, cylindrical pressure vessel on saddles. The vessel is bolted to a 4 foot high moment-resisting steel frame. The frames were anchored with cast-in-place bolts. An anchorage analysis indicated that diagonal bracing was required to reduce prying induced tension forces on anchors. The bracing was added and anchorage was found to be acceptable for SSE loading.

T-33 The Backwash Receiving Tank is a vertical, cylindrical tank on four legs. It is approximately 10.5 feet tall and 14 feet in diameter. Each leg was originally anchored to the concrete floor by two 5/8 inch shell anchors. An anchorage analysis indicated that diagonal bracing and additional anchorage was required to meet SSE loads. The tank was upgraded by adding diagonal braces and sixteen 1 inch shell anchors. The new anchorage was found to be acceptable for SSE loading.

V-813 The Drain Collector Tank is a small horizontal tank supported on 2 saddles. The anchor bolt holes in the base of the saddle were slotted in one direction and oversized in the other direction. Sliding of the tank prior to bolt engagement was a concern. The concern was resolved by welding on plates with standard size holes.

Moisture Separator The Moisture Separator is a small vessel, 6 feet long 4 inch diameter, vertically oriented and supported by two wall brackets. U-bolts connect the vessel to the brackets. The U-bolts provided only a friction support in the vertical direction, therefore vertical support was uncertain. A positive vertical support was added and the concern was resolved.

17-116, 17-104 Item 17-116 (Off Gas Sample Rack) is a small instrument rack which is well anchored and top braced. Some loose shield blocks were noted as a seismic interaction hazard for nearby tubing. Item 17-104 (Sample Chamber) is mounted on rack 17-116 and is addressed by the GIP rule-of-the-box.

5.4. Outliers

The walkdown and evaluation process produced a number of issues that were identified as potential seismic vulnerabilities. Unresolved issues are tracked by assigning outlier status to the associated piping PSSSWS or equipment SEWS. Resolution of outliers, e.g., by design modifications, was also tracked on PSSSWS and SEWS.

Table 5-8 lists issues and the method of resolution.

Table 5-1: Summary of Piping Properties for the Monticello Leakage Path Piping

Walkdown Package	Pipe Size NPS (in)	Pipe Schedule	Pipe OD (in)	Pipe Wall (in)	OD/t	Material
2913-1	6	80	6.625	0.432	15	A106B
	3	80	3.5	0.3	12	A106B
	1	160	1.315	0.25	5	A106B
2913-2	10	80	10.75	0.593	18	A106B
	2	160	2.375	0.344	7	A106B
	1-1/2	160	1.9	0.281	7	A106B
2913-3	18	80	18	0.938	19	A672, Gr. 70
	10	80	10.75	0.593	18	A672, Gr. 70
2913-4	4	80	4.5	0.337	13	A106B
2913-5	16	STD	16	0.375	43	A53B/A106B
	12	STD	12.75	0.375	34	A53B/A106B
	10	STD	10.75	0.365	29	A53B/A106B
2913-6	16	STD	16	0.375	43	A53B/A106B
	12	STD	12.75	0.375	34	A53B/A106B
	10	STD	10.75	0.365	29	A53B/A106B
2913-7	6	40	6.625	0.28	24	A53B/A106B
	3/4	80	1.05	0.154	7	A53B/A106B
2913-8	6	40	6.625	0.28	24	A53B/A106B
	3/4	80	1.05	0.154	7	A53B/A106B
2913-9	3	160	3.5	0.438	8	A106B
	3	STD	3.5	0.216	16	A53B/A106B
	2	160	2.375	0.344	7	A106B
	1	80S	1.315	0.179	7	304SS
	1	80	1.315	0.179	7	A53B/A106B
2913-10	6	80	6.626	0.432	15	CS
2913-11	18	STD	18	0.375	48	A53B/A106B
	12	STD	12.75	0.375	34	A53B/A106B
	10	40	10.75	0.365	29	A53B/A106B
	8	40	8.625	0.322	27	A53B/A106B
2913-12	6	160	6.625	0.718	9	A106B
	6	120	6.625	0.562	12	A106B
	6	80	6.625	0.432	15	A106B
	4	80	4.5	0.337	13	A106B
2913-13	24	80	24	1.22	20	SA106B
	6	120	6.625	0.562	12	SA106B
	4	120	4.5	0.438	10	SA106B
2913-14	6	120	6.625	0.562	12	A106B
	4	120	4.5	0.438	10	A106B
2913-15	3	160	3.5	0.438	8	A106B
	2	XXH	2.375	0.436	5	A106B
	1	XXH	1.315	0.358	4	A106B
2913-16	4	120	4.5	0.438	10	A106B
	3	160	3.5	0.438	8	A106B
2913-17	1	160	1.315	0.25	5	A106B

Table 5-1 Summary of Piping Properties for the Monticello Leakage Path Piping

Walkdown Package	Pipe Size NPS (in)	Pipe Schedule	Pipe OD (in)	Pipe Wall (in)	OD/t	Material
2913-18	1	160	1.315	0.218	6	A106B
	1	160	1.315	0.218	6	A312-304L
	1/2" Tubing	N/A	0.625	0.049	13	A312-304
	1/2" Tubing	N/A	0.625	0.049	13	A376-316
2913-19	1	80	1.315	0.179	7	A106B
	1	80	1.315	0.179	7	A312-304
	1/2" Tubing	N/A	0.625	0.049	13	A312-304
	1/2" Tubing	N/A	0.625	0.049	13	A376-316
2913-20	1	XXH	1.315	0.358	4	SA106B
	1/2	XXH	0.84	0.294	3	SA106B
2913-21	4	120	4.5	0.438	10	SA106B
2913-22	1	80	1.315	0.179	7	A106B
	3/4	160	1.05	0.219	5	A106B
2913-23	3	40	3.5	0.216	16	A53B/A106B
	3	40	3.5	0.216	16	A312-304L
2913-24	1	160	1.315	0.25	5	A106B
2913-25	1-1/2	160	1.9	0.281	7	A106B
	1	160	1.315	0.25	5	A106B
2913-26	2	40	2.375	0.154	15	SS
	1-1/2	40	1.9	0.145	13	SS
	1	40	1.315	0.133	10	SS
	3/4	40	0.75	0.113	7	SS
	1/2" Tubing	N/A	0.625	0.035	18	SS
2913-27-1,-2,-3	16	40	16	0.5	32	CS
	12	40	12.75	0.406	31	CS
	10	80	10.75	0.593	18	CS
	10	40	10.75	0.365	29	CS
	8	40	8.625	0.322	27	CS
	6	80	6.625	0.432	15	CS
	6	40	6.625	0.28	24	CS
	5	80	5.563	0.375	15	CS
	5	40	5.563	0.258	22	CS
	4	40	4.5	0.237	19	CS
	3-1/2	80	4	0.3	13	CS
	3	40	3.5	0.216	16	CS
	2	40	2.375	0.154	15	CS
	1-1/2	40	1.9	0.145	13	CS
	1	40	1.315	0.133	10	CS
2913-28	1-1/2	160	1.9	0.281	7	A106B
	1	160	1.315	0.25	5	A106B
2913-29	14	STD	14	0.375	37	A53B/A106B
	10	40	10.75	0.365	29	A53B/A106B
	3	40	3.5	0.216	16	A53B/A106B
	1-1/2	80	1.9	0.2	10	A53B/A106B

(1) CS = Carbon Steel Pipe; (2) SS = Stainless Steel Pipe

Table 5-2: Seismic Experience Piping Data [2], [3], [42]

Plant	Pipe Size NPS (in)	Pipe Schedule	Pipe OD (in)	Pipe Wall (in)	OD/t
Valley Steam Plant Units 1 and 2	24	20	24.00	0.375	64
	20	20	20.00	0.375	53
	18	30	18.00	0.437	41
	16	30	16.00	0.375	43
	14	30	14.00	0.375	37
	12	40	12.75	0.406	31
	12	30	12.75	0.33	39
	10	160	10.75	1.125	10
	8	160	8.6250	0.906	10
	6	40	6.6250	0.28	24
	4	160	4.5000	0.531	8
	4	40	4.5000	0.237	19
	3	160	3.5000	0.437	8
	3	80	3.5000	0.3	12
	3	40	3.5000	0.216	[illegible]
	2	160	2.3750	0.343	7
	2	40	2.3750	0.154	15
	1 1/2	160	1.9000	0.281	7
	1 1/2	40	1.9000	0.145	13
	1	40	1.3150	0.133	10
	3/4	160	1.0500	0.218	5
	3/4	40	1.0500	0.113	9
Moss Landing Units 1, 2, & 3	16	N/A	16.00	1.394	11
	12	N/A	12.75	1.148	11
Moss Landing Units 4 & 5	24	40	24.00	0.687	35
	24	N/A	24.00	1.066	23
	-	N/A	18.30	2.287	8
	16	40	16.00	0.5	32
	16	N/A	16.00	0.902	18
	-	N/A	13.20	1.668	8
Moss Landing Units 6 & 7	30	N/A	30.00	0.632	47
	26	N/A	26.00	1.128	23
	18	N/A	18.00	3.444	5
	12	N/A	12.75	2.444	5
	12	N/A	12.75	0.601	21
Ormond Beach Units 1 & 2	30	N/A	30.00	1.298	23
	30	N/A	30.00	0.719	42
	21	N/A	21.00	3.793	6

Table 5-2 Seismic Experience Piping Data [2], [3], [42]

Plant	Pipe Size NPS (in)	Pipe Schedule	Pipe OD (in)	Pipe Wall (in)	OD/t
Humboldt Unit 3	12	80	12.75	0.687	19
	10	80	10.75	0.593	18
	6	80	6.625	0.432	15
El Centro Steam Plant	20	STD	20.00	0.375	53
	18	160	18.00	1.7810	10
	18	XS	18.00	0.5000	36
	18	STD	18.00	0.3750	48
	14	40	14.00	0.4370	32
	14	STD	14.00	0.3750	37
	12	160	12.75	1.3120	10
	12	STD	12.75	0.3750	34
	10	40	10.75	0.3650	29
	8	160	8.625	0.9060	10
	8	120	8.625	0.7180	12
	8	40	8.625	0.3220	27
	6	120	6.625	0.5620	12
	6	40	6.625	0.2800	24
	4	80	4.500	0.3370	13
	4	40	4.500	0.2370	19
	3	160	3.50	0.4370	8
	3	80	3.50	0.3000	12
	3	40	3.50	0.2160	16
	2	160	2.375	0.3430	7
	2	80	2.375	0.2180	11
	2	40	2.375	0.1540	15
	1 1/2	160	1.90	0.2810	7
	1 1/2	80	1.90	0.2000	10
	1 1/2	40	1.90	0.1450	13
	1	80	1.315	0.1790	7
	1	40	1.315	0.1330	10
	3/4	80	1.050	0.1540	7
	3/4	40	1.050	0.1130	9

Table 5-3: D/t Range Comparison

Nominal Pipe Size (NPS) (ID)	Subject Monticello Piping D/t Ranges	Experience Data Piping D/t Ranges
¾	5-7	5-9
1	4-10	5-20
1 ½	7-13	7-13
2	5-15	5-15
3	8-16	8-16
3 1/2	13	
4	10-19	8-19
5	15-22	
6	9-24	9-24
8	27	10-31
10	18	10-29
12	31-34	10-34
14	37	32-37
16	32-43	11-43
18	19-48	5-41
24	20	23-35

Table 5-4(a): Predominant Materials of the Experience Data

Material	B31.1 Allowable Stress, psi
A53 B	15000
A106 B	15000
A335	14000
A120	(1)
A139	12000

(1) Stress allowables not provided by B31.1. B31.9 provides an allowable stress value of 10000.

Table 5-4(b): Predominant Materials of the Subject Monticello Piping

Material	B31.1 Allowable Stress, psi
A53 B	15000
A106 B	15000
312-304	15900
376-316	17000
312-304L	13700

Table 5-5: MNGP Span Ratios in Comparison to B31.1 Suggested Deadweight Spacing

Walkdown Package	*Pipe Type SB = Small Bore (<2.5") LB= Large Bore (>2.5") [Based on Predominant Pipe Size]*	*Maximum Vertical Support Actual Spacing Ratio to B31.1 Suggested Support Spacing (2)*	*Minimum Vertical Support Actual Spacing Ratio to B31.1 Suggested Support Spacing*	*Maximum Lateral Support Actual Spacing Ratio to B31.1 Suggested Support Spacing (LVSSR-Max) (2)*	*Minimum Lateral Support Actual Spacing Ratio to B31.1 Suggested Support Spacing (LVSSR - Min)*
2913-1	LB	1.5	1	4.2	1
2913-2	SB	1.5	.5	3	.5
2913-3	LB	1	1	3	1
2913-4	LB	2.2 (1)	1.5	7	1
2913-5	LB	1.5	1	3	2
2913-6	LB	1.5	<1	2	2
2913-7	LB	1	.5	5	N/A
2913-8	LB	1	.5	5	N/A
2913-9	LB	1	.75	6.2	5.5
	SB	1	.75	2	1
2913-10	LB	1	N/A	1.5	1
2913-11	LB	1	1.25	5.25	2
2913-12	LB	1.5	<1	2.75	1
2913-13	LB	(3)	(3)	(3)	(3)
2913-14	LB	(3)	(3)	(3)	(3)
2913-15	SB	1	<1	1.5	<1
2913-16	LB	2	1	2.5	1
2913-17	LB	1.5	<1	6	<1
2913-18	SB	1.5	1.3	5.5	1.3
2913-19	LB	(3)	(3)	(3)	(3)
2913-20	SB	1.5	<1	2	1
2913-21	LB	1.5	1	1.5	1
2913-22	SB	1	.5	1.5	1
2913-23	LB	1.5	1	5	5
2913-24	SB	1	1	1.5	1
2913-25	SB	1	1	2	1
2913-26	SB	1.5	<1	1.5	<1
2913-27-1,-2,-3	LB,SB	(4)	(4)	(4)	(4)
2913-28	SB	1	1	3	1
2913-29	LB	2	<1	2.7	2.7
2913-30	SB				

(1) These spans exclude consideration of spring hangers.

(2) Spans include consideration of modified or added supports.

(3) These lines had obvious seismic design & short spans; accepted by inspection without detailed span evaluation.

(4) This was a worse case system and was qualified by detailed analysis.

Table 5-6: Nominal Suggested Vertical Deadweight Spans per ANSI B31.1 [43]

Monticello Nominal Pipe Size** (in)	Outside Pipe Diameter (in)	Suggested B31.1 Deadweight Spans (ft) Water Service	Steam. Gas or Air Service
3/4	1.050	6*	8*
1	1.315	7	9
1 1/2	1.900	9*	11*
2	2.375	10	13
3	3.500	12	15
3 1/2	4.000	11*	12*
4	4.500	14	17
5	5.563	16	19*
6	6.625	17	21
8	8.625	19	24
10	10.750	21*	26*
12	12.750	23	30
14	14.000	25*	33*
16	16.000	27	35
18	18.000	29*	37*
24	24.000	32	42

* Interpolated values -- not given directly in ANSI B31.1.

** There are small amounts of 1/2" piping and 1/8" tubing not presented in this table.

Table 5-7: Monticello Condenser Design Data Versus Experience Data [3]

Parameter	Monticello	Moss Landing 6 & 7	Ormond Beach 1 & 2
Manufacturer	Worthington	Ingersoll Rand	Southwestern
Flow Type	Single Pass	Single Pass	Single Pass
Shell Dimensions (L x W x H)	HP: 40' x 30' x 35' LP: 36' x 30' x 35'	65' x 36' x 47'	52' x 27' x 20'
Tube Area per Shell	HP: 210,000 ft^2 LP: 189,000 ft^2	435,000 ft^2	210,000 ft^2
Shell Material	ASTM A285C	ASTM A285C	ASTM A285C
Shell Thickness	¾ inch	¾ inch	¾ inch
Operating Weight	HP: 1,900,000 lbs. LP: 1,800,000 lbs.	3,115,000 lbs.	1,767,000 lbs.
Tube Material	Type 304 S.S.	Al-brass	90-10 Cu-Ni
Tube Size	1 inch	1 inch	1 inch
Tube Length	36 to 40 feet	65 feet	53 feet
Tube Wall Thickness	18 to 22 Bwg	18 Bwg	20 Bwg
Number of Tubes	20,056 per shell	25,590	15,220 per shell
Tube Sheet Material	Munz Metal	Munz Metal	Munz Metal
Tube Sheet Thickness	1¼ inch	1½ inch	1¼ inch
No. of Tube Support Plates	13 per shell	15	14
Tube Support Plate Material	ASTM A285C	not identified	ASTM A285C
Tube Support Plate Thick.	3/4 inch	3/4 inch	5/8 inch
Tube Support Plate Spacing	33 inches	48 inches	36 to 36.5 inches
Waterbox Material	ASTM A285C	2% Ni cast iron ASTM A-48 CL 30	ASTM A285C
Waterbox Plate Thickness	3/4 inch	N/A	5/8 to 1 inch
Expansion Joint	Rubber belt	Rubber belt	St. steel
Hot Well Capacity	43,000 gallons	20,000 gallons	34,338 gallons
Hot Well Hold Time	2 min	N/A	N/A

Table 5-8: Summary of Concerns and Resolution

Identifier	Concerns	Resolution
Package 2913-4	Spatial interaction	Loose equipment moved or restrained
Package 2913-5	Loose hanger	Hanger repaired
Package 2913-4	(a) Broken U-Bolt (b) Missing U-Bolts (c) Spatial interaction	(a) Replaced (b) Installed (c) Potential target conduits determined to be not required for normal or accident conditions
Package 2913-11	(a) Lack of Lateral Restraint (b) Loose rod hanger (c) Short rod hanger (d)Poorly supported I&C line	(a) Support modified (b) Repaired (c) System qualified assuming this rod hanger failed (d) Reroute/resupport line
Package 2913-12	(a) Loose U-Bolt (b) Loose rod hanger (c) Additional lateral support required	(a) Repaired (b) Repaired (c) U-Bolt added
Package 2913-16	(a) Lack of lateral restraint (b) Spatial interaction	(a) Support modified (b) Block wall braced
Package 2913-19	(a) Sample Chamber Lacks Vertical Support (b) Tubing could Fall From Trays (c) Tubing needs lateral/vertical restraint (2 places) (d) Spatial interaction for SV-2 and 17-104	(a) Support added (b) Bands and covers added to trays (c) Restraint added (d) Lead blocks restrained
Package 2913-20	(a) Missing U-Bolt (b) Spatial interaction	(a) U-Bolt installed (b) Block wall braced
Package 2913-22	Spatial interaction	Crane rail demonstrated to be seismically adequate
Package 2913-24	(a) Lateral support required (b) Short rod hanger	(a) Support added (b) Piping qualified assuming hanger would fail.
Package 2913-26	(a) Lack of seismic support (b) Loose rod hanger (c) Loose U-Bolt	(a) Line resupported for earthquake (b) Repaired (c) Repaired
Package 2913-27-1	Lack of Lateral Support	Two new supports added
Package 2913-27-3	Lack of lateral support & spatial interaction concerns	Six new pipe supports added
Package 2913-27-4	Lack of lateral support	Three supports added
Package 2913-28	Missing support	Support reinstalled
E-2A, E-2B, E-4	Anchorage	Bracing was added to reduce anchor loads
T-33	Anchorage	Bracing and anchors were added
V-813	Anchorage	Plates added
Moisture Separator	Anchorage	A positive vertical support was added

Table 5-8 Summary of Concerns and Resolution

Identifier	Outlier Issue	Proposed Resolution
17-116, 17-104	Interaction	Shield blocks restrained
2913-OSVS-1	Corrosion/Erosion	Piping Systems are in the Erosion/corrosion Monitoring Program.
2913-OSVS-2	Possible Corrosion	Piping Systems are in Erosion/Corrosion Monitoring Program.
2913-OSVS-3	Spatial Interaction	Added Support to 14" Piping.
E-1A, E-1B	Cracked grout	Repaired with high strength epoxy grout.

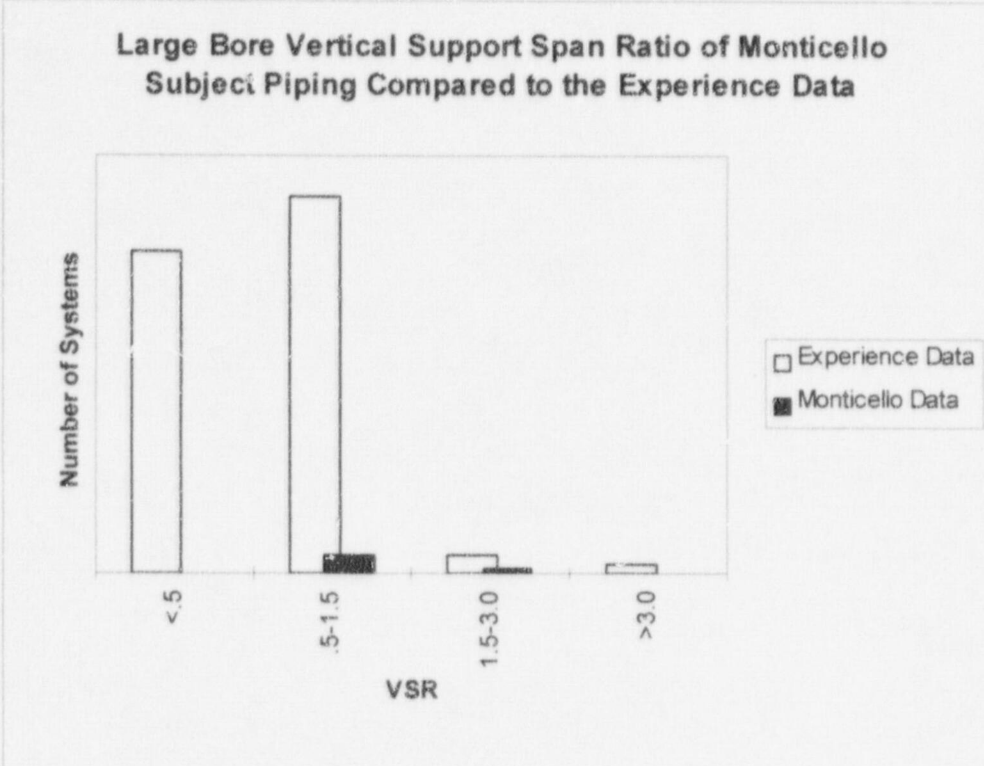


Figure 5-1

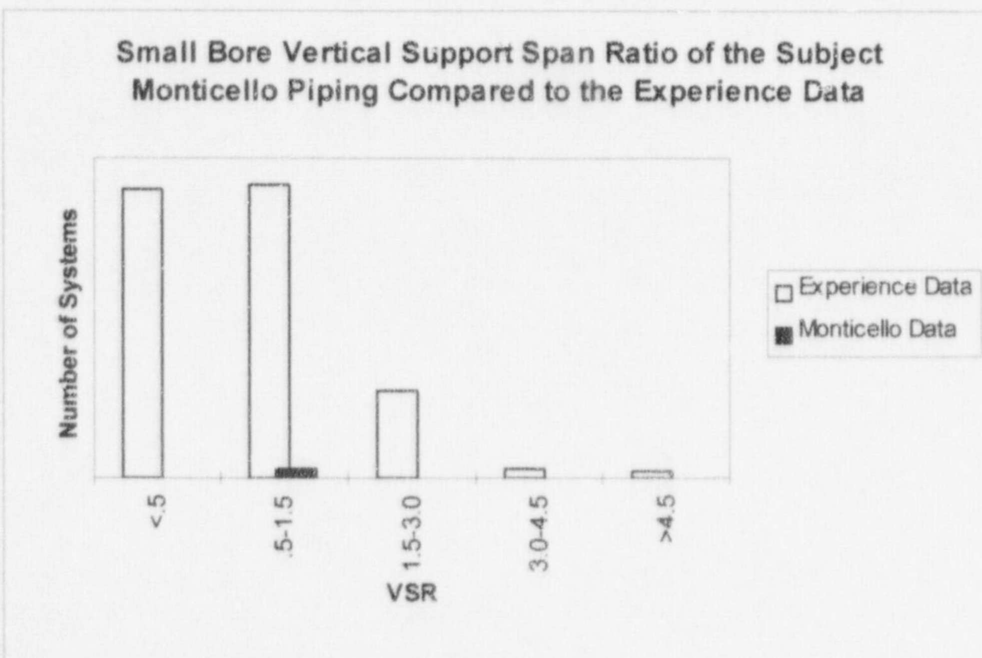


Figure 5-2

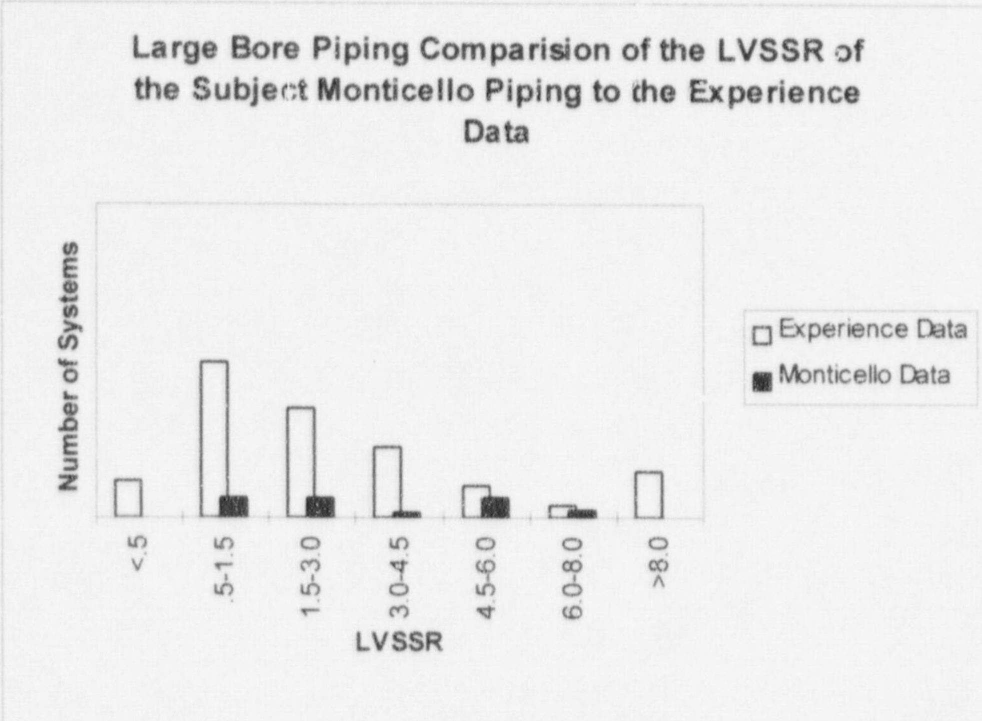


Figure 5-3

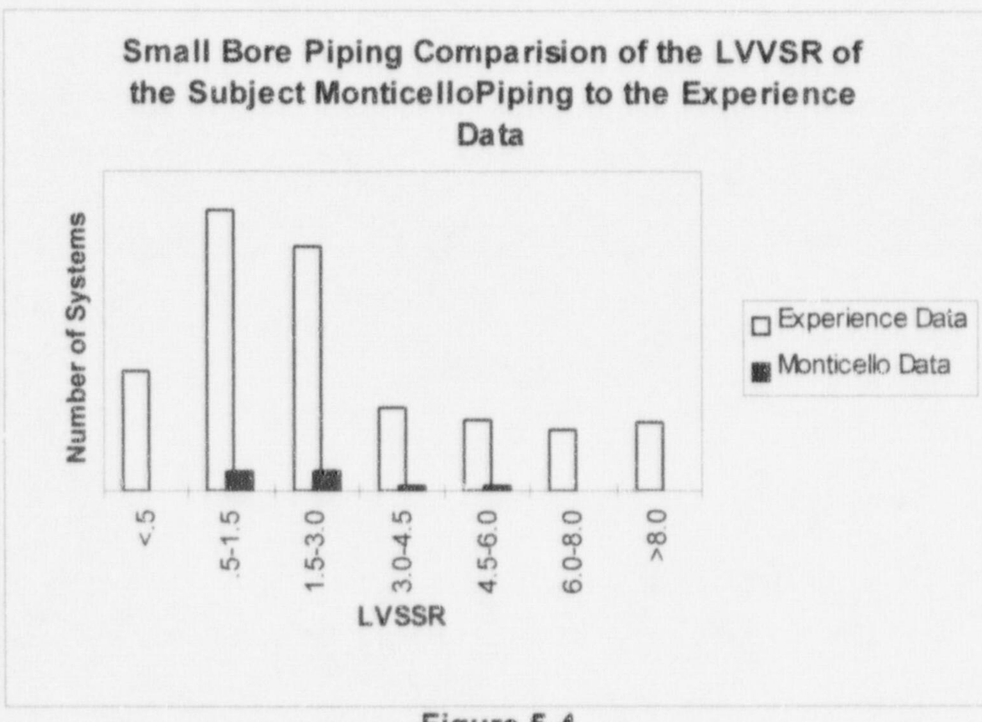


Figure 5-4

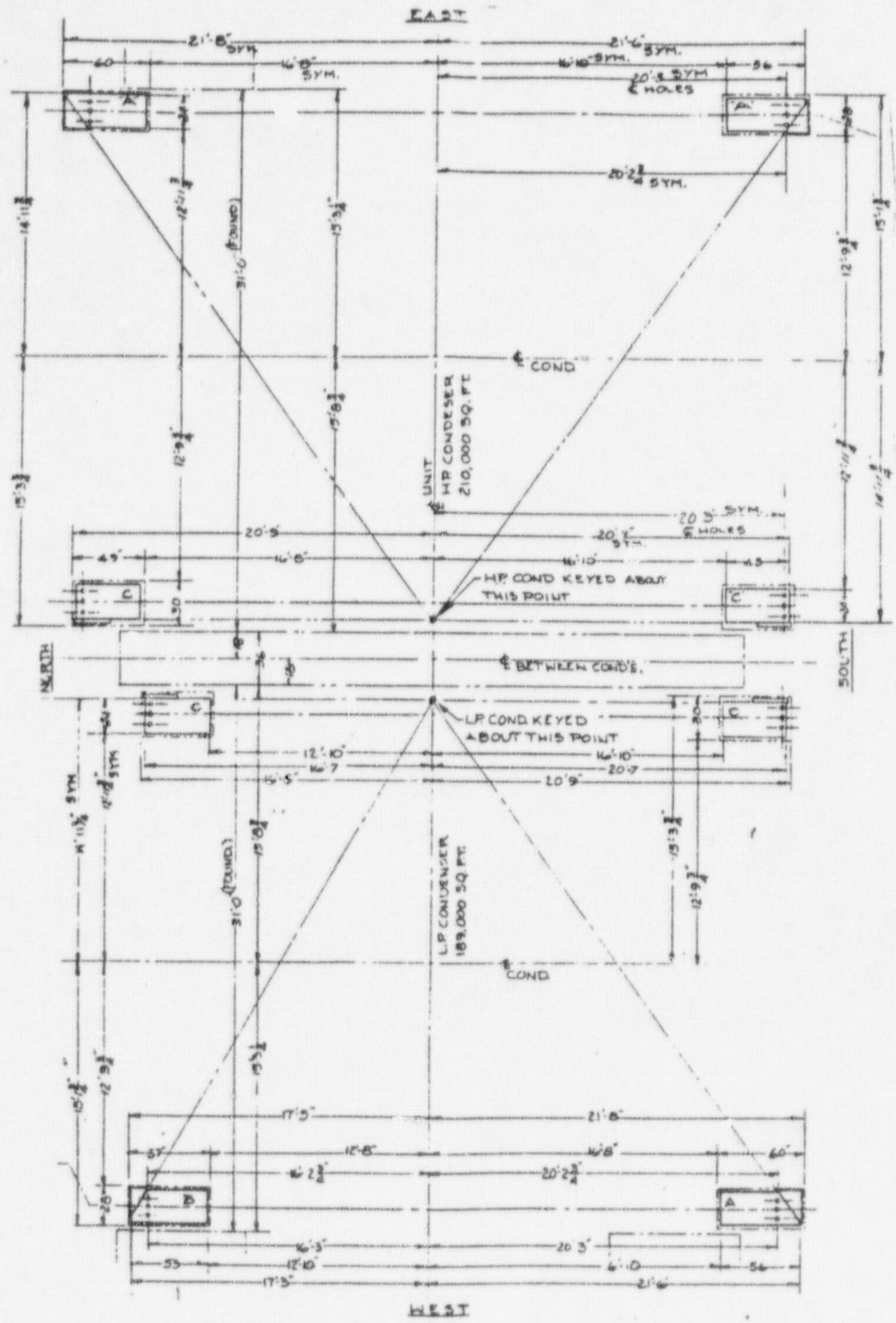
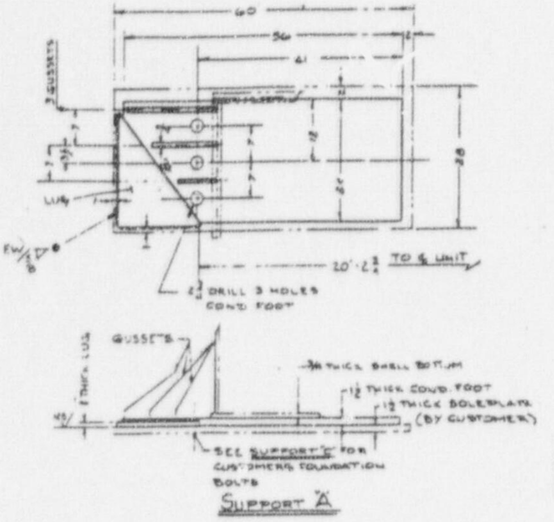


Figure 5-5: MNGS Condenser support layout from Worthington DR-127368 Rev. B



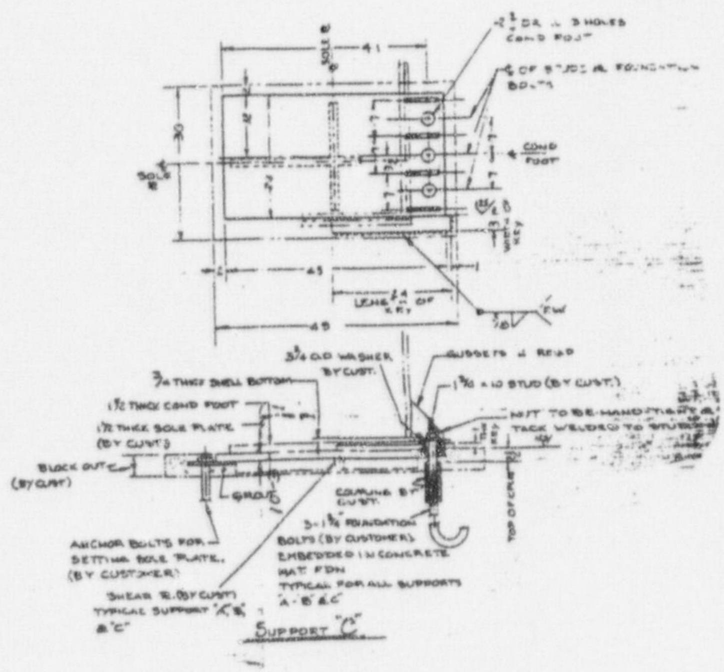


Figure 5-6: MNGS Condenser support details from Worthington DR-127368 Rev. B, Support B is similar to Support A

6. Conclusion

Piping and equipment in the MSIV leakage path were evaluated for seismic capacity. The method of seismic evaluation relied in part on the use of earthquake experience data and similarity principles. Plant specific analyses of piping and equipment were used in combination with the experience method. The method of analysis is described in Section 4. A discussion supporting the experience based method is presented in Section 3.

The results of the evaluation are summarized in Section 5. Included in these results are the identified seismic capacities concerns and the proposed resolutions for each concern. The concerns and resolution for the piping systems, equipment, and related structures are identified in Table 5-8. The resolutions identified in Table 5-8 have been implemented, and the concerns are therefore resolved. After implementation of the resolutions in Section 5, a reliable pressure boundary can be maintained downstream of the MSIVs during and after a seismic event.

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