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Survey of Strong Motion Earthquake Effects on Thermal Power Plants in California with Emphasis on Piping Systems

Appendices

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Prepared for
U.S. Nuclear Regulatory Commission

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Abstract

Volume 2 of the "Survey of Strong Motion Earthquake Effects on Thermal Power Plants in California with Emphasis on Piping Systems" contains Appendices which detail the detail design and seismic response of several power plants subjected to strong motion earthquakes. The particular plants considered include the Ormond Beach, Long Beach and Seal Beach, Burbank, El Centro, Glendale, Humboldt Bay, Kern Valley, Pasadena and Valley power plants. Included is a typical power plant piping specification and photographs of typical power plant piping specification and photographs of typical piping and support installations for the plants surveyed. Detailed piping support spacing data are also included.

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Executive Summary

The appendices included in Volume 2 of the "Survey of Strong Motion Earthquake Effects on Thermal Power Plants in California with Emphasis on Piping Systems" provide details concerning the design basis and seismic response for several power stations in California.

These appendices supply background information which supports the recommendations and conclusions reached in Volume 1. Included is a typical power plant piping specification and photographs of typical piping and support installations for the plants surveyed. Piping support spacing data is also included.

Appendix A: Summary Description of the Ormond Beach Power Plant Response to the Point Mugu Earthquake of 21 February 1973

A.0 Introduction

The Point Mugu, California, earthquake occurred at 6:46 a.m. local time, on February 21, 1973. It had a Richter magnitude of about 5.75, and the strong motion of the main shock lasted about 6 to 8 seconds. The earthquake bears a resemblance to the San Fernando event. It, too, seems to have taken place on frontal fault systems of mountain blocks in the Transverse Ranges: the Santa Monica mountains. The fault movement that caused the earthquake was of the reverse or thrusting type, as was the case in the San Fernando event.

The epicenter of the earthquake was located offshore from Point Mugu, which is southeast of Oxnard, Ventura County, California. The shock was widely felt throughout Southern and Central California and triggered several strong-motion instruments. The nearest record was obtained at Port Hueneme, about 11 miles northwest of the epicenter as shown in Figure A.1,[A.1] where a PGA of 0.13g was recorded. The horizontal accelerations were 0.13g (north-south) and 0.085g (east-west), and the vertical component of motion was 0.05g.

A.1 Description of Ormond Beach Generating Station

The station is owned and operated by Southern California Edison Co., SCE. The plant is a dual-unit, 1,500 MW oil-fired plant located a few hundred feet from the Pacific shoreline about 2 miles north of Point Mugu and south of Oxnard. The plant was designed and built by the Bechtel Power Corporation, Norwalk (Los Angeles). Unit 1 was operating at the time of the earthquake. Unit 2 was nearing completion when the Point Mugu earthquake occurred. The plant was completed a few months later, in 1973.

The plant structures were designed seismically for an equivalent static force of 0.2g and is in general conformance with standard SCE criteria. Equipment was anchored for 0.2g static equivalent overturning forces, and most piping, conduit, and tray supports were designed for dead-weight loads only. Only a few pipe braces were observed on pipes of large diameter.

Each unit consists of a 200-foot-high structural steel tower that supports the boilers. The steam turbines and generators are located on a separate concrete pedestal adjacent to the towers. There are several other small structures on the site. The plant is built over a filled lagoon, on soft sedimentary material.

A.2 Earthquake Motion

The plant is located 8 miles or less from the epicenter of the Point Mugu event. A Peak Ground Acceleration, PGA, of 0.13g was recorded about 3 miles farther from the epicenter. The peak ground motion at the site was estimated on the basis of typical attenuation relationships for California to be about 0.20g.[A.1] Applied Nucleonics Company[A.2] estimated the same PGA on the basis of observation and measurement of the displacements of pipes that impacted adjacent structural members.

A.3 Plant Performance

Unit was operating at the time of the earthquake. It was tripped off line by the earthquake. The following list of damage to equipment is extracted from a report prepared by Douglas[A.3]

- The Unit One generator differential relay tripped while carrying 600 MW. The shaking of this relay's support panel was the apparent cause for the closing of the relay contacts. A CFVB voltage balance relay also tripped due to the earthquake. The closure of the generator differential relay was the main cause for the station to remain off-line until 3.46 a.m.

- A small fire also started next to the windbox of Unit One. This fire was the result of the down-comer pipe partially breaking away from the windbox. This fire was quickly extinguished. Minor repairs to the insulation and other related items of the downcomer pipe were required.

- A 10-inch support rod on one hydraulic snubber at approximately the 150 ft. level was buckled at about a 20 degree angle. The support rod on this particular snubber was the longest one observed out of the many snubbers at the plant. This longer-than-normal length of the support rod could have been the cause of this buckling failure.

The location and size of these snubbers indicate that they were ambient vibration snubbers and not seismic snubbers.

- Four 75 foot vertical steam pipes and four 100 foot vertical steam pipes on the south and north sides of Units 1 and 2 collided with nearby catwalks and structural steel members. Consequently, dents were formed at various levels in the insulation covering of these pipes. from these dents it was determined that some of these pipes deflected over 13 inches. However, the dents in these steam pipes lines insulation were not serious enough to warrant replacement or repair.

Applied Nucleonics Company[A.2] discusses these and other effects further. The following paragraphs are extracted from their report[A.2].

- To our understanding the Unit 1 plant was tripped and shut down due to excessive bearing accelerations of the turbines and recirculating fans.

- Our inspection of both units revealed three types of damage (we do not imply that these were the only forms of damage which occurred). Inspection of several dozen hydraulic shock and sway suppressors (snubbers) on piping indicated single amplitude motion of up to three inches. These motions were easily measured by inspecting the newly cleaned vs dusty portions of the piston. One snubber had buckled its support rod attached to the structural member. This threaded rod, about 1-1/2 in. diameter and 10 in. long was bent at about 20°. This particular snubber indicated a motion of about 2 in. We noted that of the many snubbers we saw, this damaged one had the longest support rod (i.e. 10 in.) and this may explain the resulting failure.

- The next two forms of damage involved the insulation around the many large pipes in the structure. Typically, one to three inches of a fiber-glass type insulation surrounded the pipes. It was protected by thin sheet metal wrapping. Pipe diameters with insulation varied roughly from 6 in. to 24 in. On several vertical pipes, the insulation slumped downwards and exposed up to 2 in. of the pipe.

Several large pipes experienced motions large enough to cause them to collide with nearby structural members. Of special interest were eight vertical pipes about 24 in. in diameter and 75-150 feet in length on both units. By observing the collision dents in the insulation, estimates were made for their maximum response at midpoint. Motions up to nearly 14 inches were observed. Subsequent measurements with accelerometers while the pipes were pushed by two men determined their resonant frequencies (between 0.9 and 1.6 HZ) and dampings (0.3 to 1.8%).

In summary, the damage to equipment at the Ormond Beach plant was limited to the buckling of a snubber support. It is possible that malfunctioning relays tripped the operating unit. The literature that was reviewed gave no indication of damage to the structures and components of the numerous other equipment items and systems. The plant shut down normally. Figures showing typical examples of equipment from the Ormond Beach Power Station are shown on Ref. A.1.

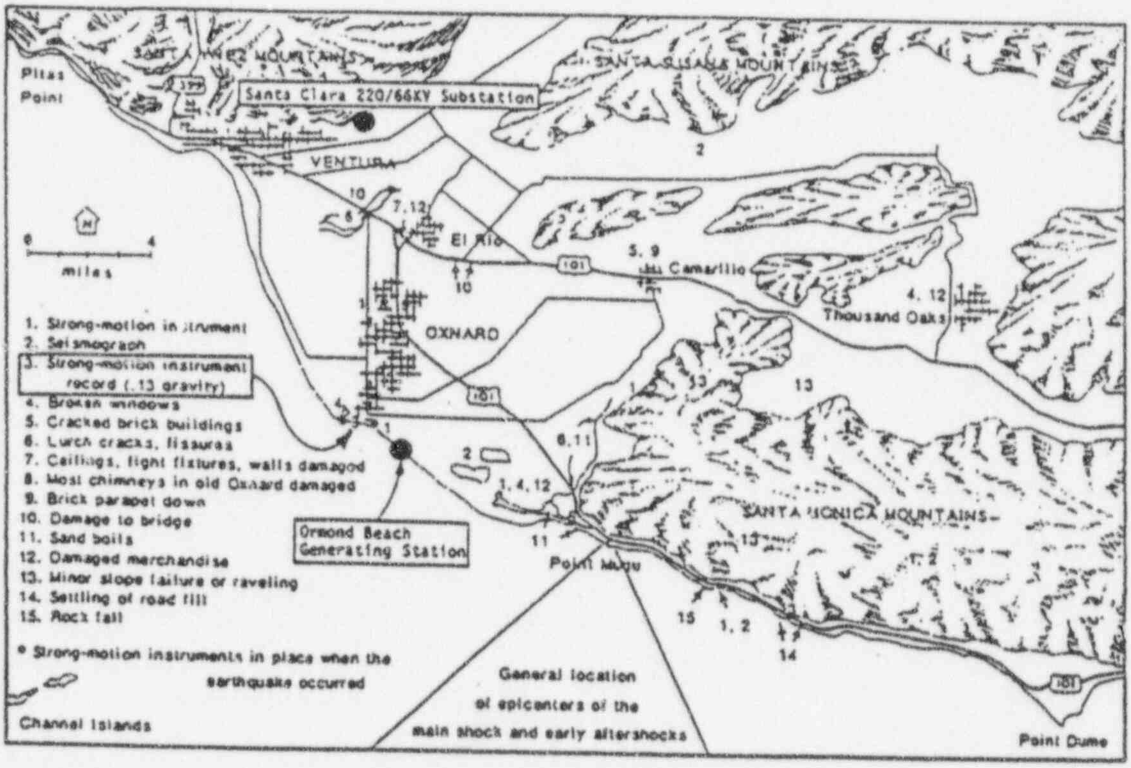


Figure A.1 - Location of two data base plants - Point Mugu earthquake. The numbers on the map show the location of earthquake-related damage and ground effects that were observed by earth-scientists and engineers on 21 February 1973 following Point Mugu earthquake (California Division of Mines and Geology 1973.)

Appendix B: The Long Beach Earthquake of 1933 and Its Effect on the Long Beach and Seal Beach Steam Power Stations

B.1 Long Beach Power Station Plant 1

The Long Beach Power Station was located on Terminal Island in Long Beach, California, about four miles from the fault that caused the Long Beach earthquake on March 10, 1933. This earthquake was of magnitude 6.3 and caused accelerations at the site of the Long Beach steam plant estimated to be about 0.25 g. Damage in Long Beach itself was very extensive, but there were no actual accelerometer records of the earthquake.

At the Long Beach Power Station site there were actually three independent plants.[B.1] Plant 1, built in 1910, consists of two sections. The first section was of reinforced concrete; the second section was a light-steel frame with reinforced-concrete sidewalls and end filler walls. The building columns, walls, and principal machinery foundations were on piles, but the floors were of mat construction poured directly on backfill. All walls were finished with stucco plaster over the concrete surfaces.

After the March 1933 earthquake, there was apparent uneven settlement of the two buildings. The floor in the turbine room settled, causing severe cracking at the adjacent walls. Settlement of the floor around one boiler caused bad sagging of an adjacent roof panel and loosened the firing aisle windows that leaned in beyond the walls. The floor in the transformer house settled as much as 1 1/4 inches, and lesser settlement was noted in the machine shop floor. Severe settlement of the blacksmith and carpenter shops resulted in these buildings pulling away from the main building about 1 1/2 inches. Severe cracking of masonry walls occurred at wall junctions and construction joints and to a lesser degree in other areas. The entire wall of the generator room moved slightly in a southerly direction. A water standpipe 36 ft in diameter and 100 ft in height stretched its anchor bolts from 1 1/16 inches to 2 inches. All the anchor bolts were stretched, which indicated a gyratory motion of the tank. A considerable amount of breakage occurred in cast-iron pipes buried in the ground around the installation. Transformer oil piping lines were broken at welded and brazed joints.

B.2 Long Beach Power Station Plants 2 and 3

Plant 2 was built in 1922 and Plant 3 was built about 1928. They were extensions to Plant 1. The Stone and Webster Engineering Corporation was the designer and builder of both Plants 2 & 3. Both plants were supported by wooden 40-ft piles on 30-in. centers driven to refusal in hard sand. The plant foundations consist of a heavy reinforced concrete mats on these piles, with pyramidal facing for concentrated loads. Building frames were integral with internal structures, resulting in a strong, probably well-damped, complex. These two plants survived the 1933 earthquake without serious damage. Minor damage to underground oil and water lines resulted in recommendations that these lines be run above ground for ease of inspection and repair. It is interesting to note that, up to 1958, these plants have undergone about 24 ft of vertical subsidence with necessary adjustments in equipment and interconnections being made as the settling occurred. (This subsidence has not resulted directly from any earthquake but is thought to be a result of the removal of offshore oil deposits and the support they have afforded to coastal regions).

No information is available on seismic design of the piping and equipment, but considering the state of the art at the time, it is probable that either the 0.2 g static design was used, or else seismic design was not considered.

Neither plant, that is to say, none of the five units suffered any significant damage. Some minor damage such as to lighting fixtures was reported, however the steam plants either operated through the earthquake or were shut down due to loss of load and were back in operation the same day. The important point is that five steam units designed with at most static methods to a 0.2g acceleration PGA probably actually experienced a 0.25g PGA with little or no damage and in particular, no piping was damaged.

B.3 Seal Beach Steam Station

The Seal Beach Steam Power Station building structures were severely damaged in the 1933 earthquake.[B.2] This damage is described in a letter from an eyewitness, H.C. Vander Heyden of the Southern California Gas Company, formerly known as the Los Angeles Gas and Electric Corporation. Excerpts from the letter are as follows:

> In the Long Beach earthquake of 1933, the Seal Beach power plant of the Los Angeles Gas and

Electric Corporation was extensively damaged. The Plant was designed and constructed by Dwight P. Robinson and Company of Chicago for the Los Angeles Gas and Electric Corporation and was completed in May, 1925 and had a 70,000-kilowatt capacity. It is located in the City of Seal Beach on the south side of the inlet to Alamitos Bay which is about six miles southeast of the City of Long Beach and about 30 miles from the business center of Los Angeles.

The building and equipment foundation, operating floors, and the water tunnels are heavy reinforced concrete. The buildings are structural steel frame, and the interior and exterior walls were non-reinforced brick, constructed as filler walls only. The two 35,000-kiowatt generating units were located on a mezzanine operating floor in the open-type turbo room and were supported on structural steel columns and girders approximately 25 ft above the main floor. The stack was of reinforced concrete, 375 ft. high, 25 ft. across the top, and it was supported above the boiler room floor on steel columns and girders; it provided natural draft for the six boiler settings. The electrical building was four stories high.

The soil at the site was coarse gravel with scattered rock formations capable of supporting foundation loads of 3500 psi when contained. The concrete structures under high tide level were ringed with continuous steel sheet piping, and the screen intake house had steel piping under the foundation as a water cutoff. There was no visible evidence of fissures or subsidence of the ground in the plant area.

The morning after the earthquake, the station looked to be in shambles. The majority of the brick walls had fallen either in or out of the buildings. The glass in the remaining windows was broken, the piping connections to the domestic water supply tank were broken and had dumped approximately 30,000 gallons of water on the roof. The structural girders, columns and braces supporting the turbine mezzanine floor were buckled, and rivets were sheared and popped; the structural frame supporting the stack was also bent, with many rivets sheared and popped.

All of the reinforced-concrete work, as well as the mechanical equipment except one turbine generator, all the piping and the boilers, and the electrical equipment with the exception of the transformers, remained in operating condition. In fact, one turbine kept running until the operators extinguished the fire from under the boilers.

The top one-third of the concrete stack was severely cracked and spalled. The main transformers, which were mounted on wheeled trucks for easy change-out, tipped over against the compartment walls, severing the electrical connections, which disconnected the electrical output from the station. This damage all happened in a period of about 30 seconds. Subsequent shocks caused additional bricks to fall without further structural damage.

The rebuilding of the station was started within one week after March 10, 1933 and the principle corrections made were:

The stack was cut 177 feet in height and forced draft fans installed.

The brick walls were replaced with reinforced brick, doweled into the floors, and tied into the steel frame of the building.

The cast-iron fittings and valves on the overhead domestic water tank were replaced with steel.

The steel columns and girders under the turbine floor were repaired and reinforced with additional heavy structural braces.

The steel braces and girders under the reduced stack (700 tons of weight removed) were repaired.

The main transformers were placed on larger and heavier constructed trucks.

The cost of rebuilding was approximately $300,000. The original cost was about $85 per kilowatt, in contrast to similar stations being built at that time, costing from $100 to $110 per kilowatt. It was evident that the majority of the saving was in the wall construction.

It was the opinion of the investigating committee that the station would have withstood this earthquake with a minimum of damage and expense if the brick walls had been designed of reinforced concrete and properly tied to the steel frame, if the stack had been supported by a concrete foundation at ground level and not carried on steel columns, and if the turbine supporting floor had been properly designed of heavier construction.

Appendix C: Typical Specifications Used in Construction of Power Plant Piping

Olive Unit #2 Detail Specifications No. 928

C.1 General

1. REQUIREMENT

(a) There shall be furnished materials, labor, equipment, transportation, etc., to complete the installation of the following items at the Public Service Department's Olive Power Plant, Unit No. 2 site, located at Lake Street and Olive Avenue, Burbank, California:

Ia. All Process and Utility Piping (Item Ia, Bid Proposal, Page P-2).

Ib. Unit Price Pipe Work (Item Ib Bid Proposal, Page P-2).

IIa. Instrument Installation and Instrument Piping (Item IIa Bid Proposal, Page P-2).

IIb. Unit Price Instrument Work (Item IIb Bid Proposal, Page P-2).

The Contractor shall furnish all materials required to complete the work of Items Ia and IIa unless specifically noted to be furnished by others in these specifications and drawings.

(b) Unit No. 2 includes a 55,000 kw turbine generator reheat unit, operating at 1450 psig, 1000°F/1000°F. The steam generating unit has a maximum capacity of 440,000 lbs/hr. This is the second unit to be installed at the Olive Power Plant site, and is of the outdoor type design.

2. CONSTRUCTION FACILITIES AND SERVICES BY THE CITY

(a) The City will furnish an engineer whose services will be available without charge to establish grades and lines.

(b) The City will furnish to the Contractor limited space for pipe and equipment storage and work area directly adjacent to the plot area. The Contractor shall exercise care to avoid stockpiling materials and placing equipment where it will interfere with any other work which is in progress by the City or by other contractors.

3. CITY INSPECTION

(a) A City inspector will be available to see that the Contractor has complied with the requirements of these specifications, but his inspection shall not relieve the Contractor of his responsibility for the correct installation of the piping and equipment.

(b) The City inspector shall approve all radiographs and witness all magnetic particle tests. Any questions arising from these inspections shall be referred to the Engineer for final decision.

(c) The City inspector shall inspect each tank, heater and pressure vessel prior to installation of pipe and prior to starting up plant.

4. CONTRACTOR'S INSPECTION

(a) The Contractor shall be responsible for the quality of work done by his organization, and shall conduct tests not only of the welding process to determine its suitability to insure welds of the required quality and strength, but also examine the welding operators to determine their qualifications and their ability to comply with the specified procedure. All welders employed on the work in the shop and in the field shall be certified for the class of work they are assigned to do. Welders shall be certified in accordance with Section IX of the ASME Boiler Construction Code, latest edition. The Contractor shall be familiar and comply with the provisions of the laws, codes and regulations governing, and be experienced in, welded pipe construction.

(b) The Contractor shall retain at his own expense, both in the shop and in the field during the progress of the work, inspectors fully qualified to inspect and pass on matters pertaining to materials and workmanship required under these Specifications.

(c) In all matters of fabricating detail, testing, and quality of workmanship, the ASA Code for Pressure Piping, B31.1, latest edition, and the ASME Boiler Code, latest edition, shall govern, as far as they may apply. All high pressure welds shall be inspected and passed by the Hartford Steam Boiler Inspection and Insurance Company, and shall have been made by certified welders. Three copies of Hartford inspection reports shall be submitted to the City.

(d) The cost of inspections and certification of work and material shall be included in the bid items.

5. COORDINATION

During the installation of piping and equipment there will be other Contractors and City personnel working in the same area. The Contractor shall coordinate his work with that of the other contractors and City personnel so that there will be a minimum of interference between working forces. The City's construction superintendent will arbitrate any problems involving coordination.

6. PLANT SITE

All bidders prior to submitting their bids shall visit the site of the work and thoroughly acquaint themselves therewith and carefully investigate and determine all conditions respecting the work to be performed. The bidders may contact the City's construction superintendent for information.

7. SCHEDULE

The Process and Utility Piping Work shall begin approximately December 2, 1963, and shall be completed no later than August 28, 1964. Instrument Installation and Instrument Piping Work shall be completed no later than September 4, 1964.

(a) Instrument installation and piping for any piping system shall, in general, not commence until hydrostatic testing of that system is completed and after larger piping is installed in the area such that the risk of damage to instruments and small tubing is minimized.

(b) Scheduled first turbine rollover is September 2, 1964. Prior to this time it will be necessary for the City to check out piping systems, instrumentation, and equipment for completion and performance. The Contractor shall endeavor to complete some of the systems and equipment installation so the City may begin its plant check out, flushing and startup procedures no later than July 15, 1964. Contractor shall submit to the construction superintendent a daily report indicating line by line completion of work on the process and utility piping and itemized instrument installation completion.

(c) The Engineer shall have the right during the course of construction of the Power Plant Unit 2 to prescribe changes in schedules of the work performed by other contractors and in all or part of the work to be performed by the Contractor under these Specifications No. 928, and the Contractor shall comply with and conform to any and all changes in schedules prescribed by the Engineer.

(d) Requests by the Contractor for changes in the schedules of the work to be performed by the Contractor must be approved in writing by the Engineer. As approval of such requests will require some time and may affect other work by the Contractor and other contractors, the Contractor shall submit all such requests to the Engineer in writing immediately when the necessity therefor becomes known to the Contractor.

(e) The Contractor is hereby notified that certain time lapses will occur between the various steam blow out and flushing phases mentioned in Paragraph 26 of these Detail Specifications and that the Contractor must supply the labor and materials for installation and removal of necessary temporary piping shown on the drawings.

(f) Any and all interruptions in the continuity of the Contractor's work caused by chemical cleaning of piping and equipment in the plant, if such cleaning is performed, and any and all interruptions in such work contemplated by the Contract Documents, including, without limiting the generality of the foregoing, interruptions due to scheduling of the work of the Contractor and other contractors at the site of the work, testing of equipment and systems, steam blow out and flushing, application of insulation, corrections of deficiencies in piping and equipment installed by the Contractor and other contractors and persons, completion of the work of other contractors, and changes in the schedules of the work of other contractors and of the Contractor under these Specifications No. 928, must be considered and taken into account by the Contractor in submitting his bid.

(g) The City reserves the right to interrupt the continuity of the Contractor's work as set forth in Subparagraph (f) of this Paragraph and by causing changes, including extra work, to be made and performed in the Contractor's work in accordance with the provisions of Paragraph 31 of the General Conditions of these Contract Documents, and the Contractor's bid shall include full compensation to the Contractor for any and all such interruptions.

(h) Any and all interruptions in the Contractor's work mentioned or referred to in Subparagraphs (f) and (g) of this Paragraph which delay the Contractor in the performance of his work shall be deemed to be unavoidable and "causes clearly beyond the control of the Contractor" within the meaning of Paragraph 3 of the General Conditions of these Contract Documents. By execution of the Agreement provided for in these Contract Documents the Contractor covenants and agrees with the City of Burbank that the Contractor neither has nor shall have any claim, demand, action or cause of action against the City on account of or in respect to any of the interruptions hereinabove mentioned and referred to or by reason of delay in performance of the Contractor's work caused by any act or omission of the City.

8. AWARD OF CONTRACT

Bidder's proposals shall be evaluated on the basis of the bid price and on the following:

(a) Ability of the Contractor to complete work in scheduled time.

(b) Experience of the Contractor in this type of work and work of comparable magnitude.

(c) Quality of past work of this nature performed by Contractor.

(d) Bidders shall possess a certificate of authorized use of the ASME Welded Power Piping Stamp as illustrated in Fig. P-41 - Section P-300 of Section I of the ASME Power Boiler Code.

9. SCAFFOLDING

Contractor shall provide all necessary scaffolding, platforming, etc. necessary for the installation, welding, stress relieving, testing, etc. of all lines included in these specifications.

10. TESTS

(a) Contractor shall hydrostatically test all lines except instrument air headers and instrument tubing which shall be bubble tested prior to acceptance by the City. These hydrostatic field tests shall be made in strict accordance with the ASA Code for Pressure Piping. All lines shall be tested to 1-1/2 times the service pressure rating as indicated on the line list. Any lines which do not have root valves shall be tested by using a blind flange or welding a temporary plate at the end of said line. Exception to this requirement will be the piping between the turbine case and the first valve on all extraction lines.

(b) Any coupling or other connections including air vents on all high points and drains on low points necessary for testing shall be furnished and installed and later plugged by the Contractor. All openings in all lines will have to be plug capped or otherwise closed off for testing and shall be done at the Contractor's expense, including the cost of any materials involved.

(c) All lines shall be hydrostatically tested using City water. After each line is made tight the final test water shall be drained and the line filled with water containing hydrozine or other oxidation prevention chemicals. All chemicals will be furnished by the City. This chemically treated water shall remain in the lines until such time as flushing or start up operations are started by the City.

11. GRATING

Contractor shall properly replace any grating, floor plate, handrail, toe boards, or any structural member which he or any of his subcontractors move, cut or loosen during the course of the contract. Contractor shall include in costs the cutting and reinforcing with sleeves all holes required in the grating. Where bearing support is cut for pipe installation, angle supports shall be installed. Where pipe runs through the grating, the grating shall be cut and supported in such a manner as to be readily removable after pipe and insulation work is completed. Reinforcing sleeves shall be concentric with the pipe within plus or minus 1/2" maximum and shall be sized to allow for insulation and expansion movement. Sleeves shall project 4" above grating to serve as kick plate and insulation protection. Grating reinforcing rings shall be welded in place in a workable manner to make a neat appearance. It shall be done in strict accordance with safety codes and grating manufacturer recommendation. All bared metal grating shall be cleaned and given one application of Galvatex. The City's inspector will inspect each cutout.

12. CLEANING UP

The Contractor shall at all times keep the premises free from accumulations of waste materials and rubbish caused by the Contractor or subcontractors. Upon completion of the work the Contractor shall remove from site all tools, equipment, temporary structures, unused materials, scaffolding, rubbish and other pipe materials belonging to him and used under his direction during construction, and shall leave all working areas broom clean. In the event of failure of the Contractor to remove all materials and rubbish, the same may be removed by the City at the expense of the Contractor.

13. DELIVERY

(a) The Contractor shall provide facilities and personnel for unloading and receiving all equipment and materials at the site of the work.

(b) The City may at the request of Contractor, furnish the personnel and facilities to unload, receive and warehouse a limited amount of equipment and materials required under this contract, and Contractor agrees to promptly pay the expense of the use of City personnel and equipment in performing this service. For this service, Contractor shall send a copy of the bill of lading to the Engineer, and City will arrange to render the service. In performing this service the City shall act as the agent of the Contractor. Although reasonable care will be taken to check and store the equipment and materials received under this paragraph, packaged materials will not be opened, and it is distinctly understood the City will in no event be responsible, nor does it assume any liability, for such equipment or materials.

ITEM Ia - PROCESS AND UTILITY PIPING

14. SCOPE OF WORK

(a) The Contractor shall furnish all necessary materials (unless specifically designated on the drawings or in these specifications to be furnished by others), transportation, shop and field fabrication and erection, labor, equipment, and tools for handling, cleaning, lifting, placing, cold springing, flanging, welding, stress relieving and testing all pipe, valves (manual, gravity, or air operated), relief valves, fittings, and other specialties to install a complete and operable piping system in strict accordance with the specifications and contract drawings listed herein. All terminal connections to equipment and tie-in connections to existing piping or piping by others shall be made by the Contractor under these specifications.

(b) It is the intent of these specifications that the Contractor shall furnish a complete plant piping system, tested and ready for operation.

(c) The Pipe Line List, drawing No. ES-1691 sheets 1 and 2, lists the pipe lines which constitute the plant piping system to be furnished and installed by the Contractor.

(d) In addition to pipe lines as listed on the pipe line list the Contractor shall include the following as part of the installation of the process and utility piping:

1. Turbine deck drain piping (dwg. ES-1698).

2. Boiler roof drain piping (dwgs. ES-1623 thru 1629 incl.).

(e) In the case of small lines all unions may not be shown on drawings, but Contractor shall furnish and install unions where necessary for pipe make-up.

(f) Any pipe lines which are required by the City and not indicated on the line list or drawings shall be installed by the Contractor in accordance with paragraph 30 of these Detail Specifications, Unit Price Pipe Work.

(g) Back welding of all 300 PSI and higher pressure plugged vent and drain connections is required after hydrotest.

(h) Reinforcing Pads: Pipe reinforcing pads shall be provided on all lines where required in accordance with ASA Code for Pressure Piping B31.1 latest edition. Reinforcing pads called for specifically on drawings shall also be applied according to the code.

(i) A special stainless steel liner will be furnished to the pipe contractor for installation into a section of the cold reheat line in accordance with the manufacturer's recommendations. The cost of installation shall be included by the Contractor.

(j) The Contractor shall include in his bid the cost to install equipment drain and other miscellaneous piping that is shown on either the piping drawings and/or flow diagrams but does not carry a separate line number.

(k) The Contractor shall include in his bid the cost of labor to install the large diameter circulating water pipe, expansion joints and valves furnished by the City as shown on drawing ES-1742. This labor shall include field measurements, fitting up, making up flanged and field welded joints and patching of cement lining. Contractor shall furnish all bolts and gaskets for this work.

(l) The Contractor shall check boiler and turbine erection drawings under Specifications #901 and #900 respectively to avoid interferences with piping systems and equipment installed under those specifications.

15. CONTRACT DRAWINGS (PROCESS AND UTILITY PIPING)

(a) The piping drawings listed in this paragraph are intended to show location, piping design, layout and assembly of the unit piping systems and are hereby made a part of the Specifications. No warranty or representation, express or implied, is made with regard to accuracy of the dimensioning of pipe 2" and smaller in diameter shown in these drawings. The Contractor is required to field fabricate all such pipe in accordance with the procedures specified in Paragraph 23 of these Detail Specifications.

(b) The routing of any piping 2-1/2" and larger in a manner different than that shown on the drawings shall be approved by the Engineer prior to fabrication and installation.

(c) All lines requiring stress analysis have been engineered as required.

(d) Dimensions on drawings are usually in feet and inches - inches only are shown when dimensions are less than 1'-0". Dimensions are to pipe center lines and contact faces of flange.

(e) "F.W." denotes field weld. All field welds located by dimension shall be held to such indicated location.

(f) "F.S." denotes field support. Contractor shall measure, cut and fit and install as per drawing ES-1746.

(g) "C.S." denotes cold spring and has been noted on drawings as required.

(h) The piping drawings are listed as follows:

	TITLE
ES-1689 Rev. B	Table of Contents
Piping Line List	
ES-1691 Rev. B (2 Sheets)	Piping Line List Sheets 1 and 2
Piping Flow Sheets	
GS-12 Rev. B	Mechanical Flow Diagram - Stm., Cond. Fuel and Water
ES-1751 Rev. B	Mechanical Flow Diagram - Air & Lube Oil Systems
ES-1705 Rev. B	Heat Balance
ES-1849 Rev. B	Service & Instrument Air Schematic

Equipment Arrangement Drawings

ES-1709	Rev. D	Equipment Arrangement - Plan Elev. 556'-0"
ES-1710	Rev. B	Equipment Arrangement - Plan Elev. 576'-0"
ES-1713	Rev. B	Equipment Arrangement - Plan Elev. 566'-0", 585'-1" and 594'-2"
ES-1714	Rev. B	Equipment Arrangement - Plan Elev. 603'-2", 614'-0" and 623'-4"
ES-1715	Rev. B	Equipment Arrangement - Plan Elev. 632'-8" and Boiler Roof Plan
ES-1716	Rev. B	Equipment Arrangement - Sectional Elevation - East
ES-1717	Rev. D	Equipment Arrangement - Sectional Elevation - West
ES-1718	Rev. B	Equipment Arrangement - Sectional Elevation - South

Piping Detail Drawings

ES-1721	Rev. B	Area Drawing Index
ES-1723	Rev. B	Piping Plan - Area A-1-Elev. 575'-0" to 556'-0"
ES-1724	Rev. B	Upper Piping Plan - Area A-1
ES-1725	Rev. B	Piping Plan - Area B-1-Elev. 575'-0" to 566'-0"
ES-1726	Rev. B	Piping Plan - Area B-1-Elev. 583'-0" to 575'-0"
ES-1727	Rev. B	Piping Plan - Area B-1-Elev. 601'-0" to 583'-0"
ES-1728	Rev. B	Piping Plan - Area B-1-Elev. 622'-0" to 601'-0"
ES-1729	Rev. B	Piping Plan - Area B-1-Above Elev. 622'-0"
ES-1730	Rev. B	Piping Plan Elev. 565'-6" to Elev. 556'-0" and Section - Area F-1
ES-1731	Rev. B	Piping Plans - Elev. 565'-6" and Above - Area F-1
ES-1732	Rev. B	Piping Plan and Sections Area D-1
ES-1735	Rev. B	Piping Plan - Area G-1-Elev. 563'-6" to 556'-0"
ES-1736	Rev. B	Piping Plan - Area G-1 Above Elev. 563'-6"
ES-1737	Rev. B	Piping Elevation-Area A-1 & B-1 Lower West Section AB-1 (inboard)
ES-1738	Rev. B	Piping Elevation - Area A-1 & B-1-Upper West - Section AB-1
ES-1739	Rev. B	Piping Elevation - Area A-1 & B-1 - Lower East - Section AB-2 (inboard)
ES-1740	Rev. B	Piping Elevation - Area A-1 & B-1 Upper East - Section AB-2 (inboard)
ES-1741	Rev. B	Piping Elevations - Area A-1 & B-1 Sections and Details.
ES-1742	Rev. B	Piping Sections Area G-1
ES-1743	Rev. B	Piping Sections Area G-1
ES-1744	Rev. B	Standard Butt Weld End Preparation
ES-1745	Rev. B	Piping Elevation Area B-1-Sections & Details
ES-1746	Rev. B	Pipe Anchors, Guides, Hangers, Pipe Shoes, Field Supports, and Misc. Details (also see ES-1699)
ES-1747	Rev. B	Piping Details Area G-1
ES-1750	Rev. B	Piping Elevation - A-1 & B-1 - Lower West - Section AB-16 (Out board)
ES-1752	Rev. B	Piping Plans Area G-2, B-1 and Misc. Details
ES-1753	Rev. C	Piping Materials Specifications
ES-1690	Rev. B	Unit No. 1 Additions - Below Elev. 576'-0"
ES-1692	Rev. B	Unit No. 1 Additions - Elev. 575'-0" to 556'-0"
ES-1693	Rev. B	Temporary Blow-Off Piping
ES-1694	Rev. B	Temporary Blow-Off Piping - Sections & Details
ES-1695	Rev. B	Condensate - Feed Water Spray Attemperator Flushing System

ES-1696	Rev. B	Condensate - Feed Water Spray Attemperator Flushing System
ES-1697	Rev. B	Condensate - Feed Water Spray Attemperator Flushing System
ES-1698	Rev. B	Piping Plan and Sections - Turbine Deck Drains
ES-1699	Rev. C (4 Sheets)	Pipe Support Details, Sheets 1 thru 4 (see ES-1746)

Reference Drawings

ES-1722	Rev. B	Plant Underground - Piping Plan
ES-1748	Rev. B	General Plan - Underground - Yard Piping

16. MATERIAL TO BE FURNISHED BY THE CITY

The City will furnish the following material to the Contractor for him to install.

(a) All valves.
(b) All expansion joints.
(c) All strainers and steam traps.
(d) All orifice plates and restriction orifices (orifice flanges by Contractor) and flow meter elements.
(e) Major supporting structural steel (Contractor shall furnish hanger support steel as indicated on hanger support details on dwgs. ES-1699 sheets 1 thru 4).
(f) Control valves and safety valves.
(g) Weld in type thermowells for welding in piping.
(h) Reheat and mainsteam spray water flow measuring elements.
(i) Reheat attemporator spray nozzle and lines for inserting in reheat steam line.
(j) Flow alarm switches, sight flow glasses and rotameters.
(k) Feedwater flow nozzle pipe assembly including mating weldneck flanges.
(l) Large diameter circulating water Line 2186WA-42" shown on drawing ES-1742.

17. PIPE FITTING AND ASSEMBLY MATERIAL

All pipe and fittings must be equal or better than the grades as listed on the Piping Materials Specifications dwg. ES-1753. These Piping Material Specifications define the material to be furnished by the Contractor to complete the work shown on the drawings, except as noted otherwise. Any proposed deviation from material specifications must have written approval by the City.

It shall be the Contractor's responsibility to compare all outlines of equipment, valves, instruments and specialty items to assure a proper mating connection. Certified outlines shall be used by the Contractor to determine the end to end, face to face, dimensional location of terminal points for the shop or field fabrication of all piping. Certified outlines will be furnished to the Contractor by the City for this purpose. In lieu of certified dimensional outlines permission may be obtained from the City to use correct catalog dimensions.

The Contractor shall provide the City with supporting papers identifying all materials which are used in completing the work covered in these Specifications.

18. EQUIPMENT IDENTIFICATION

The City will furnish the Contractor a complete equipment list, showing identification numbers for all equipment, valves, instruments, strainers, etc.

Material furnished by City will be stored in the City's warehouse adjacent to the site of the work. All valves and specialty items will be identified by tag number. Contractor must make certain that each valve drawn from the warehouse is tagged. The piping drawings indicate the valve and specialty item number corresponding to the identification tag for each given position.

In many instances, two valves or specialty items may be of identical make, size, and shape; however, the internals may be different, hence the importance of proper valve identification. The City's field inspector will not accept the installation of any valve that does not have the proper identification tag. The Contractor's work shall include the handling of all the valves and specialty items from the City's warehouse to location of the completely assembled installation.

19. WELDING TO PIPE TO BE HEAT TREATED

Insulation shoes, anchors, guides, support clips, insulation anti-slip bars, miscellaneous brackets and welded attachments shall be shop welded on all heat treated alloy or stress-relieved carbon steel pipe before heat treatment.

20. HANGERS, SUPPORTS, GUIDES AND ANCHORS

Except where specifically called out on the drawings as furnished by the City or by others, the Contractor shall furnish, handle, erect and attach to the pipe and properly adjust, all spring and rod hangers, supports, guides and anchors as indicated on the drawings. The design, fabrication and erection of structural steel shall conform to the requirements of the current issue of AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings". The hangers, supports, guides and anchors shall be located as indicated on the drawings, and manufactured in accordance to MSS-Standard Practice SP-58. However, if locations as shown on drawings are not possible or additions are required, the Engineer shall be notified and a suitable location will be selected. The Contractor shall furnish, field fabricate in accordance with the procedures specified in Paragraph 23 of these Detail Specifications and install all necessary hangers and supports for piping and tubing 2" and smaller that may not be shown or located on the drawings. Size and spacing of these hangers shall conform to the requirements of the ASA Code for Pressure Piping. The major portion of the miscellaneous steel which is to be furnished by the Contractor is indicated on drawings ES-1746 and ES-1699.

Insulation shoes when field welded shall be centered over pipe supports in cold position after line is completely installed.

Boiler drain and blow down piping shall be supported as shown on the drawings to insure against overstressing due to downward growth of the boiler under operating conditions.

21. BENDS

Bends are not permitted in A120 Spec. weld pipe. Bends are permitted in all seamless pipe, using 5 diameters bending radius or as indicated on drawings. In no case is the wall to be thinned more than 5% by bending. In case of thinning of walls in excess of 5% the size, wall thickness and line number shall be submitted to the City. The wall thickness will then be recalculated on basis of ASA-B31.1, by the Engineer and either accepted or rejected. The Engineer's decision will be final. Field fabricated pipe bends for small diameter pipe may be substituted for fittings shown on the drawings. Such bends are preferred to fittings where permitted by the Piping Material Specifications, drawing ES-1753.

22. FABRICATION OF WELDED PIPE

(a) General: Fabrication details shall be in accordance with ASA Code B31.1, latest edition, unless otherwise specified in these specifications and contract drawings. Contractor shall provide, with his proposal, two copies of all welding procedures which will be required for these specifications for the City's approval. Alternate procedures must be submitted to the City for approval before use. In addition, the Contractor shall furnish to the City a photostat copy of his ASME certificate of authorization for high pressure piping.

(b) Slip-on flanges and reducing flanges shall be welded both inside and outside.

(c) Substitutions, including heavier or thicker materials, are not permitted without written approval.

(d) The Contractor shall insure that all installed pipe is free and clear of all foreign materials, construction debris, etc.

(e) Fabrication tolerances shall be in accordance with Pipe Fabrication Institute Standard ES3 as last revised. Any refabrication of shop piping due to faulty fabrication shall be corrected at Contractor's expense. Any refabrication of field fabricated pipe shall be at Contractor's expense unless the changes are caused by relocation of equipment, structures, ducts or piping by some person other than the Contractor.

(f) Carbon Steel Pipe

1. Base Metal - May be any of those listed in ASME Section IX Group P-Number 1. Weld metal shall equal properties and analysis of base metal specifications.

Base Metal		Weld Metal	Process	Preheat	Postheat
Pipe	A53 A106	Carbon Steel	Metal Arc or Inert Arc Root and Metal Arc or submerged Arc	As needed	Stress Relieve per Code. ASA 3/4" or over ASME same.
Fittings	A234-WPA A234-WPB				
Forgings	A181 Grade I A181 Grade II A105 Grade I A105 Grade II		No Permanent backing ring unless approved by the City		

All butt welds on main boiler feedwater piping, lines 2013SH, 2014SH and 2015SH, shall be welded inert arc root and metal arc process with high deoxidizer filler metal added, or approved equal.

Cutting Bevels - Welding bevels and grooves shall be machine cut or torch cut and ground, and shall be chipped or brushed to remove cutting slag and heavy oxide scale.

2. Bending - Completed bends shall be true to dimensions and free of flat spots and corrugations.

   Cold Bending - Cold bends shall be closely examined visually, or if required by the Engineer, shall be tested by the magnetic particle method to show an absence of surface cracking. Completed bends shall be heat treated as provided herein, when radius is less than five (5) times the nominal pipe size.

   Hot Bending - Hot bending may be performed and will require no heat treatment other than to cool uniformly. Quenching or bend setting with water shall be minimized on Grade B pipe.

3. Straightening - Straightening of piping by heating bands or spots shall be done at a temperature not to exceed 1375°F and with no liquid quenching Cold straightening to correct minor misalignment is subject to approval by the City inspector.

4. Welding Procedures - Welding procedures and welders shall be qualified in accordance with ASME Code, Section IX. Two copies of all procedures and welding operator qualification test reports shall be transmitted to the City. Weld reinforcement shall be held to a minimum and edges shall merge smoothly with the base metal with no undercutting. All repairs shall be made with matching weld metal and ground flush to match normal contour.

   Fit Up - Fit-up and groove dimensions shall be within tolerances of the qualified welding procedure to permit full penetration with internal reinforcement.

   Tack Welds - Tack welds shall be fully penetrated and confined to the bottom of the welding groove. They shall be of the same quality and analysis as the weld, and excessive thickness, improperly fused starts, and all cracks or faults shall be removed to sound metal before depositing the weld. Thermal gouging will be permitted only when base metal is at preheat temperature and surfaces are ground or chipped to remove heavy slag or oxide before welding.

   Soundness - Penetration shall be completely to the weld root to the full wall thickness. Each pass shall be completed around the pipe before depositing the next. Starts shall be staggered. In each layer of welding, improperly fused starts, checks, and surface defects shall be removed to sound metal before additional welding is performed.

5. Preheating - The base metal adjacent to the welding groove shall be heated as required to produce sound welds before tacking, flame or arc gouging and during welding.

6. Heat Treatment - During heat treatment flange gasket faces, ring grooves and threads shall be protected against oxidation and damage. Heat treatment of welds when required, unless otherwise specified, consists of stress relieving in accordance with ASA B31.1 or when covered by the ASME Boiler Code. Stress relief consists of heating uniformly and slowly to 1100-1200°F, hold one hour per inch of wall thickness, minimum one-half hour, and cool slowly to 600°F. The section may be cooled uniformly in the furnace or in still air. For local heat treating both ends of line shall be closed to prevent drafts during heat treating.

g) Alloy Pipe 1/2 to 2 Chrome - 1/2 Moly Pipe

1. Base Metal - May be any of those listed in ASME Section IX Group P-Number 4. Weld metal shall equal properties and analysis of base metal specification.

Base Metal	Weld Metal	Process	Preheat	Postheat
Pipe A335-P12 CrMo 1/2 A335-P11 Cr-1-1/4 Mo-1/2	Cr-1-1/4 Mo-1/2	Metal Arc or Inert Arc Root and Metal Arc or Sub-merged Arc. No permanent backing ring unless approved by the Engineer.	400-600 Low Hydrogen 250° min.	1325°F/Hr/in.
Fittings A234-WP12 A234-WP11				
Forgings A182-F12 A182-F11				

All butt welds on all alloy piping shall be inert arc root and metal arc except where special connections are specified.

Cutting Bevels - Welding bevels and grooves shall be machine cut or torch cut and shall be ground or chipped to bright metal.

2. Bending - Completed bends shall be true to dimensions and free of flat spots and corrugations. (See Par. 22 (f) Sub. 2)

Cold Bending - Cold bends shall be closely examined visually or by magnetic particle to show an absence of surface cracking. Completed bends shall be heat treated as provided herein. Prior to bending Brinell hardness shall not exceed 163 BHN.

Hot Bending - Hot bending may be performed between 1250 and 1400°F, which will require no heat treatment, only covering to cool uniformly. Bending shall not be performed in the range of 1450 to 1700°F, unless the entire surface of the completed bend is magnetic particle inspected. Completed bends made at 1450°F to 1700°F shall be heat treated as provided herein. Quenching or bend setting with water shall not be permitted. Air cooling from above 1400° requires full heat treatment.

3. Straightening - Straightening of piping by heating bends shall be done at a temperature not to exceed 1375°F and with no liquid quenching. Cold straightening to correct minor misalignment is

subject to approval by the City inspector.

4. Welding Procedures - Welding procedures and welders shall be qualified in accordance with ASME Code, Section IX. Weld reinforcement shall be held to a minimum and edges shall merge smoothly with the base metal with no undercutting. All repairs shall be made with matching weld metal and ground flush to match normal contour. Two copies of all procedures and welding operator qualification test reports shall be transmitted to the Engineer prior to proceeding with the work.

   Fit-Up - Fit-up and groove dimensions shall be with tolerances of the qualified welding procedure to permit full penetration without internal reinforcement.

   Tack-Welds - Tack-welds shall be fully penetrated and confined to the bottom of the welding groove. They shall be of same quality and analysis as the weld, and excessive thickness, improperly fused starts and all cracks or faults shall be removed to sound metal before depositing the weld. Thermal gouging will be permitted only when base metal is at preheat temperature and surfaces are ground or chipped to bright metal before welding.

   Soundness - Penetration shall be completely to the weld root to the full wall thickness. Each pass shall be completed around the pipe before depositing the next. Starts shall be staggered. Improperly fused starts, checks and surface defects shall be removed to sound metal before welding.

5. Preheating - The base metal adjacent to the welding groove shall be preheated to 400-600°F before tacking, flame or arc gouging and during welding.

6. Interruption of preheating and welding shall be permitted only after two passes minimum or one-third the groove depth has been completed. Weld shall be covered to cool uniformly. Preheat shall be established prior to continuation of welding.

7. Cooling After Welding - The completed groove weld shall be covered to cool uniformly from the preheat temperature if heat treatment is not to be performed immediately before cooling below preheat temperature.

8. Heat Treatment - During heat treatment flange gasket faces, ring grooves and threads shall be protected against oxidation and damage. Heat treatment of welds is required and, unless otherwise specified, consists of subcritical anneal. Minimum strength of welded joint shall meet Code requirements.

   Subcritical anneal consists of heating uniformly to 1300-1350°F, in not less than two hours, hold one hour per inch of wall thickness, minimum one and one-half hours, and cool 100-150°F per hour to 1100°F. Below 1100°F the section may be cooled uniformly in the furnace or in still air by covering a distance of two diameters or a minimum of one foot each side of weld with 1/4-inch of asbestos. For local heat treating, both ends of line shall be closed to prevent drafts during heat treating.

(h) Bi-Metallic Connections - Where different types of metal are connected together, the lower stress specification shall apply. When welding carbon steel pipe to alloy valves (SF & SH specs) use 25-20 stainless steel welding electrode.

(i) Painting - All uninsulated, unprotected carbon steel pipe and supports shall be cleaned of rust, loose scale, oil, grease or other foreign substances, and given one coat of zinc chromate primer.

(j) Cleaning Pipe - All pipe shall be carefully inspected for internal cleanliness and all dirt and foreign material removed. All welds shall be inspected internally and all loose metal and slag removed prior to final installation. Where a final weld cannot be visually inspected, an inert arc root weld is required and no acetylene gas cutting will be allowed. Prior to installation, ends of spools shall be covered to keep out all dirt, foreign material, etc.

(k) Marking - Piping shall be piece marked by tagging and painting identification. All alloy pipe shall be code colored on not less than two feet on each end of the pipe.

(l) Protecting for Shipment - Flange faces, machined surfaces and threads shall be clean and coated with corrosion preventative such as Rust Ban 324 or waterproof grease. Flange faces shall be protected by securely fastened wooden or metal covers. Couplings shall be protected by steel pipe plugs and threads by metal protectors.

23. FIELD FABRICATION

All lines sizes two (2) inches and smaller as shown on the drawings shall be field fabricated unless the Contractor at his own risk and responsibility chooses to shop fabricate such lines. No warranty or representation, express or implied, is made by the City with regard to accuracy of the drawings respecting piping sizes 2" and smaller in diameter. The Contractor is required to verify and measure in the field the routing and dimensions of all lines 2" and smaller in diameter so as to avoid interferences with structures, equipment and larger pipe and to accomplish field fabrication of pipe sizes 2" and smaller in diameter in accordance with the Specifications. The term "Field Fabricate" as used in these specifications and on the drawings shall mean measuring, cutting and fitting in the field, and routing and installing in place by the Contractor, all of the pipe, fittings and valves shown on the drawings, and shall include any instrument connection that might not be indicated on the drawings.

All lines two (2) inches and smaller detailed and checked on the drawings are shown to designate the desired routing and general location and for estimating materials and quantities of such piping, but final dimensions and configurations to provide clearances for pipe, fittings, valves, insulation, equipment and structures shall be the responsibility of the Contractor. Field routing of pipe shall be done in a neat and orderly manner consistent with good piping practice.

The Contractor shall generally follow the routing indicated on the drawings. If deviations from this routing are necessary or expedient, such deviations must be approved by the City's construction superintendent before deviation is made. The Contractor shall show the rerouting of all lines on sketches for the City's use in preparing "As Built" drawings.

24. PIPING SPOOLS

Piping spool drawings are not furnished as part of these Specifications. Piping contractor shall make up his own spool drawings from the drawings listed herein. He is and shall be held responsible for any and all errors in shop or field fabrication due to inaccuracy in his spool drawings. The Contractor shall furnish the Engineer for his information three (3) copies of all drawings made for shop fabricated pipe, before fabrication.

25. FITTING UP

It shall be the responsibility of the Contractor to fit up all lines square and plumb. Under no conditions shall any pipe anchored to any piece of equipment be forced in place except where cold springing is required. To make certain that no piece of equipment is strained during pipe installation, all joints, connections or flanges between the equipment and pipe shall be left free until the pipe has been completely welded. The City's inspector shall then be called to make an examination of the line prior to making up the last connection to the equipment.

The orientation of hand wheels shall be as indicated on th drawings. Whenever orientation is not indicated, Contractor shall orient for best operation and passage clearance.

26. STEAM BLOWOUT AND FLUSHING PIPING

Steam Line Blowout

The blowout procedure is divided into three phases and is covered by Contract Drawings Nos. ES-1693 and ES-1694. Blowout procedure will be conducted by the City.

Phase I - Blow superheated and main steam line through turbine stop valve to atmosphere through stack line No. 2148-12"

Phase II - Blow cold reheat line from turbine to reverse current valve on boiler. After completion of main steam line blow-out as per Phase I, the Contractor shall remove stack line No. 2148-12", install line 2149-12" from main steam turbine valve to connect to line No. 2017SF-12" and proceed as indicated in Section X-X of drawing No. ES-1694 adding flanged stack to RCV #6 and using a portion of line No. 2148 to complete the installation.

Phase III - Blow hot reheat line through reheat stop valve to atmosphere. After completion of cold reheat blow Phase II, Contractor shall remove blowout stack from RCV #6, and reassemble check valve. Contractor shall assemble stack from parts of Phase I and II as indicated on drawing ES-1694 for final blow from reheat stop valve.

Appendix D: Detailed Description of Selected Power Plants

D.1 Valley Steam Plant Units 1 and 2

D.1.0 Technical Description

D.1.1 Steam Generating Facilities

D.1.1.1 Boiler Structure - Structural

The boiler structure is designed as two separate units under a common roof. Boilers Nos. 1 and 2 occupy the east half of the area and serve the unit No. 1 main and house turbines, while boilers Nos. 3 and 4 occupy the west half of the area and serve the unit No. 2 main and house turbines. Two reinforced concrete mats, each 3 ft-0 in. thick, 66 ft-6 in. wide and 80 ft-0 in. long, serve as a foundation mat under each set of boilers. Interconnected footing walls, built on these mats are 5 ft-4 in. high to grade and vary in width from 42 in. to 60 in. Sand backfill was provided between footing walls and a reinforced concrete floor slab 6 in. thick was poured flush to grade. A fuel oil piping trench makes a loop between the two boiler units, forming an island upon which the primary fuel oil pumps are located. Twenty-four main structural steel columns and eight canopy support columns rise 100 ft to form the supporting steel for the boilers and the double hip roof structure. Beams and cross-bracing form five levels at grades 400, 412, 444, 452 and 470. The firing aisle portion of grade 412, between the two boiler units, has a reinforced concrete floor 6 in. thick. The remainder of 412 grade and all other levels have floors of galvanized steel grating. The double hip roof and sides down to grade 470 are covered with corrugated asbestos siding to protect the boiler steam drums from the weather. The remainder of the structure is open, except the central section down to grade 412, which has corrugated asbestos siding on the north and south ends and 1/8 in. steel plate flashing between boilers to effect a seal-off, thereby providing a sheltered firing aisle from grade 412 to the canopy at grade 470.

D.1.1.2 Boiler System

Four Babcock & Wilcox radiant type, single pass water tube boilers are installed in the boiler housing. Each boiler has a rated continuous capacity of 450,000 lb of steam per hr at 1,380 psi, with a maximum 24 hr capacity of 517,000 lb per hr. Boilers are of the two-drum type, with a steam drum 72 in. inside diameter and 26 ft-10 in. long of 5 15/16 in. wall thickness and a lower mud drum 42 in. inside diam and 32 ft long of 3 in. thickness. 165 generating tubes provide a total effective heating surface of 5,122 sq ft. The bare tube water-cooled furnace is 21 ft wide x 21 ft deep x 56 ft high, with a volume of 18,350 cu ft and an effective heating surface of 4,350 sq ft. A pendant type, two-section superheater with bottom drum at temperature control is mounted above the furnace and has a total effective heating surface of 14,968 sq ft. The economizer section situated where the flue gases pass from the superheater section into the air heaters is composed of 500, 2 1/2 in. diam tubes each raising 522,675 lb of feed water per hr from an inlet temperature of 375° F to a final temperature of 475° with oil fuel and to 490° F with gas fuel. The flue gases then pass downward through the tubes of a vertical air heater. The air heater section contains 2,457, 2 1/2 in. diam No. 14 gage tubes, each 42 ft long mounted in a 21 ft sq bundle for a total effective heating surface of 67,600 sq ft. When the boilers are being operated on oil fuel, the air heaters are designed to raise 493,000 lb of air from an inlet temperature of 80° F to a final temperature of 562° F. A return bend aerofin steam coil 14 ft high by 20 ft long covers the air inlet to the air heater to preheat the entering air during cold weather. This heater operates with 100 psi steam and has a capacity to raise 700,000 lb of air per hr from 30° F to 165° F. Each boiler is equipped with 14,I.K. air driven soot blower units and six G9B calorized elements in the boiler and superheater sections. Three straight line soot blowers are located at the bottom of the air heater section. The soot blowers are powered by air motors and operate on 600 psi steam through sequential control from a master panel board.

The boiler draft system is composed of a single inlet forced draft fan mounted on a common shaft with a double inlet induced draft fan and powered by a 2,000 hp electric motor running at a speed of 715 rpm. The forced draft fan draws in 700,000 lb of outside air per hr and forces it around the air heater tubes to the burner wind box at a pressure of 25 in. of water. The induced draft fan draws the flue gases from the boiler, through the air heater tubes and delivers the gases to the stack at the rate of 810,000 lb per hr with a discharge pressure of 13.5 in. of water. Each boiler has one self-supporting welded steel plate stack 11 ft in diam and 140 ft high. The stack interiors are lined the full length with a two in. thick coating of Haydite Lumnite gunite.

Each boiler is fired by six Peabody Engineering company constant differential pump type combination gas and oil burners mounted in two rows of three burners each across the furnace front wall, facing the grade 412 boiler firing aisle (each burner has a capacity of 36,200 lb of oil per hr or 11,800 cfm of gas). Fuel oil for these burners is stored in a tank farm composed of two 80,000 barrel and two 40,800 barrel welded steel tanks located approximately 500 ft to the north of the boiler area. These tanks are all fitted with Horton floating roofs to eliminate evaporative losses and fire hazard and are surrounded and sectioned off by earth dikes in accordance with Section 53 of the National Fire Code. Fuel oil is drawn from these tanks through a horizontal straight tube primary suction heater with a 1,052 sq ft heating surface. Steam at 100 psi is piped throughout the tank farm and is utilized as a heating medium. Fuel oil temperature is thermostatically controlled at 120 F. Oil suction lines are spirally traced with steam coils and insulated with three-ply weatherproofed Asbestocel to retain this heat. Fuel oil is drawn through approximately 700 ft of 12 in. dia. welded steel pipe to the primary fuel oil pumps, which are located directly beneath the boiler firing aisle at ground grade 385 in the boiler housing structure. Ten primary fuel oil suction pumps are mounted in a row with the 12 in. fuel oil suction piping looped around them in a trench covered with checkered plate. Five of these pumps serve boilers Nos. 1 and 2 of the primary fuel oil pumps are of the internal gear type, each having a capacity of approximately 28,000 lb of oil per hr at a 400 psi discharge pressure. Four of these pumps are powered by 60 hp, 440 v electric motors, connected to operate at two speeds by means of resistors and short circuiting air circuit breakers in the rotor circuit. The fifth pump is powered by a 60 hp, type DS-120 GE single stage steam turbine. An automatic sequence, activated by a 20-point drum controller, energizes these pumps as necessary to maintain constant primary discharge header pressure. The primary discharge fuel oil then passes through a series of three secondary fuel oil heaters located on the platform at grade 400 directly above the primary fuel oil pumps. These heaters are horizontal straight tube floating head closed heaters utilizing 100 psi steam for a heating medium. Each heater is 28 1/4 in. in diam and 18 ft-1 1/2 in. long with 338 tubes, having a total of 1,070 sq ft of heating surface. Fuel oil is raised to a final temperature of 250 F by the operation of thermostatically controlled heater by-pass valves and then enters the suction side of the secondary fuel oil pumps. There are eight secondary fuel oil pumps, each a four-stage centrifugal pump with a 75 gpm capacity at 300 psi differential, connected directly to a 40 hp, 3,500 rpm motor. Four secondary pumps are constantly in service delivering fuel oil at 250 F and 600 psi to the fuel oil manifold serving twelve Peabody burners, six for each boiler.

A 16 in. diam pipe line brings natural gas at 40 psi into the plant site from the Pacific Gas and Electric Company gas feeder to the Bakersfield area. The raw gas passes through a vertical involute separation tank, 42 in. in diam and 19 ft-3 in. high, where sand, dust and debris are removed by cyclonic action. The gas pressure is then reduced to 10 psi at a dual reducing station and is fed through Bailey Gas-Air flow meters to the Peabody gas burner ring as a stand-by fuel.

D.1.1.3 Power Plant Building - Structural

The power plant building is a reinforced concrete structure. The building is 176 ft wide by 198 ft long and occupies approximately 31,400 sq ft of area. The structure is supported on spread footings, tied together with concrete struts.

The building is a three-level structure with a ground floor at grade 386, an intermediate piping and conduit level at grade 400, and an operating level at grade 412. The structure is divided into three bays, from south to north as follows: the turbine bay, the auxiliary bay and the control bay. The turbine bay is 159 long by 93 ft wide and 80 ft to the roof, and houses the two main turbine generator units. The auxiliary bay is 159 ft long, 46 ft wide and 58 ft to the roof and houses air compressors and service pumps on the ground level; piping, heat exchangers and electrical conduit runs on the intermediate level; and the boiler feed pumps, evaporators and the two house unit turbine generators on the operating floor grade. The control bay is 159 ft long, 40 ft wide and 58 ft to the roof and houses the station service switchgear on the ground level, electrical conduit and control piping on the intermediate level and the turbine generator and boiler control panels on the operating floor. A machine shop 40 ft wide by 93 ft long by 26 ft high, with locker and wash facilities adjoins the turbine bay to the east. An entrance lobby, auditorium and first aid station occupy the northeast corner of the ground level. The northeast corner of the intermediate level is occupied by a battery charging room and the entire east end of the auxiliary and control bay operating level is devoted to six large office rooms, storage rooms and toilet facilities for the operating personnel.

A passenger elevator which is framed into the surge tank tower serves all floors, including the auxiliary bay roof and the upper levels of the adjacent boiler housing.

D.1.2 Power Plant - Mechanical

D.1.2.1 Unit No. 1

Steam at 1,350 psi and 925 F is carried from boilers Nos. 1 and 2 across the auxiliary bay roof in a schedule 160 carbon molybdenum steam header 14 in. in diam, and then drops into the power station building to the stop valves to the main unit and house unit No. 1 turbines.

The unit No. 1 main generating unit consists of a General Electric 20-stage, single casing, single flow turbine, extraction, condensing type, direct connected to a General Electric alternating current generator running at a speed of 1,800 rpm. Steam is extracted from the turbine at the fifth state (228.5 psi) for heater No. 1, at the ninth stage (46 psi) for the evaporator supply, at the sixteenth stage (9.6 psi) for heater No. 4 and the exhaust steam flows into the condenser at 3 in. Hg absolute pressure.

The alternating current generator has a rated capacity of 60,000 kw and a maximum of 75,000 kva at 0.8 pf, 1,800 rpm for 13,800, 3 phase, 60 cycle service. The generator is air-cooled through a water-cooled heat exchanger in a closed duct work system and is protected from fire by 21 fifty-lb CO_2 cylinders which are automatically released by thermostatic bulbs in the air duct.

The main unit condenser is a Foster Wheeler crossflow type consisting of 5,900 tubes, each 7/8 in. by 18 BWG by 26 ft-2 1/8 in. long for a total of 35,000 sq ft of condensing surface. Two Foster Wheeler Corporation single stage horizontal water pumps, each with a capacity of 32,500 gpm at 55 ft tdh and 495 rpm are driven by 600 hp, 2,300 volt squirrel cage motors to circulate cooling water through the condenser tubing. A Foster Wheeler Corporation twin element two-stage air ejector utilizes 200 psi steam to remove any air leakage into the condenser at a maximum rate of 202.5 lbs of air vapor mixture per hr for each two-stage element.

The unit No. 1 house unit turbine generator consists of a General Electric Company six-stage automatic extraction-admission condensing turbine running at 3,600 rpm to drive a General Electric Company alternating current generator. Power generation is at 2,400 volt, 3 phase, 60 cycle with a rated capacity of 6,000 kw and a maximum output of 7,500 kva at 0.8 pf. Only one extraction stage is provided on the house unit turbine to supply 5 psi gage steam for the unit No. 1 deaerating heater. The generator is air-cooled by a closed duct work system with a water-cooled heat exchanger. The generator is protected from fire by five 50 lb CO_2 cylinders which are automatically released into the air duct by thermostats set at 210 F. The turbine exhaust steam flows into a Foster Wheeler Corporation single pass reverse flow condenser consisting of 972 tubes, each 7/8 in. by 18 BWG by 18 ft-2 1/8 in. long having a total condensing surface of 4,000 sq ft. A Foster Wheeler Corporation single stage horizontal double suction pump powered by a 150 hp, 2,300 volt, 700 rpm motor circulates 9,000 gpm through the condenser tubing at 51.5 ft tdh.

A Foster Wheeler twin element two-stage air ejector, utilizing 200 psi steam, removes air leakage to the condenser at a maximum rate of 202.5 lb per lb per hr for each element.

Condensate from the hot well of the main condenser is drawn into either one of a dual condensate pump unit mounted directly beneath the condenser. The pumps are Foster Wheeler Corporation three-stage horizontal pumps powered by 100 hp, 400 v motors and each has a discharge capacity of 1,200 gpm at 185 ft tdh. The condensate is pumped first through the inner and aftercooling chests of the air ejector as a condensing medium for the 200 psi ejector steam. A regulating by-pass valve then returns a portions of the condensate to the condenser hot well as required to maintain a constant hot well water level.

Condensate from the house unit condenser hot well is drawn into a similar dual condensate pump unit installed directly beneath the hot well. The two condensate pumps are Foster Wheeler Corporation two-stage horizontal pumps driven by 25 hp, 400 v motors. The condensate is first pumped through the inner and aftercoolers of the house unit air ejector as a condensing hot well as required to maintain the required hot well level. The remainder of the condensate is joined with the main unit condensate after the air ejector and is forced through feed water heater No. 4.

Feed water heater No. 4 is a Foster Wheeler Corporation vertical type heater. The heater is 37 1/2 in. inside diam by 22 ft-3 in. long with 545 tubes each 7/8 in. by 18 BWG by 18 ft-10 7/8 in. long. Sixteenth stage extraction steam at 9.6 psi is fed into the shell of this heater to raise the condensate being pumped through the tubes from 118 F entering temperature to 189 F discharge temperature.

The condensate is then pumped to deaerating feed water heater No. 3 located on the auxiliary bay roof.

The 825,000 lb per hr Elliot deaerating heater and vent condenser consist of a horizontal tank 12 ft-6 in. diam by 13 ft-4 in., upon which is mounted a vent condenser 22 in. diam by 7 ft 11 1/4 in. long. The feed water passes over a series of cast iron deaerating trays within the heater where its temperature is raised from 189 F to 228 F and the oxygen content is removed to a maximum of 0.005 cc of oxygen per liter. A diaphragm valved by-pass assembly, operated by a deaerator normal level float, by-passes excess condensate to a 17,000 gallon surge tank, mounted on top of the elevator shaft, to provide a "floating" storage for maintaining the deaerator normal level under rapid load change demands.

The deaerated and heated condensate is drawn from heater No. 4 through an 18 in. downcomer to a header 16 in. in diam at grade 401.33, from which 12 in. suction headers take off to the primary suction of boiler feed pumps Nos. 1, 2 and 3 located on the auxiliary bay operating floor at grade 412.

Each Ingersoll Rand Company boiler feed pump consists of a primary and secondary pump mounted on a single bedplate with a 2,000 hp, 2,300 volt General Electric Company 3,570 rpm constant speed motor as a common driver for both pumps. The primary pumps are four-stage centrifugal units with a capacity of 575,000 lb per hour of boiler feed water at a discharge pressure of 500 psi and 228 F. The secondary boiler feed pumps are seven-stage centrifugal pumps with a capacity of 575,000 lb of feed water at 1,400 psi discharge pressure and 400 F.

The primary boiler feed water discharge is pumped through the Foster Wheeler Corporation evaporator condenser where its temperature is raised from 228 F to 240 F. The feed water then passes through a Foster Wheeler Corporation heater drain cooler 27 1/2 in. in diam by 15 ft-0 long and its temperature is raised from 240 F to 254 F. The feed water then passes through heater No. 2, a Foster Wheeler Corporation vertical heater 41 1/2 in. ID and 22 ft-4 3/4 in. long, where its temperature is raised from 254 F to 330 F. The feed water then passes to the final feed water heater No. 1, a Foster Wheeler Corporation vertical heater 41 1/2 in. ID by 22 ft-5 1/2 in. long, where its temperature is raised to a final 402 F. The feed water is then drawn into the secondary boiler feed pumps and discharged into the boiler feed header at a pressure of 2,300 psi. A feed water control valve at each boiler regulates this pressure to approximately 1,400 psi and admits feed water to maintain a constant water level in the boiler drum through the economizer.

The unit 1 Turbine requires a flow of 74,000 gpm of cooling water through the main and house unit No. 1 condensers, to hold a condenser vacuum of 3 in. Hg absolute. This water load is circulated through the condenser water tubes by the Foster Wheeler Corporation circulating pumps described previously and is discharged into a pipe 60 in. in diam running to two Foster Wheeler Corporation forced draft cooling towers. The heat is dissipated to the atmosphere by forced evaporative cooling and the water is again returned to the circulating water pumps through a suction header 66 in. in diam.

D.1.2.2 Unit No. 2

Steam from boilers Nos. 3 and 4 is carried across the auxiliary bay roof in two parallel carbon molybdenum schedule 160 headers 12 in. in diam which are joined into one 16 in. header that drops to the stop valve of the main unit No. 2 turbine. A six in. header drops to the stop valve of the house unit No. 2 turbine from the high pressure side of the reducing station steam header.

The unit No. 2 main generating unit consists of a General Electric 17-stage, single casing, single flow turbine, extraction, condensing type, direct connected to a General Electric hydrogen cooled alternating current generator running at a speed of 1,800 rpm. Steam is extracted from the turbine at the fourth stage (363.0 psi) for heater No. 1, at the sixth stage (224.0 psi) for heater No. 2, at the ninth stage (84.0 psi) for heater No. 3 and evaporator steam supply, and at the fourteenth stage (7.5 psi) for heater No. 5. Exhaust steam flows into the condenser at 3 in. Hg absolute.

The hydrogen-cooled alternating current generator has a rated capacity of 80,000 kw with a maximum of 100,000 kva at .8 pf, 1,800 rpm for 13,800 volt, 3 phase, 60 cycle service at 0.5 psi hydrogen pressure. The generator is cooled by a water-cooled hydrogen atmosphere that may be raised to 15 psi. The rated capacity of the generator is raised to 100,000 kw under a hydrogen pressure of 15 psi. A hydrogen seal oil unit separates the air and salvages the entrained hydrogen from the shaft sealing and bearing oil system. An eight-bottle hydrogen rack with manifold provides for make-up of hydrogen losses and a six-bottle CO_2 manifold provides purging gas to displace the hydrogen when generator repairs are necessary.

The main unit No. 2 condenser is an Ingersoll Rand Company crossflow type with 7,974, 7/8 in. by 18 BWG tubes, each 26 ft-2 5/16 in. long for a total of 47,500 sq ft of surface area. Two Ingersoll Rand Company No. 36 AFV single stage circulating pumps with 48 in. diam suction and 36 in. diam discharge, each circulate 47,500 gpm of water at 65 ft tdh through the condenser tubing. These pumps are driven by General Electric Company 1,000 hp, 4,160 volt squirrel cage motors. An Ingersoll Rand Company two-stage twin element steam jet pump air ejector, operating on 1,350 psi, 935 F throttle steam orificed to 200 psi removes air leakage at a maximum rate of 202.5 lb of air per hr for each element.

The unit No. 2 house turbine generator consists of a General Electric six-stage automatic extraction-admission, condensing unit running at a speed of 3,600 rpm to drive a General Electric Company alternating current generator. Power is generated by this unit at 4,160 volts, 3 phase, 60 cycle, with a rated output of 7,500 kw and maximum of 9,375 kw, or 10,714 kva at 0.7 pf. One extraction stage provides 22 psi steam for deaerating heater NO. 4 located on the auxiliary bay roof. The generator is air-cooled by a closed duct work system with a General Electric water-cooled surface heat exchanger. The generator is protected from fire by five 50 lb CO_2 cylinders which are automatically released into the air duct by thermostats set at 220 F. Manually operated fog nozzles located in the bell ends of the generator are also provided to extinguish a generator fire. One 50 lb CO_2 cylinder is automatically released into the turbine lubricating oil tank by "rate of rise" thermostat in case of a fire in the lubricating oil storage and pumping unit. The 972, 7/8 in. OD, 18 BWG tubes, each 18 ft-2 1/8 in. long having a total of 4,000 sq ft of surface area. A Foster Wheeler Corporation single stage 18 in. horizontal double suction circulating water pump forces 9,000 gpm of cooling water through the house unit condenser at 51.5 ft tdh. The pump is driven by a 150 hp, 4,160 volt Continental motor at 705 rpm. A Foster Wheeler Corporation twin element two-stage air ejector, utilizing 1,500 psi 935 F steam, orificed to 200 psi, removes air leakage to he condenser at a maximum rate of 150 lb per hr per element.

Condensate from the hot well of the main unit condenser is drawn into either one of a dual condensate pump unit set directly beneath the condenser hot well. The two main unit condensate pumps are Ingersoll Rand Company, two-stage horizontal pumps with 14 in. suction and 12 in. discharge, having a capacity of 1,600 gpm at 185 ft tdh, and are driven by 125 hp, 400 volt squirrel cage splashproof General Electric Company motors. The condensate is pumped through the inner and aftercooling chests of the main unit air ejector as a cooling medium for the air ejector jet steam. A regulatory by-pass valve then returns a portion of the condensate hot well as required to maintain a constant hot well level.

The condensate from the house unit condenser hot well is drawn into a similar dual condensate pump unit beneath its condenser. Two Foster Wheeler Corporation, two-stage horizontal pumps, with five in. suction and three in. discharge having a 170 gpm capacity at 185 ft dynamic head, are driven at 1,750 rpm by 10 hp, medium for the jet steam, and is then by-passed back to the condenser hot well as needed to maintain constant level. The remainder of the condensate is joined with the main unit condensate, and the combined flow passed through heater No. 5 where its temperature is raised from 117 F to 170° F.

Heater No. 5 is a C. F. Braun Company vertical heater, 38 in. ID by 19 ft-3 in. long, with 1,152, 3/4 in. by 16 gage tubes each 16 ft-0 in. long, and has a capacity of 710,000 lb of water per hr. Heat is supplied to the shell by the 14th stage extraction from the main turbine (180 F at 7.5 psi gage).

The condensate leaves heater No. 5 and is forced by the condensate pump discharge head to deaerating feed water heater No. 4 located on the auxiliary bay roof at grade 444. A by-pass valve assembly, operated by a normal level Mercoid float switch on the deaerator, maintains constant working level in the deaerator tank and diverts excess condensate to storage in the 25,000 gallon surge tank mounted on top of the elevator shaft at grade 490. The surge tank provides a "floating storage" on the deaerator to supply instant boiler feed make-up in case of rapid load changes.

Deaeratoring feed water heater No. 4 is a Worthington Pump and Machinery Corporation unit with a rated capacity of 1,093,000 lb per hr. The unit consists of a horizontally mounted tank, 12 ft-0 in. in diam by 22 ft-0 in. long, upon which are mounted two vent condensers 2 ft-2 in. in diam by 6 ft-6 in. long. The condensate passes over a series of trays within the heater and its temperature is raised from 167 F to 228 F. The five psi gage steam utilized for heating and venting is obtained from the single extraction stage on the house unit turbine. The equipment is designed to remove oxygen from the feed water so that the quantity remaining will not exceed 0.005 cc of oxygen per liter. The heated and deaerated feed water is drawn through an 18 in. downcomer into a header 16 in. in diam at grade 401, from which 12 in. diam headers take off to the suction inlets of primary boiler feed pumps Nos. 4 and 5. This 16 in. diam feed water header runs through to connect with a similar header from unit No. 1 deaerator. Block valves are installed on each side of the primary suction to boiler feed pump No. 3, thereby tying the feed water systems of the two units together and making it possible to utilize boiler feed pump No. 3 as a stand-by pump for either unit No. 1 or unit No. 2.

Boiler feed pumps Nos. 4 and 5 are identical Ingersoll Rand combination primary and secondary pumps and have a common 2,000 hp driver as described for unit

No. 1, but the motors for pumps Nos. 4 and 5 are powered from the 4,160 volt system supplied by the unit No. 2 house turbine. All five boiler feed pumps are equipped with baffled orifices and recirculation flow control valves on both primary and secondary discharge, so that the pumps on stand-by service are always kept heated and ready for instant service. The labyrinth seals of the secondary pumps are fed by injection from the primary pump discharge at 500 psi and 220 F. This sealing water is bled from the pumps seals by labyrinth leak-off back pressure flow control valves into either of two closed drip tanks 36 in. diam by 8 ft long which are suspended just below the 400 grade.

The boiler feed water is discharged from primary feed pumps Nos. 4 and 5 at 500 psi and 228 F and forced through the Griscom Russell evaporator condenser where its temperature is raised from 220 F to 247 F.

The evaporator condenser is a horizontal two-pass, tube and shell heat exchanger 31 inc. OD by 19 ft long with 2,205 sq ft effective surface.

The feed water leaves this unit and is then forced through No. 3 extraction heater, where its temperature is raised from 247 F to 303 F.

No. 3 extraction heater is a vertical tube and shell type heat exchanger manufactured by the American Locomotive Company. The heater is 44 1/4 in. ID by 23 ft-9 in. long, contains 1,230, 3/4 in. No. 18 BWG tubes 18 ft-9 in. long, and has a capacity of 1,040,800 lb per hr.

The feed water leaves No. 3 heater and is then forced through No. 2 heater, where its temperature is raised from 303 F to 382 F.

No. 2 heater is a vertical shell and tube heat exchanger also manufactured by the American Locomotive Company. The shell is 44 1/4 in. ID by 23 ft-9 1/2 in. long and contains 1,200, 3/4 in. No. 18 BWG tubes each 18 ft-9 in. long.

The feed water leaves No. 2 heater and is then forced through No. 1 heater where its temperature is raised from 382 F to 425 F.

No. 1 heater is also a vertical shell and tube heat exchanger built by American Locomotive Company. It is 44 1/4 in. inside diam by 19 ft-3 in. long and has 1,238, 3/4 in. No. 18 BWG tubes each 14 ft-8 in. long.

The feed water is drawn from No. 1 heater by the secondary boiler feed pump suction and is discharged into the boiler feed header at 2,300 psi. Feed water control valves regulate this pressure to 1,400 psi at each boiler and admit make-up water through the economizer to maintain constant boiler drum level in boilers Nos. 3 and 4, thus completing the steam and condensate cycle for unit No. 2.

The Unit 2 turbine requires a flow of 104,000 gpm of cooling water through main and house unit No. 2 condensers. This quantity is circulated through the condenser water tubes and out to three Foster Wheeler Corporation induced draft cooling towers through a pipe 72 in. in diam. An 80 in. diam pipe returns this water to the circulators after the heat has been released by evaporative cooling.

The evaporative effect required to release the heat at the cooling towers amounts to approximately 1 1/2% of the water circulated, or 1,110 gpm for unit No. 1 and 1,560 gpm for unit No. 2. The hardness residue left behind by evaporation causes a hardness concentration buildup in the circulating water and blowdown facilities eight in. in diam are provided to blow approximately 1,000 gpm from each system to the sewer. This water loss is constantly being replenished to the individual systems from the 750,000 gallon raw water storage tank, the flow being regulated by Republic Flow Meter Company level controllers located at each of the cooling tower suction wells. These controllers operate one 12 in. diam butterfly make-up valve for each unit and inject metered make-up water into the respective systems at the point where the return water pipe enters the building.

D.1.3 Emergency Power

D.1.3.1 125 Volt d-c System

125 volt d-c power for controls, alarms, motor operated valves and emergency lighting is provided by the station storage battery located in a battery room in the northeast corner of the building on grade 400.0. This battery consists of 60 chloride cells, Exide type FM-17, rated 640 amp hrs (8 hr rate).

Two Electric Products Company motor generator sets comprising 40 hp induction motors for 440 volt, 1,750 rpm service, 25 kw diverter pole generators for 140 volt d-c service are located adjacent to the battery room and are used for battery charging.

D.2 HUMBOLDT BAY FOSSIL FUEL POWER PLANT UNITS 1 AND 2

1. PLANT DESIGN

SECTION INDEX

A. Location
B. Design Summary
C. Steam Design Conditions
D. Heat Balances and Performance Curves

REFERENCE DRAWINGS

Drawing - Main Steam Design Conditions - See under Section 1-C
Drawing - 2200-HBD-1 Change 0 (Bechtel Corp.) Heat Balance Diagram Maximum Load with B.F.P. Turbine Driver
Drawing - 2200-HBD-2 Change 0 (Bechtel Corp.) Heat Balance Diagram Maximum Load with B.F.P. Motor Driver
Drawing - 2200-HBD-2 Change 0 (Bechtel Corp.) Heat Balance Diagram approximately 3/4 Load with B.F.P. Turbine Driver
Drawing - 2200-HBD-3 Change 0 (Bechtel Corp.) Heat Balance Diagram approximately 1/2 Load with B.F.P. Turbine Driver
Drawing - 2200-HBD-5 Change 0 (Bechtel Corp.) Heat Balance Diagram approximately 1/4 Load with B.F.P. Turbine Driver
Drawing - 2200-HBD-6 Change 0 (Bechtel Corp.) Heat Balance Diagram approximately 5% Load with B.F.P. Turbine Driver
Drawing - 2200-HBD-7 Change 0 (Bechtel Corp.) Heat Balance Diagram approximately 5% Load with Motor Driver

A. Location

The site of the Humboldt Bay Steam Power Plant consists of 137 acres of land located on Buhne Point approximately three miles south of the City Limits of Eureka, Humboldt County, California.

The property lies northwesterly of the Northwestern Pacific Railroad and occupies all of Buhne point except the King Salmon resort area. The northerly boundary is on the main ship channel of Humboldt Bay. An arm of the property extends southwesterly to the Field's Landing navigation channel.

Terrain varies from submerged and low tidal land protected by dikes and tide gates to a high precipitous bluff along the northwestern boundry. Elevations range from approximately -30' to + 75' based upon a datum of mean sea level.

The ground floor level of the Power Building is at elevation + 12 and the natural 12' contour passes through the plant location. The switchyard is located on filled ground. General characteristics of the site and its development are shown as a frontispiece to this volume.

B. Design Summary

Connection to System

Power is generated at 13.8 kv and carried thru insulated cable generator

B. Design Summary

Connection to System (Con't)

leads to open bus work furnishing the main transformer low voltage connections. The transformer bank steps the voltage up from 13.8 kv to 60 (nominal) kv.

Power is then supplied to the Pacific Gas & Electric Company's 60 kv power transmission system serving the Humboldt Bay area. Three transmission lines leave the steam plant's 60 kv bus switching station. One line terminates at the Humboldt substation southeast of Eureka. Another line terminates at the Bridgeville substation after serving several substation taps along the way. The third line terminates at Humboldt Junction where it may be connected to either of two lines between the Humboldt substation and Station E at Eureka.

All three lines are protected by high speed impedance relays and the station control system is arranged to provide testing, reclosing and similar features as used in Pacific Gas & Electric Company's standard automatic substations.

The circuit breakers are rated to interrupt 1,000,000 kva.

Auxiliary power is provided through either of two house transformers, one being connected to the 13.8 kv bus and the other to the 60 kv bus. All plant auxiliaries operate at 2300 volts or 480 volts.

Rating and Capability of Principle Equipment

The present plant Unit No. 1 consists of a steam generator and its associated equipment serving a turbine generator and its associated equipment. The station unit has a nominal rated generating capacity of 50,000 kilowatts.

Principle equipment for the plant is rated at the following continuous operating conditions:

Number Per Unit	Equipment	Rated Capacity
1	Steam Generator	475,000 lb/hr steam at 900 psig and 900°F.
1	Turbine Generator	50,000 kilowatts
3	Main Transformers	Low voltage - 13,800 delta High voltage - 36,400/ 63,000 grounded wye 13,330 kva self-cooled 17,777 kva forced air cooled 22,220 kva forced oil - air cooled

B. Design Summary

Rating and Capability of Principle Equipment (Con'd)

At maximum plant load (corresponding to guaranteed maximum turbine throttle flow) the expected total plant generation is approximately 54,500 kw gross and 53,100 kw net. To allow for manufacturing tolerances the turbine is designed for a throttle flow 5% greater than the guaranteed flow. With the plant operating at this design load, it is estimated that the total gross generation will be 56,000 kw.

Design Conditions

Two transmission lines normally supply the power used in the Humboldt area and therefore, the power plant is designed as backup capacity for these lines, which are subject to unavoidable outages as a result of the severe winter weather conditions to which they are exposed. The basic design of the present single boiler-turbine installation provides for the plant to operate normally at 5% load and to increase to maximum load in two minutes in case of the loss of either one of the two transmission lines. In case of the loss of both transmission lines the plant is designed to automatically increase to maximum load in three seconds.

In order to obtain the required fast load pickup of the plant, the boiler drum accumlative capacity is utilized. Throttle pressure at the turbine varies linearly with steam flow from 1050 psig at 5% load to 850 psig at maximum guaranteed throttle flow. During fast load pickup conditions the required throttle pressure of the turbine drops causing the boiler drum water to flash into steam thus providing the necessary flow to the turbine until the combustion control can accuate the fuel valves and bring the heat release in the furnace up to the necessary high load condition.

In order to maintain maximum plant capability during upset electrical conditions all essential electric motors in the plant as well as their driven equipment are designed to carry full plant load with the system electrical frequency at 90% of normal and/or the voltage at 65% of normal.

In order to provide maximum electrical power output during peak station requirements one of the boiler feed pumps is driven by a steam turbine driver. This steam turbine driven pump is normally the operating unit with the motor driven unit a spare.

For the purpose of economic evaluations in the design of the plant the following load distribution was assumed.

Load	Duration of time
50,000 kw	10%
25,000 kw	25%
2500 kw	50%
Outage	15%

B. Design Summary

Design Conditions (Con'd)

The following economic evaluation factors were used:

Energy Charge	3.0 mils per kwhr
Capitalization	13.5%
Capacity cost	$75 per kw

Main Turbine Generator

The turbine generator manufactured by the Westinghouse Electric Corporation, is a 3600 rpm tandem compound, double flow, condensing, non re-heat, non-automatic extraction turbine directly connected to a 2 pole, 3 phase, 60 cycle, 3600 rpm, 13,800 volt hydrogen cooled generator. At rated throttle flow the turbine is designed to operate with 850 psig, 900°F steam and with 1-1/2 inches of mercury absolute exhaust pressure. Field excitation for the generator is supplied by a shaft driven exciter and controlled by a static voltage regulator through a magnetic amplifier.

Steam for the turbine is condensed in a double path, cross flow surface condenser having 27,500 sq. ft. of effective surface. Cooling water is supplied through an intake canal from Humboldt Bay and after passing through traveling screens is pumped by two circulating water pumps operating in parallel through inlet pipes to the main condenser. Cooling water leaving the condenser is returned to the Bay via discharge pipes and a canal.

Auxiliary Power System

Power for the plant auxiliaries is supplied by the main turbine generator through 3 phase transformers and a 2400 volt bus system. Power is distributed from the bus system to the various auxiliaries at four voltage levels: 2400 volt, 480 volt, and 120/208 volts. Power at 480 volts and 120/208 volts is reduced from 2400 volts first by 3 phase transformers to 480 volts, and secondly, from 480 to 120/208 volts by lighting transformers.

An alternate source of 2400 volt power for operation of plant auxiliaries is available through house transformer number two supplied directly from the 60 kv liner. Automatic transfer to this system is provided in the event of an emergency.

Condensate and Feedwater Flow

Feedwater for each unit is heated in five major stages by four shell and tube feed heaters and one direct contact steam deaerator. At maximum load, feedwater temperature at the boiler inlet is approximately 424°F.

B. Design Summary

Steam Generators

The draft system for the steam generator includes one forced draft fan, one induced draft fan, and one steel stack approximately 120 ft. high by 10'-0" inside diameter. Combustion air entering each Ljungstrom preheater is semi-automatically regulated by the steam air heater and controller for cold end corrosion protection.

Combustion and feedwater controls are pneumatically operated and provide for automatic and remote manual operation of the steam generator.

At low loads steam temperature control is achieved by introducing cold air into the rear of the furnace has much the same effect with respect to superheat temperature as has the utilization of gas recirculation (see Pittsburg and Morro Bay Data Books). The cold air, furnished by the forced draft fan and controlled by a Bailey operated damper, has a blanketing effect on the rear water wall tubes, increases the fuel flow due both to the necessity of heating the incoming air as well to the increased generating duty of front and side walls, increased furnace exit temperature, and increases the mass flow in the superheater section of the boiler thus improving heat transfer by virtue of increased gas velocity. The introduction of an automatically controlled amount of cold air into the bottom of the furnace is somewhat unique in steam generator design and actual setting of control of this air with respect to desired final S.H. temperature will be determined by operating experience.

Fuel System

Fuel oil is delivered to the plant from ocean-going tankers through a 14" fill line. The 14" fill line is sized to deliver a 1500 SSF viscosity oil at approximately 2000 barrels per hour after it is up to the pumping temperature of 155°F. During periods when the line is inoperative and when it is being brought up to temperature it is necessary to keep the line filled with a relative light oil (650 SSU at the pumping temperature of 155°F).

A fuel oil transfer system for transferring the oil from the 65,000 barrel storage tank to the 3000 barrel fuel oil service tank is provided and consists of rotary gear type transfer pumps and shell and tube heat exchangers.

Fuel oil from the service tank is supplied to the boiler through positive displacement primary pumps and through a secondary heat exchange and pumping system.

B. Desigr Summary

The heating system in the secondary fuel oil circuit consists of fin tube type fuel oil heaters supplied with heating steam from a closed circuit reboiler system which in turn receives its heating steam from the 142 psig auxiliary steam system.

The quantity of oil admitted to the boiler is automatically regulated by recirculation control which, operating in response to the combustion control signal, sets the secondary system pressure.

A light oil tank and pump is provided for the start up of the boiler and for purging the heavy oil lines when they are not in use.

A Propane tank and reducing valve provides the necessary gas for the ignitors at the burners.

Miscellaneous Services

Water for the fire water system, the domestic water system, and for the bearing lubrication of the circulating water pump is furnished from the fresh water tanks. These tanks in turn are supplied from the shallow well pumps. A domestic water booster pump provides the necessary pumping power for the domestic water system and a main and spare fire pump are provided for the fire water system. Water for the bearings of the circulating water pumps flows by gravity from the fresh water tanks.

Water for the gland sealing water system flows by gravity from a gland seal supply tank, filled by the main condensate pumps, to the turbine gland seal and the pump shaft seals. Leak off from the turbine shaft and from some of the pumps is returned to a gland seal return tank for discharge to heater No. 5.

The plant cooling water system utilizes chemically treated distilled water which is pumped in a closed system from two cooling water pumps, one of which is a spare, to the units requiring cooling. The pumps are mounted in a concrete pit and the water is returned to this pit after cooling the units. Circulating water from the main circulating water pumps is discharged through either of two full capacity heat exchangers utilized for cooling the closed distilled water system.

An interconnected service and instrument air system is provided. Two 210 scfm air compressors and aftercoolers serve this system. Instrument air is distributed from the instrument air receiver through an air dryer at several pressure levels. Air for the service air system is removed from the service air receiver and distributed at a pressure level of 100 psig.

A continuous by-pass lubrication oil filter system is provided for the main turbine. A clean and dirty lube oil storage tank and a transfer oil pump are also provided. Provision is made for the installation of a portable centrifuge at strategic locations.

STEAM GENERATION

SECTION INDEX

REFERENCE DRAWINGS

Drawing 54223-R, Change 2, P & I Diagram - Boiler
Drawing 54221-R, Change 2, P & I Diagram - Steam & Condensate
Drawing 54225-R, Change 2, P & I Diagram - Fuel Oil
Drawing 54226-R, Change 2, P & I Diagram - Compressed Air
Drawing 7043F (B. & W. Co.) Sectional Side View, Boiler Arrangement
Drawing 22898E (B. & W. Co.) Arrangement of Primary Superheater
Drawing 32184E (B. & W. Co.) Arrangement of Secondary Superheater
Drawing A-232141 (Air Preheater Corp.) General Arrg't. Ljungstrom Air Preheater
Drawing A-24386-D (Peabody Engr. Corp.) Type H-26 Burner Assembly
Drawing Fig. AP-7, Sect. 5 (Diamond Pwr. Specialty Corp.) Soot Blower Air Control System
Drawing K-17921 (American Blower Corp.) #675 American "H.S." Forced Draft Fan
Drawing 60-A-6322 (Westinghouse Elect. Corp.) #2073 H.D. Fan, 2/3 D.W.D.I. (I.D.)
Drawing 3779 (Walter R. Cole & Co.) Boiler Blow-Off Tank
Drawing E-5022419 (Bailey Meter Co.) Combustion & Feedwater Control Dia.

A. Steam Generation - General

Steam Generator

For steam generation there is installed one two-drum type Babcock & Wilcox Company Unit, rated at 475,000 lb/hr and designed for a maximum continuous generating capacity of 533,750 lb/hr for all purposes, including auxiliary steam requirements, with conditions at the superheater outlet of 498,750 lb/hr steam flow, 900 psig and 900 FTT, with feedwater at 420 F and an entering air temperature of 80 F, burning oil fuel. The unit is comprised to two-drum boiler section, water-cooled furnace, continuous tube two stage pendant convection superheater, a Ljungstrom regenerative type air preheater and Peabody mechanical atomizing oil burners. The unit is equipped with Diamond retractable soot blowers, air-driven, using steam as the blowing medium. For controlling superheated steam temperature a B & W spray type attemperator and a cold air connection at the rear of the furnace is provided.

The entire unit is top supported from a structural steel framework designed to carry all loading to which the unit may be subjected, including all live and dead loads, platform loads, earthquake and wind loads. The boiler section consists of a 72" I.D. welded steam drum, 31'-0" long, of 6-7/16" and 3-7/16" shell plate thickness and a lower drum 42" I.D., 24'-0" long, of 3-9/16" plate thickness, the drums connected by 1,617 generating tubes 2-1/2" O.D. swage to 2" O.D. and expanded into the drums. The pressure parts are designed for 1,125 psig, drum plates of 70,000 psi T.S. Heating surface of the boiler section is 19,481 sq. ft.

The steam drum is fitted internally with 36 - 14" dia. by 27" high cyclone type steam and water separators for the circulation system and a steam baffle, Type TB Scrubber, 28 ft. long, designed to pass high purity steam with less than 1 ppm of solids carryover. Boiler water is introduced directly into the drum through an 8" internal perforated feed pipe. Chemical feed and continuous blowdown connections are also provided in addition to the usual drum mountings. The steam drum water level is indicated by Yarway illuminated water gages and may be observed at the firing floor through a combination of mirrors. The level is also indicated, recorded, controlled and high and low level annunciated on the instrument board. At normal operating level the boiler holds approximately 179,000 lb. of water.

The water holding capacity and the operating pressure of the boiler is utilized in providing the quick pick up feature of the plant. At minimum plant loads the controlled throttle steam pressure of the turbine is 1050 psig. This controlled pressure drops linearly with load to 850 psig at maximum plant load. As plant load picks up rapidly (by reason of 2 power line-break) from minimum to maximum, the required turbine throttle pressure drops to 850 psig. The stored water in the boiler (which before the load increase was at a temperature level corresponding to 1050 psig), is therefore free to expand and to flash into steam at the lower pressure. The flashed steam provides the necessary capacity for the turbine to pick-up to maximum load in 3 seconds (see Turbine-Generator Section of Data Book), and to maintain the load until the furnace fires are increased by combustion control to the necessary heat release.

The furnace is completely enclosed by water-cooled walls of the plain tangent-tube type. Water supply to the walls is taken from the lower drum through downcomer tubes connected to the lower headers. Discharge tubes connect the upper sidewall headers to the steam drum. All wall tubes, supply and discharge tubes are field welded to stubs in the headers which were installed in the factory. Tube connections into the drums are expanded into grooved tube seats. Each wall is fitted at the lower header with a drain connection and a blanked connection for acid cleaning. The furance rear wall design provides for a future television installation for burner observation.

The furnace volume is approximately 16,200 cu. ft. and has a heating surface of 4,138 sq. ft. Studs for attaching plastic and insulation are welded to the tubes. A system of buckstays, tie bars and guides provide support for the water walls with full allowance for expansion movements.

The superheater is of the continuous tube type designed for a pressure of 1,125 psig. with an operating pressure at the outlet of 900 psig and a temperature of 900 FTT. The superheater is divided into two pendant non-drainable sections, a primary and a secondary section, with the tubes connected to headers located outside and above the furnace roof tubes. The primary section receives saturated steam from the steam drum through connecting tubes. After passing through the primary section the steam enters into a cross-over pipe, wherein is located the spray attemperator, and thence into the secondary section. On leaving the secondary section the steam is conducted through the main steam line to the turbine.

Steam temperature at the superheater outlet is controlled by regulating the flow of attemperator spray water and by introducing cold air into the rear of the furnace. The cold air-by-pass damper will be open at low boiler ratings and then close off as soon as the superheat set point has been reached. At higher boiler ratings the attemperator water valve opens to admit spray water to hold constant temperature. A single spray type desuperheater provides the attemperation necessary to maintain the steam temperature at 900 F at the superheater outlet. The spray nozzle discharges feedwater into the steam and is of the Venturi type equipped with a thermal sleeve to insure mixing and to prevent thermal shock in the pipe wall. The amount of spray water added to the steam attemperators is regulated by temperature controllers, actuating regulating valves through the combustion control system. For curves of superheater performance and desuperheater spray water requirements see Section 2.B.

Combustion and feedwater controls (described in Section 2.H) are pneumatically operated and provide for automatic, remote and manual operation of the steam generators. Control boards with their associated instruments are located adjacent to the boiler on the firing floor.

Safety valves required for the protection of the boiler and superheater are provided. The drum and superheater valves are of the Consolidated Maxiflow type; in addition there is installed an auxiliary electrically operated relief valve mounted on the secondary superheater outlet header. This valve is set to open automatically due to a preset pressure signal from either the superheater outlet or the steam drum and may also be manually opened by closing a switch at the control panel. The valve functions as a purging device and also acts to prevent the main safety valves from lifting except on major over-pressures. The power control valve, as it is generally called, is a Consolidated Electromatic Relief Valve, Type 1533D. An Edward Fig. 1511-Y-A shut-off valve with a by-pass is installed between the Electromatic valve and the header to facilitate maintenance. Safety valve capacities and settings are included in the data under Section 2.B.

Soot Blowing System

The soot blowing equipment consists of 7 Diamond Power Specialty Corporation Type 1K retractable blowers, driven by air motors, of which 4 are located in the boiler section and 3 in the superheater section. Provision is made for 2 additional future blowers in the superheater section should they be required. Blowing steam is taken from the primary superheater outlet header and reduced to 600 psig through a pressure reducing valve. A safety valve is provided to protect the blowing line from over-pressure. The Ljungstrom air preheater is equipped with a steam cleaning device in the gas outlet duct and a combination steam-water cleaning device in the gas inlet duct, both using steam from the soot blower header through a branch line.

A Diamond automatic sequential air control system is provided to perform all functions of operation from a central control panel. A blowing program is set up on the panel for the blowers to be operated and after starting the blowing cycle each blower lance in sequence is automatically inserted and retracted from the furnace. During insertion and retraction steam is blown from nozzles located at the end of the rotating lance. An alarm is provided to annunciate upon failure of power air or blowing steam. (See Steam Section 5 for precautionary notes relative to use of soot blowing steam).

Fuel Burning Equipment

The boiler is fired by 6 Peabody Engineering Corporation oil burners mounted in air registers and arranged in a double tier of 3 each across the front of the windbox. The oil burners are Type BL, wide range, mechanical atomizing,set in Type H-26 insulated swing front air registers. The burners are equipped with a retracting gear of the rack and pinion type, Emsco swivel joints and Peabody Type SL-1 automatic gas-electric ignitors. (See also Section 3, Fuel System).

Draft and Air Preheating Equipment

One forced draft fan and one induced draft fan, each fitted with suitable control dampers, are provided to supply the air required in burning the fuel and for removal of the gaseous products of combustion. The forced draft fan draws air from outdoors and discharges the air through a steam type air heater located in the fan discharge duct and a regenerative type air preheater installed at the boiler gas flue outlet. The heated air then passes through secondary ducts, located on each side of the furnace, entering the windbox at each end where it is distributed to the separate air registers and thence into the furnace. Flue gas leaving the boiler section is passed through the gas side of the regenerative air preheater to the induced draft fan which discharges directly into a 10'-0" I.D. by 120 ft. high steel stack mounted on a steel structure above the fan.

B. Steam Generator

Steam Generator Unit

Furnished by	Babcock & Wilcox Co.
Specification No.	4404
Purchase Order No.	23-3
Number of Units	1
Location	Area 4, Elevation +12'-0"

Equipment furnished under above contract:

One Boiler with Water-Cooled Furnace
One Primary Superheater
One Secondary Superheater
One Attemperator with Controls
One Ljungstrom Air Preheater and Accessories
Six Peabody Oil Burners with Retracting Mechanism and Automatic Ignitors
Two Constant Differential Fuel Oil Pumps and Motors (Secondary Fuel Oil Pumps, See Section 3)
Seven Diamond Sootblowers, with Steam Reducing Station and Automatic Controls
Flues
  Boiler to Air Preheater
Ducts
  Air Preheater Outlet to Burners
Refractories and Insulation
Structural Steel Supports
Appurtenances, Safety Valves and Fittings, Power Control Valve

Notes:

(1) All pressure parts are designed and constructed in accordance with the ASME Boiler Code, the California State Boiler Safety Orders, the A.S.A. Code for Pressure Piping, Regulations of the National Board of Fire Underwriters and other applicable codes.

(2) For data on Secondary Fuel Oil Pumps, see Section 3B.

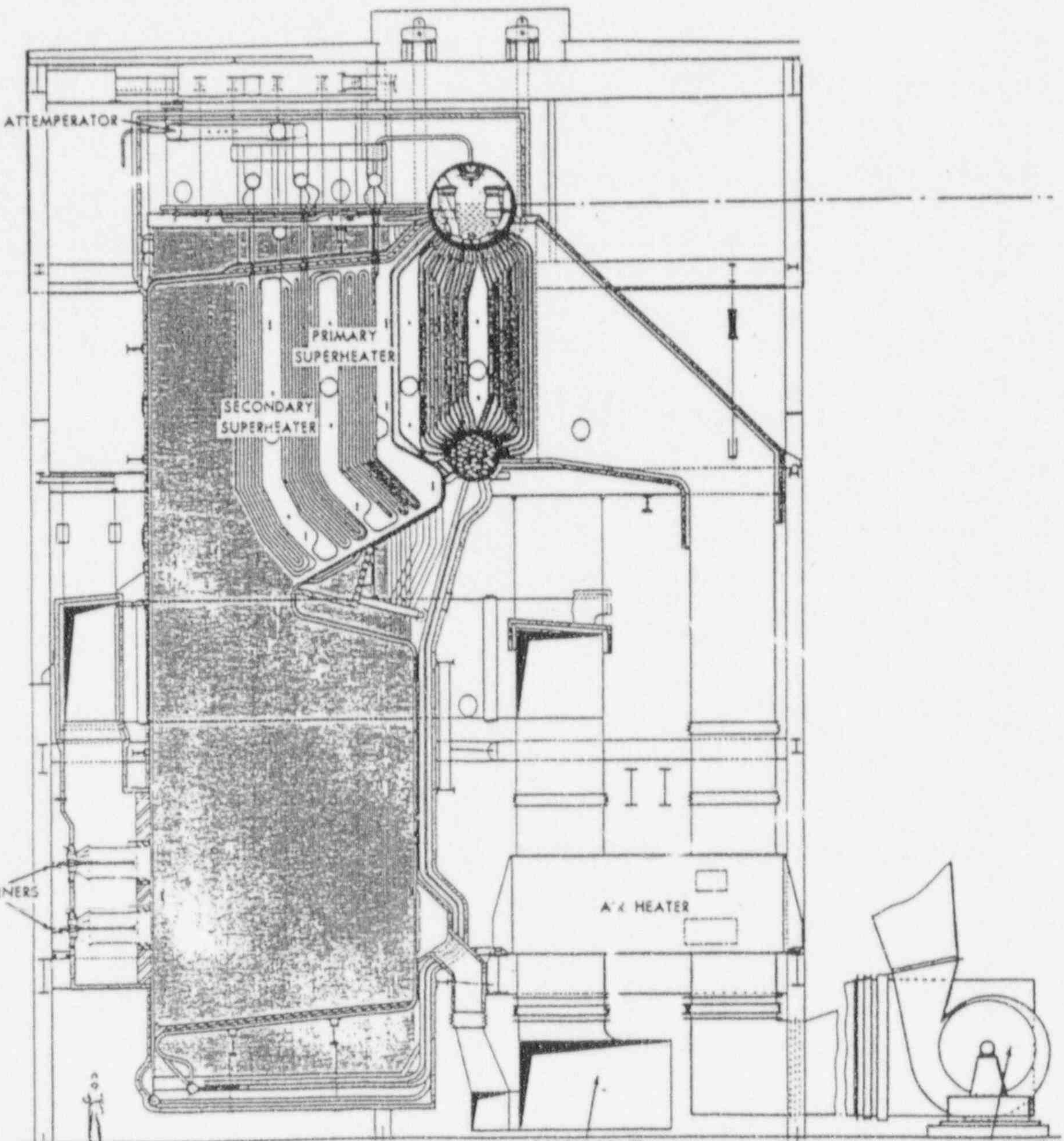


Figure D.1 PACIFIC GAS & ELECTRIC COMPANY
HUMBOLDT BAY STEAM PLANT
BUHNE POINT, EUREKA, CALIFORNIA
B & W CONTRACT NO. S-9891

B. Steam Generator

Boiler and Furnace

Type	Two drum, water-cooled furnace
Size	21'-0" wide / 72"
Generating Capacity, lb/hr	553,750 (Max. Continuous)
Steam conditions	
Superheater Outlet	498,750 lb/hr
Superheater Outlet	900 psig, 900 F
Steam Drum	995 psig
Steam Drum Pressure, psig	
Design	1125
Hydrostatic Test	1688 (1-1/2 times max. design)
Steam Drum	
Diameter, in.	72
Straight length, ft-in.	31-0
Plate thickness, in.	3-7/16 shell plate, 6-7/16 tube plate
Internals	
Scrubber baffle	Tube TB, 28'-0" long
Steam separator	36 Cyclones, 14" dia. x 27" high
Lower Drum	
Diameter, in.	42
Straight length, ft-in.	24-0
Shell plate thickness, in.	3-9/16
Drum Plate	70,000 psi tensile strength welded
Water Capacities, lb.	
Centerline, Steam Drum	179,000
Minimum safe level at 5% rated flow	170,000
Water Level, in.	
Minimum drum level	-9-1/2
Normal level	±0
Maximum level	±10
Furnace	
Volume, cu. ft.	162,000
Width at burners, ft-in.	21-0 c.l.
Width at boiler, ft-in.	21-0-1/2 c.l.

B. Steam Generator

Boiler and Furnace (Cont'd.)

	Bare Tubes	Refractory Covered
Area		
Sides	1,580	
Front and furnace roof	1,328	
Rear	815	
Furnace floor		415
Total	4,138	
Heating Surface, sq. ft.		
Boiler	19,481	
Water cooled walls	4,138	
Total	23,619	

Wall Tubes	
Sides	158-3" dia. spaced 3" and 6"
Front and furnace roof	83-3" dia. spaced 3" and 6"
Rear, superheater floor, screen, furnace floor	83-3" dia. spaced 3" and 6"
Water Wall Headers	11-3/4" x 1" thick for sides, front and rear walls
Generating Tubes	1617 - 2-1/2" O.D.
Circulator Tubes	
Supply	35 - 4-1/2" diam., .220" thick
Discharge	50 - 3" diam., .150" thick
Weights, pounds	
Boiler	314,372
Water cooled furnace walls	278,040
Casing (top vestibule only)	22,315
Structural steel	745,000
Baffle mix, Kaocast K-20	65,000
Refractory and insulation - see B&W drawings 31110E through 31119E	
Valves	
Safety	See Safety Valve section
Continuous blowdown	2 - 2" Hancock 538EP
Feedwater regulator	3 - 1" Hancock 535EP
Power control	2 - 1" Hancock 535EP
Steam sampling	2 - 1" Hancock 535EP
Vent	3 - 1-1/2" Hancock 537EP
Blowoff	2 sets 1-1/2" Yarway 3981-81

B. Steam Generator

Boiler and Furnace (Cont'd.)

Valves, cont'd.	
Water sampling	2 - 1" Hancock 535EP
Chemical feed	2 - 3/4" Powell 6031WE
Steam gage shutoff	2 - 1" Hancock 535EP
Steam gage test	1 - 1/4" Hancock 531EP
Water gage lock	4 - 1-1/2" Vogt SW11107
Water gage drip	4 - 1" Hanclck 535EP
Feed stop	1 - 6" Edward 4017Y
Feed check	1 - 6" Edward 4094Y
Furnace drain	4 sets - 1-1/2" Yarway 3981-81
Steam Pressure Gage	1 - 12" Ashcroft #1079D
Water Gage Assembly	2 - Yarway #4187
Illuminators	4 - Yarway Type M

B. Steam Generator

PREDICTED PERFORMANCE DATA

Load Condition with Oil Fuel**					
	Steam at Drum Outlet	(M LBS/HR)	205	303	530
	Steam at SH Outlet	" " "	190	285	475
	SH Desup. Spray	" " "	5.5	18	43.0
FLOW	Feedwater	" " "	205	303	530
	Air from FD Fan	" " "	200	293	467
	Gas to ID Fan	" " "	239	342	532
	Fuel	" " "	13.4	19.6	31.2
PRESS.	Steam Drum	(PSIG)	916	935	995
	Superheater Outlet	"	900	900	900
	Steam at SH Outlet	(°F)	900	900	900
	Feedwater	"	340	370	420
	Flue Gas Entering AH	"	595	630	710
Temp.	Flue Gas Leaving AH (Uncorr.)	"	282	304	350
	Flue Gas Leaving AH (Corr.)	"	262	285	330
	Air Leaving AH	"	489	496	528
	Air Entering AH	"	80	80	80
	Ducts, Dampers, Orifice, SAH, Etc.	(INS. W.G.)	0.08	0.13	2.83
	Air Heater	" "	0.6	1.0	2.2
AIR	Burner	" "	1.8	3.5	7.9
LOSSES	(Less) Furnace Stack Effect	" "	0.5	0.6	0.6
	Steam Air Heater	" "	0.23	0.42	0.8
	Total	" "	3.21	5.65	14.3
	Furnace	(IN. W.G.	0.1	0.1	0.1
	Boiler SH, RH, & Econ.	" "	0.5	1.0	2.4
DRAFT	Air Heater	" "	0.5	0.9	1.9
LOSSES	Ducts, Dampers	" "	0.3	0.6	0.9
	Stack Effect (Boiler Back Pass)	" "	0.2	0.3	0.3
	Total	" "	1.6	2.9	5.6
Number of Burners in Use			6	6	6
Heat Release		(M $BTU/FT^3/HR$)	15.3	22.3	35.6
Excess Air Leaving Furnace*		(%)	24	21	18
Efficiency Overall		(%)	87.62	87.42	86.72
Total Allow. Aux. Steam: Drum Pri SH Outlet		(M LBS/HR)	15	18	55
Max. Allowable Boiler Concentration		PPM	1000	1000	1000
Solids in Steam		PPM	1	1	1

* Based on 10% excess air at burners.

** Type #6, 18,500 BTU/lb. U.A. % by wt. Ash 0.15, S 2.0, H_2 10.0, C 86.2, N_2-O_2 1.65.

Appendix E: Photographs Showing Typical Piping and Support Installations for the Power Plants Surveyed

E.1 Piping Layouts

In Figures E.1 through E.17 are shown typical small bore piping installations in the power plants surveyed which experienced strong motion earthquakes equal to or greater than 0.2g ZPGA.

E.2 Piping Support

In Figures E.18 to E.68 are shown typical piping support installations in the same power plants.

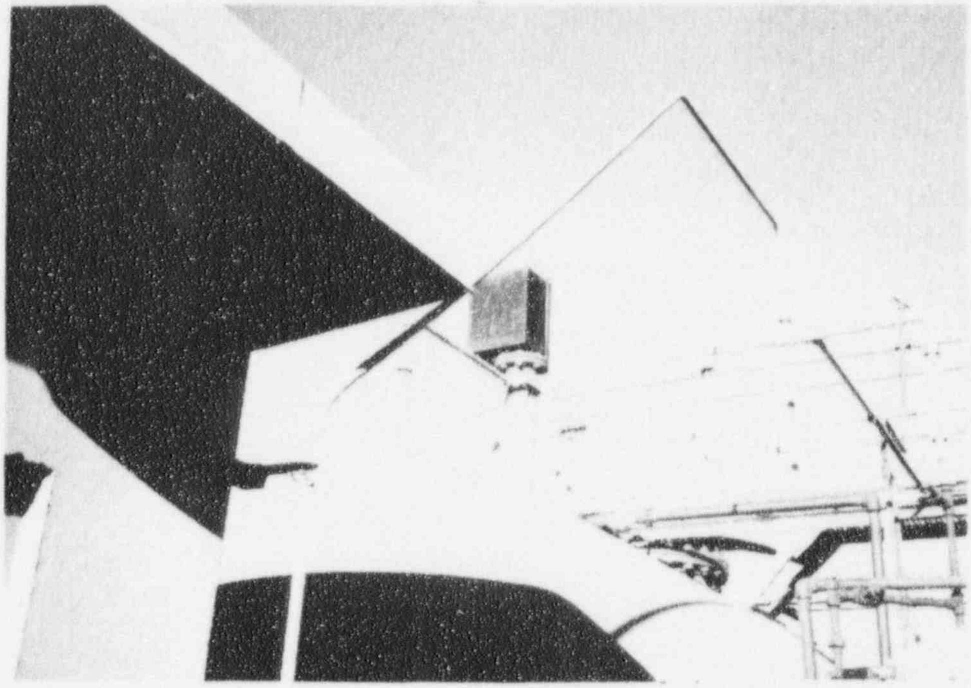


Figure E.1 Unsupported Small Bore Piping in Valley Unit 1

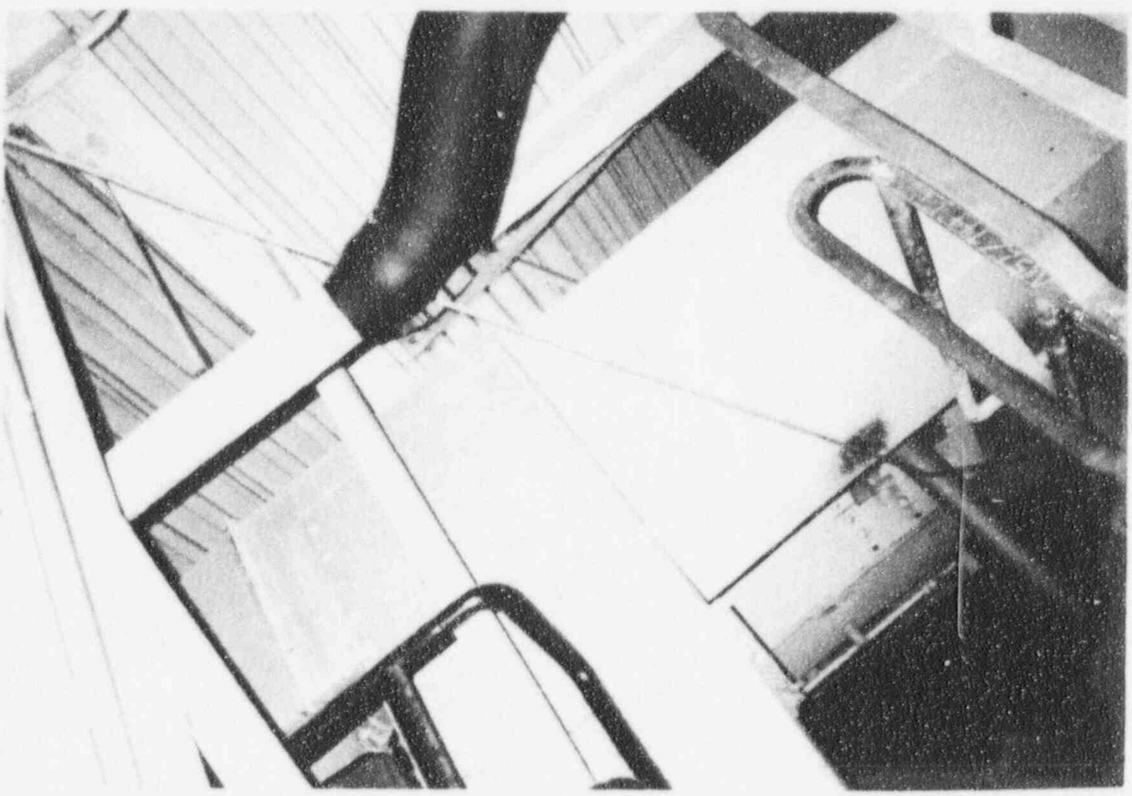


Figure E.2 Unsupported Small Bore Piping in Humboldt Bay Unit 1

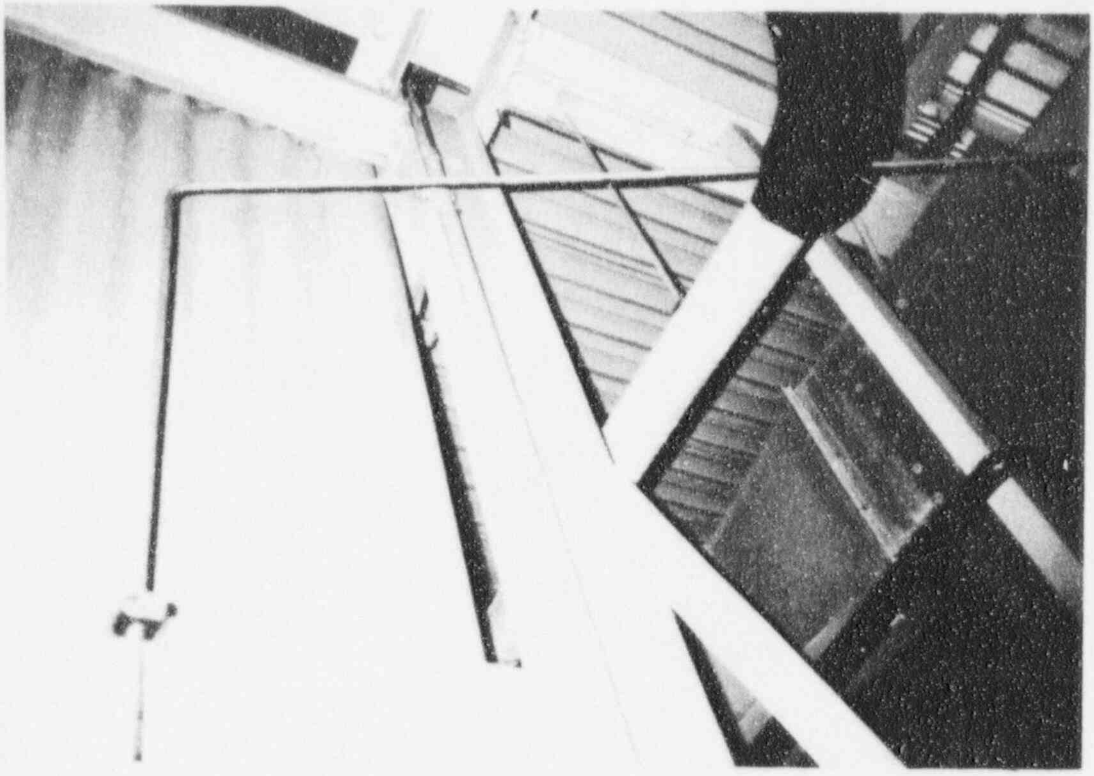


Figure E.3 Unsupported Small Bore Piping in Humboldt Bay Unit 1

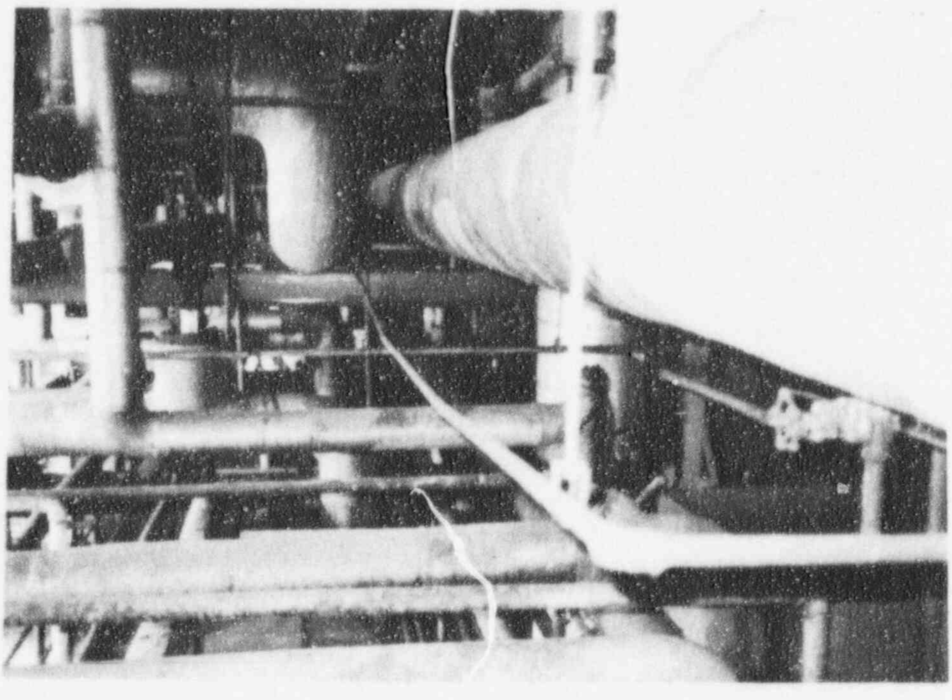


Figure E.4 Unsupported Small Bore Piping with Noticeable Sag in Magnolia Unit 1

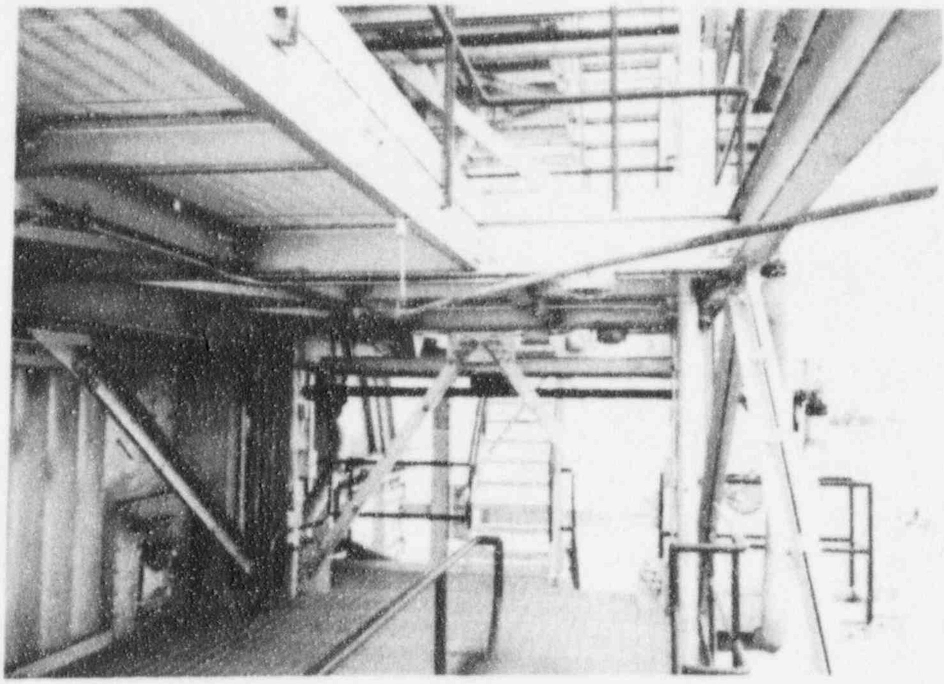


Figure E.5 Unsupported Small Bore Piping in El Centro Unit 1

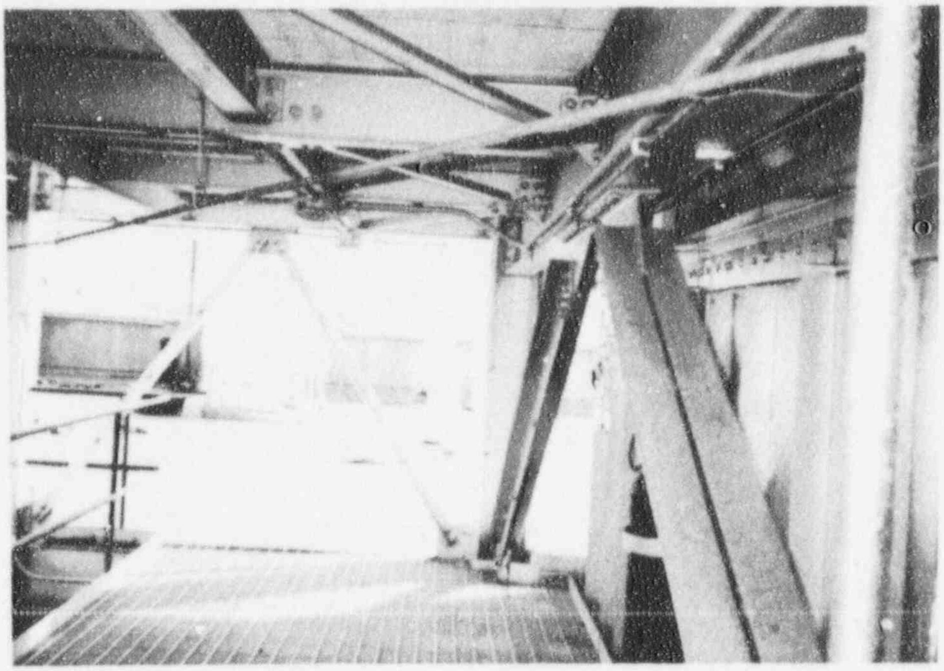


Figure E.6 Unsupported Small Bore Piping in El Centro Unit 3

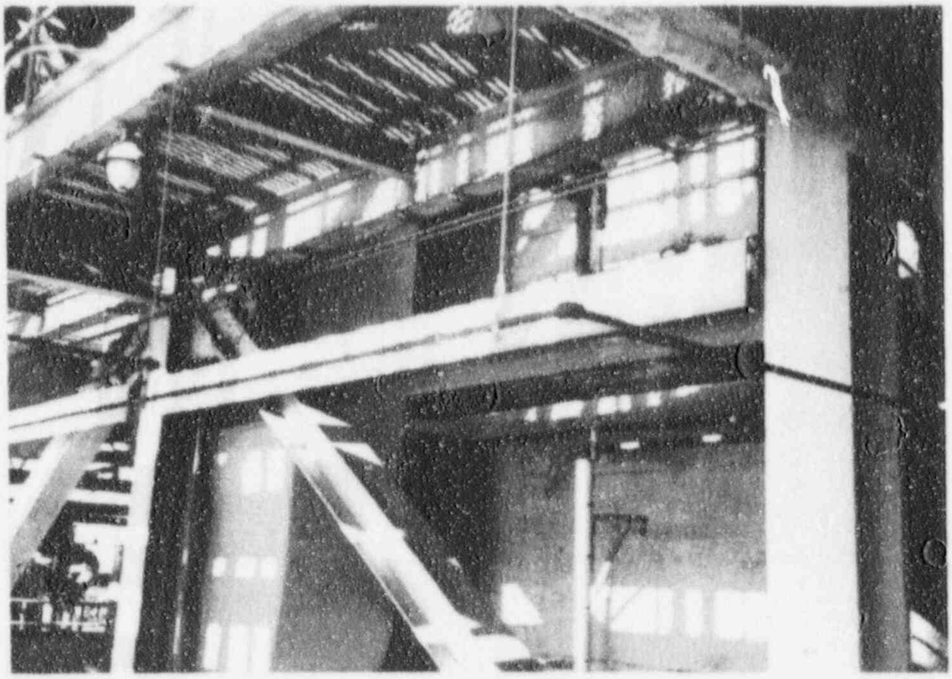


Figure E.7 Unsupported Long Span Small Bore Pipe in Valley Unit 3

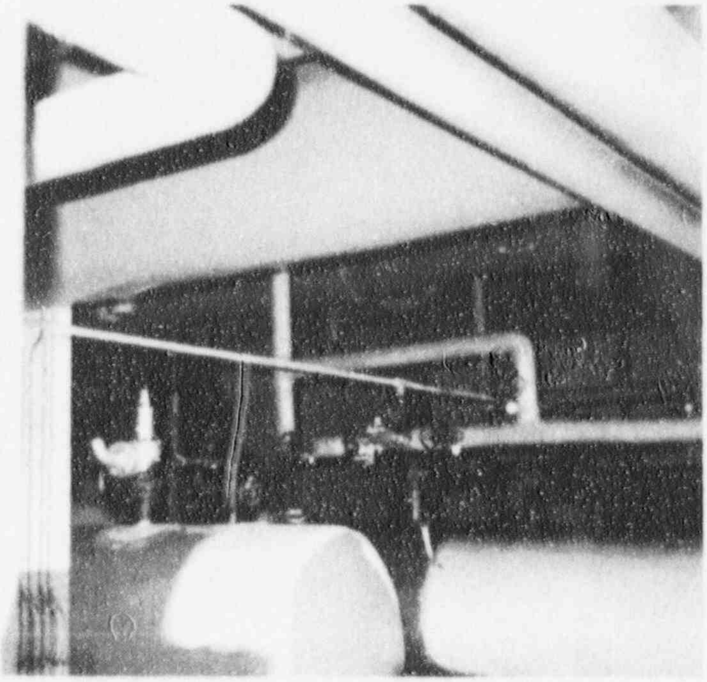


Figure E.8 Unsupported Small Bore Pipe in Olive Unit 2

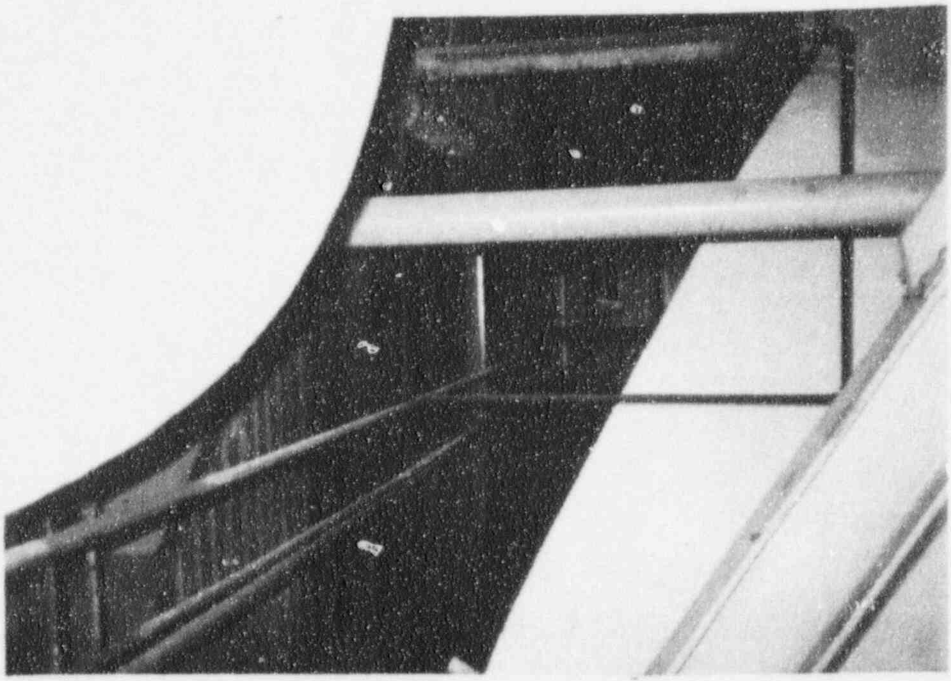


Figure E.9 Unsupported Small Bore Pipe in Magnolia Unit 3

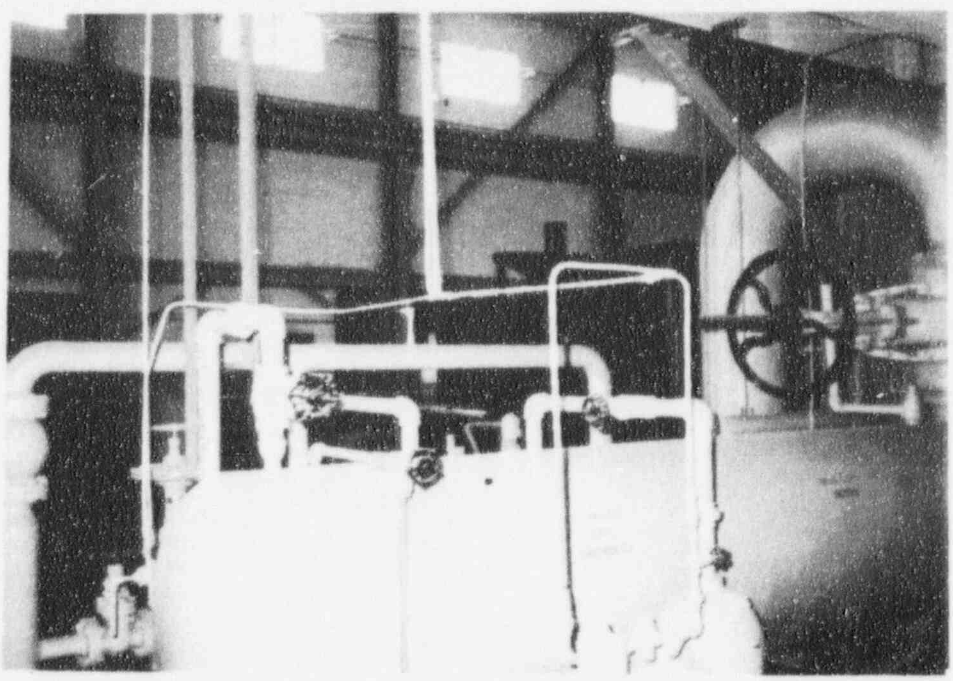


Figure E.10 Unsupported Small Bore Pipe in El Centro Unit 2

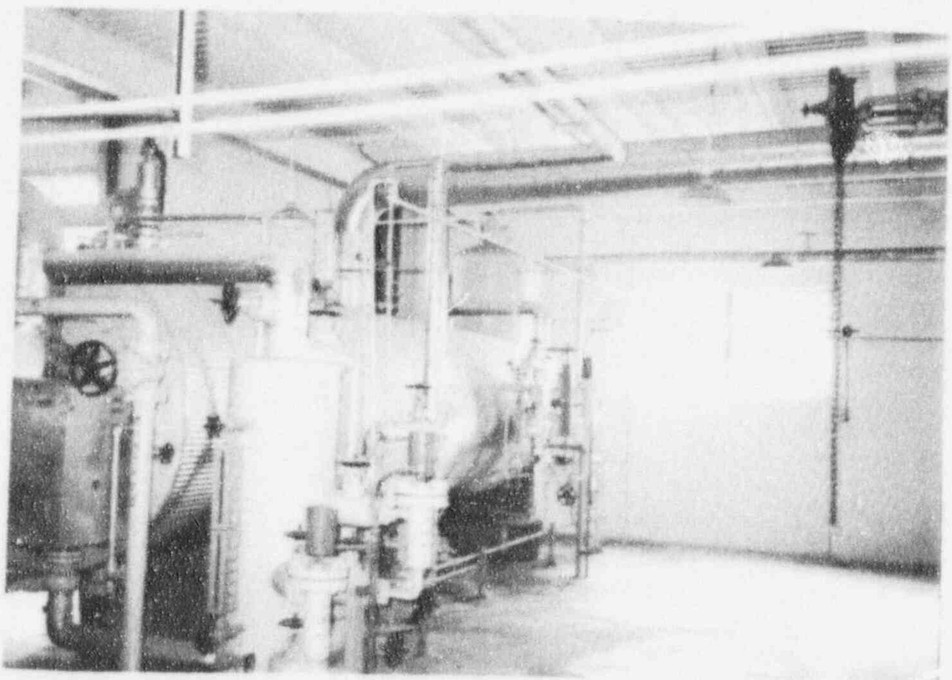


Figure E.11 Unsupported Small Bore Pipe in El Centro Unit 4

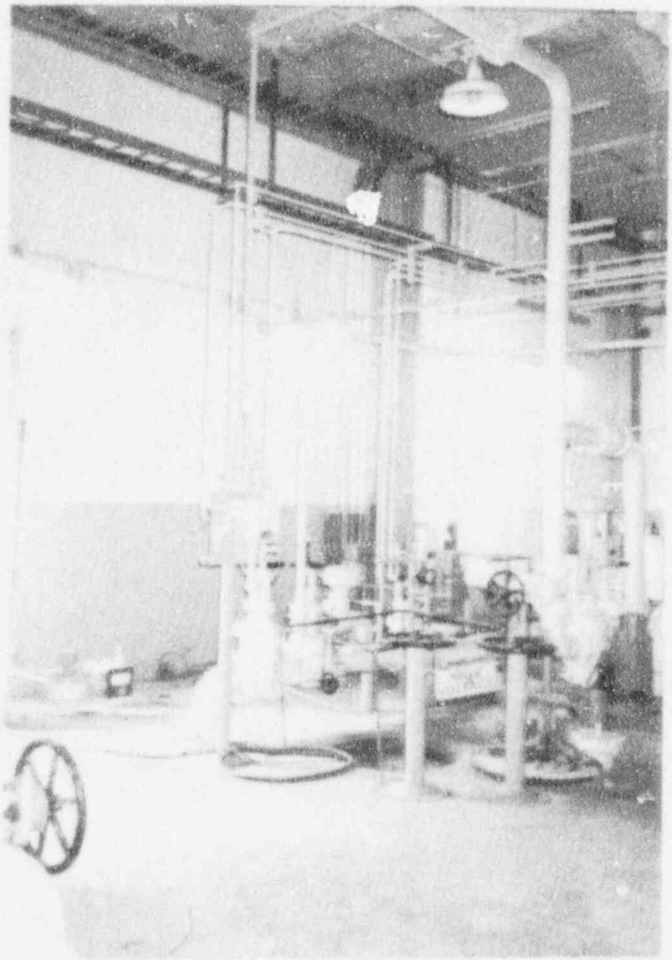


Figure E.12 Unsupported Long Vertical Runs in Small Bore Piping in El Centro Unit 4

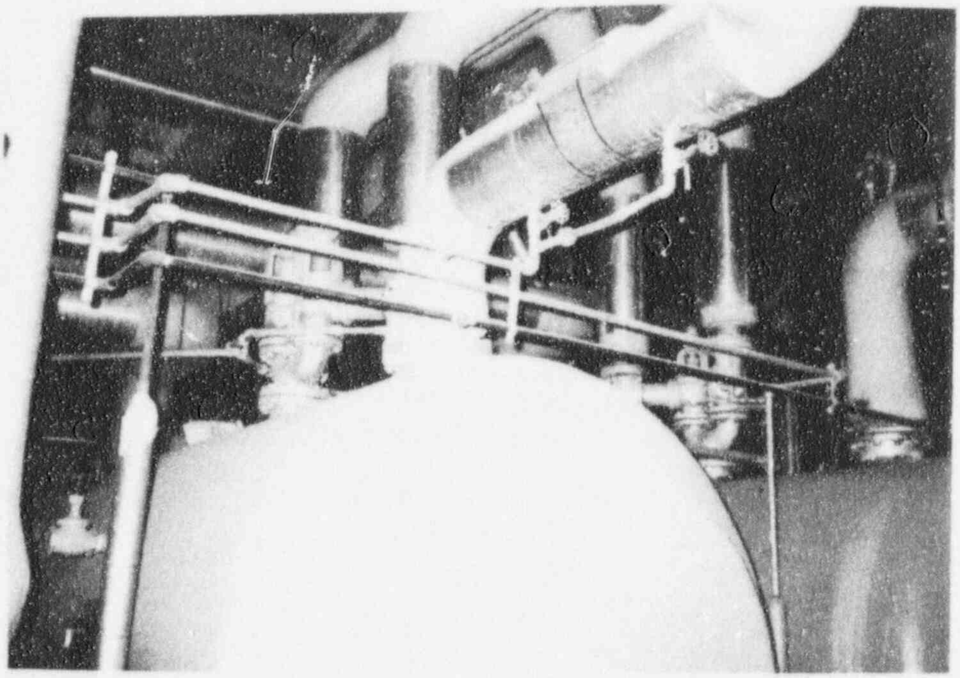


Figure E.13 Small Bore Piping Supporting Other Small Bore Pipe in Kern Unit 1

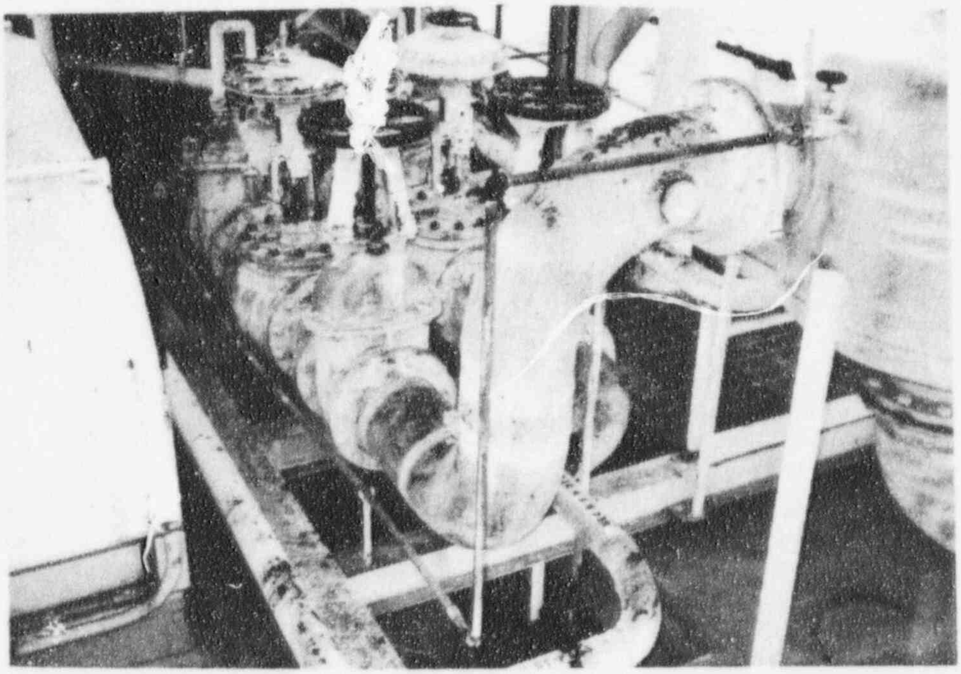


Figure E.14 Unsupported Small Bore Piping Kern Unit 1

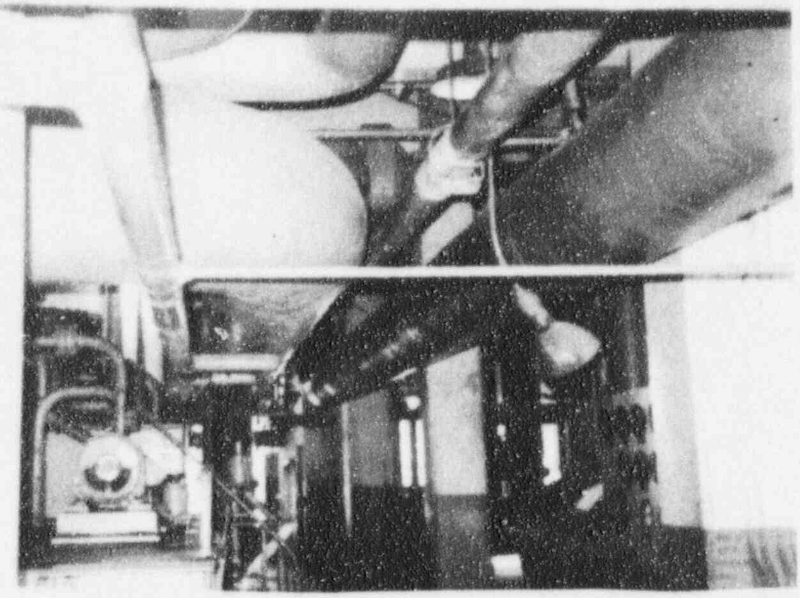


Figure E.15 Example of Non-Flexible Branch Line Connection in Olive Unit 2

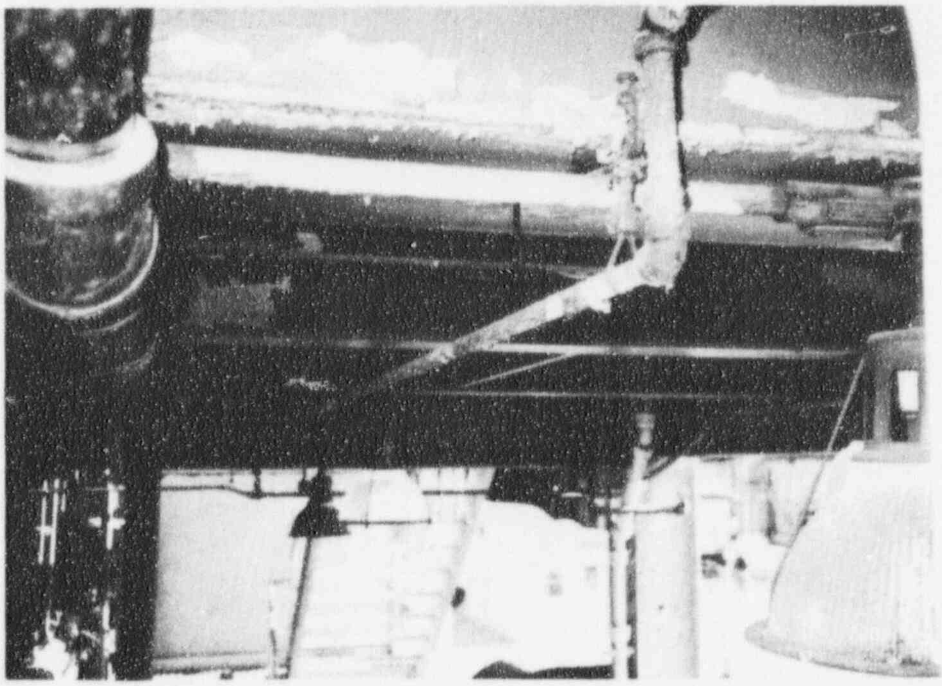


Figure E.16 Unsupported Corroded Bore Line in Valley Unit 3

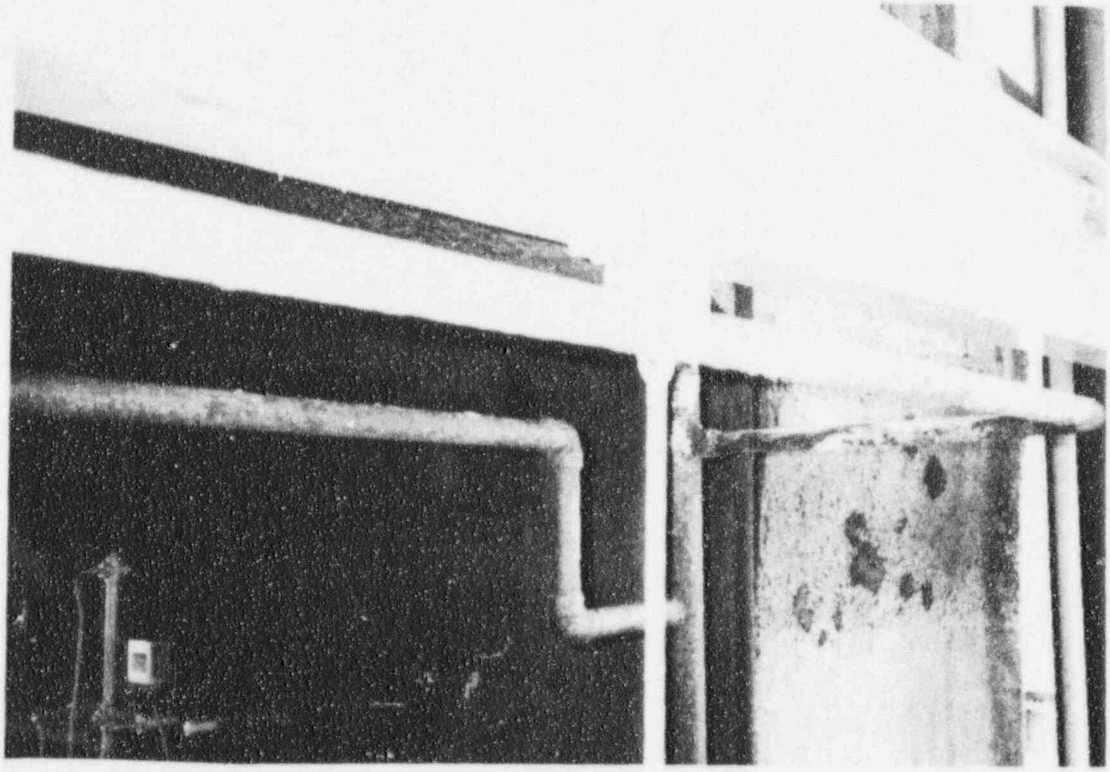


Figure E.17 Unsupported Corroded Small Bore Line in Humboldt Bay Unit 1

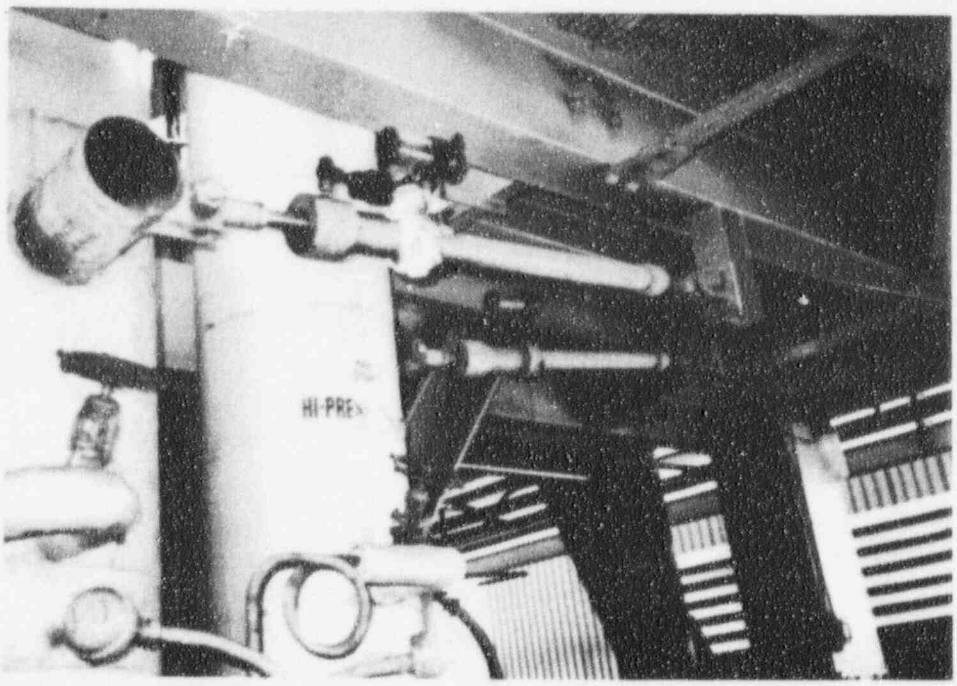


Figure E.18 Snubber Support of Main Steam Line on Magnolia Unit 3

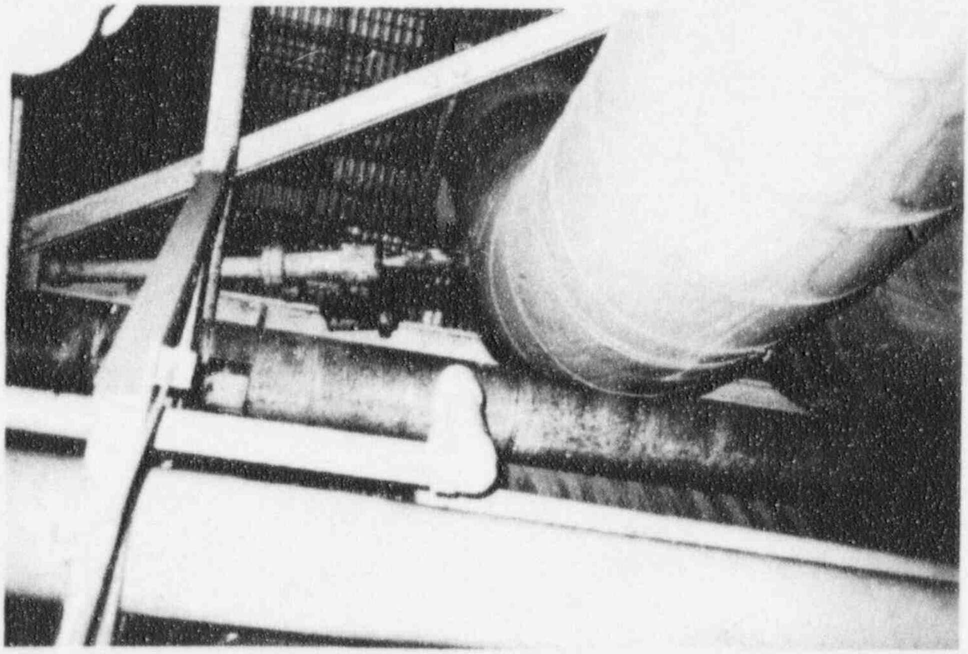


Figure E.19 Snubber Support of Main Steam Line on Pasedena Broadway Unit 3

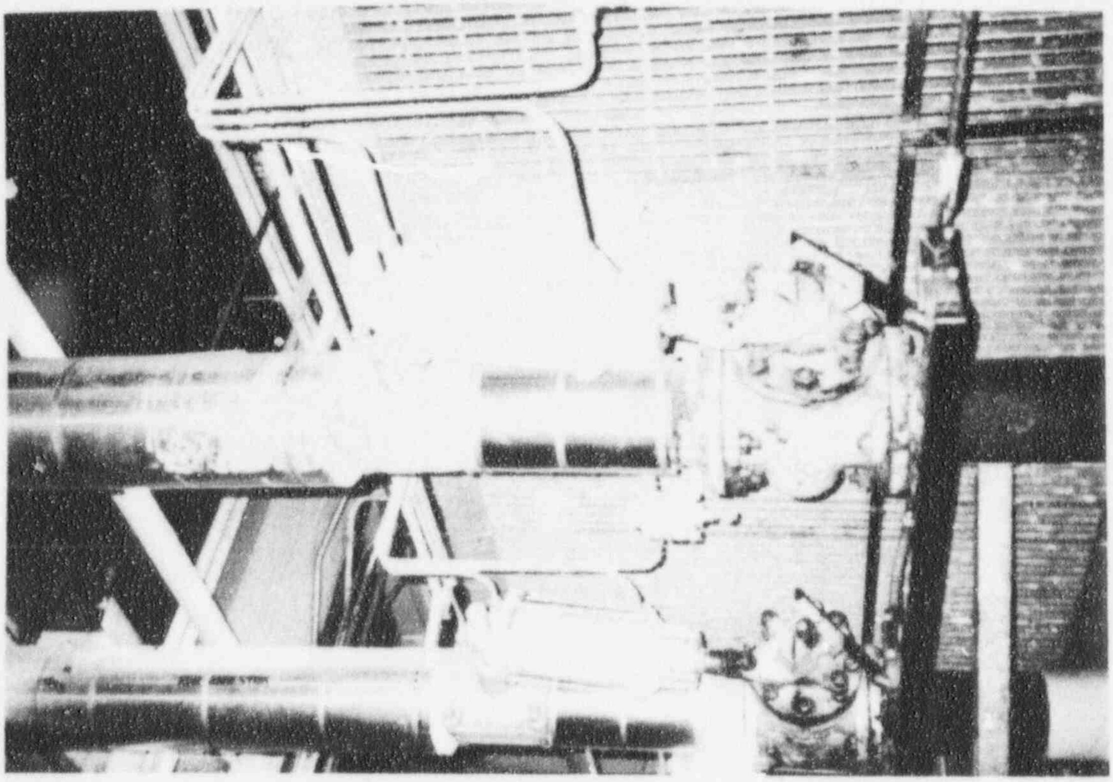


Figure E. 20 Snubber Support of Oil Feed Lines to Boiler on Humboldt Bay Unit 2

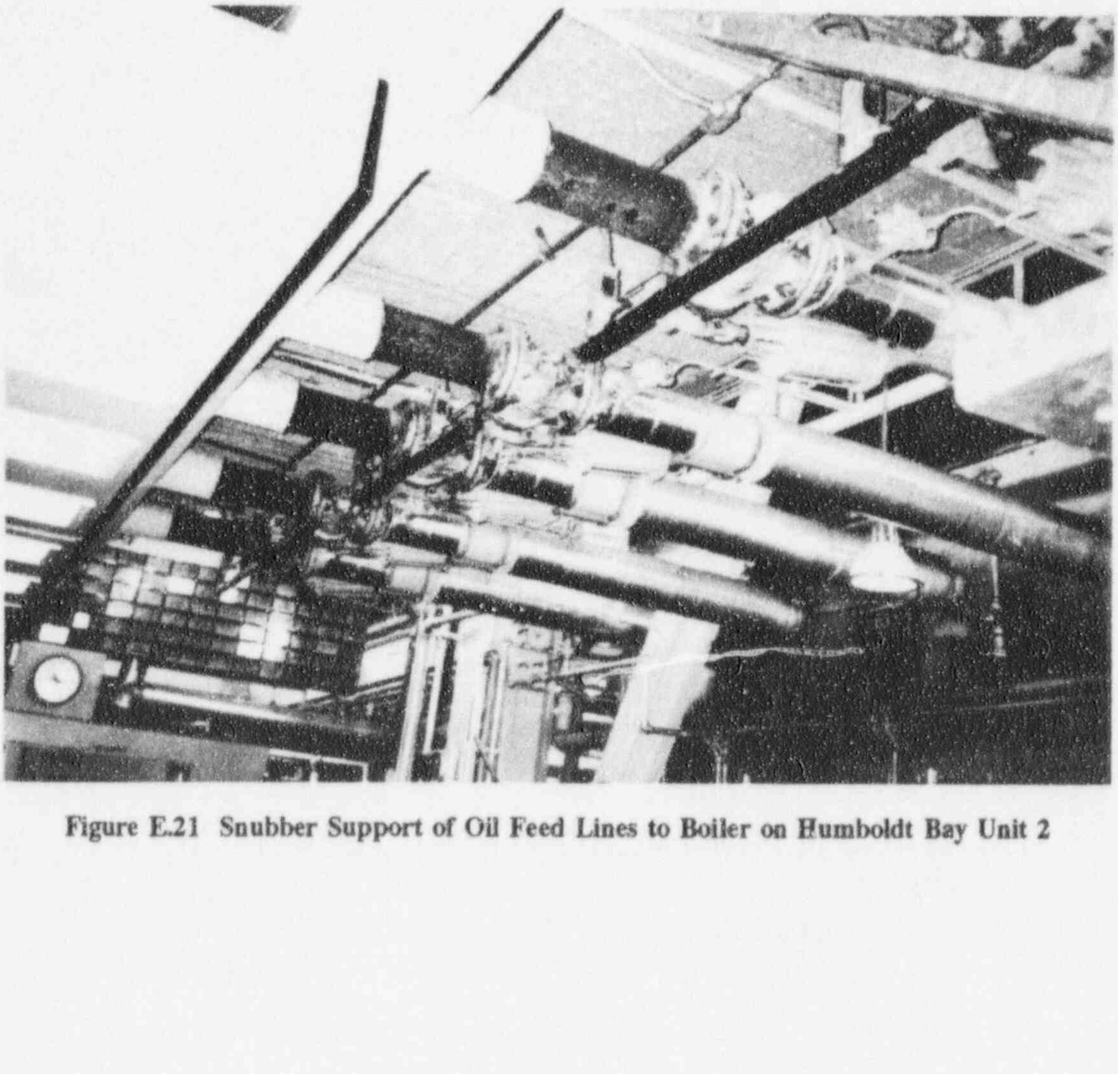


Figure E.21 Snubber Support of Oil Feed Lines to Boiler on Humboldt Bay Unit 2

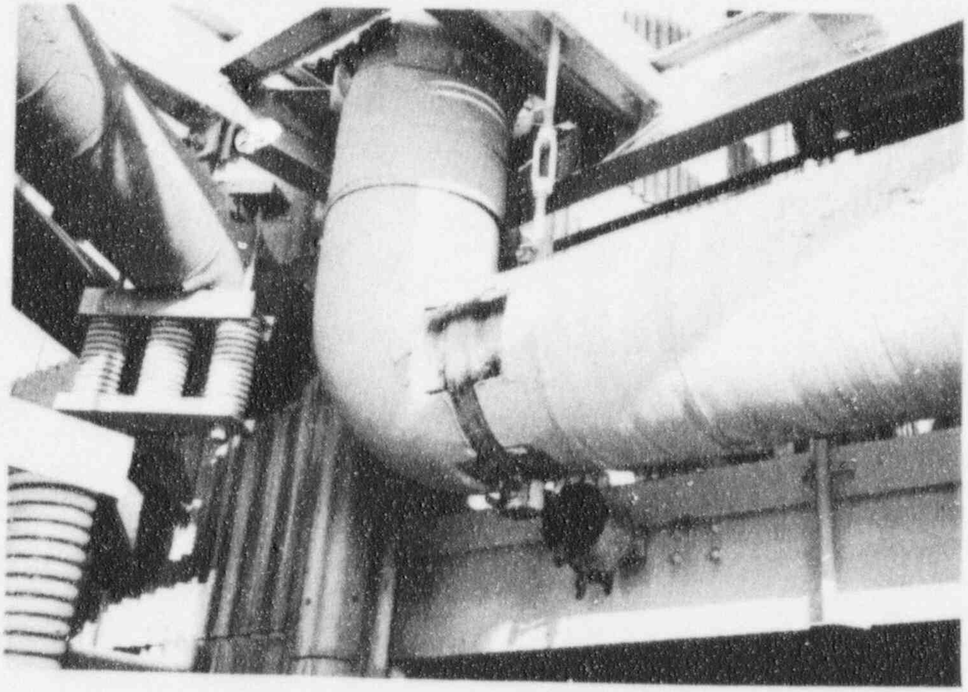


Figure E.22 Snubber Support of Feedwater Line on Kern Unit 1

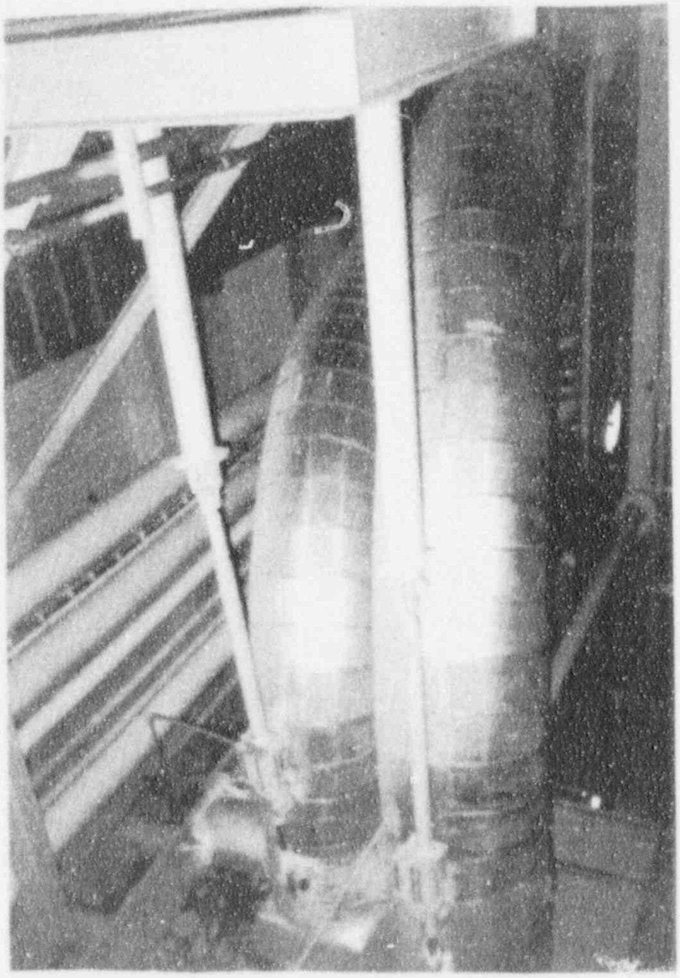


Figure E.23 Snubber Support of Main Steam Lines of El Centro Unit 4

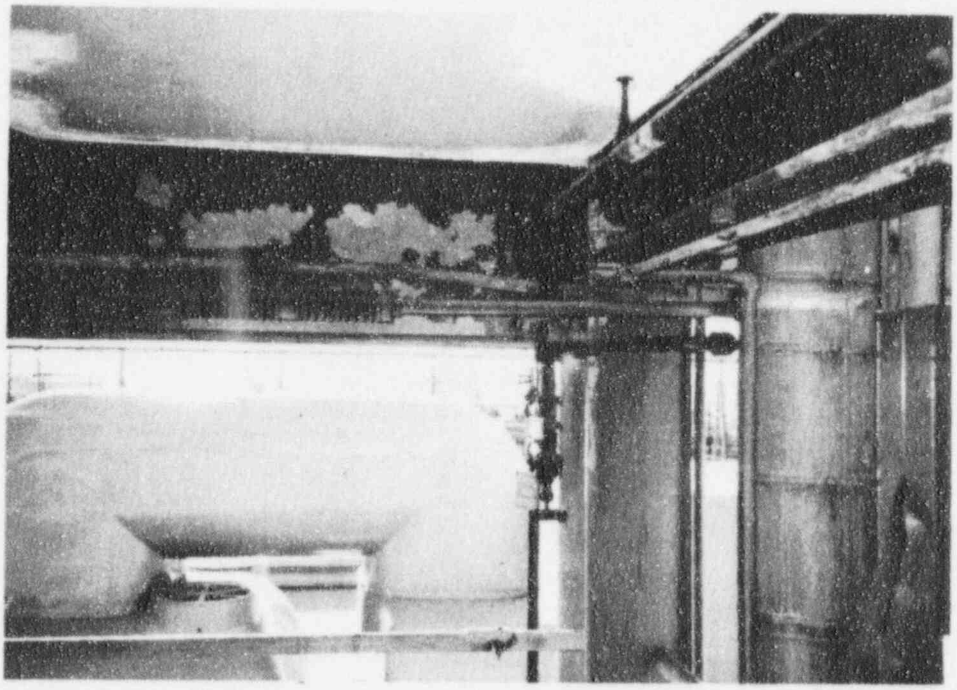


Figure E.24 Lateral Sway Brace Support of Large Bore Hot Line in Valley Unit 3

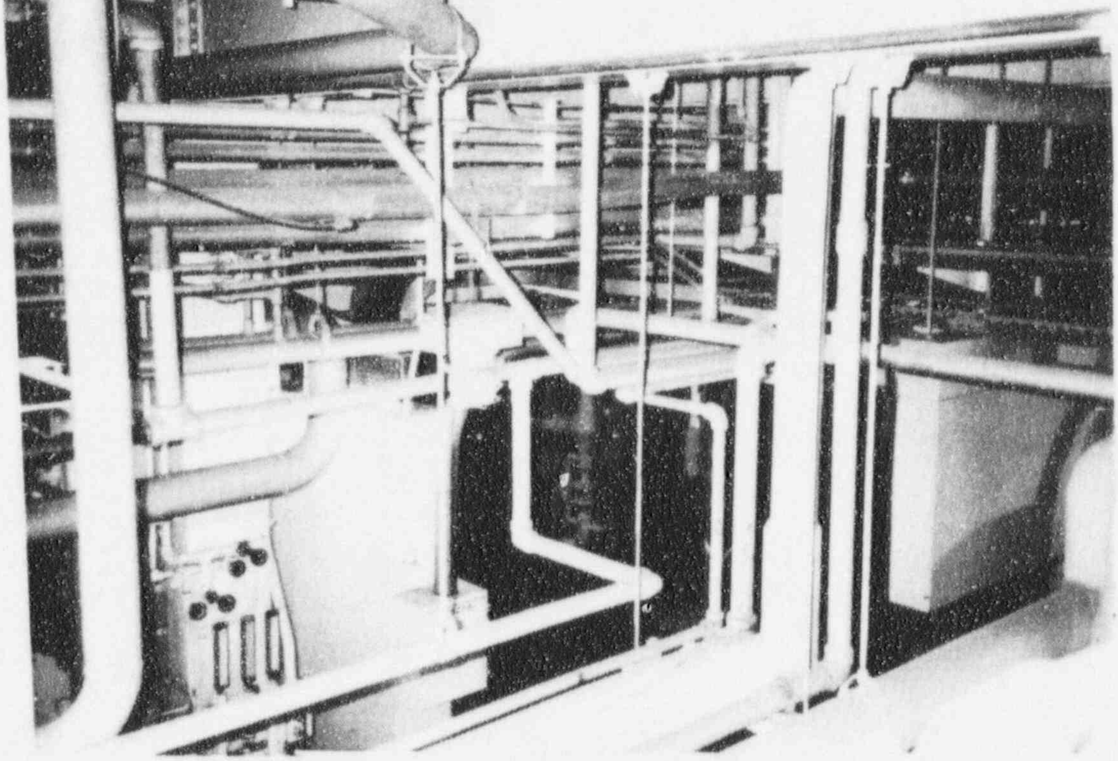


Figure E.25 Pipe Supporting Pipe in Humboldt Bay Unit 2

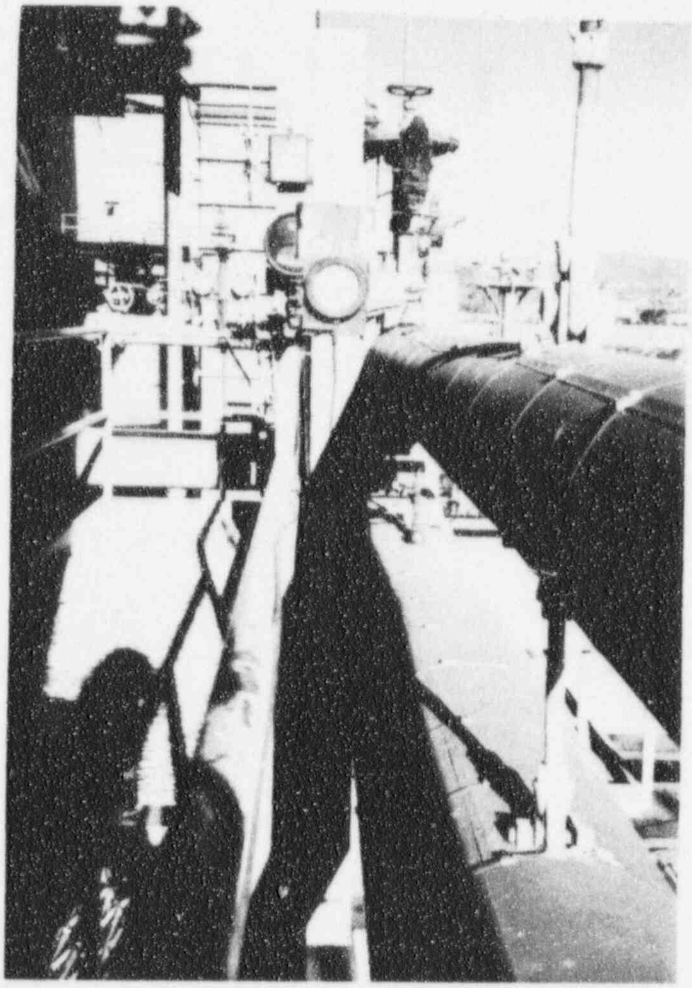


Figure E.26 Pipe Supporting Pipe in Valley Unit 3

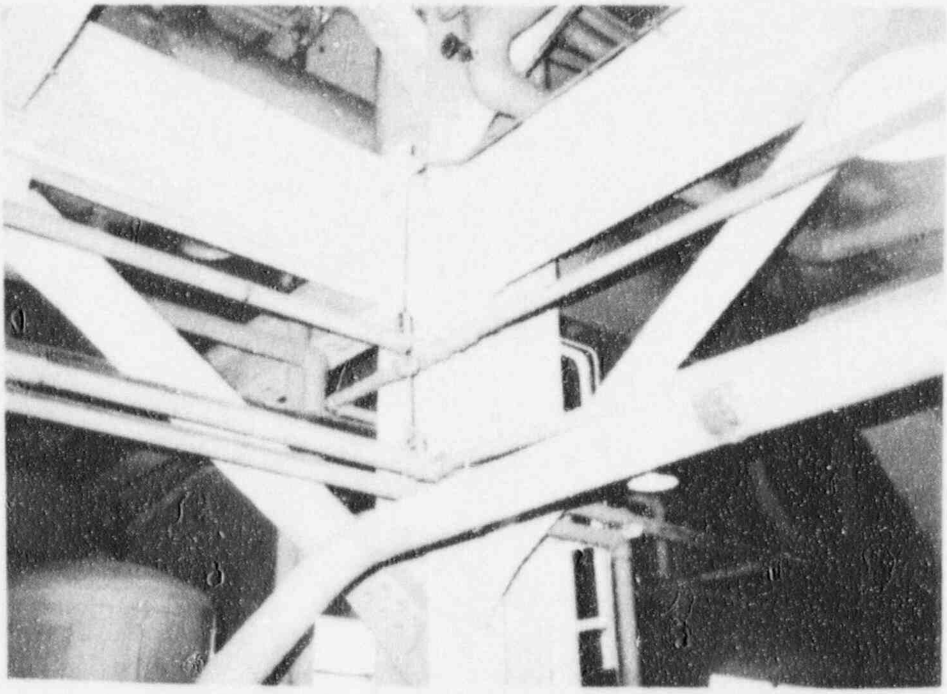


Figure E.27 Pipe Supporting Pipe in Centro Unit 1

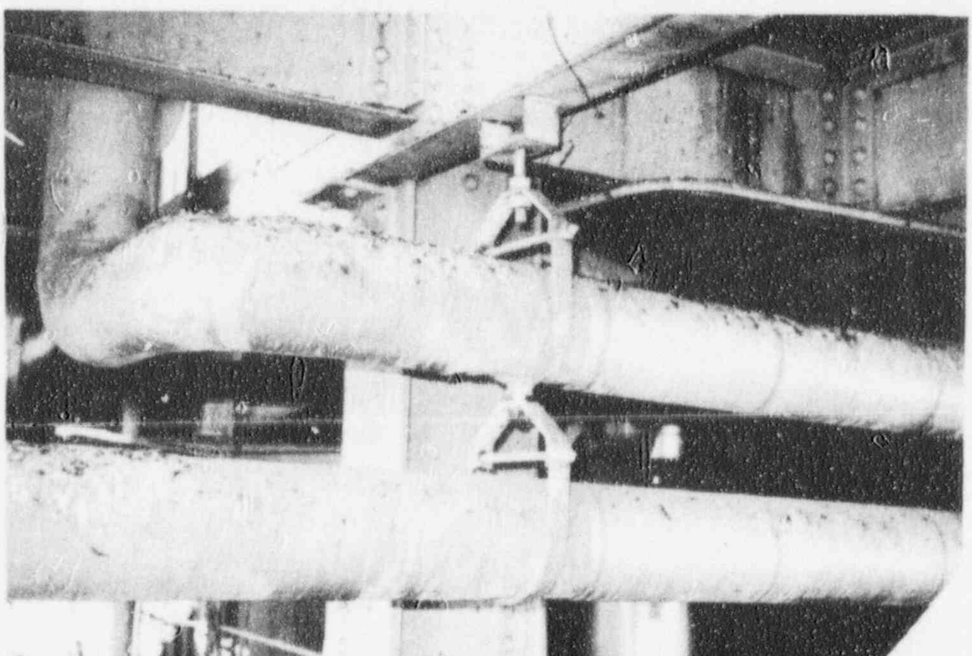


Figure E.28 Pipe Supporting Pipe in Kern Unit 1

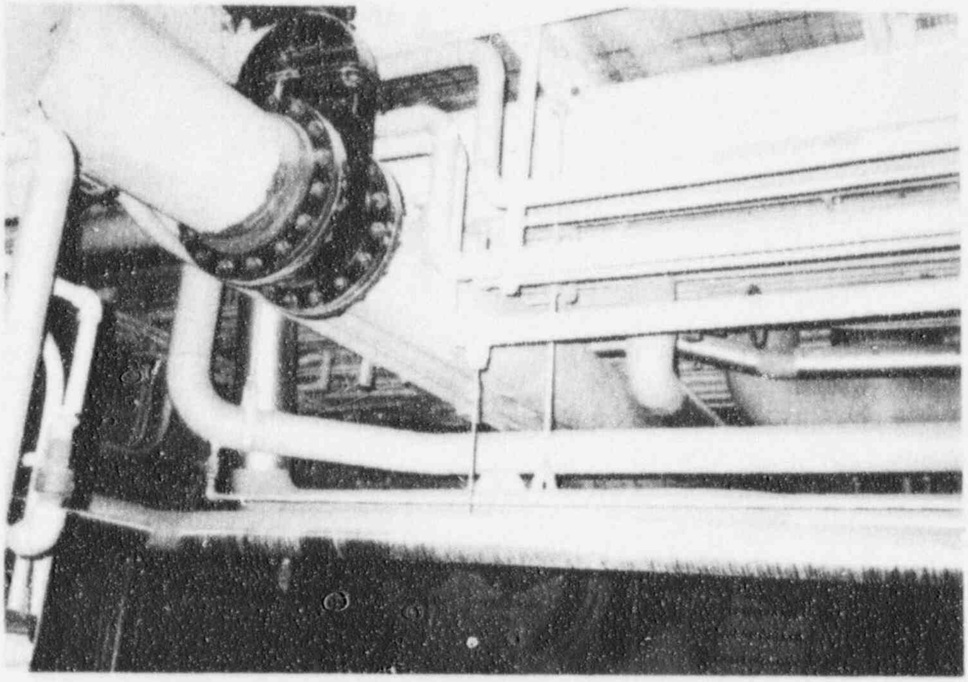


Figure E29 Pipe Supporting Pipe in Kern Unit 1

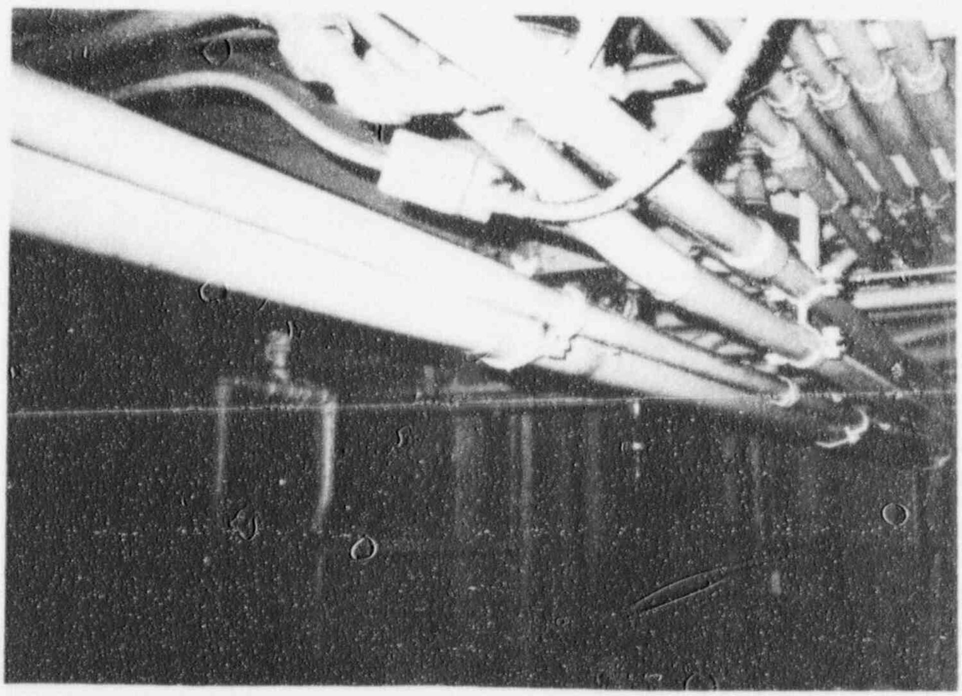


Figure E.30 Pipe Supporting Pipe in Kern Unit 1

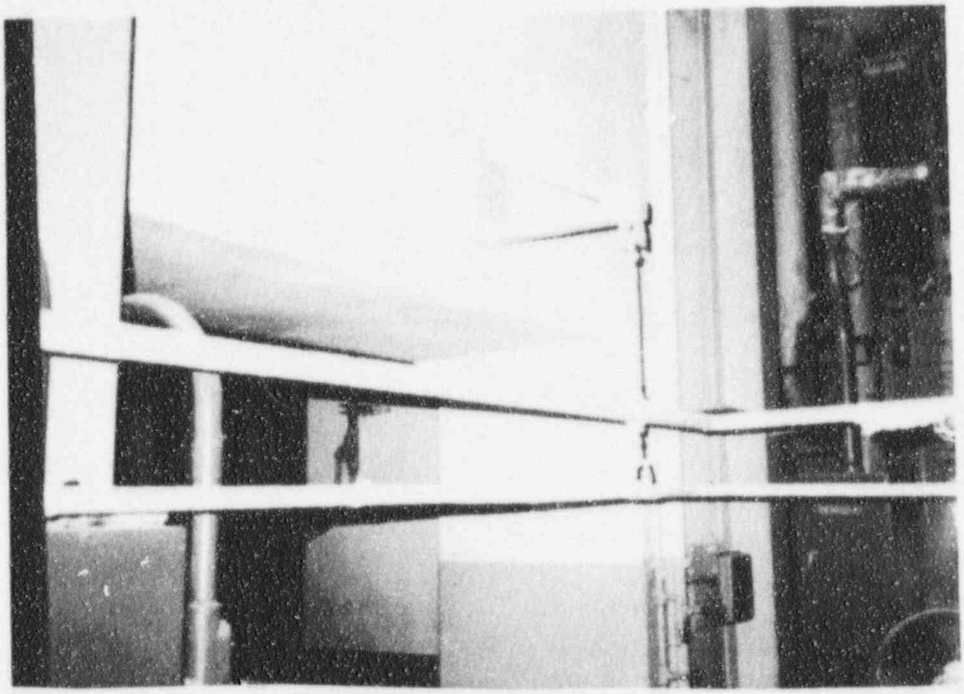


Figure E.31 Pipe Supporting Pipe in Centro Unit 4

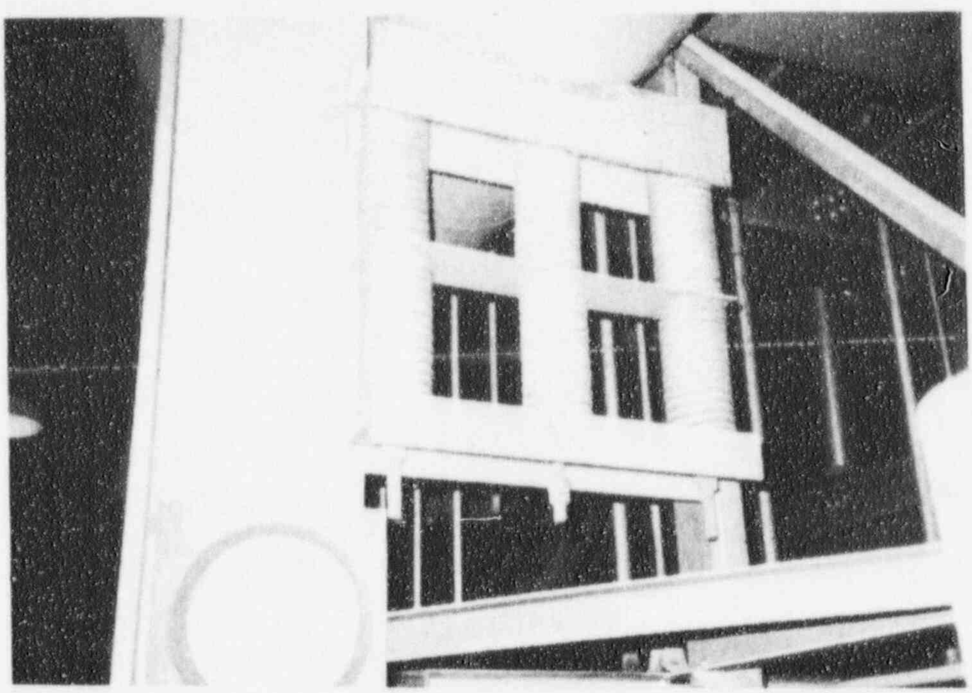


Figure E.32 Field Fabricated Spring Hanger in Kern Unit 1

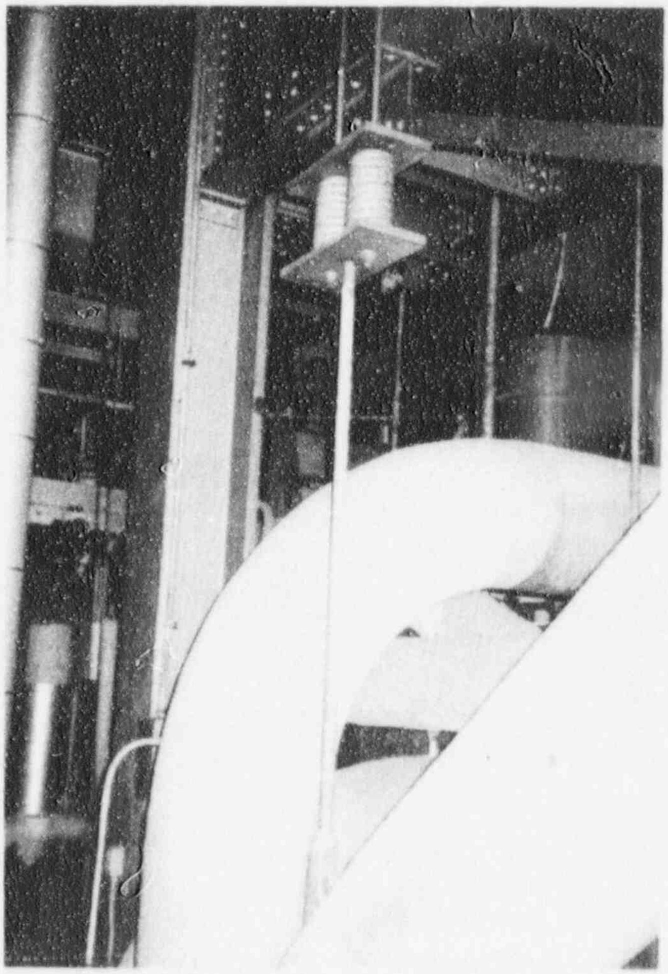


Figure E.33 Field Fabricated Spring Hanger in Kern Unit 1

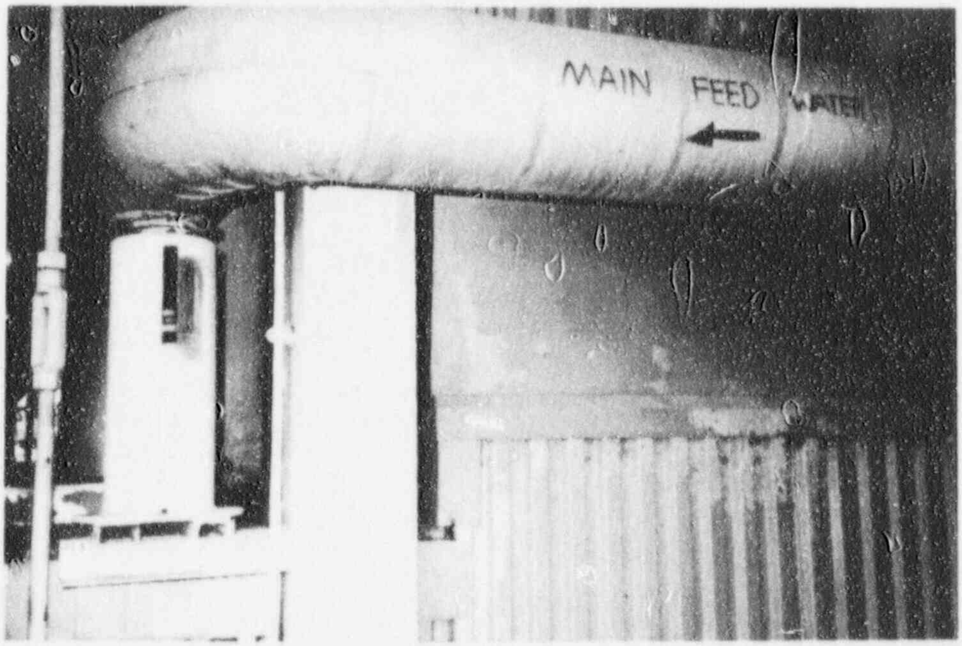


Figure E.34 Spring Support for Main Feedwater Line for Pasadena Broadway Unit 2

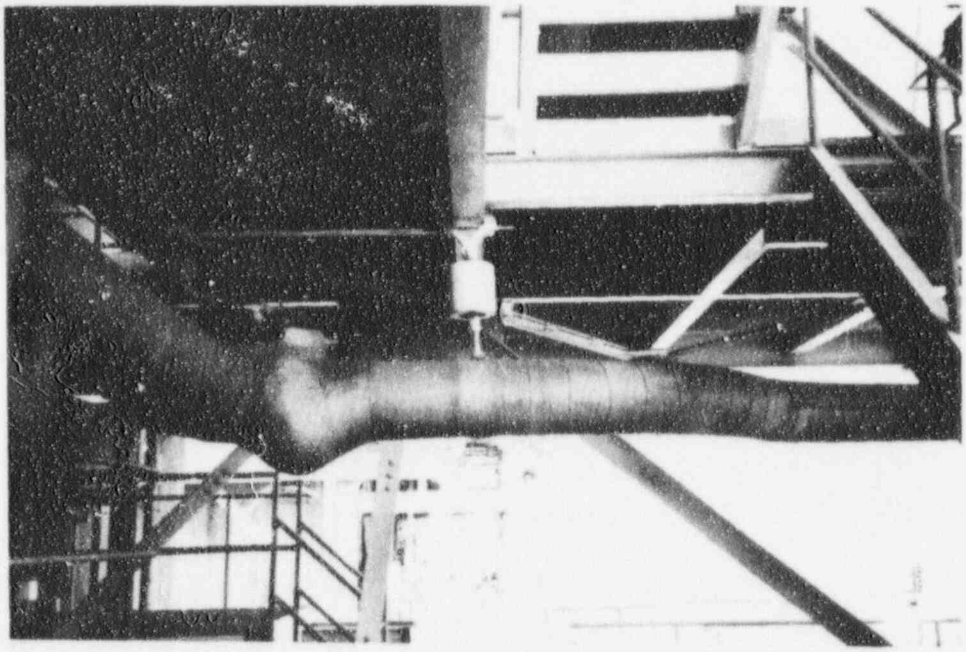


Figure E.35 Spring Hanger for Large Bore Hot Line for Pasadena Broadway Unit 1

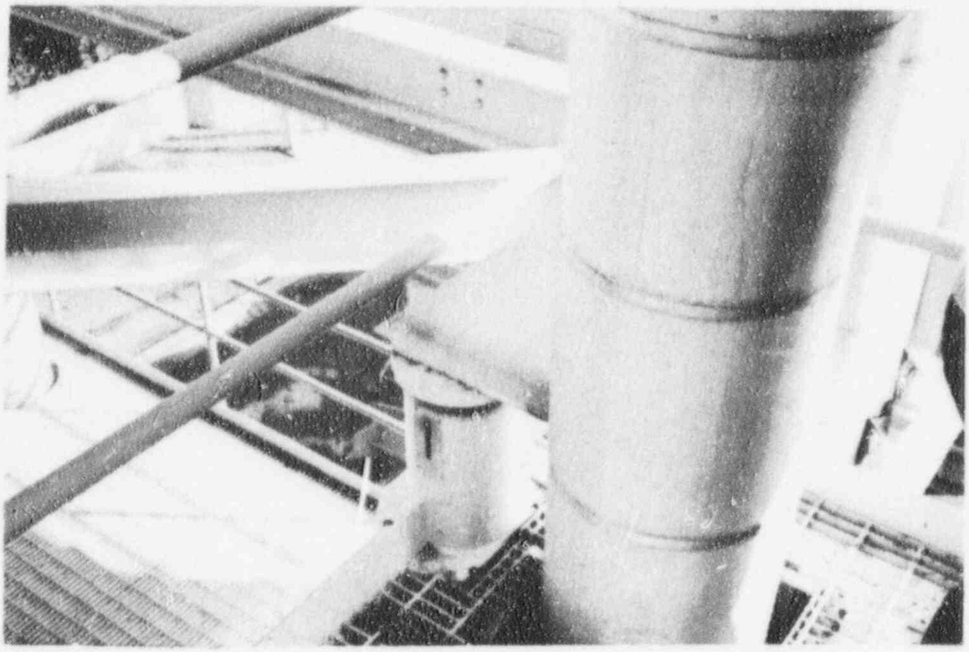


Figure E.36 Spring Support for Main Steam Line for Pasadena Broadway Unit 2

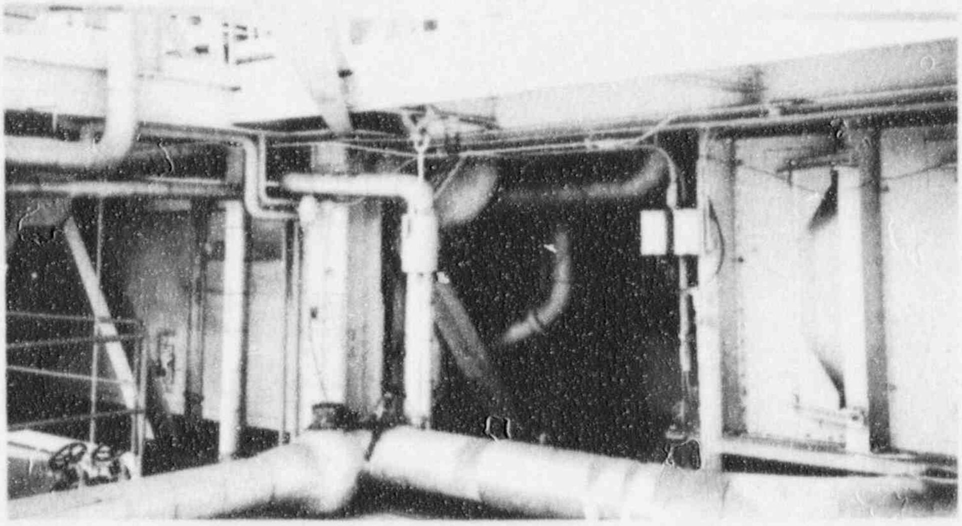


Figure E.37 Spring Hanger for Large Bore Hot Line in Pasadena Broadway Unit 1

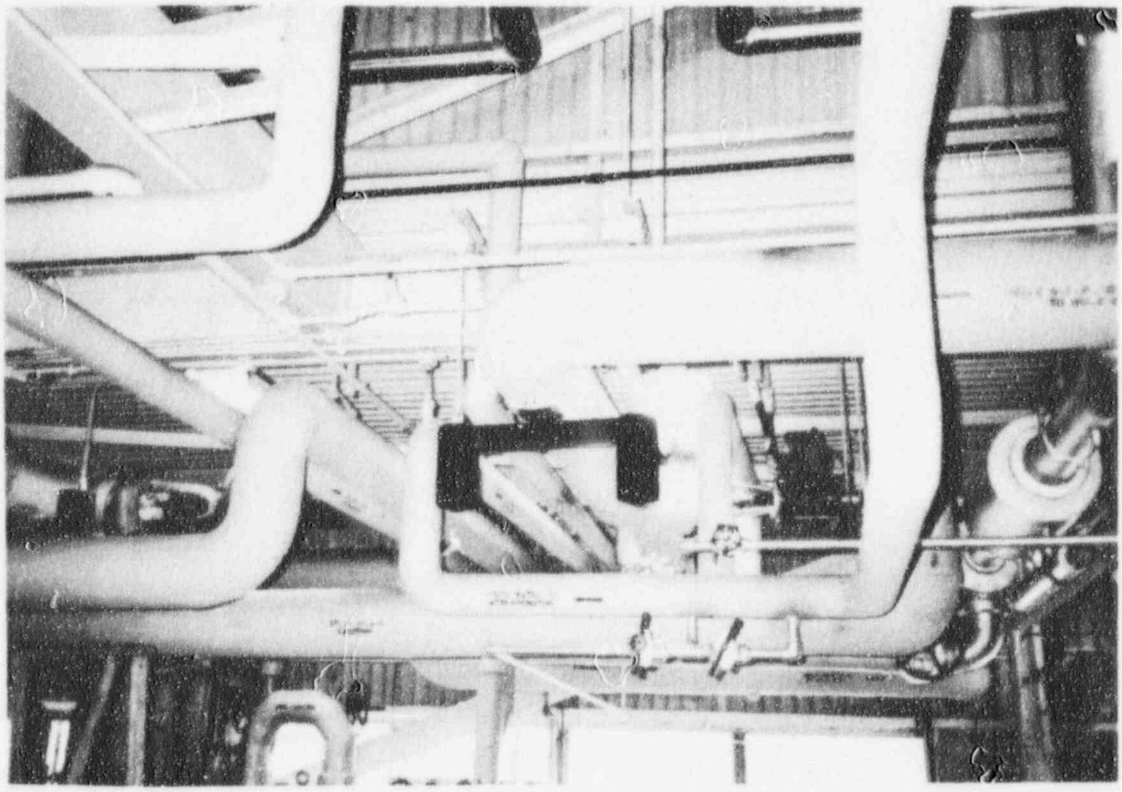


Figure E.38 Spring Trapeze Support Large Bore Hot Line in Humboldt Bay Unit 2

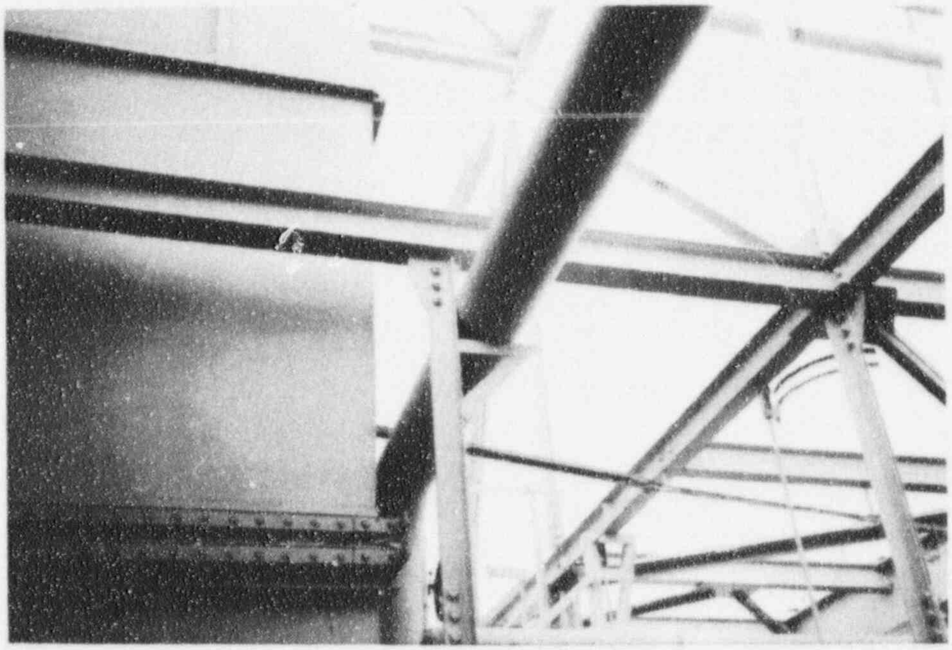


Figure E.39 Knee Brace Support for Large Bore Cold Line in Pasadena Broadway Unit 2

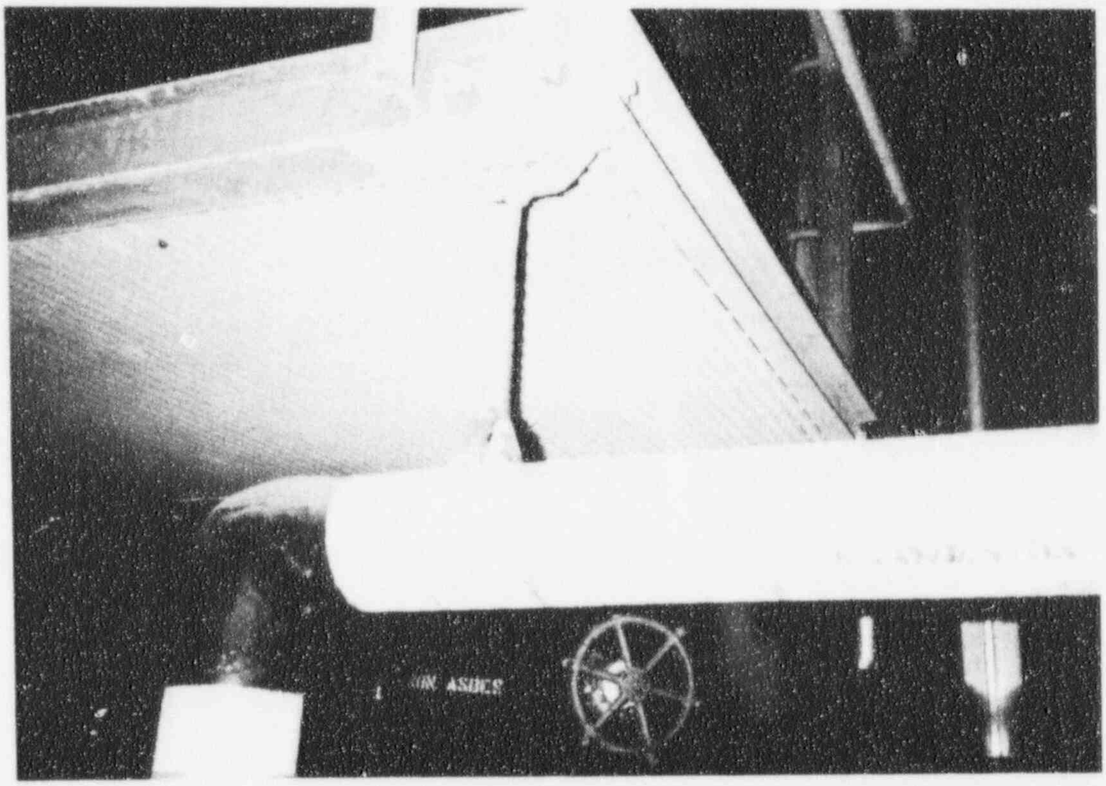


Figure E.40 Field Fabricated Support from Platform Steel in Humboldt Bay Unit 1

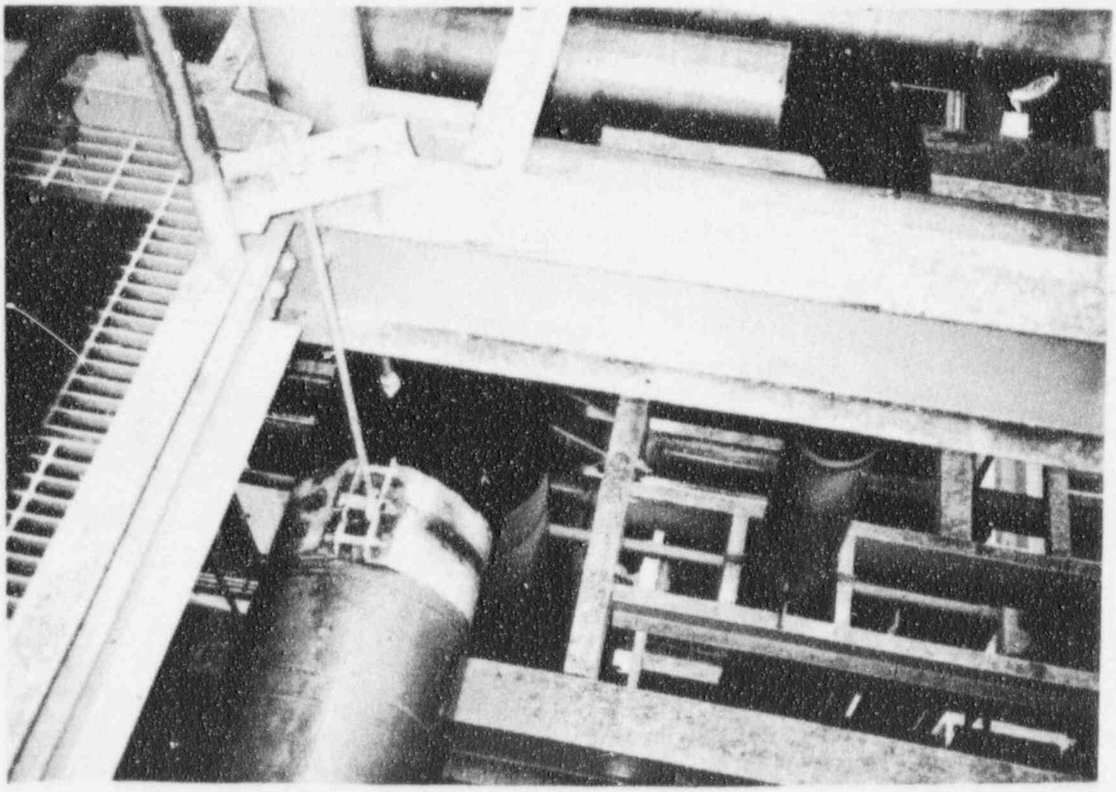


Figure E.41 Unseated Support of Large Bore Hot Line in Humboldt Bay Unit 1

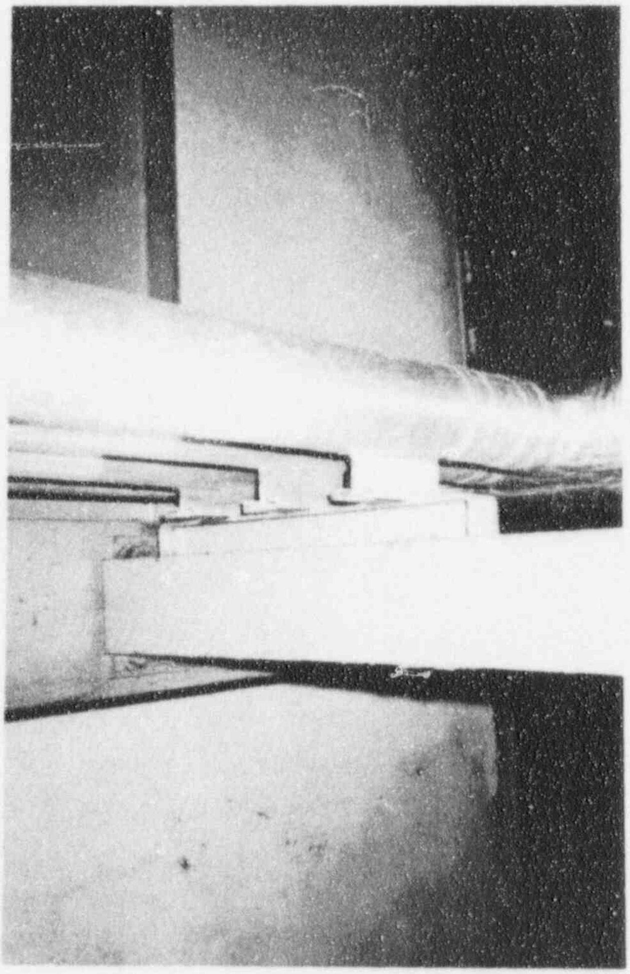


Figure E.42 Guide Supports for Large Bore Hot Line in Glendale Unit 4

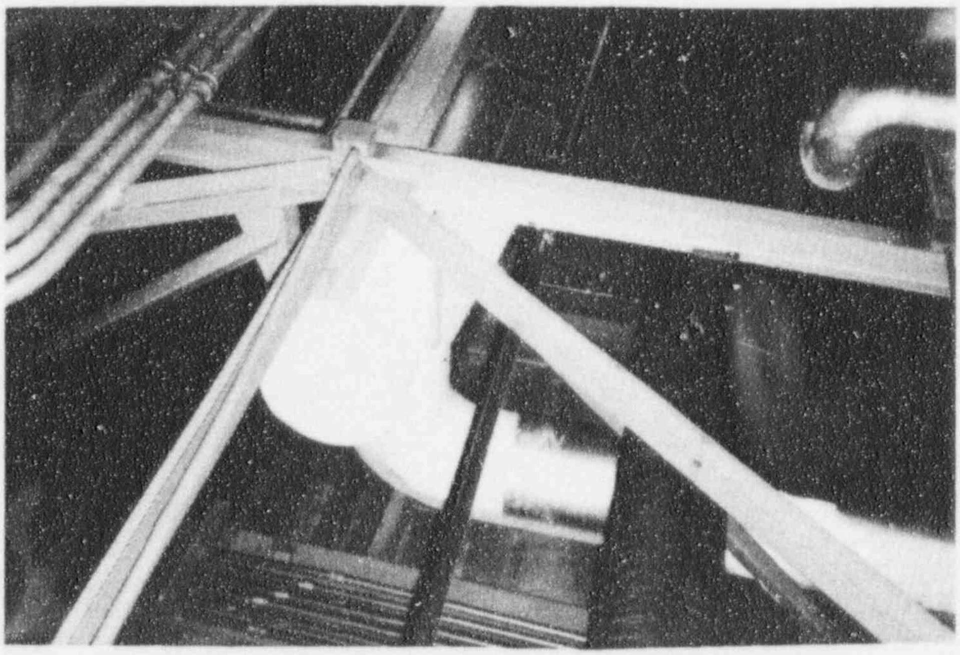


Figure E. 43 Guide Support for Large Bore Hot Line in Glendale Unit 2

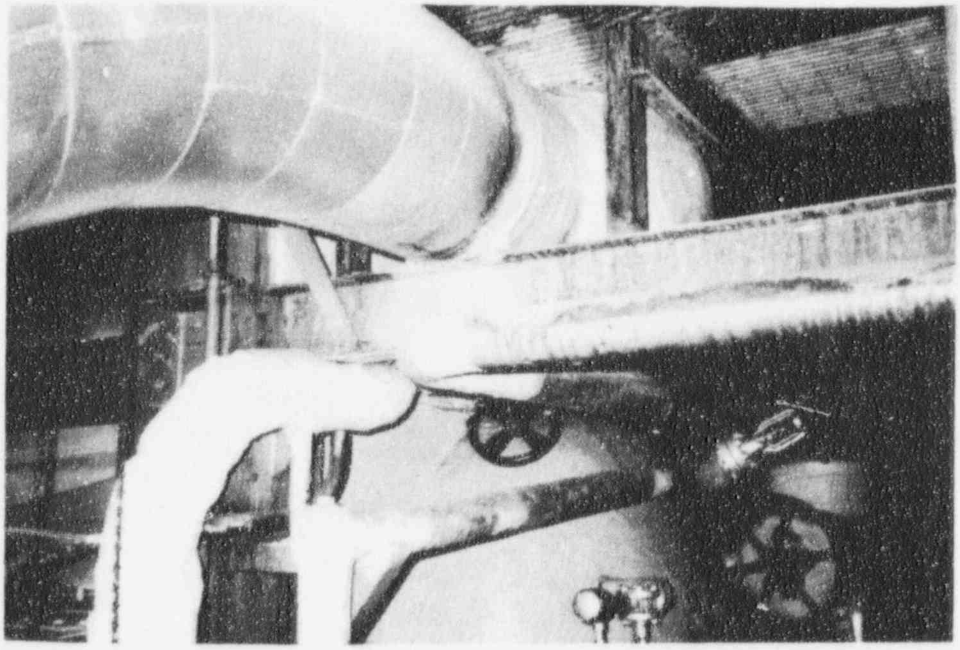


Figure E.44 Deadweight Support for Main Steam Line in Glendale Unit 1

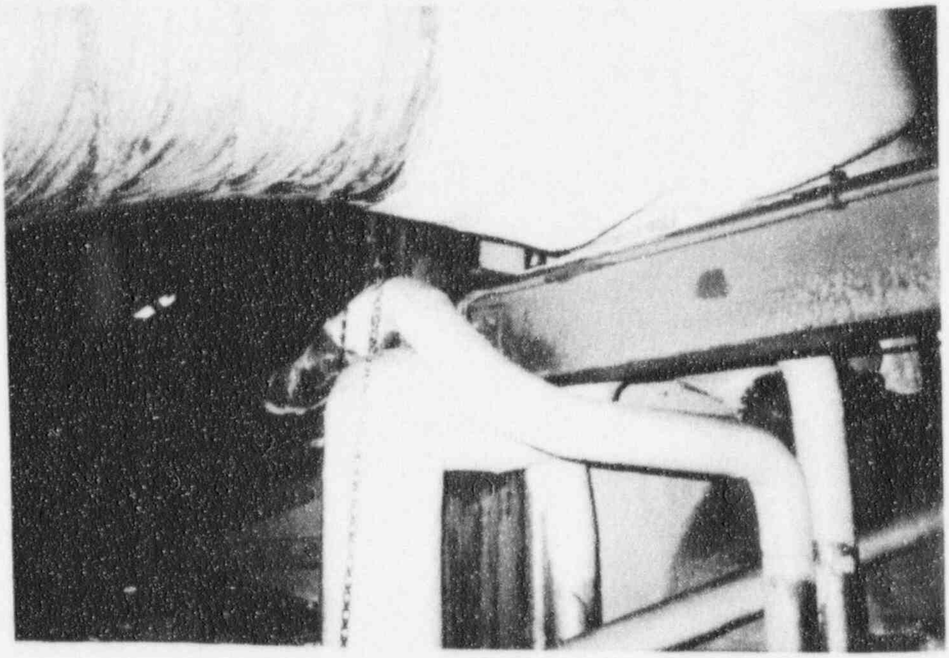


Figure E.45 Deadweight Support for Main Steam Line in Glendale Unit 1

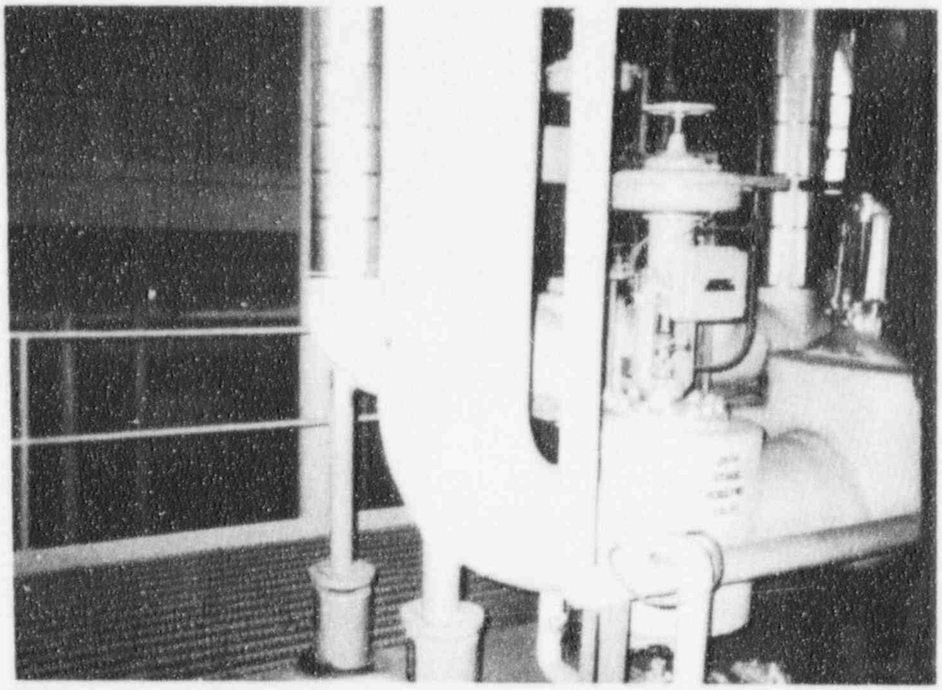


Figure E.46 Spring Support for Large Bore Hot Line in El Centro Unit 4

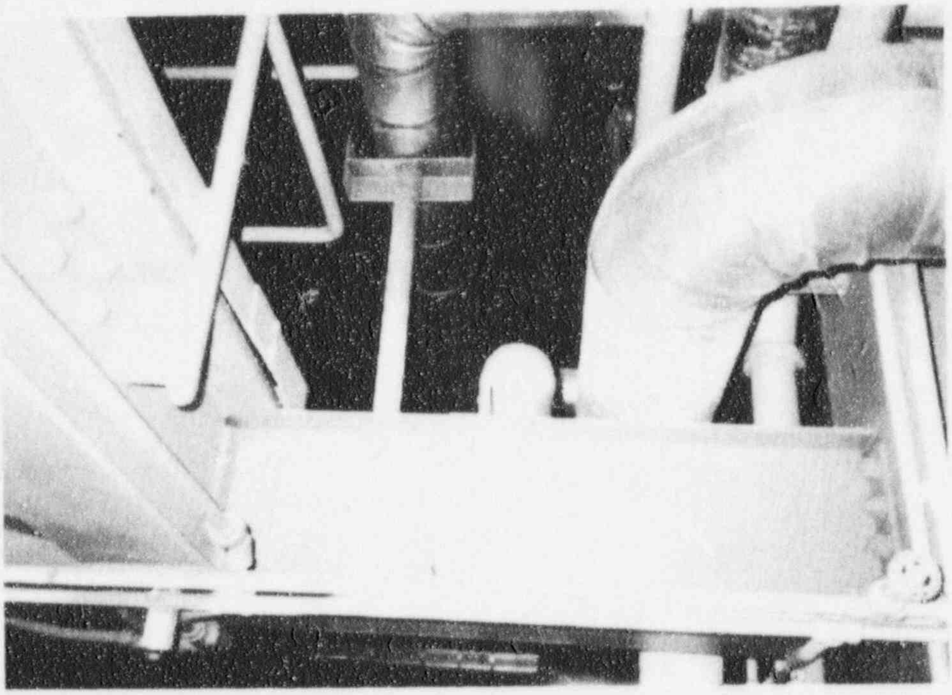


Figure E. 47 Guided Support for Large Bore Hot Lines in El Centro Unit 3

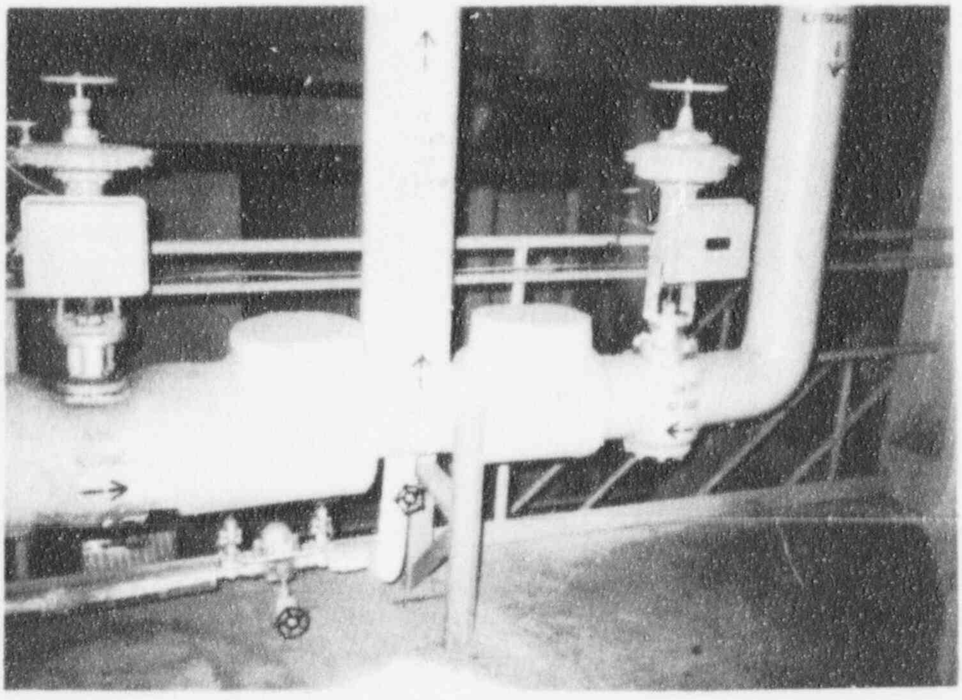


Figure E. 48 Guided Support for Large Bore Hot Line in El Centro Unit 4

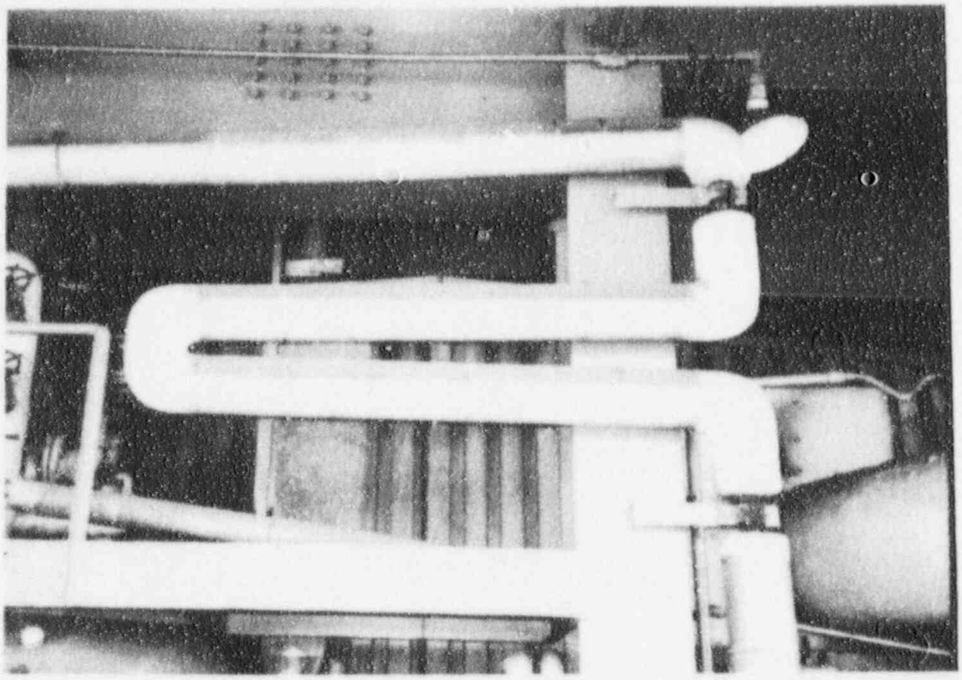


Figure E.49 Expansion Loop in Small Bore Hot Line in Olive Unit 1

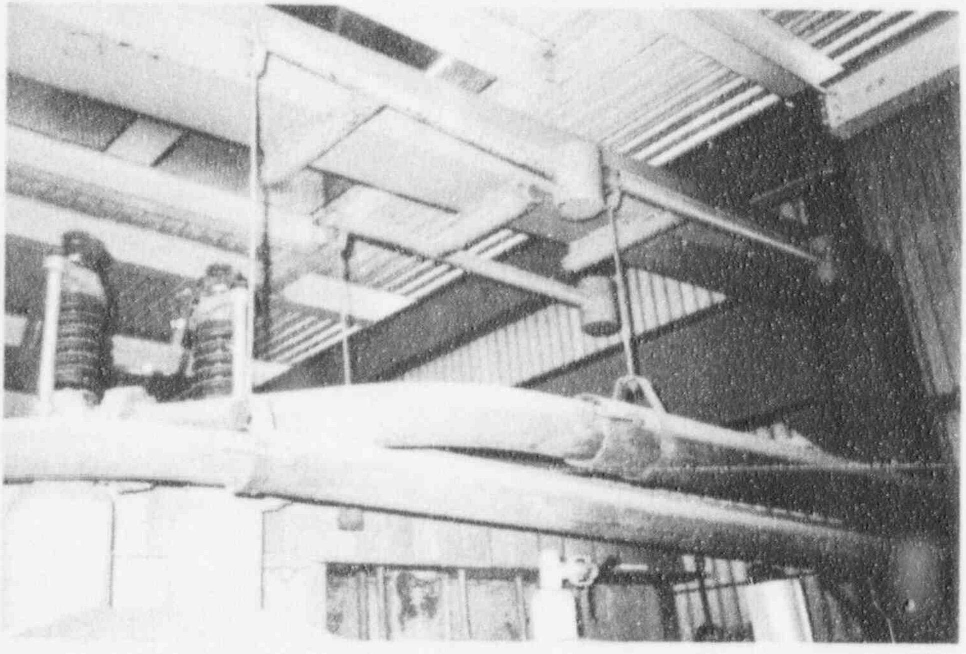


Figure E.50 Guide Pipe and Support for Large Bore Cold Lines in Glendale Unit 3

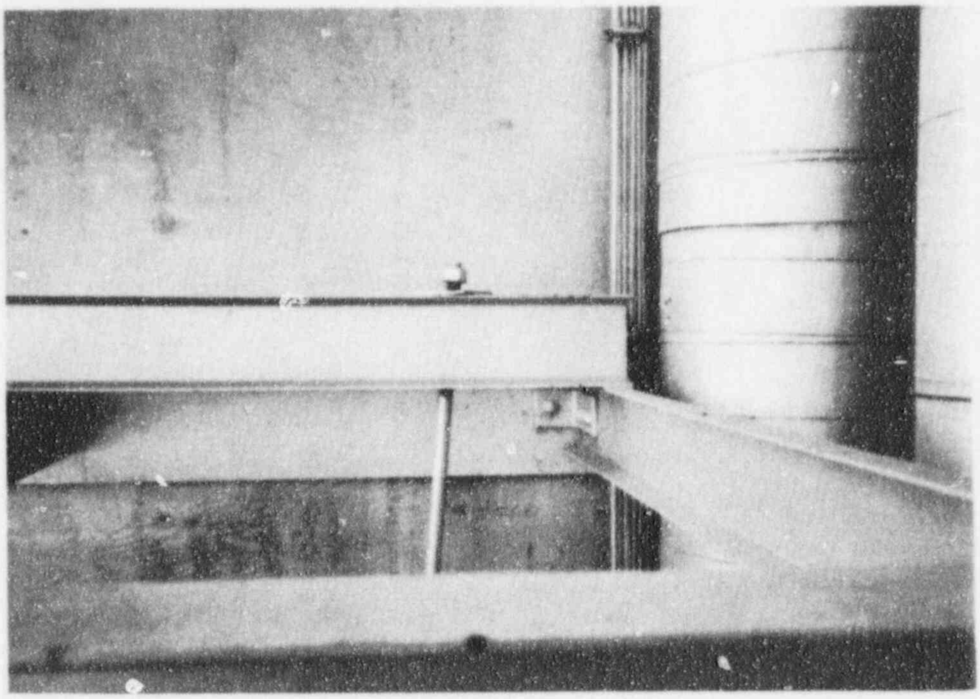


Figure E.51 Unseated Vertical Support in El Centro Unit 2

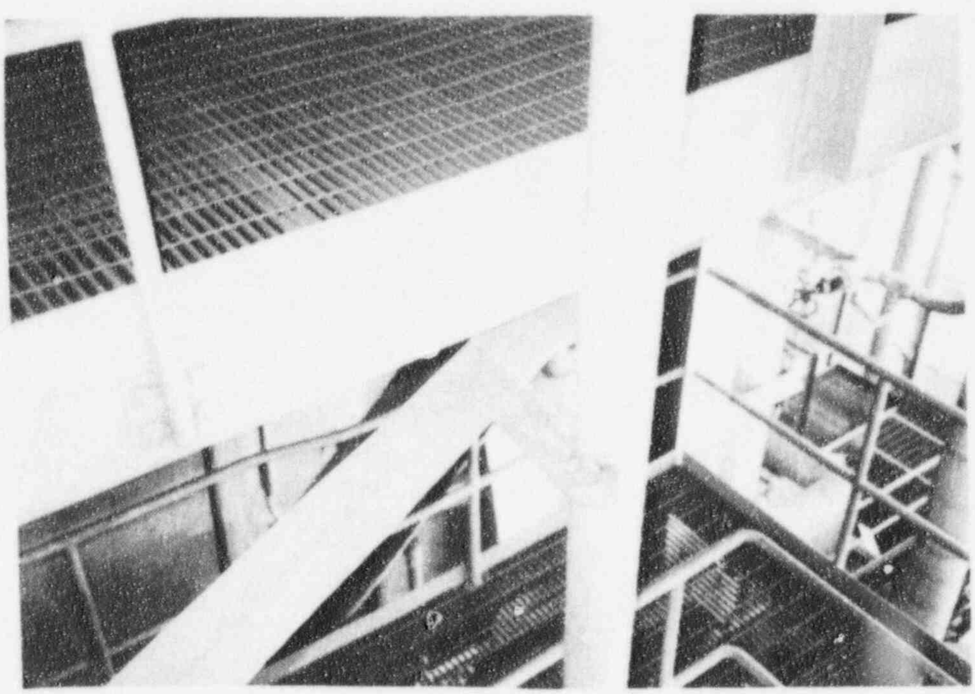


Figure E.52 U-Bolt Vertical Lateral Restraint in Small Bore Hot Pipe in Olive Unit 1

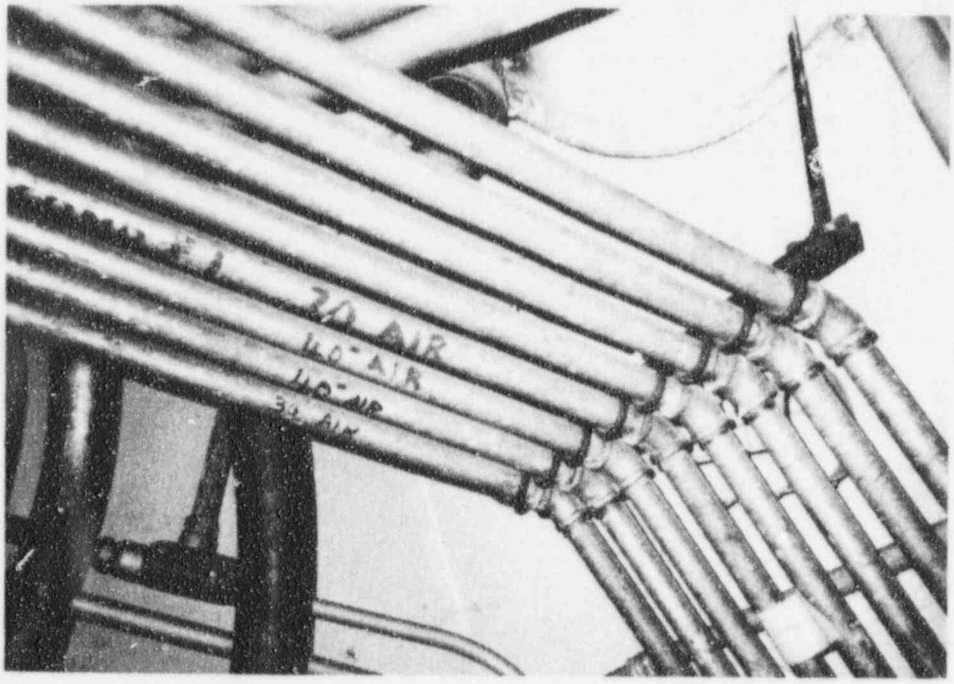


Figure E.53 Trapeze and U-Bolt Supported Small Bore Cold Piping in Kern Unit 1

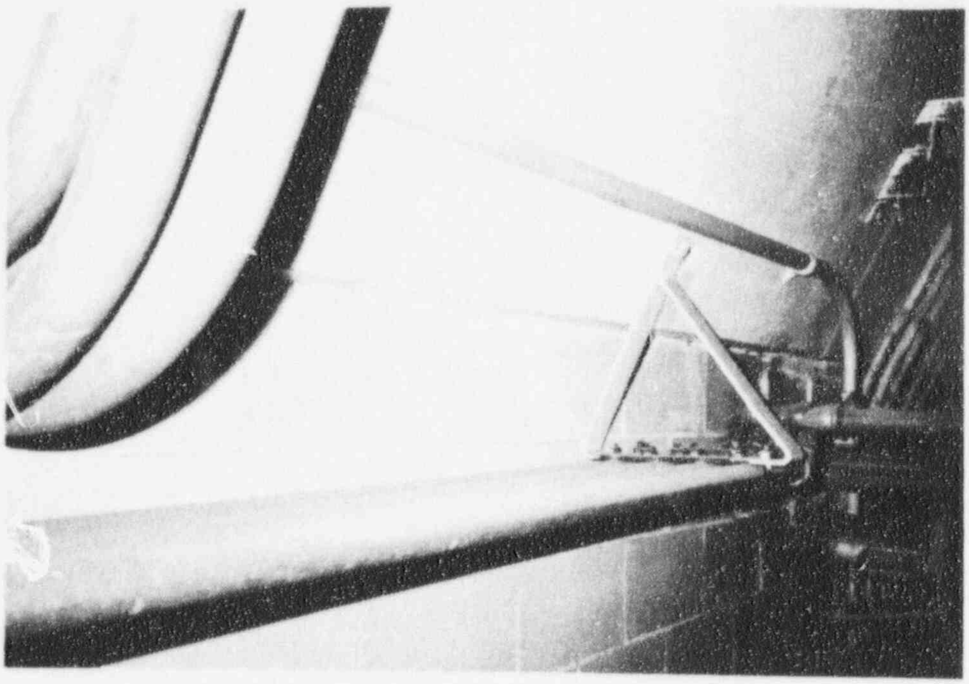


Figure E.54 Field Fabricated Support in Kern Unit 1

Figure E.55 Expansion Loop on Support of Small Bore Hot Line in Glendale Unit 3

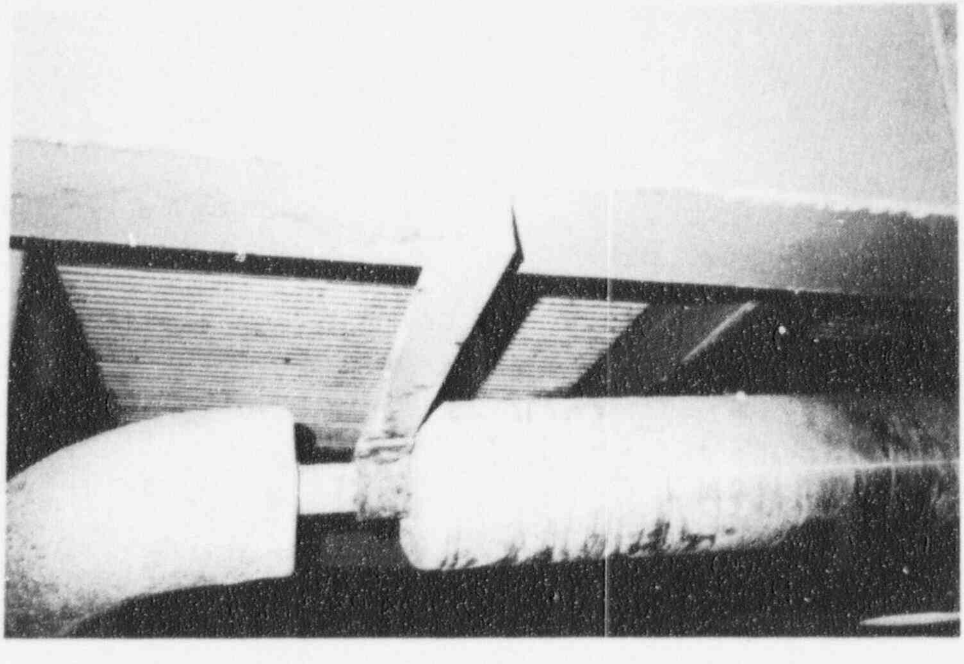


Figure E.56 U-Bolt Support of Small Bore Hot Line in Glendale Unit 3

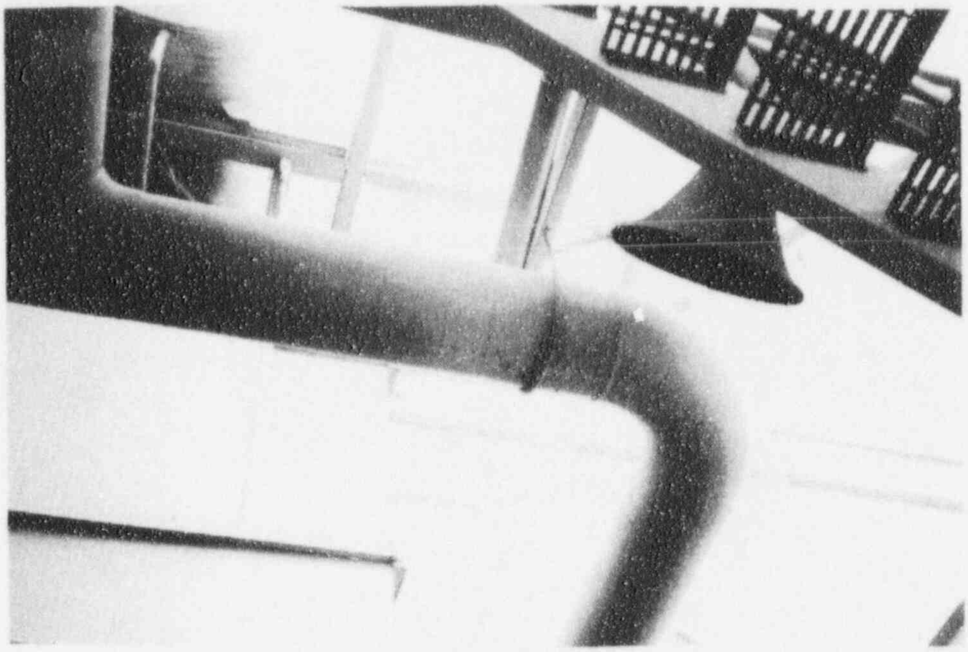


Figure E.57 U-Bolt Support of Large Bore Hot Line in Pasadena Broadway Unit 2

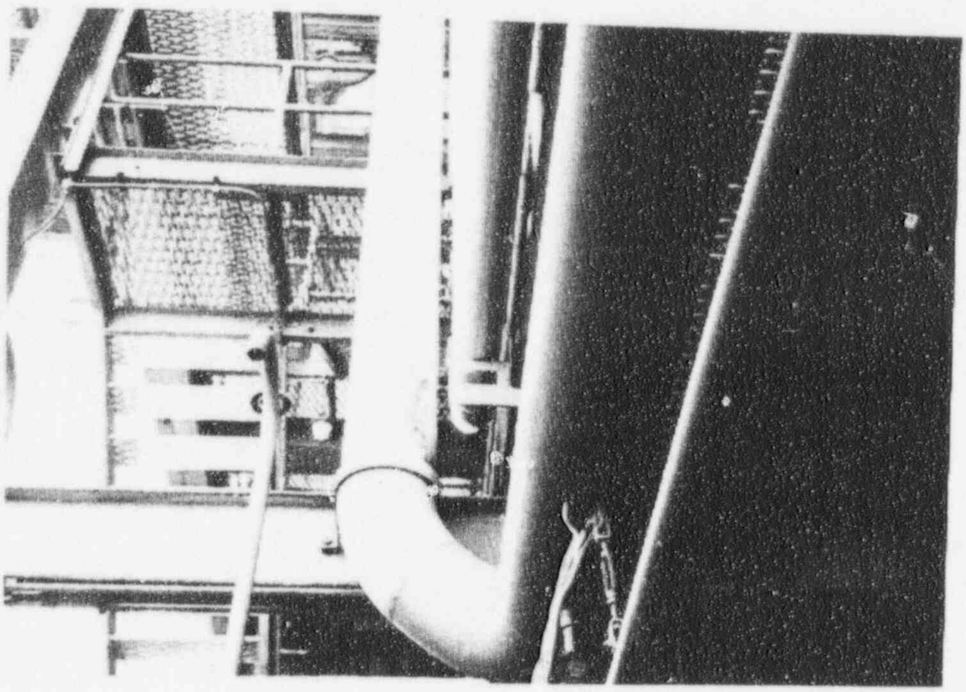


Figure E.58 U-Bolt Support of Large Bore Cold Line and Pipe Supporting Pipe in Valley Unit 1

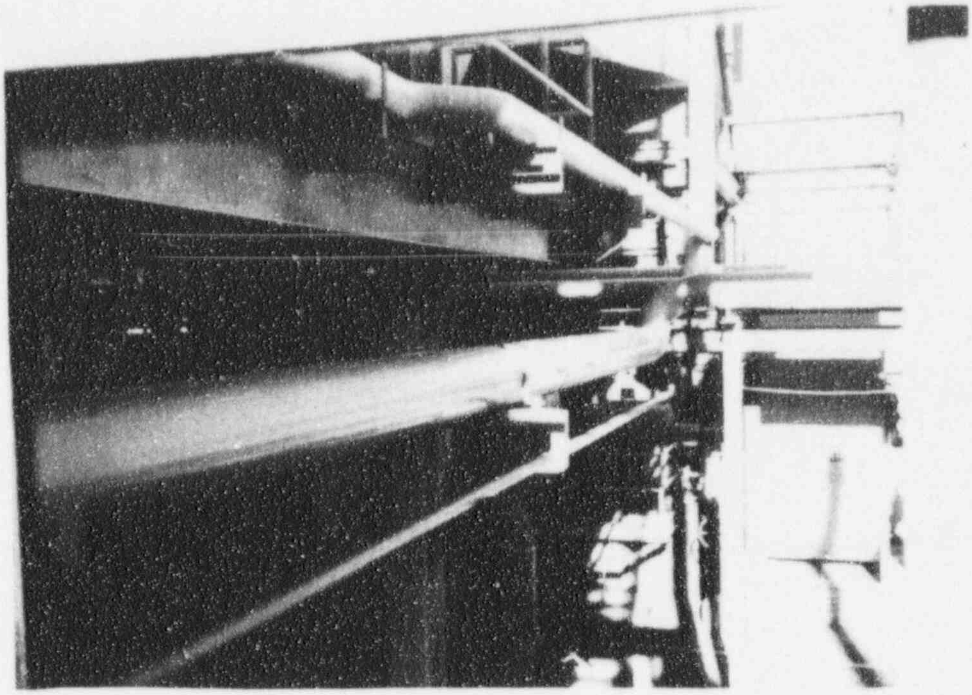


Figure E.59 U-Bolt Supported Large Bore Cold Piping in Valley Unit 1

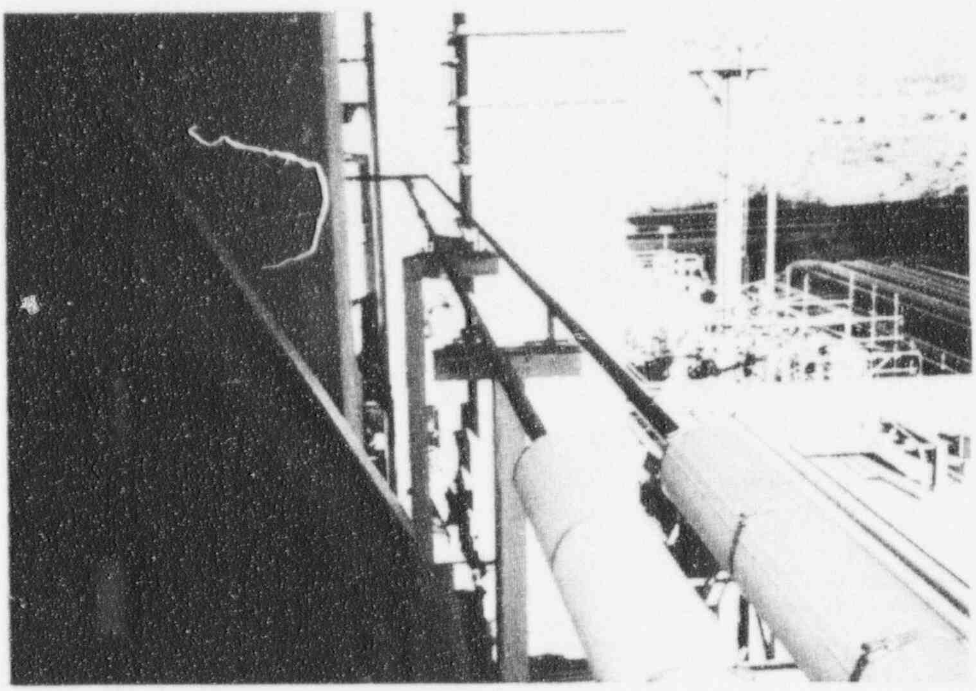


Figure E.60 Guided Small Bore Hot Lines in Valley Unit 2

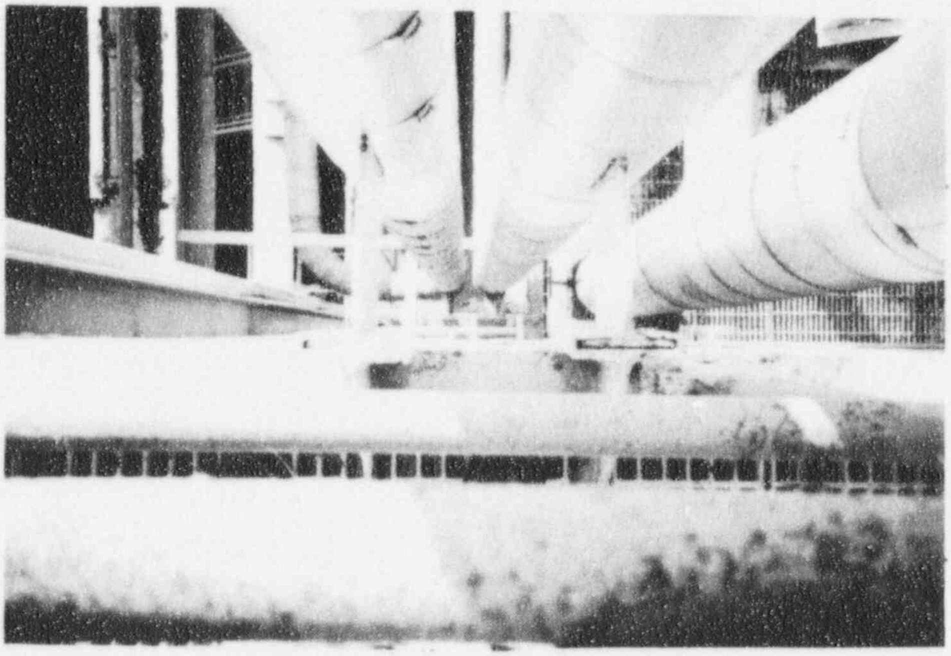


Figure E.61 Guided Large Bore Hot Lines in Pasadena Broadway Unit 3

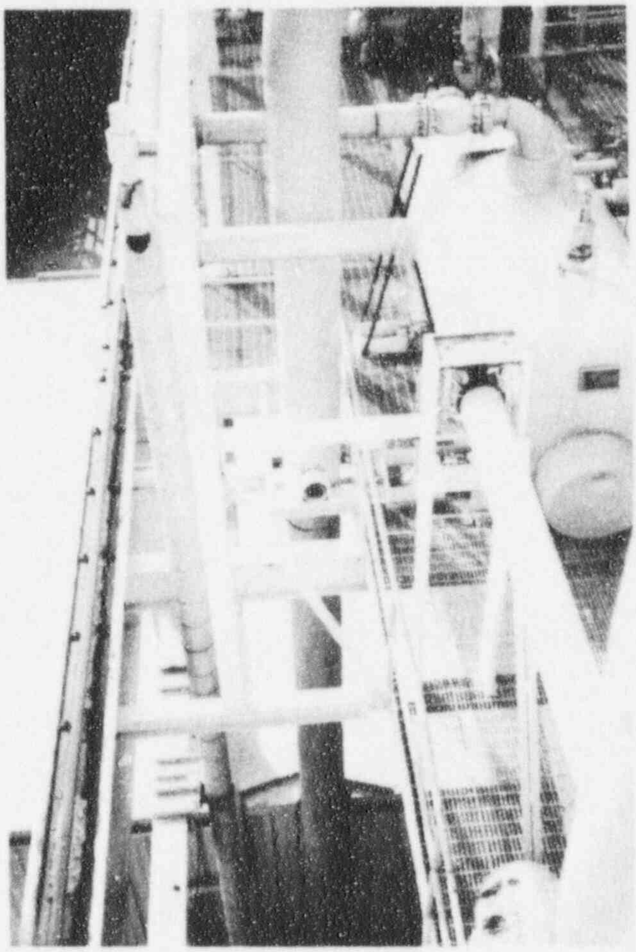


Figure E.62 Anchor or Large Bore Hot Line in Pasadena Broadway Unit 2

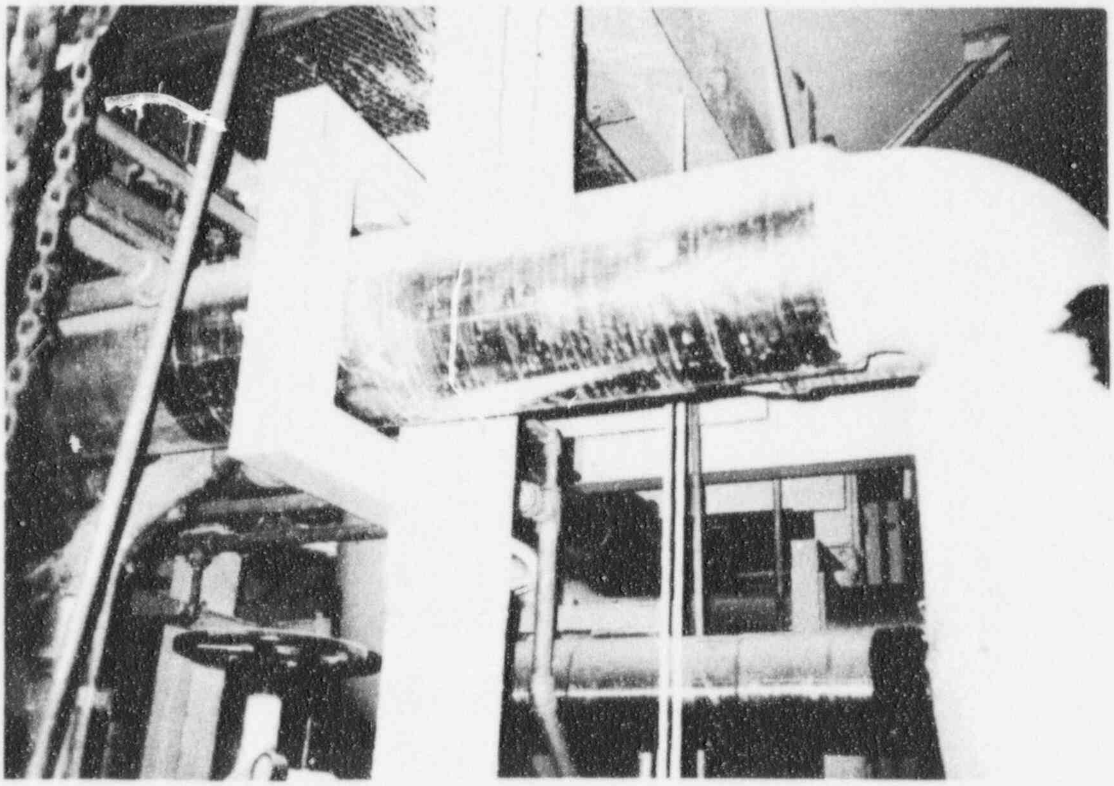


Figure E.63 Guided Restraint on Large Bore Hot Line in Humboldt Bay Unit 3

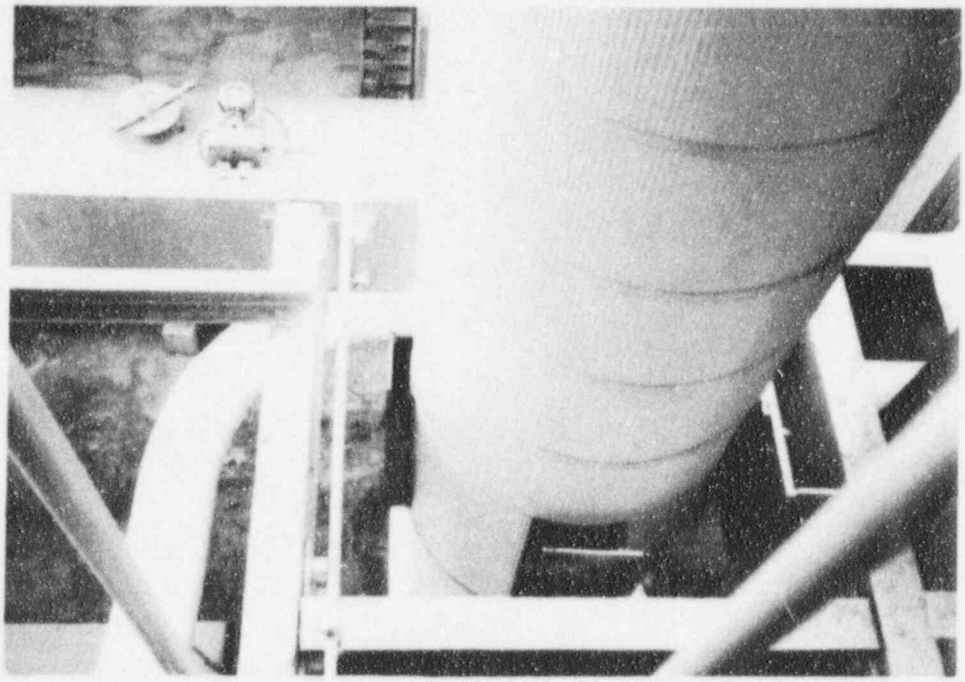


Figure E.64 Guided Restraint for Main Steam Line in El Centro Unit 3

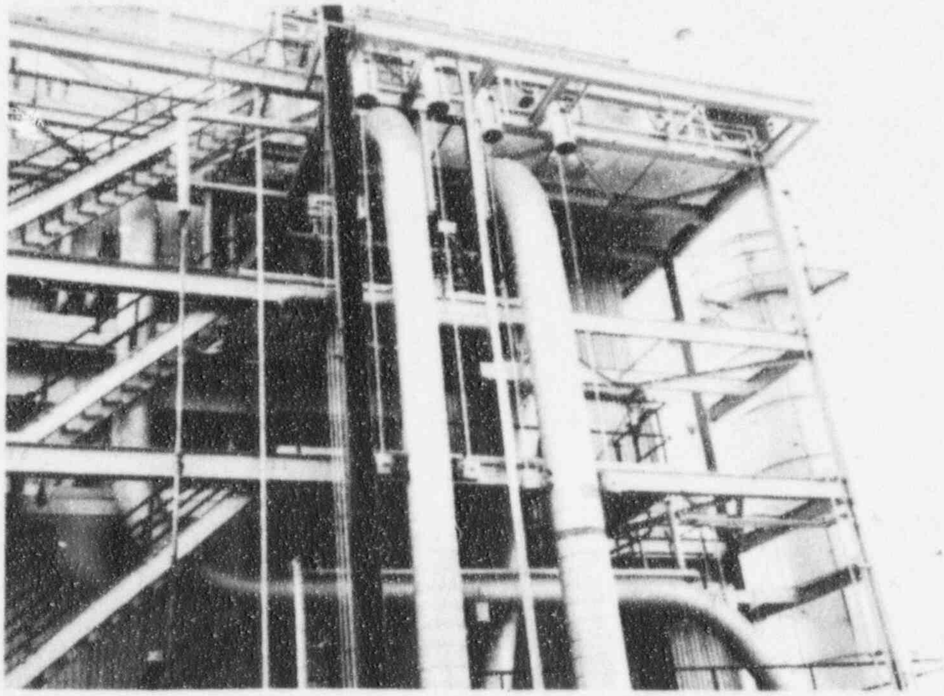


Figure E.65 Long Vertical Hangers and Springs for Main Steam Line on El Centro Unit 2

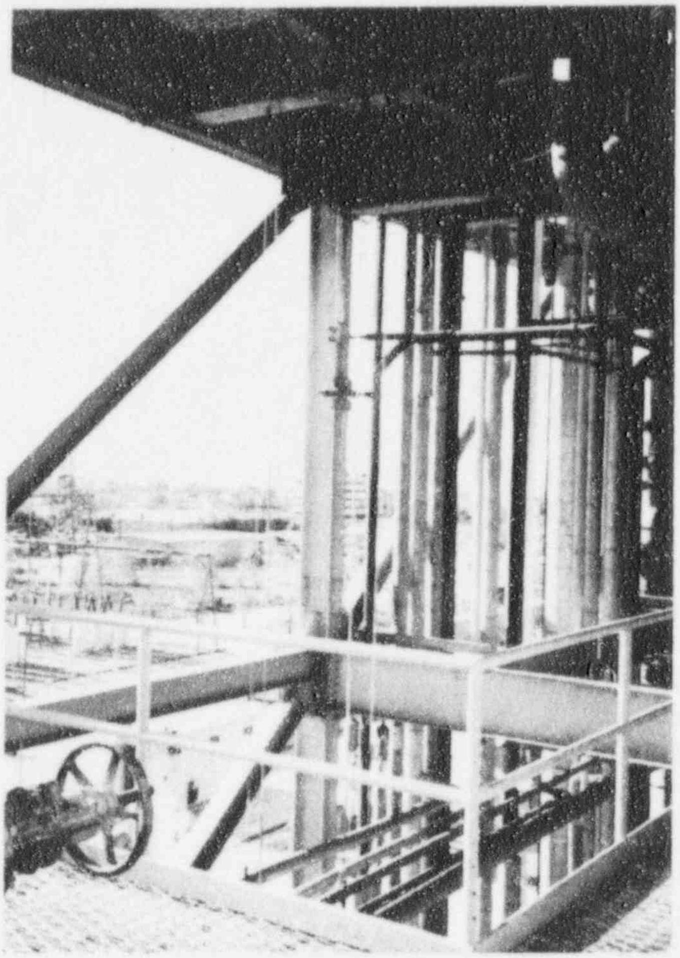


Figure E.66 Long Vertical Hangers for Large Bore Hot Lines in Valley Unit 3

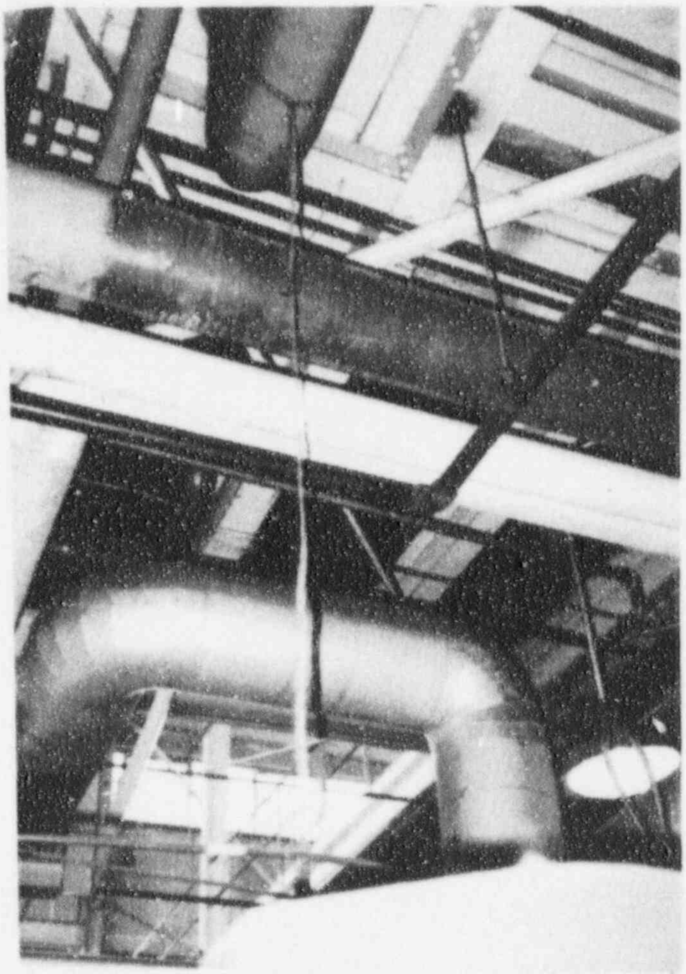


Figure E.67 Field Fabricated Hangers in Olive Unit 2

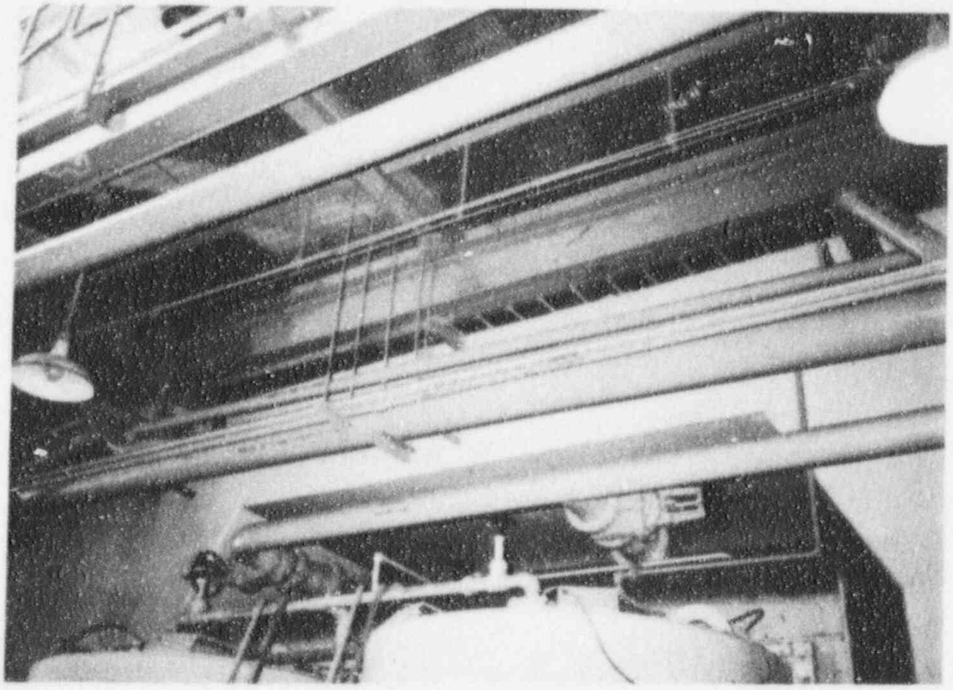


Figure E.68 Long Trapeze Supports for Large and Small Bore Cold Lines in El Centro Unit 4

Appendix F: Piping Support Data Base Developed from Valley Steam Plants Units 1 to 4, El Centro Plants Units 1-4 and Moss Landing Units 1-5

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
1a	1	12	1000	w	steam drum	0		0		100	
1a	1	12	1000	w	csh	20		0.67		100	
1a	1	12	1000	w	csh	6		0.2		100	
1a	1	12	1000	w	csh	14	40.0	0.47	1.33	100	
1a	1	12	1000	w	downcomer	0		0		100	
1b	2	12	1000	w	steam drum	0		0		100	
1b	2	12	1000	w	csh	20		0.67		100	
1b	2	12	1000	w	csh	6		0.2		100	
1b	2	12	1000	w	csh	14	40.0	0.47	1.33	100	
1b	2	12	1000	w	downcomer	0		0		100	
2a	1	3	hot	w	pump	0		0		100	
2a	1	3	hot	w	sh	2		0.13		100	
2a	1	3	hot	w	sh	10		0.67		100	
2a	1	3	hot	w	sh	8		0.53		100	
2a	1	3	hot	w	sh	12		0.8		100	
2a	1	3	hot	w	sh	10		0.67		100	
2a	1	3	hot	w	downcomer	12	54.0	0.8	3.60	100	
2b	2	3	hot	w	pump	0		0		100	
2b	2	3	hot	w	sh	2		0.13		100	
2b	2	3	hot	w	sh	10		0.67		100	
2b	2	3	hot	w	sh	8		0.53		100	
2b	2	3	hot	w	sh	12		0.8		100	
2b	2	3	hot	w	sh	10		0.67		100	
2b	2	3	hot	w	downcomer	12	54.0	0.8	3.60	100	
3a	1	3	hot	w	downcomer	0		0		100	
3a	1	3	hot	w	h	1		0.07		100	
3a	1	3	hot	w	h	15		1		100	
3a	1	3	hot	w	h	12		0.8		100	
3a	1	3	hot	w	h	12		0.8		100	
3a	1	3	hot	w	h	12		0.8		100	
3a	1	3	hot	w	hor el	8		0.53		100	
3a	1	3	hot	w	h	3		0.2		100	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
3a	1	3	hot	w	sway brace	1	64.0	0.07	4.27	100	
3a	1	3	hot	w	h	3		0.2		100	
3a	1	3	hot	w	tank	27	30.0	1.8	2.00	100	
3b	2	3	hot	w	down comme	0		0		100	
3b	2	3	hot	w	h	1		0.07		100	
3b	2	3	hot	w	h	15		1		100	
3b	2	3	hot	w	h	12		0.8		100	
3b	2	3	hot	w	h	12		0.8		100	
3b	2	3	hot	w	h	12		0.8		100	
3b	2	3	hot	w	hor el	8		0.53		100	
3b	2	3	hot	w	h	3		0.2		100	
3b	2	3	hot	w	sway brace	1	64.0	0.07	4.27	100	
3b	2	3	hot	w	h	3		0.2		100	
3b	2	3	hot	w	tank	27	30.0	1.8	2.00	100	
4a	1	4	cold	w	U bolt	0		0		100	
4a	1	4	cold	w	h	12		0.85		100	
4a	1	4	cold	w	h	10		0.71		100	
4a	1	4	cold	w	h	10		0.71		100	
4a	1	4	cold	w	U bolt	12	15.0	0.85	1.07	100	
4a	1	4	cold	w	U bolt	14	14.0	1	1.00	100	
4a	1	4	cold	w	h	9		0.67		100	
4a	1	4	cold	w	h	12		0.85		100	
4a	1	4	cold	w	U bolt	12	32.0	0.71	2.29	100	
4a	1	4	cold	w	h	10	10.0	0.71	0.71	100	
4b	2	4	cold	w	U bolt	0		0		100	
4b	2	4	cold	w	h	12		0.85		100	
4b	2	4	cold	w	h	10		0.71		100	
4b	2	4	cold	w	h	10		0.71		100	
4b	2	4	cold	w	U bolt	12	15.0	0.85	1.07	100	
4b	2	4	cold	w	U bolt	14	14.0	1	1.00	100	
4b	2	4	cold	w	h	9		0.67		100	
4b	2	4	cold	w	h	12		0.85		100	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
4b	2	4	cold	w	U bolt	12	32.0	0.85	2.29	100	
4b	2	4	cold	w	h	10	10.0	0.71	0.71	100	
5a	1	8	hot	w	tank	0		0		100	
5a	1	8	hot	w	hor el	2		0.08		100	
5a	1	8	hot	w	sh	8		0.33		100	
5a	1	8	hot	w	sh	18		0.75		100	
5a	1	8	hot	w	hor brace	1	29.0	0.04	1.21	100	
5a	1	8	hot	w	sh	1		0.04		100	
5a	1	8	hot	w	downcomer	16	17.0	0.66	0.71	100	
5b	1	8	hot	w	tank	0		0		100	
5b	1	8	hot	w	hor el	2		0.08		100	
5b	1	8	hot	w	sh	8		0.33		100	
5b	1	8	hot	w	sh	18		0.75		100	
5b	1	8	hot	w	hor brace	1	29.0	0.04	1.21	100	
5b	1	8	hot	w	sh	1		0.04		100	
5b	1	8	hot	w	downcomer	16	17.0	0.66	0.71	100	
6a	1	1	cold	t	downcomer	0		0		80	
6a	1	1	cold	t	h	5		0.71		80	
6a	1	1	cold	t	h	5		0.71		80	
6a	1	1	cold	t	hor el	14		2		80	
6a	1	1	cold	t	h	1		0.14		80	
6a	1	1	cold	t	hor el	6		0.86		80	
6a	1	1	cold	t	tank	2	33.0	0.28	4.71	80	
6b	1	1	cold	t	downcomer	0		0		80	
6b	1	1	cold	t	h	5		0.71		80	
6b	1	1	cold	t	h	5		0.71		80	
6b	1	1	cold	t	hor el	14		2		80	
6b	1	1	cold	t	h	1		0.14		80	
6b	1	1	cold	t	hor el	6		0.86		80	
6b	1	1	cold	t	tank	2	33.0	0.29	4.71	80	
6c	1	1	cold	t	downcomer	0		0		80	
6c	1	1	cold	t	h	10		1.43		80	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
6c	1	1	cold	t	h	12		1.71		80	
6c	1	1	cold	t	h	14		2		80	
6c	1	1	cold	t	hor el	10		1.43		80	
6c	1	1	cold	t	h	2		0.29		80	
6c	1	1	cold	t	downcomer	3	51.0	0.43	7.29	80	
6d	1	1	cold	t	downcomer	0		0		80	
6d	1	1	cold	t	h	10		1.43		80	
6d	1	1	cold	t	h	12		1.71		80	
6d	1	1	cold	t	h	14		2		80	
6d	1	1	cold	t	hor el	10		1.43		80	
6d	1	1	cold	t	h	2		0.29		80	
6d	1	1	cold	t	downcomer	3	51.0	0.43	7.29	80	
7a	1	3	hot	w	downcomer	0		0		80	
7a	1	3	hot	w	sh	6		0.4		80	
7a	1	3	hot	w	sh	18		1.2		80	
7a	1	3	hot	w	sh	15		1		80	
7a	1	3	hot	w	s brace ho	2	51.0	0.13	3.40	80	
7a	1	3	hot	w	sh	9		0.6		80	
7a	1	3	hot	w	hor el	16		1.07		80	
7a	1	3	hot	w	sh	1		0.07		80	
7a	1	3	hot	w	vert riser	4.5	30.5	0.3	2.03	80	
7a	1	3	hot	w	downcomer	4.5		0.3		80	
7a	1	3	hot	w	downcomer	1		0.07		80	
7a	1	3	hot	w	sh	2		0.13		80	
7a	1	3	hot	w	sh	10		0.67		80	
7a	1	3	hot	w	downcomer	2	19.5	0.13	1.30	80	
7b	2	3	hot	w	downcomer	0		0		80	
7b	2	3	hot	w	sh	6		0.4		80	
7b	2	3	hot	w	sh	18		1.2		80	
7b	2	3	hot	w	sh	15		1		80	
7b	2	3	hot	w	s brace ho	2	51.0	0.13	3.40	80	
7b	2	3	hot	w	sh	9		0.6		80	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
7b	2	3	hot	w	hor el	16		1.07		80	
7b	2	3	hot	w	sh	1		0.07		80	
7b	2	3	hot	w	vert riser	4.5	30.5	0.3	2.03	80	
7b	2	3	hot	w	downcomer	4.5		0.3		80	
7b	2	3	hot	w	downcomer	1		0.07		80	
7b	2	3	hot	w	sh	2		0.13		80	
7b	2	3	hot	w	sh	10		0.67		80	
7b	2	3	hot	w	downcomer	2	19.5	0.13	1.30	80	
8a	1	3	cold	w	downcomer	0		0		80	
8a	1	3	cold	w	hor el	2		0.17		80	
8a	1	3	cold	w	h	3		0.25		80	
8a	1	3	cold	w	h	10		0.83		80	
8a	1	3	cold	w	h	18		1.5		80	
8a	1	3	cold	w	downcomer	2	8.0	0.17	0.67	80	
8a	1	3	cold	w	h	5		0.42		80	
8a	1	3	cold	w	h	12		1		80	
8a	1	3	cold	w	h	13		1.08		80	
8a	1	3	cold	w	h	15		1.25		80	
8a	1	3	cold	w	hor el	3		0.25		80	
8a	1	3	cold	w	vert drum	2	85.0	0.17	7.08	80	
8b	2	3	cold	w	downcomer	0		0		80	
8b	2	3	cold	w	hor el	2		0.17		80	
8b	2	3	cold	w	h	3		0.25		80	
8b	2	3	cold	w	h	10		0.83		80	
8b	2	3	cold	w	h	18		1.5		80	
8b	2	3	cold	w	downcomer	2	8.0	0.17	0.67	80	
8b	2	3	cold	w	h	5		0.42		80	
8b	2	3	cold	w	h	12		1		80	
8b	2	3	cold	w	h	13		1.08		80	
8b	2	3	cold	w	h	15		1.25		80	
8b	2	3	cold	w	hor el	3		0.25		80	
8b	2	3	cold	w	vert drum	2	85.0	0.17	7.08	80	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
9a	1	1	cold	sw	downcomer	0		0		80	
9a	1	1	cold	sw	h	1		0.14		80	
9a	1	1	cold	sw	hor el	1		0.14		80	
9a	1	1	cold	sw	hor el	1.5		0.21		80	
9a	1	1	cold	sw	h	1		0.14		80	
9a	1	1	cold	sw	h	10		1.43		80	
9a	1	1	cold	sw	h	10		1.43		80	
9a	1	1	cold	sw	h	13		1.86		80	
9a	1	1	cold	sw	hor el	2		0.29		80	
9a	1	1	cold	sw	wall	8	47.5	1.14	6.79	80	
9b	1	1	cold	sw	downcomer	0		0		80	
9b	1	1	cold	sw	h	1		0.14		80	
9b	1	1	cold	sw	hor el	1		0.14		80	
9b	1	1	cold	sw	hor el	1.5		0.21		80	
9b	1	1	cold	sw	h	1		0.14		80	
9b	1	1	cold	sw	h	10		1.43		80	
9b	1	1	cold	sw	h	10		1.43		80	
9b	1	1	cold	sw	h	13		1.86		80	
9b	1	1	cold	sw	hor el	2		0.29		80	
9b	1	1	cold	sw	wall	8	47.5	1.14	6.79	80	
9c	2	1	cold	sw	downcomer	0		0		80	
9c	2	1	cold	sw	h	1		0.14		80	
9c	2	1	cold	sw	hor el	1		0.14		80	
9c	2	1	cold	sw	hor el	1.5		0.21		80	
9c	2	1	cold	sw	h	1		0.14		80	
9c	2	1	cold	sw	h	10		1.43		80	
9c	2	1	cold	sw	h	10		1.43		80	
9c	2	1	cold	sw	h	13		1.86		80	
9c	2	1	cold	sw	hor el	2		0.29		80	
9c	2	1	cold	sw	wall	8	47.5	1.14	6.79	80	
9d	2	1	cold	sw	downcomer	0		0		80	
9d	2	1	cold	sw	h	1		0.14		80	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
9d	2	1	cold	sw	hor el	1		0.14		80	
9d	2	1	cold	sw	hor el	1.5		0.21		80	
9d	2	1	cold	sw	h	1		0.14		80	
9d	2	1	cold	sw	h	10		1.43		80	
9d	2	1	cold	sw	h	10		1.43		80	
9d	2	1	cold	sw	h	13		1.86		80	
9d	2	1	cold	sw	hor el	2		0.29		80	
9d	2	1	cold	sw	wall	8	47.5	1.14	6.79	80	
10a	1	1	cold	t	pipe main	0		0		80	
10a	1	1	cold	t	h	5		0.71		80	
10a	1	1	cold	t	U bolt	5	10.0	0.71	1.43	80	
10a	1	1	cold	t	h	8		1.14		80	
10a	1	1	cold	t	reel	5	13.0	0.71	1.86	80	
10b	2	1	cold	t	pipe main	0		0		80	
10b	2	1	cold	t	h	5		0.71		80	
10b	2	1	cold	t	U bolt	5	10.0	0.71	1.43	80	
10b	2	1	cold	t	h	8		1.14		80	
10b	2	1	cold	t	hose reel	5	13.0	0.71	1.86	80	
10c	1	1	cold	sw	riser	0		0		80	
10c	1	1	cold	sw	h	15		2.14		80	
edit	1	1	edit	sw	hor el	2		0.29		80	
10c	1	1	cold	sw	h	2		0.29		80	
10c	1	1	cold	sw	vert el	0.5		0.07		80	
10c	1	1	cold	sw	vert	15		2.14		80	
10c	1	1	cold	sw	vert el	10		1.43		80	
10c	1	1	cold	sw	h	10		1.43		80	
10c	1	1	cold	sw	hor el	8		1.14		80	
10c	1	1	cold	sw	equip nozz	2	40.0	0.29	5.71	80	
10d	2	1	cold	sw	riser	0		0		80	
10d	2	1	cold	sw	h	15		2.14		80	
10d	2	1	cold	sw	hor el	2		0.29		80	
10d	2	1	cold	sw	h	2		0.29		80	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
10d	2	1	cold	sw	vert el	0.5		0.07		80	
10d	2	1	cold	sw	vert	15		2.14		80	
10d	2	1	cold	sw	vert el	10		1.43		80	
10d	2	1	cold	sw	h	10		1.43		80	
10d	2	1	cold	sw	hor el	8		1.14		80	
10d	2	1	cold	sw	equip nozz	2	40.0	0.29	5.71	80	
11a	1	8	hot	w	downcomer	0		0		60	
11a	1	8	hot	w	sh	2		0.08		60	
11a	1	8	hot	w	hor el	12		0.5		60	
11a	1	8	hot	w	sh	1		0.04		60	
11a	1	8	hot	w	sh	12		0.5		60	
11a	1	8	hot	w	downcomer	4	31.0	0.17	1.29	60	
11b	2	8	hot	w	downcomer	0		0		60	
11b	2	8	hot	w	sh	2		0.08		60	
11b	2	8	hot	w	hor el	12		0.5		60	
11b	2	8	hot	w	sh	1		0.04		60	
11b	2	8	hot	w	sh	12		0.5		60	
11b	2	8	hot	w	downcomer	4	31.0	0.17	1.29	60	
12a	1	1.5	cold	sw	wall	0		0		60	
12a	1	1.5	cold	sw	h	6		0.71		60	
12a	1	1.5	cold	sw	h	9		1.06		60	
12a	1	1.5	cold	sw	hor el	4		0.47		60	
12a	1	1.5	cold	sw	h	1		0.12		60	
12a	1	1.5	cold	sw	h	4		0.47		60	
12a	1	1.5	cold	sw	h	6		0.71		60	
12a	1	1.5	cold	sw	hor el	3		0.35		60	
12a	1	1.5	cold	sw	h	6		0.71		60	
12a	1	1.5	cold	sw	h	12		1.41		60	
12a	1	1.5	cold	sw	hor el	10		1.18		60	
12a	1	1.5	cold	sw	h	3		0.35		60	
12a	1	1.5	cold	sw	riser	1		0.12		60	
12a	1	1.5	cold	sw	h	10		1.18		60	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
12a	1	1.5	cold	sw	downcomer	1	76.0	0.12	8.94	60	
12b	2	1.5	cold	sw	wall	0		0		60	
12b	2	1.5	cold	sw	h	6		0.71		60	
12b	2	1.5	cold	sw	h	9		1.06		60	
12b	2	1.5	cold	sw	hor el	4		0.47		60	
12b	2	1.5	cold	sw	h	1		0.12		60	
12b	2	1.5	cold	sw	h	4		0.47		60	
12b	2	1.5	cold	sw	h	6		0.71		60	
12b	2	1.5	cold	sw	hor el	3		0.35		60	
12b	2	1.5	cold	sw	h	6		0.71		60	
12b	2	1.5	cold	sw	h	12		1.41		60	
12b	2	1.5	cold	sw	hor el	10		1.18		60	
12b	2	1.5	cold	sw	h	3		0.35		60	
12b	2	1.5	cold	sw	riser	1		0.12		60	
12b	2	1.5	cold	sw	h	10		1.18		60	
12b	2	1.5	cold	sw	downcomer	1	76.0	0.12	8.94	60	
13a	1	2	cold	sw	tank	0		0		35	
13a	1	2	cold	sw	downcomer	2		0.2		35	
13a	1	2	cold	sw	vert el	5		0.5		35	
13a	1	2	cold	sw	h	1		0.1		35	
13a	1	2	cold	sw	h	10		1		35	
13a	1	2	cold	sw	hor el	1		0.1		35	
13a	1	2	cold	sw	hor el	10		1		35	
13a	1	2	cold	sw	h	4		0.4		35	
13a	1	2	cold	sw	h	14		1.4		35	
13a	1	2	cold	sw	h	9		0.9		35	
13a	1	2	cold	sw	hor el	2		0.2		35	
13a	1	2	cold	sw	h	4		0.4		35	
13a	1	2	cold	sw	downcomer	1	63.0	0.1	6.30	35	
13b	1	2	cold	sw	tank	0		0		35	
13b	1	2	cold	sw	downcomer	2		0.2		35	
13b	1	2	cold	sw	vert el	5		0.5		35	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
13b	1	2	cold	sw	h	1		0.1		35	
13b	1	2	cold	sw	h	10		1		35	
13b	1	2	cold	sw	hor el	1		0.1		35	
13b	1	2	cold	sw	hor el	10		1		35	
13b	1	2	cold	sw	h	4		0.4		35	
13b	1	2	cold	sw	h	14		1.4		35	
13b	1	2	cold	sw	h	9		0.9		35	
13b	1	2	cold	sw	hor el	2		0.2		35	
13b	1	2	cold	sw	h	4		0.4		35	
13b	1	2	cold	sw	downcomer	1	63.0	0.1	6.30	35	
13c	1	2	cold	sw	tank	0		0		35	
13c	1	2	cold	sw	downcomer	2		0.2		35	
13c	1	2	cold	sw	vert el	5		0.5		35	
13c	1	2	cold	sw	h	1		0.1		35	
13c	1	2	cold	sw	h	10		1		35	
13c	1	2	cold	sw	hor el	1		0.1		35	
13c	1	2	cold	sw	hor el	10		1		35	
13c	1	2	cold	sw	h	4		0.4		35	
13c	1	2	cold	sw	h	14		1.4		35	
13c	1	2	cold	sw	h	9		0.9		35	
13c	1	2	cold	sw	hor el	2		0.2		35	
13c	1	2	cold	sw	h	4		0.4		35	
13c	1	2	cold	sw	downcomer	1	63.0	0.1	6.30	35	
13d	2	2	cold	sw	tank	0		0		35	
13d	2	2	cold	sw	downcomer	2		0.2		35	
13d	2	2	cold	sw	vert el	5		0.5		35	
13d	2	2	cold	sw	h	1		0.1		35	
13d	2	2	cold	sw	h	10		1		35	
13d	2	2	cold	sw	hor el	1		0.1		35	
13d	2	2	cold	sw	hor el	10		1		35	
13d	2	2	cold	sw	h	4		0.4		35	
13d	2	2	cold	sw	h	14		1.4		35	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
13d	2	2	cold	sw	h	9		0.9		35	
13d	2	2	cold	sw	hor el	2		0.2		35	
13d	2	2	cold	sw	h	4		0.4		35	
13d	2	2	cold	sw	downcomer	1	63.0	0.1	6.30	35	
13e	2	2	cold	sw	tank	4		0.4		35	
13e	2	2	cold	sw	downcomer	2		0.2		35	
13e	2	2	cold	sw	vert el	5		0.5		35	
13e	2	2	cold	sw	h	1		0.1		35	
13e	2	2	cold	sw	h	10		1		35	
13e	2	2	cold	sw	hor el	1		0.1		35	
13e	2	2	cold	sw	hor el	10		1		35	
13e	2	2	cold	sw	h	4		0.4		35	
13e	2	2	cold	sw	h	14		1.4		35	
13e	2	2	cold	sw	h	9		0.9		35	
13e	2	2	cold	sw	hor el	2		0.2		35	
13e	2	2	cold	sw	h	4		0.4		35	
13e	2	2	cold	sw	downcomer	1	63.0	0.1	6.30	35	
13f	2	2	cold	sw	tank	0		0		35	
13f	2	2	cold	sw	downcomer	2		0.2		35	
13f	2	2	cold	sw	vert el	5		0.5		35	
13f	2	2	cold	sw	h	1		0.1		35	
13f	2	2	cold	sw	h	10		1		35	
13f	2	2	cold	sw	hor el	1		0.1		35	
13f	2	2	cold	sw	hor el	10		1		35	
13f	2	2	cold	sw	h	4		0.4		35	
13f	2	2	cold	sw	h	14		1.4		35	
13f	2	2	cold	sw	h	9		0.9		35	
13f	2	2	cold	sw	hor el	2		0.2		35	
13f	2	2	cold	sw	h	4		0.4		35	
13f	2	2	cold	sw	downcomer	1	63.0	0.1	6.30	35	
14a	1	0.75	cold	t	downcomer	0		0		35	
14a	1	0.75	cold	t	valve	6		1.2		35	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
14a	1	0.75	cold	t	hor el	9		1.8		35	
14a	1	0.75	cold	t	tee	8	43.0	1.6	8.60	35	
14a	1	0.75	cold	t	h	12		2.4		35	
14a	1	0.75	cold	t	downcomer	4	16.0	0.8	3.20	35	
14a	1	0.75	cold	t	h	0.5		0.1		35	
14a	1	0.75	cold	t	h	6		1.2		35	
14a	1	0.75	cold	t	U bolt	6	12.5	1.2	2.50	35	
14a	1	0.75	cold	t	h	6		1.2		35	
14a	1	0.75	cold	t	h	6		1.2		35	
14a	1	0.75	cold	t	U bolt	6	18.0	1.2	3.60	35	
14a	1	0.75	cold	t	h	2		0.4		35	
14a	1	0.75	cold	t	hor el	1		0.2		35	
14a	1	0.75	cold	t	h	5		1		35	
14a	1	0.75	cold	t	downcomer	1	9.0	0.2	1.80	35	
14b	2	0.75	cold	t	downcomer	0		0		35	
14b	2	0.75	cold	t	valve	6		1.2		35	
14b	2	0.75	cold	t	hor el	9		1.8		35	
14b	2	0.75	cold	t	tee	8	43.0	1.6	8.60	35	
14b	2	0.75	cold	t	h	12		2.4		35	
14b	2	0.75	cold	t	downcomer	4	16.0	0.8	3.20	35	
14b	2	0.75	cold	t	h	0.5		0.1		35	
14b	2	0.75	cold	t	h	6		1.2		35	
14b	2	0.75	cold	t	U bolt	6	12.5	1.2	2.50	35	
14b	2	0.75	cold	t	h	6		1.2		35	
14b	2	0.75	cold	t	h	6		1.2		35	
14b	2	0.75	cold	t	U bolt	6	18.0	1.2	3.60	35	
14b	2	0.75	cold	t	h	2		0.4		35	
14b	2	0.75	cold	t	hor el	1		0.2		35	
14b	2	0.75	cold	t	h	5		1		35	
14b	2	0.75	cold	t	downcomer	1	9.0	0.2	1.80	35	
15a	1	8	hot	w	vert el	1		0.04		20	
15a	1	8	hot	w	riser to v	20		0.83		20	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
15a	1	8	hot	w	sh	1		0.04		20	
15a	1	8	hot	w	hor el	1		0.04		20	
15a	1	8	hot	w	sh	1		0.04		20	
15a	1	8	hot	w	sh	12		0.5		20	
15a	1	8	hot	w	sh	12		0.5		20	
15a	1	8	hot	w	sway brace	1	28.0	0.04	1.17	20	
15a	1	8	hot	w	hor el	4		0.17		20	
15a	1	8	hot	w	sh	3		0.13		20	
15a	1	8	hot	w	tee	18	25.0	0.75	1.04	20	
15a	1	6	hot	w	h	12	12.0	0.57	0.57	20	
15a	1	6	hot	w	sh	6		0.29		20	
15a	1	6	hot	w	sh	21		1		20	
15a	1	6	hot	w	45 sway b	1		0.05		20	
15a	1	6	hot	w	tee	1	29.0	0.05	1.38	20	
15a	1	3	hot	w	h	8	8.0	0.53	0.53	20	
15a	1	3	hot	w	45 sway b	2	2.0	0.13	0.13	20	
15a	1	3	hot	w	sh	21		1.4		20	
15a	1	3	hot	w	hor el	3		0.2		20	
15a	1	3	hot	w	sh	10		0.67		20	
15a	1	3	hot	w	sway brace	6	40.0	0.4	2.67	20	
15a	1	3	hot	w	sh	8		0.53		20	
15a	1	3	hot	w	sh	6		0.4		20	
15a	1	3	hot	w	sh	18		1.2		20	
15a	1	3	hot	w	sh	18		1.2		20	
15a	1	3	hot	w	sh	18		1.2		20	
15a	1	3	hot	w	sh	18		1.2		20	
15a	1	3	hot	w	tank	2	88.0	0.13	5.87	20	
15b	2	8	hot	w	vert el	1		0.04		20	
15b	2	8	hot	w	riser to v	20		0.83		20	
15b	2	8	hot	w	sh	1		0.04		20	
15b	2	8	hot	w	hor el	1		0.04		20	
15b	2	8	hot	w	sh	1		0.04		20	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horiz Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
15b	2	8	hot	w	sh	12		0.5		20	
15b	2	8	hot	w	sh	12		0.5		20	
15b	2	8	hot	w	sway brace	1	28.0	0.04	1.67	20	
15b	2	8	hot	w	hor el	4		0.17		20	
15b	2	8	hot	w	sh	3		0.13		20	
15b	2	8	hot	w	tee	18	25.0	0.75	1.04	20	
15b	2	6	hot	w	h	12	12.0	0.57	0.57	20	
15b	2	6	hot	w	sh	6		0.29		20	
15b	2	6	hot	w	sh	21		1		20	
15b	2	6	hot	w	45 sway b	1		0.05		20	
15b	2	6	hot	w	tee	1	29.0	0.05	1.38	20	
15b	2	3	hot	w	h	8	8.0	0.53	0.53	20	
15b	2	3	hot	w	45 sway b	2	2.0	0.13	0.13	20	
15b	2	3	hot	w	sh	21		1.4		20	
15b	2	3	hot	w	hor el	3		0.2		20	
15b	2	3	hot	w	sh	10		0.67		20	
15b	2	3	hot	w	sway brace	6	40.0	0.4	2.67	20	
15b	2	3	hot	w	sh	8		0.53		20	
15b	2	3	hot	w	sh	6		0.4		20	
15b	2	3	hot	w	sh	18		1.2		20	
15b	2	3	hot	w	sh	18		1.2		20	
15b	2	3	hot	w	sh	18		1.2		20	
15b	2	3	hot	w	sh	18		1.2		20	
15b	2	3	hot	w	tank	2	88.0	0.13	5.87	20	
16a	1	2	cold	t	equip nozz	0		0		0	
16a	1	2	cold	t	hor el	3		0.3		0	
16a	1	2	cold	t	h	2		0.2		0	
16a	1	2	cold	t	h	9		0.9		0	
16a	1	2	cold	t	h	9	23.0	0.9	2.30	0	
16a	1	2	cold	t	h	6		0.6		0	
16a	1	2	cold	t	h	6		0.6		0	
16a	1	2	cold	t	hor el	5		0.5		0	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horiz Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
16a	1	2	cold	t	h	1		0.1		0	
16a	1	2	cold	t	h	6		0.6		0	
16a	1	2	cold	t	hor el	1		0.1		0	
16a	1	2	cold	t	sway brace	8	33.0	0.8	3.30	0	
16b	2	2	cold	t	equip nozz	0		0		0	
16b	2	2	cold	t	hor el	3		0.3		0	
16b	2	2	cold	t	h	2		0.2		0	
16b	2	2	cold	t	h	9		0.9		0	
16b	2	2	cold	t	h	9	23.0	0.9	2.30	0	
16b	2	2	cold	t	h	6		0.6		0	
16b	2	2	cold	t	h	6		0.6		0	
16b	2	2	cold	t	hor el	5		0.5		0	
16b	2	2	cold	t	h	1		0.1		0	
16b	2	2	cold	t	h	6		0.6		0	
16b	2	2	cold	t	hor el	1		0.1		0	
16b	2	2	cold	t	sway brace	8	33.0	0.8	3.30	0	
17a	1	1.5	cold	t	vert riser	0		0		0	
17a	1	1.5	cold	t	hor tee	10		1.18		0	
17a	1	1.5	cold	t	h	2		0.24		0	
17a	1	1.5	cold	t	h	10		1.18		0	
17a	1	1.5	cold	t	h	12		1.41		0	
17a	1	1.5	cold	t	h	10		1.18		0	
17a	1	1.5	cold	t	vert el	0.5		0.06		0	
17a	1	1.5	cold	t	vert drop,	3		0.35		0	
17a	1	1.5	cold	t	vert el	0		0		0	
17a	1	1.5	cold	t	h	4		0.47		0	
17a	1	1.5	cold	t	h	8		0.94		0	
17a	1	1.5	cold	t	h	8		0.94		0	
17a	1	1.5	cold	t	hor tie ro	6	[illegible]	0.71	8.65	0	
17a	1	1.5	cold	t		3		0.35		0	
17a	1	1.5	cold	t	h	6		0.71		0	
17a	1	1.5	cold	t	h	12		1.41		0	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
17a	1	1.5	cold	t	h	6		0.71		0	
17a	1	1.5	cold	t	vert riser	3	30.0	0.35	3.53	0	
17b	2	1.5	cold	t	vert riser	0		0		0	
17b	2	1.5	cold	t	tee	10		1.18		0	
17b	2	1.5	cold	t	h	2		0.24		0	
17b	2	1.5	cold	t	h	10		1.18		0	
17b	2	1.5	cold	t	h	12		1.41		0	
17b	2	1.5	cold	t	h	10		1.18		0	
17b	2	1.5	cold	t	vert el	0.5		0.06		0	
17b	2	1.5	cold	t	vert drop,	3		0.35		0	
17b	2	1.5	cold	t	vert el	0		0		0	
17b	2	1.5	cold	t	h	4		0.47		0	
17b	2	1.5	cold	t	h	8		0.94		0	
17b	2	1.5	cold	t	h	8		0.94		0	
17b	2	1.5	cold	t	hor tie ro	6	73.5	0.71	8.65	0	
17b	2	1.5	cold	t		3		0.35		0	
17b	2	1.5	cold	t	h	6		0.71		0	
17b	2	1.5	cold	t	h	12		1.41		0	
17b	2	1.5	cold	t	h	6		0.71		0	
17b	2	1.5	cold	t	vert riser	3	30.0	0.35	3.53	0	
18a	3	4	hot	w	downcomer	5		0.29		90	Valley Steam Pl
18a	3	4	hot	w	tee	3	8.0	0.18	0.47	90	
18a	3	4	hot	w	branch	0		0		90	
18a	3	4	hot	w	h	15		0.88		90	
18a	3	4	hot	w	tee	15	33.0	0.88	1.94	90	
18a	3	4	hot	w	h/brch w l	8		0.47		90	
18a	3	4	hot	w	h	3		0.18		90	
18a	3	4	hot	w	h	12		0.71		90	
18a	3	4	hot	w	h	12		0.71		90	
18a	3	4	hot	w	sh	18		1.06		90	
18a	3	4	hot	w	hor el	6		0.35		90	
18a	3	4	hot	w	hor el	5		0.29		90	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
18a	3	4	hot	w	sh	1		0.06		90	
18a	3	4	hot	w	hor el	15		0.88		90	
18a	3	4	hot	w	sh	1		0.06		90	
18a	3	4	hot	w	downcomer	1	82.0	0.06	4.82	90	
18b	4	4	hot	w	downcomer	5		0.29		90	
18b	4	4	hot	w	tee	3	8.0	0.18	0.47	90	
18b	4	4	hot	w	branch	0		0		90	
18b	4	4	hot	w	h	15		0.88		90	
18b	4	4	hot	w	tee	15	33.0	0.88	1.94	90	
18b	4	4	hot	w	h/brch w l	8		0.47		90	
18b	4	4	hot	w	h	3		0.18		90	
18b	4	4	hot	w	h	12		0.71		90	
18b	4	4	hot	w	h	12		0.71		90	
18b	4	4	hot	w	sh	18		1.06		90	
18b	4	4	hot	w	hor el	6		0.35		90	
18b	4	4	hot	w	hor el	5		0.29		90	
18b	4	4	hot	w	sh	1		0.06		90	
18b	4	4	hot	w	hor el	15		0.88		90	
18b	4	4	hot	w	sh	1		0.06		90	
18b	4	4	hot	w	downcomer	1	82.0	0.06	4.82	90	
19a	3	3	cold	w	h	0		0		90	
19a	3	3	cold	w	hor el	12		1		90	
19a	3	3	cold	w	h	3		0.25		90	
19a	3	3	cold	w	h	12		1		90	
19a	3	3	cold	w	h	12		1		90	
19a	3	3	cold	w	vert rise	12	51.0	1	4.25	90	
19a	3	3	cold	w	h	1		0.08		90	
19a	3	3	cold	w	h	12		1		90	
19a	3	3	cold	w	h	12		1		90	
19a	3	3	cold	w	h	12		1		90	
19a	3	3	cold	w	h	12		1		90	
19a	3	3	cold	w	h	12		1		90	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
19a	3	3	cold	w	h	12		1		90	
19a	3	3	cold	w	h	12		1		90	
19a	3	3	cold	w	h	15	100.0	1.25	8.33	90	
19b	4	3	cold	w	h	0		0		90	
19b	4	3	cold	w	hor el	12		1		90	
19b	4	3	cold	w	h	3		0.25		90	
19b	4	3	cold	w	h	12		1		90	
19b	4	3	cold	w	h	12		1		90	
19b	4	3	cold	w	vert rise	12	51.0	1	4.25	90	
19b	4	3	cold	w	h	1		0.25		90	
19b	4	3	cold	w	h	12		1		90	
19b	4	3	cold	w	h	12		1		90	
19b	4	3	cold	w	h	12		1		90	
19b	4	3	cold	w	h	12		1		90	
19b	4	3	cold	w	h	12		1		90	
19b	4	3	cold	w	h	12		1		90	
19b	4	3	cold	w	h	12		1		90	
19b	4	3	cold	w	h	12	100.0	1	8.33	90	
20a1	3	0.75	cold	sw	wall	0		0		90	
20a1	3	0.75	cold	sw	U-bolt tra	3	3.0	0.6	0.60	90	
20a1	3	0.75	cold	sw	vert el	1		0.2		90	
20a1	3	0.75	cold	sw	vert drop	3		0.6		90	
20a1	3	0.75	cold	sw	vert elbow	3	10.0	0.6	2.00	90	
20a2	3	0.75	cold	sw	wall	0		0		90	
20a2	3	0.75	cold	sw	U-bolt tra	3	3.0	0.6	0.60	90	
20a2	3	0.75	cold	sw	vert el	1		0.2		90	
20a2	3	0.75	cold	sw	vert drop	3		0.6		90	
20a2	3	0.75	cold	sw	vert elbow	3	10.0	0.6	2.00	90	
20b1	4	0.75	cold	sw	wall	0		0		90	
20b1	4	0.75	cold	sw	U-bolt tra	3	3.0	0.6	0.60	90	
20b1	4	0.75	cold	sw	vert el	1		0.2		90	
20b1	4	0.75	cold	sw	vert drop	3		0.6		90	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
20b1	4	0.75	cold	sw	vert elbow	3	10.0	0.6	2.00	90	
20b2	4	0.75	cold	sw	wall	0		0		90	
20b2	4	0.75	cold	sw	U-bolt tra	3	3.0	0.6	0.60	90	
20b2	4	0.75	cold	sw	vert el	1		0.2		90	
20b2	4	0.75	cold	sw	vert drop	3		0.6		90	
20b2	4	0.75	cold	sw	vert elbow	3	10.0	0.6	2.00	90	
21a	3	1	cold	t	vert el	1		0.14		90	
21a	3	1	cold	t	vert elbow	2		0.29		90	
21a	3	1	cold	t	h	2		0.29		90	
21a	3	1	cold	t	h	6		0.86		90	
21a	3	1	cold	t	h	6		0.86		90	
21a	3	1	cold	t	hor el	9		1.29		90	
21a	3	1	cold	t	lateral re	6	32.0	0.86	4.57	90	
21a	3	1	cold	t	h	9		1.29		90	
21a	3	1	cold	t	h	9		1.29		90	
21a	3	1	cold	t	lateral re	1	19.0	0.14	2.71	90	
21b	4	1	cold	t	vert el	1		0.14		90	
21b	4	1	cold	t	vert elbow	2		0.29		90	
21b	4	1	cold	t	h	2		0.29		90	
21b	4	1	cold	t	h	6		0.86		90	
21b	4	1	cold	t	h	6		0.86		90	
21b	4	1	cold	t	hor el	9		1.29		90	
21b	4	1	cold	t	lateral re	6	32.0	0.86	4.57	90	
21b	4	1	cold	t	h	9		1.29		90	
21b	4	1	cold	t	h	9		1.29		90	
21b	4	1	cold	t	lateral re	1	19.0	0.14	2.71	90	
22a	3	0.75	cold	sw	downcomer	0		0		90	
22a	3	0.75	cold	sw	h	2		0.4		90	
22a	3	0.75	cold	sw	hor el	0.5		0.1		90	
22a	3	0.75	cold	sw	h	4		0.8		90	
22a	3	0.75	cold	sw	hor el	1		0.2		90	
22a	3	0.75	cold	sw	downcomer	3	10.5	0.6	2.10	90	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
22b	4	0.75	cold	sw	downcomer	0		0		90	
22b	4	0.75	cold	sw	h	2		0.4		90	
22b	4	0.75	cold	sw	hor el	0.5		0.1		90	
22b	4	0.75	cold	sw	h	4		0.8		90	
22b	4	0.75	cold	sw	hor el	1		0.2		90	
22b	4	0.75	cold	sw	downcomer	3	10.5	0.6	2.1	90	
23	4	0.75	cold	sw	downcomer	0		0		75	Begin El Centro
23	4	0.75	col	sw	h	2		0.4		75	
23	4	0.75	cold	sw	h	1		0.2		75	
23	4	0.75	cold	sw	h	4		0.8		75	
23	4	0.75	cold	sw	hor el	1		0.2		75	
23	4	0.75	cold	sw	hor U-bolt	8		1.6		75	
23	4	0.75	cold	sw	downcomer	0.5	20.0	0.1	4.00	75	
24a	4	0.75	cold	sw	riser U-bo	1		0.2		75	
24a	4	0.75	cold	sw	tee	4		0.8		75	
24a	4	0.75	cold	sw	U-bolt tie	6		1.2		75	
24a	4	0.75	cold	sw	riser	2	13.0	0.4	2.60	75	
24b	4	0.75	cold	sw	riser U-bo	1		0.2		75	
24b	4	0.75	cold	sw	tee	4		0.8		75	
24b	4	0.75	cold	sw	U-bolt tie	6		1.2		75	
24b	4	0.75	cold	sw	riser	2	13.0	0.4	2.60	75	
25	4	3	hot	w	downcomer	0		0		70	
25	4	3	hot	w	h	1		0.07		70	
25	4	3	hot	w	h	12		0.8		70	
25	4	3	hot	w	h	14		0.93		70	
25	4	3	hot	w	h	14		0.93		70	
25	4	3	hot	w	hor el	6		0.4		70	
25	4	3	hot	w	h	2		0.13		70	
25	4	3	hot	w	h	6		0.4		70	
25	4	3	hot	w	hor el	10		0.67		70	
25	4	3	hot	w		3	68.0	0.2	4.53	70	
26	4	0.75	cold	sw	downcomer	0		0		70	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
26	4	0.75	cold	sw	h	2		0.4		70	
26	4	0.75	cold	sw	h	12		2.4		70	
26	4	0.75	cold	sw	h	14		2.8		70	
26	4	0.75	cold	sw	h	12		2.4		70	
26	4	0.75	cold	sw	hor el	1		0.2		70	
26	4	0.75	cold	sw	hor el	10		2		70	
26	4	0.75	cold	sw	hor el	2	53.0	0.4	10.60	70	
27	4	1	hot	sw	downcomer	0		0		70	
27	4	1	hot	sw	U-bolt	2		0.22		70	
27	4	1	hot	sw	downcomer	8	10.0	0.89	1.11	70	
27	4	1	hot	sw	U-bolt	4		0.44		70	
27	4	1	hot	sw	downcomer	4		0.44		70	
27	4	1	hot	sw	wall	2	10.0	0.22	1.11	70	
28	3	3	hot	w	downcomer	0		0		60	
28	3	3	hot	w	downcomer	5		0.4		60	
28	3	3	hot	w	U-bolt	3		0.2		60	
28	3	3	hot	w	10 ft rise	20		1.33		60	
28	3	3	hot	w	riser lat	10		0.67		60	
28	3	3	hot	w	h	1		0.07		60	
28	3	2	hot	w	riser	1	41.0	0.08	3.15	60	
28a	3	2	hot	w	h	12		0.92		60	
28a	3	2	hot	w	wall	10	22.0	0.77	1.69	60	
28b	3	3	hot	w	h	1		0.07		60	
28b	3	3	hot	w	hor el	10		0.67		60	
28b	3	3	hot	w	sh	20		1.33		60	
28b	3	3	hot	w	sh	10		0.67		60	
28b	3	3	hot	w	riser	10	51.0	0.67	3.40	60	
29	3	4	hot	w	downcomer	6		0.35		30	
29	3	4	hot	w	h	7		0.41		30	
29	3	4	hot	w	h	10		0.59		30	
29	3	4	hot	w	h	12		0.71		30	
29	3	4	hot	w	hor el	3		0.18		30	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
29	3	4	hot	w	h	10		0.59		30	
29	3	4	hot	w	downcomer	4	52.0	0.24	3.06	30	
30	3	1	hot	t	downcomer	0		0		30	
30	3	1	hot	t	h	3		0.33		30	
30	3	1	hot	t	h	10		1.11		30	
30	3	1	cold	t	h	10		1.43		30	
30	3	1	cold	t	hor el	10		1.43		30	
30	3	1	cold	t	h	3		0.43		30	
30	3	1	cold	t	h	15		2.14		30	
30	3	0.75	cold	t	hor el	6		1.2		30	
30	3	0.75	cold	t	U-bolt	16	73.0	3.2	14.60	30	
30a	3	0.75	cold	t	hor el	12		2.4		30	
30a	3	0.75	cold	t	U-bolt to	5		1		30	
30a	3	0.75	cold	t	vert el to	10	27.0	2	5.40	30	
30b	3	0.75	cold	t	vert el	12		2.4		30	
30b	3	0.75	cold	t	U-bolt to	5		1		30	
30b	3	0.75	cold	t	vert elbow	10	27.0	2	5.40	30	
31	4	6	cold	w	downcomer	0		0		0	
31	4	6	cold	w	h	2		0.12		0	
31	4	6	cold	w	h	14		0.82		0	
31	4	6	cold	w	hor el	3		0.18		0	
31	4	6	cold	w	h	6		0.35		0	
31	4	6	cold	w	hor el	30		1.76		0	
31	4	6	cold	w	riser	2	57.0	0.12	3.35	0	
32	4	8	cold	w	downcomer	0		0		0	
32	4	8	cold	w	hor el	6		0.32		0	
32	4	8	cold	w	U-bolt tra	15		0.79		0	
32	4	8	cold	w	U-bolt tra	15		0.79		0	
32	4	8	cold	flang e		12	48.0	0.63	2.53	0	
32	4	6	cold	w	riser	3		0.18		0	
32	4	6	cold	w	tank	6	9.0	0.35	0.53	0	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
32	4	2	cold	sw	vert el	16		1.6		0	
32	4	2	cold	sw	riser	3	19.0	0.3	1.90	0	
33	3	8	cold	w	downcomer	0		0		0	
33	3	8	cold	w	sh	15		0.79		0	
33	3	8	cold	w	guide	22	37.0	1.16	1.95	0	
33	3	8	cold	w	sh	21		1.11		0	
33	3	8	cold	w	sh	12		0.63		0	
33	3	8	cold	w	guide	24	57.0	1.26	3.00	0	
34	3	3	cold	w	downcomer	0		0		0	
34	3	3	cold	w	wall	15		1.25		0	
34	3	3	cold	w	U-bolt tra	22		1.83		0	
34	3	3	cold	w	downcomer	8		0.67		0	
34	3	3	cold	w		15	60.0	1.25	5.00	0	
35	3	6	hot	w	downcomer	0		0		0	
35	3	6	hot	w	vert el	3		0.14		0	
35	3	6	hot	w	riser	3		0.14		0	
35	3	6	hot	w	sh	15		0.71		0	
35	3	6	hot	w	sh	20		0.95		0	
35	3	6	hot	w	lateral re	6	47.0	0.29	2.24	0	
35	3	6	hot	w	h	15		0.71		0	
35	3	6	hot	w	hor el	6		0.29		0	
35	3	6	hot	w	h	12	33.0	0.57	1.57	0	
36	1	1.5	hot	sw	wall	0		0		0	
36	1	1.5	hot	sw	h	1		0.09		0	
36	1	1.5	hot	sw	hor el	18		1.64		0	
36	1	1.5	hot	sw	h	2		0.18		0	
36	1	1.5	hot	sw	h	13		1.18		0	
36	1	1.5	hot	sw	h	12		1.09		0	
36	1	1.5	hot	sw	hor el	2	48.0	0.18	4.36	0	
36	1	1.5	hot	sw	riser	0		0		0	
37		1	hot	w	downcomer	0		0		0	
37		1	hot	w	hor el	10		1.11		0	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horiz Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
37		1	hot	w	U-bolt	0.3	10.0	0.03	1.11	0	
37		1	hot	w	hor el	3		0.33		0	
37		1	hot	w	guide	8	11.0	0.89	1.22	0	
37		1	hot	w	guide	8	8.0	0.89	0.89	0	
37		1	hot	w	guide	8	8.0	0.89	0.89	0	
38a	1	1.25	cold	t	hor el	20		2.5		0	
38a	1	1.25	cold	t	h	2		0.25		0	
38a	1	1.25	cold	t	h	15		1.88		0	
38a	1	1.25	cold	t	h	12		1.5		0	
38a	1	1.25	cold	t	h	15		1.88		0	
38a	1	1.25	cold	t	hor el	1		0.13		0	
38a	1	1.25	cold	t	h	1		0.13		0	
38a	1	1.25	cold	t	h	14		1.75		0	
38a	1	1.25	cold	t	h	14		1.75		0	
38a	1	1.25	cold	t	h	18		2.25		0	
38a	1	1.25	cold	t	h	15		1.88		0	
38a	1	1.25	cold	t	h	12		1.5		0	
38a	1	1.25	cold	t	hor el	3		0.38		0	
38a	1	1.25	cold	t	downcomer	4	146.0	0.5	18.25	0	
38b	1	1.25	cold	t	hor el	20		2.5		0	
38b	1	1.25	cold	t	h	2		0.25		0	
38b	1	1.25	cold	t	h	15		1.88		0	
38b	1	1.25	cold	t	h	12		1.5		0	
38b	1	1.25	cold	t	h	15		1.88		0	
38b	1	1.25	cold	t	hor el	1		0.13		0	
38b	1	1.25	cold	t	h	1		0.13		0	
38b	1	1.25	cold	t	h	14		1.75		0	
38b	1	1.25	cold	t	h	14		1.75		0	
38b	1	1.25	cold	t	h	18		2.25		0	
38b	1	1.25	cold	t	h	15		1.88		0	
38b	1	1.25	cold	t	h	12		1.5		0	
38b	1	1.25	cold	t	hor el	3		0.38		0	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
38b	1	1.25	cold	t	downcomer	4	146.0	0.5	18.25	0	
39a	1	4	cold	w	downcomer	0		0		0	
39a	1	4	cold	w	h	12		0.86		0	
39a	1	4	cold	w	h	12		0.86		0	
39a	1	4	cold	w	h	12		0.86		0	
39a	1	4	cold	w	h	12		0.86		0	
39a	1	4	cold	w	h	15		1.07		0	
39a	1	4	cold	w	h	15		1.07		0	
39a	1	4	cold	w	h	10		0.71		0	
39a	1	4	cold	w	h	12		0.86		0	
39a	1	4	cold	w	h	12		0.86		0	
39a	1	4	cold	w	h	12		0.86		0	
39a	1	4	cold	w	h	12		0.86		0	
39a	1	4	cold	w	h	12		0.86		0	
39a	1	4	cold	w	h	24		1.71		0	
39a	1	4	cold	w	pump	4	176.0	0.29	12.57	0	
39b	2	4	cold	w	downcomer	0		0		0	
39b	2	4	cold	w	h	12		0.86		0	
39b	2	4	cold	w	h	12		0.86		0	
39b	2	4	cold	w	h	12		0.86		0	
39b	2	4	cold	w	h	12		0.86		0	
39b	2	4	cold	w	h	15		1.07		0	
39b	2	4	cold	w	h	15		1.07		0	
39b	2	4	cold	w	h	10		0.71		0	
39b	2	4	cold	w	h	12		0.86		0	
39b	2	4	cold	w	h	12		0.86		0	
39b	2	4	cold	w	h	12		0.86		0	
39b	2	4	cold	w	h	12		0.86		0	
39b	2	4	cold	w	h	12		0.86		0	
39b	2	4	cold	w	h	24		1.71		0	
39b	2	4	cold	w	pump	4	176.0	0.29	12.57	0	
40	2	1.5	hot	sw	downcomer	0		0		0	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
40	2	1.5	hot	sw	h	6		0.55		0	
40	2	1.5	hot	sw	h	24		2.18		0	
40	2	1.5	hot	sw	tank	18	48.0	1.64	4.36	0	
41a	5	12.00	hot		dearator	0.0		0.00		85	Begin Moss Landing Units 4 & 5
41a	5	12.00	hot		hor el	4.0		0.13		85	
41a	5	12.00	hot		sh	4.0		0.13		85	
41a	5	12.00	hot		sh	10.0		0.33		85	
41a	5	12.00	hot		dc	8.0	26.0	0.24	0.86	85	
41b	4	12.00	hot		dearator	0.0		0.00		85	
41b	4	12.00	hot		hor el	4.0		0.13		85	
41b	4	12.00	hot		sh	4.0		0.13		85	
41b	4	12.00	hot		sh	10.0		0.33		85	
41b	4	12.00	hot		dc	8.0	26.0	0.24	0.86	85	
42a	5	2.00	hot		dc	0.0		0.00		85	
42a	5	2.00	hot		u b	6.0	6.0	0.46	0.46	85	
42a	5	2.00	hot		u b	12.0	12.0	0.92	0.92	85	
42a	5	2.00	hot		u b	12.0	12.0	0.92	0.92	85	
42a	5	2.00	hot		u b	12.0	12.0	0.92	0.92	85	
42a	5	2.00	hot		dc	6.0	6.0	0.46	0.46	85	
42b	4	2.00	hot	SW	dc	0.0		0.00		85	
42b	4	2.00	hot	SW	u b	6.0	6.0	0.46	0.46	85	
42b	4	2.00	hot	SW	u b	12.0	12.0	0.92	0.92	85	
42a	4	2.00	hot	SW	u b	12.0	12.0	0.92	0.92	85	
42b	4	2.00	hot	SW	dc	6.0	6.0	0.46	0.46	85	
43a	5	3.00	cold	w	dc	0.0		0.00		70	
43a	4	3.00	cold	w	h	4.0		0.33		70	
43a	5	3.00	cold	w	h	15.0		1.25		70	
43a	5	3.00	cold	w	hor el	15.0		1.25		70	
43a	5	3.00	cold	w	h	1.0		0.08		70	
43a	5	3.00	cold	w	h	18.0		1.50		70	
43a	5	3.00	cold	w	Lat restraint	15.0	68.00	1.25	5.67	70	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
43b	4	3.00	cold	w	dc	0.0		0.00		70	
43b	[illegible]	3.00	cold	w	h	4.0		0.33		70	
43b	4	3.00	cold	w	h	15.0		1.25		70	
43b	4	3.00	cold	w	hor el	15.0		1.25		70	
43b	4	3.00	cold	w	h	1.0		0.08		70	
43b	4	3.00	cold	w	h	18.0		1.50		70	
43b	4	3.00	cold	w	Lat restraint	15.0	68.00	1.25	5.67	70	
44a	5	1.00	cold	SW	dc	0.0		0.00		30 X 2	
44a	5	1.00	cold	SW	u b	4.0	4.0	0.57	0.57	30	
44a	5	1.00	cold	SW	u b	9.0	9.0	1.29	1.29	30	
44a	5	1.00	cold	SW	u b	6.0	6.0	0.86	0.86	30	
44b	4	1.00	cold	SW	dc	0.0		0.00		30	
44b	4	1.00	cold	SW	dc	4.0	4.0	0.57	0.57	30	
44b	4	1.00	cold	SW	dc	9.0	9.0	1.29	1.29	30	
44b	4	1.00	cold	SW	dc	6.0	6.0	0.86	0.86	30	
44c	5	1.50	cold	SW	dc	0.0		0.00		30 X 3	
44c	5	1.50	cold	SW	u b	4.0	4.0	0.47	0.47	30	
44c	5	1.50	cold	SW	u b	9.0	9.0	1.06	1.06	30	
44c	5	1.50	cold	SW	u b	6.0	6.0	0.71	0.71	30	
44d	4	1.50	cold	SW	dc	0.0		0.00		30 X 3	
44d	4	1.50	cold	SW	ub	4.0	4.0	0.47	0.47	30	
44d	4	1.50	cold	SW	u b	9.0	9.0	1.06	1.06	30	
44d	4	1.50	cold	SW	u b	6.0	6.0	0.71	0.71	30	
45a	5	4.00	hot	w	dc	0.0		0.00		30	
45a	5	4.00	hot	w	sh	2.0		0.12		30	
45a	5	4.00	hot	w	hor el	18.0		1.06		30	
45a	5	4.00	hot	w	sh	1.0		0.06		30	
45a	5	4.00	hot	w	sh	14.0		0.82		30	
45a	5	4.00	hot	w	dc	15.0	50.00	0.88	2.94	30	
45b	4	4.00	hot	w	dc	0.0		0.00		30	
45b	4	4.00	hot	w	sh	2.0		0.12		30	
45b	4	4.00	hot	w	hor el	18.0		1.06		30	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
45b	4	4.00	hot	w	sh	1.0		0.06		30	
45b	4	4.00	hot	w	sh	14.0		0.82		30	
45b	4	4.00	hot	w	dc	15.0		0.88	2.94	30	
46a	5	2.00	hot	SW	PUMP	0.0		0.00		30	
46a	5	2.00	hot	SW	vert el	10.0		0.77		30	
46a	5	2.00	hot	SW	hor el	2.0		0.15		30	
46a	5	2.00	hot	SW	hor el	8.0		0.62		30	
46a	5	2.00	hot	SW	sh	4.0		0.31		30	
46a	5	2.00	hot	SW	hor el	6.0		0.46		30	
46a	5	2.00	hot	SW	h	11.0		0.85		30	
46a	5	2.00	hot	SW	h	12.0		0.92		30	
46a	5	2.00	hot	SW	h	12.0		0.92		30	
46a	5	2.00	hot	SW	wall	10.0	75.0	0.77	5.77	30	
46a	5	2.00	hot	SW	h	3.0		0.23		30	
46a	5	2.00	hot	SW	h	12.0		0.92		30	
46a	5	2.00	hot	SW	riser	6.0	21.0	0.46	1.62	30	
46b	5	2.00	hot	SW	pump	0.0		0.00		30	
46b	5	2.00	hot	SW	vert el	10.0		0.77		30	
46b	5	2.00	hot	SW	hor el	2.0		0.15		30	
46b	5	2.00	hot	SW	u b	8.0		0.62		30	
46b	5	1.00	hot	SW	sh	4.0		0.31		30	
45b	5	2.00	hot	SW	hor el	6.0		0.46		30	
46b	5	2.00	hot	SW	h	11.0		0.85		30	
46b	5	2.00	hot	SW	h	11.0		0.85		30	
46b	5	2.00	hot	SW	h	12.0		0.92		30	
46b	5	2.00	hot	SW	h	12.0		0.92		30	
46b	5	2.00	hot	SW	wall	10.0	75.0	0.77	5.77	30	
46b	5	2.00	hot	SW	h	3.0		0.23		30	
46b	5	2.00	hot	SW	h	12.0		0.92		30	
46b	5	2.00	hot	SW	riser	6.0	21.0	0.46	1.62	30	
47a	5	1.00	cold	t	dc	0.0		0.00		30	
47a	5	1.00	cold	t	u b	6.0	6.0	0.86	0.86	30	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
47a	5	1.00	cold	t	hor el	12.0		1.71		30	
47a	5	1.00	cold	t	u b	1.0	13.0	0.14	1.86	30	
47a	5	1.00	cold	t	u b	6.0		0.86		30	
47a	5	1.00	cold	t	hor el	1.0		0.14		30	
47a	5	1.00	cold	t	u b	6.0	7.0	0.86	1.0	30	
47a	5	1.00	cold	t	hor el	2.0		0.28		30	
47a	5	1.00	cold	t	u b	6.0	8.0	0.86	1.14	30	
47a	5	1.00	cold	t	riser	2.0	2.0	0.28	0.28	30	
47b	4	1.00	cold	t	dc	0.0		0.00		30	
47b	4	1.00	cold	t	u b	6.0	6.0	0.86	0.86	30	
47b	4	1.00	cold	t	hor el	12.0		1.71		30	
47b	4	1.00	cold	t	u b	1.0	13.0	0.14	1.86	30	
47b	4	1.00	cold	t	ub	6.0		0.86		30	
47b	4	1.00	cold	t	hor el	1.0		0.14		30	
47b	4	1.00	cold	t	u b	6.0	7.0	0.86	1.0	30	
47b	4	1.00	cold	t	hor el	2.0		0.28		30	
47b	4	1.00	cold	t	u b	6.0	8.0	0.86	1.14	30	
48a	5	2.00	hot	SW	preheater	0.0		0.00		30	
48a	5	2.00	hot	SW	hor el	12.0		0.92		30	
48a	5	2.00	hot	SW	u b	8.0	20.00	0.62	1.54	30	
48a	5	2.00	hot	SW	u b	14.0	14.00	1.08	1.08	30	
48a	5	2.00	hot	SW	tat restraint	5.0	5.00	0.38	0.38	30	
48a	5	2.00	hot	SW	u b	6.0	6.00	0.42	0.42	30	
48a	5	2.00	hot	SW	dc	8.0	8.00	0.62	0.62	30	
48b	4	2.00	hot	SW	preheater	0.0		0.00		30	
48b	4	2.00	hot	SW	hor et	12.0		0.92		30	
48b	4	2.00	hot	SW	u b	8.0	20.00	0.62	1.54	30	
48b	4	2.00	hot	SW	u b	14.0	14.00	1.08	1.08	30	
48b	4	2.00	hot	SW	tat restraint	5.0	5.00	0.42	0.42	30	
48b	4	2.00	hot	SW	u b	6.0	6.00	0.42	0.42	30	
48b	4	2.00	hot	SW	dc	8.0	8.00	0.62	0.62	30	
49a	5	0.75	cold	SW	vert et	0.0		0.00		15	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
49a	5	0.75	cold	SW	vert et	25.0		5.00		15	
49a	5	0.75	cold	SW	vert el	21.0		4.20		15	
49a	5	0.75	cold	SW	h	21.0		4.20		15	
49a	5	0.75	cold	SW	cantilever	4.0	71.00	0.80	14.2	15	
49b	4	0.75	cold	SW	vert et	0.0		0.00		15	
-49b	4	0.75	cold	SW	vert et	25.0		5.00		15	
49b	4	0.75	cold	SW	h	21.0		4.20		15	
49b	4	0.75	cold	SW	h	21.0		4.20		15	
49a	4	0.75	cold	SW	cantilever	4.0	71.00	0.80	14.2	15	
50a	5	1.00	hot	SW	vert et	0.0		0.00		15	
50a	5	1.00	hot	SW	vert et	3.0		0.33		15	
50a	5	1.00	hot	SW	u b	10.0	13.00	1.11	1.44	15	
50a	5	1.00	hot	SW	h	6.0		0.67		15	
50a	5	1.00	hot	SW	hor et	4.0		0.44		15	
50a	5	1.00	hot	SW	h	9.0		1.00		15	
50a	5	1.00	hot	SW	h	10.0		1.11		15	
50a	5	1.00	hot	SW	h	10.0		1.11		15	
50a	5	1.00	hot	SW	hor tee	1.0	40.00	0.11	4.44	15	
50a	5	1.00	hot	SW	h	9.0		1.00		15	
50a	5	1.00	hot	SW	hor tee	10.0	19.00	1.11	2.11	15	
50a	5	1.00	hot	SW	h	1.0		0.11		15	
50a	5	1.00	hot	SW	h	12.0		1.33		15	
50a	5	1.00	hot	SW	hor et	1.0		0.11		15	
50a	5	1.00	hot	SW	wall	8.0	22.00	0.89	2.44	15	
50b	4	1.00	hot	SW	vert et	0.0		0.00		15	
50b	4	1.00	hot	SW	vert et	3.0		0.33		15	
50b	4	1.00	hot	SW	u b	10.0	13.00	1.11	1.44	15	
50b	4	1.00	hot	SW	h	6.0		0.67		15	
50b	4	1.00	hot	SW	hor et	4.0		0.44		15	
50b	4	1.00	hot	SW	h	9.0		1.00		15	
50b	4	1.00	hot		h	10.0		1.11		15	
50b	4	1.00	hot		h	10.0		1.11		15	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
50b	4	1.00	hot		hor tee	1.0	40.00	0.11	4.44	15	
50b	4	1.00	hot		h	9.0		1.00		15	
50b	4	1.00	hot		hor tee	10.0	19.00	1.11	2.11	15	
50b	4	1.00	hot		h	1.0		0.11		15	
50b	4	1.00	hot		h	12.0		1.33		15	
50b	4	1.00	hot		hor el	1.0		0.11		15	
50b	5	1.00	hot		waLL	8.0	22.00	0.89	2.55	15	
51a	5	2.50	cold		h	0.0		0.00		15	
51a	5	2.50	cold		h	20.0		1.82		15	
51a	5	2.50	cold		h	20.0		1.82		15	
51a	5	2.50	cold		h	20.0		1.82		15	
51a	5	2.50	cold		hor el	10.0		0.91		15	
51a	5	2.50	cold		h	3.0		0.27		15	
51a	5	2.50	cold		h	18.0		1.64		15	
51a	5	2.50	cold		h	15.0		1.36		15	
51a	5	2.50	cold		h	10.0		0.91		15	
51a	5	2.50	cold		h	10.0		0.91		15	
51a	5	2.50	cold		h	12.0		1.09		15	
51a	5	2.50	cold		hor tee	3.0	131.0	0.27	11.9	15	
51a'	5	4.00	cold		h	3.0		0.21		15	
51a	5	4.00	cold		hor el	15.0		1.07		15	
51a	5	4.00	cold		h	3.0		0.21		15	
51a	5	4.00	cold		h	12.0		0.86		15	
51a	5	4.00	cold		wall	8.0	41.0	0.57	2.93	15	
51b	5	2.50	cold		h	0.0		0.00		15	
51b	5	2.50	cold		h	20.0		1.82		15	
51b	5	2.50	cold		h	20.0		1.82		15	
51b	5	2.50	cold		h	20.0		1.82		15	
51b	5	2.50	cold		hor el	10.0		0.91		15	
51b	5	2.50	cold		h	3.0		0.27		15	
51b	5	2.50	cold		h	18.0		1.64		15	
51b	5	2.50	cold		h	15.0		1.36		15	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
51b	5	2.50	cold		h	10.0		0.91		15	
51b	5	2.50	cold		h	10.0		0.91		15	
51b	5	2.50	cold		h	12.0		1.09		15	
51b	5	2.50	cold		hor el	3.0	131.00	0.27	11.9	15	
51b	5	4.00	cold		h	3.0		0.21		15	
51b	5	4.00	cold		hor el	15.0		1.07		15	
51b	5	4.00	cold		h	3.0		0.21		15	
51a	5	4.00	cold		h	12.0		0.86		15	
51b	5	4.00	cold		waLL	8.0	41.00	0.57	2.93	15	
52a	5	6.00	hot		dc	0.0		0.00		15	
52a	5	6.00	hot		h	8.0		0.38		15	
52a	5	6.00	hot		h	8.0		0.38		15	
52a	5	6.00	hot	w	h	8.0		0.38		15	
52a	5	6.00	hot	w	h	20.0		0.95		15	
52a	5	6.00	hot	w	h	20.0		0.95		15	
52a	5	6.00	hot	w	hor el	2.0		0.10		15	
52a	5	6.00	hot	w	h	18.0		0.86		15	
52a	5	6.00	hot	w	riser	1.0	89.00	0.05	4.24	15	
52b	4	6.00	hot	w	dc	0.0		0.00		15	
52b	4	6.00	hot	w	h	8.0		0.38		15	
52b	4	6.00	hot	w	h	8.0		0.38		15	
52b	4	6.00	hot	w	h	8.0		0.38		15	
52b	4	6.00	hot	w	h	20.0		0.95		15	
52a	4	6.00	hot	w	h	20.0		0.95		15	
52b	4	6.00	hot	w	hor el	2.0		0.10		15	
52b	4	6.00	hot	w	h	18.0		0.86		15	
52b	4	5.00	hot	w	riser	1.0	89.0	0.05	4.24	15	
53a	5	1.00	hot	SW	riser	0.0		0.00		15	
53a	5	1.00	hot	SW	h	1.0		0.11		15	
53a	5	1.00	hot	SW	hor el	18.0		2.00		15	
53a	5	1.00	hot	SW	h	4.0		0.44		15	
53a	5	1.00	hot	SW	h	12.0		1.33		15	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
53a	5	1.00	hot	SW	hor el	6.0		0.67		15	
53a	5	1.00	hot	SW	h	1.0		0.11		15	
53a	5	1.00	hot	SW	dc	8.0	50.00	8.90	5.56	15	
53b	4	1.00	hot	SW	riser	0.0		0.00		15	
53b	4	1.00	hot	SW	h	1.0		0.11		15	
53b	4	1.00	hot	SW	hor el	18.0		2.00		15	
53b	4	1.00	hot	SW	h	4.0		0.44		15	
53b	4	1.00	hot	SW	h	12.0		1.33		15	
53b	4	1.00	hot	SW	hor el	6.0		0.67		15	
53b	4	1.00	hot	SW	h	1.0		0.11		15	
53b	4	1.00	hot	SW	dc	8.0	50.00	0.89	5.56	15	
54a	5	6.00	cold	w	dc	0.0		0.00		15	
54a	5	6.00	cold	w	h	4.0		0.24		15	
54a	5	6.00	cold	w	h	16.0		0.94		15	
54a	5	6.00	cold	w	h	12.0		0.71		15	
54a	5	6.00	cold	w	cantilever	9.0	41.00	0.53	2.41	15	
54b	4	6.00	cold	w	dc	0.0		0.00		15	
54b	4	6.00	cold	w	h	4.0		0.24		15	
54b	4	6.00	cold	w	h	16.0		0.94		15	
54b	4	6.00	cold	w	h	12.0		0.71		15	
54b	4	6.00	cold	w	cantilever	9.0	41.0	0.53	2.41	15	
55a	5	1.00	cold	t	floor	0.0		0.00		15	
55a	5	1.00	cold	t	vert el	6.0		0.86		15	
55a	5	1.00	cold	t	ub	3.0	9.00	0.43	1.29	15	
55a	5	1.00	cold	t	hor el	6.0		0.86		15	
55a	5	1.00	cold	t	ub	2.0	8.00	0.29	1.14	15	
55a	5	1.00	cold	t	ub	8.0	8.00	1.14	1.14	15	
55a	5	1.00	cold	t	hor et	2.0		0.29		15	
55a	5	1.00	cold	t	ub	8.0	10.00	1.14	1.43	15	
55a	5	1.00	cold	t	ub	6.0	6.00	0.86	0.86	15	
55b	4	1.00	cold	t	floor	0.0		0.00		15	
55b	4	1.00	cold	t	vert et	6.0		0.86		15	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
55b	5	1.00	cold	t	ub	3.0	9.00	0.43	1.29	15	
55b	4	1.00	cold	t	hor et	6.0		0.86		15	
55b	4	1.00	cold	t	ub	2.0	8.00	0.29		15	
55b	4	1.00	cold	t	ub	8.0	8.00	1.14	1.14	15	
55b	4	1.00	cold	t	hor et	2.0		0.29		15	
55b	4	1.00	cold	t	ub	8.0	10.00	1.14	1.43	15	
55b	4	1.00	cold	t	ub	6.0	6.00	0.86		15	
56a	5	1.00	cold	SW	F.W. Line	0.0		0.00		15	
56a	5	1.00	cold	SW	hor et	3.0		0.43		15	
56a	5	1.00	cold	SW	vert et	6.0		0.86		15	
56a	5	1.00	cold	SW	ub	2.0	11.00	0.29	1.57	15	
56a	5	1.00	cold	SW	vert et	2.0		0.29		15	
56a	5	1.00	cold	SW	h	6.0		0.86		15	
56a	5	1.00	cold	SW	vert et	1.0		0.15		15	
56a	5	1.00	cold	SW	vert et	4.0		0.88		15	
56a	5	1.00	cold	SW	hor et	4.0		0.58		15	
56a	5	1.00	cold	SW	ub	3.0	20.0	0.43	2.86	15	
56a	5	1.00	cold	SW	ub	15.0	15.00	2.14	2.14	15	
56a	5	1.00	cold	SW	ub	12.0	12.00	1.71	1.71	15	
56a	5	1.00	cold	SW	h	12.0		1.71		15	
56a	5	1.00	cold	SW	hor et	1.0		0.14		15	
56a	5	1.00	cold	SW	hor et	10.0		1.42		15	
56a	5	1.00	cold	SW	vert et	4.0		0.57		15	
56a	5	1.00	cold	SW	ub	2.0	29.00	0.29	4.14	15	
56b	4	1.00	cold	SW	F.W. Line	0.0		0.00		15	
56b	4	1.00	cold	SW	hor et	3.0		0.43		15	
56b	4	1.00	cold	SW	vert et	6.0		0.86		15	
56b	4	1.00	cold	SW	ub	2.0	11.00	0.29	1.57	15	
56b	4	1.00	cold	SW	vert et	2.0		0.29		15	
56b	4	1.00	cold	SW	h	6.0		0.86		15	
56b	4	1.00	cold	SW	vert et	1.0		0.14		15	
56b	4	1.00	cold	SW	vert et	4.0		0.58		15	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
56b	4	1.00	cold	SW	hor et	4.0		0.58		15	
56b	4	1.00	cold	SW	ub	3.0	20.00	4.30	2.86	15	
56a	5	1.00	cold	SW	ub	15.0	15.00	2.14	2.14	15	
56b	4	1.00	cold	SW	ub	12.0	12.00	1.71	1.71	15	
56b	4	1.00	cold	SW	h	12.0		1.71		15	
56b	4	1.00	cold	SW	hor et	1.0		0.14		15	
56b	4	1.00	cold	SW	hor et	10.0		1.42		15	
56b	4	1.00	cold	SW	vert et	4.0		0.57		15	
56b	4	1.00	cold		ub	2.0	29.00	0.29	4.14	15	
57a	5	6.00	cold		dc	0.0		0.00		0	
57a	5	6.00	cold		hor el	3.0		0.18		0	
57a	5	6.00	cold		h	2.0		0.12		0	
57a	5	6.00	cold		h	25.0		1.47		0	
57a	5	6.00	cold		h	25.0		1.47		0	
57a	5	6.00	cold		hor el	3.0		0.18		0	
57a	5	6.00	cold		h	3.0		0.18		0	
57a	5	6.00	cold		h	21.0		1.24		0	
57a	5	6.00	cold		h	18.0		1.06		0	
57a	6	6.00	cold		h	18.0		1.06		0	
57a	5	6.00	cold		h	18.0	136.0	1.06	8.00	0	
57b	4	6.00	cold		dc	0.0		0.00		0	
57b	4	6.00	cold		hor el	3.0		0.18		0	
57b	4	6.00	cold		h	2.0		0.12		0	
57b	4	6.00	cold		h	25.0		1.47		0	
57b	4	6.00	cold		h	25.0		1.47		0	
57b	4	6.00	cold		hor el	3.0		0.18		0	
57b	4	6.00	cold		h	3.0		0.18		0	
57b	4	6.00	cold		h	21.0		1.24		0	
57b	4	6.00	cold		h	18.0		1.06		0	
57b	4	6.00	cold		h	18.0		1.06		0	
57b	4	6.00	cold		h	18.0	136.00	1.06	8.00	0	
58a	5	4.00	cold		h	0.0		0.00		0	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
58a	5	4.00	cold		h	10.0		0.71		0	
58a	5	4.00	cold		hor el	12.0		0.85		0	
58a	5	4.00	cold		h	3.0		0.21		0	
58a	5	4.00	cold		tat rest	12.0	37.00	0.86	2.64	0	
58a	5	4.00	cold		tat rest	18.0	18.00	1.29	1.29	0	
58a	5	4.00	cold		tat rest	24.0	24.00	1.71	1.71	0	
58a	5	4.00	cold		hor el	3.0		0.21		0	
58a	5	4.00	cold		stantion	18.0	21.00	1.29	1.50	0	
58b	4	4.00	cold		hor el	10.0		0.71		0	
58b	4	4.00	cold		hor el	12.0		0.85		0	
58a	4	4.00	cold		h	3.0		0.21		0	
58b	4	4.00	cold		tat rest	12.0	37.00	0.86	2.64	0	
58b	4	4.00	cold		tat rest	18.0	18.00	1.29	1.29	0	
58a	4	4.00	cold		tat rest	24.0	24.00	1.71	1.71	0	
58b	4	4.00	cold		hor el	3.0		0.00		0	
58a	4	4.00	cold		stantion	18.0	21.00	1.29	1.50	0	
59a	5	8.00	cold		ub	0.0	0.00	0.00	0.00	0	
59a	5	8.00	cold		h	21.0	1.11	0.00	0.00	0	
59b	4	8.00	cold		dc	2.0	23.00	0.11	1.21	0	
59b	4	8.00	cold		ub	0.0		0.00		0	
59a	4	8.00	cold		h	21.0	1.11	0.00	0.00	0	
59b	4	8.00	cold		dc	2.0	23.00	0.11	1.21	0	
60a	5	2.00	cold	SW	dc	0.0		0.00		0	
60a	5	2.00	cold	SW	ub	2.0	2.00	0.20	0.02	0	
60a	5	2.00	cold	SW	ub	15.0	15.00	1.50	1.5	0	
60a	5	2.00	cold	SW	hor et	15.0		1.50		0	
60a	5	2.00	cold	SW	ub	6.0	21.00	0.60	2.1	0	
60a	5	2.00	cold	SW	ub	12.0	12.00	1.20	1.2	0	
60a	5	2.00	cold	SW	ub	12.0	12.00	1.20	1.2	0	
60a	5	2.00	cold	SW	h	15.0		1.50		0	
60a	5	2.00	cold	SW	bracket	12.0		1.20		0	
60a	5	2.00	cold	SW	hor et	1.0		0.10		0	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
60a	5	2.00	cold	SW	bracket	5.0		0.50		0	
60a	5	2.00	cold	SW	h	10.0		1.00		0	
60a	5	2.00	cold	SW	ub	10.0	53.00	1.00	5.33	0	
60a	5	2.00	cold	SW	hor et	1.0		0.00	0.00	0	
60a	5	2.00	cold	SW	ub	18.0	19.00	1.80	1.9	0	
60a	5	2.00	cold	SW	ub	12.0	12.00	1.20	1.20	0	
60b	5	2.00	cold	SW	hor et	15.0	0.00	1.50	0.00	0	
60a	5	2.00	cold	SW	ub	1.0	16.00	0.10	1.6	0	
60a	5	2.00	cold	SW	ub	12.0	12.00	1.20	1.0	0	
60a	5	1.00	cold	SW	ub	15.0	15.00	2.14	2.140	0	
60a	5	1.00	cold	SW	ub	15.0	15.00	0.00	0.00	0	
60a	5	1.00	cold	SW	ub	10.0	10.00	1.43	1.43	0	
60a	5	1.00	cold	SW	h	10.0	0.00	1.43	0	0	
60a	5	1.00	cold	SW	vert et	10.0	0.00	1.43	0.00	0	
60a	5	1.00	cold	SW	ub	12.0	32.00	1.71	4.75	0	
60a	5	1.00	cold	SW	ub	12.0	12.00	1.71	1.71	0	
60b	4	2.00	cold	SW	dc	0.0	0.00	0.00	0.00	0	
60b	4	2.00	cold	SW	ub	2.0	2.0	0.20	0.20	0	
60b	4	2.00	cold	SW	[illegible]	15.0	15.00	1.50	1.50	0	
60b	4	2.00	cold	SW	hor et	15.0		1.50		0	
60b	4	2.00	cold	SW	ub	6.0	21.00	0.60	2.10	0	
60b	4	2.000	cold	SW	ub	12.0	12.00	1.20		0	
60b	4	2.000	cold	SW	h	15.0		1.50		0	
60b	4	2.000	cold	SW	bracket	12.0		1.20		0	
60b	4	2.000	cold	SW	hor et	1.0		0.10		0	
60b	4	2.000	cold	SW	bracket	5.0		0.50		0	
60b	4	2.000	cold	SW	h	10.0		1.00		0	
60b	4	2.000	cold	SW	ub	10.0	53.00	1.00	5.30	0	
60b	4	2.000	cold	SW	hor et	1.0		0.10		0	
60a	4	2.000	cold	SW	ub	18.0	19.00	1.80	1.9	0	
60b	4	2.000	cold	SW	ub	12.0	12.00	1.20	1.20	0	
60b	4	2.000	cold	SW	hor et	15.0		1.50		0	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
60b	4	2.000	cold	SW	ub	1.0	16.00	0.10	1.60	0	
60b	4	2.000	cold	SW	ub	12.0	12.00	1.20	1.20	0	
60b	4	2.000	cold	SW	ub	15.0	15.00	1.50	1.50	0	
60b	4	2.000	cold	SW	ub	15.0	15.00	1.50	1.50	0	
60b	4	2.000	cold	SW	ub	10.0	10.00	1.00	1.00	0	
60b	4	2.000	cold	SW	h	10.0		1.00		0	
60b	4	2.000	cold	SW	vert et	10.0		1.00		0	
60b	4	2.000	cold	SW	ub	12.0	32.00	1.20	3.20	0	
60b	4	2.000	cold	SW	ub	12.0	12.00	1.20	1.20	0	
61a	5	1.000	hot	SW	hor el	15.0		1.70		0	
61a	5	1.000	hot	SW	h	1.0		0.10		0	
61a	5	1.000	hot	SW	h	24.0		2.70		0	
61a	5	1.000	hot	SW	hor et	2.0		0.20		0	
61a	5	1.000	hot	SW	Lat rest	1.0	43.00	0.10	4.80	0	
61a	5	1.000	hot	SW	h	4.0		0.40		0	
61a	5	1.000	hot	SW	h	10.0		1.10		0	
61a	5	1.000	hot	SW	h	6.0		0.70		0	
61a	5	1.000	hot	SW	h	8.0		0.80		0	
61a	5	1.000	hot	SW	h	8.0		0.80		0	
61a	5	1.000	hot	SW	hor et	2.0		0.20		0	
61a	5	1.000	hot	SW	h	10.0		1.10		0	
61a	5	1.000	hot	SW	h	8.0		0.80		0	
61a	5	1.000	hot	SW	hor et	2.0		0.20		0	
61a	5	1.000	hot	SW	dc	2.0	60.00	0.20	6.70	0	
61b	5	1.000	hot	SW	Large pipe	0.0		0.00		0	
61b	5	1.000	hot	SW	hor et	15.0		1.60		0	
61b	5	1.000	hot	SW	h	1.0		0.10		0	
61b	5	1.000	hot	SW	h	24.0		2.70		0	
61b	5	1.000	hot	SW	hor et	2.0		0.20		0	
61b	5	1.000	hot	SW	Lateral restraint	1.0	43.00	0.10	0.00	0	
61b	5	1.000	hot	SW	h	4.0		0.40		0	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
61b	5	1.000	hot	SW	h	10.0		1.10		0	
61b	5	1.000	hot	SW	h	6.0		0.70		0	
61b	5	1.000	hot	SW	h	8.0		0.90		0	
61b	5	1.000	hot	SW	h	8.0		0.90		0	
61b	5	1.000	hot	SW	hor et	2.0		0.20		0	
61b	5	1.000	hot	SW	h	10.0		1.10		0	
61b	5	1.000	hot	SW	h	8.0		0.90		0	
61b	5	1.000	hot	SW	dc	2.0	60.00	0.20	6.70	0	
62a	5	1.500	cold	t	Lateral restraint	0.0		0.00		0	
62a	5	1.500	cold	t	h	6.0		0.70		0	
62a	5	1.500	cold	t	h	6.0		0.70		0	
62a	5	1.500	cold	t	h	8.0		0.90		0	
62a	5	1.500	hor et	t	hor et	8.0		0.90		0	
62a	5	1.500	cold	t	Lateral restraint	3.0	31.00	0.30	3.60	0	
62a	5	1.500	cold	t	hor tee	10.0	10.00	1.20	1.20	0	
62a	5	1.500	cold	t	h	2.0		0.30		0	
62a	5	1.500	cold	t	h	12.0		1.30		0	
62a	5	1.500	cold	t	hor et	4.0		0.50		0	
62a	5	1.500	cold	t	Large pipe	4.0	22.00	0.50	2.70	0	
62b	4	1.500	cold		lateral restraint	0.0		0.00		0	
62b	4	1.500	cold		h	6.0		0.70		0	
62b	4	1.500	cold		h	6.0		0.70		0	
62b	4	1.500	cold		h	8.0	0.00	0.90		0	
62b	4	1.500	cold		hor et	8.0		0.90		0	
62b	4	1.500	cold		lateral restraint	3.0	31.00	0.30	3.60	0	
62b	4	1.500	cold		hor tee	10.0	10.00	1.20	1.20	0	
62b	4	1.500	cold		h	2.0		0.30		0	
62b	4	1.500	cold		hor eL	4.0		0.50		0	
63a	5	2.000	cold		riser	0.0		0.00		0	
63a	5	2.000	cold		h	8.0		0.80		0	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
63a	5	2.000	cold		h	6.0		0.60		0	
63a	5	2.000	cold		h	6.0		0.60		0	
63a	5	2.000	cold		l	8.0		0.80		0	
63a	5	2.000	cold		h	6.0		0.60		0	
63a	5	2.000	cold		h	10.0		1.00		0	
63a	5	2.000	cold		h	10.0		1.00		0	
63a	5	2.000	cold		hor et	2.0		0.20		0	
63a	5	2.000	cold		h	4.0		0.40		0	
63a	5	2.000	cold		h	15.0		1.50		0	
63a	5	2.000	cold		h	12.0		1.20		0	
63a	5	2.000	cold		hor et	2.0		0.20		0	
63a	5	2.000	cold		ub stantion	1.0	90.00	0.10	9.00	0	
63b	4	2.000	cold		riser	0.0		0.00		0	
63b	4	2.000	cold		h	8.0		0.80		0	
63b	4	2.000	cold		h	6.0		0.60		0	
63b	5	2.000	cold		h	6.0		0.60		0	
63b	5	2.000	cold		h	8.0		0.80		0	
63b	4	2.000	cold		h	6.0		0.60		0	
63b	4	2.000	cold		h	10.0		1.00		0	
63b	4	2.000	cold		h	10.0		1.00		0	
63b	4	2.000	cold		hor et	2.0		0.20		0	
63b	4	2.000	cold		h	4.0		0.40		0	
63b	4	2.000	cold		h	15.0		1.50		0	
63b	4	2.000	cold		h	12.0		1.20		0	
63b	4	2.000	cold		hor et	2.0		0.20		0	
63b	4	2.000	cold		ub stantion	1.0	90.0	0.10	9.00	0	
64a	5	1.000	cold		dc	0.0		0.00		0	
64a	5	1.000	cold		ub	2.0	2.00	0.30	0.30	0	
64a	5	1.000	cold		ub	4.0	4.00	0.60	0.60	0	
64a	5	1.000	cold		ub	24.0	24.00	3.40	3.40	0	
64a	5	1.000	cold		ub	12.0	12.00	1.70	1.70	0	
64a	5	1.000	cold		hor et	12.0		1.70		0	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
64a	5	1.000	cold		ub	1.0	13.00	0.10	1.90	0	
64a	5	1.000	cold		ub	15.0	15.00	2.10	2.10	0	
64a	5	1.000	cold		ub	15.0	15.00	2.10	2.10	0	
64a	5	1.000	cold		ub	2.0	2.00	0.30	0.30	0	
64b	4	1.000	cold		dc	0.0		0.00		0	
64b	4	1.000	cold		ub	2.0	2.0	0.30	0.30	0	
64b	4	1.000	cold		ub	4.0	4.00	0.60	0.60	0	
64b	4	1.000	cold		ub	24.0	24.00	3.40	3.40	0	
64b	4	1.000	cold		ub	12.0	12.00	1.70	1.70	0	
64b	4	1.000	cold		hor el	12.0		1.70		0	
64b	4	1.000	cold		ub	15.0	15.00	2.10	2.10	0	
64b	4	1.000	cold		ub	15.0	15.00	2.10	2.10	0	
64b	4	1.000	cold		ub	2.0	2.00	0.30	0.30	0	
65a	5	4.000	cold		riser	0.0		0.00		0	
65a	5	4.000	cold		h	12.0		0.90		0	
65a	5	4.000	cold		h	15.0		1.10		0	
65a	5	4.000	cold		h	12.0		0.90		0	
65a	5	4.000	cold		h	18.0		1.30		0	
65a	5	4.000	cold		h	24.0		1.80		0	
65a	5	4.000	cold		h	18.0		1.30		0	
65a	5	4.000	cold		h	16.0		1.10		0	
65a	5	4.000	cold		vert el	3.0		0.20		0	
65a	5	4.000	cold		vert el	8.0		0.60		0	
65a	5	4.000	cold		bracket	10.0		0.70		0	
65a	5	4.000	cold		bracket	10.0		0.70		0	
65a	5	4.000	cold		bracket	10.0		0.70		0	
65a	5	4.000	cold		bracket	10.0		0.70		0	
65a	5	4.000	cold		vert tee	6.0	156.00	0.40	11.1	0	
65a	5	4.000	cold		h	4.0		0.30		0	
65a	5	4.000	cold		h	15.0		1.10		0	
65a	5	4.000	cold		h	15.0		1.10		0	
65a	5	4.000	cold		h	12.0		0.90		0	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
65a	5	4.000	cold		ub	8.0	54.00	0.60	3.90	0	
65b	4	4.000	cold		riser	0.0		0.00		0	
65b	4	4.000	cold		h	12.0		0.90		0	
65b	4	4.000	cold		h	15.0		1.10		0	
65b	4	4.000	cold		h	12.0		0.90		0	
65b	4	4.000	cold		h	18.0		1.30		0	
65b	4	4.000	cold		h	24.0		1.80		0	
65b	4	4.000	cold		h	18.0		1.00		0	
65b	4	4.000	cold		h	16.0		1.10		0	
65b	4	4.000	cold		vert el	3.0		0.20		0	
65b	4	4.000	cold		vert el	8.0		0.60		0	
65b	4	4.000	cold		bracket	10.0		0.70		0	
65b	4	4.000	cold		bracket	10.0		0.70		0	
65b	4	4.000	cold		bracket	10.0		0.70		0	
65b	4	4.000	cold		bracket	10.0		0.70		0	
65b	4	4.000	cold		vert tee	6.0	156.00	0.40	11.00	0	
65b	4	4.000	cold		h	4.0		0.30		0	
	4	4.000	cold		h	15.0		1.10		0	
	4	4.000	cold		h	15.0		1.10	0.00	0	
	4	4.000	cold		h	12.0		0.90		0	
	4	4.000	cold		ub	8.0	54.00	0.60	3.90	0	
	5	2.000	cold		pipe	0.0		0.00		0	
	5	2.000	cold		h	6.0		0.60		0	
	5	2.000	cold		h	12.0		1.20		0	
	5	2.000	cold		h	12.0		1.20		0	
	5	2.000	cold		h	15.0		1.50		0	
	5	2.000	cold		pipe	8.0	53.00	0.80	5.30	0	
	4	2.000	cold		pipe	0.0		0.00		0	
	4	2.000	cold		h	6.0		0.60		0	
	4	2.000	cold		h	12.0		1.20		0	
	4	2.000	cold		h	12.0		1.20		0	
	4	2.000	cold		h	15.0		1.50		0	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
	4	2.000	cold		pipe	8.0	53.00	0.80	5.30	0	
	5	0.750	cold		pump	0.0		0.00		0	
	5	0.750	cold		vert et	8.0		1.60		0	
	5	0.750	cold		ub	1.0	9.00	0.20	0.20	0	
	5	0.750	cold		vert hor et	3.0	3.00	0.60	0.60	0	
	5	0.750	cold		ub	8.0	8.00	1.60	1.60	0	
	5	0.750	cold		hor et	1.0	1.00	0.20	0.20	0	
	5	0.750	cold		ub	3.0	3.00	0.00	0.00	0	
	5	0.750	cold		vert et	1.0		0.20		0	
	5	0.750	cold		pump	8.0	9.00	1.60	1.80	0	
	4	0.750	cold		pump	0.0		0.00		0	
	4	0.750	cold		vert et	8.0		1.60		0	
	4	0.750	cold		ub	1.0	9.0	0.20	1.80	0	
	4	0.750	cold		vert hor et	3.0	3.00	0.60	0.60	0	
	4	0.750	cold		ub	8.0	8.00	1.60	1.60	0	
	4	0.750	cold		hor et	1.0	1.00	0.20	0.20	0	
	4	0.750	cold		ub	3.0	3.00	0.60	0.60	0	
	4	0.750	cold		vert et	1.0		2.00		0	
	1-3	3.000	hot		waLL	0.0		0.00		25	
68	1-3	3.000	hot	w	hor et	3.0		0.20		25	
68	1-3	3.000	hot	w	h	2.0		0.10		25	
68	1-3	3.000	hot	w	h	15.0		1.00		25	
68	1-3	3.000	hot	w	h	12.0		8.00		25	
68	1-3	3.000	hot	w	hor et	1.0		0.10		25	
68	1-3	3.000	hot	w	h	12.0		0.80		25	
68	1-3	3.000	hot	w	h	12.0		0.80		0	
68	1-3	3.000	hot	w	h	12.0		0.80		25	
68	1-3	3.000	hot	w	h	12.0		0.80		25	
68	1-3	3.000	hot	w	h	12.0		0.80		25	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
68	1-3	3.000	hot	w		12.0		0.80		25	
68	1-3	3.000	hot	w	stantion	6.0	115.00	0.40	7.70	25	
68	1-3	3.000	hot	w	h	6.0		0.40		25	
68	1-3	3.000	hot	w	h	20.0		1.30		25	
68	1-3	3.000	hot	w	h	20.0	46.00	1.30	1.70	0	
68	1-3	12.00	hot	w	wall	0.0		0.00		0	
69	1-3	12.00	hot	w	hor et	10.0		0.30		0	
69	1-3	12.00	hot	w	anchor	10.0	20.00	0.30	0.60	0	
69	1-3	12.00	hot	w	hor et	10.0		3.00		0	
69	1-3	12.00	hot	w	h	6.0		0.20		0	
69	1-3	12.00	hot	w	h	12.0		0.40		0	
69	1-3	12.00	hot	w	hor et	4.0		0.10		0	
69	1-3	12.00	hot	w	hor et	10.0		0.30		0	
69	1-3	12.00	hot	w	h	4.0		0.10		0	
69	1-3	12.00	hot	w	hor et	4.0		0.10		0	
69	1-3	12.00	hot	w	h	8.0		0.30		0	
69	1-3	12.00	hot	w	h	24.0		0.30		0	
69	1-3	12.00	hot	w	hor et	21.0		0.70		0	
69	1-3	12.00	hot	w	h	1.0		0.00		0	
69	1-3	12.00	hot	w	hor et	12.0		0.30		0	
69	1-3	12.00	hot	w	h	4.0		0.10		0	
69	1-3	12.00	hot	w	h	15.0		0.50		0	
69	1-3	12.00	hot	w	h	15.0		0.50		0	
69	1-3	12.00	hot	w	h	15.0		0.50		0	
69	1-3	12.00	hot	w	h	15.0		0.50		0	
69	1-3	12.00	hot	w	h	18.0		0.60		0	
69	1-3	12.00	hot		h	18.0		0.60		0	
69	1-3	12.00	hot	w	h	18.0		0.60		0	
69	1-3	12.00	hot	w	h	16.0		0.50		0	
69	1-3	12.00	hot	w	hor et	10.0		0.30		0	
69	1-3	12.00	hot	w	wall	12.0	261.00	0.30	8.70	0	
70	1-3	3.000	cold	w	ub	0.0		0.00		0	

1Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
70	1-3	3.000	cold	w	hor el	6.0		0.50		0	
70	1-3	3.000	cold	w	h	10.0		0.80		0	
70	1-3	3.000	cold	w	h	6.0		0.50		0	
70	1-3	3.000	cold	w	h	18.0		1.50		0	
70	1-3	3.000	cold	w	h	12.0		1.00		0	
70	1-3	3.000	cold	w	h	10.0		0.80		0	
70	1-3	3.000	cold	w	h	15.0		1.30		0	
70	1-3	3.000	cold	w	h	10.0		0.80		0	
70	1-3	3.000	cold	w	h	12.0		1.00		0	
70	1-3	3.000	cold	w	h	15.0		1.30		0	
70	1-3	3.000	cold	w	h	15.0		1.30		0	
70	1-3	3.000	cold	w	h	15.0		1.30		0	
70	1-3	3.000	cold	w	h	12.0		1.00		0	
70	1-3	3.000	cold	w	h	12.0		1.00		0	
70	1-3	3.000	cold	w	h	12.0		1.00		0	
70	1-3	3.000	cold	w	dc	2.0	182.00	0.20	15.20	0	
71	1-3	6.000	cold	w	dc	0.0		0.00		0	
71	1-3	6.000	cold	w	h	3.0		0.20		0	
71	1-3	6.000	cold	w	h	24.0		1.40		0	
71	1-3	6.000	cold	w	h	32.0		1.90		0	
71	1-3	6.000	cold	w	hor el	18.0		1.10		0	
71	1-3	6.000	cold	w	h	3.0		0.20		0	
71	1-3	6.000	cold	w	h	12.0		0.70		0	
71	1-3	6.000	cold	w	h	15.0	107.00	0.90	6.30	0	
72	13	12.00	hot	w	dc	0.0		0.00		60	
72	1-3	12.00	hot	w	sh	20.0		0.60		60	
72	1-3	12.00	hot	w	sh	15.0		0.50		0	
72	1-3	12.00	hot	w	sh	36.0		1.20		60	
72	1-3	12.00	hot	w	snubber	30.0	91.00	1.00	3.00	0	
72	1-3	12.00	hot	w	sh	36.0		1.20		0	
72	1-3	12.00	hot	w	dc	4.0	40.00	0.10	1.30	0	
73	1-3	4.000	hot	w	dc	0.0		0.00		60	

Line No	Unit	Pipe Size (in)	Temp	Conn Type	Support Type	Vert Span (ft)	Horia Span (ft)	Norm Vert Span (ft)	Norm Horz Span (ft)	Plant Elevation Above Grade	Remarks
73	1-3	4.000	hot	w	h	4.0		0.20		60	
73	1-3	4.000	hot	w	anchor	12.0	16.00	0.70	0.90	60	
73	1-3	4.000	hot	w	hor el	12.0		0.70		60	
73	1-3	4.000	hot	w	h	6.0		0.30		60	
73	1-3	4.000	hot	w	h	12.0		0.70		60	
73	1-3	4.000	hot	w	h	8.0		0.50		0	
73	1-3	4.000	hot	w	hor el	6.0		0.30		60	
73	1-3	4.000	hot	w	hor el	6.0		0.30		60	
73	1-3	4.000	hot	w	anchor	8.0	58.00	0.50	3.40	60	
73	1-3	4.000	hot	w	sh	8.0	8.00	0.50	0.50	60	
73	1-3	4.000	hot	w	riser	2.0	10.0	0.10	0.60	60	
74	1-3	1.000	cold	SW	dc	0.0		0.00		0	
74	1-3	1.000	cold	SW	ub	2.0	2.00	0.30	0.30	0	
74	1-3	1.000	cold	SW	hor el	2.0		0.30		0	
74	1-3	1.000	cold	SW	h	10.0		1.40		0	
74	1-3	1.000	cold	SW	hor el	1.0		0.10		0	
74	1-3	1.000	cold	SW	bracket	12.0		1.70		0	
74	1-3	1.000	cold	SW	bracket	10.0		1.40		0	
74	1-3	1.000	cold	SW	h	30.0		4.30		0	
74	1-3	1.000	cold	SW	h	18.0		2.60		0	
74	1-3	1.000	cold	SW	h	15.0		2.10		0	
74	1-3	1.000	cold	SW	hor el	6.0		0.90		0	
74	1-3	1.000	cold	SW	ub	12.0	116.0	1.70	16.60	0	
74	1-3	1.000	cold	SW	ub	18.0	18.00	2.60	2.60	0	
74	1-3	1.000	cold	SW	pipe	8.0	8.00	1.10	1.10	0	
75	1-3	3.000	hot	w	riser	0.0		0.00		20	
75	1-3	3.000	hot	w	hor el	4.0		3.00		20	
75	1-3	3.000	hot	w	hor el	3.0		0.20		20	

Notations:

csh =	constant spring hanger
cold=	design temperature equal to or less than 150°F
dc =	discontinue mapping run
h =	hanger support
hor el =	horizontal elbow
hot =	design temperature greater than 150°F
sh =	spring hanger support
sw =	socket welded connection
t =	threaded connection
ub =	u bolt support
w =	welded connection

Norm Vert Span = the horizontal span between vertical supports divided by the suggested horizontal deadweight span given in Table NF 3611.1 of ASME BPVC Code Section III

Norm Hor. Span = the horizontal span between lateral supports divided by the suggested horizontal deadweight span given in Table NF 3611.1 of ASME BPVC Code Section III

Appendix G: Burbank Power Plant

G.0 Burbank Power Plant

G.1 Plant Description

The Burbank Public Service Department presently operates two steam power plants designated the Magnolia and Olive plants with four operating units each. The plants are located on the eastern edge of the central San Fernando Valley on a flat alluvial site as shown in Figure G.1.

The total continuous net capability for both plants is currently 226 Mwe on oil and 233 Mwe on gas. Operable generating units on the Magnolia-Olive site are:

Magnolia Plant

Unit	Type	Net Continuous Capability Oil	Net Continuous Capability Gas	Installed
M-2	Steam Turbine (Combined Cycle)	-	-	1943
M-3	Steam Turbine	20 MW	20 MW	1949
M-4	Steam Turbine	28 MW	30 MW	1953
M-5	Combustion Turbine	17 MW	17 MW	1969
		76 MW*	78 MW*	

*Includes 11 MW output from Magnolia 2 when operated in combined cycle with Olive 4.

Olive Plant

Unit	Type	Net Continuous Capability Oil	Net Continuous Capability Gas	Installed
0-1	Steam Turbine	42 MW	42 MW	1959
0-2	Steam Turbine	58 MW**	60 MW**	1964
0-3	Combustion Turbine	19 MW	22 MW	1972
0-4	Combustion Turbine	31 MW	31 MW	1975
		150 MW	155 MW	

**Includes 5 MW available from the Olive 3 heat recovery steam generator. The M-3, M-4 and 0-1 and 0-2 units are of particular interest because they are steam turbine units having piping which is more characteristic of nuclear power plants and 0-3 and 0-4 were not in existence at the time of the San Fernando earthquake. The 0-2 unit includes a 55 KW turbine generator with reheat. The initial steam design pressure and temperature is 1450 psig and 1000° F. The boiler has a maximum steam capacity of 440,000 Lbs/hr.

The Magnolia and Olive Units consist of steel-framed boiler structures, concrete turbine-steam generator pedestals, and a two-story concrete masonry control building that houses the switchgear and control rooms.

G.2 Summary Description of Effects From The San Fernando Earthquake

G.2.1 Olive Plant

The Olive units were tripped off the line by the earthquake on February 9th at 0600:42. Olive No. 1 was off the line 2 hours 9 minutes. Olive No. 2 was off the line 2 hours 24 minutes.

Both Olive Plant units 01 and 02 were tripped off the line by "Differential Relay" action resulting from shaking the relay contacts together during the earthquake. Relay action automatically transferred station power to the "Start-up Transformer."

The Watch Engineer made an attempt to reset the Olive No. 1 turbine stop valve but upon returning to the control room he determined that all station power was lost. Without auxiliary power turbines slowed down. Vacuum was not broken in an attempt to prolong the roll.

G.2.2 Magnolia Plant

Both Magnolia Units No. 2 and No. 3 which were in operation at the time of the earthquake were knocked off the line as a result of the earthquake. Magnolia No. 2 was off the line 2 hours 43 minutes. Magnolia No. 3 was off the line 3 hours 28 minutes.

During the earthquake a fuel oil gage line on the boiler front at Magnolia No. 3 was broken spraying fuel oil over the boiler front and floor and through the grating down to the first floor. The resulting reduced fuel oil pressure and poor boiler ignition
convinced the Watch Engineer he had to kill M-3 boiler fires and trip the turbine.

On Magnolia No. 1 and 2 the Auxiliary Generator started. However, the draft fans and feed pumps could not be started so the boiler fires had to be killed and the turbine tripped.

The Auxiliary Generator continued to run and draw steam from the now unfired boiler so the Assistant Engineer closed the steam to the Auxiliary Turbine.

Both Magnolia No. 2 and 3 turbines were kept rolling with steam since both are equipped with steam driven oil pumps so bearing lubrication and hydraulic control of No. 3 stop valve is possible even without station power.

G.3 Time Sequence of Events Following The Earthquake

The earthquake event sequence at the Burbank Power Plants due to the San Fernando earthquake as described in Power Plant log was as follows:

DATE
2/9/71
TIME

0600 SYSTEMS

System Load - 79.0 mw.
Generation - 34.0 MW.
Intertie - 46.0 MW.

0600:42 Strong earthquake.

0602 Lost all generation, several 4 Kv. feeders and 34.5 Kv. Transmission Lines OCB's relayed open, at 0610 Burbank-Toluca Valley 69Kv .Lines were opened or relayed open at R>S>"E" only, system black.

Set-up 34.5 Kv. busses at Burbank Sub. to get auxiliary power to Olive and Magnolia plants with Magnolia Generator No. 5 on Black-out condition, but was unable to due to earthquake closing contacts on critical relays, including main transformer.

Magnolia Terry Auxiliary Generator came on automatically, but dropped off.

0605 to 0635 No communication with Los Angeles Dispatcher.

0625 Manually put Magnolia Terry Auxiliary Generator on 2500 V. Bus No. 2 and 2500 V. Bus No. 3 through 2500 V. Bus No. 4, unable to carry auxiliary equipment due to low steam pressure.

0630 Several attempts made to get Magnolia Generator No. 5 on, without success.

0635 Made contact with Los Angeles dispatcher on Bell System phone, they will get a hot line to them.

0637 Burbank-Toluca-Valley 69 Kv. Line closed at R.S. "E", auxiliary equipment at Olive and Magnolia plants energized. Started picking up 4 Kv. Feeders at Alameda, Burbank and McCambridge Subx. Burbank-Toluca-Valley No. 1 69 Kv. Line loaded up to 40.0 MW.

0713 Cleared all 4 Kv. ACB's at Pacific Sub., bad regulators threw oil over entire rack.

0720 Energized NBC Sub.

0727 Los Angeles Dispatcher says to reduce draw at R.S. "E" to 5.0 MW Hoover, started opening 4 Kv. Feeders. Draw at R.S. "E" 33 MW.

0731 Made attempt to start Magnolia Generator No. 5, aborted.

0745 Closed Burbank-Toluca-Valley No. 2 69 Kv. Line at R.S. "E".

0749 Los Angeles Dispatcher says we are still overdrawing, we told Los Angeles Dispatcher we were getting our

	generators on line and would reduce draw to 5.0 MW Hoover.
0752	Draw at R.S. "E" reduced to 5.0 MW.
0757	Olive Generator No. 1 on line.
0800	Started picking up load as generation would permit.
0836	Olive Generator No. 2 on line.
0845	Magnolia Generator No. 2 on line.
0930	Magnolia Generator No. 3 on line.

G.4 Earthquake Damage Summary

G.4.1 Olive Plant, Units 1 and 2

Several relays tripped during the earthquake, taking both of the Olive units off line. According to the plant's trouble report, the two units were tripped by the action of one or more differential relays located on the main control panel on the second floor of the control building. Station power was still available at this time. Relay actuation caused the main steam stop valve to close in Unit 1. The watch engineer left the control room and reset the valve, returning the flow of steam to the turbine. At about this time, however, the two units lost their normal supply of station power front the outside grid. An attempt was made to supply station power to the Olive units by starting the Magnolia gas peaking unit; however, tripped relays on the control panel prevented immediate start-up. Station power was lost for about half an hour until substation relays were reset in the Los Angeles power grid and station power returned from the outside. The furnaces of the two Olive units were purged, and the boilers were relit about an hour after the earthquake.

G.4.1.1 Damage to Piping

The following piping and related damage was noted at the Olive Plant:

1. A broken valve and pipe at the demineralizer tank
2. A broken front center-line guide on the Unit 2 boiler casing located at the top of the boiler structure.

The demineralized tank and attached piping that sustained damage in the earthquake are shown in Figure 2-4 of Appendix B of Reference G.1 and Figure 22 of Reference G.2.

G.4.2 Magnolia Plant, Units 1 through 5

Magnolia Units 2 and 3 were on line at the time of the earthquake and remained on line throughout the earthquake. A 1 1/2 inch fuel-oil gage line as shown in Figure 4.22 of Volume 1 ruptured in Unit 3, spraying oil on the front face of the furnace and on the surrounding floor. This caused a drop in the fuel-oil pressure to the burners.

After the earthquake, the system load from the outside grid began to increase the demand on the power generating stations remaining on line. This increased load on the small Magnolia units began to exceed their generating capacity. The increasing demand, combined with the reduced fuel-oil pressure and difficulty in maintaining proper builder combustion and steam pressure convinced the watch engineer that he had to manually trip both units of the Magnolia plant off line. All power to the station was lost. An attempt was then made to start the Magnolia Unit 5 gas peaking plant to supply the plant with power, but tripped relays prevented start-up. The main turbines on Magnolia Units 2 and 3 were kept rolling since they were equipped with steam-driven lubrication oil pumps supplied front eh residual steam in the boilers. About half an hour after the earthquake, station power was restored front eh outside grid. A few minutes later, plant engineers discovered the tripped relays on the Magnolia Unit 5 controls, reset them, and started a gas turbine fired peaking plant. Magnolia Units 2 and 3 were brought back on line about three hours after the earthquake.

G.4.2.1 Damage to Piping

The following piping and related damage was noted at the Magnolia Plant.

1. The demineralized-water tank in the plant yard was not anchored and shifted, breaking attached piping connections at near the base of the tank (see Figure 2-5 of Appendix B of Reference G.1 and Figure 23 of Reference G.2.

2. A fuel-oil gage line in Unit 3 broke (see Figure G.2).

3. A 2-inch-diameter pipe connecting to the Unit 3 main cooling-water line cracked. The plant operators thought this crack resulted in a minor leak since it did not impair restarting the plant.

4. The plant's demineralized cation tank shifted on its supports.

G.5 Seismic Design Basis of Piping

The Olive and Magnolia Units plant structures were designed for an equivalent static horizontal force of 0.20g. The design of equipment in the plant included no particular seismic design considerations other than normal floor anchorage based on operating requirements.[1] Piping is primarily rod-hung for dead-weight support only. Generally, no provision for lateral restraint of piping was found.

The technical specification used for procurement of piping for the most recent steam turbine plant (Olive 2, 1964) is shown in Appendix C. It should be noted that the piping contractor was to supply all hangers, supports etc. to ASME B31.1, MSS SP-58 and AISC requirements. No mention was made of seismic requirements. The line list for the Olive 2 Unit is shown in Table 4.3 of Volume 1 of this report.

G.6 Seismic Demand From The San Fernando Earthquake

The Burbank Power plant is located about 14 miles from the epicenter of the San Fernando earthquake and about 4 miles from the causative fault. The estimated peak horizontal ground acceleration at the plant site was 0.35 g in the east-west direction and 0.29g in the two horizontal directions and 0.14g in the vertical direction. The plant is also supported by Alluvium. The 0.28g PGA was scaled in the same ratio. The closest recorded time history motion and resultant ground response spectra demand for various values of damping in a nominal N-S, E-W and Vertical direction applicable to the Burbank Power Plant Site was recorded at 633 E. Broadway, Glendale is shown in Appendix C.4 of Reference G.3.

G.7 References

(G.1) NRC Seismic Design Task Group and Stevenson and Associates, Report of the U.S. Regulatory Commission Piping Review Committee, "Summary and Evaluation of Historical Strong Motion Earthquake Seismic Response and Damage to Above Ground Industrial Piping," NUREG 1061 Vol. 2 Addendum, April 1985.

(G.2) Yanev, P.I. and Swan, S.W., "Pilot Program Report, Program for the Development of an Alternate Approach to Seismic Equipment Qualification," Vol. I Prepared for Seismic Qualification Utilities Group, by EQE Inc.

(G.3) Yanev, P.I. and Swan, S.W., "Pilot Program Report Appendices, Program for the Development of an Alternate Approach to Seismic Equipment Qualification," Vol. II Prepared for Seismic Qualification Utilities Group, by EQE Inc.

[1] Normally any rotating or reciprocal operating equipment would be bolted down in order to resist starting torques or reactions during normal operation. Such positive anchorage would normally be sufficient to resist earthquake effects up to a level to cause significant structural damage and failure of the building structure supporting and housing the equipment.

Figure G.1 Burbank Power Plant - Olive and Magnolia Units

Appendix H: El Centro Power Plant

H.0 El Centro Power Plant

H.1 Plant Description

H.1.1 Introduction

The El Centro Power Plant is the principal electric power generating facility of the Imperial Irrigation District. The facility consists of four units that burn oil or natural gas. Units 1, 2, and 3 were designed by Gibbs and Hill, and were built in 1949, 1952, and 1957, respectively. Unit 4 an 80-MW facility designed by The Fluor Corporation, Ltd. was built in 1968. Figure H.1 is a plot plan of the four units and associated fuel storage tank, cooling towers and transformer yard. In this evaluation most of the available information relates to Unit 4.

When Unit 4 was added, the existing station building was extended southward by adding three 31-ft bays. There are no E-W walls between the units. A 2.75 ft space between the last column line of Unit 3 and the first column line of Unit 4 was provided to allow for possible differential settlement. Thus, total southward extension was 95.75 ft. Figure H.2 is an elevation view that shows the three added bays of Unit 4.

In the E-W direction, the width of each bay as well as the overall width of Unit 4 were made the same as those for the existing building. From east to west these widths are 30 ft (service bay), 55 ft (central or turbine bay), 25 ft (heater bay), and 18 ft (auxiliary bay), for a total of 128 ft. The boiler structure, from which the boilers are suspended, extends an additional 76.5 ft westward from the building proper, for an overall E-W width of 204.5 ft as shown in an elevation view in Figure H.3.

The heights of the service and turbine bays for unit 4 were the same as for the existing units. The operating floor remained at 20 ft above grade. The height of the heater and auxiliary bays were increased to suit the requirements of the new equipment. The existing control room for Unit 3 was extended 34 ft southward to serve Unit 4. A new air conditioning system was installed to serve the requirements of the larger control room and to provide make-up cooled air. The existing passenger elevator located at the southwest corner of Unit 3 provides access to the roof and the upper platforms of Boiler No. 4. This plant description was extracted from References H.1 and H.2 which contain additional description information.

H.1.2 Foundation Media

The soil at the El Centro Power Plant site consists of very deep alluvial deposits composed primarily of stiff to hard clay underlain with lamination of silty clay loam and sandy loam. Several sources of data were used to estimate the shear wave velocity to be used in calculating the soil stiffness:

- Dames & Moore report (H.3) indicates a shear strength of around 1500 psf.

- USGS report on the differential array gives average shear wave velocities as a function of depth (H.1, H.4).

- NUREG-0029, Vol. 1 (H.5) which indicates a shear wave velocity of about 650 ft/s at 10^{-2} percent shear strain. These tests were for the soil at the Imperial Irrigation District Terminal Station located at the corner of Commercial Avenue and Third Street in El Centro, approximately 1 km from the plant.

In Ref. H.1 it was concluded that a shear wave velocity of 650 ft/s is representative of the site foundation media. This value is based primarily on the in-situ impulse test on soil conditions deemed representative of the plant. It represents an average value to a depth equal to the width of the foundation.

H.1.3 Foundation

The three main structures of Unit 4 the turbine building, the boiler support tower, and the turbine-generator pedestal are founded on a single 12.2-ft-thick hollow honeycomb-like reinforced concrete foundations can be seen in Figures H.2 and H.3. The foundation of Unit 4 is structurally independent from the foundations for the other three units. The plan dimensions of the foundation are approximately 96 ft by 207 ft. The bottom slab is 18-in. thick and rests atop unexcavated ground at El. 936.8 ft. The top of the foundation is at El. 949 ft, which corresponds to the existing site grade level. The top slab consists of 7-in.-thick pre-cast concrete panels supported on a girder system and interlocked by a 5-in.-thick topping slab that serves as the ground floor. The increased column spacing and heavier loads for Unit 4 as compared to Units 1, 2, and 3 required thicker shear walls (honeycomb web members) in the foundation.

H.1.4 Principal Structures

The turbine building structure of Unit #4 consists of eight moment-resisting structural steel frames and three reinforced concrete shear walls. The shear walls are cast monolithically with the exterior steel frames on the east, west, and south sides of the building. Within the turbine building, in addition to the ground level slab at El. 949 ft, there is an operating floor at El. 998.7 ft.

The boiler support tower of Unit #4 has three braced frames and one combination braced and moment-resisting frame that is shared with and forms a contiguous connection to the turbine building at column line G between lines 15 and 16. The boiler house extends an additional 45 ft above the turbine building to El. 1045 ft. The boiler is hung from the top of the boiler house by steel rods. Lateral restraint for the boiler is provided by rigid bumper stops at various elevations throughout the boiler house.

A reinforced concrete pedestal supports the turbine-generator. The pedestal's eight columns form three bays in the N-S direction and one bay in the E-W direction. The pedestal is isolated from the building at the operating floor level by a 1-in. gap.

H.1.5 Other Structures

Each of the first three units of El Centro power plant has a gunite-lined steel stack supported on an independent concrete foundation. The unlined Unit 4 stack is supported on a steel braced frame with later support provided by the boiler structure.

There are six unanchored, fixed-roof fuel flat bottom oil storage tanks at the site as shown in Figure H.1. One, two and three tanks have a capacity of 15,000 barrels (1 barrel equals 42 gal of petroleum) each; tanks 4 and 5 can hold 45,000 barrels, each; No. 6, the largest, can hold 115,000 barrels, and is 135 ft in diameter and about 45 ft high.

H.2 Summary of Effects from the El Centro-1979 Earthquake on the El Centro Power Plant

On October 15, 1979, at 4:16:55 p.m. (PDT) an earthquake shook the Imperial Valley of California. The earthquake had a Richter magnitude M_L of 6.6. The epicenter was on the Imperial Fault, 16 km east of Calexico. Three after-shocks that exceeded magnitude $M_L = 5$ occurred about 6.5, 7, and 7.5 hours after the main shock. There was no loss of life in this sparsely populated agricultural area, but there was some property damage and extensive damage to irrigation canals and subsurface drain tiles.

When the earthquake occurred, Units 3 and 4 of the four-unit dual oil and gas fired El Centro Steam Plant were operating. Units 1 and 2 were shut down for maintenance. The operating units tripped off line when station power was lost because of a short circuit resulting from a broken insulator in a lightning rod in Unit 1. Unit 3 was restored to service within 15 minutes after the main shock. Unit 4 was restored to service within 2 hours. Much of the time was spent by plant personnel inspecting for damage.

There was some minor damage to the facility; however, the two operating units safely shut down with no known malfunctions of electrical control and instrumentation equipment during or after the earthquake. The most notable damage occurred at Units 3 and 4, which developed leaks in the cooling water piping for the hydrogen cooler and the exciter cooler. The leaks occurred in locations weakened by corrosion. The piping is made of 3- and 4-in. diameter welded carbon steel pipes with some threaded and unthreaded couplings. By expedient plugging of leaks, Unit 3 was kept in service. Unit 4 was removed from service at 9:40 p.m. that evening to make repairs.

H.2.1 Structures, Mechanical and Electrical Equipment and Vertical Tanks

Descriptions of the earthquake effect on structures, mechanical and electrical equipment can be found in Ref. H.1.

H.2.2 Piping

No high temperature or high pressure piping failed during the earthquake. However, a Victaulic coupling on a straight section of a 2-in. diameter cooling water line was damaged as shown in Figure 9 of Ref. H.1.

Additionally, 4-in. diameter hydrogen cooling water lines in Units 4 failed in straight runs in areas which had been either weld repaired or at the time of the earthquake excessively corroded as shown in Figure 37 of Ref. H.2 and Figure 4.26 of Volume 1 of this report. Circumferential cracks in these corroded lines, apparently caused by the earthquake, were observed; however, leakage was minimal since the cracks were later found to be essentially closed.

Another piping failure resulted from movement of an unanchored pumphouse filter in Units 1 and 2. Movement of the filter caused failure of a small threaded pipe.

The yoke of an air-operated valve on a steam-supply line to the evaporator failed as shown in Figure 37 of Ref. H.2. It was located on the mezzanine, above the turbine deck. The yoke failure was attributed to repeated impact of the valve operator with an adjacent girder.

General observations indicate that the piping systems are hung in a more flexible manner than that which would be required by current NRC criteria. For example, the Unit 4 main steam line moved about 1.5 inch, impacting a structural steel member and denting its insulation. A lateral snubber, which was about 6 feet away, may not have been operable.

The circulating water lines are buried and are concrete/bell and spigot with 0-rings in diameters of 36 in., 40 in., 48 in., and 60 in. for Units 1-4, respectively. No evidence of failure or excessive leakage of these underground pipes was observed.

H.3 Summary of Effects from the Superstition Hills Earthquake of November 24, 1987 on the El Centro Power Plant

Following the November 24, 1987, Superstition Hills earthquake, power to most of the Imperial Irrigation District customers was lost due to the failure of elevated high-voltage lines. Ninety-five percent of power was restored about 20 minutes after the earthquake struck, with four or five downed conductors impeding full resumption. Only Unit 3 of the four-unit El Centro Steam Plant was on line when the magnitude 6.0 earthquake struck at 5:16 A.M. The unit was taken off line to permit a damage inspection. It was put back on line at 5:52 A.M.

H.3.1 Damage to Piping

A minor leak opened in a 1 inch pipe line where a threaded joint connected to the Unit 2 deaerator tank as shown in Figures 4.23 and 4.24 of Volume 1 of this report. This failure was probably caused by the effects of corrosion at the threaded joint connection. Insulation on a steam line in Unit 4 was dented by an adjacent pipe. The unit had been in operation during the 1979 earthquake when interaction of the same two lines had caused a similar dent.

H.3.2 Additional Earthquake Damage

Local collapse occurred in two areas of the roof of the 45,000-barrel-capacity No. 4 fuel-oil storage tank. This unanchored vertical tank, 250 feet in diameter by 40 feet tall, was 75 percent full at the time of the earthquake. The tank shifted approximately 1/8-inch to the southwest. No wall buckling or wrinkling was noted. Plant personnel indicated that this was the only tank that did not sustain heavy roof damage during the 1979 earthquake.

Seismic stops on the east and west sides of the Unit 4 boiler buckled. Similar damage had occurred in the 1979 earthquake.

H.4 Seismic Design Basis of Piping

According to the engineering-design and construction completion report by Fluor Corporation (H.6), the original seismic design of Unit 4 as follows:

"The architectural and structural treatment of the building, with minor modifications dictated by variations in size and arrangement of equipment, was carried out in general conformity with criteria established for the previous three units. The building frame was of the rigid frame structural steel type of design. The framing was designed to handle specified loads and to resist stresses from earthquake shocks equivalent to a horizontal force of 0.2 of live and dead weights supported. It was assumed that this force was applied to the center of gravity of the live and dead weights, and then transferred to the structure and foundation."

The equipment procurement specifications read:

"The area is also subject to seismic disturbances, and all equipment supplied shall be designed to resist seismic forces of 0.2g magnitude."

H.5 Seismic Demand from the Imperial 1979 Earthquake

The dynamic characteristics and seismic demand requirements for the El Centro Steam Plant Unit 4 are perhaps the most thoroughly studied for a fossil power station to as yet appear in the literature.(H.1, H.2)

A significant set of time history accelerometer records was obtained for the Imperial 1979 earthquake from a 13-recording station local array that was located transverse to the Imperial fault through the town of El Centro. The time history motion (base line corrected) closest to the El Centro Steam Plant recorded by USGS station No. 5165 which was located at ground level in an instrument shelter at coordinates 32.796 N and 115.535 W is less than one half kilometer from the El Centro Power Plant as shown in Figure H.4.. It should be noted that the recording instrument was located on a relatively small concrete pad which is atypical of the location of most seismic strong motion recording instruments. Such instruments historically have been located on much larger building foundations. The larger mats are thought to have a smoothing effect on earthquake motions in much the same way large ships have less response to sea waves than do smaller ships. In order to compensate for this mat size effect it is suggested that the acceleration values shown in Figure H.5 should be multiplied by a 0.6 factor.

In Ref. H.1 7 percent damped ground spectra based on the VSGS station No. 5165 recorded time history motions for the nominal N-S, E-W and vertical directions were developed as shown in Figures H.5a, b and c respectively. In addition the El Centro Unit #4 building structures were dynamically modeled as shown in Figure 21 of Ref. H-1. Floor response spectra shown in Figures 3, 4 and 5 of Ref. H.1 were also developed for selected building locations as shown in Ref. H.1.

H.6 Seismic Demand from the Superstition Hills Earthquake of November 24, 1987

In Figure H.4 is also shown the location of the strong-motion recording accelerometers station in close proximity to the El Centro Steam Plant which recorded the Superstition Hills earthquake. This recording station is CSMIP Station 01335 and is located at the Imperial County Center in the free field at 9th and Main St. El Centro within 0.75 miles of the El Centro steam plant. In Figures H.6 is shown the time history motion recorded (base line uncorrected) in El Centro from the November 24 Magnitude 6.0 event at CSMIP Station 01335.

Response spectra from the Superstition Hills earthquake time history acceleration recordings have not been generated. Peak ground acceleration at the plant is estimated to be the same as at the CSMIP Station, namely 0.36g maximum horizontal component and 0.13g vertical.

H.7 References

(H.1) Murray, R.C. et.al., "Equipment Response at the El Centro Steam Plant During the October 15, 1979 Imperial Valley Earthquake," NUREG/CR-1665 Prepared for the U.S. Nuclear Regulatory Commission, October 1980.

(H.2) Yanev, P.I. and Swan, S.W., "Pilot Program Report, Program for the Development of an Alternate Approach to Seismic Equipment Qualification," Vol. 1 Prepared for Seismic Qualification Utilities Group, by EQE Inc.

(H.3) Dames & Moore, "Report of Soil and Foundation Investigation, El Centro Steam Station and Switching Station, El Centro, California," (1946).

(H.4) Bycroft, G. Noel, "El Centro California Differential Ground Motion Array," USGS Open-File Report No. 80-919 (1980).

(H.5) Shannon & Wilson, Inc., and Agbabian Associates, "Geotechnical and Strong Motion Earthquake Data from U.S. Accelerograph Stations, Ferndale, Cholame, and El Centro, California," NUREG-0029 (1976) Vol. 1.

(H.6) The Fluor Corporation, Limited, "Engineering - Design and Construction Completion Report for the Imperial Irrigation District El Centro Steam Plant 80 MW Unit No. 4," Los Angeles, California (1968).

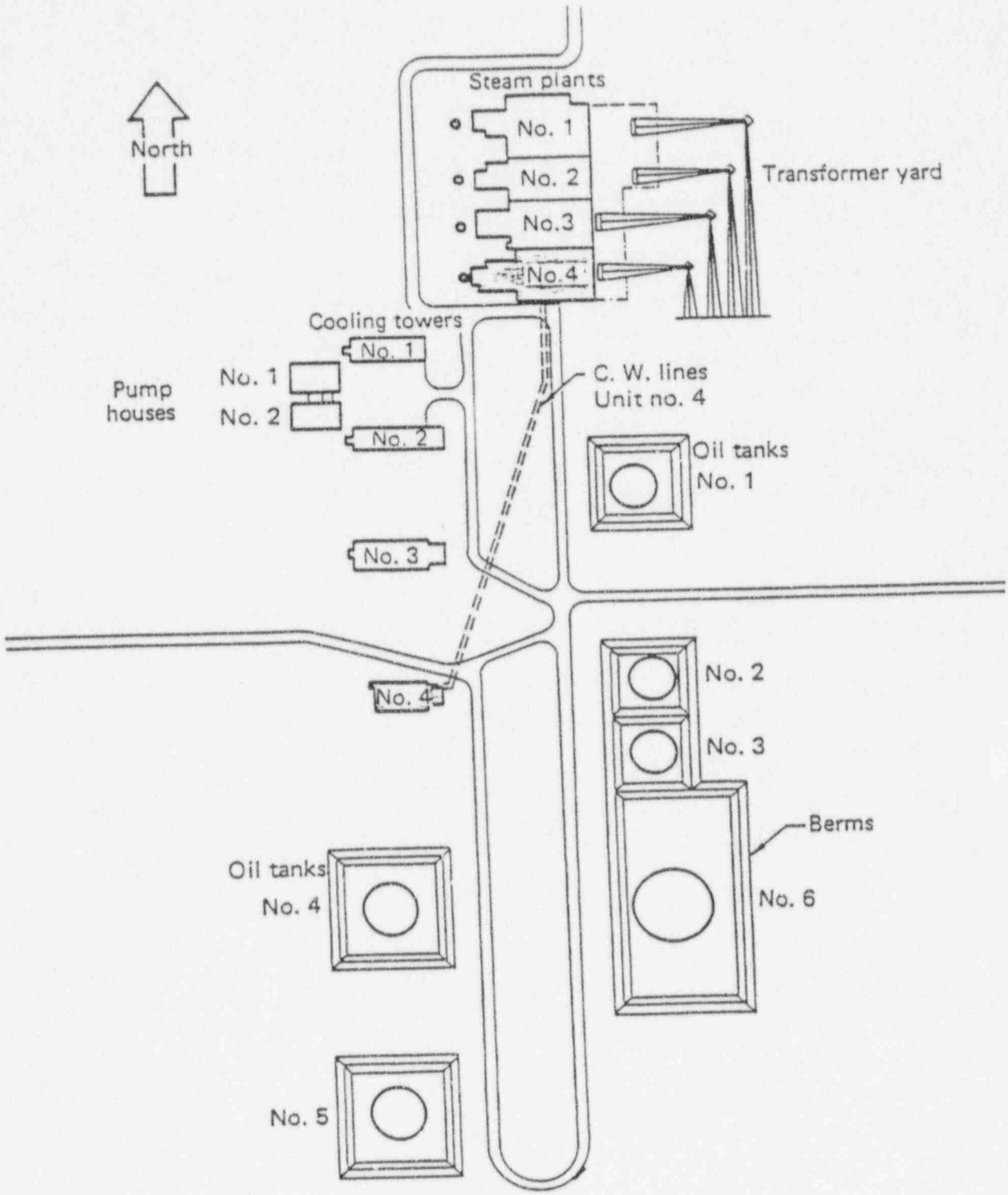


Figure H.1 Plot plan El Centro Steam Plant

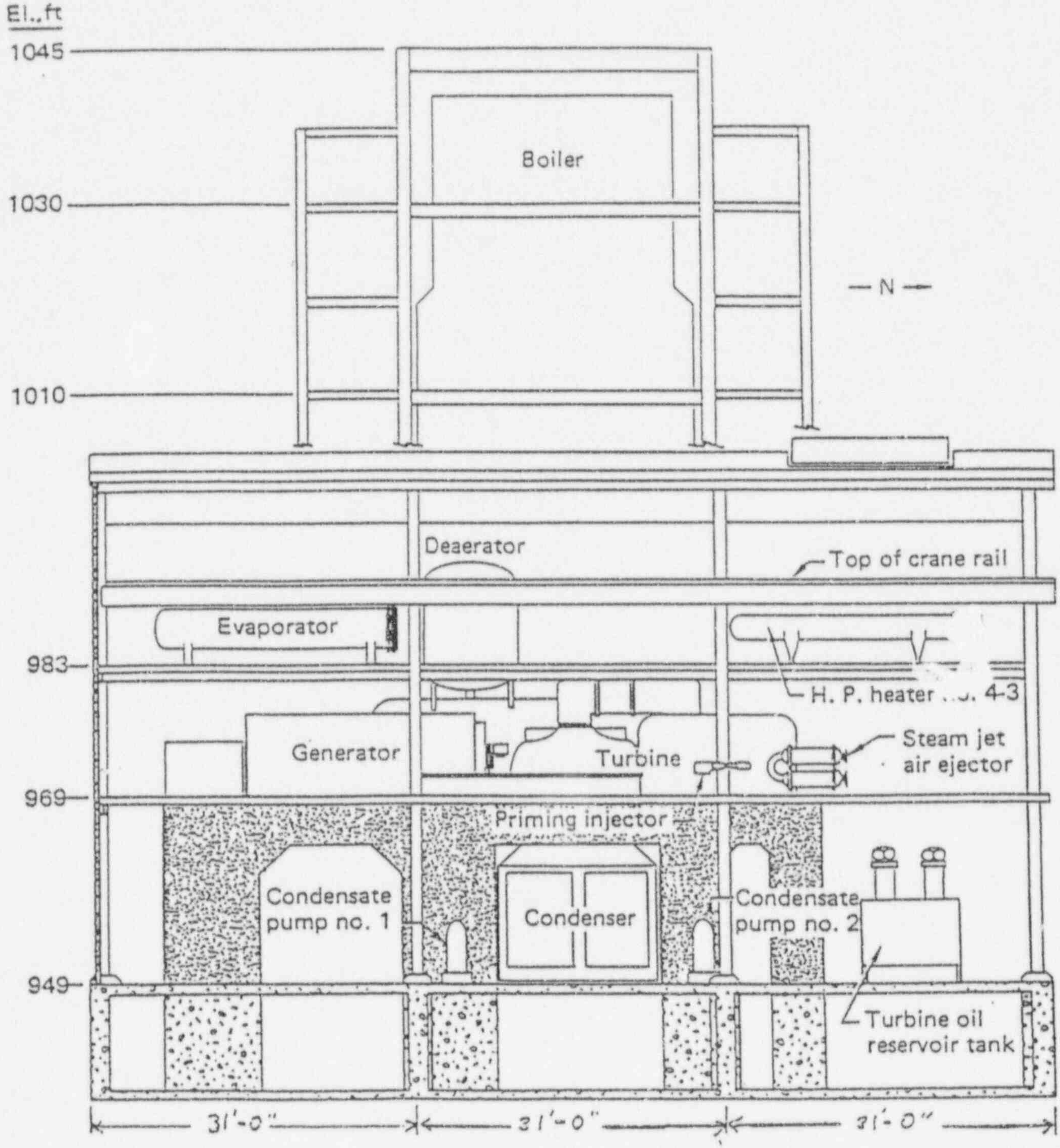


Figure H.2 N-S Elevation View of El Centro Unit 4

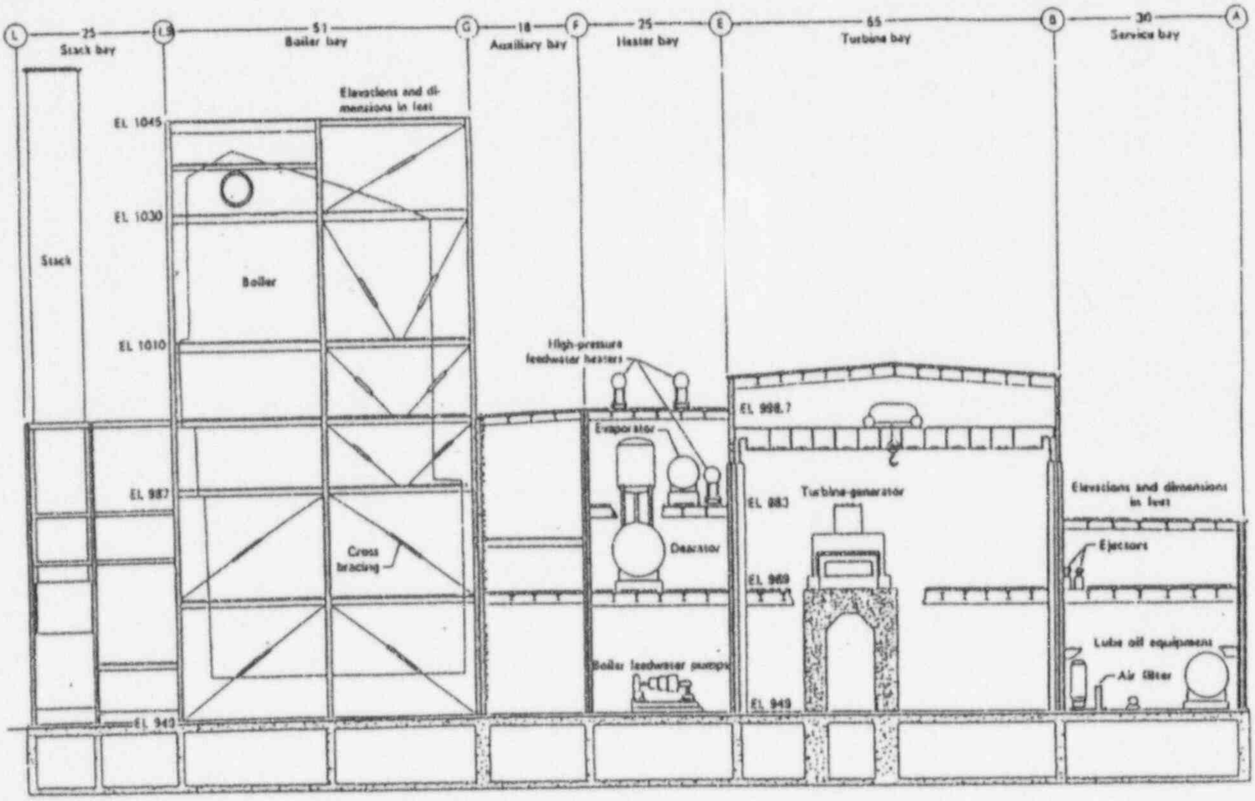


Figure H.3 E-W Elevation View of El Centro Unit 4

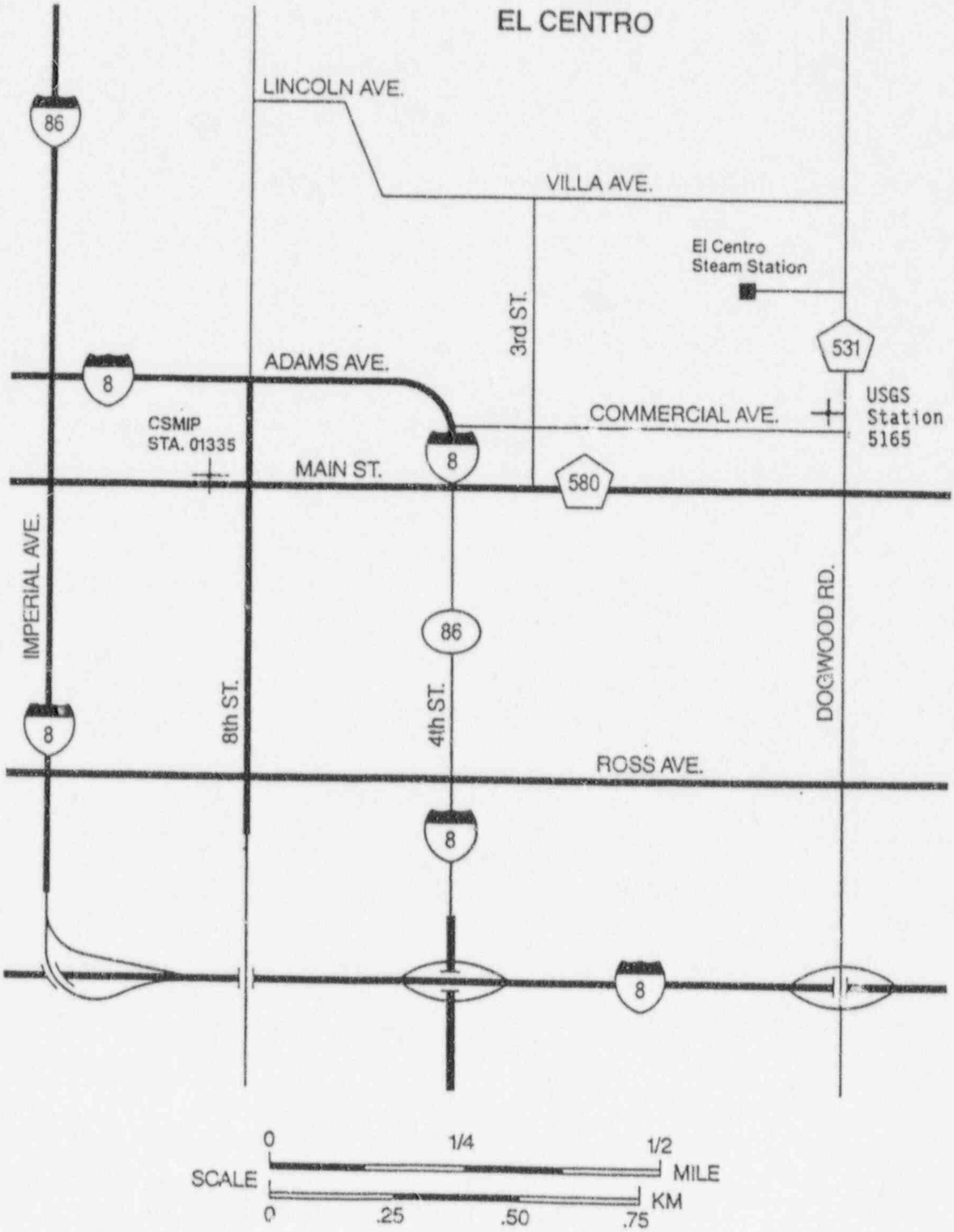


Figure H.4 Map of El Centro Showing Location of Recording Station CSMIP Station 01335 and USGS Station 5165 Relative to the El Centro Steam Station

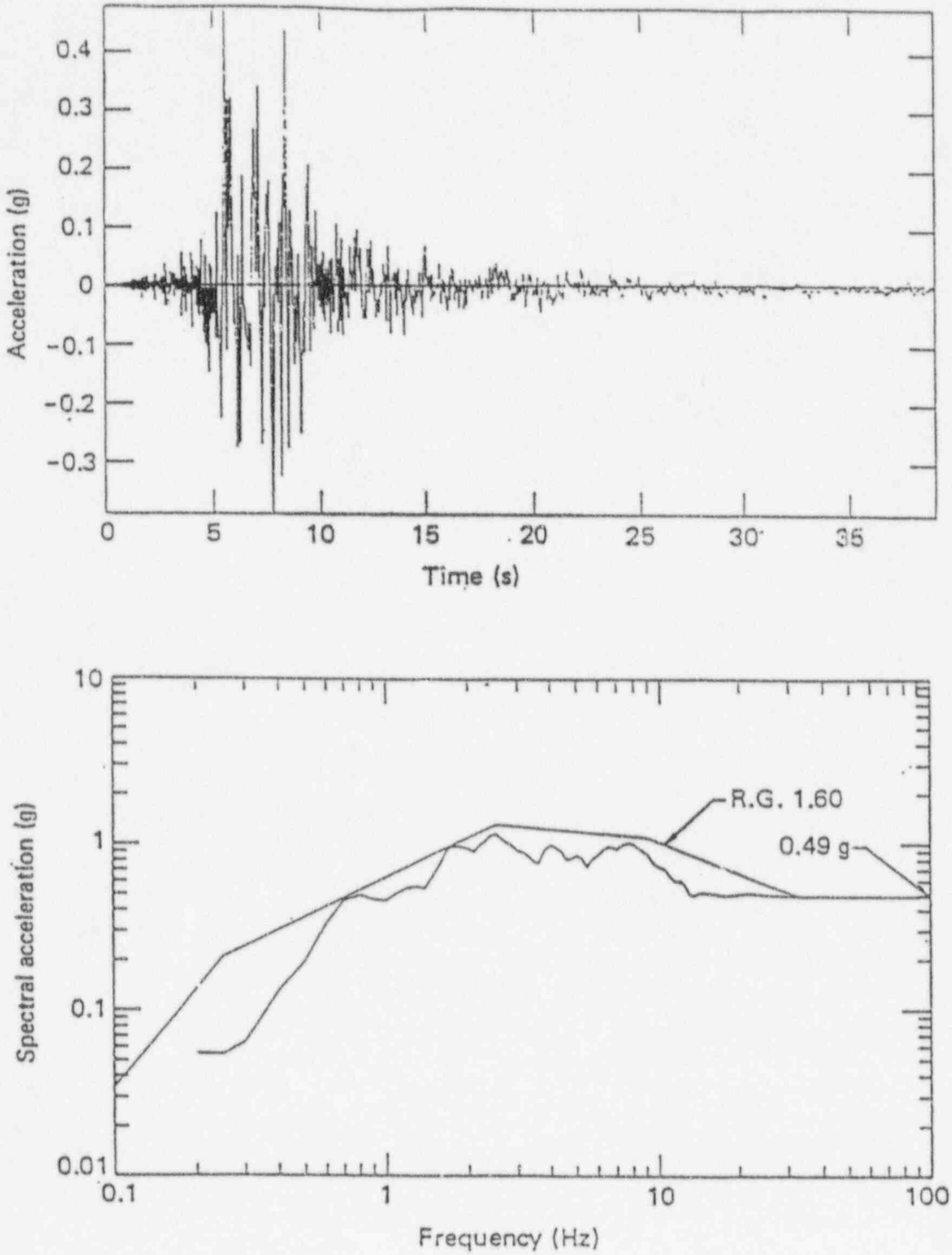
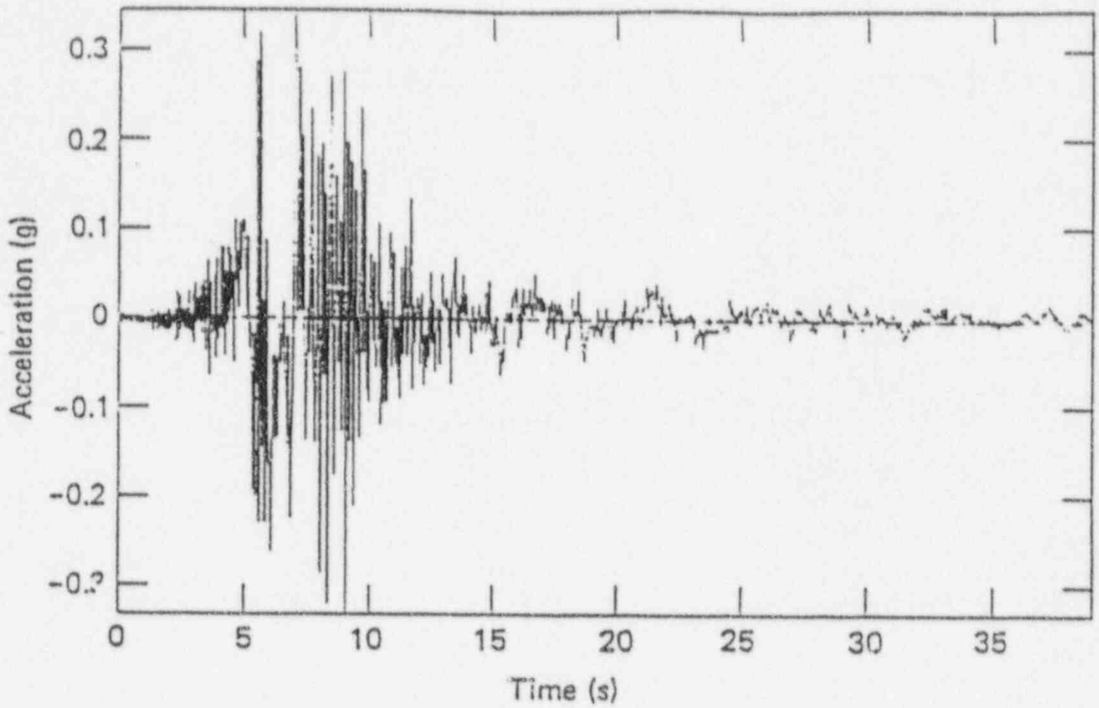


Figure H.5 (a) Recorded Time-History and Resultant Response Spectra at the VSGS Station No. 5165 Due to 1979 Earthquake in N-S Direction



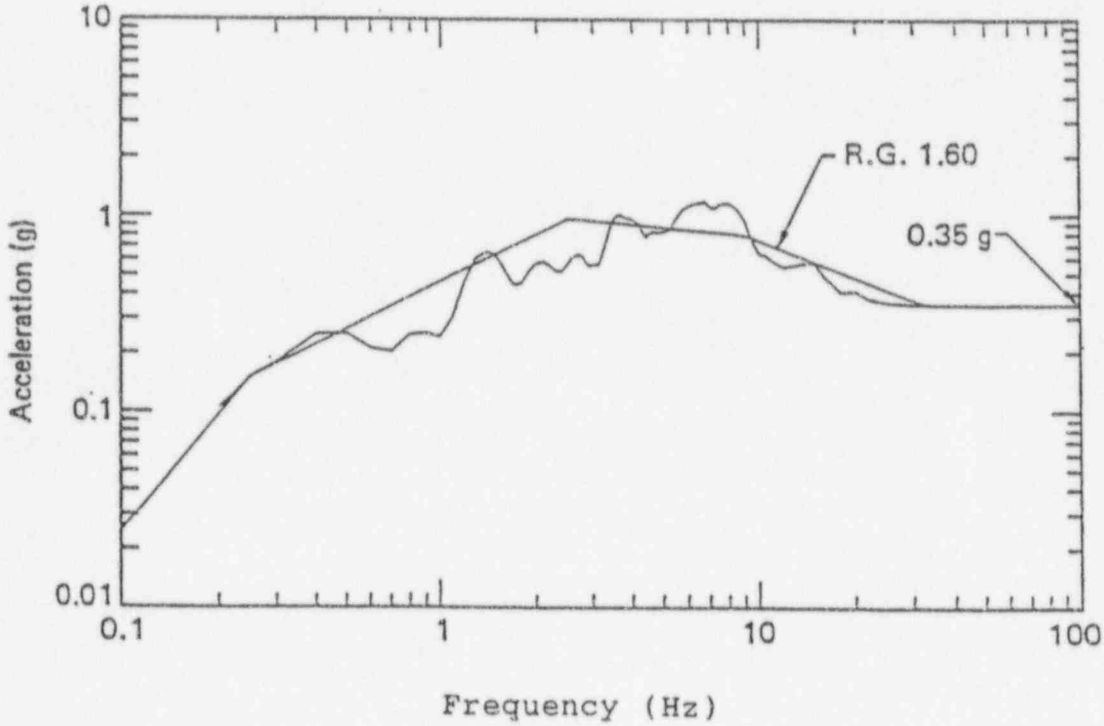
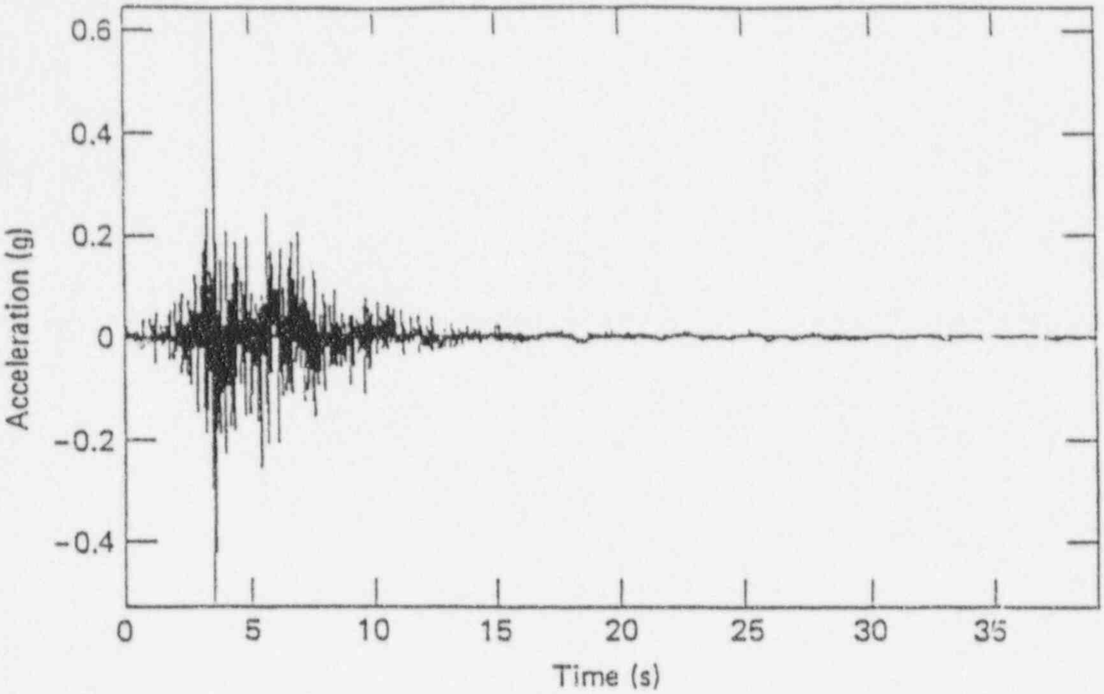


Figure H.5 (b) Recorded Time-History and Resultant Response Spectra at the VSGS Station No. 5165 Due to 1979 Earthquake in E-W Direction



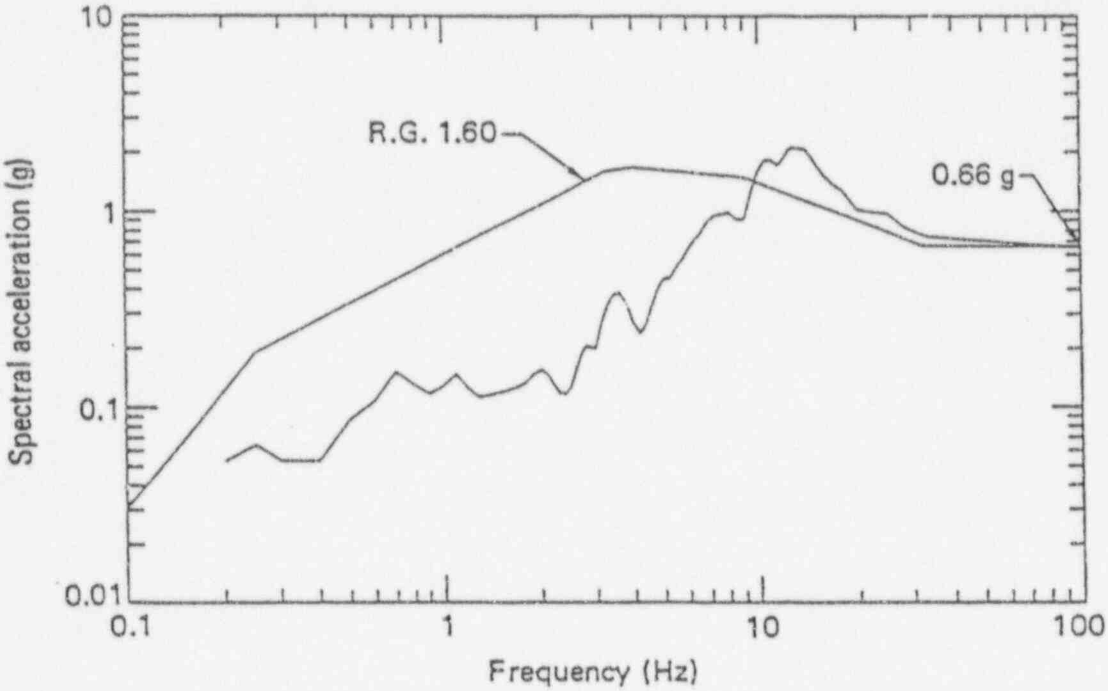


Figure H.5 (c) Recorded Time-History and Resultant Response Spectra at the VSGS Station No. 5165 Due to 1979 Earthquake in Vertical Direction

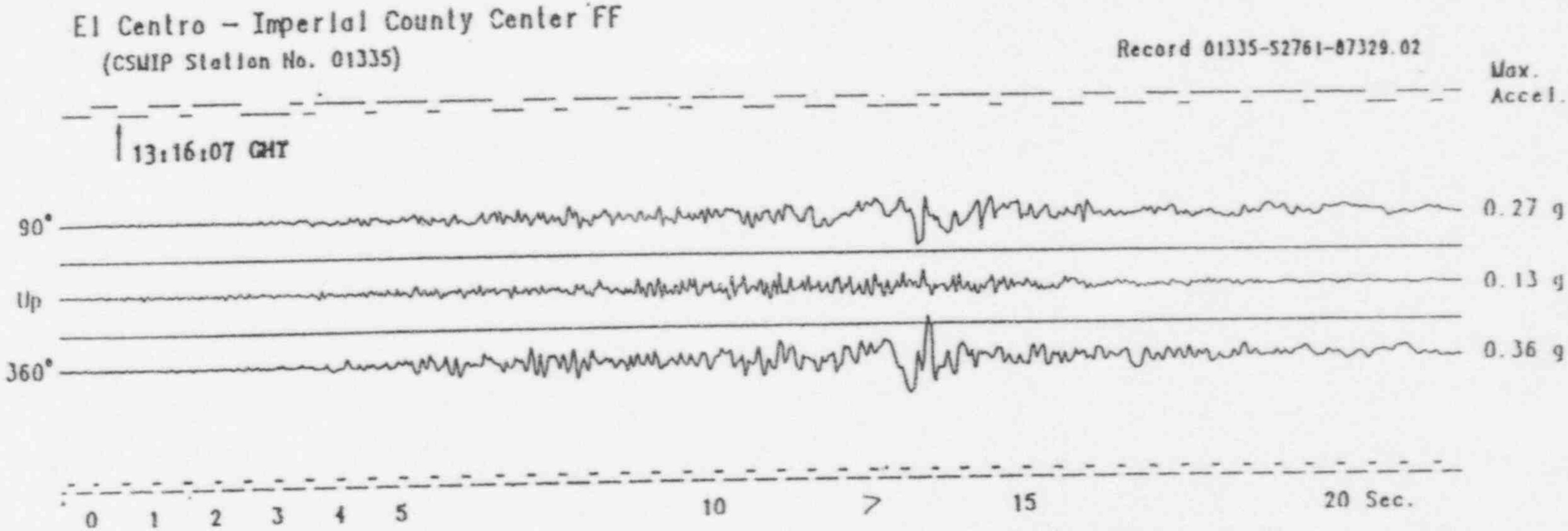


Figure H.6 Recorded Time-History at CSMIP Station No. 01335 Due to 1979 Earthquake

Appendix I: Glendale Power Plant

I.0 Glendale Power Plant

I.1 General Description

The Glendale Power Station is owned and operated by the City of Glendale. It is located on the southern edge of the San Fernando valley on the west side of Interstate Highway 5 in a flat area of recent alluvia on the north bank of the Los Angeles River. The plant currently consists of 8 units, 5 of which were installed at the time of the San Fernando earthquake in 1971. The basic data for these 5 stations is summarized as follows:

Duel Fired Gas and Oil Steam Turbine Generators

	No. 1 Unit	No. 2 Unit	No. 3 Unit	No. 4 Unit	No. 5 Unit
Date Installed	1941	1947	1953	1959	1964
Name Plate KW	20,000	20,000	20,000	44,000	44,000
Steam Pressure	600 lb.	600 lb.	850 lb.	1250 lb.	1250 lb.
Turbine Manuf.	G.E.	G.E.	G.E.	G.E.	G.E.
Steam Boiler Manuf.	Combustion Engineering	Combustion Engineering	Babcock & Wilcox	Riley Stoker	Riley Stoker

All five units of the plant are housed in a continuous building, which consists of a large concrete basement and operating floor that supports steel-framed boiler structures similar in layout and appearance as shown in Figure I.1. None of the units employ reheat. The turbine operating floor is located about 6 feet above grade which is closer to grade than any of the other power stations surveyed.

I.2 Summary of Recorded Effects from the San Fernando Earthquake

Units 3, 4, and 5 were in operation at the time of the earthquake and they continued to operate and to generate power during and after the earthquake. One and one-half hours after the earthquake, all three units were tripped because of system disturbances in the Los Angeles area grid. Units 3 and 4 were brought back on line 2 minutes later; Unit 5, nine minutes later.

I.3 Time Sequence of Events Following the Earthquake

The earthquake event sequence at th[illegible]ndale Plant due to the San Fernando earthquake a[illegible]escribed in the Power Plant log was as follows:

0600 - **City of Glendale system 58 NHW**

A. Steam generation 27 NMW.
B. Hydro generation 31 NMW.

0600 - **Turbo-alternators in service.**

A. No. 3 Unit @ 4 MW--on load block control.
B. No. 4 Unit @ 13 MW--on load block control.
C. No. 5 Unit @ 12.5 MW--on load block control.

1.Load Limit settings.

a. No. 3 Unit @ 12.
b. No. 4 Unit @ 29.
c. No. 5 Unit @ 33.

2. Boilers in service.

a. #1-A & 2 Boilers--pilot fire--gas fuel.
b. #3 Boiler--gas fuel.
c. #4 Boiler--oil fuel.
d. #5 Boiler--gas fuel.

(1) Gas fuel schedule--A-3.

0601 - **Earthquake.**

A. Received load block trip alarm on:

1. #4 Unit and #5 Unit.

a. #3 Unit on load block control.

B. Received primary alarm:

1. #1 Bank differential (#1 Unit off the line).
2. Glendale-Rossmoyne & Glendale-Grandview No. 34.5 KV lines relayed.
3. Glendale-Howard North & South, Glendale-Western 34.5 KV lines remained in service.
4. Glendale-Grandview South, Glendale-Acacia East & West, Glendale-Fremont North & South 34.5 KV lines relayed at their respective stations.
5. Potential relay targets: #2 Unit left (off the line), #3 Unit both, #4 Unit left, #5 Unit left.
6. Nos. 3, 4, & 5 Units stayed on the line, including auxiliary power.

C. High frequency.
1. Push back to receiving Station "E" approximately 14 MW.

a. Readjustment of units' output.

(1) #3 Unit--5Mw.
(2) #4 Unit--5 MW.
(3) #5 Unit--5 MW.
Total 15 gross MW.

0610 - Systems separation.

A. Reverse power to Receiving Station "E" 23 NMW.

1. Reverse power relay at Western @ 58.5 Hertz (-6 MW to -23 MW).

0611 - Messrs. Miller and Taylor arrived at steam plant.

A. Mr. Miller contacted Mr. Lou Barreli, Glendale Chief Substation Operator, asking him to pick up 34.5 KV transmission lines to other sub-stations.

0630 - No. 4 Unit on frequency control.

A. Glendale-Rossmoyne and Glendale-Grandview North 34.5 KV line O.C.B.'s closed at steam plant.

0715-0729 - An attempt to automatic synchronize by Howard Sub-station (system 65 MW).

A. Howard Sub-station operator contacted Station "E" requesting that they synchronize to Glendale.

0730 - Overcurrent relay trips.

A. #3 Unit--2 phases B & C.
#4 Unit--3 phases.
#5 Unit--3 phases.
B. #4 Unit amplidyne tripped off; restarted same.
C. Glendale system on Station "E" at Western Sub-station with 56 MW.
D. Sub-station operator shedding stations to reduce load (Western Sub on "E" @ 5 MW).

0732 - Nos. 3 & 4 Units on the line.

0739 - No. 5 Unit on the line.

0735-0745 Picking up Glendale system.

0758 - Automatic synchronized to Receiving Station "E" successful by Glendale Sub-station.

I.4 Earthquake Damage Summary, Piping

The originally reported damage in the San Fernando Earthquake consisted of two broken water lines, one in the cooling-water line to the induced-draft fan and air preheated of the Unit 3 boiler, and the other on the Unit No. 2 influent water line to the demineralize tank. The areas of these breaks is shown in Figure 2-7 of

Appendix B of Reference I.1. During this survey, it was indicated by plant personnel that there also had been a small branch line break to the main coolant pipe of Unit G-3 as shown in Figure 4.19 of Vol. 1 of this report.

I.5 Seismic Demand from the San Fernando Earthquake at the Power Plant Site

For Glendale plant as for the Burbank plant, the closest strong motion recording for the San Fernando earthquake was at 633 E. Broadway Ave. Glendale. This recording station was 19 miles SSE of the epicenter. The Glendale plant is located 2.5 miles NW from the recording station and 17 miles SSE of the epicenter. The ground response spectra developed in Ref. I.2 Appendix E Figure Spectra SF-G are considered applicable to the plant site. The site Glendale plant intensity was a Modified Mercalli VII.

I.6 Reference

I.1 NRC Seismic Design Task Group and Stevenson and Associates, Report of the U.S. Regulatory Commission Piping Review Committee, "Summary and Evaluation of Historical Strong Motion Earthquake Seismic Response and Damage to Above Ground Industrial Piping", NUREG 1061 Vol. 2 Addendum, April 1985.

I.2 Yanev, P.I. and Swan, S.W., "Pilot Program Report Appendices, Program for Development of an Alternate Approach to Seismic Equipment Qualification", Vol. II Prepared for Seismic Qualification Utilities Group, by EQE Inc.

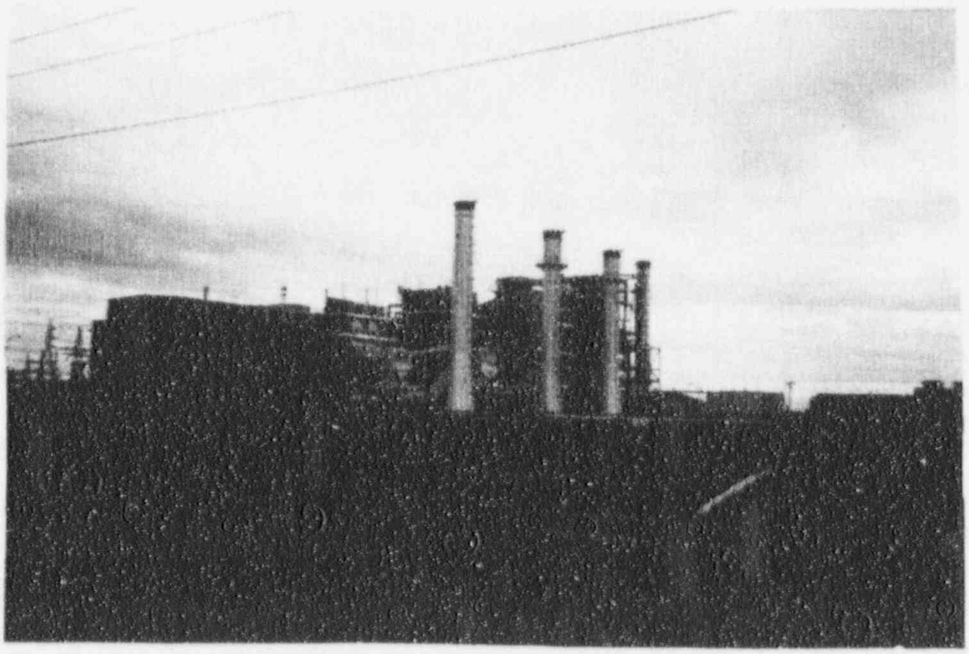


Figure I.1 Glendale Power Station I-5

Appendix J: Humboldt Bay Power Plant

J.0 Humboldt Bay Power Plant

J.1 Humboldt Bay Power Plant

The Humboldt Bay power plant is located on Humboldt Bay, California, just northeast of the town of King Salmon and about 5 miles southwest of Eureka, California. The facility, owned and operated by Pacific Gas and Electric Company (PG&E), consists of three units. The nuclear plant (unit 3) is a 63 MW plant. The other two units (unit 1 and 2) are older, 52 MWe duel oil and gas fired boilers which drive steam turbine generators. Unit 1 began operation in 1956. Units 2 and 3 began operation in 1958 and 1962 respectively. In Appendix D.2 is a more detailed description of Unit 1 which also applies to Unit 2.

A plan of the Humboldt Bay plant is shown in Figure J.1. Unit 3 is at the eastern end of the facility. The soil in the vicinity of the plant at grade consists of about 40 feet of clay overlain by several feet of fill. The Unit 3 reactor is housed in a steel dry well vessel surrounded by a reinforced concrete caisson beneath the structural steel refueling building as shown in elevation view in Figure J.2. About 300 feet south of the refueling building is the light, shallowly embedded storage building.

Units 1 and 2 are conventionally steam boilers supported by a structural steel frame metal sided structure as shown in Figure 1 of Ref. J.1.

J.2 Summary of Recorded Earthquake Effects

J.2.1 Ferndale Earthquake - 1975

Units 1 and 2 automatically tripped during the earthquake due to spurious action of some electrical relays. After Inspection, Units 1 & 2 were both returned to the grid in less than one-half hour with no reported difficulties. The turbine vibration pick-ups on the outside of the bearing caps for Unit 1 and 2 reportedly did not alarm nor did their recorders indicate any above background vibration during the earthquake.

Humboldt Bay Unit-3 was in process of a refueling operation at the time of the earthquake. The earthquake was reported by plant personnel on duty in the refueling building as perceptible upward motion followed by smaller movements of brief duration. Choppy waves about 9" to 12" high were observed in the spent fuel pool.

The reactor nuclear instrumentation and safety systems were checked for functional operation after the earthquake by plant personnel in accordance with Operating Instructions and all such instruments and controls were found operational. Tank volumes were also checked and no loss of contents was found.

The only Unit 3 device to inadvertently trip during the earthquake was the General Electric relay, 63ZZ, mounted in the Valve Control Center. This is not unexpected as this relay was previously identified by Bechtel as requiring seismic qualification. This 63ZZ is a redundant relay to 63Z which did not trip and 63ZZ was operational after the earthquake.

J.2.2 Eureka Earthquake - 1980

The effects of the earthquake on plant structures, piping, equipment, and components appeared to be minimal.

Both Units 1 and 2 were operating at the time of the earthquake and were shut down because of it. According to reports, they were shut down because:

(1) A protective relay for the Unit 1 generator phase differential voltage vibrated open and tripped the generator (the relay was GE type 2CFD 12B2A).

(2) Gas flow to both Units 1 and 2 was lost when vibration caused closure of mercoid switches on the low-to-high pressure gas piping isolation lines. The switch closure caused the valves to close.

(3) Air-flow indication was lost for Unit 2 because a float, riding on mercury came loose from the yoke for the indicator. Loss of indication necessitates unit shutdown.

J.3 Time Sequence of Events Following the Earthquake

J.3.1 Ferndale Earthquake - 1975

At 0146 on June 7, 1975 the status of the Humboldt Bay Plant was as follows:

a. The oil and gas fired 52 MWe fossil fuel Unit Nos. 1 and 2 were operating using gas fuel at 6 and 11 MWe, respectively.

b. Nuclear Unit No. 3 was out of service for a scheduled five-week refueling, maintenance and modification outage that had commenced on May 30, 1975.

At the time of the earthquake, a total of 13 plant personnel were in the plant. This augmented crew included an extra Shift Foreman, a Nuclear Engineer, and extra operating personnel who were involved n reactor refueling work. A Shift Foreman and two operators were on the reactor refueling platform at the time of the earthquake. These individuals left the refueling building shortly after the earthquake occurred. The Plant Superintendent and Supervisor of Operations, upon feeling the earthquake at home, came to the plant to provide assistance. They arrived at 0211.

The effect of the earthquake on the operating Unit Nos. 1 and 2 was to trip both units' generator oil circuit breakers (OCB's) and auxiliary transformer OCB's. Auxiliary electrical equipment associated with these units transferred to the Plant start up bank which remained energized from the Plant's 60 KV bus. The two fossil units continued to roll under control of a governor at approximate synchronous speed. This situation apparently resulted from spurious auxiliary relay action which caused a loss of generator field on both units. No primary relay "targets" were observed to have dropped. In addition, spurious relay action caused the closure of a motor-operated gas supply valve to Unit 1 which resulted in the tripping of the forced draft fan on Unit 1 boiler.

Unit Nos. 1 and 2 operators investigated these occurrences, "walked the units down," verified that no significant damage had occurred, purges and "lit off" No. 1 boiler, and restored the fields to the generators on the two units. At 0205 (19 minutes after the earthquake), Unit 2 was reparalleled to the system.

On nuclear Unit No. 3, the only abnormal condition caused by the earthquake involved spurious action of one of a pair of redundant relays in the refueling building high differential pressure protection system. These relays had been identified in the seismic review work then in progress as requiring qualification testing or replacement. This relay, designated 63ZZ, is a General Electric (GE) type HEA relay, as is its redundant counterpart, 63Z. The effect of this spurious relay action was to close the primary system isolation valves associated with the emergency condenser and reactor cleanup systems and to trip the reactor cleanup pump. These actions had no safety significance relative to the refueling mode of operation of Unit 3.

J.3.2 Eureka Earthquake - 1980

At this time there is not available a time sequence of events for this earthquake.

J.4 Earthquake Damage Summary

J.4.1 Ferndale Earthquake - 1975

No comprehensive description of the behavior of Humboldt Bay Station in the Ferndale earthquake has appeared in the published literature, hence it is included herein for completeness.

J.4.1.1 Outdoor and Common Plant Facilities

A. Raw Water Storage Tank

Very minor tank motions on their foundation but no permanent physical displacement. This was evidenced on the east side by small clumps of asphalt paving having broken loose from under the tank steel skirt in contact with the foundation and above adjoining asphalt paving. Tank was reportedly filled to normal full capacity at the time of the earthquake. The tank sides, roof, and outside piping showed no visible sign of recent paint cracking and chipping or buckling. An apparent flat area in the tank southwest side near grade at the inlet pipe is due to an old field modification.

B. Fire Pump House

Hollow concrete block wall-concrete slab floor construction showed no indication of recent cracking, chipping, or displacement. Auto diesel fire pump, electric driven fire pumps and associated piping and control panels showed no visible signs of recent paint cracking and chipping or displacement. Loosely attached auxiliary equipment and piping showed no signs of any effects.

C. Diesel Supply Tank

Tank, concrete saddles and associated piping showed no visible signs of recent paint cracking and chipping or displacement. Earth dike adjacent to tank showed no visible signs of surface cracks or displacement.

D. Propane Tank

Tank, concrete saddles and associated piping showed no visible signs of recent paint cracking and chipping or displacement. Tank was filled to slightly more than one-half full capacity at time of earthquake.

E. Unit 2 Condensate Storage Tanks

Very minor evidence of small tank motion on foundation but no paint cracking and chipping or displacement. Recent very narrow disturbed soil line around periphery south portion of tank foundation.

F. Unit 1 Condensate Storage Tanks

No visible evidence of tank motion on foundations, paint cracking and chipping or displacement.

G. Intake Structure Units 1, 2 & 3

No discernible effects to structures or Unit 3 pumps, valves and control panels.

H. 60KV Switchyard

No discernible visible effects except for Oil Circuit Breaker No. 82 which weighs about 8 tons mounted about 4' above ground on a slender metal frame support. The four support legs are bolted to a combination oil sump and concrete foundation. There appears to be a less than 1/4" displacement of one support relative to the concrete and some signs of paint cracking and chipping on the several bolts on one side. It is difficult to assess this local paint cracking phenomenon as the supports are of galvanized steel which is a poor undersurface for paint.

I. Unit 1, 2 & 3 Main Transformers: 70KVA, Single Phase, Oil Filled

Main transformers are bolted to concrete pad foundations. No visible effects except on single phase transformer serving Unit No. 1. this transformer is phase C and one of the anchor bolt attachments show some chipping of paint at the bolt nut. There was no indication of any horizontal displacement of this transformer.

J. Unit 1, 2 & 3 Bus Bar Towers Behind Transformers

No discernible effects except for minor paint and concrete cracking and chipping at base of east and west towers of Unit 3. There towers are slender and constructed of galvanized steel members.

K. Storage Building

High hollow concrete block walls - concrete floor slab and timer roof construction which houses one accelerograph pick-up bolted to floor slab near east wall. No discernible effects on storage building structure or its contents.

J.4.1.2 Units 1 & 2

The only minor discernible structural effects observed were as follows:

A. There were indications of some paint cracking and chipping on several bolts for secondary bracing on the south face of Unit 2. There was no evidence of plastic deformation. There was no visible sign of paint cracking and chipping or displacement on major columns or beams including concrete footings for Units 1 and 2.

B. A recent rotation of two secondary 1 inch square steel bar guides located inside of the Unit 2 air preheaters west support was observed. There was no visible displacement of the support or the larger outside restraints.

C. There is some evidence of upper portion Unit 2 boiler wall movement horizontally (less than $\pm$ 1/2") against its guides which could be partially attributed to thermal expansion movement. There was no visible permanent displacement.

D. The Unit 1 & 2 deaerators located on their respective boiler house roofs both indicated small movement by some minor signs of paint cracking and chipping on several support legs at their bolted anchorages to the structural steel.

E. The Unit 1 condenser and its spring supports were examined and there was no visible signs of paint cracking and chipping or displacement. Fragile dried paint drips and films between the coil springs were undisturbed.

F. No discernible visible effects on Units 1 & 2 electrical panels were observed.

J.4.1.3 Unit 3

A. Control Room

There were no signs of any movement or stresses on the floor attachments or structural members of the panels. Board is approximately 7 feet wide, 15 feet long and 8 feet high with a considerable amount of electrical components mounted on the face panels. On one section of the board are 85 lb recorders mounts in rows from 2 feet to 7 feet above the floor. On the North-east corner of the board are radiation detector and magnetic tape recording equipment weighing approximately 200 lb and mounted directly to the Reactor Board without additional floor supports.

The Reactor Board shows no visible movements of equipment or any discernible effects of the seismic event. The control room structural steel and reinforced concrete, concrete block and transit siding showed no discernible effects. Recent signs of cracking were not observed in several expansion joints in the concrete walls and floor.

B. Reactor Feed Pump Room

This room encloses most of the Plant's cable trays. Inspection of tray supports as well as supports for raceways, junction boxes and wall mounted control cabinets indicated no visible effects due to the seismic event.

C. Emergency Transformer at Grade

Emergency Transformer 3L4 is a 45KVA, 3-phase dry type transformer bolted directly to a 6 inch high concrete pad. No visible signs of transformer movement.

D. Turbine Enclosure Concrete Panels

The turbine of Unit 3 is enclosed by heavy concrete panels which are primarily held in position by gravity with a limited number of weak bolted connections between panels. There was no discernible movement of the vertical concrete panels or their bolted connections.

E. Roof Area and Parapets

There were no discernible signs of cracks or movement of the roofs or parapets of the auxiliary-turbine building or refueling building.

F. Chimney

The concrete chimney was observed from the refueling building roof and inside and outside of the base. Older cracks along cold construction joints and random cracking are visible, but it was difficult to ascertain the possible extent of recent crack development, if any.

G. Outside Condensate Storage Tank

The aluminum condensate tank and associated piping on the north side of the refueling building shows no discernible effects. Two tank anchorage bolts were bent due to earlier construction fit-up. Two small concrete piping supports at grade need replacement.

H. Outside Low-Level Liquid Radwaste Storage Tanks

No discernible effects around tank concrete foundation pads.

I. Pipe Gallery

There were no discernible structural effects in the main steam and feedwater pipe galleries.

J. Main Steam & Feedwater Pipe Hangers and Supports

Other than apparent routine maintenance adjustments to certain piping hangers and supports, there were no discernible effects attributable to the earthquake.

K. Main Condenser

The Unit 3 Main Condenser room shows some signs of older concrete cracking but no discernible signs directly attributable to the earthquake.

L. Drywell Outer Concrete Surface

The concrete surface on the outside of the drywell on the south side at elevation -14 in the reactor caisson shows signs of older cracking which could be attributable to a 1) dry shrinkage, or 2) reactive concrete, other than the possible effects of the earthquake. This statement also generally applies to other discussed massive concrete that exhibits older cracking.

M. Reactor Caisson Access Shaft

There is evidence of older concrete cracking along the vertical joints of the reactor caisson with the radial walls, some cold construction joints and some random wall cracks. It was difficult to ascertain if there was any possible development of these cracks as a result of the earthquake. An old concrete sealed construction opening for the drywell concrete at elevation -14 shows signs of cracking around the joint which is not directly attributable to the earthquake. There were no discernible signs of paint cracking or chipping on structural steel in the shaft. Certain critical equipment in the shaft was observed as follows:

1. Scram Dump Tank at elevation -66 had no visible signs of paint cracking and chipping or displacement on steel supports. Tank support bolts need routine maintenance tightening.

2. Suppression Tank Cooler at elevation -2 had no visible signs of paint cracking and chipping or displacement on steel supports.

3. The complex maze of accumulators and associated piping and valves at elevation -54 showed no discernible effects. Valve actuator hanger supports need routine maintenance.

N. Refueling Building Concrete Walls and Floor

There is evidence of older concrete cracking. It was difficult to ascertain if there was any possible recent development of these cracks.

There is evidence of a significant size concrete crack in the reinforced concrete column outside the upper air lock at elevation +27. Subsequent review of detailed drawings indicates that this crack might possibly be attributed to a combination of loadings including the bridge crane. It is difficult to ascertain at this time if there was any recent development of this crack. It did appear that there was any damage to the strength of the column.

O. Poison Tank

The front steel support leg of the poison tank at elevation +12 inside the refueling building along the north wall shows minor signs of paint cracking at the contact with the concrete slab.

P. Emergency Condenser

There were no discernible signs of paint cracking and chipping or displacement of the lower supports.

Q. Spent Fuel Pool

There are older concrete cracks in the spent fuel pool curb on the refueling building floor which are apparently due to heavy loads being placed on it during fuel movement operations (casks).

J.4.2 Eureka Earthquake - 1980

J.4.2.1 The Effects on Plant Structures, Tanks and Mechanical Equipment

The effects of the Eureka Earthquake-1980 on the Humboldt Bay power station are summarized in Ref. J.2.

J.4.2.2 Effects on Piping

Effects on piping were minimal. Only two piping failures and one support failure were noted for the fossil plant piping. None of these types of failures would be expected to occur in safety-related nuclear plant piping (and none did). One failure in the fossil piping was the result of a poor choice of a brittle material for a buried pipe. The other two failures appeared to be the result of severe deterioration caused by lack of inspection and maintenance.

The failure in the buried pipe was a leak in a 6-in. transite pipe for the fire loop around the plant. The pipe was buried about 6 ft. Reportedly, previous leaks in this piping were caused by water hammer and by heavy equipment passing over it.

The second failure was a pinhole leak in a weld joint for a 2-inch boiler feedwater line for Unit 1. Reportedly, examination during repair revealed substantial wall erosion, necessitating the replacement of a complete spool piece. Figure 14 of Ref. J.1 shows the piping and configuration after the repair. The chipped grout at the bottom of the support base plate in Figure 14 should be noted. This figure does not show that only a vertical deadweight support was provided at the top of this piping configuration. Given the chipped grout and the piping configuration, it is obvious that the area where the leak occurred was highly stressed. The coupling of this stress with the pipe wall erosion apparently led to the development of the leak.

The third failure was a sheared bolt on a Grinnel vertical spring hanger for the Unit 1 main steam line (see Figure 15 of Ref. J.1).

The support was exposed to the weather and badly corroded. Examination of the sheared bolt indicated that the corrosion had frozen the bolt to the slot in which it was intended to slide. Only about two-thirds of the failure plane appeared to be attributable to the earthquake; about one-third of the surface appeared to have been cracked before the event. An identical hanger on the opposite side of the line (which appeared to have moved properly) appears to be undamaged. Failure appeared to be the result of the locking of a partially failed bolt, which caused its overload.

The only effect noted in the Unit 3 safety-related piping was a deformed expansion bellows on the shutdown system discharge line in the shutdown room near the line's containment penetration into the valve gallery.

Figure 16 of Ref. J.1 shows spans of fossil plant piping about 60 ft. long, supported by deadweight hangers only, which were apparently undamaged. The hangers are about 2 to 3 ft. long. The direction of strongest motion was perpendicular to the spans. Interestingly, no denting of the insulation was obvious from vantage points approximately 15 to 20 ft. away. Figure 17 of Ref. J.1 shows typical weathered Unit 1 and 2 piping which was undamaged.

J.5 Seismic Design Basis

J.5.1 Seismic Design Basis for Units 1 and 2 Building Structures and Piping

It was PG&E policy at the time of construction of the Humboldt Bay Units to design all major structures for an 0.2g static lateral load factor applied to dead and 50 percent of live load. Their is no evidence that this criteria resulted in any requirement to laterally restrain any piping or use snubbers.

After the 1975 earthquake the building structure of Unit 2 adjacent to Unit 3 was modified and strengthened as part of the seismic upgrade of Unit 3 performed in the 1975 - 1976 time frame.

J.5.2 Seismic Design Basis for Unit 3 Building Structure and Piping

This unit was originally (1962) designed for a 0.25g horizontal static seismic load. In 1975 - 1976 the nuclear safety related building structures and piping were upgraded to meet a modern seismic Operational Basis Earthquake, OBE, load of 0.25g horizontal and 0.17g vertical zero period ground acceleration, defined dynamically by Regulatory Guide 1.60 ground response spectra and compatible floor spectra. A Safe Shutdown Earthquake, SSE, load of 0.5g horizontal and 0.33 vertical zero period ground acceleration defined by the R.G. 1.60 ground response spectrum were also established in 1975 - 1976. This seismic design change from the original static 0.25g load leads to significant modifications of Unit 3 structural steel and the addition of lateral restrains to piping systems.

J.6 Earthquake Seismic Demand

J.6.1 Ferndale Earthquake - 1975

J.6.1.1 Strong-Motion Instrumentation and Calibration

Seismic instrumentation at the Humboldt Bay Power Plant consists of an early Teledyne type MTS-100 seismic recording system. This system had been in operation since September 1971. Strong motion instruments are located at elevation +12 (plant grade level) and elevation -66 in the refueling building. A strong motion instrument is also situated in a storage building (elevation +12) a distance of about 300 feet south of the reactor caisson.

All three components of each strong-motion instruments are multiplexed onto on channel of a four channel FM recorder. Thus, 3 three-component accelerograms and a timing channel are present on one magnetic tape.

The strong-motion instruments located at the Humboldt Bay Power Plant were calibrated on May 28, 1975, 10 days before the Ferndale earthquake. Since these devices have a dc frequency response, "tilt" calibrations procedures were used to properly calibrate the instruments. After the Ferndale earthquake the equipment calibration was again checked. The calibration factors computed at this time were found to be identical to those obtained prior to the earthquake. This would indicate that the strong-motion records obtained during the June 7, 1975 Ferndale earthquake are accurate.

Digitization of the magnetic tape was accomplished by using an analog to digital converter and sampling the analog FM signal at a rate of 0.005 seconds or 200 samples per second.

J.6.1.2 Analyses of Digitized Data

Maximum values of acceleration scaled from strip chart accelerograms of the original Humboldt Bay magnetic tape record are shown in parentheses on Table J.1. These were obtained by taking one-half of the maximum peak-to-peak value. Also shown on Table J.1 are maximum values of acceleration obtained after baseline correcting the digitized data. These values are the absolute maximum values and are not one-half of the maximum peak-to-peak value.

It can be seen from Table J.1 that at all three instrumented locations the maximum accelerations occurred in the transverse direction.

Baseline corrected acceleration time histories for all three components at each of the three instrumented locations are shown in Figures J.3 to J.5. A total duration of 20 seconds was used for purposes of presentation and response spectra computation although the actual duration of strong shaking was only about three to five seconds. Response spectra were also computed using only 12 seconds of the digitized data and the results agreed reasonably well with those obtained using the entire 20 second duration.

Time histories of velocity and displacement were computed for all nine components of acceleration. These were obtained by integrating the baseline corrected acceleration time histories. The maximum values of velocity and displacement for all three components at each instrumented location are given in Table J.2.

Response spectra have been computed for all nine components of acceleration for structural damping values of 2, 5 and 7 percent. These are shown in log-log tripartite form in Figures J.6 to J.8. Transverse response spectra are presented in Figure J.9 for the same components as compared to the R.G.1.60 spectrum for a 2 percent damping value. For both horizontal components the peak response occurs at a frequency of about 2 to 3 Hz. For the longitudinal component at the fundamental response occurs at a frequency of about 3 Hz with a second peak at around 4 to 5 Hz. At elevation -66 in the refueling building there is no well-defined peak present in the transverse component, however in the longitudinal direction the peak response occurs at about 5 Hz. The vertical component in the storage building (elevation +12) contains no well-defined peak. In the refueling building the peak vertical response occurs at a frequency of about 5 Hz at elevation +12 and about 3 Hz at elevation -66. It appears that for all nine strong-motion records obtained at the Unit 3 Humboldt Bay Power Plant the peak response occurs in the frequency range of 2 to 5 Hz (0.20 to 0.50 seconds).

J.6.1.3 Conclusions

The strong-motion records measured at the Humboldt Bay Power Plant during the Ferndale earthquake of June 7, 1975 have been digitized and baseline corrected. Time histories of acceleration, velocity and displacement together with the maximum values of these response have been computed for all three components at each of the three instrumented locations. Response spectra have also been evaluated for all nine components for various structural damping values.

The results of this evaluation indicated that the duration of strong shaking for the seismic event was only about three to five seconds. Because of this short duration liquefaction of the sandy soils at the site would not have been expected. There was in fact no evidence of liquefaction in the immediate vicinity of the plant site.

The high level of acceleration (0.35g) recorded in the storage building in the transverse direction is of interest since it exceeds the value assigned to the OBE (0.25g) for use in seismic evaluation of the plant. Although information on the subsurface soil conditions at the storage building is not available at this time, borings previously drilled in the vicinity of the storage building can be used to approximate the soil profile. The upper soils consists of about 40 feet of clay overlain by several feet of fill. The large peak acceleration recorded in the storage building is thought to be the result of local site amplification effects produced by the relatively soft soil profile particularly in the upper clay layers. Alternatively if the free field ground (acceleration at grade is used as the reference acceleration design value there is an obvious reduction with embeddment. Results of one dimensional wave propagation analyses previously performed indicate that the peak acceleration at the ground surface is a function of the properties of the upper clayey soils. As the clay was made stiffer the peak acceleration at the ground level decreased and vice versa.

J.6.2 Eureka Earthquake - 1980

J.6.2.1 Instrumentation Records

The Humboldt Bay Power Plant at the time of the Eureka earthquake was equipped with a TERA Technology seismographic system to sense triaxial acceleration at three locations and record digital time histories on magnetic tape. Because of an apparently degraded low-voltage power supply in the recording system at the time of the quake, analysis of these accelerograph produced no useful record. The instrumentation was on a one-year service interval and was scheduled to be serviced one week after the Eureka earthquake.

As back-up for these accelerographs, the plant was equipped with three TERA Technology film recorders which sense and record the triaxial peak accelerations which occur at their locations. Thus, nine different readings were possible. Based on the staff's visual inspection of one of the instruments, it appears that these instruments were not maintained in such a way to prevent a build-up of dirt and grit on the internal mechanisms. As a result, they did not function properly. The only peak acceleration readings obtained from the potential total of nine were the preliminarily reported peak accelerations of 0.4g (E-W), 0.2g (N-S), and 0.16g (v); moreover, because of the condition of the instruments, these readings are considered to be highly unreliable.

The only instrument which is believed to have functional properly was the Engdahl spectra recorder located at the operating floor (+12 ft elevation) in refueling building of Unit 3. This recorder provided triaxial peak spectral accelerations at selected frequencies; these data are presented in Tables J.3 to J.5. The Engdahl data show that the predominant direction of motion was in the plant-designated E-W direction (defined as being rotated counterclockwise 35 degrees from true E-W), with N-S and vertical measured motions significantly less.

The 1975 spectrum should be viewed and compared to the 1980 event spectrum with care. The 1980 event spectrum was obtained directly from a 2% damped recorder; the spectrum for the 1975 event was available only at 5% damping. Therefore, it was necessary to approximately adjust the 5% spectrum to a level consistent with 2% damping. This was accomplished in a simple manner by ratioing 84th percentile spectral amplification factors from NUREG/CR-0098[2] for two different damping and applying them to the 5% damped spectrum. However, because the amplification factors in NUREG/CR-0098 are applicable to smoothed, broad-band design ground spectra and correspond to a mean-plus-one standard deviation of amplification factors considering a suite of earthquake time histories, this spectrum can be considered only approximate. It is useful for only a qualitative comparison; its quantitative value is questionable.

From a comparison of the two spectra, it appears that the 1980 earthquake had more energy associated with lower frequencies than did the 1975 event, although the 1975 earthquake had more energy associated with the higher frequencies than did the 1980 event. This observation is consistent with: (1) the near-field, short-duration nature of the 1975 event versus the far-field, longer-duration nature of the 1980 event; and (3) the types of damage (or lack therefore) observed.

Based on consideration of the above and of the results of previous seismic analyses of Humboldt Bay Power Plant Unit 3, it appears that the peak ground acceleration in the free-field at the plant from the Eureka earthquake was in the range of about 0.2g to 0.25g. It should also be noted that the Intensity (MMVII) vicinity of the power plant was the same as the Ferndale 1975 relatively near field (15 miles) epicentral distance Magnitude 5.5 as compared to the Eureka 1980 (75 miles) epicentral distance Magnitude 7.1 earthquake.

J.7 Reference

(J.1) Herring, K.S., Rooney, V., and Chokshi,

[2] "Development of Criteria for Seismic Review of Selected Nuclear Power Plants," USNRC Report NUREG/CR-0098, Nathan M. Newmark, Consulting Engineering Services, June 1978.

N.C., "Reconnaissance Report: Effects of November 8, 1980 Earthquake on Humboldt Bay Power Plant and Eureka, California Area", NUREG 0766, U.S. Nuclear Regulatory Commission, June, 1981.

Table J.1 - Maximum Values of Acceleration (G's) Measured During the Ferndale 1975 Earthquake

Location	Transverse	Longitudinal	Vertical
Storage Bldg. (Elev. +12)	.35 (.30)*	.26 (.19)	.07 (.03)
Refueling Bldg. (Elev. +12)	.25 (.19)	.20 (.14)	.13 (.10)
Refueling Bldg.	.16 (.12)	.12 (.09)	.10 (.08)

* Values in parentheses are the original base line uncorrected values obtained from strip chart records.

Table J.2 - *Maximum Values of Velocity and Displacement Computed from Measured Ferndale 1975 Accelerations

Location	Transverse		Longitudinal		Vertical	
	V	D	V	D	V	D
Storage Bldg. (Elev. +12)	1.08	.23	.41	.40	.11	.13
Refueling Bldg. (Elev. +12)	.63	.49	.36	.18	.19	.12
Refueling Bldg. (Elev. -66)	.32	.10	.22	.14	.16	.09

*Velocity - feet/second
Displacement - feet

Table J.3 - Peak Spectral Shock Recorder Humboldt Bay Pcwer Station

PSR1200 - H (North/South)

Recorder S/N 898 Calibration Date 1-2-80

Record Plates S/N 14 H6 Surface A Date 11-12-80

Reed Number	Frequency	Acceleration Sensitivity		Displacement		Equivalent Static Acceleration
		g/inch	g/mm	inches	mm	(g)
1	1.96	.336	.0132	0.0531	-	0.18
2	2.56	.545	.0215	0.367	-	0.20
3	3.12	.793	.0312	0.287	-	0.23
4	3.95	1.19	.0468	0.124	-	0.15
5	5.00	1.95	.0767	0.130	-	0.25
6	6.28	2.99	.118	0.037	-	0.11
7	7.92	4.61	.181	0.016	-	0.07
8	10.1	7.58	.298	0.006	-	0.05
9	12.7	5.85	.230	0	-	0.00
10	16.0	8.77	.345	0.007*	-	0.06*
11	20.2	16.0	.630	0	-	0.00
12	25.5	23.5	.926	0	-	0.00

* Doubtful record since .007 vs. .002

Damping: 2 percent viscous damping (Q of 25) displacement seems physically impossible.

Table J.4 - Peak Spectral Shock Recorder Humboldt Bay Power Station

PSR1200 - H (East/West)

Recorder S/N 887 Calibration Date 1-2-80

Record Plates S/N '' U1 Surface A Date 11-12-80

Reed Number	Frequency	Acceleration Sensitivity		Displacement*		Equivalent Static Acceleration
		g/inch	g/mm	inches	mm	(g)
1	1.98	.353	.0139	1.04	-	0.39
2	2.49	.509	.0200	1.743	-	0.89
3	3.14	.791	.0311	1.773	-	0.40
4	3.99	1.24	.0467	0.528	-	0.65
5	4.98	1.91	.0753	0.325	-	0.62
6	6.40	2.91	.114	0.104	-	0.30
7	7.95	4.63	.182	0.055	-	0.25
8	10.1	7.35	.289	0.024	-	0.21
9	12.8	6.33	.249	0.043	-	0.27
10	16.0	8.70	.342	0.025	-	0.22
11	20.3	16.1	.635	0.017	-	0.27
12	25.4	24.1	.949	0.015	-	0.36

* Multiple zero lines, strongest zero used to measure dee peaks.

Damping: 2 percent viscous damping (Q of 25)

Table J.5 - Peak Spectral Shock Recorder Humboldt Bay Power Station

PSR1200 - V (Vertical)

Recorder S/N 897 Calibration Date 1-2-80

Record Plates S/N 14 MO Surface A Date 11-12-80

Reed Number	Frequency	Acceleration Sensitivity		Displacement*		Equivalent Static Acceleration
		g/inch	g/mm	inches	mm	(g)
1	1.98	.318	.0125	0.043	-	0.45
2	2.55	.506	.0199	0.181	-	0.09
3	3.17	.794	.0313	NoRec.	-	0
4	4.07	1.12	.0440	0.014*	-	0.02
5	4.97	1.90	.0747	0.048	-	0.09
6	6.35	3.07	.121	0.010	-	0.031
7	7.97	4.71	.185	0	-	0
8	9.98	7.46	.294	0.008	-	0.06
9	12.7	6.23	.245	0	-	0
10	16.0	9.17	.361	0	-	0
11	20.1	16.3	.640	0	-	0
12	25.4	25.6	1.01	0	-	0

* Poor Record-Poor Contact
Damping: 2 percent viscous damping (Q of 25)

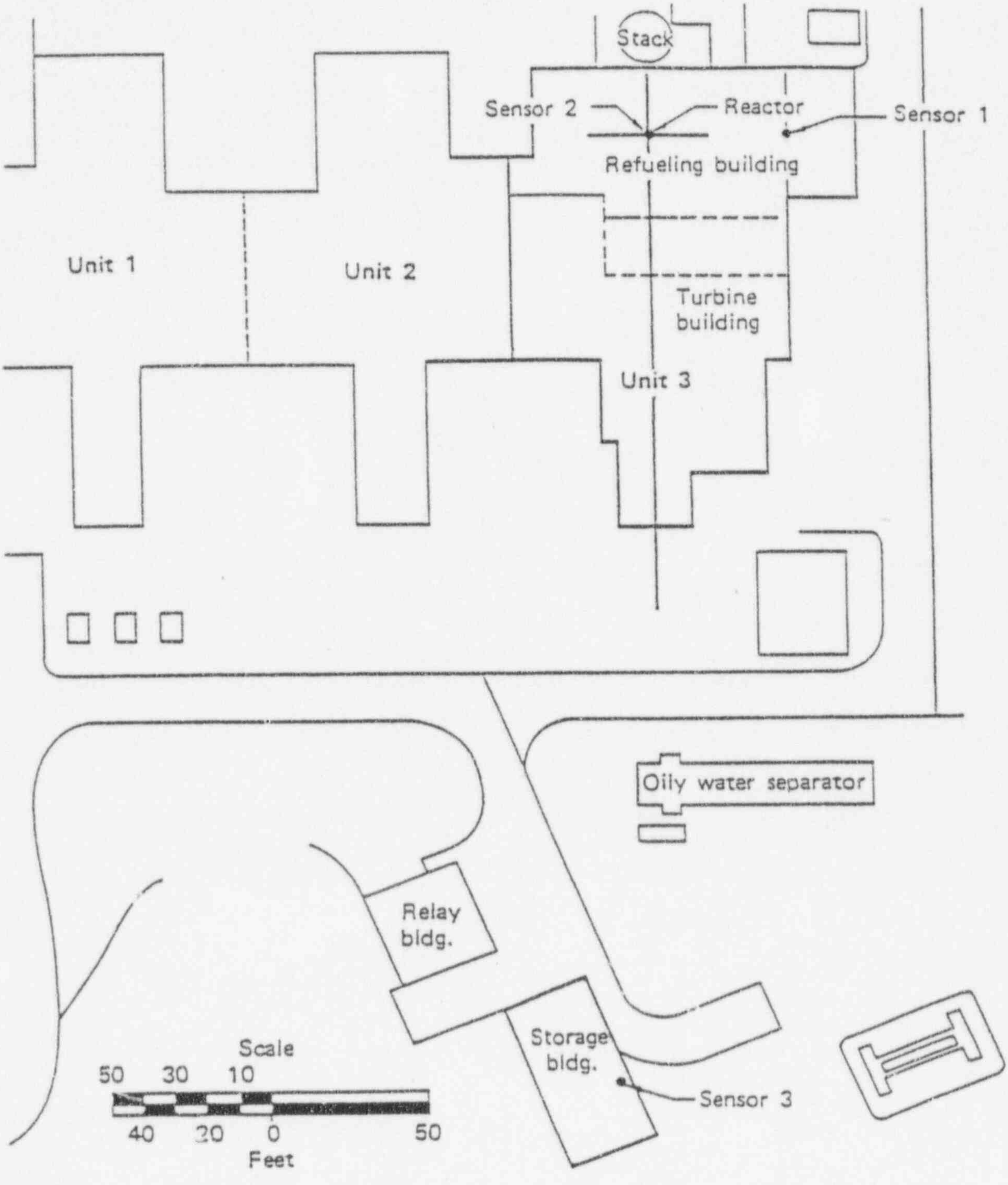


Figure J-1 - Plan of Humboldt Bay Power Plant Showing Location of Strong Motion Accelerations

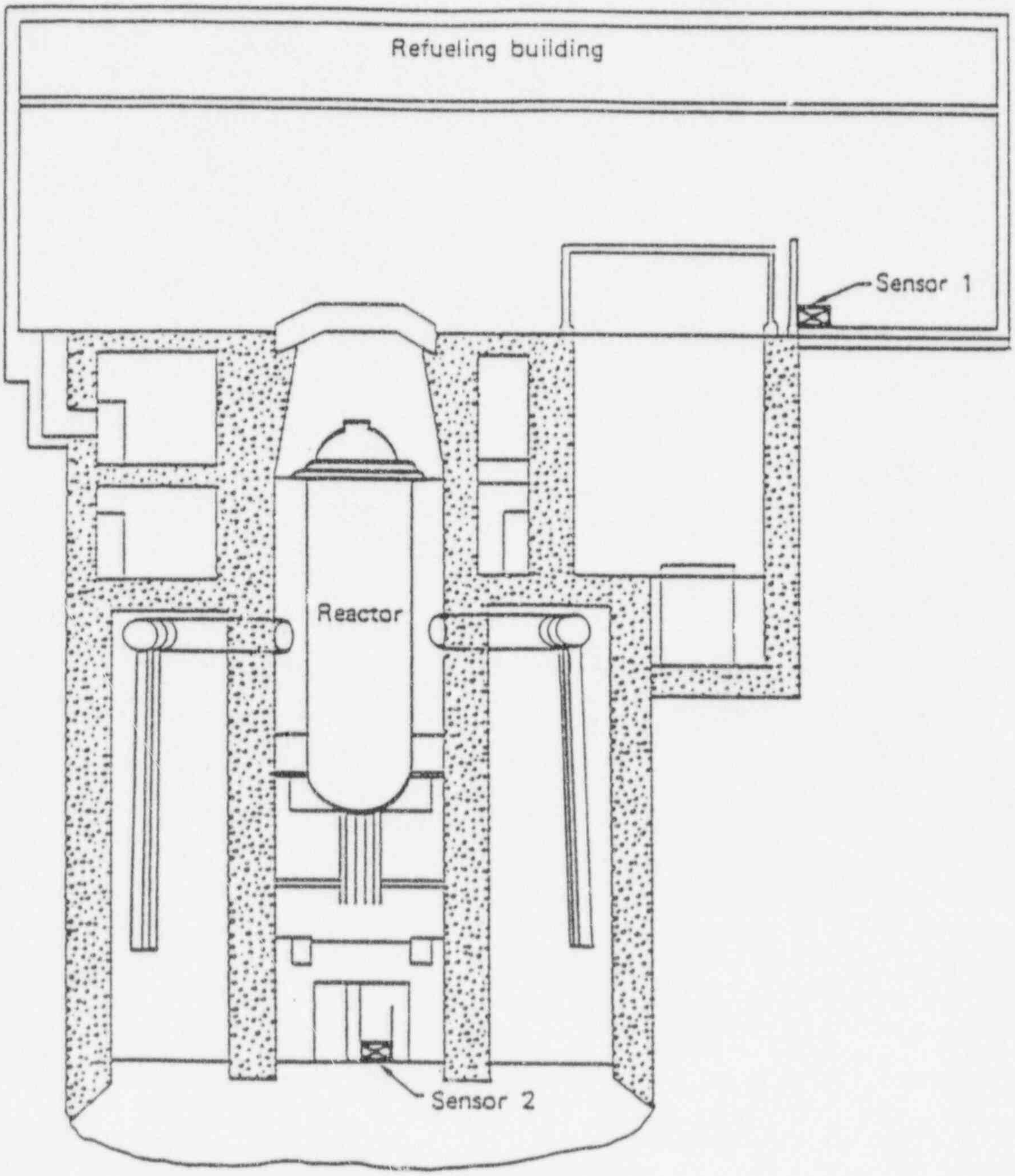


Figure J-2 - Elevation View of Refueling Building, Facing North, Showing Location of Strong Motion Accelerographs

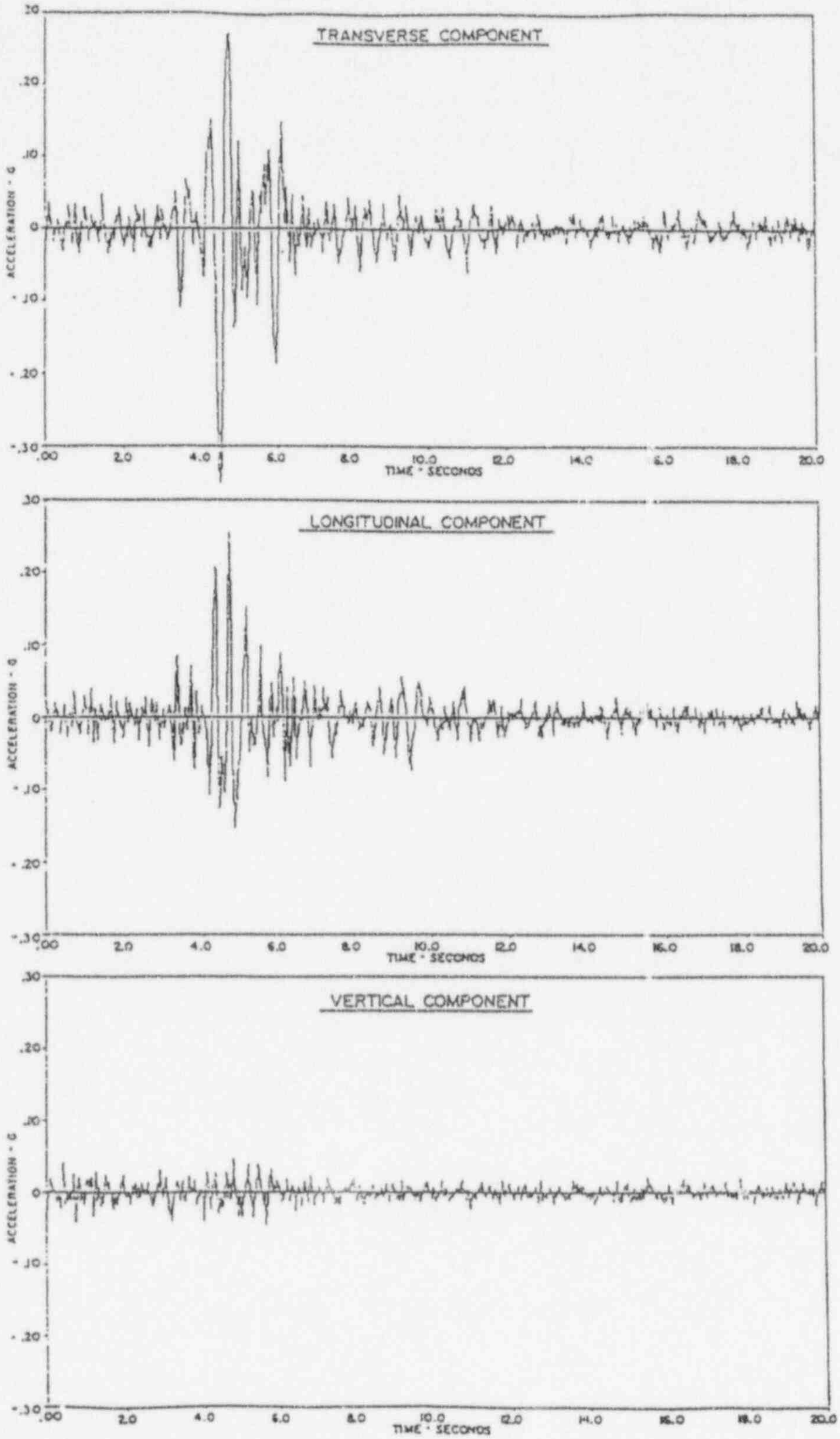


Figure J-3 - Acceleration Time-Histories in the Storage Building (Elevation +12) Due to 1975 Earthquake

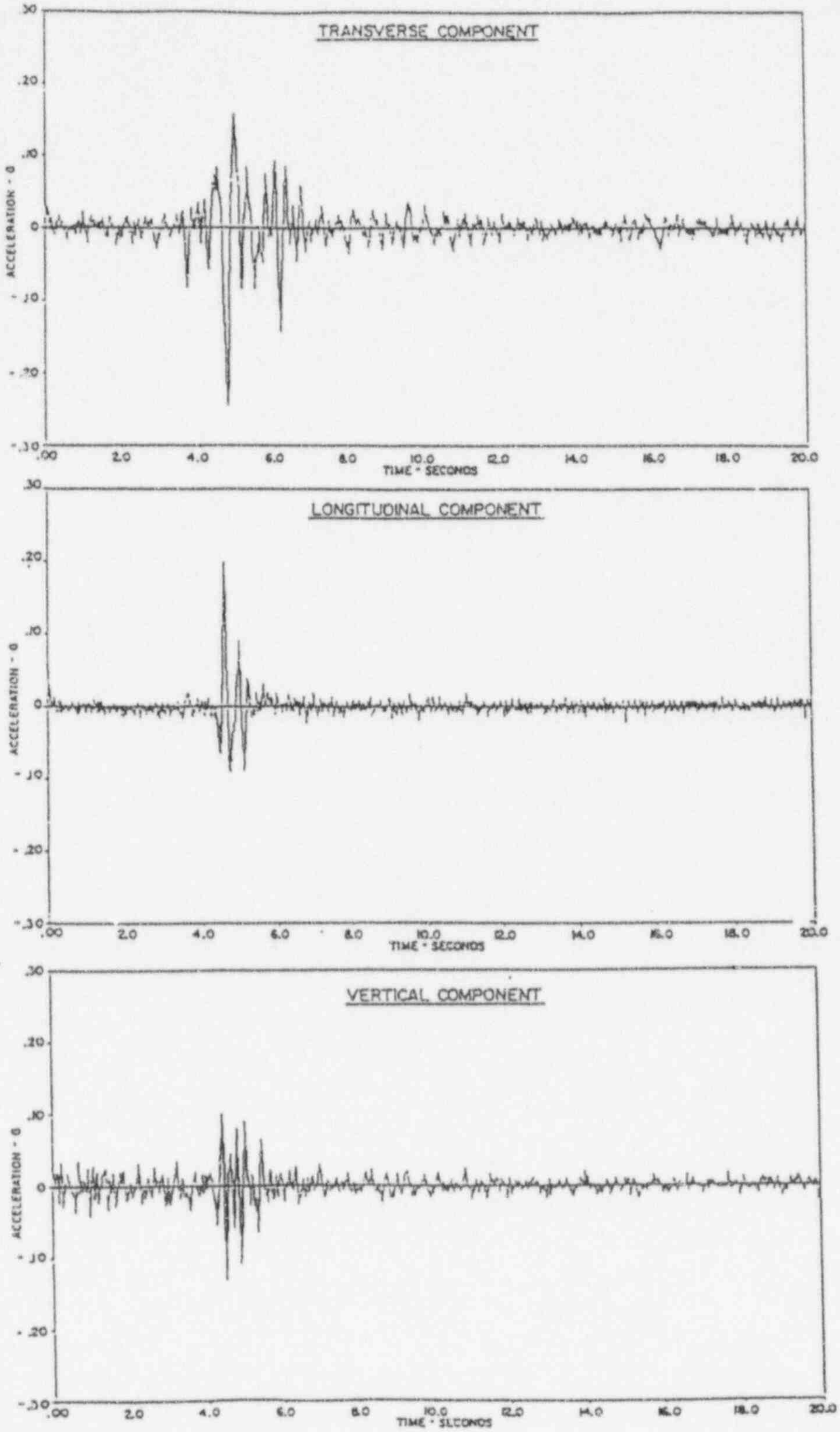


Figure J-4 - Acceleration Time-Histories in the Refueling Building (Elevation +12) Due to 1975 Earthquake

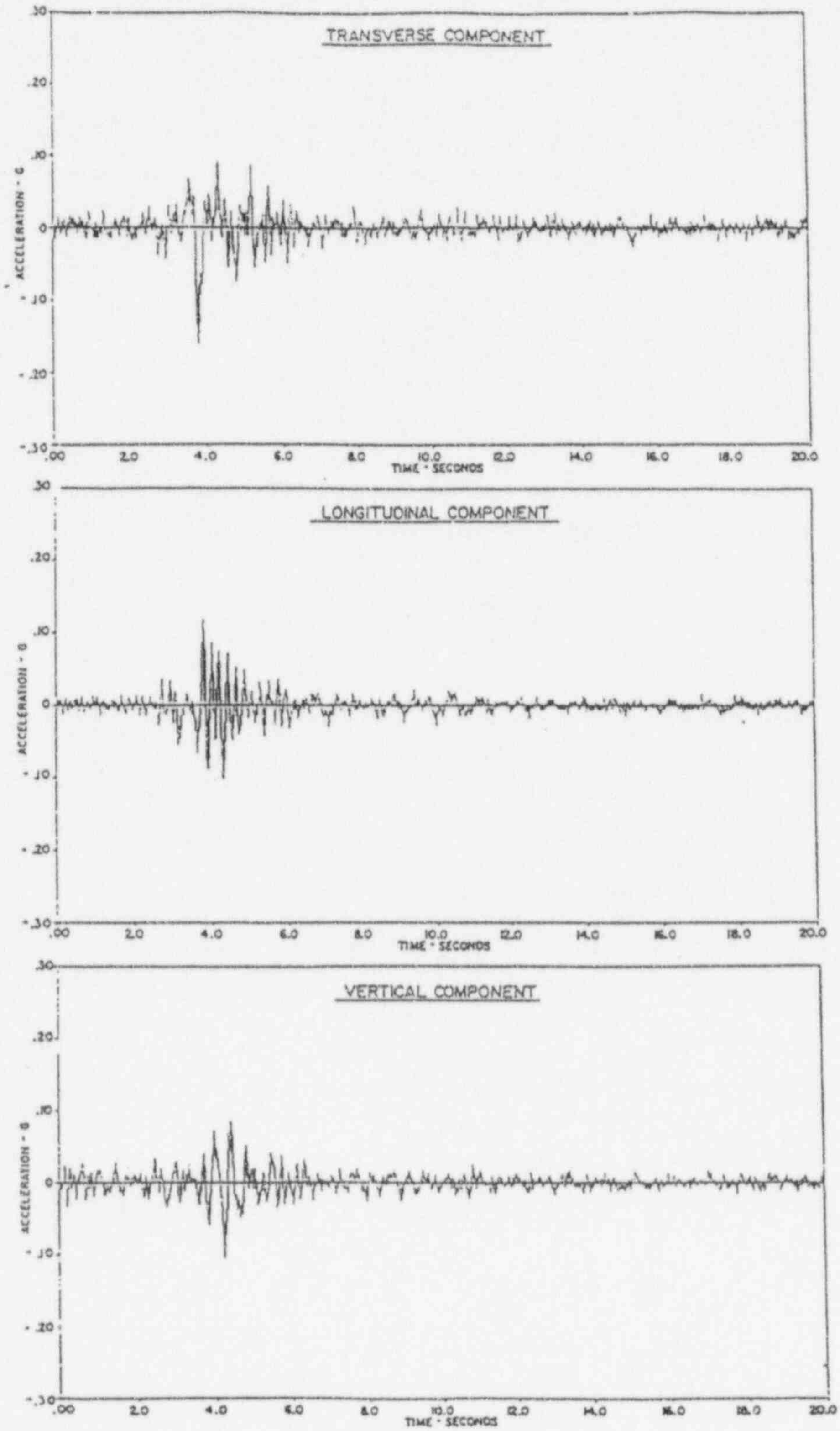


Figure J-5 - Acceleration Time-Histories in the Refueling Building (Elevation -66) Due to 1975 Earthquake

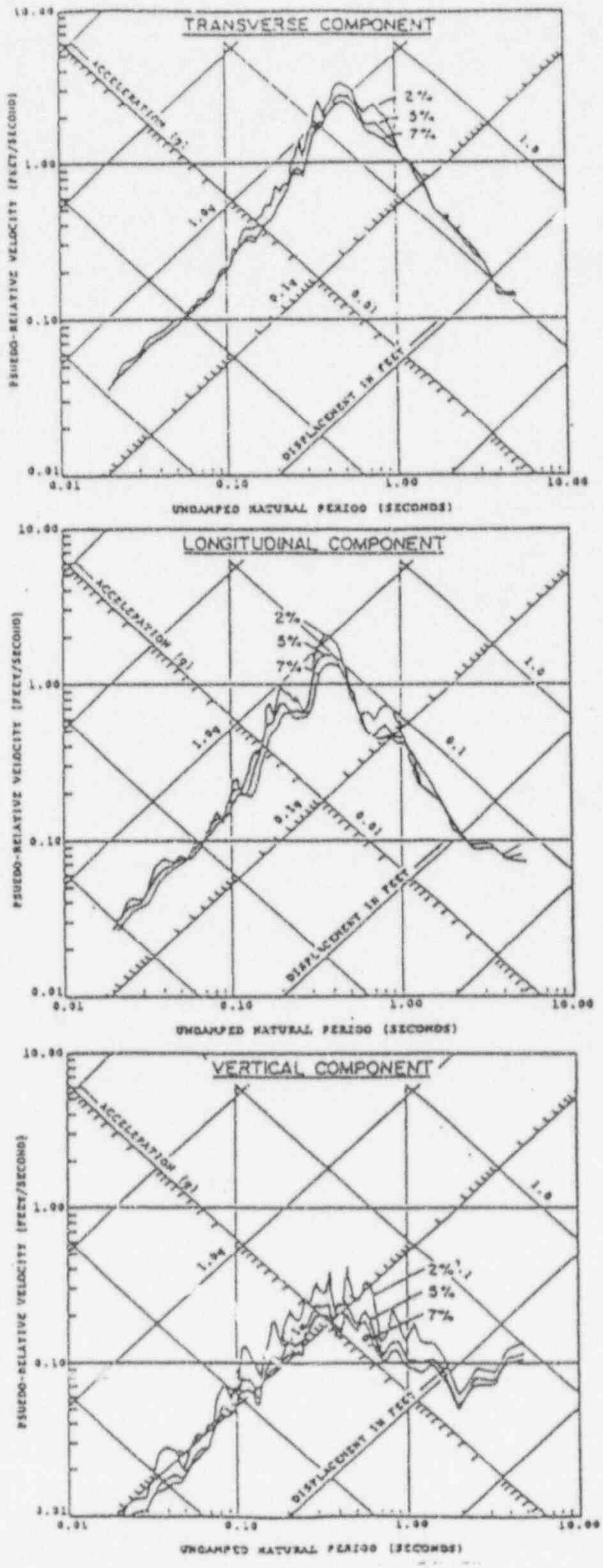


Figure J-6 - Response Spectra for Storage Building (Elevation +12) Due to 1975 Earthquake

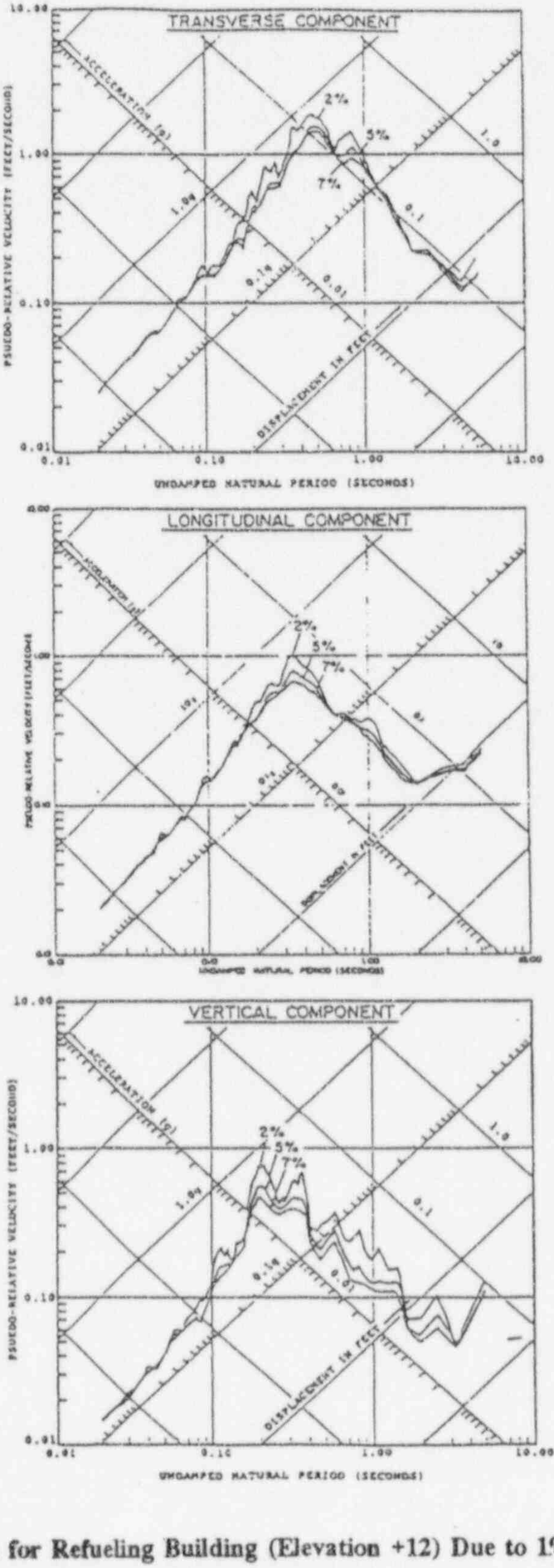


Figure J-7 - Response Spectra for Refueling Building (Elevation +12) Due to 1975 Earthquake

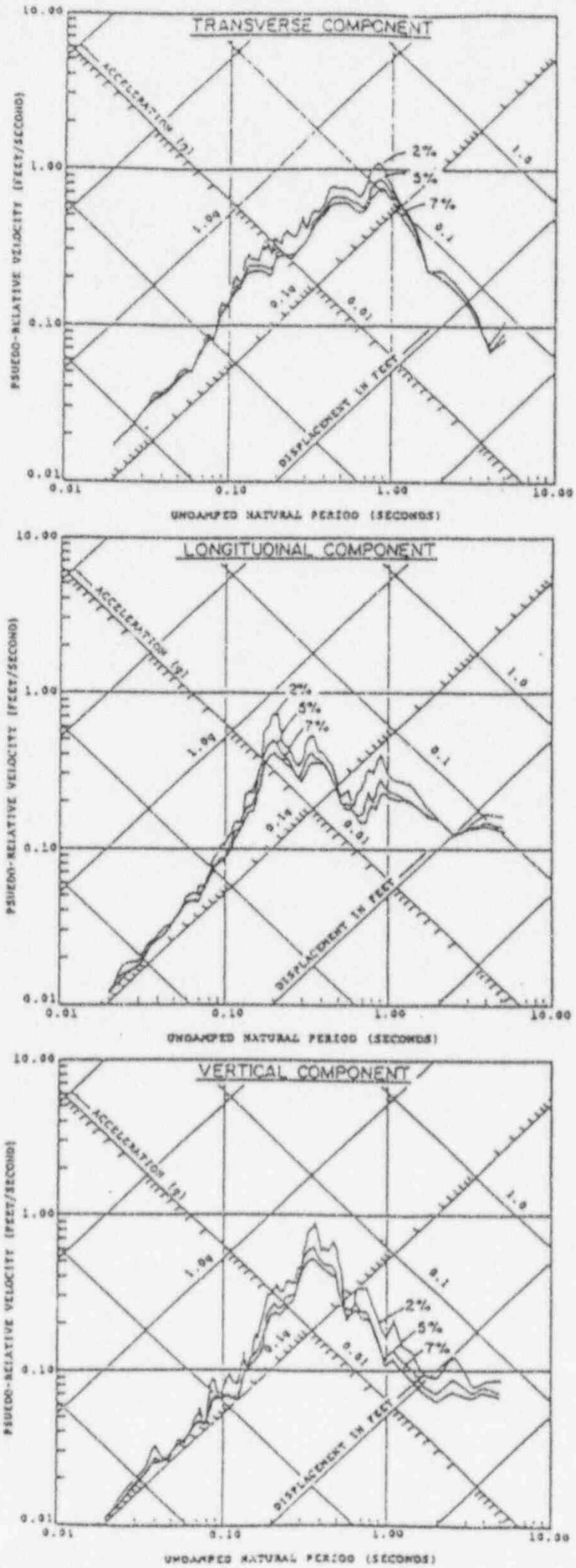


Figure J-8 - Response Spectra for Refueling Building (Elevation -66) Due to 1975 Earthquake

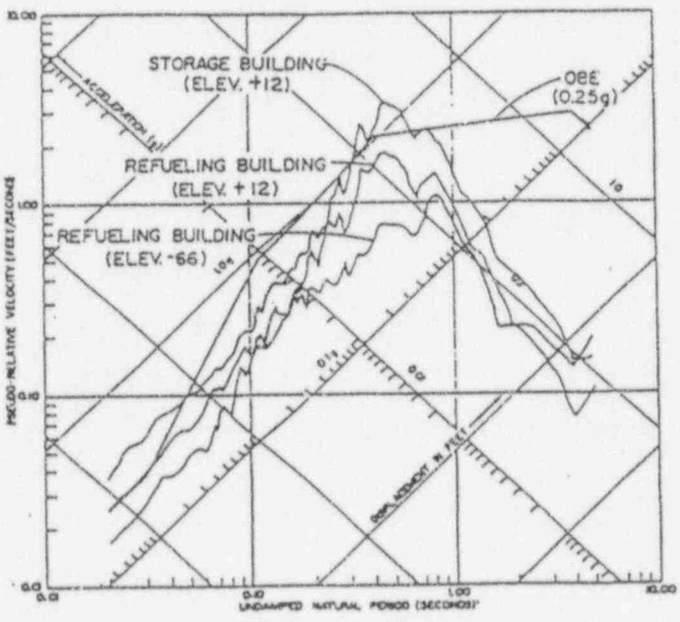


Figure J-9 - Response Spectra Comparison for 2 Percent Damped Transverse Spectra at Various Locations Due to 1975 Earthquake to a 0.25G NRC R.G. 1.60 Spectra

Appendix K: Kern Valley Power Plant

K.0 Kern Valley Power Plant

K.1 General Description

The Kern Steam Power Plant is owned by the Pacific Gas and Electric Company and is located in the southern end of the San Joaquin Valley, approximately four miles west of the City of Bakersfield, Kern County, California. Construction work started on Units 1 and 2 in September 1946 and was completed in March 1950. The plant site consists of a 77.5 acre plot of level sandy soil, bordered on the north by Rosedale Highway, on the east by Coffee Road, and on the south by the A.T. & S.F. Railroad. The power plant was designed to have a rated output of 173,500 kilowatts. Currently the plant is in a cold standby condition and has been since 1985. Current plant arrangements are shown in Figures K.1 and K.2.

Four Babcock & Wilcox radiant type boilers, each with a rated capacity of 450,000 lbs. and a maximum capacity of 517,000 lbs. of steam per hour at 1,380 psi gage and 935° F total temperature are semi-enclosed in a structure 114 feet high. The boiler house structure is of structural steel, immediately adjacent to the power plant or turbine hall building. The boilers are equipped to burn either gas or fuel oil. A tank farm north of the boiler area provides storage for 241,600 barrels of fuel oil in two 80,000 barrel and two 40,800 barrel welded steel plate tanks with Horton floating roofs. Gas at 40 psi is supplied through a 16 inch underground pipe line connected to the Kettleman Hill feeder in Bakersfield.

The power plant building consists of structural steel framing and reinforced concrete walls, floors and roofs. The turbine bay houses the two main turbine generators, unit No. 1 rated at 60,000 kw is air-cooled and unit No. 2 is rated at 100,000 kw with hydrogen cooling gas at 15 psi. Both units operate at 1,800 rpm with 1,350 psi throttle steam at 925° F total temperature. Two house unit turbine generators, one rated at 6,000 kw and the other at 7,500 kw, each air-cooled, supply all power required to run the auxiliary equipment in the plant. The remainder of the three-story structure is occupied by the auxiliary equipment, piping, conduit and electrical controls and switchgear necessary for modern fossil fuel steam power plant.

All water to meet the consumption of this plant is obtained from six wells located on the site in pairs, comprising one shallow well (120 feet deep) and one deep well (500 feet deep). Cooling water for the turbine condensers is circulated by low head pumps through the condensers require 74,000 gallons of water per minute from two Foster Wheeler Corporation forced draft cooling towers, to maintain a minimum condenser vacuum of 27 inch of mercury. The two unit No. 1 cooling towers are each 225 feet long, 39 feet wide and 24 feet high, of select redwood construction, built upon concrete basins. Fourteen four-bladed fans of 12 feet diam force air up through the drip trays for forced draft cooling. Unit No. 2 main and house turbine condensers require 104,000 gallons per min to 225 feet long and 29 feet high serve to cool the water for unit No. 2. These towers are also of select redwood construction mounted upon basins. Seven, four-bladed fans of 18 feet-6 inch diameter are mounted horizontally on the top of each of these towers to promote air circulation through the drip baffles by drawing up air through the louvers along the tower base.

Other yard structures and equipment include a permanent stores and warehouse building of reinforced concrete construction, a transformer oil pump house, two 10,000 gallon oil storage tanks with a piping system to the 70 kv and 110 kv switchyards, and the main and station service transformers. A foam preparation building houses equipment which provides foam for oil fires. A precast concrete incinerator provides facilities for waste disposal.

K.2 Summary of Recorded Earthquake Effects From the Kern County Earthquake of 7/21/52

The plant operated through the earthquake with no significant damage. The plant was shutdown after the earthquake due to loss of load but was returned to service in a few hours. There was no recorded damage to power plant piping. Damage from the earthquake was limited to the Fuel Oil Storage Tanks, Boiler Controls and a small house turbine thrust bearings.

K.2.1 Description of Repairs of Earthquake Induced Damage to Oil Storage Tanks

K.2.1.1 No. 1 Fuel Oil Tank: Oil slopped through seal on to roof. Roof remained in guide bar. Several angle truss supports badly bent. Several rod supports for roof supports bent and twisted.

Estimated Cost for Repairs.............$500.00

(This cost excludes tank drainage and purging for internal inspection.)

K.2.1.2 **No. 2 Fuel Oil Tank:** Oil slopped through seal on to roof. Roof came out of guide bar and turned clockwise about 24 inches. Seal irregular at tank shell.

Estimated Cost for repairs................$800.00

(This cost excludes tank drainage and purging for internal inspection.)

K.2.1.3 **Fuel Oil Tank No. 3:** Oil slopped over tank on the southeast side and on the northwest side. The seal ripped out between 2 1/2 trusses on the southeast side and between 3 trusses on the northwest side. Approximately 10 feet of roof came out of the guide bar and turned clockwise about 12 inches. The ladder broke away from supports and lay on the roof. A number of roof hanger assemblies were damaged. Five were thrown completely out of the seal space.

Estimated Cost for repairs........$10,000.00

K.2.1.4 **No. 4 Fuel Oil Tank:** Oil slopped through seal on to the tank roof. The roof came out of guide bar and turned clockwise about 36 inches. Ladder wheels bounced off of their tracks. Several angle truss supports were badly bent.

Estimated Cost for repairs...........$800.00

(This cost excludes tank drainage and purging for internal inspection.)

K.2.2 Description of Earthquake Damage to Bailey Boiler Controls

A quantity of mercury was spilled from the air flow meters on all boilers, these instruments required recalibration.

Estimated Cost for labor and repairs

....$150.00

K.3 Earthquake Design Basis

K.3.1 Structures

The structures of the Kern Valley Power Plant were designed for 0.2 lateral load on a static basis with stress limits increased by 0.33 for combined dead, live, and earthquake loadings. Foundations are soil bearing footings at shallow depth.

K.3.2 Piping

The spacing of hangers and supports for piping of other materials were in accordance with the current practice to carry dead and thermal loads with vertical support spacing as failures.

Pipe Size	Maximum Spacing of Hangers & Supports
1″ and smaller	6 feet
1 1/4″ to 2 1/2″, inclusive	10 feet
3″ and 4″	14 feet
6″ and 8″	18 feet
10″ and larger	22 feet

All pipe hangers, supports, guides and anchors were attached to the steel and concrete building structures furnished by the Purchaser wherever practicable, otherwise auxiliary steel was used. The Contractor was responsible for the safety and appearance of this work and of these attachments to existing new or old structures, including their effect on these structures. As discussed in Section 5.5.2 only the main heat transport ruptures were seismically designed. In general no other lateral support was provided for piping.

K.4 Seismic Demand from the Kern County Earthquake at the Kern Valley Power Station

The Magnitude 7.7 Kern County Earthquake occurred at 0452 local time on July 21, 1952. Its epicenter was located at 35°.00N and 119°.02'W at Wheeler Ridge on

US Route 99 and Interstate 5 which is approximately 26.4 miles SSW of the Kern Valley power plant. The Earthquake Intensity at the Kern Valley Power Plant site was VIII. The earthquake ground motion was measured at the Lincoln School at 810 N Sixth St. in Taft, California which is approximately 30.3 miles NNW of the epicenter. The Intensity in Taft was VII with a recorded peak ground acceleration of .17g. This suggests a zero period ground acceleration at the power plant site of between 0.25 and 0.3g.

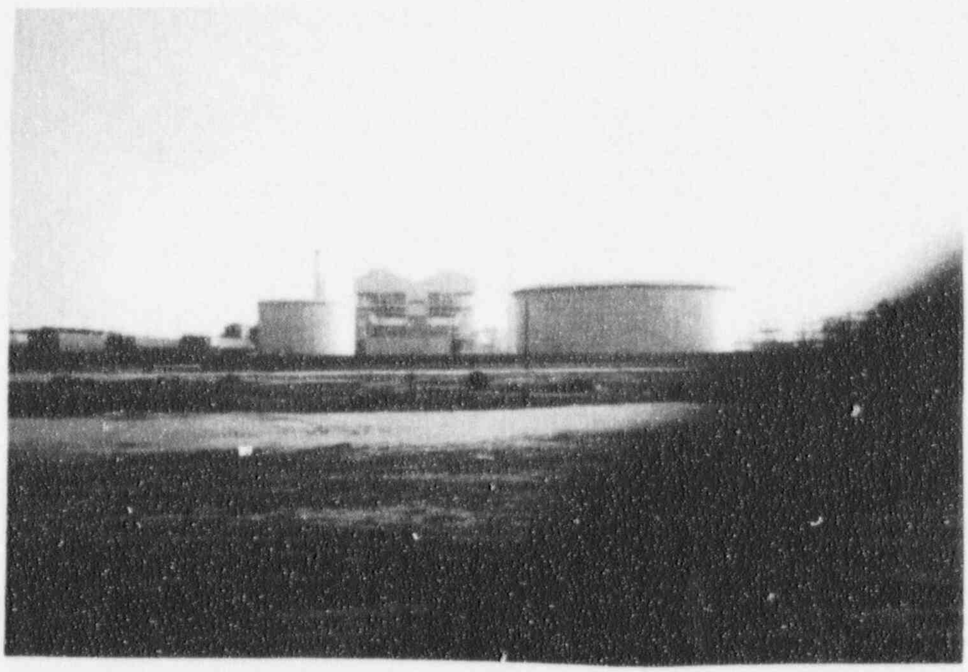


Figure K.1 - End View of Kern Valley Units 1 & 2 Power Station

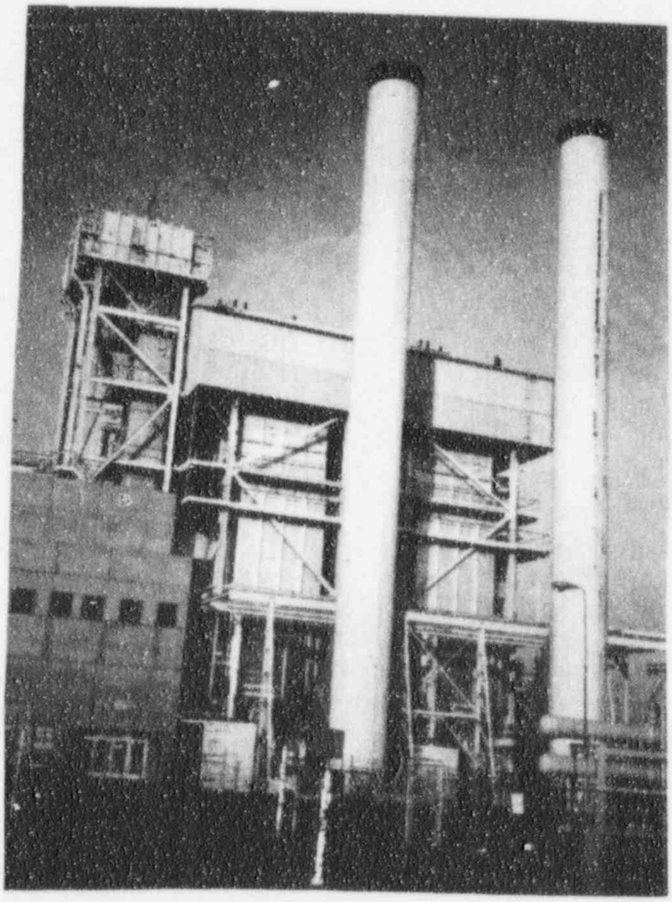


Figure K.2 Side View of Kern Valley Unit 1 Power Station

Appendix L: Pasadena Power Plant

L.0 Pasadena Power Plant

L.1 Plant Description

L.1.1 General

The Pasadena power plant is owned and operated by the city of Pasadena. It is located on the southern edge of the city of Pasadena, in the Los Angeles Basin adjacent to the San Fernando Valley. The plant at the time of the San Fernando earthquake had four generating units with a total capacity of 206 MWe. Broadway Units B1 and B2, each having a capacity of 45 MWe, were built in 1955 and 1957, respectively. The total height of the B1 Unit above grade is 62.0'. Broadway Unit B3 is a 71 MWe unit and was built in 1965 and extends approximately 80 feet above grade. Unit 4, the Glenarm Plant, was built in 1933 and has a capacity of 45 MWe and has a total height of approximately 6 feet above grade.

All four units are in separate structures, and all the Broadway Units 1 to 3 except for the reinforced concrete turbine-generator pedestals are braced steel-framed buildings as shown in Figure 2-8 of Appendix B of Ref. L.1. The Glenarm unit is enclosed primarily by a masonry structure with the boiler supported by overhead structural steel.

L.1.2 Civil-Structural

The Steam Generator (Boiler) and Precipitate support structures for all the B-1 to B-3 Broadway Units are conventional shear connected structural steel framing systems as shown in Figure L.1. Horizontal trusses are integrated with the boiler walk ways and platforms to provide lateral support to the steam generator support columns. Vertical diagonal bracing is provided in selected bays to transfer wind and seismic loads to the foundations.

The older Glenarm structure is masonry block and reinforced concrete shear wall construction for the most part with a steel truss supported roof in the turbine hall and structural steel supports the boiler. Of all the units surveyed the Glenarm structure is the only one which contained significant quantities of masonry block. While the block showed significant cracking at openings as shown in Figure L.2 and some spalling of attached tile ash shown in Figure L.3 there was no collapse or loss of support of the masonry walls.

The steam drum and boiler support level for Units B1-B3 have enclosed penthouses with corrugated asbestos cement siding and roof deck. The remainder of the structures are open.

Steel framing on B-1 is typically riveted. Steel framing on B-2 is typical shop riveted and field bolted. On unit B-3 the frame is typically shop welded and field bolted.

Foundations for boiler area structures and equipment are generally conventional reinforced concrete spread footings and equipment bases supported on compacted fill.

The turbine - generator foundation mat and pedestal is a 4.0 ft. thick reinforced concrete slab which supports the turbine-generated pedestal and the condenser. The pedestal is a massive reinforced concrete rigid frame structure which supports the turbine and generator equipment. A one-inch thick topping slab is placed over the top slab of the pedestal to form a part of the operating floor. A one-inch gap provides physical separation of the pedestal where it is adjacent to other structures. An independent reinforced concrete Exciter Room building is located at grade at the north end of the Turbine-Generator pedestal.

The control and service buildings are conventional steel framed structures with 6 inch thick reinforced concrete floor slabs at elevation 16 feet 6 inches. Roofs are of built-up construction over steel decking. The wall covering is steel siding.

L.1.3 Systems

L.1.3.1 Turbine-Generator

The turbine-generator units for B-1 and B-2 consist of 3600 rpm tandem compound, non-reheat, condensing, multi-valve steam turbine directly connected to a hydrogen cooled, 2-pole, 60-Hz, 3-phase generator and a direct driven exciter. The basic system parameters for the units are as follows:

- Throttle steam pressure 1250 psig
- Throttle steam temperature 950 F
- Exhaust pressure 1.5 "Hg
- Generator rated gross output 40,000 KW

- Generator maximum gross output 44,000 KW
- Hydrogen pressure at maximum output 15 psig

The turbine supplies extraction steam to five feedwater heaters, including a dearator. The condenser is fixed to the turbine exhaust flange and is spring-supported at its base.

Turbine supervisory instruments are as originally supplied, with the exception that Bentley-Nevada vibration and expansion monitoring systems and digital tachometers have been retro-fitted.

Plant design includes special design features to allow the plant to accept 20-MWe load swings over a 20-minute period and to minimize maintenance requirements. These include: 1) automatic controls for the boiler combustion, feedwater and steam systems, 2) boiler design to permit full steam temperature to be maintained down to about 20 percent load, 3) an effort to eliminate gasketed piping joints, 4) use of corrosion-resistant materials in valves and piping, and 5) welded feedwater heaters.

L.1.3.2 Condensate and Feedwater

The condensate and feedwater systems for units B-1 and B-2 provide the primary water supply to the boiler for steam generation. The condensate and feedwater systems consist of the following major equipment components:

- Main Condenser
- Condensate Pumps
- Feedwater Heaters
- Deaerator
- Boiler Feed Booster Pump/High Pressure Feed Pump

L.1.3.3 Fuel Oil Supply

The fuel oil supply system consists of fuel oil storage tanks (56,000 bbls), and fuel oil burning tanks (40,000 bbls). The burning tank supplies the 63gpm primary fuel oil pumps. From here the oil is passed through heaters and then to the burners.

L.1.4 Piping

L.1.4.1 Main Steam Piping

Broadway Unit 1 and 2 main steam piping consists of a conventional single lead system routed from the boiler superheater outlet nozzle through the stop valve and to the turbine inlet nozzle. The main steam piping design temperature and pressure are 950° F and 1500 psig, respectively. there are six pipe support assemblies which consist of two variable springs, three rigid supports and one sway brace. The system is also equipped with a Bailey Meter flow nozzle located in the riser.

The piping material specified is CR-MO A158 Gr., P12 seamless pipe welding classification as shown on drawing 8-2-1250. The pipe is 10-inch diameter, schedule 160.

L.1.4.2 Top Heater Extraction Piping

The extraction piping for Units B-1 and B-2 consists of a single lead system from the turbine Number 5 extraction to the heater Number 1 inlet nozzle. The extraction piping design temperature and pressure are 660° F and 330 psig, respectively. The piping system contains two manually operated gate valves and a check valve and is supported with rod type hanger supports.

The extraction steam piping specified material is A53 or A106 Gr. B seamless. The pipe is 6-inch diameter, schedule 40.

L.1.4.3 Boiler Feedwater Piping

The boiler feed piping for Units B-1 and B-2 consists of 4-inch diameter, schedule 120 discharge lines from the three main feedwater pump outlet nozzles into a single 6-inch diameter, schedule 120 line to the economizer inlet header. The boiler feedwater piping approximate design temperature and pressure are 420°F and 1400 psig, respectively. The boiler feedwater piping system contains six manually operated gate valves, four check valves and one Bailey regulator valve.

The boiler feedwater piping system for Units B-1 and B-2 has three supports which consist of one variable spring, one lateral rigid restraint and one two-direction rigid restrains. The piping material specified is A-A158

P11 seamless.

L.2 Summary of Recorded Events

L.2.1 San Fernando Earthquake - 1971

At the time of the San Fernando earthquake, Units B1 and B3 were in operation, and Units B2 and Glenarm were on hot standby. According to the power Production Superintendent, the two operating units did not trip but continued to operate throughout the earthquake.

L.2.2 Whittier Narrows Earthquake - 1987

Two of four units in the Pasadena Power Plant were on line and operated through the earthquake. One unit was manually tripped by the operators immediately afterward, due to a false reading of air flow to the boilers.

L.3 Time Sequence of Events Following the Earthquake

L.3.1 San Fernando Earthquake - 1971

The following is the outage report prepared by the power dispatching supervisor.

0601 February 9, 1971 Earthquake

0601 <u>Dispatch Center</u>

Load Frequency Control tripped. B-1 and B-3 picked up 22 MW. System frequency to 59.4 (per Southern California Edison). Was taking 10 MW from SCE. Picked up to balance. 3408 O.C.B. relayed B o target.

0601 <u>Glenarm Substation</u>

G-2 Circuit relayed. Ground target. Wires down at Church Street and Romney Avenue.

0601 <u>Santa Anita Substation</u>

34-8 O.C.b. relayed. A o overcurrent relay.
34-10 O.C.B. relayed. B o overcurrent relay.

3405 O.C.B. relayed. P.J.V. sudden pressure at E.O.S.

0601 Hastings Substation

Ban 1-A and 2-A A.C.B.'s relayed on undervoltage.
Bus ties closed.

0601 E.O.S. Substation

Sudden pressure relay operated. Station picked up on E-3.

0601 Chest Substation

Bank 1-A, 2-A and 3-A A.C.B.'s relayed on undervoltage.
Bus ties closed.
C-1 Circuit relayed and re-closed. One operation, no targets.

0618 Dispatch Center

Closed 34-8 O.C.B.

0618 Santa Anita Substation

Closed 34-8 O.C.B.

0620 Closed 34-10 O.C.B.

0700 Hastings Substation

Opened 34-5 in South G & W.
Closed 34-K.V. tie position in south G & W.

0715 E.O.S. Substation

Opened 34-5 position in West G & W.

0752 Closed 34-5 position in west G & W.

0754 Santa Anita Substation

Closed 34-5 O.C.B.

0755 E.O.S. Substation

Closed Bank main A.C.B.
Opened Bus tie A.C.B.
Opened E-3 emergency feed.

0759 Hastings Substation

Closed 34-5 in South G & W.
Opened 34-K.V. tie position.

0837 Glenarm Substation

All Load picked up on G-2 Circuit.
Back to normal.

L.3.2 Whittier Narrows Earthquake - 1987

A time sequence of events for this earthquake relative to the Pasadena Power Plant is not currently available.

L.4 Earthquake Damage Summary

L.4.1 San Fernando Earthquake - 1971

The only reported malfunction during the earthquake was in an air-flow monitor that records the intake of air into the Unit B-3 furnace. The monitor is mounted several floors above grade, in the boiler structure. A linkage in the monitor became disconnected during the earthquake so that erroneous air-flow readings were monitored in the control room. No other damage or malfunction was reported in the plant's trouble report or by the operators who were on duty at the time.

L.4.2 Whittier's Narrows Earthquake - 1987

A false air-flow reading was caused by the disconnection of a mechanical linkage in the flowmeter. It should be noted that this was the same air flowmeter that had malfunctioned during the San Fernando Earthquake as discussed in Section L.4.1.

L.5 Seismic Design Basis for Building Structures and Piping

Units B1 and B2 structures were probably designed to Los Angeles City Building Code which is equivalent to the then current (1955 - 1957) Uniform Building Code. Main heat transport piping for Units B1 and B2 were probably designed to a 0.2g static load. However, there is no evidence during a walkdown that Units B1 and B2 piping support was affected by seismic considerations.

Unit B3 structure also appears to have been designed for the then current Los Angeles or Uniform Building Code (1965). There was however explicit seismic design of main heat transport piping to resist seismic effects. Piping Isometrics are as shown in Figures 5.1 to 5.5 of Volume 1 of this report. The seismic analysis on the lines shown was performed by Basic Engineers, Pittsburgh, Pa. during August - December 1963. The seismic analysis was performed by applying a static 0.2g acceleration times mass in two orthogonal horizontal directions simultaneously and computing resultant stresses. Resultant stresses were required to meet the provisions of the ASA B.31.1.0-1955 Code. One result of this analysis was to require a main steam line snubber as shown in Figure L.3.

There is no indication that the Glenarm Unit structure or piping were seismically designed.

L.6 Seismic Demand

In Figure 3.6 of Volume 1 of this report is shown the location of a) the Pasadena power plant, b) the closest strong motion record locations for the San Fernando and Whittier Narrows earthquakes and c) the epicenter locations for the two earthquakes.

L.6.1 San Fernando Earthquake

The Pasadena plant is located about 21 miles from the epicenter of the San Fernando earthquake. There was no ground breakage at the plant. The Intensity at the plant site was VII. PGA was estimated to be 0.20g and 0.16g in the two horizontal directions. The ground motion recorded at Millikan Library of the California Institute of Technology, Pasadena, was considered representative of the motion at the power plant site because the geologic and soil conditions at that location are similar to those of the plant site and because of its proximity to the plant (1.5 miles). Both sites are on intermediate alluvium and are approximately the same distance from the epicenter of the San Fernando earthquake. The Millikan Library records had PGA's of 0.22g (north-south), 0.18g (east-west) and 0.12g (vertical).

L.6.2 Whittier Narrows Earthquake - 1987

The October 1, 1987 Whittier Narrows Earthquake (M_L = 5.9) occurred at 7:42 a.m., Pacific Daylight Time (PDT) at an epicentral location of 34° 3.0'N, 118° 4.8'W, about 15 km northeast of downtown Los Angeles, at a focal depth of about 14 km approximately 12 miles SSE of the Pasadena power plant site. The maximum Modified Mercalli Intensity (MMI) assigned to the epicentral area was VII with a value of VII also being assigned to the Pasadena power plant site.

The closest strong motion acceleration recording instrument (approximately 1.25 miles) to the Pasadena power station (Southwestern Academy 2800 Monterey, Road, San Marino) for the Whittier Narrows earthquake recorded a peak acceleration of 0.2g N-S, 0.15g E-W and 0.14g vertical.

L.7 References

(L.1) Seismic Design Task Group, "Report of the U.S. Nuclear Regulatory Commission Piping Review Committee: Summary and Evaluation of Historical Strong-Motion Earthquake Seismic Response and Damage to Above Ground Identical Piping", NUREG 1061, Volume 2 Addendum, U.S. Nuclear Regulatory Commission, April 1985.

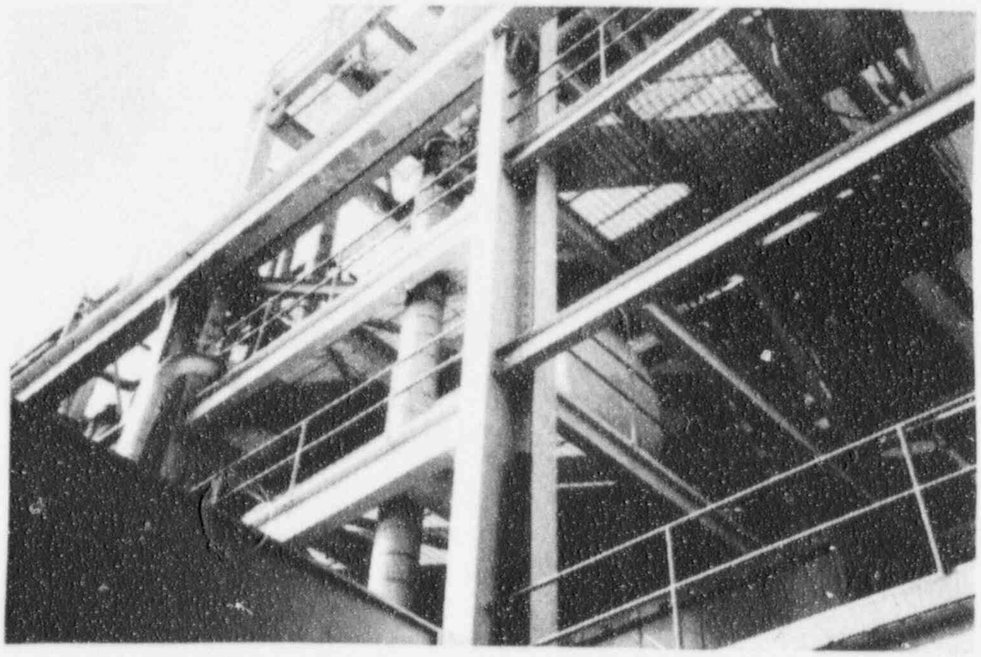


Figure L.1 - Structure Steel Framing for Broadway Unit 1 to 3

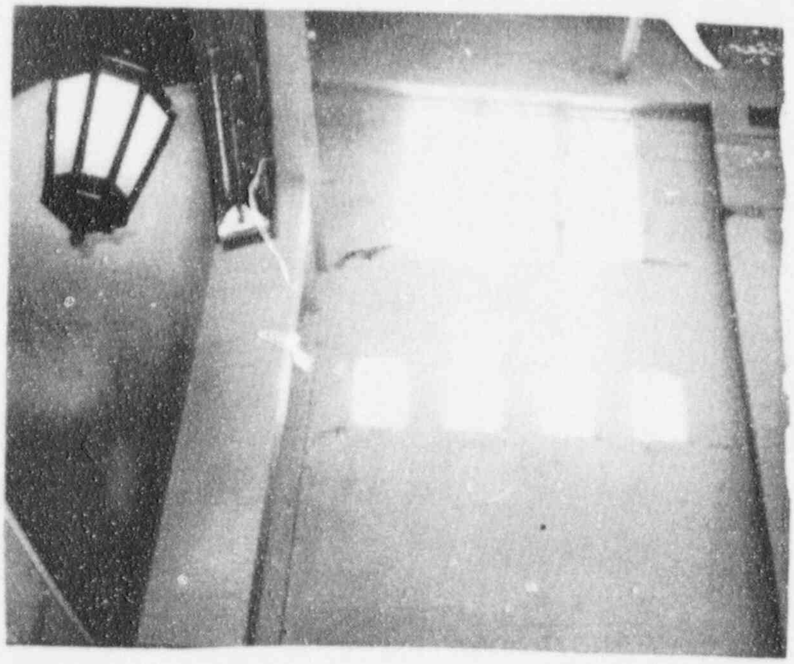


Figure L.2 - Glenarm Internal Cracking of Masonry Block Due to Earthquake

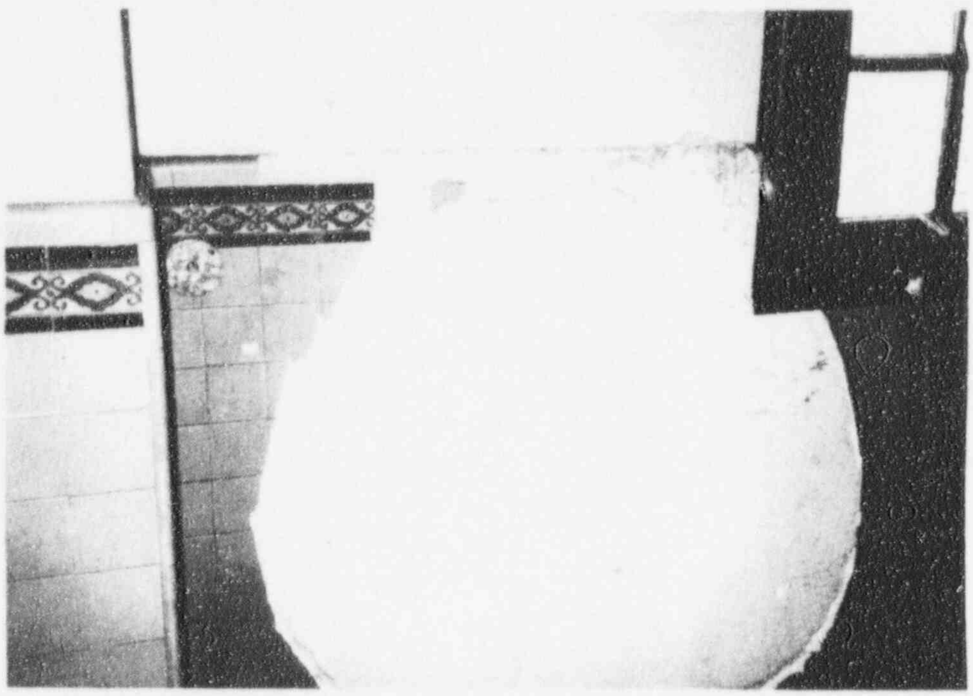
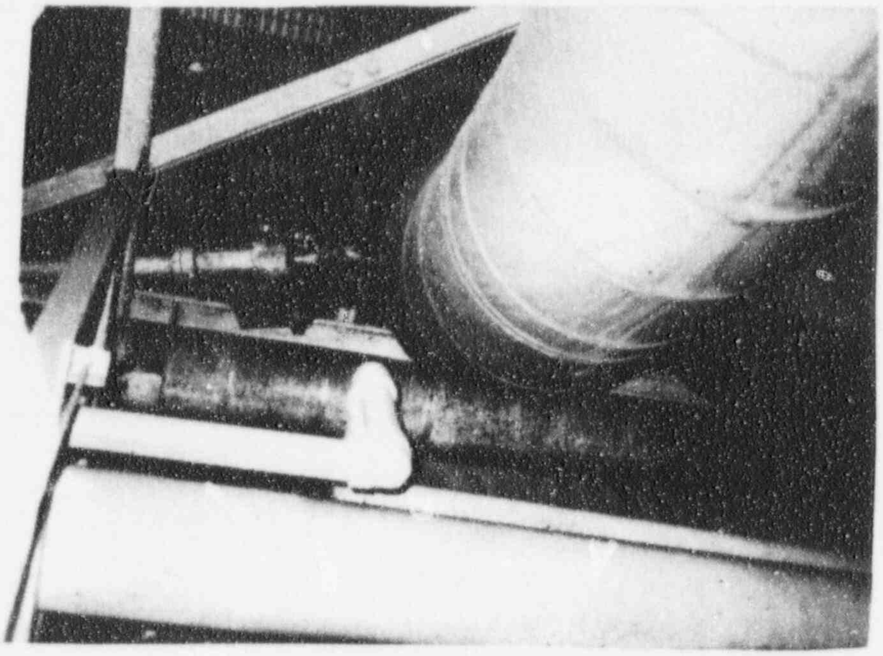


Figure L.3 - Glenarm Spalling Damage Due to Earthquake



L.4 - Snubber Support on Main Steam Line for Broadway Unit 3

Appendix M: Valley Power Plant

M.0 Valley Power Plant

M.1 Plant Description

M.1.1 General

The Valley Steam Plant is located on a 150-acre site in the central San Fernando Valley and is owned and operated by the Los Angeles Department of Water and Power (see Figures 15 of Reference M.1). The plant has four generating units with a total capacity of 513 MWe. Units 1 through 4 were constructed in 1954, 1954, 1955, and 1956, respectively; and their individual capacities are 100, 100, 157, and 157 MWe, respectively. Because of the area's mild climate, much of the plant piping and equipment is located outdoors.

The main structures consist of braced steel frames supporting the boilers, concrete foundations for the turbine-generator units, and concrete-surfaced decks in the steel-framed turbine building. The plant is located in a flat, alluvial area, on sand, gravel, and boulders that extend to a depth of more than 500 feet. The permanent water table is about 200 feet below the surface.

The Valley Steam Plant, typical of other California power plants, is essentially an outdoor plant. Complete housing is provided only for operating personnel and for equipment that, for practical or economic reasons, cannot be located outdoors. All major equipment, including the boilers, turbines, generators, and unit auxiliary power centers are weatherproofed and located outdoors.

The main plant structure consists of steel framework supporting the boilers, concrete foundations for the turbine generator units, and concrete surfaced decks to provide accessibility to plant equipment for operation and maintenance. To handle heavy equipment a traveling gantry crane capable of lifting 225 tons is installed on the turbine generator deck.

Each of the four generating units is designed to operate as an independent power plant with individual boiler, transformer, switchgear, and auxiliary equipment.

The boilers that supply steam to the turbine generator units either burn fuel oil, or natural gas, and can be converted to the use of coal as a fuel if required in the future. The boilers for the 100,000 kilowatt Units 1 and 2 are 115 feet high and the boilers for the 156,250 kilowatt Units 3 and 4 are 150 feet high. Each boiler for Units 1 and 2 is capable of producing 850,000 pounds of steam per hour at a pressure of 1500 pounds per square inch and a temperature of 1000° F. Each boiler for Units 3 and 4 is capable of producing 1,200,000 pounds of steam per hour at 1850 pounds per square inch with an initial temperature of 1000° F and reheat temperature of 1000° F. Operating at full load, the four units consume about 630,000 barrels of fuel oil per month. Six fuel oil storage tanks are installed to insure a dependable fuel supply, and space has been reserved for the storage of coal, in case of future conversion to coal.

The steam generated provides the power for driving the generators at 3600 revolutions per minute. Each generator delivers power directly to a three-phase transformer which steps up the voltage from 13,800 volts for Units 1 and 2 and from 18,000 volts for Units 3 and 4, to 138,000 volts for transmission through the switchyard to the transmission lines and on to power receiving stations. The exhaust steam is discharged from the turbines into the condensers where the steam is condensed into feed water and returned to the boilers. With the four generating units in operation, the Valley Steam Plant requires about 284,000 gallons of condenser circulating water per minute for condensing the exhaust steam from the turbines. After passing through the condensers, the water is cooled by evaporation in eight cooling towers. Water required for plant use is supplied by means of a 48 inch pipeline connected with the Los Angeles Owens River Aqueduct and supplemented with wells on or near the plant site.

M.1.2 Structural Aspects of the Plant

M.1.2.1 Site Preparation and Excavation

A total of 600,000 cubic yards of earth work was required for the project. The amount of cut and full was balanced to provide backfill wherever necessary and to provide material to construct the earth dikes surrounding the fuel oil storage tanks. Earth material at the site is a well graded sand and gravel capable of being compacted to high densities.

M.1.2.2 Column and Equipment Foundations

The soil is known to be sand, gravel and boulders to depths of over 500 feet, with the permanent water table fluctuating around 200 feet below the surface in the recent past.

Most of the plant footings are isolated square or rectangular footings. Due to the magnitude of the boiler column loads, which are as high as 800 tons per column, it was necessary to use a number of combined footings in these areas.

Construction of the smaller footings presented no unusual problems. In order to prevent cold joints, the large combined boiler footings, which were up to 7-1/2 feet thick, were poured by beginning at one end and placing inclined rather than horizontal layers. Approximately 2400 cubic yards of concrete and 120 tons of reinforcing steel were used in the building and boiler feed pump foundations for the four units.

M.1.2.3 Turbine Generator Foundations

In designing the turbine generator foundations, consideration was given to the vibration of the turbine and generator. In order to dampen the effects of the vibration of these units, massive foundations were provided having a weight ratio of foundation to the machine of approximately 5 to 1.

In constructing the foundations, the largest monolithic pours in the entire project were made. The matt foundation for each of these structures contained 1100 cubic yards of concrete. A total of 9400 cubic yards of concrete and 470 tons of reinforcing steel were used for the foundations of the four units.

M.1.2.4 Structural Steel Frame

The structural steel frame in the boiler bay for Units 3 and 4 attains the height of a 13 story building. At the top of this bay are welded plate girders that support the boilers and carry over 1000 tons each. These girders are approximately 10 feet deep and 55 feet long with 3 inch by 28 inch flanges. A planned sequence of welding and preheating to 200° F. was used to avoid distortion and residual weld stresses. Cover plated columns weighing up to 730 pounds per foot are required to support these girders.

In addition to equipment loads, the steel frame supports floor live loads ranging from 100 to 250 pounds per square foot, the latter loading being used for the turbine bay floor.

In Units 1 and 2 rivets were used for all connections; however, in keeping with the latest construction developments, high tensile bolts were used for all field connections and a majority of the shop connections in Units 3 and 4.

In Figures M.1 and M.2 are shown typical structural steel framing used in construction of the Valley Power Plant.

A total of 4200 tons of structural steel was required for the four units.

M.1.2.5 Superstructure

The superstructure includes the concrete floor slabs, stairways, concrete and plaster filler walls, equipment supports, and miscellaneous platforms that are required to complete the Main Building. Concrete floors are used wherever heavy usage, vibration or protection from the weather is required. Steel grating floors are used to provide access to the many operating platforms around the boiler.

M.1.3 Steam Boilers

M.1.3.1 Boiler Units 1 and 2

The steam capacity of each of the boiler units is 850,000 lbs/hr at a temperature of 1000° F and 1500 psi-g at the superheater outlet. The steam drum is 66 inches ID with a 5 inch wall thickness and is 47 feet 4 inches in length. The boiler contains approximately 33,000 gallons (275,000 pounds) of water when filled to the normal water level in the drum. The total weight of the boiler in operation, including the air heater, is 2,675,000 pounds which is entirely supported by hanger rods from overhead steel.

As the boiler is hung from the top and is tied at the front and one side by seismic ties, the boiler expands downward, toward the rear, and toward one side due to thermal expansion when placed in operation. The approximate linear expansions are 4-3/4 inches downward, 1-3/4 inches to the rear, and 1-1/2 inches to the side.

The top part of the boiler above the water wall tubes and furnace roof tubes is enclosed in a metal casing with an inner layer of insulation. The refractory and insulation enclosing the tangent tube furnace water walls and the tubes forming the convection area enclosure are attached to and supported by the tubes. With the exception of the top portion of the boiler, a relatively expensive outer steel casing has been eliminated and a canvas and adhesive weatherproof coating used in its place to protect the insulation and provide an airtight enclosure.

The steam turbines for Valley Steam Plant, Units 1 and 2 are each rated at 100,000 kwe maximum capability. the turbines are of the tandem compound double flow type and consist of on Curtis stage and 36 reaction stages. Steam from the boiler is supplied at 1450 psi gauge and 1000° F. to turbine. The steam passes through the high pressure turbine through the cross-over, and then is divided in half as it goes through the low pressure turbine, each half flowing in opposite directions and then exhausting to the condenser.

About 800,000 pounds per hour of steam is admitted to the inlet valves under full load. Each pound of steam increases in volume about 550 times from the time it enters the machine to the time it leaves the machine. The temperature changes from 1000° F. to 100° F. and the pressure changes from 1450 psi gauge to about one psi absolute. In the low pressure turbine, the last stage blades are 23 inches in length and the velocity at the tips of the blades is about 1000 miles an hour. Due to centrifugal force, there is a pull at the base of each of these 23 inch blades (there are 250 of them) of about 30 tons when rotating at the operating speed of 3600 rpm.

Steam is extracted from the turbine at the 16th, 22nd, 28th, 33rd, and 35th stages for feedwater heating in a regenerative cycle. However, unlike Units 3 and 4 there is no reheat cycle on these turbines. The regenerative cycle increases the turbine cycle efficiency by about 13 percent and also reduces the amount of steam going to the condenser requiring smaller condensing equipment.

M.1.3.2 Units 3 and 4

The design for Units 3 and 4 is essentially identical with respect to plant arrangement. Units 3 and 4 differ from Units 1 and 2 in that they are each rated 156,250 kw and the turbines employ reheat.

The boiler for each of Units 3 and 4 is rated 1,200,000 pounds of steam per hour at a pressure of 1850 psi and a temperature of 1000° F and unlike Units 1 and 2 employs a reheat cycle. Each turbine is of the tandem compound triple flow reheat type. After the steam has passed through the high pressure stage of the turbine, the steam is returned to the boiler at a lower pressure and temperature and is reheated to 1000° F. After reheat, the steam is passed through the intermediate and low pressure stages of the turbine and then exhausted to the condenser.

M.2 Summary of Recorded Effects from the San Fernando Earthquake

At the time of the San Fernando earthquake, Units 1, 3, and 4 were on line. Unit 2 was down for scheduled maintenance. The earthquake tripped Units 1 and 4 off line. The trip is attributed to the sudden-pressure relays, located on the floor below the control room, that are associated with the high-voltage switchyard equipment tying the plant into the Los Angeles power grid. Both Unit 1 and Unit 4 lost station power, and all equipment came to a stop. Unit 3 stayed on line throughout the earthquake; however, the flow of gas fuel was interrupted by the closing of a control valve that was activated by the vibration of a Mercoil switch. Because Unit 3 was still on line, the operators energized the tie buses between the three units so that Unit 3 furnace were relit at 6:20 a.m., 19 minutes after the earthquake. With the plant's lighting system functioning, the operators were able to make a cursory inspection of Units 1 and 4 to determine whether any obvious damage had occurred. Nothing was seen that would prevent the units from restarting. The plant's log shows Unit 4 coming back on line at 6:50 a.m., 49 minutes after the earthquake, and Unit 1 at 7:12 a.m.

The local gas utility requested the plant to switch from gas to oil fuel after the earthquake. Ruptures of underground gas lines in the San Fernando Valley had created problems in the normal supply of gas fuel. Subsequently, the plant's log notes that Unit 2 switched to oil fuel at 7:25 a.m., Unit 3 at 7:45 a.m., and Unit 4 at 8:20 a.m. Oil fuel is supplied from large tanks located on the plant site northeast of the four units. Switching from gas to oil (fuel required activation of a completely different system of pumps, piping, valves, and controls that feed the furnace burners. No malfunction of any component in the fuel oil system was reported for any of the three operating units. At 10:55 a.m., the log notes that load was reduced in Unit 4 for inspection of the condenser, which was later found to contain some ruptured tubes.

M.3 Time Sequence of Events Following the Earthquake

M.3.1 Description of Incident

On Tuesday, February 9, 1971 at 0601 hours, Units 1 and 4 were tripped off the line by an earthquake. Unit 1 was resynchronized at 0704 and Unit 4 at 0650.

M.3.2 Plant Conditions Prior to Trouble

Unit 1 - 32 MW	Unit 3 - 38 MW
Unit 2 - S.I.R.	Unit 4 - 42 MW

Station Services energized from No. 2 138/230 KV line.

M.3.3 Excerpts from Plant Logs

Control Room "A" Log:

0601 - Unit 1 off line - Earthquake. Lost both buses 138/230 KV and everything else.

0704 - Unit 1 on line.

Control Room "B" Log:

0602 - Lose of all units due to earthquake.

0620 - Unit 3 on line.

0650 - Unit 4 on line.

0712 - Unit 1 on line.

0725 - Unit 1 fuel change to all fuel oil.

0740 - Closed Valley - Hollywood OCB to No. 2 Bus. Would not close.

0741 - Closed Transformer Bank C OCB to No. 2 Bus. Would not close.

0745 - Unit 3 fuel change - all oil.

0749 - Closed Valley - Hollywood Line 1 OCB to No. 2 after resetting MG-6 relay to No.1 2 Bus.

0750 - Closed OCB's from 3 and 4 Units and Transformer Banks B and C to No. 2 Bus. No. 2 138 KV Bus normal.

0752 - Closed OCB's on Valley - Rinaldi Lines 1 and 2 to Bus No.2.

0754 - Transferred Outside Service to normal.

0820 - Fuel change on Unit No. 4 to all fuel oil.

1055 - Load Limit on No. 4 Unit of 100 MW to take condenser out one side at a time to check for leaks.

M.3.4 Analysis of Incident

Units 1 and 4 were tripped by their CFD relays which were actuated by severe jolts from the earthquake.

Unit 3 remained on the line, however, during the confusion it was assumed that all units including the Station Service had been lost. No. 3 boiler fires were tripped by the earthquake actuating the low pressure fuel gas mercoid switch. When it was discovered that Unit 3 was still on the line, the tie buses were energized to supply Units 1 and 4 and Station Service with power. The boiler was purged and burners lighted.

No. 2 138/230 KV Bus was tripped by the Sudden Pressure Relay on 230 KV Tank F. When an attempt was made to energize the bus, the breakers failed to reclose and it was assumed that the bus was damaged. Later it was discovered that the MG-6 relay had not been reset which is a requirement before the bus can be energized after a trip. No. 1 138/230 KV Bus did not trip as reported in the "B" Control Room Log.

In addition to the above information, some of the problems and damage caused by the earthquake were as follows:

(1) No. 4 Unit main bank "A" phase lightning arrestor was broken.

(2) No. 4 boiler water was highly contaminated by some ruptured tubes in the condenser.

(3) On all units, loads were increased and fuel changes made with controls on hand due to automatic components being jolted severely enough to throw them out of calibration or in some instances linkage on metering devices had become disconnected.

(4) Lack of normal lighting during the period the

Station Service was de-energized added to the confusion.

(5) Due to high turbidity of the city water supply, the Raw Water Storage Tank was isolated to use for makeup to the deminerialzer and fire lines were used to maintain cooling tower basin levels.

M.4 Earthquake Damage Summary

The plant's trouble report notes the following damage to equipment.

- A lightning arrestor in the switchyard was broken.
- At Unit 4, a few circulating water tubes in the condenser were ruptured. The damage was noticed when contamination began to appear in the boiler feedwater. This was the only reported failure of piping and tubing of any kind at the plant as a result of the earthquake.
- The plant was operated manually following the earthquake because the operators were not confident of the automatic control systems and in particular the condition of relays which initiate or impede operation of the automatic control.

M.5 Seismic Design Basis

M.5.1 Building Structure and Foundations

The building structure was designed for a 0.2g static acceleration.

The soil is sand, gravel and boulders to depths of over 500 feet, with the permanent water table fluctuating around 200 feet below the surface.

Most of the plant footings are isolated square or rectangular footings. Due to the magnitude of the boiler column loads, which are as high as 800 tons per column for Units 3 and 4, it was necessary to use a number of combined footings in these areas. Seismic shear reactions up to 250 tons from bracing frames were transmitted to the soil by friction and passive resistance using ties between footings where necessary. Seismic uplift reactions were resisted by the dead loads plus the weight of footings and soil and the standards for spread footings. Seismic shear loads were transmitted from the bracing to the concrete by means of horizontal dowels welded to the edge of the column plates. These plates were recessed into the tops of the footings.

The structural steel framing in the boiler bay for Units 1 and 2 attain the height of a 9 story building. Units 3 and 4 attain the height of a 13 story building. In Units 3 and 4 at the top of the boiler bay are welded plate girders that support the boilers and carry over 1000 tons each. These girders are approximately 10 feet deep and 55 feet long with 3 inch by 28 inch flanges.

In an outdoor plant, the elimination of concrete shear walls necessitates the use of cantilever shear frames to resist seismic forces. These frames transmit the seismic forces to the footings and shear loads of up to 250 tons are induced in individual members. The seismic coefficient used to calculated the shear loads of the boiler and other equipment was .20 of gravity; and for the structure, a modified coefficient higher than required by the then current Los Angeles City Building Code was used, starting at .20 gravity instead of .13.

In addition to equipment loads, the steel frame supports floor live loads ranging from 100 to 250 pounds per square foot, the latter loading being used for the turbine bay floor.

The major pipe system in the plant also appears to have been designed for a 0.2g static load. However, after the San Fernando earthquake there was a seismic upgrade program instituted for all LADWAP facilities. This program resulted in the addition of 45 degree sway braces on a few piping systems as typically shown in Figure M.3. In total approximately 50 such sway braces were observed on Units 1-4 piping. However, there appears to be no uniform sway brace policy having been followed. Several small bore pipe were braced while adjacent large bore pipe were not.

M.6 Seismic Demand from the San Fernando Earthquake

The closest strong motion record of the San Fernando earthquake to the Valley Power Plant was in the Hollywood Inn located at 8244 Orion Avenue, Sepulveda, thirteen miles SSW of the epicenter and five miles west of the power station. The power plant was located approximately 11 miles SSE of the epicenter. The Magnitude at or near the epicenter was estimated at Magnitude XI. The Magnitude at the strong motion recording station closest to the power plant site and at the Valley Power Plant Site is estimated as VIII.

Strong motion time histories were recorded on the ground floor at the Holiday Inn at 8244 Orion Avenue location is shown in Section C3 of Reference M.2. The resultant response spectra for various values of damping are also shown in Section C3 of Reference M.2. It should be noted the peak acceleration (base line corrected) was 0.27g in the N-S direction. This suggests that the peak zero period ground acceleration at the power plant site since it is somewhat closer to the epicenter was approximately 0.3g. It should be noted that in Reference M.2 a ground response spectrum was scaled up from the 8244 Orion Avenue record from 0.27 g to 0.4g peak zero period acceleration (N-S) at the Valley Power Plant site. Both SSRAP[(M.3)] and the NRC Staff have noted the Valley Power Plant zero period ground acceleration as reported in Reference M.2 may have been over estimated.[(M.4)] SSRAP has suggested a 0.6 multiplication factor on the Reference Bounding Spectra (0.6 x .5 ZPGA = .3 ZPGA) and the NRC Staff a 0.5 factor. It is not clear on what basis SSRAP and the NRC Staff have developed their multiplies but a simple look at the recorded peak of 0.27g at 3244 Orion Avenue and relative epicentral distances of 13 miles versus 11 miles suggest a maximum ZPGA of about 0.3g at the Valley Power Plant site. An estimated ground spectra for the Valley Power Plant site based on the spectra given in Reference M.2 normalized to a 0.3g zero period ground acceleration is given in Figure M.4.

M.7 References

(M.1) Yanev, P.I. and Swan, S.W., "Program for the Development of an Alternate Approach to Seismic Equipment Qualification-Pilot Program Report", Volume I, EQE, Incorporated, Prepared for Seismic Qualification Utilities Group.

(M.2) Yanev, P.I. and Swan, S.W., "Program for the Development of an Alternate Approach to Seismic Equipment Qualification-Pilot Program Report", Volume II Appendices, EQE, Incorporated, Prepared for Seismic Qualification Utilities Group.

(M.3) Kennedy, R.P. et.al., "Use of Seismic Experience and Test Data to Show Ruggedness of Equipment in Nuclear Power Plants", Prepared for the Seismic Qualification Utility Group and in Cooperation with the U.S. NRC, Rev. 4 February 1991.

(M.4) Internal NRC Letter Communication to G. Bajchi Concerning the Acceleration Levels Associated with the San Fernando Earthquake at the Valley Power Station Site.

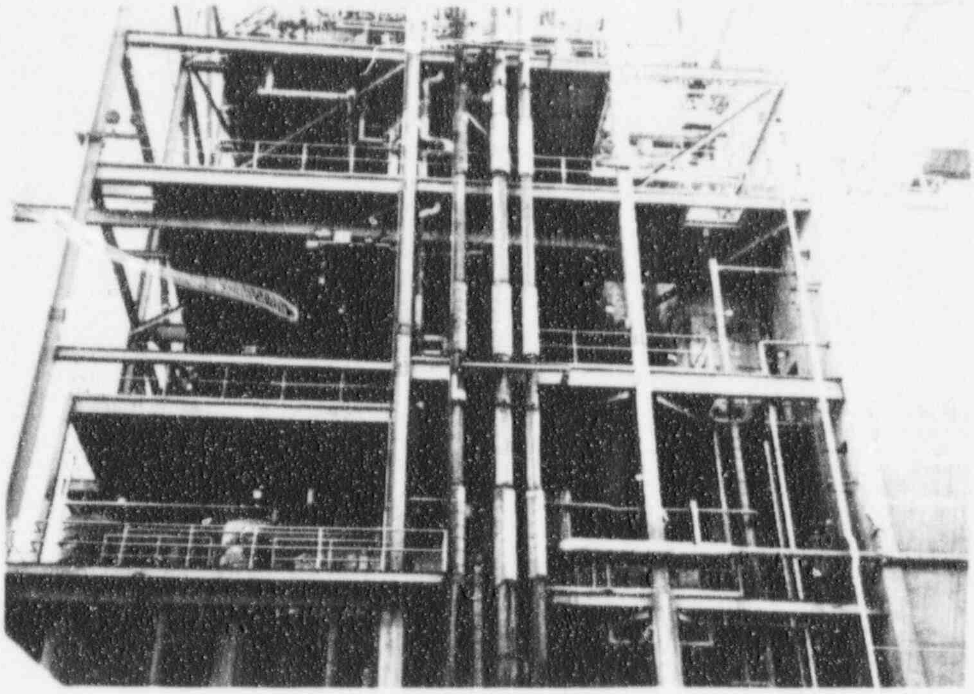


Figure M.1 - Structural Steel Framing for Valley Unit 3

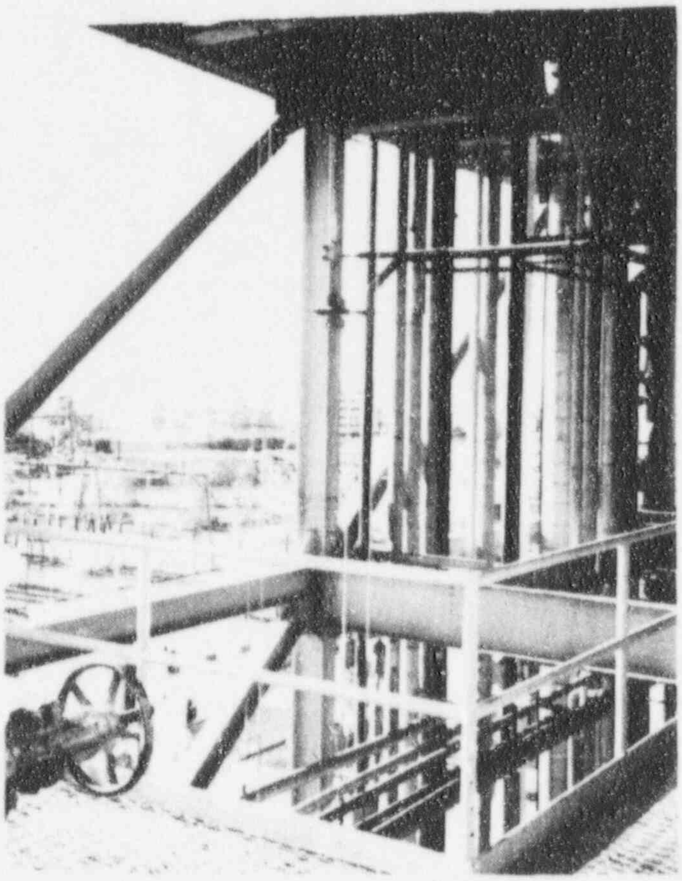


Figure M.2 - Structural Steel Framing for Valley Unit 3 Showing Diagonal Vertical Bracing

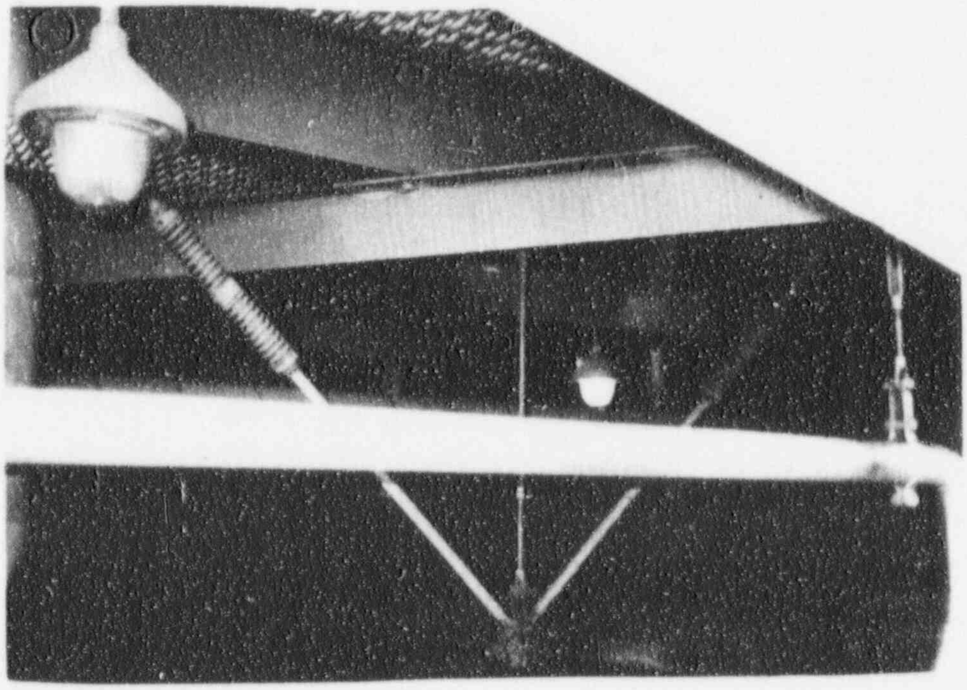


Figure M.3 - Typical Sway Brace Used in Support of Pipe Valley Unit 1

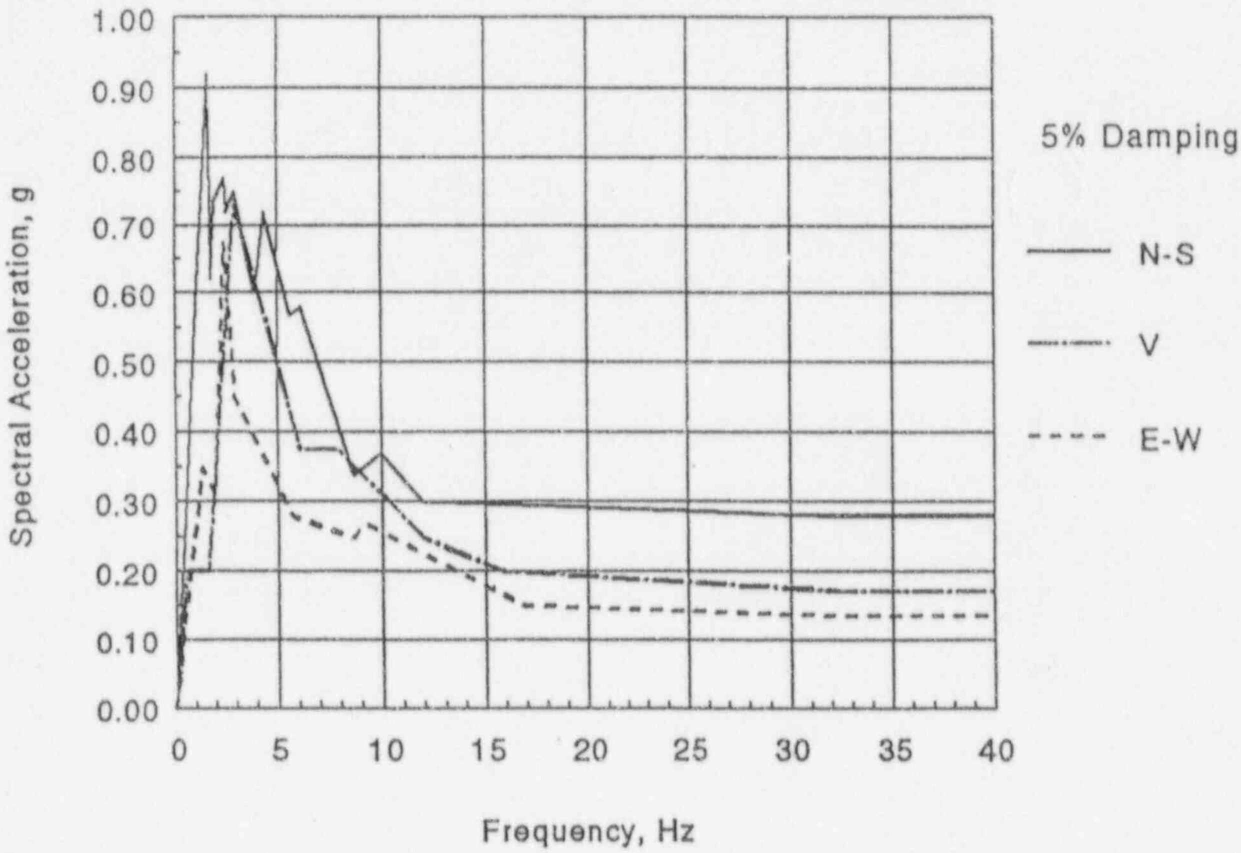


Figure M.4 - Estimated San Fernando Earthquake, Valley Steam Plant Site Ground R.S.

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Volume 2 of the "Survey of Strong Motion Earthquake Effects on Thermal Power Plants in California with Emphasis on Piping Systems" contains Appendices which detail the detail design and seismic response of several power plants subjected to strong motion earthquakes. The particular plants considered include the Ormond Beach, Long Beach and Seal Beach, Burbank, El Centro, Glendale, Humboldt Bay, Kern Valley, Pasadena and Valley power plants. Included is a typical power plant piping specification and photographs of typical power plant piping specification and photographs of typical piping and support installations for the plants surveyed. Detailed piping support spacing data are also included.

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