QUANTITATIVE PIPING EXPERIENCE DATA SUPPORTING THE RESULTS OF THE MILLSTONE III NUCLEAR POWER PLANT SEISMIC INTERACTION STUDY

Prepared for: NORTHEAST UTILITIES SERVICE COMPANY

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EXECUTIVE SUMMARY

A seismic interaction study of the Millstone III Nuclear Power Plant has been conducted by EQE Incorporated for Northeast Utilities Service Company. This study was performed to identify potential hazards to Category 1 components posed by Category 2 components that were not designed for seismic loads. It utilized experience data from past earthquakes to identify and account for realistic seismic interactions. The experience data base indicates that the most frequent and hazardous seismic interactions are sliding equipment, falling ceiling fixtures, and piping impact, and that piping systems have a very high tolerance for seismic interactions. The Millstone III seismic interaction study recommended criteria to be used to identify realistic piping interactions.

The study described in this report was performed to present the quantitative data for piping that supports the application of experience data in the Millstone III seismic interaction study. A number of comparisons between the El Centro Steam Plant Unit 4 data base and the Millstone III Category 2 piping were developed. These comparisons were performed for the key parameters that influence the potential for and damage due to seismic interaction, including:

1. Ground motion response spectra

2. In-structure response spectra

3. Piping materials

4. Piping sizes

5. Piping operating conditions

6. Piping components and construction

7. Support spacings

8. Support types and design

This study demonstrates that the El Centro Plant data base generally envelopes the Millstone III Category 2 piping for these parameters. Because the data base envelopes the Category 2 piping, it can be concluded that the use of experience data to conduct the Millstone III seismic interaction study is appropriate.

1. INTRODUCTION

A seismic interaction study of the Millstone III Nuclear Power Plant has been conducted by EQE Incorporated for Northeast Utilities Service Company (NUSCO). This study is described in detail in Reference 1. The seismic interaction study was performed to identify potential hazards to Category 1 components posed by Category 2 components that were not designed for seismic loads. This hazard may occur due to impact or spatial interference resulting from seismic excitation.

The seismic interaction study for Millstone III utilized experience data from past earthquakes to identify and account for realistic seismic interactions. The use of experience data to address seismic interactions is considered to be appropriate since the data base includes the effects of eight earthquakes on over 40 power generating stations, substations, and industrial facilities. These sites contain equipment similar to that found in a nuclear power plant. A review of the damage contained in the data base provides an indication of the types of credible interaction scenarios along with the level of seismic motion at the threshold of occurrence. This review can also reveal which interactions should not receive an undue amount of attention in an interaction study. The experience data base can be used to develop criteria for the resolution of potential interaction scenarios.

A survey of the experience data base in Reference 1 revealed that the most frequent and hazardous seismic interactions are as follows:

- Sliding equipment
- Falling ceiling fixtures
- Piping impact

A detailed review of the seismic interaction of piping at the El Centro Steam Plant was then performed. A walkdown of the plant identified 290 potential seismic interactions of piping and piping components. This number is conservative since not all piping systems were covered. Of these interactions, only one instance of

an air-operated valve impacting a steel column actually resulted in earthquake-induced damage. This was the only case of seismic interaction resulting in damage evidenced in the 40 data base facilities that were available at the time Reference 1 was written. A few more interactions were produced by the recent Chile earthquake.

The experience data base indicates that piping systems have a very high tolerance for seismic interaction. Reference 1 concluded the following:

1. Impact of Non-Category 1 piping on Category 1 piping should be considered a potential hazard only if specific conditions exist.

2. Failure of piping attachments due to seismic interaction is a credible hazard and should be checked.

3. The supports for the Millstone III piping will remain intact under the design basis seismic loads even if seismic loads were not considered in their design.

In addition, a recent study completed by EQE Incorporated has compiled a survey of earthquake-induced piping damage (Reference 8). A review of this damage survey shows no evidence of welded piping suffering a complete loss of structural integrity with subsequent impact on and damage to adjacent components. Most of the Millstone III Category 2 piping is of welded construction and would also be expected to perform successfully without total collapse during an earthquake.

The purpose of this report is to present the quantitative data supporting the use of piping experience data to conduct the Millstone III seismic interaction study. The conclusions of Reference 1 will be validated by quantitatively demonstrating that the seismic input, piping, and piping support parameters of the experience data base plants envelope the corresponding parameters of the Millstone III Category 2 piping. So long as this enveloping is shown, the conclusions of the Millstone III seismic interaction study are appropriate since they were

2. EL CENTRO STEAM PLANT UNIT 4 PIPING

The piping of the El Centro Steam Plant Unit 4 was selected for comparison to the Millstone III Category 2 piping for the following reasons:

1. The plant was the most heavily shaken, and the most heavily damaged of the seven major power plants reviewed in detail in the Seismic Qualification Utilities Group (SQUG) program.
2. A ground motion record of about 0.5g peak horizontal ground acceleration was taken at the site.
3. A wide variety of piping configurations is present; only a few of the primary piping systems in Unit 4 were designed for seismic loads.
4. Substantial amounts of documentation on the earthquake input and piping systems were readily available for use in this study.

2.1 General Description of Piping

The El Centro Plant Unit 4 piping ranges from essentially rigid to very flexible, depending on length of run. Piping runs were found with response frequencies as low as 1 Hz. Most piping is carbon steel, although a few stainless steel lines are associated with the water demineralization systems. The piping includes both threaded connections in the low pressure lines, such as in the component cooling or fire water systems; or a combination of welded and flanged connections in the high pressure systems such as steam or feedwater. Piping ranges in size from a large inventory of pneumatic instrument tubing (typically 1/2-inch diameter), up to 18-inch lines in the main steam system and a 30-inch abovegrade line in the circulating water system. Pipe supports are primarily rod or spring hangers. All high temperature lines are insulated, typically with a 1-1/2-inch to 3-inch layer of calcium silicate wrapped in sheet metal lagging, or an equivalent insulation.

3. PARAMETRIC COMPARISON OF THE MILLSTONE III CATEGORY 2 PIPING

To demonstrate the applicability of the experience data base on seismic interaction of piping, a series of comparisons between the Millstone III Category 2 piping and the El Centro Plant Unit 4 piping were made. These comparisons were performed for categories of characteristics that most significantly influence the potential for and damage due to seismic interaction of piping. These categories are:

- Seismic Input
- Piping Parameters
- Support Parameters

The seismic loads and displacements to which the Millstone III piping may be subjected by the Safe Shutdown Earthquake can be measured relative to the loads and displacements experienced by the El Centro Plant piping during the 1979 Imperial Valley Earthquake by a comparison of the seismic input. The piping and support parameters can allow comparisons of both the piping capacity, dynamic response, and potential for seismic interaction. The intent of these comparisons is to show that the El Centro Plant piping characteristics envelope the corresponding Millstone III Category 2 piping characteristics.

3.1 Comparison of Seismic Input

The magnitude of the seismic loads to which piping systems may be subjected depends upon the level of seismic input. A comparison of the seismic input to which the El Centro Plant Unit 4 piping was subjected by the October 15, 1979 earthquake and the input to the Millstone III piping for the Safe Shutdown Earthquake can be performed as follows:

1. Comparison of the ground motion response spectra
2. Comparison of the in-structure response spectra
3. Comparison of potential anchor support motion as measured by interstory relative drifts

3.1.1 Ground Motion Response Spectra

In their January, 1985 report prepared for the Seismic Qualification Utility Group (Reference 2), the Senior Seismic Review and Advisory Panel (SSRAP) noted that comparisons of ground response spectra should be emphasized when comparing experience data base plants to nuclear facilities. This is because floor spectra typically were generally not available for the data base plants and realistic floor spectra are often not available in nuclear plants. Floor response spectra are usually very conservatively computed and tend to show much larger amplifications than actually exist. Studies conducted by the Seismic Safety Margin Research Program (References 3 and 4) demonstrated that the large conservatism which exists in traditionally computed floor spectra is due to the use of conservative damping levels for the structure and insufficient consideration of factors such as wave scattering and embedment. Therefore, comparison of the El Centro ground response spectra to the Millstone SSE ground response spectra gives the most realistic indication of the high margins which can be expected for the Millstone III Category 2 piping.

The Imperial Valley was extensively instrumented prior to the earthquake by a network of strong motion accelerographs. A 13-station linear array was located straddling the fault. In addition, a digital recording differential array was placed in a large vacant lot near El Centro Plant Unit 4. Station 5165 at the south end of the differential array was positioned less than one kilometer from the plant. A digitized corrected version of the time history from Station 5165 has been used in three separate dynamic analyses (References 5, 6, and 7) to recreate the seismic response of the Unit 4 structure. This set of time histories has been selected by these analysts as being the most appropriate for their studies.

The seven percent damped El Centro ground motion response spectra in the N-S, E-W, and vertical directions for the time histories recorded at Station 5165 are shown in Figures 3-1 through 3-3. Also presented in Figures 3-1 through 3-3 are the seven percent damped horizontal and

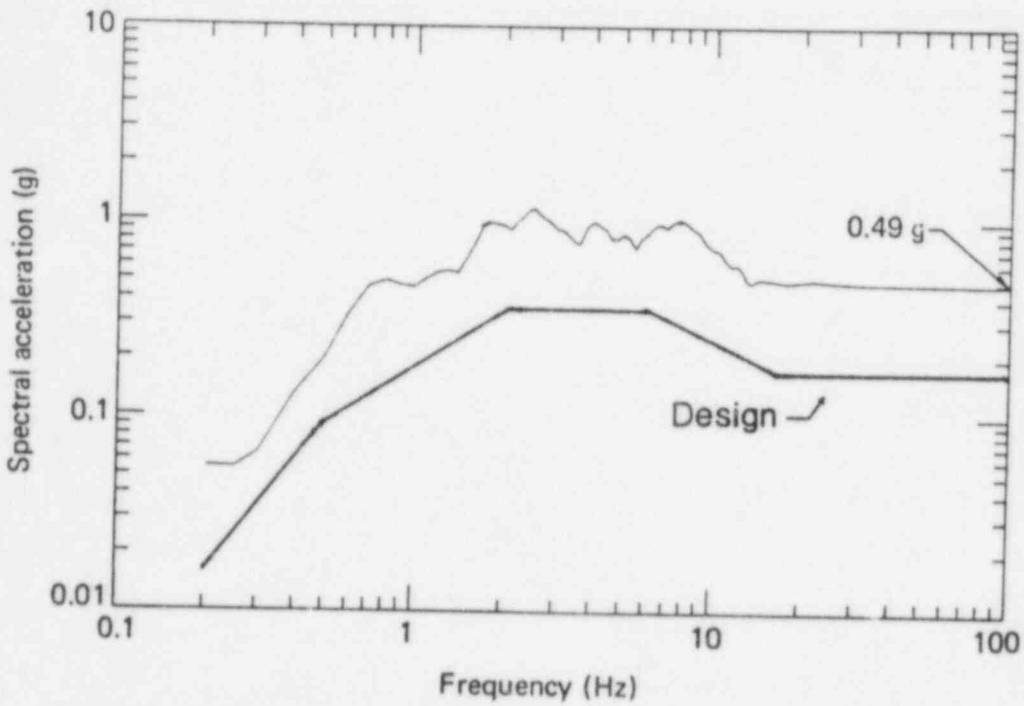

Figure 3-1 Comparison of El Centro N-S Response Spectrum with Millstone III Horizontal Design Ground Response Spectrum, 7% Damping.

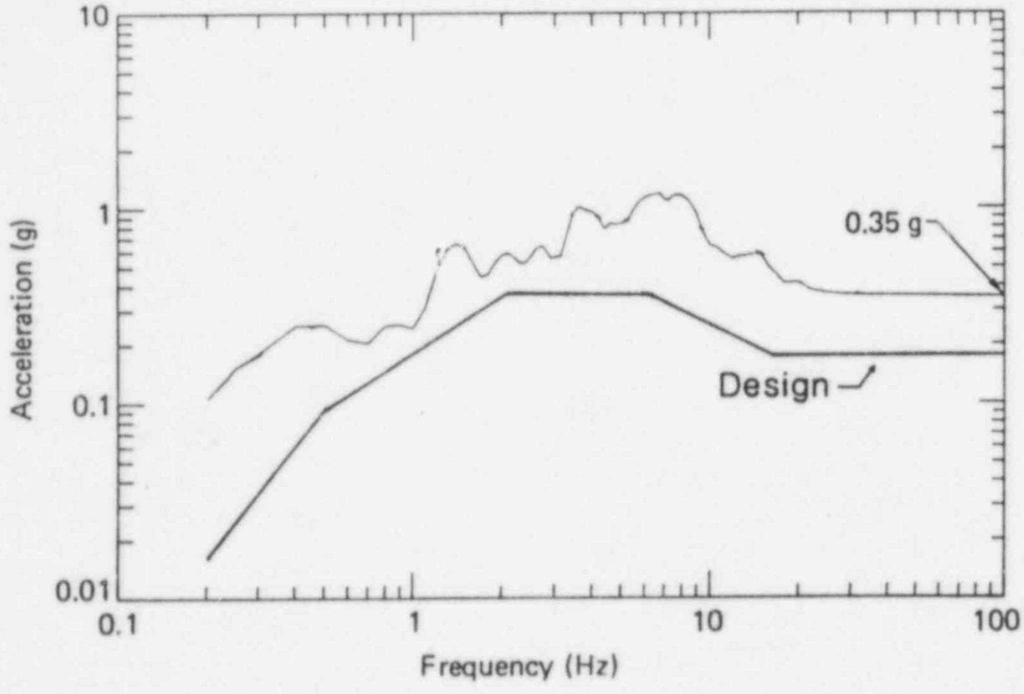

Figure 3-2 Comparison of El Centro E-W Response Spectrum with Millstone III Horizontal Design Ground Response Spectrum, 7% Damping.

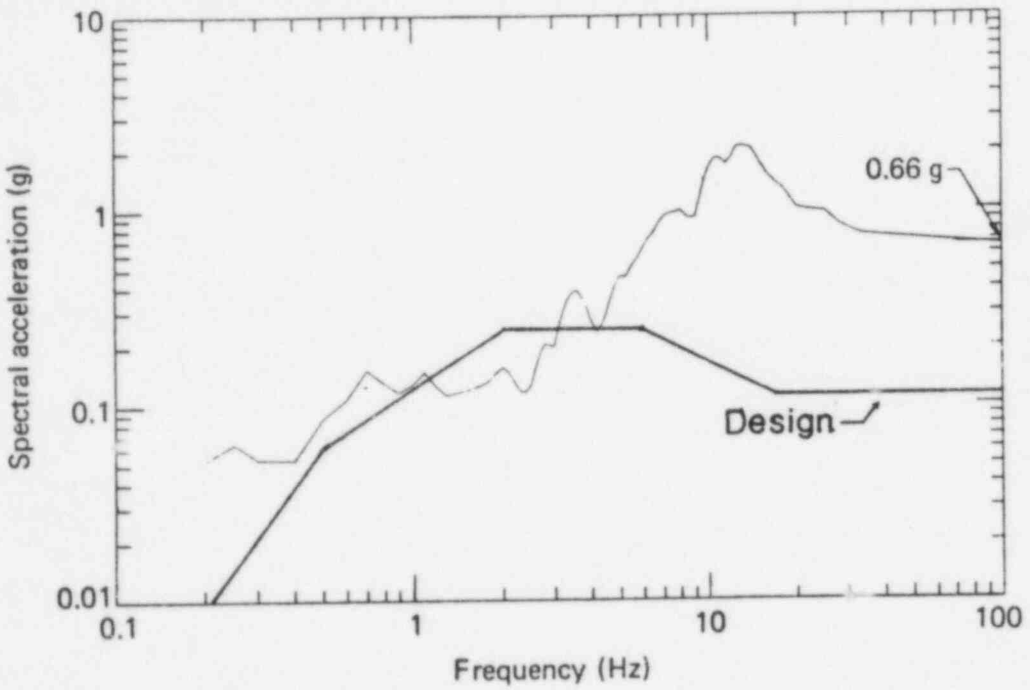

Figure 3-3 Comparison of El Centro Vertical Response Spectrum with Millstone III Vertical Ground Response Spectrum, 7% Damping.

vertical ground spectra for the Safe Shutdown Earthquake (SSE) adopted for the design of Millstone III. The N-S and E-W ground spectra for the El Centro earthquake envelope the Millstone III horizontal design spectra at all frequencies. The margin between these spectra is as much as a factor of about three. The El Centro earthquake vertical spectrum exceeds the Millstone III vertical design spectrum for frequencies of about 3 Hz or greater. The difference between these spectra can be greater than a factor of ten. The Millstone III vertical design spectrum slightly exceeds the El Centro earthquake vertical spectrum for frequencies between about 1 Hz and 3 Hz. However, most real structures have vertical frequencies in excess of 3 Hz. This is particularly true for the reinforced concrete shear wall structures comprising the Millstone III Plant. The comparisons of ground spectra indicate that the seismic input experienced by the El Centro Plant Unit 4 structure was well in excess of the ground motion to which the Millstone III structures would be subjected by the SSE. It can be concluded that the El Centro ground motion input clearly envelope the Millstone III design ground motion input.

3.1.2 In-Structure Response Spectra

Seismic interaction can occur if two adjacent components displace sufficiently to close their separation. Another measure of the potential for seismic interaction can be obtained by a comparison of the spectral displacements from the El Centro Plant and Millstone III in-structure response spectra. Worst case in-structure response spectra from each facility will be compared. By demonstrating that El Centro Plant piping experienced displacements much larger than those anticipated for Millstone III piping, it can be concluded that Millstone III Category 2 piping can accommodate SSE motion without causing damage to Category 1 piping or equipment due to seismic interaction.

Reference 5 developed in-structure response spectra for the El Centro Unit 4 Steam Plant. The analytical model used to generate these spectra conservatively represented the soil-structure interaction effects by including very large soil radiation damping. High soil damping

decreases dynamic amplification and results in lower in-structure response spectra than would be calculated with a best estimate approach. Table 3-1 presents tabulated results from this study. These results were based upon in-structure spectra from the bottom story of the structure to minimize the beneficial effects of structure dynamic amplification. Because of these conservatisms, the actual displacements experienced by El Centro piping during the 1979 Imperial Valley Earthquake would be expected to be higher than those shown in Table 3-1.

Also shown in Table 3-1 are worst case results for three Millstone III structures; the auxiliary building, control building, and reactor internal structure. These particular structures were chosen based upon an envelope of in-structure response spectra for all structures containing Category 2 piping. Spectral displacements were determined from in-structure response spectra developed for the top floor of each structure. Since the majority of Millstone III Category 2 piping is located at lower elevations in these structures, the tabulated results represent an upper bound on expected SSE seismic motion.

Typical El Centro Plant piping is quite flexible, with a significant portion of the piping systems having fundamental frequencies as low as 1 Hz (Reference 1). El Centro Plant piping with fundamental frequencies in the 1 to 4 Hz range accommodated spectral displacements from 5.3 to 1.1 inches. At higher frequencies, spectral displacements were lower, ranging from 0.2 inches at 8 Hz to 0.01 inches at 33 Hz.

Frequencies for Millstone III Category 2 piping were estimated using simple hand calculations for typical piping sizes and support spacings specified in the design criteria. Based on these results, Millstone III piping is estimated to have lower bound fundamental frequencies ranging from 2.5 Hz in the horizontal direction to 10 Hz in the vertical direction. For the worst case, Millstone III SSE spectral displacements are on the order of 2.3 inches. This is a factor of 2 less than the spectral displacements accommodated by El Centro Plant piping without damaging seismic interactions. More typical piping runs with closer support spacings would have even higher frequencies, and experience even

Table 3-1

Comparison of El Centro versus Millstone Spectral Displacements

	Spectral Displacement (inches)					
Facility	1Hz.	2Hz.	4Hz.	8Hz.	10Hz.	33Hz.
El Centro Unit 4 Steam Plant	5.3	3.1	1.1	0.17	0.07	0.005
M3 Control Building	3.4	1.5	0.58	0.44	0.13	0.005
M3 Auxiliary Building	3.4	1.8	0.52	0.58	0.24	0.005
M3 Reactor Internal Structure	3.4	2.0	2.3	0.20	0.17	0.007

1. All results are for maximum horizontal response 4% critical damping

smaller displacements. Better performance would be expected for these lines. This comparison clearly demonstrates that Millstone III Category 2 piping can accommodate SSE dynamic response without damaging interactions.

3.1.3 Seismic Anchor Movement

During the 1979 Imperial Valley Earthquake, piping systems located in the boiler structure and heater building of the El Centro Unit 4 Steam Plant (Figure 3-4) were subjected to significant anchor support motion. Post-earthquake walkdowns of the facility by plant personnel did not demonstrate any evidence of piping system collapse or seismic interaction as a result of anchor motion. This can probably be attributed to the fact that piping systems are very ductile and have an inherent capability to accommodate large relative displacements through system flexibility and local load redistribution. By demonstrating that anchor support displacements experienced by El Centro Plant piping systems meet or exceed maximum expected movement at Millstone III for SSE ground motion, it can be concluded that Millstone III Category 2 piping can accommodate SSE displacements without collapse or damaging seismic interaction.

One measure of potential anchor support motion can be achieved by converting structural displacements between adjacent floors to interstory relative drifts measured in in/ft of structure height. This is a convenient way of comparing results between structures having dissimilar story heights. In addition, since piping anchor points are not known, it provides a reasonable method for comparing the magnitude of potential anchor support displacements.

Analytical studies presented in References 5, 6, and 7 tabulated maximum story displacements for the El Centro Unit 4 boiler structure and heater building. These displacements were used to calculate interstory relative drifts in order to assess the anchor support movements experienced by El Centro Plant piping systems. Results are tabulated below along with the corresponding results for Millstone III. Millstone III results are very conservatively based upon worst case interstory

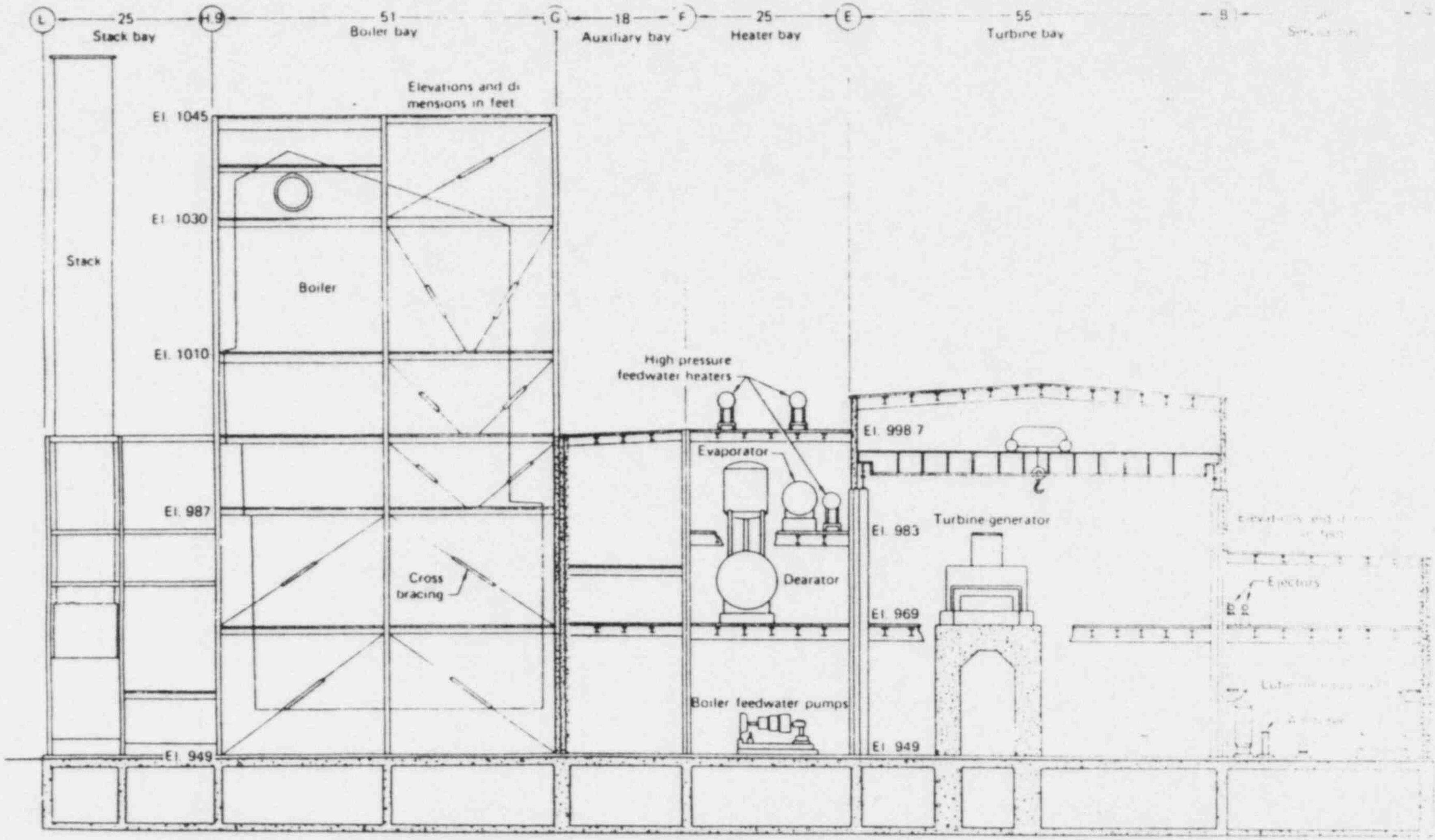

Figure 3-4 Elevation Drawing, Looking North, of the El Centro Steam Plant, Unit 4 (Reference 5).

relative drifts calculated for all structures having potential seismic interactions between Category 1 and Category 2 piping.

Interstory Relative Drift Comparisons

	El Centro	Millstone
Range of Predicted Displacements	0.003-0.06 in/ft	0.002-0.003 in/ft

As shown by these results, El Centro Plant piping experienced anchor motions up to 20 times as large as the largest expected anchor motion for Millstone III. Even in the worst case, the smallest predicted interstory relative drift for the El Centro Plant was as large as the peak expected relative interstory drift at Millstone III. Because of the excellent performance of the many El Centro Plant piping systems, it is evident that piping collapse or seismic interaction resulting from anchor support motion is not a credible failure mode.

3.2 Comparison of Piping Parameters

It is possible to identify a number of parameters that influence the capacity, response, and potential for seismic interaction of piping systems. The most important parameters include the following:

1. Material
2. Size
3. Operating Conditions
4. Components and Construction

Comparisons between the El Centro Plant and Millstone III Category 2 piping were performed for each of these parameters. These comparisons were based upon data contained in the piping specifications and pipe line lists available for these plants. A copy of the El Centro Plant pipe line list is contained in Appendix A.

3.2.1 Comparison of Piping Materials

Figure 3-5 displays the different types of piping materials and the number of lines constructed of these materials found at the El Centro Plant. The materials are identified by their ASTM specification number. As shown in Figure 3-5, most of the piping lines consist of A-53, Grade B carbon steel. Other types of carbon steel as well as stainless and chrome-moly steel are also included in the El Centro Plant data base. Although there are not large quantities of some of these materials, their mechanical properties (strength, modulus of elasticity, ultimate strain, etc.) are not significantly different from the properties of materials found in greater abundance.

The Millstone III Category 2 piping systems of interest are constructed of the following materials:

1. A-106, Grade B carbon steel
2. A-312, Type 304 stainless steel
3. A-312, Type 304L stainless steel
4. A-358, Type 304L, Class 1 stainless steel
5. A-376, Type 304 stainless steel
6. A-376, Type 304L stainless steel
7. A-335, Grade P22 chrome-moly steel
8. Fiberglass reinforced plastic pipe

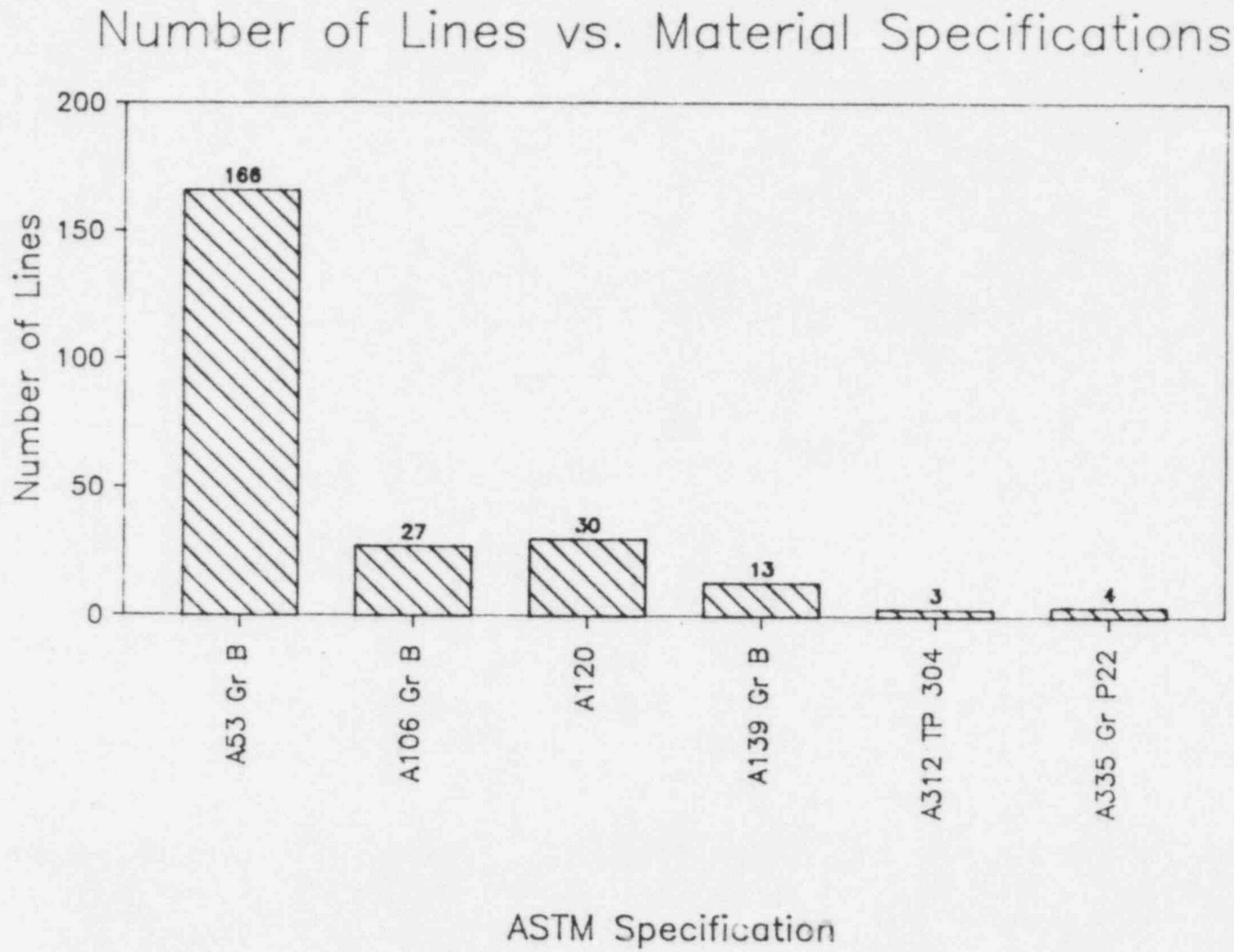

Figure 3-5 El Centro Plant Piping Material Specifications

Materials 1, 2, and 7 listed above are represented by the El Centro Plant data base. Only a few piping systems are constructed of Materials 4 and 8. Furthermore, they are not represented in the El Centro data and should be treated on a case by case basis at Millstone III. Materials 3, 5, and 6 are not used at the El Centro Plant. However, their mechanical properties are very similar to A-312, Type 304 stainless steel which is included in the El Centro Plant data base. This comparison shows that the El Centro Plant piping materials essentially encompasses the Millstone III Category 2 piping materials.

3.2.2 Comparison of Piping Sizes

Figure 3-6 presents the total number of lines constructed of the various pipe diameters contained in the El Centro Plant data base. Pipe diameters range from 0.5 inches to 30 inches. Pipe diameters of 10 inches and less are represented in significant numbers. Figures 3-7 to 3-14 show the number of lines constructed of these pipe diameters for each of the different pipe schedules contained in the El Centro Plant data base. Piping is found in nearly all schedules ranging from Schedule 10 to Schedule 160. Most of the data consists of Schedules 40 and 80 pipe.

The Millstone III Category 2 piping that has the potential for seismic interaction with Category 1 piping or equipment is 12 inches in diameter or less. The piping schedules vary from Schedule 10S to Schedule 80. In contrast, the El Centro Plant data base piping has diameters up to 20 and 30 inches and wall thicknesses ranging from Schedule 10 to Schedule 160. This comparison clearly indicates that the data base pipe sizes envelope the Millstone III Category 2 piping.

3.2.3 Comparison of Piping Operating Conditions

The operating pressures and temperatures of the El Centro Plant piping were compiled from the pipe line lists. Figure 3-15 illustrates the range of operating pressures for each of the pipe diameters used at the El Centro Plant. This figure contains the number of lines having operating pressures occurring in prescribed ranges. These ranges

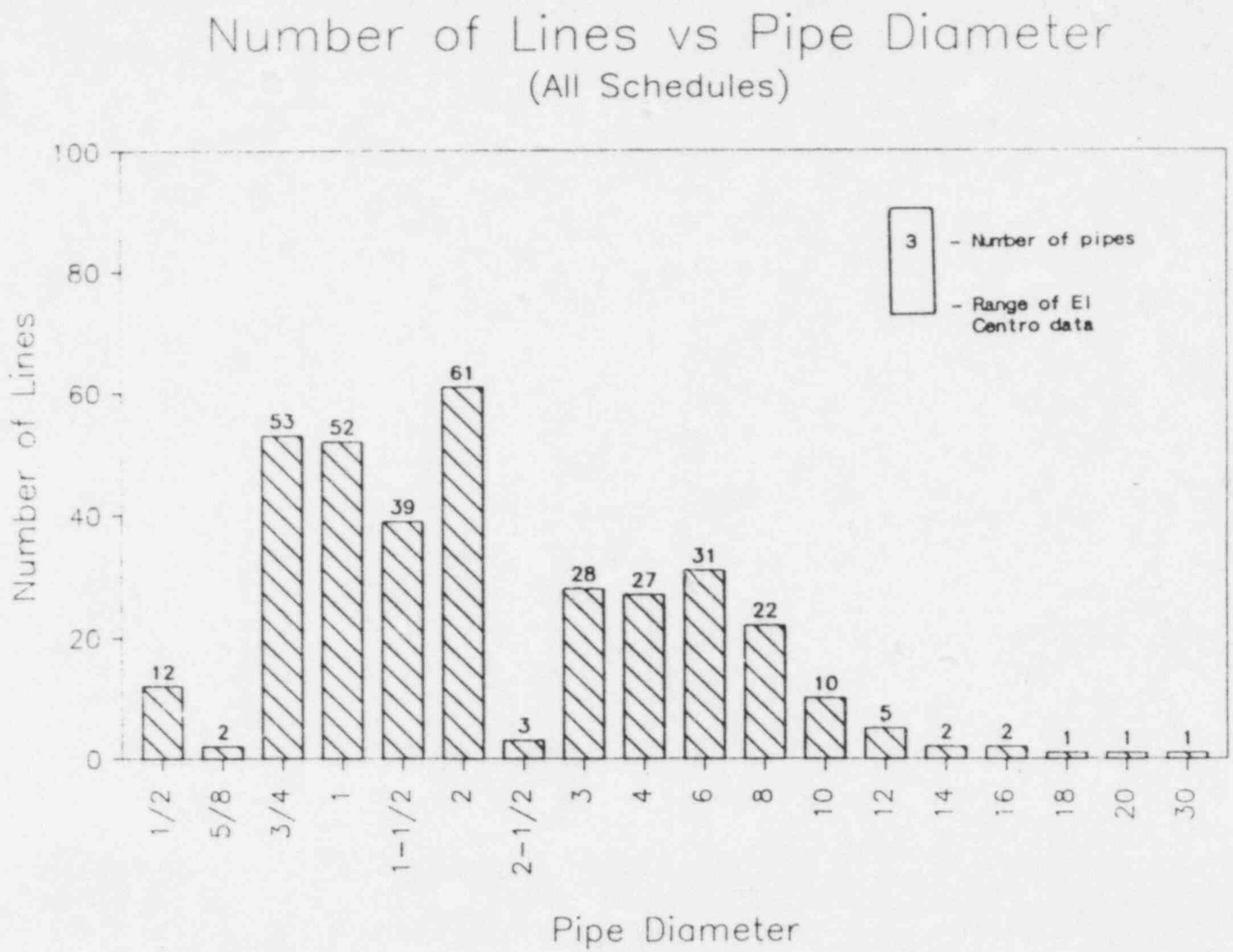

Figure 3-6 El Centro Plant Piping Sizes, All Schedules

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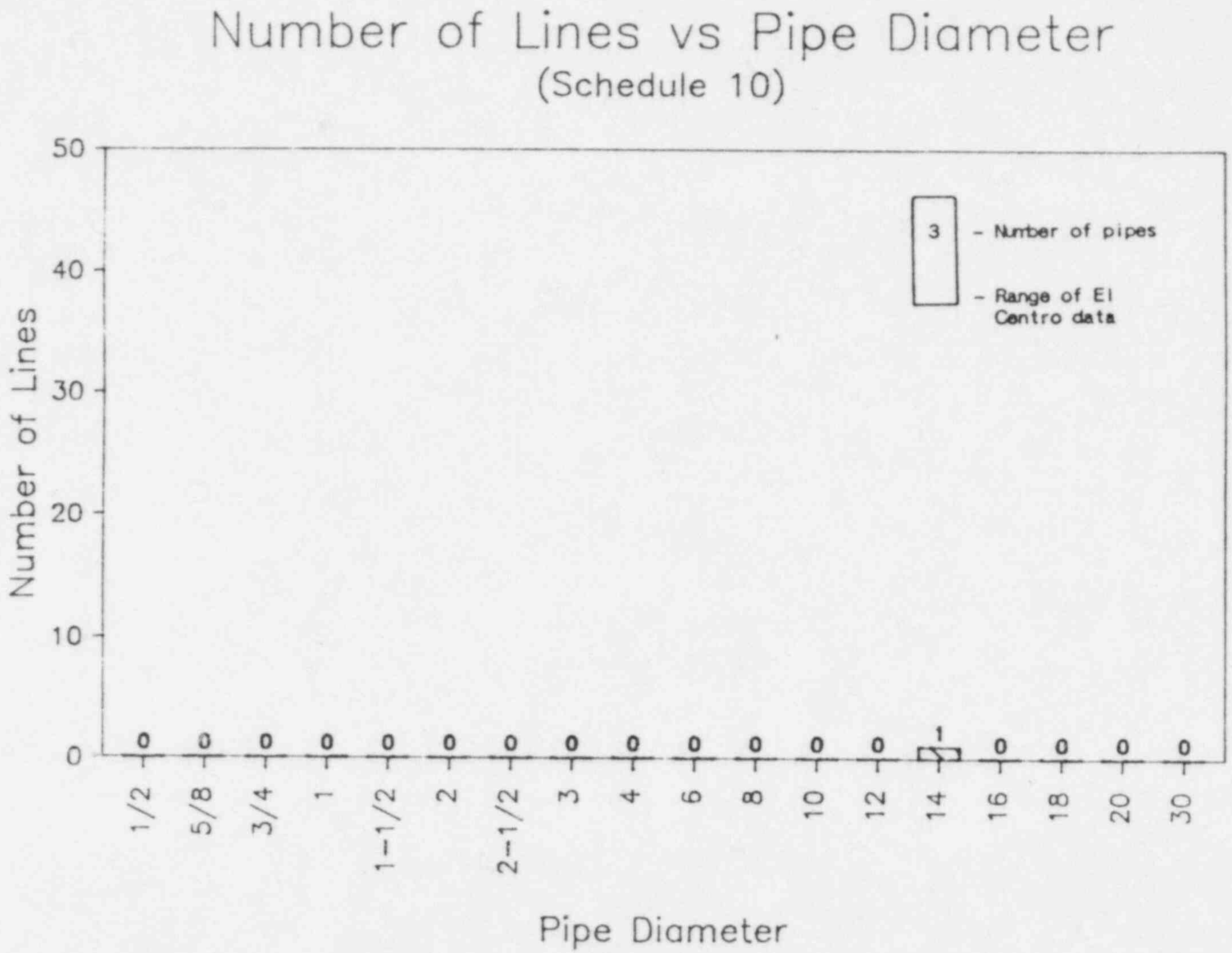

Figure 3-7 El Centro Plant Piping Sizes, Schedule 10

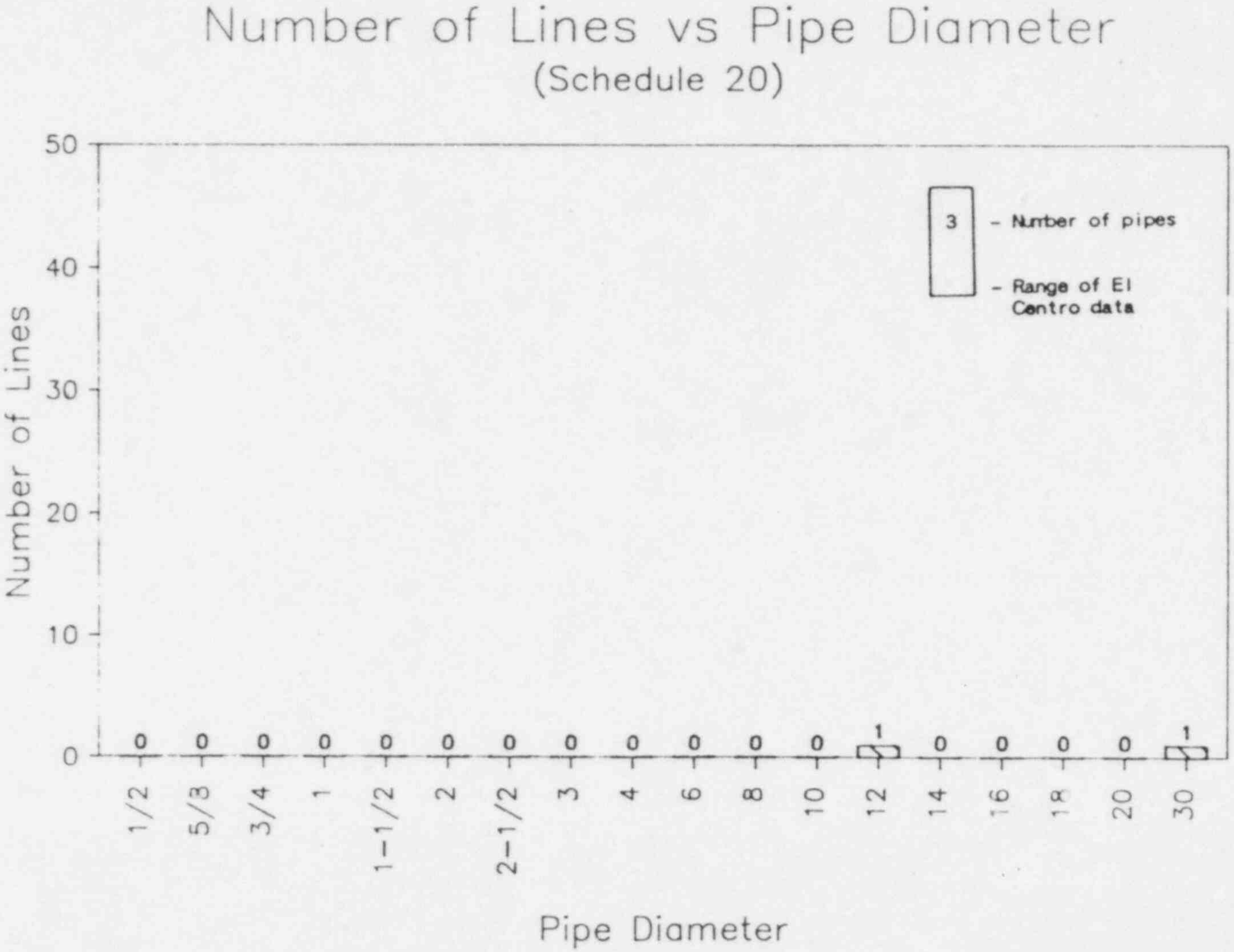

Figure 3-8 El Centro Plant Piping Sizes, Schedule 20

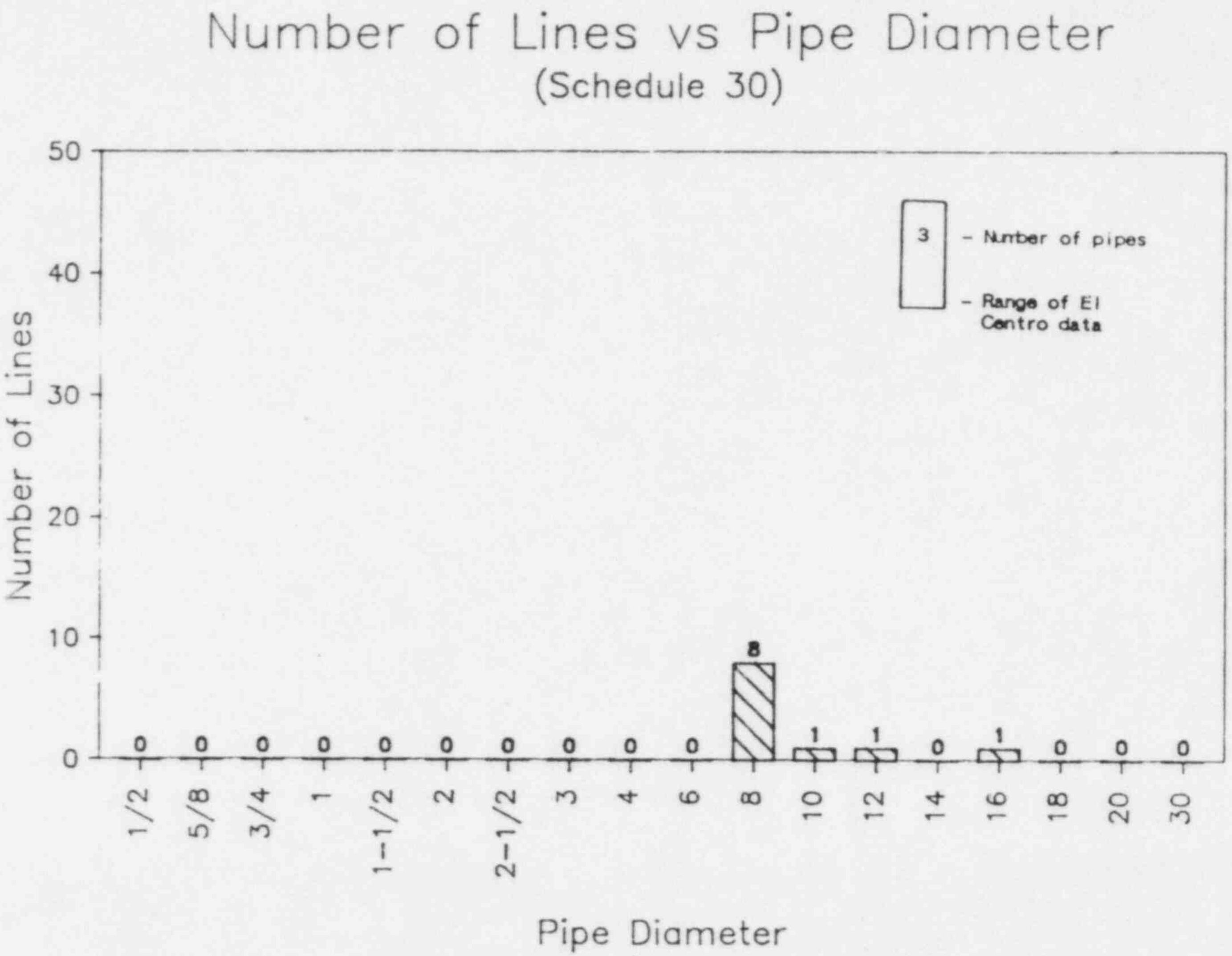

Figure 3-9 El Centro Plant Piping Sizes, Schedule 30

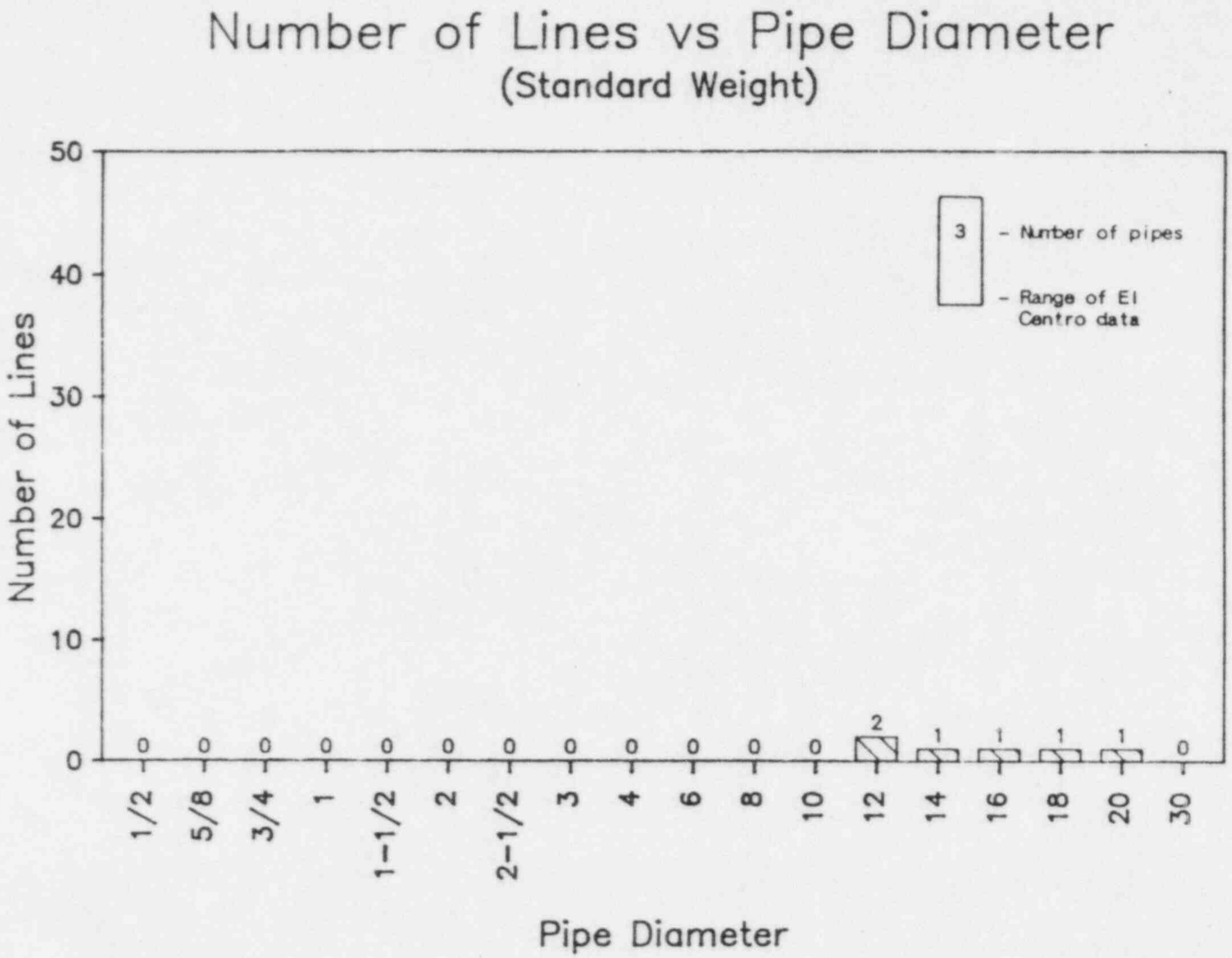

Figure 3-10 El Centro Plant Piping Sizes, Standard Weights

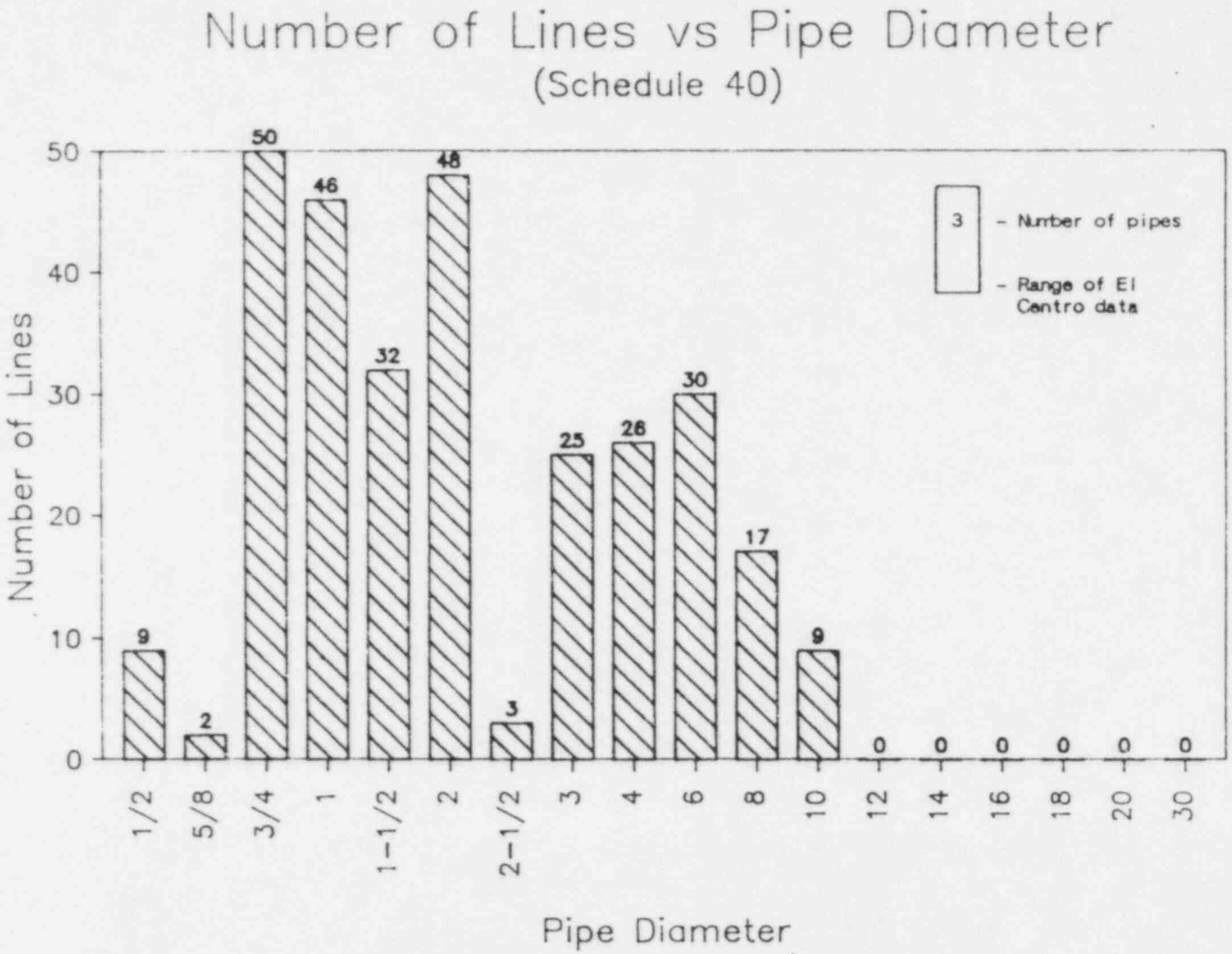

Figure 3-11 El Centro Plant Piping Sizes, Schedule 40

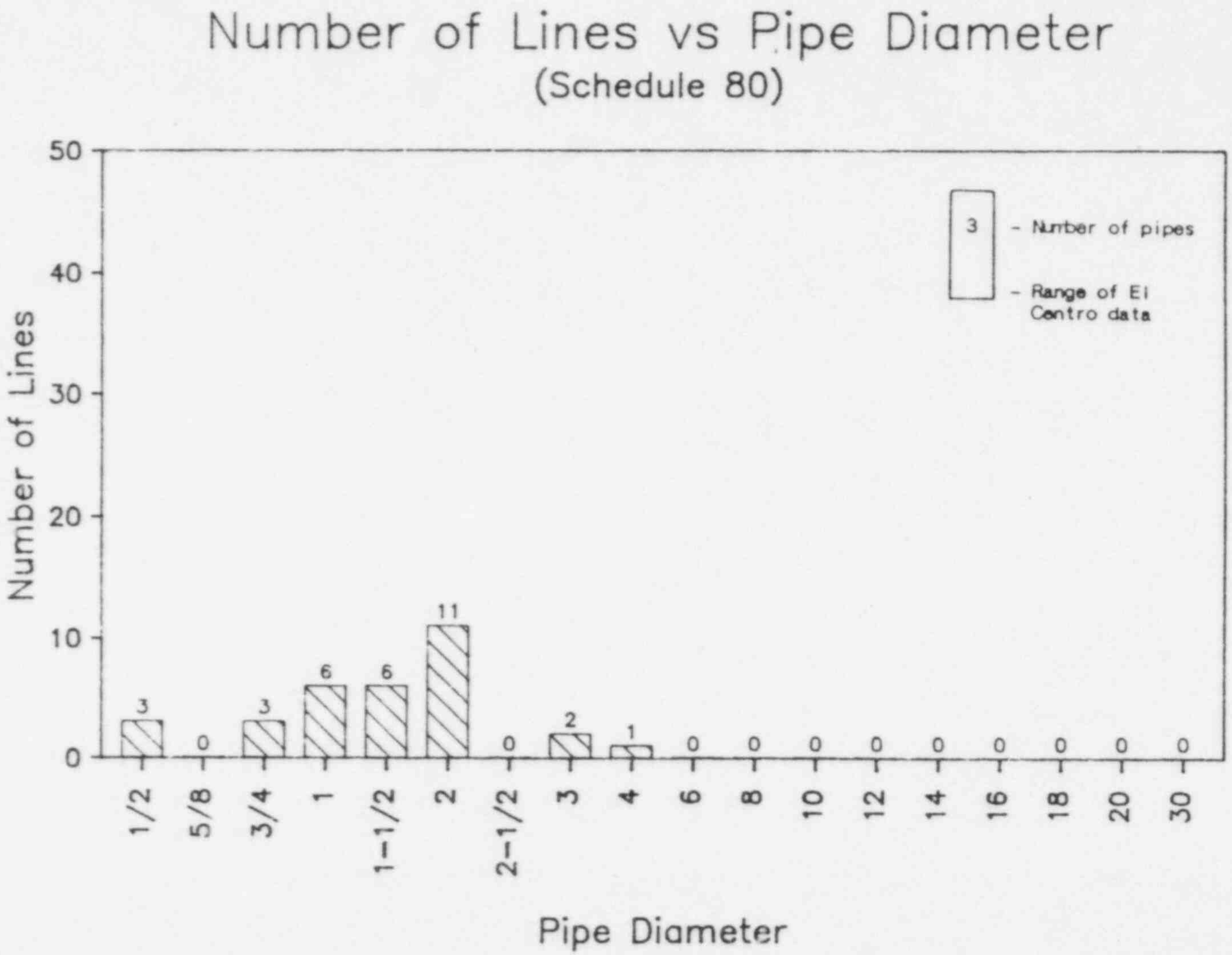

Figure 3-12 El Centro Plant Piping Sizes, Schedule 80

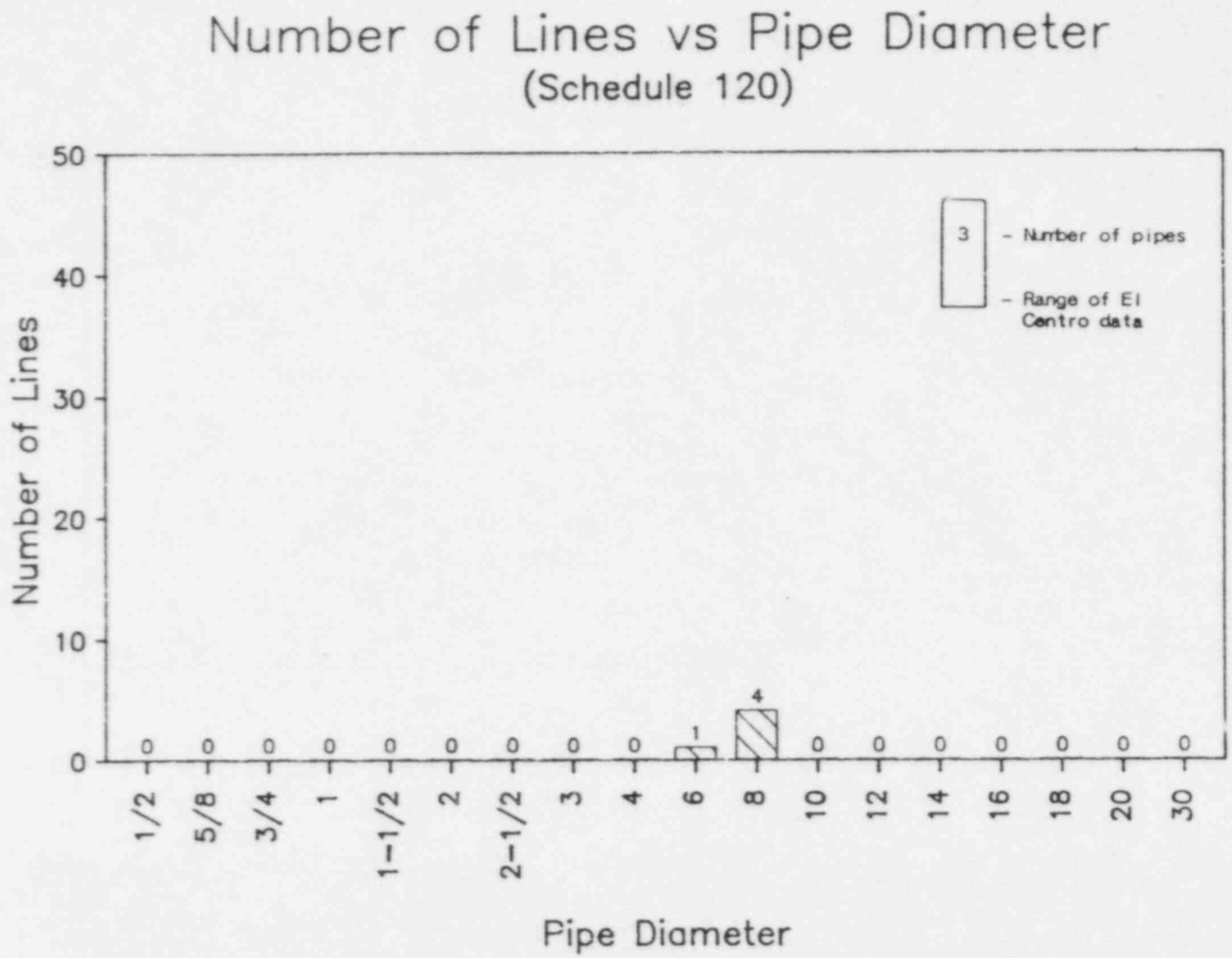

Figure 3-13 El Centro Plant Piping Sizes, Schedule 120

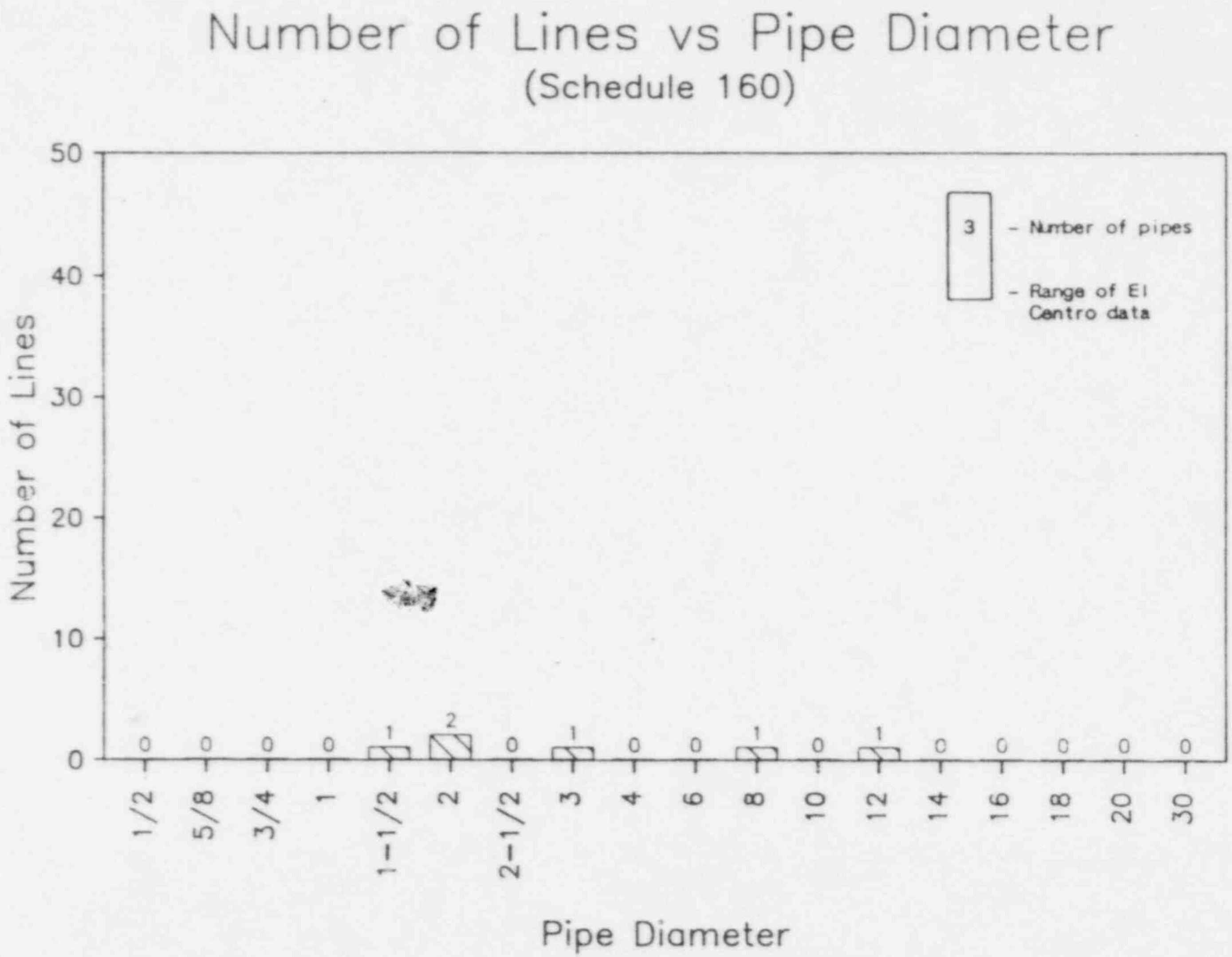

Figure 3-14 El Centro Plant Piping Sizes, Schedule 160

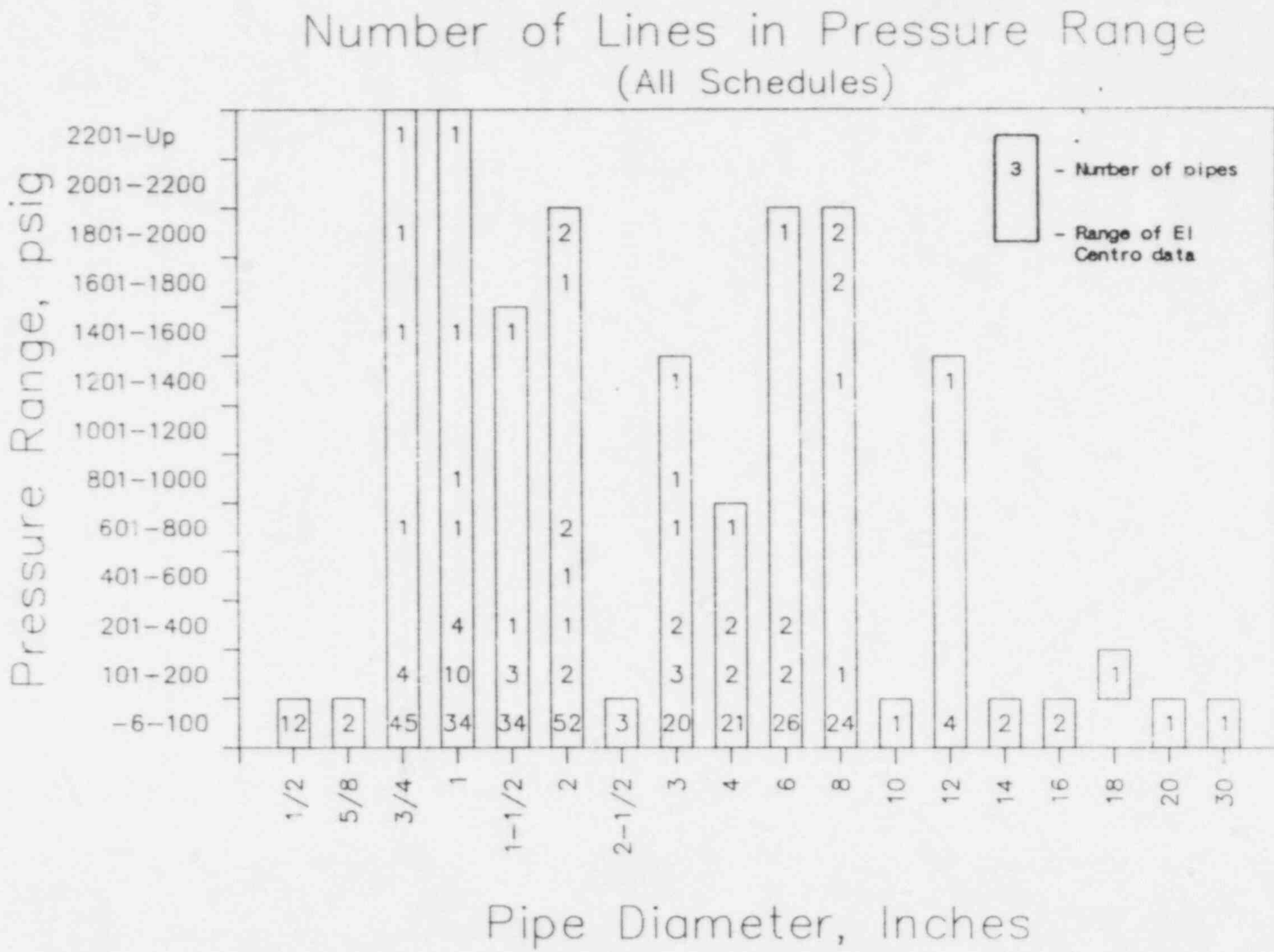

Figure 3-15 El Centro Plant Pipe Operating Pressures, All Schedules

encompass pressures from -6 psi to over 2400 psi. Most of the systems have operating pressures less than 400 psi. Figures 3-16 to 3-23 show the same information for each of the pipe schedules. Pipe Schedules 10 to 40 are used primarily for the lower operating pressures (400 psi or less). Schedule 80 pipe is used for operating pressures from 400 psi to 1000 psi. Schedules 120 and 160 pipe are mostly used for operating pressures in excess of 1200 psi.

Figure 3-24 presents the range of operating temperatures for each of the pipe diameters used at the El Centro Plant. This figure shows the number of lines with operating temperatures within prescribed 100^{o}F intervals. Operating temperatures as high as 1005^{o}F occur. Most of the piping systems have operating temperatures less than 400^{o}F. Similar plots for each of the different pipe schedules are shown in Figures 3-25 to 3-32.

Design pressures and temperatures for the Millstone III Category 2 piping are available from the piping specifications. The maximum design pressure and temperature for any Category 2 line are 1380 psi and 1050^{o}F, respectively. These values compare with the El Centro Plant data base maximum operating pressure and temperature of 2400 psi and 1005^{o}F. This comparison shows that the data base adequately bounds the Millstone III Category 2 piping.

3.2.4 Comparison of Piping Components and Construction

Components that are integral with the piping systems include attachments and fittings. The potential for seismic interaction of attachments such as valves and thermocouples with adjacent structures or piping has already been addressed by the review criteria recommendations of Reference 1. The Category 2 attachments (valves, couplings, etc.) and fittings (tees, branches, elbows, etc) used at Millstone III are similar to or the same as other components used throughout the utility industry. The performance of these components would be expected to be no worse than the performance exhibited by the seismic experience data base as a whole.

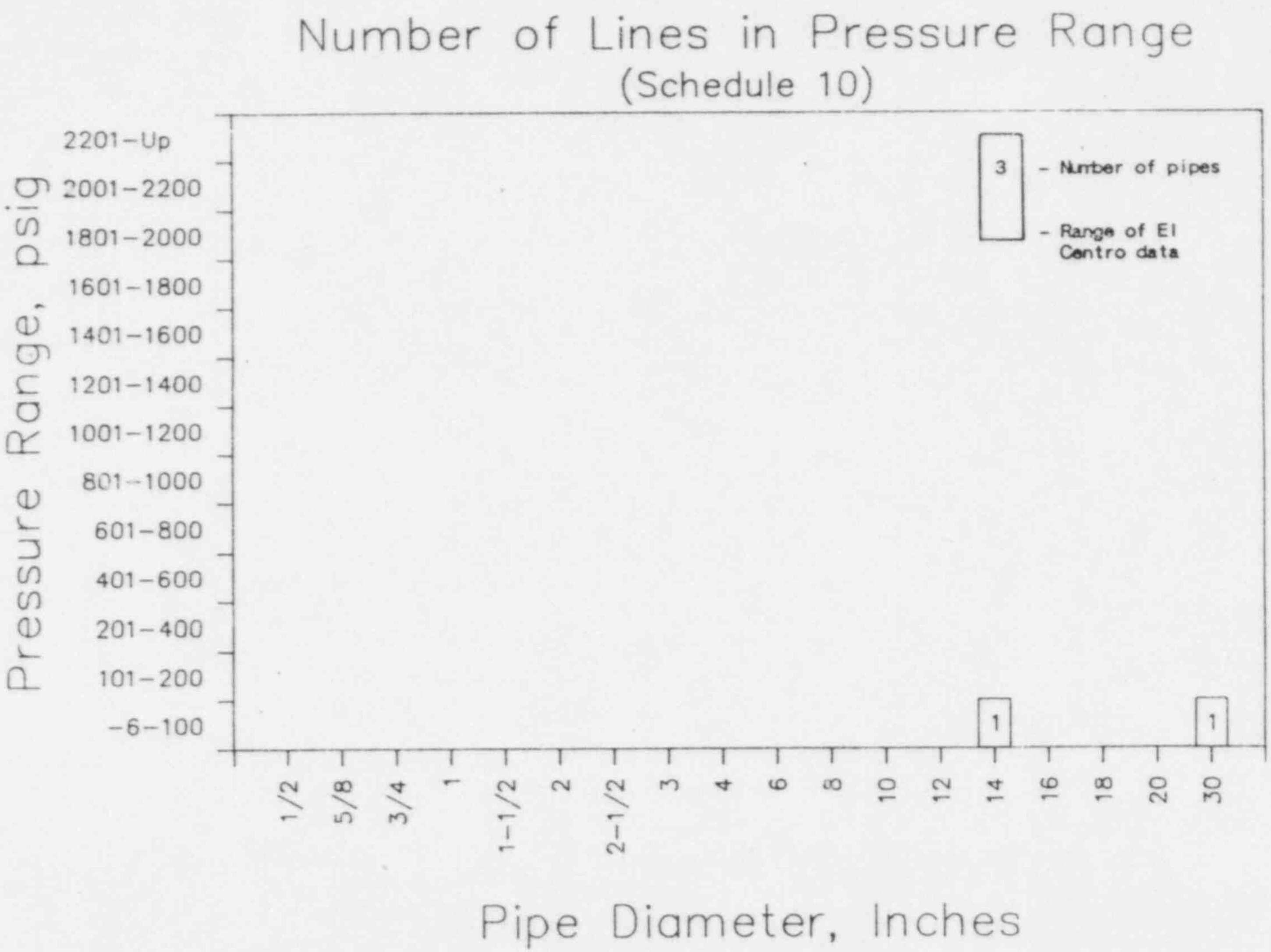

Figure 3-16 El Centro Plant Pipe Operating Pressures, Schedule 10

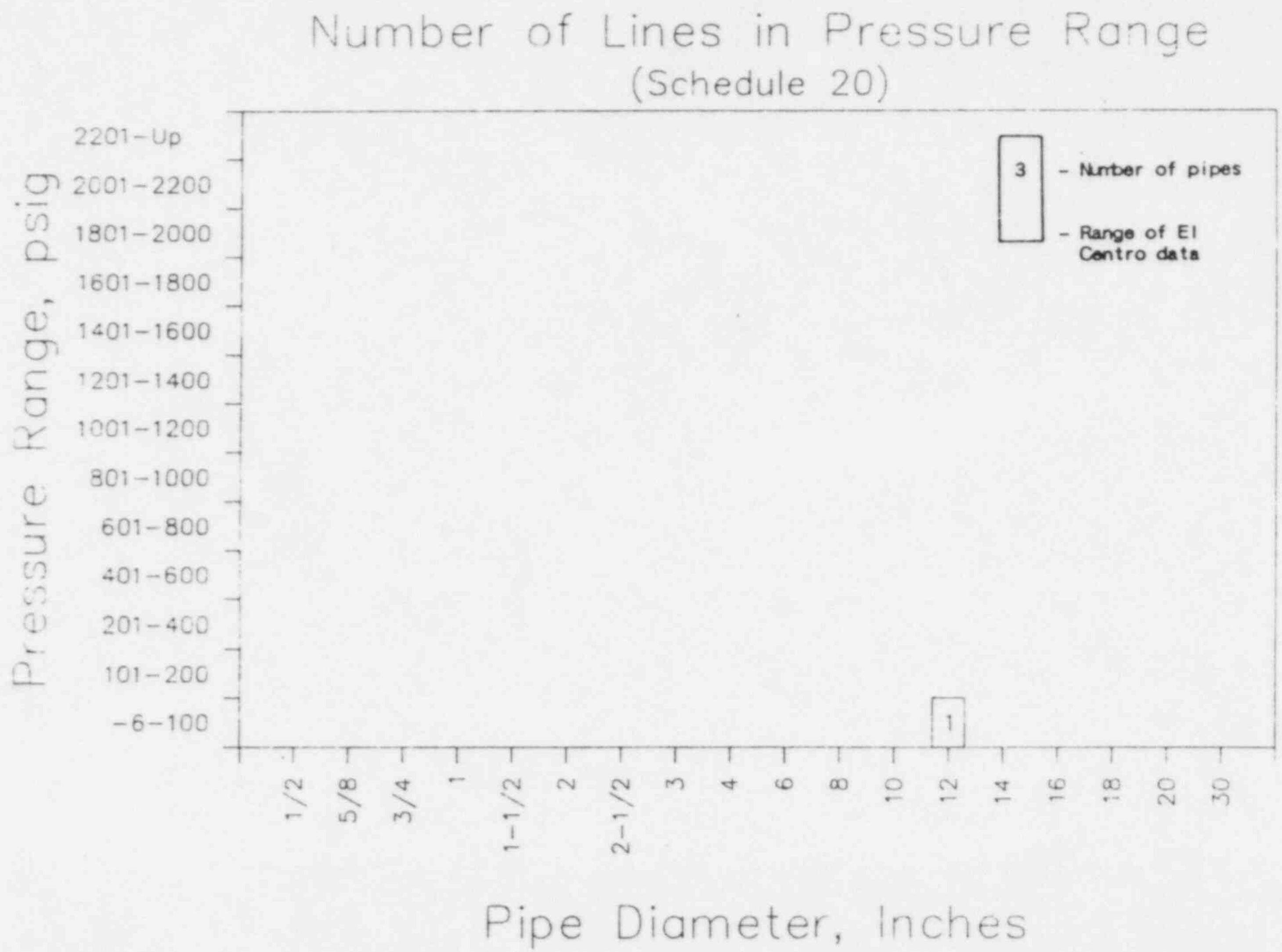

Figure 3-17 El Centro Plant Pipe Operating Pressures, Schedule 20

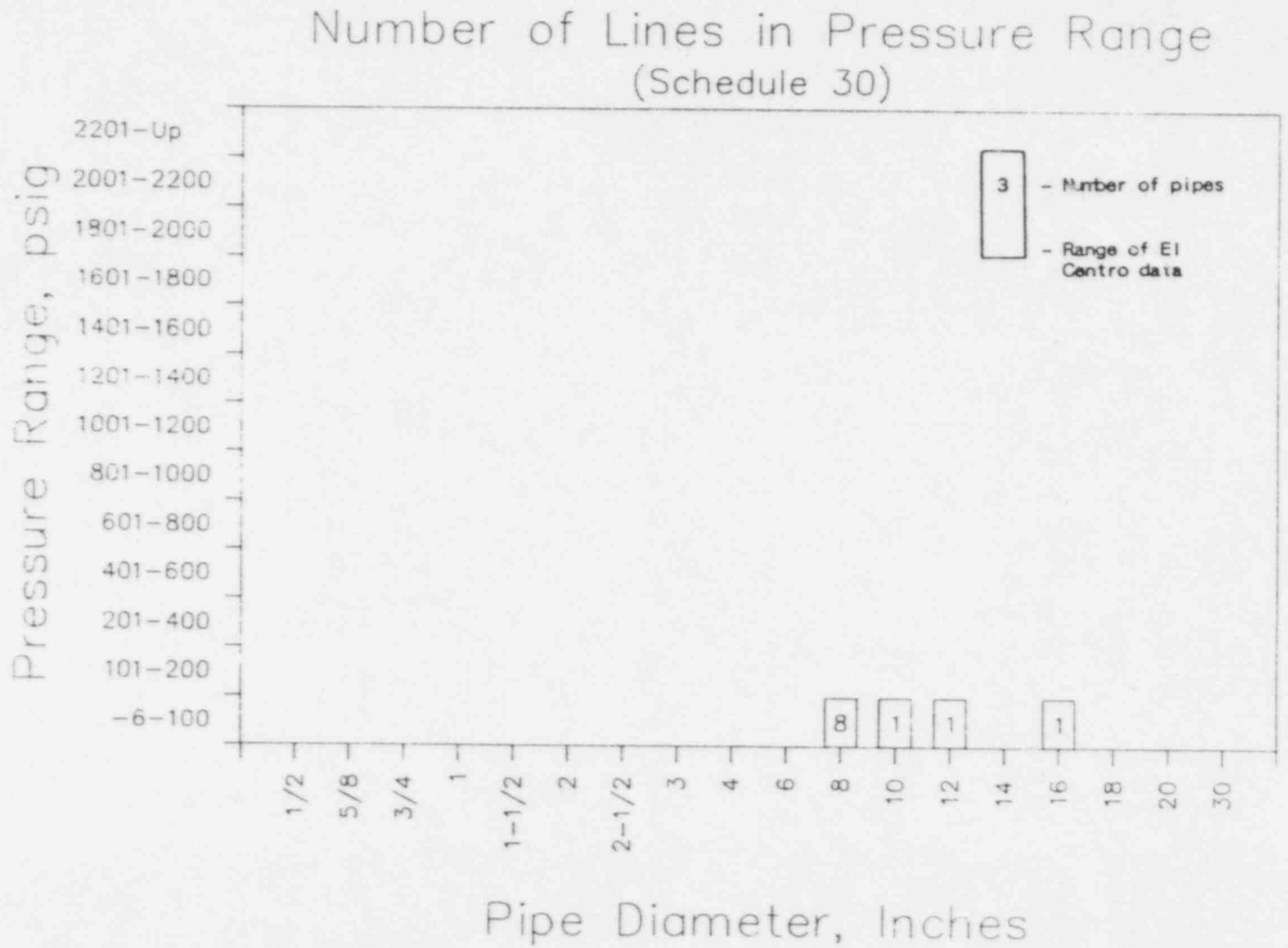

Figure 3-18 El Centro Plant Pipe Operating Pressures, Schedule 30

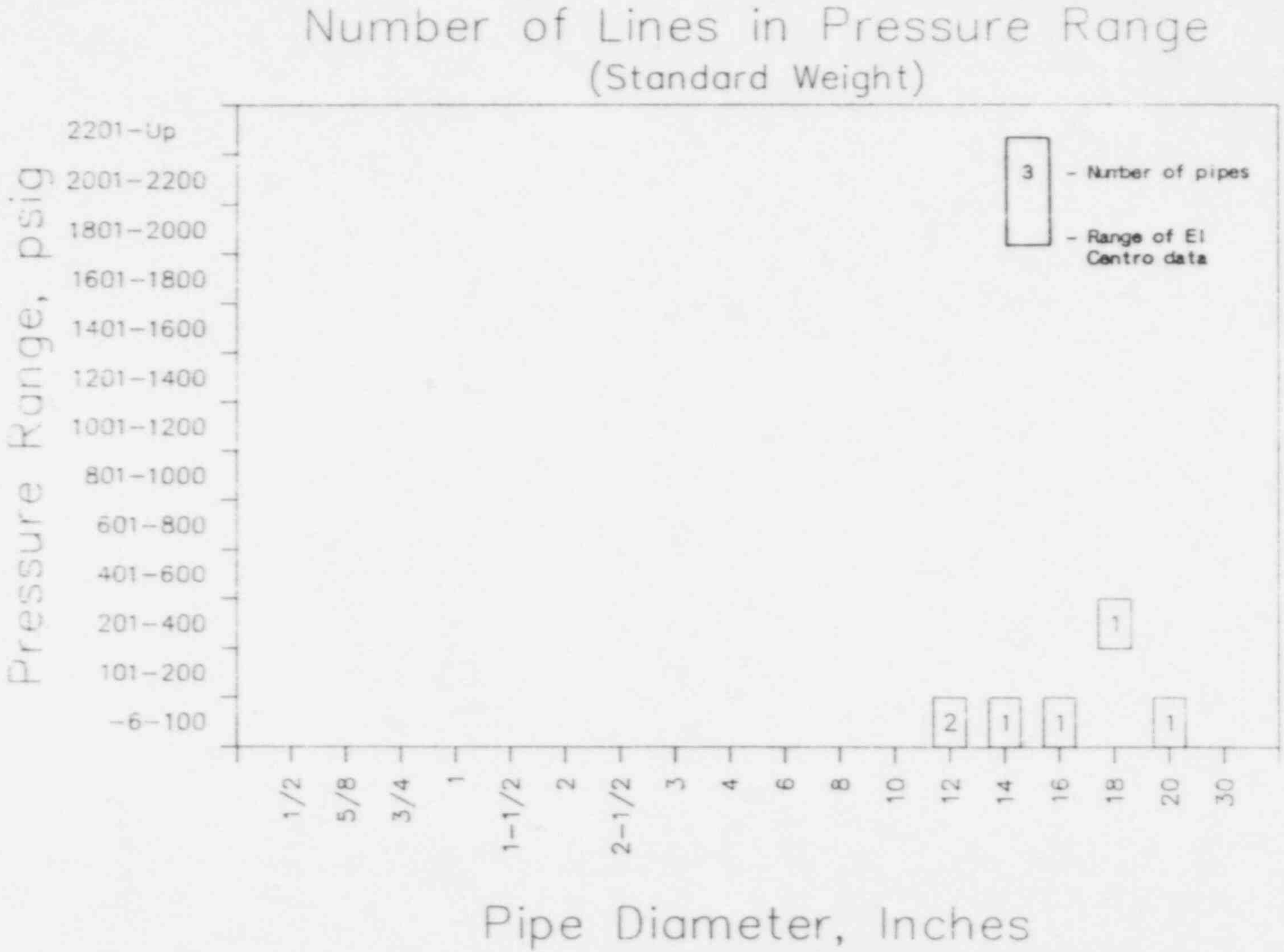

Figure 3-19 El Centro Plant Pipe Operating Pressures, Standard Weight

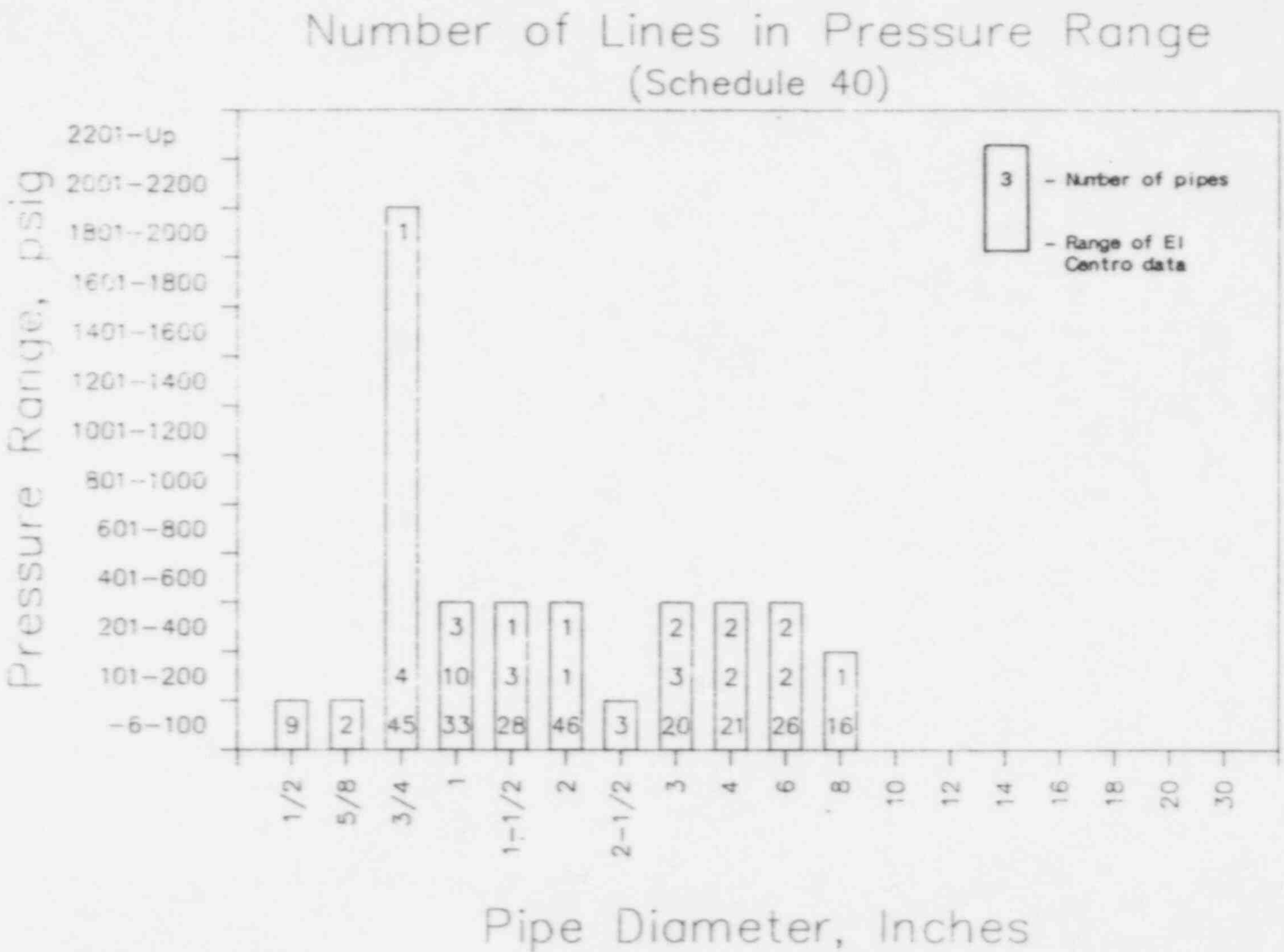

Figure 3-20 El Centro Plant Pipe Operating Pressures, Schedule 40

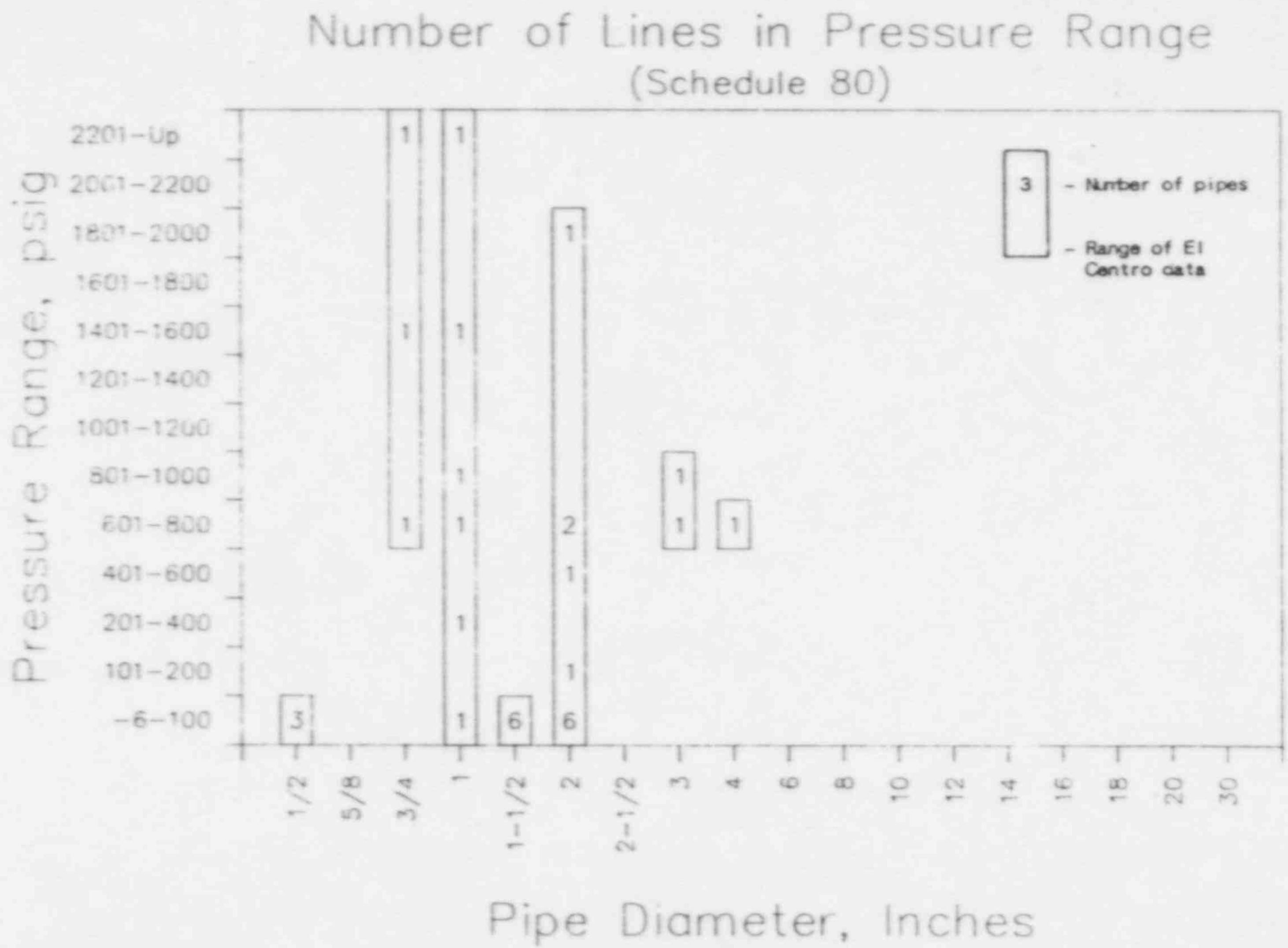

Figure 3-21 El Centro Plant Pipe Operating Pressures, Schedule 80

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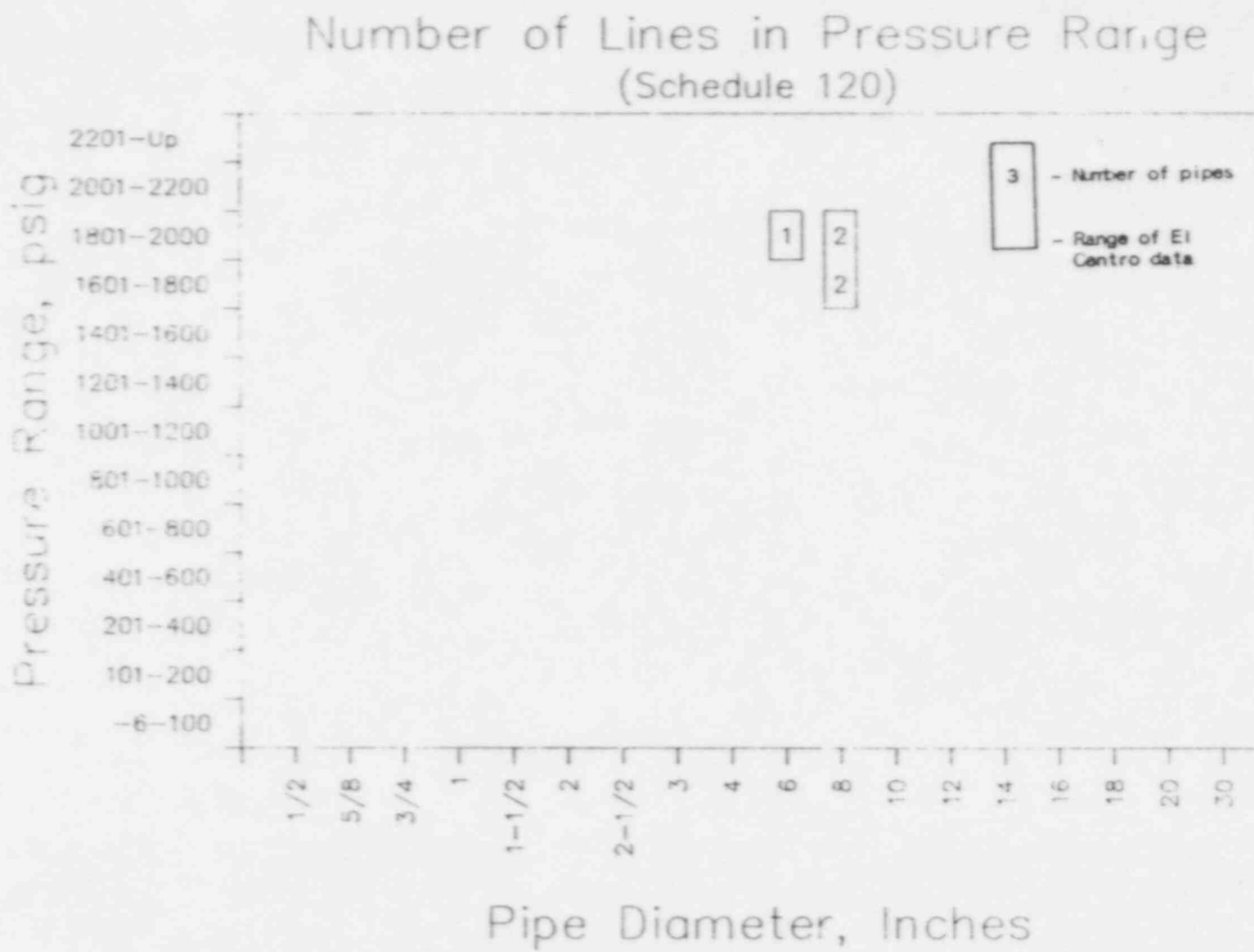

Figure 3-22 El Centro Plant Pipe Operating Pressures, Schedule 120

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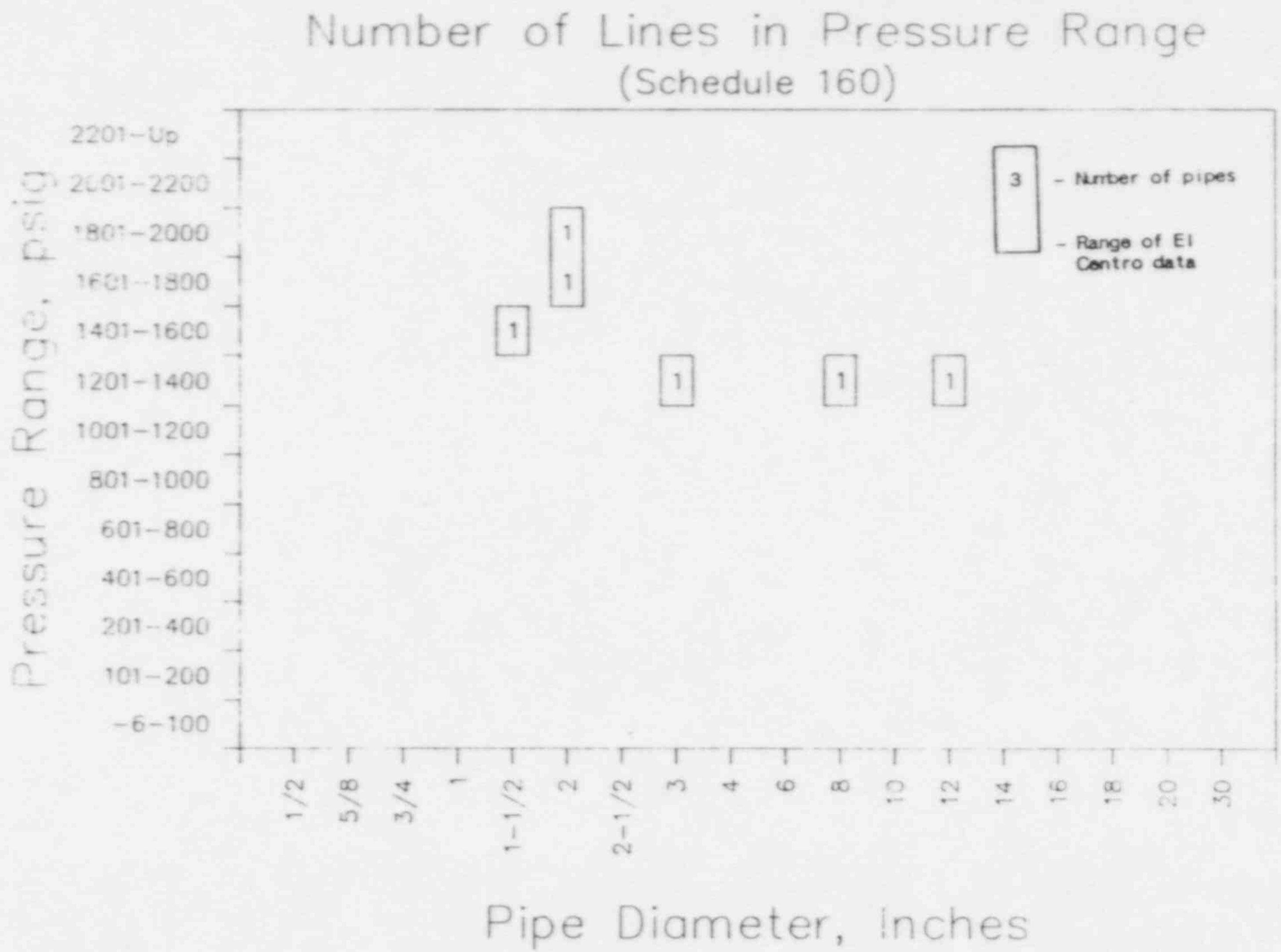


Figure 3-23 El Centro Plant Pipe Operating Pressures, Schedule 160

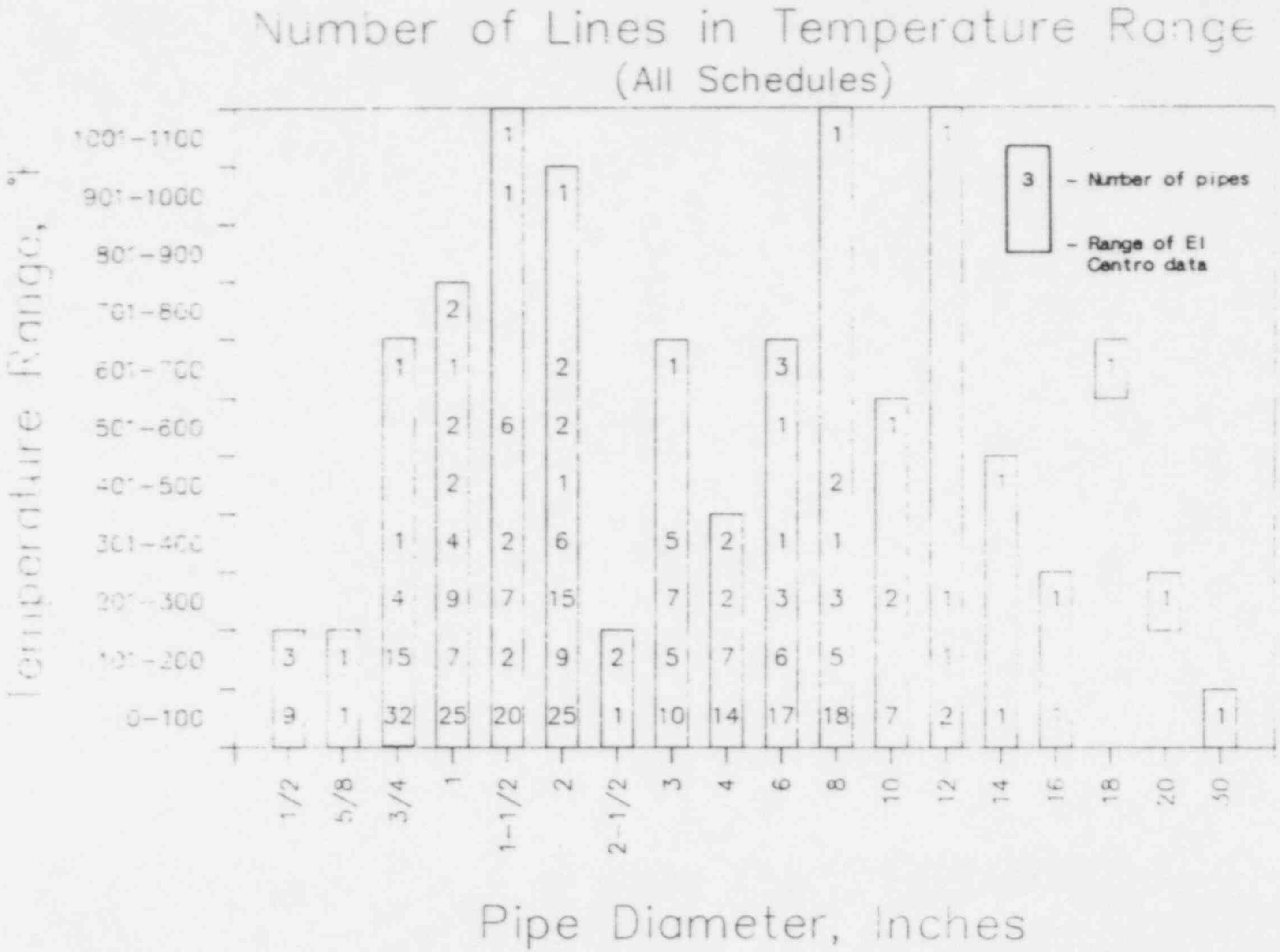


Figure 3-24 El Centro Plant Pipe Operating Temperatures, All Schedules

EQE

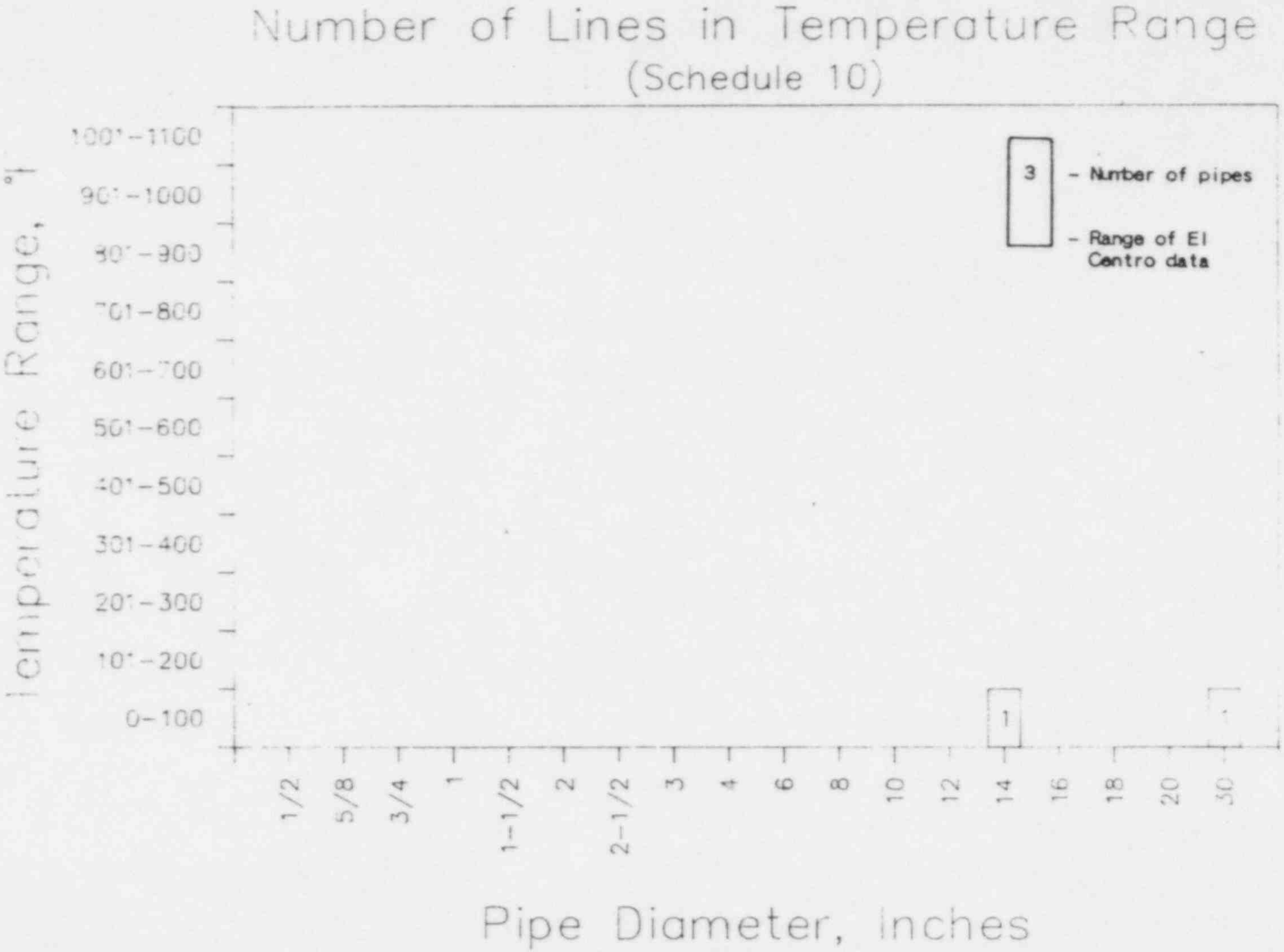


Figure 3-25 El Centro Plant Pipe Operating Temperatures, Schedule 10

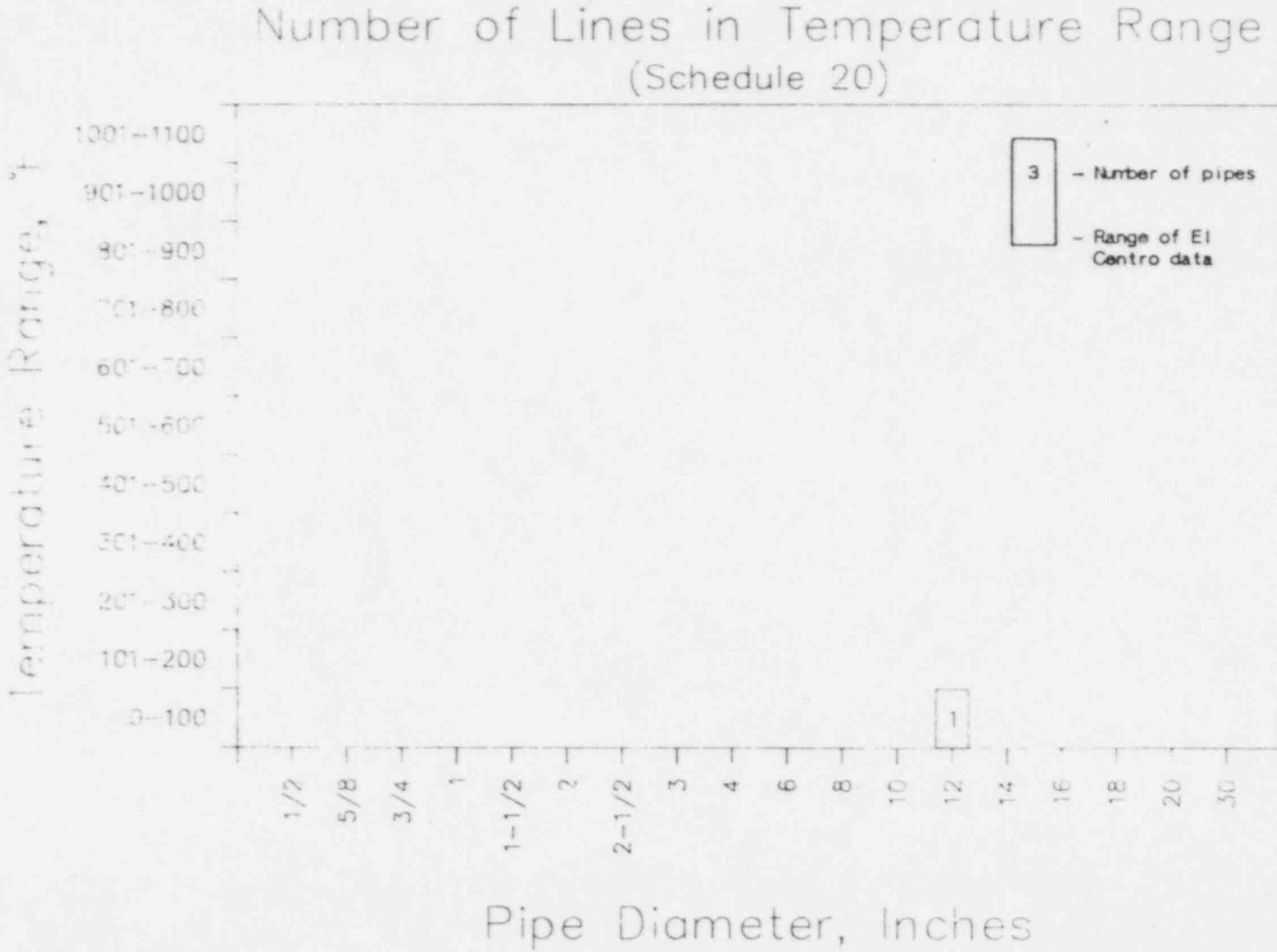


Figure 3-26 El Centro Plant Pipe Operating Temperatures, Schedule 20

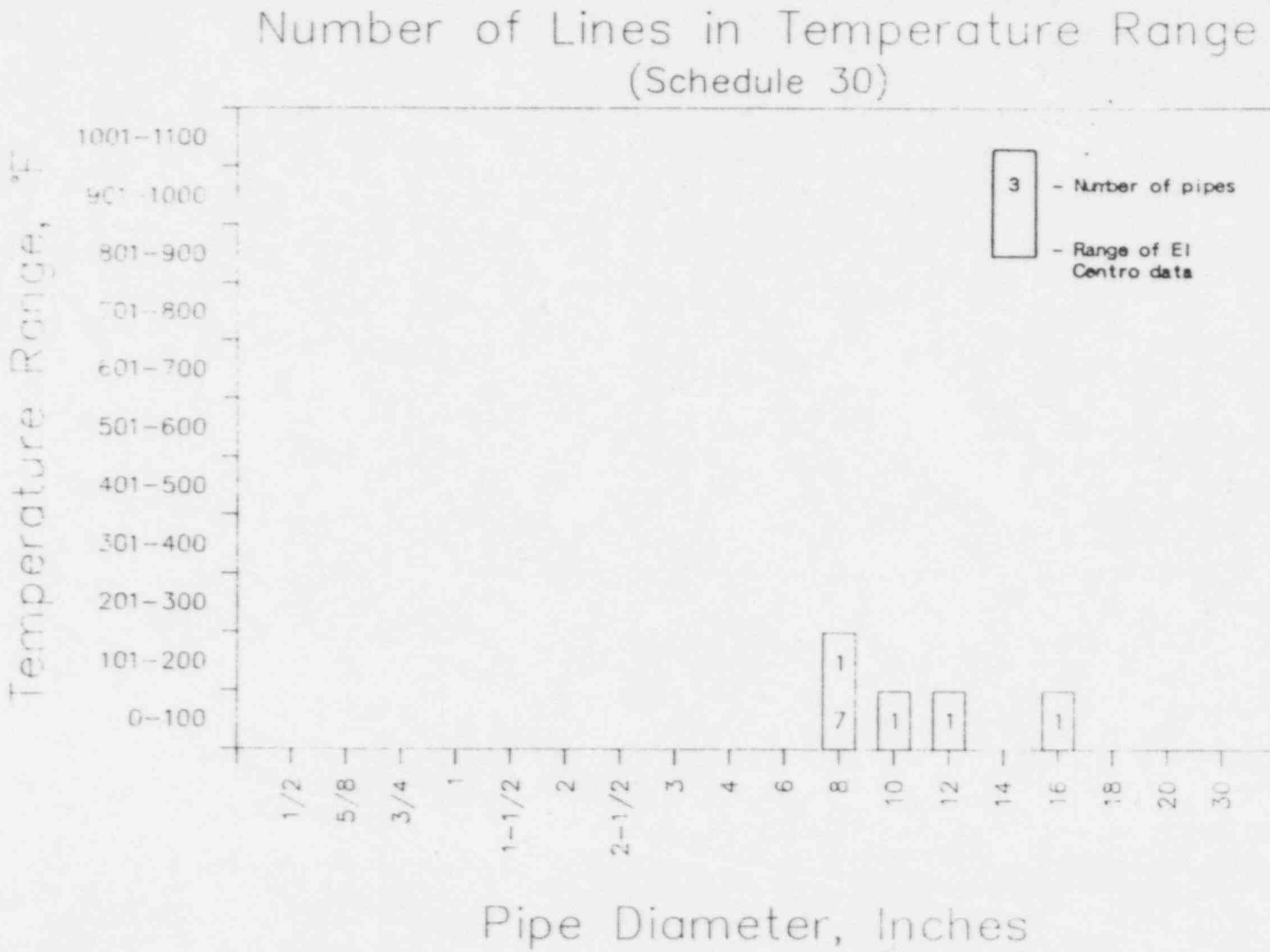
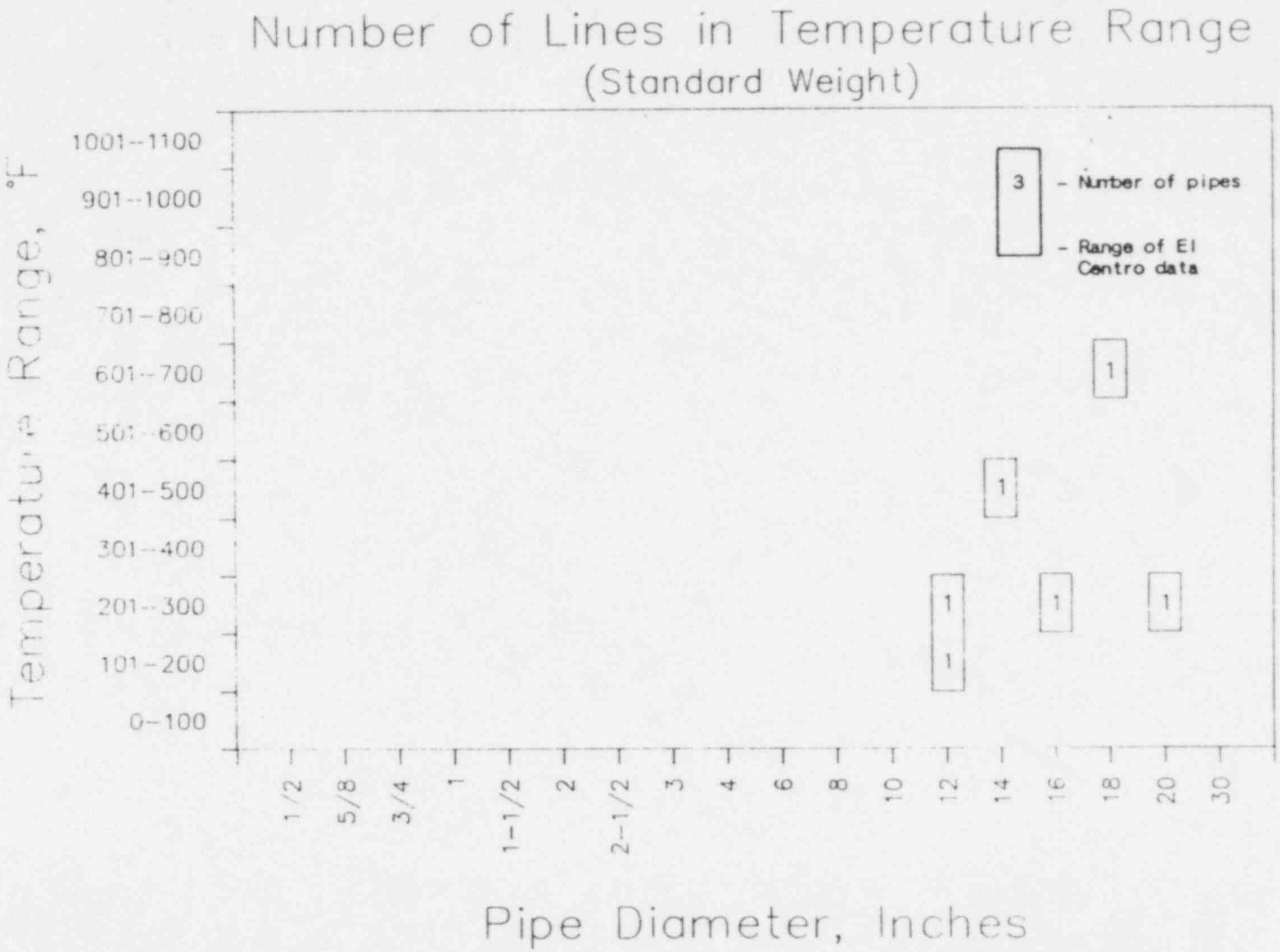


Figure 3-27 El Centro Plant Pipe Operating Temperatures, Schedule 30



EQE

Figure 3-28 El Centro Plant Pipe Operating Temperatures, Standard Weight

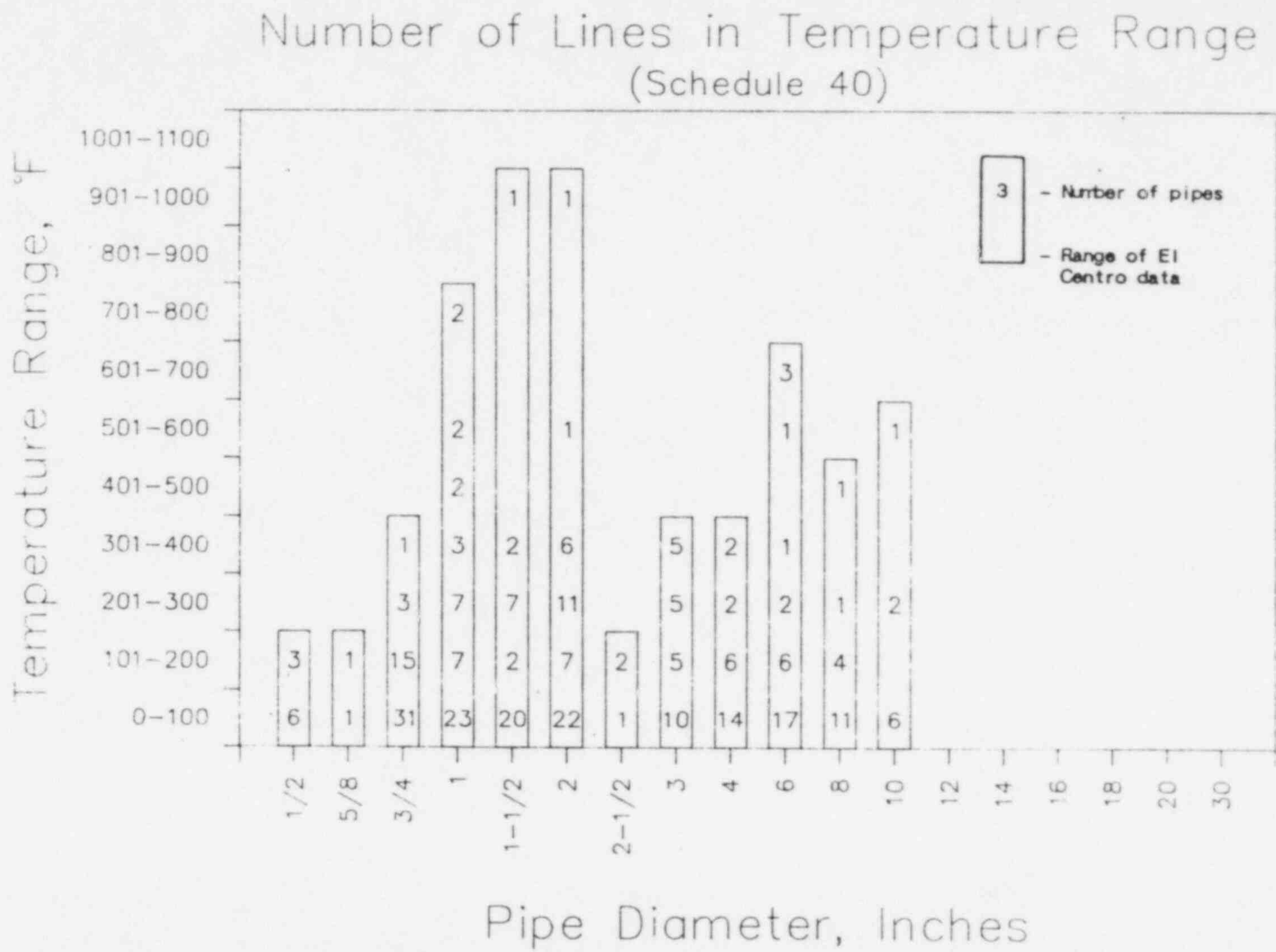
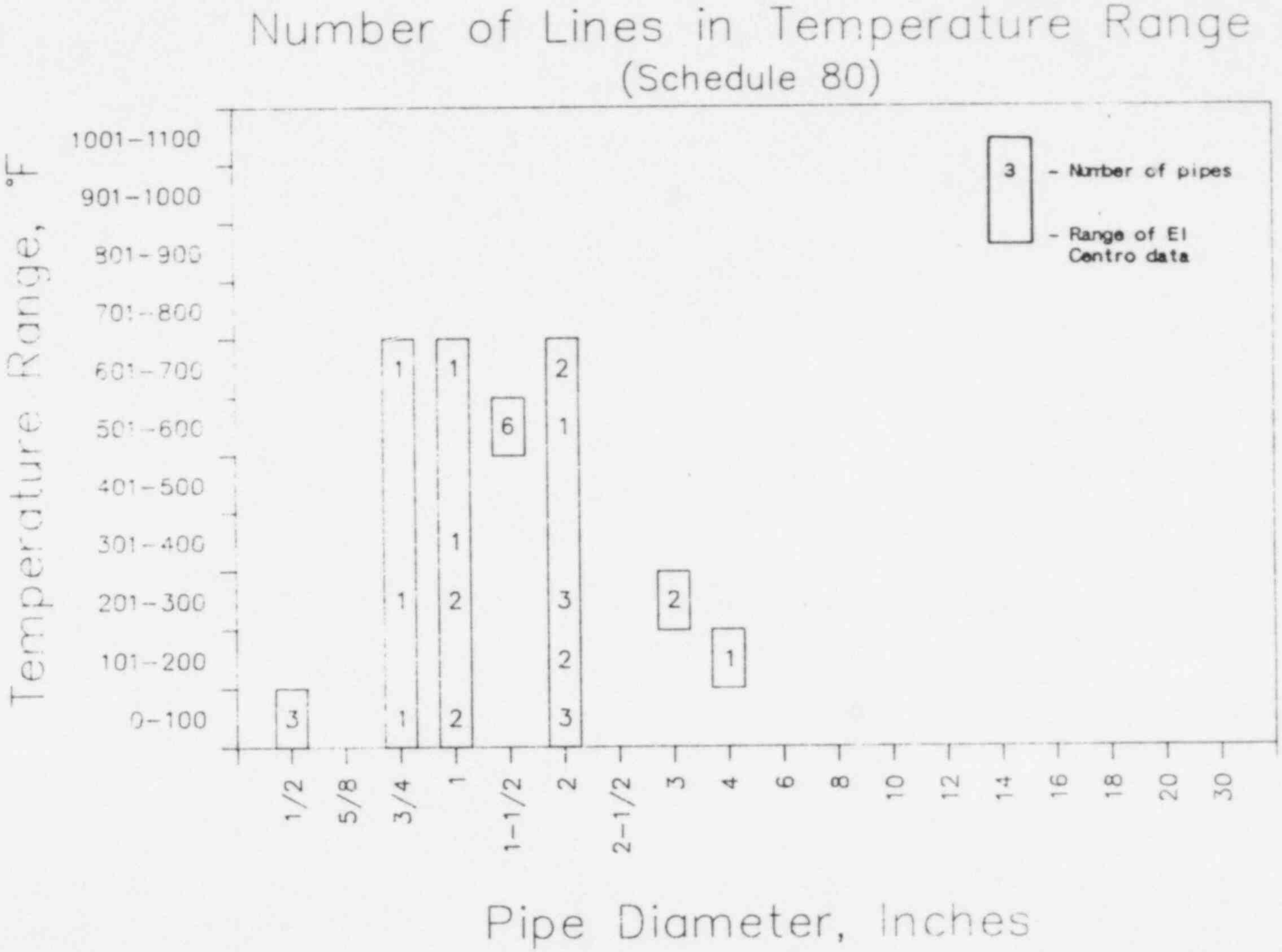
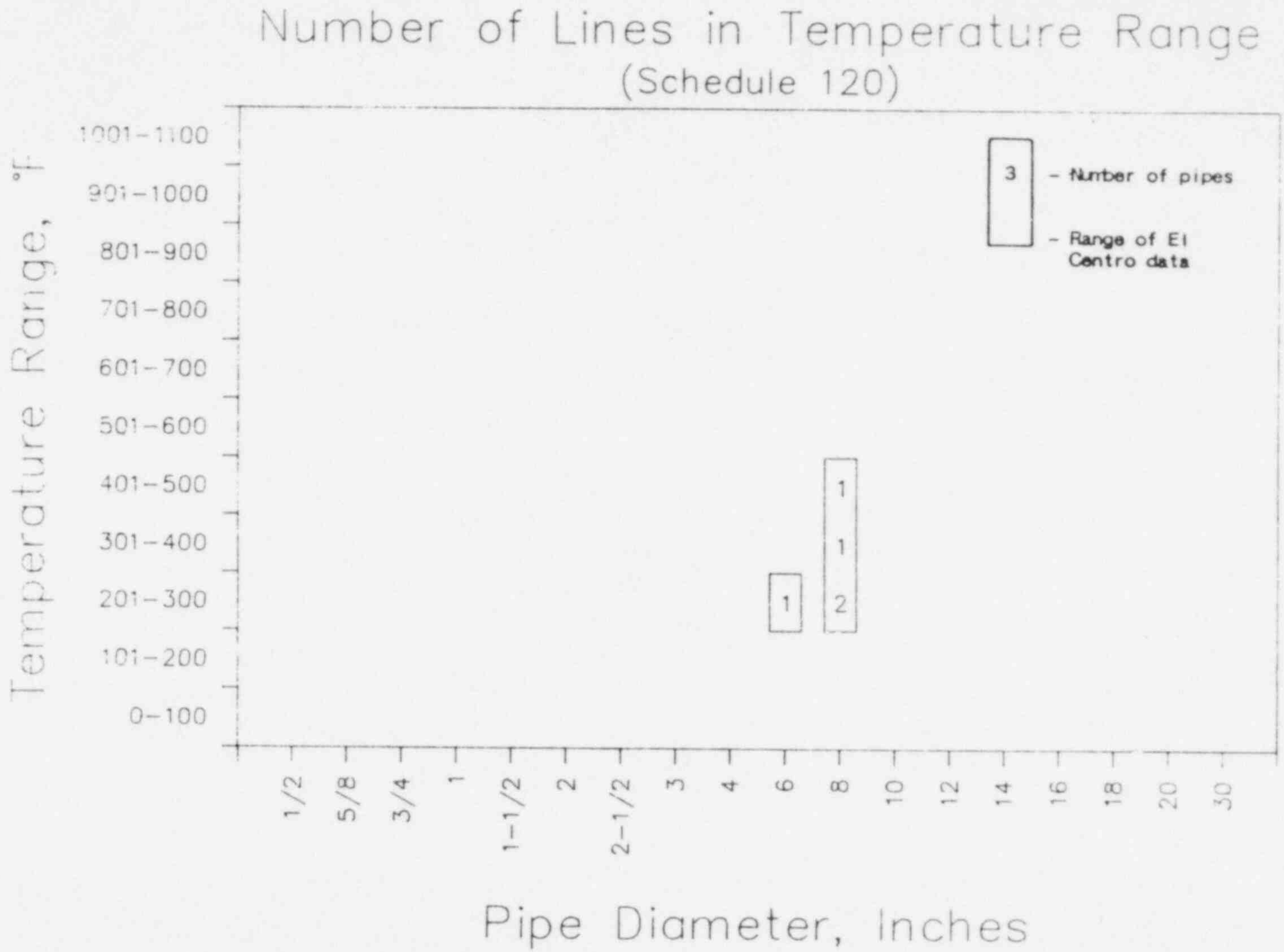


Figure 3-29 El Centro Plant Pipe Operating Temperatures, Schedule 40



EQE **Figure 3-30 El Centro Plant Pipe Operating Temperatures, Schedule 80**



EQE

Figure 3-31 El Centro Plant Pipe Operating Temperatures, Schedule 120

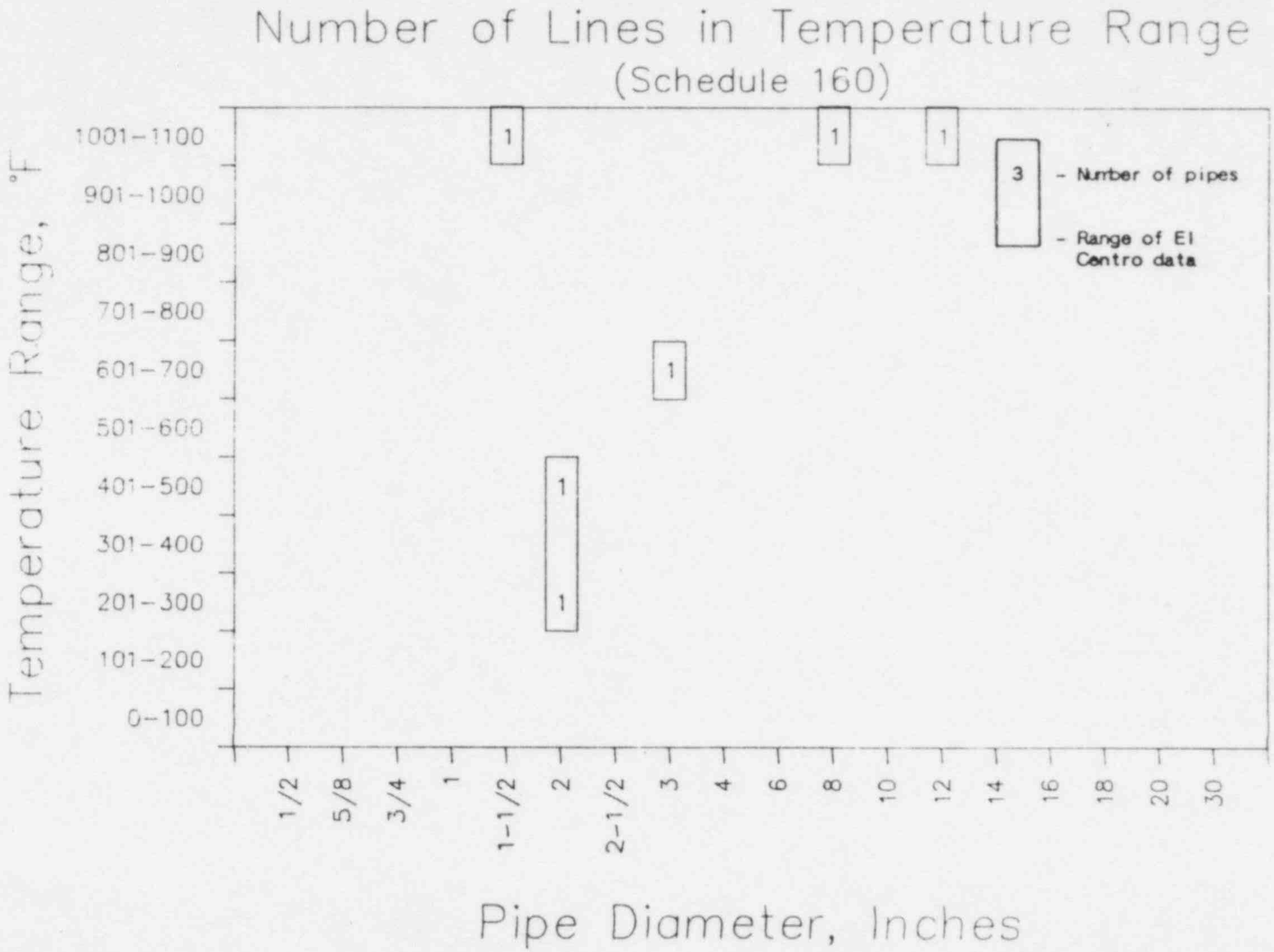


Figure 3-32 El Centro Plant Pipe Operating Temperatures, Schedule 160

EQE

Most of the Category 2 piping systems that can potentially interact with Category 1 components or piping at Millstone III are butt or socket welded. The El Centro Plant piping as well as the experience data base as a whole contains examples of welded, flanged, and threaded construction. The Millstone III Category 2 piping construction is adequately represented by the experience data base.

3.3 Comparison of Support Parameters

The following support parameters are identified as being the most important for definition of the capacity, response, and potential for seismic interaction of piping systems:

1. Support Spacing

2. Support Type and Design

Comparisons for these parameters between the El Centro Plant data base and the Millstone III Category 2 piping were performed. These comparisons were based upon available piping isometric drawings, support specifications, and support detail drawings.

3.3.1 Support Spacing

Different support spacing criteria were used for the Millstone III Category 2 small bore and large bore piping. Piping with diameters of two inches or less were considered small bore while piping with diameters of 2.5 inches or greater were considered large bore. For small bore nonannulus piping, vertical supports are required within the maximum span lengths shown in either Tables 3-2 or 3-3. These maximum span lengths are measured along the length of the pipe. The span lengths shown in Table 3-3 must be reduced by a factor of 0.75 if the pipe undergoes a horizontal change in direction. Vertical supports are also required at each concentrated load such as valves, traps, strainers, and risers. To control pipe sway, lateral restraints for small bore piping are required at approximately 30 foot intervals.

Table 3-2

Maximum Spans for Millstone III Category 2 Small Bore, Carbon/Stainless Steel Piping

Pipe Size	Pipe and Liquid and Insulation	Pipe and Liquid	Pipe and Air/Steam and Insulation	Pipe Only
2"	10'-0"	10'-0"	13'-0"	13'-0"
1 1/2"	9'-0"	9'-6"	12'-0"	12'-0"
1"	7'-0"	7'-6"	9'-0"	9'-0"
3/4"	6'-0"	6'-6"	8'-0"	8'-0"
1/2"	5'-6"	6'-0"		
3/8"	5'-6"	6'-0"		

Table 3-3

Alternate Maximum Spans for Millstone III Category 2
Small Bore Carbon/Stainless Steel Piping

Pipe Size	Pipe and Liquid Insulation		Pipe and Liquid		Pipe and Air/Steam and Insulation		Pipe Only	
	Sch 40	Sch 80	Sch 40	Sch 80	Sch 40	Sch 80	Sch 40	Sch 80
2"	11'-0"	12'-0"	13'-0"	13'-0"	13'-0"	13'-0"	14'-0"	14'-0"
1 1/2"	10'-0"	10'-0"	12'-0"	12'-0"	11'-0"	11'-0"	13'-0"	14'-0"
1"	7'-0"	8'-0"	9'-0"	9'-6"	8'-0"	8'-0"	10'-0"	10'-0"
3/4"	5'-0"	6'-0"	6'-0"	7'-6"	5'-6"	6'-0"	7'-0"	8'-0"

Vertical pipe supports for the Millstone III Category 2 large bore piping are required within the maximum span lengths prescribed in the ANSI/ASME B31.1 Code that are shown in Table 3-4. These span lengths are measured along the length of the pipe and were typically reduced in the design process by a factor of approximately 0.75 for piping with horizontal changes in direction. Vertical supports are also provided at risers longer than half of a maximum span length and other concentrated loads. Horizontal supports are typically provided at every second or third vertical support.

Support spacings for the El Centro Plant data base were obtained from the piping isometric drawings. Only data for piping with diameters of 1 inch or greater were compiled. Figures 3-33 and 3-34 show the number of occurrences of different vertical and horizontal support spacings for the El Centro Plant lines containing liquid. These spacings are measured along the length of the pipe and are provided for each pipe diameter. Figures 3-35 and 3-36 show the same information for piping containing vapor.

The maximum support spacings permitted for the Millstone III Category 2 piping are also noted in Figures 3-33 to 3-36. This comparison clearly indicates that the Millstone III vertical and horizontal support spacings are enveloped by the El Centro Plant data base. There are several cases where the El Centro Plant support spacings greatly exceed those permitted at Millstone III. This observation indicates that the El Centro Plant piping has a much greater range of flexibility than the Millstone III Category 2 piping. Piping flexibility is a direct measure of the potential for occurrence of and damage due to seismic interaction. Highly flexible piping will undergo greater displacement during an earthquake. It can be concluded that the El Centro Plant data base piping is more vulnerable to damage due to seismic interaction than the Millstone III Category 2 piping.

Table 3-4

Maximum Spans for Millstone III Large Bore Piping from ANSI/ASME B31.1

Nominal Pipe (in)	Water Service (feet)	Steam, Gas or Air Service (feet)
3	12	15
4	14	17
6	17	21
8	19	24
12	23	30
16	27	35
20	30	39
24	32	42

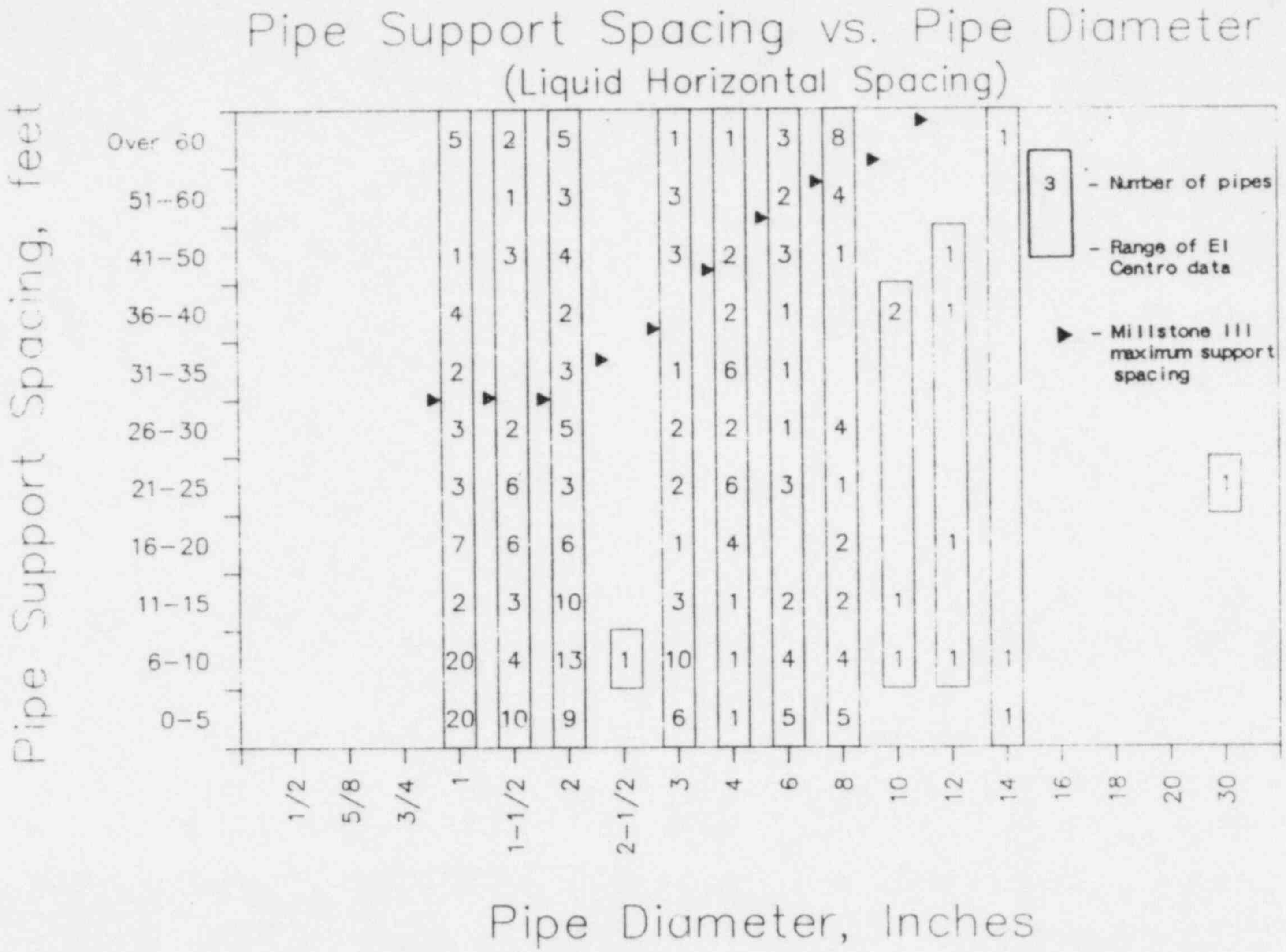
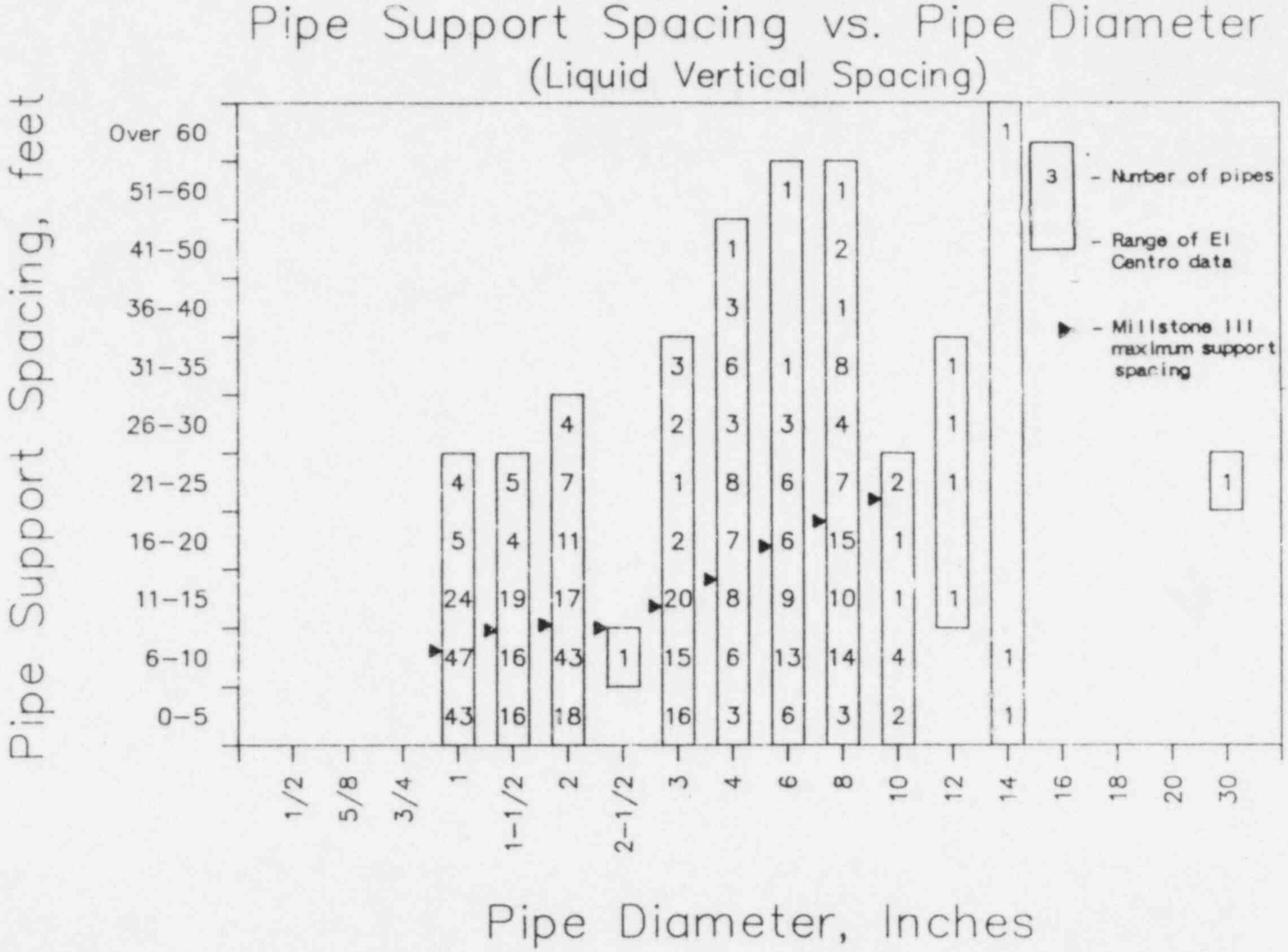


Figure 3-33 El Centro Plant Pipe Horizontal Support Spacing, Liquid Filled Pipes, All Schedules



EQE

Figure 3-34 El Centro Plant Pipe Vertical Support Spacing, Liquid Filled Pipes, All Schedules

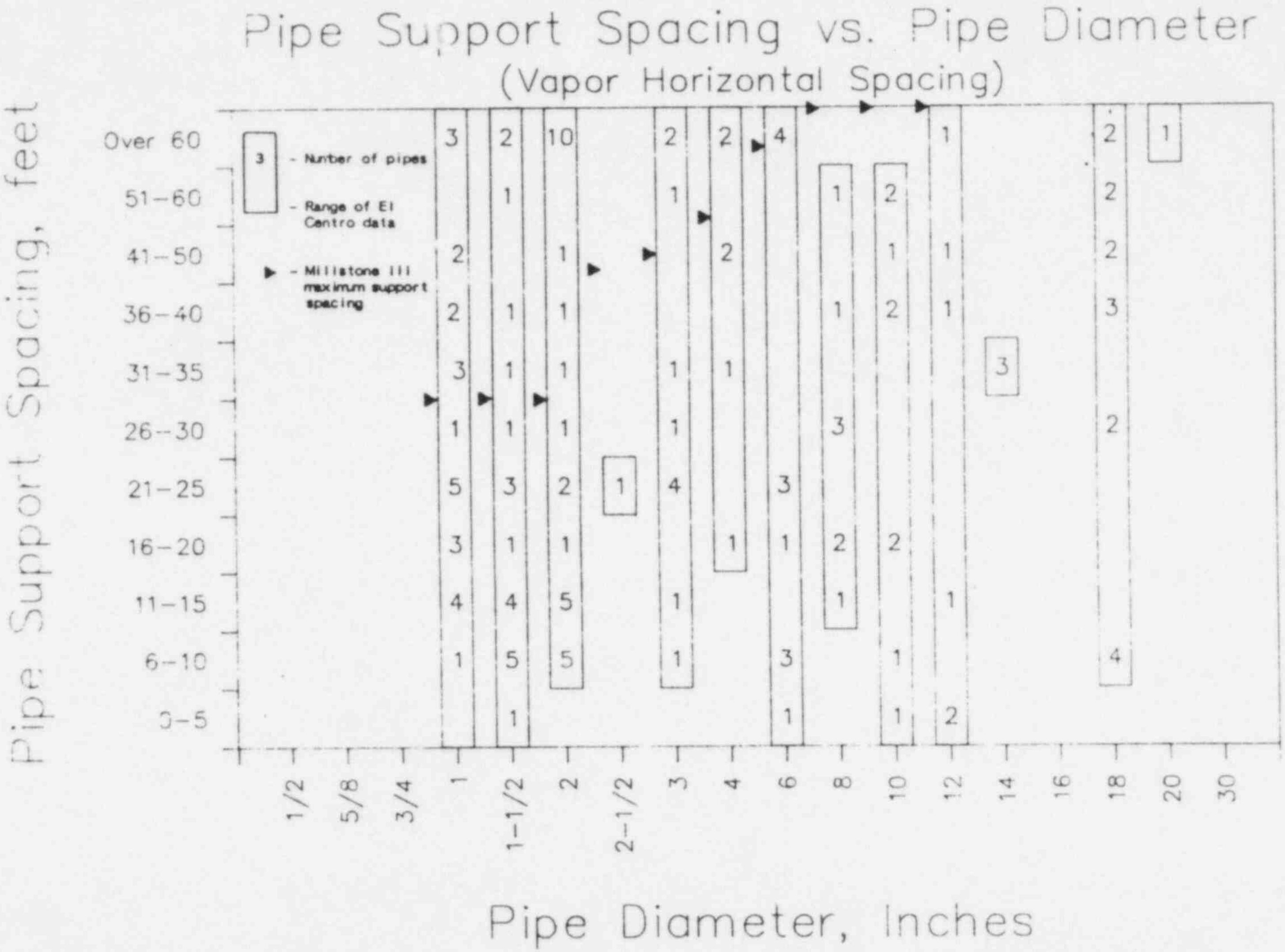


Figure 3-35 El Centro Plant Pipe Horizontal Support Spacing, Air or Steam Pipes, All Schedules

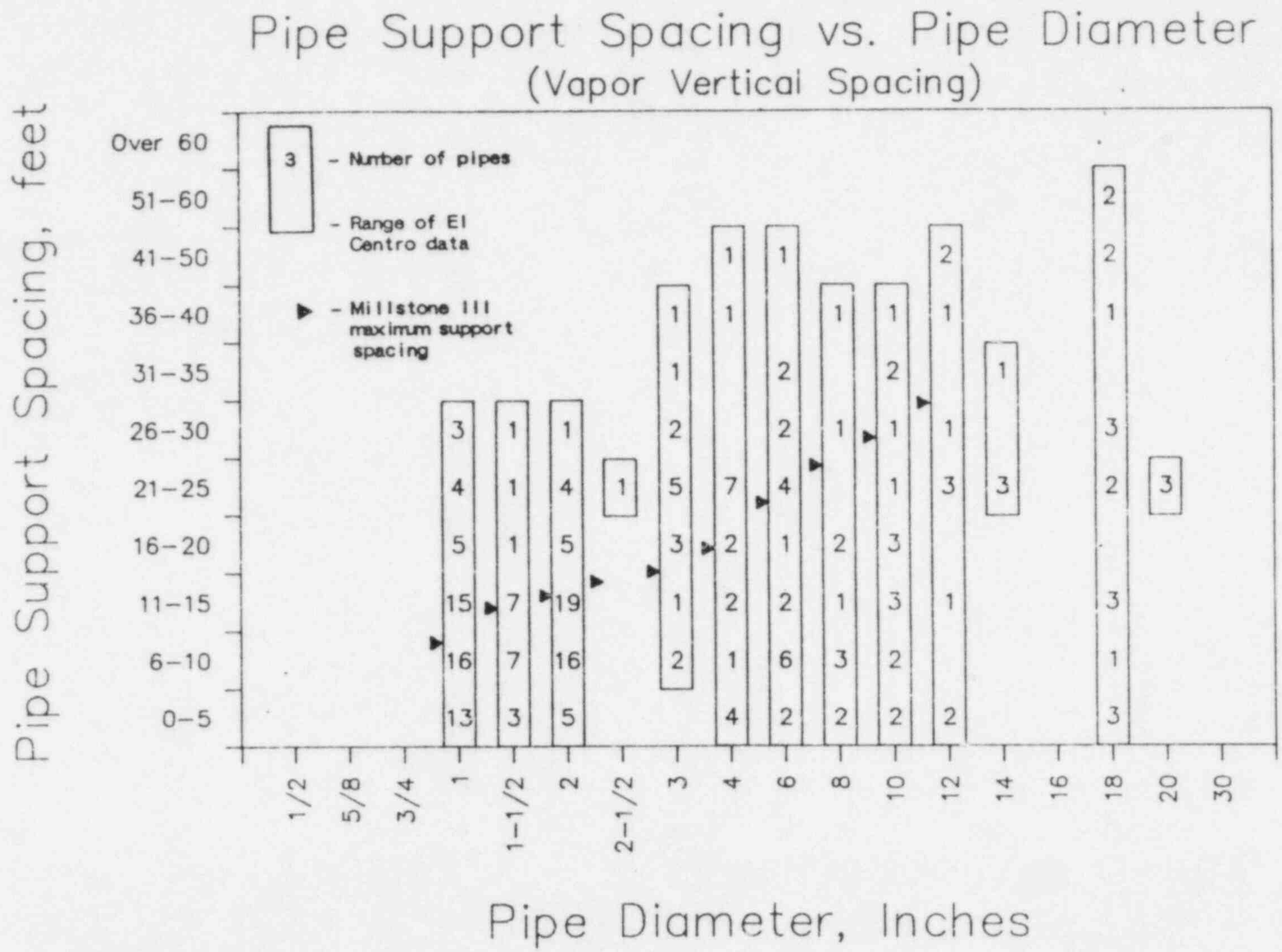


Figure 3-36 El Centro Plant Pipe Vertical Support Spacing, Air or Steam Pipes, All Schedules

3.3.2 Comparison of Support Types and Design

The following support types are found at the El Centro Plant:

1. Rod Hangers
2. Field Supports
3. Dummy Supports
4. Springs
5. Guides
6. Pick-ups
7. Anchors
8. Snubbers

Types 1 to 3 are intended to provide resistance against dead load only. Type 4 provides support against vertical translations in both the upward and downward directions. Type 5 resists vertical translation in the downward direction only and lateral translation. Type 6 resists vertical translations in both directions and lateral translation. Type 7 provides restraint against all translations and rotations. Type 8 resists sudden movements along its longitudinal axis. The number of each type of support are shown in Table 3-5 for the different pipe diameters. The El Centro Plant data base includes significant numbers of rod hangers, field supports, springs, and pick-ups.

The following types of supports are used for the Millstone III Category 2 piping:

1. Rod Hanger
2. Sliding Supports
3. Springs

Table 3-5

El Centro Plant Pipe Supports

Pipe Size, (in)	Rod Hanger	Field Supports	Dummy Supports	Springs	Guides	Pick-ups	Anchors	Snubbers
1	34	52	3	1	0	15	1	0
1½	23	11	1	0	2	9	0	0
2	35	48	2	3	0	7	2	0
3	6	33	0	0	2	0	0	0
4	11	16	5	2	0	4	0	0
6	6	28	2	5	0	0	2	0
8	21	13	2	15	0	0	3	1
10	2	0	0	10	0	0	0	2
12	1	0	0	5	0	0	0	0
14	0	1	1	7	0	0	0	7
16	0	0	0	0	0	0	0	0
18	0	7	0	13	0	0	0	13
20	0	0	o	2	0	0	0	2

Table 3-6

Millstone III Category 2 Pipe Supports

Pipe Size (in)	Rod Hanger	Sliding Support	Spring	Restraint	Anchor	Snubber
3	152	207	5	112	97	0
4	180	241	21	199	55	9
6	43	51	11	42	11	0
8	7	15	5	31	5	0
10	26	58	3	8	6	0
12	7	2	8	3	3	0

4. Restraints

5. Anchors

6. Snubbers

Sliding supports provide the same type of resistance as hanger rods. Restraints (U-bolts, sway struts, and box frames) function similar to the El Centro Plant pick-up supports. The numbers of each type of support are listed in Table 3-6 for each pipe diameter. Most of the Millstone III Category 2 pipe supports consist of rod hangers, sliding supports, and restraints.

A comparison of the El Centro Plant data base shows that all of the different types of functions (one way, two way, etc.) of the Millstone III Category 2 pipe supports are included in the El Centro Plant data base. Furthermore, the data base contains certain support types that are not used at Millstone III. The range of pipe diameters attached to the data base pipe supports also generally encompasses the range of Millstone III pipe diameters. The Millstone III Category 2 piping utilizes significantly more restraints and anchors. These supports provide greater resistance against vertical and lateral movements. The Millstone III piping would be expected to be stiffer and thus less vulnerable to seismic interaction than the data base piping.

This comparison shows that the type and function of the El Centro Plant data base pipe supports as well as the range of pipe diameters attached to these supports generally envelopes the Millstone III Category 2 pipe supports. A quantitative assessment of the pipe support capacities was not performed. However, review of the small bore pipe support details and the large bore design criteria indicates that degree of resistance provided by the Millstone III Category 2 pipe supports would be expected to be at least as great as the support resistance contained in the El Centro Plant data base.

4. CONCLUSIONS

Criteria to identify potential seismic interactions between Category 2 components not designed for seismic load with Category 1 components at the Millstone III Nuclear Power Plant were developed in Reference 1. This criteria was based upon the use of experience data from past earthquakes to identify and account for realistic seismic interactions. The study described in this report was conducted to present the quantitative experience data supporting the conclusions of Reference 1 regarding the hazard to Category 1 components posed by seismic interaction with Category 2 piping.

The conclusions of Reference 1 are appropriate so long as the key parameters of the experience data base facilities envelope the corresponding parameters of the Millstone III Category 2 piping. The key parameters that influence the potential for and damage due to seismic interaction are seismic input, piping parameters, and support parameters. In this study, comparisons were made between the El Centro Plant data base and the Millstone III Category 2 piping. These comparisons were performed for:

1. Ground motion response spectra
2. In-structure response spectra
3. Piping materials
4. Piping sizes
5. Piping operating conditions
6. Piping components and construction
7. Support spacings
8. Support types and design

The quantitative comparisons performed for each of these parameters demonstrate that the El Centro Plant data base generally envelopes the

Millstone III Category 2 piping. It should be noted that the El Centro Plant is only one facility contained in the seismic experience data base. It is expected that enveloping of the Millstone III Category 2 piping could be extended by incorporating data from all of the data base facilities.

Because the key parameters of the experience data base envelope the parameters of the Millstone III Category 2 piping, it can be concluded that the use of experience data to identify realistic seismic interactions and the level of seismic motion at the threshold of occurrence is valid. The criteria recommended in Reference 1 for the performance of a seismic interaction study at Millstone III are appropriate.

REFERENCES

1. "The Application of Experience Data to Seismic Interaction at the Millstone III Nuclear Power Plant", prepared for: Northeast Utilities Service Company, EQE Incorporated, January 1985.

2. Kennedy, R.P., von Riesemann, W.A., Ibanez, P., Schiff, A.J., and Wyllie, L.A., "Use of Past Earthquake Experience Data to Show Seismic Ruggedness of Certain Classes of Equipment in Nuclear Power Plants", Senior Seismic Review and Advisory Panel, prepared for the Seismic Qualification Utility Group, Revised January 1985.

3. Bumpus, S.E., Johnson, J.J., and Smith, P.D., "Best Estimate Method vs. Evaluation Method: A Comparison of Two Techniques in Evaluating Seismic Analysis and Design", prepared for Division of Reactor Safety Research, USNRC, Lawrence Livermore National Laboratory, NUREG/CR-1489, UCRL-52746, May 1980.

4. "Seismic Safety Margins Research Program, Executive Summary Number 1-Best Estimate vs. Evaluation Method", prepared for U.S. Nuclear Regulatory Commission, Lawrence Livermore Laboratory, LLL-TB-026.

5. Murray, R.C. Nelson, T.A., et.al, "Response of El Centro Steam Plant Equipment During the October 15,1979, Imperial Valley Earthquake", Lawrence Livermore Laboratory, NUREG/CR-1665, UCRL-53004, September, 1980.

6. "Investigations of the Effects on Structures of Three California Earthquakes", URS/John A. Blume & Associates, Engineers, April, 1981.

7. Kennedy, R.P., Short, S.A., et.al, "Engineering Characterization of Ground Motion Task I: Effects of Characteristics of Free-Field Motion on Structural Response", Structural Mechanics Associates, NUREG/CR-3805, April, 1984.

8. "Power Piping During and After Earthquakes", prepared for: Electric Power Research Institute, EQE Incorporated, To be published October 1985.

Appendix A

El Centro Steam Plant Unit 4 Pipe Line List

PIPE LINE LIST

LS-P- 210.01

4247 — Sheet 1 of 2

Rev.	Flow Diag. No.	Line No.	Class	Size	Ins.	Commodity	Phase	Origin (From)	To	Press. Design / Oper.	Temp. Design / Oper.	Remarks
2	221	101	SA	16" 12" 3/4	Ih	Boiler Feed Water	L	Deaerator Heater #4-2	Boiler Feed Pump #4-1,2,3	150 / 25	250 / 249	—
1		102	SH	6" 8" 2"	Ih	Boiler Feed Water	L	Boiler Feed Pump #4 1,2,3	H.P. Heater #4-3	2135 / 1827	254 / 254	—
1		103	SH	8"	Ih	Boiler Feed Water	L	H.P. Heater #4-3	H.P. Heater #4-4	2135 / 1815	290 / 290	—
1		104	SH	8"	Ih	Boiler Feed Water	L	H.P. Heater #4-4	H.P. Heater #4-5	2135 / 1795	355 / 355	—
1		105	SH	8" 2"	Ih	Boiler Feed Water	L	H.P. Heater #4-5	Boiler Econ. Inlet Header	2135 / 1760	500 / 436	—
1	200	106	SIA	12" 8"	Ih	Main Steam	V	Superheater outlet Header @ Boiler	H.P. Turbine Throttle Valve	1565 / 1405	1005 / 1005	SR
		107	SD	18"	Ih	Cold Reheat Steam	V	H.P. Turbine	Reheat Inlet @ Boiler	375 / 365	679 / 679	—
1		108	SFA	18" 12"	Ih	Hot Reheat Steam	V	Reheat Outlet Hdr @ Boiler	Stop Valves @ I.P. Turbine Inlet	350 / 335	1005 / 1005	—
		109	SD	6"	Ih	#5 Extraction Steam	V	Ln# 107 SD @ H.P. Turbine	H.P. Heater #4-5	375 / 359	679 / 679	—
		110	SD	8"	Ih	#4 Extraction Steam	V	I.P. Turbine	H.P. Heater #4-4	150 / 130	800 / 795	—
		111	SC	10"	Ih	#3 Extraction Steam	V	I.P. Turbine	H.P. Heater #4-3	50 / 43	582 / 582	—
1		112	SC	14" 8"	Ih	#2 Extraction Steam	V	I.P. Turbine	Deaerator Heater #4-2	30 / 15	450 / 448	—
1		113	SC	20" 16"	Ih	#1 Extraction Steam	V	L.P. Turbine	L.P. Heater #4-1	50 / -6	263 / 263	—
1		114	SH	3"	Ih	H.P. Aux Steam	V	Boiler Steam Drum	Thru PCV-1V to Ln# 115 SC	1700 / 1600	[illegible] / 604	—
1		115	SC	4"	Ih	Aux Steam	V	Ln# 347 SD	Thru PC 3V To Ln 126 SC	150 / 100	365 / 358	—

Revisions: 1 — 6-29-67 Issued; 2 — 7-6-67 Drafted

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PIPE LINE LIST

JOB NO. 4247
SHEET NO. 2 REV. 2
DATE [illegible] BY [illegible]

65-F-210.02

REV	FLOW DIAG. NO.	LINE NO.	LINE CLASS	LINE SIZE		COMMODITY	VAP. / LIQ.	DESCRIPTION ORIGIN FROM	DESCRIPTION TERMINUS TO	DES. PSIG / OPER. PSIG	DES. °F / OPER. °F	REINF. PAD / POST HEAT TREAT
1	200	116	SJA	2" 1½"	Ih	Main Steam	V	Ln# 106 SJA	Steam Jet Ejector #4 & Turbine Gen.	1565 / 1500	1005 / 1005	—
1		117	SD	4"	Ih	Aux. Steam	V	Hdr# 347SD	Ln# 125 SD @ TRC-404aV	350 / 275	435 / 415	—
2	201	118	SD	1½"	Is	Boiler Feed Wtr.	L	Boiler Feed Wtr Pumps No 4-1, 4-2, 4-3	Line 335 SA	600 / 35	254 / 254	—
1	203	119	SC	1" ¾"	Is	Cond.	L	Heater @ Fuel Oil Storage Tank	to Grade	Atmos / Atmos	200 / 190	—
1		120										—
1	201	121	SD	6"	Ih	#5 Extraction Steam	V	Ln# 109SD & 115 SC	Thru PIC-417V to Ln# 112 SC	375 / 359	679 / 679	—
1		122	SC	10"	Ih	Steam	V	Evaporator #4	Ln# 112 SC @ Deaerator Heater #4-2	50 [illegible] / 15	300 / 250	—
2	200 203	123	SC	3" 2" 1½" ¾"	Ih	Aux. Steam	V	Hdr# 115 SC	Suction Header @ Fuel Oil Working Tank & Fuel F.O. Pump	150 / 100	365 / 338	—
1	203	124	SC	3"	Ib	Aux. Steam	V	Existing Unit #1 3" Stm. Hdr.	Fuel Oil Heaters #4-1 Inc. Trap Piping	150 / 100	365 / 338	—
1	200	125	SD	6" 4" 2"	Ih	#4 Stm.	V	Ln# 117 SD	Thru TRC 404bV to Steam-Air Htrs.	150 / 130	365 / 338	—
1	200 201	126	SC	6" 2"	Ih	#3 Extraction Steam	V	Ln# 111 SC	Evaporator #4 & Reservoir	50 / 43	582 / 582	—
1		127										—
1		128										—
1	200	129	SA	6"	No	Stm. & Cond.	V / L	Surface Condenser No 4	Hogging Eject. & Stm. Jet Ejectors	Atmos / [illegible]	212 / 100	—
1	201	130	SJA	1½"	Ih	H.P. Stm.	V	Boiler H.T. Super Htr. Outlet Hdr.	Line 231 BD	1565 / 1505	1005 / 1005	—

Revisions: 1 — 4-24-[illegible] [illegible]; 2 — 7-6-6? Douglas

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FORM E-440 REV

THE FLUOR CORPORATION, LTD.

PIPE LINE LIST

JOB NO. 4249
SHEET NO. 3 REV. 2
DATE 10/31/66 BY DM

LS-P-210, 03

REV.	FLOW DIAG. NO.	LINE NO.	LINE CLASS	LINE SIZE	INSUL	COMMODITY	VAP. / LIQ.	DESCRIPTION ORIGIN FROM	DESCRIPTION TERMINUS TO	DES. PSIG / OPER PSIG	DES. °F / OPER °F	REINF. PAD / POST HEAT TREAT
1	201	131	SD	3" 2"	Ih	Cond	L	H.P. Heater #4-5	H.P. Heater #4-4 Ln. 132 SC	375 / 350	365 / 365	—
1		132	SC	3"	Ih	Cond	L	H.P. Heater #4-4 Ln. 131 SD	H.P. Heater #4-3	150 / 120	300 / 300	—
		133	SC	4"	Ih	Cond	L	H.P. Heater #4-3	Deaerator Heater #4-2	50 / 35	265 / 264	—
2		134	SA	2" 4"	No	Cond	L	L.P. Heater #4-1 & Gland Seal Stm Condenser	Condenser #4	50 / -6	186 / 135	—
2		135	SA	10"	No	Cond	L	Condenser #4 Hot well	Condensate Pump #4-1	50 / 1.5" Hg	100 / 91.7	—
2		136	SA	10"	No	Cond	L	Condenser #4 Hot well	Condensate Pump #4-2	50 / 1.5" Hg	100 / 91.7	—
1		137	SA	8"	No	Cond	L	Condensate Pumps #4-1,2	Steam Jet Air Ejector	150 / 80	100 / 92	—
1		138	SA	8"	No	Cond	L	Inter & After Cond.	Gland Seal Steam Condenser	150 / 65	100 / 93	—
1		139	SA	8"	No	Cond	L	Gland Seal Steam Condenser	L.P. Heater #4-1	150 / 55	100 / 97	—
2		140	SA	3"	No	Cond	L	Ln# 139 SA	Condenser #4-1	150 / 55	100 / 97	—
1		141	SA	8"	Ih	Cond	L	L.P. Heater #4-1	Deaerator Heater #4-2	150 / 45	200 / 186	—
1		142	SA	4" 8"	No	Cond	L	Ln# 138 SA	Surge Tank #4	150 / 60	100 / 92.8	—
1		143	SA	6" 4"	No	Cond	L	Surge Tank #4	Condenser #4	50 / Atm	100 / 90	—
1		144	SH	2"	Ih	Boiler Feed Water	L	Ln# 102 SH	Superheater [illegible] Boiler	2135 / 1827	254 / 254	—
1		145	SH	2"	Ih	H.P. Water	L	Boiler Feed Pumps 4-1,2,3	Thru TKC-4-V6 Vlv Desuperheater @ Boiler	900 / 600	259 / 254	—

Revisions: 1 — 4-24-67 [illegible]; 2 — 9-6-67 Douglas

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PIPE LINE LIST

JOB NO. 4249
SHEET NO. 4 REV. 3
DATE 10/26/66 BY CM

SS-P-210.04

REV	FLOW DIAG. NO.	LINE NO.	LINE CLASS	LINE SIZE	INSUL.	COMMODITY	VAP. / LIQ.	DESCRIPTION: ORIGIN (FROM)	DESCRIPTION: TERMINUS (TO)	DES. PSIG / OPER. PSIG	DES. °F / OPER. °F	REINF. PAD / POST HEAT TREAT
1	206	146	(F)	36"	No	Circulating Water	L	Cooling Tower #4	Circulating Water Pump #4-1	50 / 5	115 / 90	—
1		147	(F)	36"	No	Circulating Water	L	Cooling Tower #4	Circulating Water Pump #4-2	50 / 5	115 / 90	—
1	206 / 20[illegible]	148	(F)	36" / 51"	No	Circulating Water	L	Circulating Water Pumps #4-1,2	Condenser #4 @ Turbine	50 / 25	115 / 90	—
1		149	(F)	51"	No	Circulating Water	L	Condenser #4 @ Turbine	Line 349 WA @ Cooling tower #4	50 / 25	115 / 90	—
	206	150	WA	8"	No	Service Water	L	Cooling Tower #4	Service Water Pump #4-1	50 / 5	100 / 80	—
		151	WA	8'	No	Service Water	L	Cooling Tower #4	Service Water Pump #4-2	50 / 5	100 / 80	—
	206 / 202	152	WA	4" / 6"	No	Service Water	L	Service Water Pumps #4-1,2	Service Water Header	150 / 120	100 / 80	—
	202	153	WA	8" / 6"	No	Service Water	L	Service Water Pump #4-1	Ln# 149 (F) @ Cooling Tower #4	150 / 30	100 / 90	—
	206	154	WA	14"	No	Cooling Tower Make-up	L	Cooling Tower Make-up Pumps #4-1,2	Cooling Tower #4	50 / 10	100 / 80	—
1		155										—
3	202	156	WA	12" / 8"	No	Circulating Water	L	Twin Strainer	LN. 158 WA, 160 WA & Turbine Coolers	50 / 10	100 / 80	—
3		157	WA	8"	No	Circulating Water	L	Turbine Lube Oil Coolers	LN. 149 (F) & LN. 332 WA	50 / 30	130 / 110	—
3	202	158	WA	2" / 3"	No	Circulating Water	L	Ln# 156 WA	Exciter Air Cooler	50 / 30	100 / 80	—
3		159	WA	8" / 8" / 6"	No	Circulating Water	L	Exciter Air Cooler	LN# 163 & LN# 332	50 / 30	100 / 90	—
3		160	WA	8" / 4"	No	Circulating Water	L	Ln# 156 WA	Hydrogen Coolers	50 / 30	100 / 80	—

Rev. 1	Rev. 2	Rev. 3
11/4/66 CM	4-25-67 [illegible]	7-6-67 [illegible]

PRINTED IN U.S.A.

(F) Lines Furnished by Others

FORM [illegible] REV.

PIPE LINE LIST

JOB NO. 4247
SHEET NO. 5 REV. 3
DATE 10/26/66 BY DM

SPEC 210.05

REV.	FLOW DIAG. NO.	LINE NO.	CLASS	SIZE		COMMODITY	CODE	DESCRIPTION FROM	DESCRIPTION TO	DES. PSIG / OPER. PSIG	DES. °F / OPER. °F	REINF. PAD / POST HEAT TREAT
3	202 204	161	WA	1" 3"	No	Circulating Water	L	Hydrogen Coolers	Ln# 149 (?) & 333	50 / 25	100 / 95	—
3		162	WA	3/4" 2"	No	Circulating Water	L	Ln# 158 WA	Seal Oil Cooler & Seal Oil Unit Vacuum Pump	50 / 25	100 / 80	—
3		163	WA	3/4 1½" 2" 4"	No	Circulating Water	L	Seal Oil Cooler & Seal Oil Unit Vacuum Pump	Ln# 159 WA & 332 WA	50 / 25	100 / 90	—
3	202	164	WA	3/4" 1"	No	Service Water	L	Hdr# 152 WA	FD Fans	150 / 120	100 / 80	—
		165	WA	6"	No	Service Water	L	FD Fans	Service Water Return Pump	50 / 15	150 / 90	—
		166	WA	1½"	No	Service Water	L	Ln# 152 WA	Sample Coolers	150 / 120	100 / 80	—
3		167	WA	4"	No	Service Water	L	Sample Coolers	Ln# 169 WA	50 / 15	150 / 90	—
3		168	WA	3/4" 1½"	No	Service Water & Drain	L	Hdr# 152 WA	Boiler Feed Pumps #4-1,2,3 & LNS to drain 168	150 / 120	100 / 80	—
3		169	WA	4"	No	Service Water	L	Boiler Feed Pumps #4-1,2,3	Ln# 165 WA	50 / 15	150 / 90	—
		170	WA	3"	No	Service Water	L	Hdr# 152 WA	Evaporator #4	150 / 120	150 / 80	—
1		171										—
2	202 204	172	WA	1"	No	Service Water	L	Hdr# 152 WA	Plant & Air Compressor #4	150 / 120	100 / 80	—
3		173										
3	204	174	WA	1"	No	Service Water		Plant Air Aftercooler	Drain	150 / 120	180 / 160	—
3		175	WA	3/4" 1"	No	Service Water	L	Instrument Air Compr #4	Instr. Air Aftercooler	150 / 120	150 / 130	—

Revisions: 1 — 11/2/66 DM; 2 — 4-13-67 ymos; 3 — 7-6-67 Douglas

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FORM E-68C R1 V3

944

THE FLUOR CORPORATION, LTD.

PIPE LINE LIST

JOB NO. 4247
SHEET NO. 6 REV. 3
DATE 2/26/66 BY D.M.

210.06

REV.	FLOW DIAG. NO.	LINE NO.	CLASS	SIZE	INS.	COMMODITY	VAP. / LIQ.	DESCRIPTION ORIGIN FROM	TERMINUS TO	DES. PSIG / OPER. PSIG	DES. °F / OPER. °F	REINF. PAD / POST HEAT TREAT
1	202 204	176	WA	1"	No	Service Water	L	Instr Air Aftercooler	Drain	150 / 120	180 / 160	—
3	202	177	WA	3/4	No	Service Water	L	Hdr# 152 WA	Const Diff Oil Pump	150 / 120	100 / 80	—
		178	WA	1"	No	Service Water	L	Constant Diff Oil Pump	Ln# 169 WA	50 / 15	100 / 90	—
		179	NA	6" 4"	No	Service Water	L	Drainage Pump #4-1	Existing Drain to ditch	50 / 10	100 / 80	—
	202	180	WA	6"	No	Circulating Water	L	Ln# 147 (F) @ Cooling Tower #4-1	Ln# 179 WA @ Drainage Pump #4-1	50 / 10	100 / 80	—
3		181										
3		182										
1		183										—
1	206	184	⊛ PVC	½"	No	H_2SO_4	L	Acid Pump	Cooling Tower # 4-1 including Acid Tk drain	15 / 5	Amb / Amb	—
3		185	⊛ PVC		No	Chlorine	V	Chlorine Gas System	Chlorinator			—
1		186	WA	1"	No	Service Water	L	Ln# 152 WA	Line 356WA @ Safety Shower	150 / 120	100 / 80	—
1		187	⊛ PVC	1"	No	Chlorinated Water	L	Chlorinator	Line # 148 SI	150 / 120	100 / 80	—
3		188	WA	1"	No	Circulating Water	L	Ln# 148 (F)	Cooling Tower Basin	50 / 5	100 / 80	—
1		189										—
3	204	190	AA	6"	No	Instr. Air	V	Atmos	Instr. Air Comp	Atmos / Atmos	Amb / Amb	—

Revisions: 1 — 11/8/66 DM; 2 — 4-28-67 ...; 3 — 7-6-67 Douglas

PRINTED IN U.S.A. FORM E-640 REV.

PIPE LINE LIST

JOB NO. 4349
SHEET NO. 7 REV. 2
DATE [illegible] DM

210.07

Rev.	Flow Diag. No.	Line No.	Class	Size	Ins.	Commodity		DESCRIPTION Origin From	Terminus To	Des. PSIG / Oper. PSIG	Des. °F / Oper. °F	Reinf. Pad / Post Heat Treat
△	203	191	FC	8"	No	Fuel Gas	V	Existing 12" Header	Thru PIC-413 V to Ln# 192 FA	150 / 68	100 / 80	—
△		192	FA	10" 12"	No	Fuel Gas	V	Ln# 191 FC	Unit No 4 Burners	50 / 40/15	100 / 80	—
△		193	FA	1"	No	Fuel Gas	V	Ln# 192 FA	Unit No 4 Pilots	50 / 40/5	100 / 80	—
△		194	FA	6	Ih ST	Fuel Oil	L	Existing Ln. from Existing Tank	Fuel Oil Storage Tank #4-1	150 / 50	150 / 110	—
△		195	FA	8"	Ih ST	Fuel Oil	L	Fuel Oil Storage Tank #4	Fuel Oil Trans. Pump #4-1	50 / 5	150 / 110	—
△1		196	FA	8"	Ih ST	Fuel Oil	L	Fuel Oil Trans. Pump #4-1	Ln.# 197 FA & Fuel Oil Working Tank #4	150 / 50	150 / 110	—
△		197	FA	6" 2" 3/4"	Ih ST	Fuel Oil	L	Fuel Oil Working Tank #4 & Ln# 196 FA	F.O. Circ Pump #4-1 & H.P. F.O. Pumps #4-1&2	50 / 5	150 / 125	—
△2		198	FE	4" 2"	Ih	Fuel Oil	L	F.O. Circ. Pump #4-1 & H.P. F.O. Pumps #1 & 2	Fuel Oil Heater #4	1000 / 675	150 / 125	—
△		199	FE	3"	Ih	Fuel Oil	L	Fuel Oil Heater #4	Diff Oil Pump #4	1000 / 675	300 / 250	—
△		200	FE	1" 3"	Ih	Fuel Oil	L	Diff. Oil Pump #4	Burners	1000 / 675	300 / 250	—
△1		201	FC	1" 2" 4"	Ih	Fuel Oil	L	Line # 199 FE & Line 300 FE	Fuel Oil Working Tank #4	150 / 50	300 / 250	—
△	203	202	AA	1"	No	Air	V	Hdr #	Unit No. 4 Pilots	125 / 100	Amb / Amb	—
△2	203	203	SC	1"	Ih	Steam	V	Hdr # 347 SD	Ln. # 200 & 201 @ Unit 4 Burners	150 / 100	365 / 338	—
△2		204	SC	3"	No	Smothering Steam	V	Ln. # 124 SC	Fuel Oil Storage Tank 4	150 / 100	365 / 338	—
△1		205	FA	6"	No	Oily Water	L	Fuel Oil Storage Tank No. 4	Water Drain	50 / 5	150 / 110	—

△1 4-14-67 MBS | △2 1-6-65 Douglas | △ | △ | △ | △ | △ | △

PRINTED IN U.S.A. FORM E-440 REV.

PIPE LINE LIST

S.P. 210.08

4241
SHEET 2
10/31/66 DN

REV	FLOW DIA NO.	NO.	[illegible]	SIZE	[illegible]	COMMODITY	VAP / LIQ	DESCRIPTION FROM	DESCRIPTION TO	PRESS	TEMP	REINF PAD
2	200 201	206	SA	2"	Ih	Cond	L	Steam-Air Heaters	Ln#142 SA	25 15	261 250	—
1	200	207	SA	3/4" 2"	Ib	Cond	L	Lines 128x 359sc & 360sc	Cond Tank #4	Atm Atm	200 190	—
1	200 201	208	SA	3"	Ih	Cond	L	Cond Tank #4	Ln#142SA @ Surge Tank #4	Atm Atm	200 190	—
2	200	209	SA	2" 4"	Ib	Cond	V L	Cond Tank #4	Tank Trim	Atm Atm	200 190	—
2		210	SA	3/4" 3"	No	Cond	L	After Condenser	Drain	Atm Atm	150 100	—
		211	SA	6" 10"	No	Vent	V	Hogging Jet Ejector #4	Atmos	Atm Atm	150 100	—
		212	SD	3/4" 6" 8"	No	Stm & Cond	V L	PSV 1 @ Boiler #4	Atmos & Drain	Atm Atm	150 100	—
	200	213	AA	1" 3/4"	No	Service Air	V	Hdr #	Evaporator #4-1	125 100	Amb Amb	—
1	200 201	214	SA	3" 2" 1½"	Ih	Steam & Water	V L	Deaerator Heater #4-2	Heater Trim	150 25	250 249	—
1		215	SA	3/4"	No	Cond	V L	Gland Seal Steam Condenser	Trim	150 55	100 97	—
2		216	SA	3" 1½" 1" 3/4"	Ih	Steam & Cond	V L	L.P. Heater #4-1	Heater Trim	150 55	186 185	—
		217	SA	3" 2" 1½" 3/4"	Ih	Steam & Cond	V L	H.P. Heater #4-3	Heater Trim	50 35	265 264	—
		218	SC	3" 1½" 1"	Ih	Steam & Cond	V L	H.P. Heater #4-4	Heater Trim	150 120	300 300	—
		219	SD	3" 1½" 1"	Ih	Steam & Cond	V L	H.P. Heater #4-5	Heater Trim	375 350	365 365	—
2	200 201 202	220	SA	4" 2" 1½"	No	Steam & Cond	V L	Condenser #4	Condenser Trim	50 1.5" Hg	100 91.7	—

1 [illegible] 2 7-6-67 Design

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FORM E-[illegible] REV.

THE FLUOR CORPORATION, LTD

PIPE LINE LIST

JOB NO. 4249
SHEET NO. 9 REV. 2
DATE 10/31/66 BY DM

GS-P 210.09

REV	FLOW DIAG. NO.	LINE NO.	CLASS	SIZE	INSUL	COMMODITY	VAP / LIQ	DESCRIPTION ORIGIN (FROM)	TERMINUS (TO)	DES. PSIG / OPER. PSIG	DES. °F / OPER. °F	REINF. PAD / POST HEAT TREAT
2	201	221	SH	¾" 1"	Ih	Blowdown	L	60" ID Steam Drum @ Boiler	Evaporator	1700 / 1600	608 / 604	—
1		222	[illegible]			[illegible]						—
1	201	223	BD	2"	Is	Blowdown	L	Blowdown Valve in Ln. #221SH	Blowdown Flash Tank No 4	50 / Atm	608 / 604	—
1	200	224	AA	[illegible]	No	EXH.	L	Gland Stm. Cond. Blower	To Atmos	[illegible] / Atms	50 / 100	—
1		225										—
1		226										
1		227	[illegible]									
1		228										
1		229										—
1		230										—
1	201	231	BD	2"	Is	Boiler Blowdown & Drains	V / L	Blowdown valves on various Lines	Blowdown Flash Tank No 4	50 / Atm	200 / 190	—
1		232	SA	[illegible]	Is	Cond & Steam	V / L	Blowdown Flash Tank No 4	Drainage & Vent to Atmos	Atm / Atm	200 / 150	—
1	200 201	233	BD	1"	Ih	Hot Reheat Stm. Start-up Drain	L	Ln# 108 SFA @ I.P. Turbine	Ln# 247 SA @ Surface Condenser #4	315 / [illegible]	425 / 400	—
1	201	234	SA	1"	Ih	Cond	L	Soot Blower Discharge Traps	Surge Tank No 4	Atm / Atm	200 / 150	—
1		235	WA	2"	Ho	Treated Water	L	Hdr # in Unit #1	Evaporator #4	75 / 50	100 / 80	—

Revisions: 1 — 4-26-67 [illegible]; 2 — 7-6-67 Douglas

PRINTED IN U.S.A.   FORM E-660 REV.

THE FLUOR CORPORATION, LTD.

PIPE LINE LIST

JOB NO. 4249
SHEET NO. 10 REV. 3
DATE 10/21/66 BY DM

SSF-210.10

REV	FLOW DIAG. NO.	LINE NO.	CLASS	SIZE	INSUL	COMMODITY	VAP. / LIQ.	DESCRIPTION — ORIGIN FROM	DESCRIPTION — TERMINUS TO	DES. PSIG / OPER. PSIG	DES. °F / OPER. °F	REINF. PAD / POST HEAT TREAT
1	201	236	SC	1½	Is	B.D. Water	L	Evaporator #4	Blowdown Flash Tank No. 4	50 / 15	297 / 250	—
3	200 / 201	237	SC	6" 3" 1½" 1"	Ih / Is	Steam & Cond	V / L	Evaporator #4	Evaporator Trim	50 / 15	297 / 250	—
1	201	238	SA	6"	Ih	B.F. Water	L	Deaerator Heater #4-2 Thru HIC 478V	Ln# 142 SA	25 / 10	267 / 240	—
1		239	SA	2"	Ih	B.F. Water	L	FO-4 on Ln# 102 SH	Deaerator Heater #4-2	50 / 15	254 / 254	—
1		240	SA	2"	Ih	B.F. Water	L	FO-5 on Ln# 102 SH	Deaerator Heater #4-2	50 / 15	254 / 254	—
1		241	SA	2"	Ih	B.F. Water	L	FO-6 on Ln# 102 SH	Deaerator Heater #4-2	50 / 15	254 / 254	—
1		242	SA	1½"	Ih	Cond	L	Inter & After Condensers @ Stm Jet Air Ejector	Condenser Trim	150 / 65	100 / 98	—
1		243	SA	2" thru 10"	Ih	Cond	V / L	Surge Tank No. 4	Tank Trim	50 / Atm	100 / 90	
1	201 / 204	244	SA	2" / 1½"	No	Cond	L	Ln# 142 SA	Gland Steam Desuperheater @ Turbine	150 / 60	100 / 92.8	—
3		245										
3		246										
3	201	247	SD	6"	Ih	Stm & Cond.	V / L	H.P. Bridle on Surface Condenser #4		150 / 100	800 / 700	
3		248	SA	6"	Ih	Stm & Cond.	V / L	L.P. Bridle on Surface Condenser #4		50 / 25	100 / 100	
1	200 / 201	249	SD	1"	Ih	Steam	V	Ln# 109 SD Upstream of RCV-5	Ln# 247 SD @ Condenser #4	375 / 350/Vac	679 / 600	5"
1		250	SD	1"	Ih	Steam	V	Ln# 109 SD Downstream of RCV-5	Ln# 247 SD @ Condenser #4	375 / 350/Vac	679 / 600	—

Rev. 1	Rev. 2	Rev. 3						
11/8/66 DM	#232 [illegible]	9-6-61 Douglas						

PRINTED IN U.S.A.

FORM E-540 REV.

THE FLUOR CORPORATION LTD.

PIPE LINE LIST

JOB NO. [illegible]
SHEET NO. 11 REV. 2
DATE [illegible] BY [illegible]

85-F-210.11

REV.	FLOW DIAG. NO.	LINE NO.	CLASS	SIZE		COMMODITY	VAP. / LIQ.	ORIGIN (FROM)	TERMINUS (TO)	DES. PSIG / OPER. PSIG	DES. °F / OPER. °F	REINF. PAD / POST HEAT TREAT.
2	201 203	251	SA	3/4 2" 1"	No	Cond	L	Ln. # 244 SA	Chemical Solution Tanks: Sulphite Dissolver # 4-2	150 / 60	100 / 92.8	—
1	203	252	CCD	1"	No	Sulfite Solution	L	Sulphite Solution Tank No. 4-1	Sulphite dissolver # 4-1	Atm / Atm	100 / 92.8	—
1		253	CCD	1"	No	Sulfite Solution	L	Sulphite Solution Tank # 4-1	Sulphite Pump 4-1	Atm / Atm	100 / 92.8	—
1		254	CCD	1"	No	Organic Solution	L	Organic Solution Tank # 4-3	Organic Pump # 4-3	Atm / Atm	100 / 92.8	—
1		255	CCD	1"	No	Amine Solution	L	Amine Solution Tank # 4-1	Amine Pump 4-1	Atm / Atm	100 / 92.8	—
1		256	CP	3/4" 1"	No	Phosphate Solution	L	Phosphate Solution Tank # 4-3	Phosphate Pump # 4-2	Atm / Atm	100 / 92.8	--
1		257	CCD	1"	No	Caustic Solution	L	Caustic Solution Tank # 4-2	Caustic Pump # 4-2	Atm / Atm	100 / 92.8	—
2		258	CH	3/4" 1"	No	Chemical Solution	L	Sulphite, Organic, & Amine Pumps # 4-1 & 4-3	Ln. # 102 SH	3000 / 2400	100 / 92.8	—
1		259	CJP	1/2" 3/4	No	Phosphate Solution	L	Phosphate Pump # 4-2	60" ID Steam Drum @ Boiler # 4	2500 / 1300	100 / 92.8	—
1	203 201	260	CCD	3/4"	No	Caustic Solution	L	Caustic Pump # 4-2	Evaporator No. 4	150 / 50	100 / 92.8	—
2	203	261	CCD	2" 1½"	No	Sulfite Solution	L	Sulphite Dissolver # 4-2	Tank Trim	Atm / Atm	100 / 92.8	—
2		262	CCD	1½" 3/4"	No	Sulfite Solution	L	Sulphite Solution Tank # 4-1	Tank Trim	Atm / Atm	100 / 92.8	—
2		263	CCD	1½" 3/4"	No	Organic Solution	L	Organic Solution Tank # 4-3	Tank Trim	Atm / Atm	100 / 92.8	—
2		264	CCD	1½" 3/4"	No	Amine Solution	L	Amine Solution Tank # 4-1	Tank Trim	Atm / Atm	100 / 92.8	—
2		265	CP	1½" 3/4"	No	Phosphate Solution	L	Phosphate Solution Tank # 4-3	Tank Trim	Atm / Atm	100 / 92.8	—

Revisions: 1 — 4-3-67 [illegible]; 2 — 9-6-67 Douglas

PRINTED IN U.S.A. FORM E-640 REV.

THE FLUOR CORPORATION, LTD.

PIPE LINE LIST

JOB NO. 4:49
SHEET NO. 12 REV. 2
DATE 12/21/66 BY [illegible]

65-P-210.12

REV	FLOW DIAG. NO.	LINE NO.	LINE CLASS	LINE SIZE	INSUL.	COMMODITY	VAP. / LIQ.	DESCRIPTION ORIGIN FROM	DESCRIPTION TERMINUS TO	DES. PSIG / OPER. PSIG	DES. °F / OPER. °F	REINF. PAD / POST HEAT TREAT
2	202	266	CCD	1½ / ¾"	No	Caustic Solution	L	Caustic Solution Tank # 4-2	Tank Trim	Atm / Atm	[illegible] / 93 E	—
1		267										—
	203 / 200	268	FA	6	No	Fuel Oil	L	Fuel Oil Work Tank No. 4	Tank Trim	50 / 5	150 / 135	—
1	200 / 201	269	SD	1"	Ih	Steam	V	Ln# 110 SD Upstream of RCV-4	Ln# 247 SD @ Condenser #4	150 / 180	800 / 790	—
1		270	SD	1"	Ih	Steam	V	Ln# 110 SD Downstream of RCV-4	Ln# 247 SD @ Condenser #4	150 / 180	800 / 790	—
1		271	SA	1"	Ih	Steam	V	Ln# 111 SC Upstream of RCV-3	Ln# 248 SA @ Condenser #4	50 / -6	268 / 268	—
1		272	SA	1"	Ih	Steam	V	Ln# 111 SC Downstream of RCV-3	Ln# 248 SA @ Condenser #4	50 / -6	268 / 268	—
		273	SA	1"	Ih	Steam	V	Ln# 112 SC Upstream of RCV-2A	Ln# 248 SA @ Condenser #4	50 / 15	450 / 448	—
1		274	SA	1"	Ih	Steam	V	Ln# 112 SC Downstream of RCV-2B	Ln# 248 SA @ Condenser #4	50 / 15	450 / 443	—
2	201	275	SA	1"	NO	Steam	V	Condensate Pump # 4-1	Condenser #4	50 / 1.5" Hg	100 / 91.7	—
2		276	SA	1"	NO	Steam	V	Condensate Pump #4-2	Condenser #4	50 / 1.5" Hg	100 / 91.7	—
1		277	SA	4"	No	Cond.	L	Ln# 145 SA @ Surge tank # 4	Ln# 101 SA @ BFP # 4-1 & Ln# 169 WA	90/150 / Atm/25	100/250 / 90/250	—
		278	SC	2"	Ih	Cond	L	Evaporator #4	Thru LC-7V to Ln# 279 SA	50 / 15	250 / 210	—
		279	SA	2"	Ih	Cond	L	Ln# 278 SC	Deaerator Heater # 4-2	50 / 15	250 / 210	—
2	200 / 201	280	BD	2"	No	Main Stm Start-up Drain	V / L	Ln# 106 SJA @ H.P. Turbine	Ln # 223 BD. @ Blowdown Flash Tank No. 4	1800 / 150	608 / 604	—

Revisions: 1 — 1-25-67 [illegible]; 2 — 9-6-67 Douglas

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FORM E-640 REV.

FLUOR CORPORATION

PIPE LINE LIST

JOB NO. 4247
SHEET NO. 13 REV. 3
DATE 10/31/… BY D/A

65-P-210.13

REV.	FLOW DIAG. NO.	LINE NO.	CLASS	SIZE	INSUL.	COMMODITY	VAP. / LIQ.	DESCRIPTION ORIGIN FROM	DESCRIPTION TERMINUS TO	DES. PSIG / OPER. PSIG	DES. °F / OPER. °F	REINF. PAD / POST HEAT TREAT
1	200 / 201	281	SA	2"	Ih	Steam & Cond	V / L	H.P. Heater #4-3, 4, 5	Ln# 248 SA & Deaerator Heater #4-2	50 / -6	263 / 263	—
1		282	SA	2"	Ih	Steam & Cond	V / L	L.P. Heater #4-1	Ln# 248 SA @ Condenser #4	50 / -6	263 / 263	—
1		283										—
3	204 / 201	284	BD	2"	Ih	Stm & Cond		Throttle drain on Westinghouse dwg # 718-J141	Ln# 247 SD @ Condenser #4	50 / 50/Vac	600 / 600	—
3		285	BD	1½"	Ih	Stm & Cond		Impulse Chamber drain on Westinghouse dwg # 718-J141	Ln# 247 SD @ Condenser #4	50 / 50/Vac	600 / 600	—
2		286	BD	1½"	Ih	Stm & Cond.		Dr. from Outer Cyc on Westinghouse dwg # 683-J159	Ln# 247 SD @ Condenser #4	50 / 50/Vac	600 / 600	—
2		287	BD	1½"	Ih	Stm. & Cond		Dr. from Outer Cyc on Westinghouse dwg # 683-J159	Ln# 247 SD @ Condenser #4	50 / 50/Vac	600 / 600	—
2		288	BD	1½"	Ih	Stm. & Cond.		Dr from Outer Cyc on Westinghouse dwg # 683-J159	Ln# 247 SD @ Condenser #4	50 / 50/Vac	600 / 600	—
3		289	BD	1½"	Ih	Stm. & Cond.		Inter. Valve Drain on Westinghouse dwg # 718-J141	Ln# 247 SD @ Condenser #4	50 / 50/Vac	600 / 600	—
3		290	BD	1½"	Ih	Stm. & Cond.		Reheat Stop Valve Dr on Westinghouse dwg # 718-J141	Ln# 247 SD @ Condenser #4	50 / 50/Vac	600 / 600	—
1		291										—
2		292										
2	204	293	AA	2" / 1½"	No	Air	V	Plant Air Aftercooler	Plant Air Filter & Plant Air Rec.	150 / 100	AMB / AMB	—
2		294	AA	2" / 1½"	No	Air	V	Plant Air Filter	Line 294 AA	150 / 100	AMB / AMB	—
2		295	AA	2" / 1½" / ¾"	No	Plant Air	V	Plant Air Receiver	Header thru Unit # 4	150 / 100	AMB / AMB	—

Rev. 1	Rev. 2	Rev. 3						
11/8/66 DIA	4-7-67 …	7-6-67 Douglas						

APPROVED THE FLUOR CORPORATION, LTD.

PIPE LINE LIST

JOB NO. 4241
SHEET NO. 14 REV. 2
DATE 11/C... BY DW

45-F-210.14

REV.	FLOW DIAG. NO.	LINE NO.	CLASS	SIZE	INSUL.	COMMODITY	VAP. / LIQ.	DESCRIPTION — ORIGIN (FROM)	DESCRIPTION — TERMINUS (TO)	DES. PSIG / OPER. PSIG	DES. °F / OPER. °F	REINF. PAD / POST HEAT TREAT
1	204	296	AA	3/4"	No	Air & Water	V / L	Plant Air Aftercooler	Exchanger Trim (Incl Drain)	150 / 100	AMB / AMB	—
1		297	AA	1" 1/2"	No	Air & Water	V / L	Plant Air Receiver	Vessel Trim (Incl Drain)	150 / 100	AMB / AMB	—
1		298	AA	1/2"	No	Control Air	V	Instr Air Receiver	Instr Air Compressor	150 / 100	AMB / AMB	—
2		299	AA	4"	Is	Air	V	Instr Air Compressor No. 4	Instr Air Aftercooler No. 4	150 / 100	250 / 200	—
1		300	AA	2" 1 1/2"	No	Air	V	Instr Air Aftercooler No 4	Instr Air Filter	150 / 100	AMB / AMB	—
1		301	AA	2" 1 1/2"	No	Air	V	Instr Air Filter	Instr Air Receiver No. 4	150 / 100	AMB / AMB	—
1		302	AA	2"	No	Air	V	Instr Air Receiver No 4	LN. 306AA.	150 / 100	AMB / AMB	—
1		303	AA	2"	No	Instr Air	V	Instr. Air Dryer No. 4	Header thru Unit #4	150 / 100	AMB / AMB	—
2		304	AA	1/2" 3/4"	Is	Air	V / L	Instr Air Aftercooler No 4	Exchanger Trim (Incl Trim)	150 / 100	250 / 200	—
1		305	AA	3/4" 1/2" 1"	No	Air	V / L	Instr Air Receiver No 4	Vessel Trim (Incl Trim)	150 / 100	AMB / AMB	—
1		306	AA	2"	No	Plant Air,	V	To & From Unit #3	Ln# 295AA & Ln# 302AA @ Air Compressors	150 / 100	AMB / AMB	—
2		307				—						
1	204	308	LC	2" 3"	No	Turbine Lube Oil	L	L.O. Storage tank No. 4	L.O. Transfer Pump No. 4	50 / Atm	130 / AMB	—
1		309	LC	3"	No	Turbine Lube Oil	L	L.O. Trans. Pump No. 4	Storage tank No. 4 & Ln# 310LC @ Oil Conditioner	50 / 35	130 / 120	—
1		310	LC	2"	No	Turbine Oil Make-up	L	Oil Conditioner & Ln# 309LC @ L.O. Trans. Pump	Turbine Oil Reservoir No. 4	150 / 75	130 / 120	—

Revisions: 1 — 4-25-67 ... ; 2 — 7-6-67 Davelas

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FORM E-640 REV. ...

APPROVED

THE FLUOR CORPORATION, LTD

PIPE LINE LIST

JOB NO. 4241
SHEET NO. 15 REV. 2
DATE [illegible] BY DM

[illegible]- 210. 15

REV.	FLOW DIAG. NO.	LINE NO.	LINE CLASS	LINE SIZE		SERVICE	VAP. / LIQ.	DESCRIPTION ORIGIN / FROM	DESCRIPTION TERMINUS / TO	DES. PSIG / OPER. PSIG	DES. °F / OPER. °F	REINF. PAD / POST HEAT TREAT
1	204	311	LC	3/4" 3"	No	Turbine Oil	L	Drains on Turbine Oil Reservoir & Coolers	In #[illegible] L.O. Trans Pump No 4	50 / Atm	130 / 120	—
2		312	LC	2" 3/4	No	Turbine Oil	L	Over flow on Turbine Oil Reservoir No 4	Lube Oil Pump & Oil Conditioner No 4	50 / Atm	130 / 120	—
1		313	LC	3" 2	No	Turbine Oil	L	Storage tank & Oil Conditioner	Drain	50 / Atm	130 / AMB	—
1		314	LC	2"	No	Turbine Lube Oil	V / L	L O Storage Tank No 4	Tank Trim	50 / Atm	130 / AMB	—
1		315	LC	3/4"	No	Turbine Lube Oil	L	Oil Conditioner No 4	Drain	50 / Atm	130 / 120	—
1	204 202	316	LC	3/4" 1"	No	Turbine Oil & Water	V / L	Turbine Oil Coolers (2)	Exchanger Trim	50 / 30	130 / 120	—
2	204	317	LC	1/2" 3/4"	No	Turbine Oil	V / L	Turbine Oil Reservoir No 4	Trim (Incl Drain)	50 / Atm	130 / 120	—
1		318	LC	3"	No	Turbine Oil	V / L	Turbine Oil Reservoir & Exhauster	Vent & Drain	50 / Atm	130 / 120	—
1		319	LC	3/4" 1 1/2" 2"	No	Seal Oil	V / L	Separator in Seal Oil Unit No 4	Vent & Drain	50 / Atm	130 / 120	—
1		320										—
1	204	321	LC	1"	No	Seal Oil	L	Seal Oil Unit No 4	(2) Lines to Drain	50 / Atm	130 / 120	—
1		322	LC	4" 2 1/2"	No	Gland Oil	V / L	Gland Oil Loop Seal Tank	H_2 Oil Vapor Extractor No 4	50 / Atm	130 / 120	—
1		323	LC	4" 2 1/2	No	Gland Oil	V / L	H_2 Oil Vapor Extractor No 4	Vent to Atmos & Loop Seal Drain	50 / Atm	130 / 120	—
1		324	AA	1/2" 3/4" 3/4	No	Air & Water	V / L	Various Conns on Hydrogen Coolers & Gen 4	Vents & Drains to Drain Pan	50 / Atm	120 / 110	—
1		325	AA	1 1/2"	No	Air	V	Furnished Line @ Generator No 4	CO_2 Bottle CO_2 Gas & Manifold			—

REV. 1	REV. 2						
1: 4-25-[illegible] [illegible]	2: 7-6-67 Douglas						

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FORM E-440 REV. [illegible]

301

APP

PIPE LINE LIST

No. 4241
Sheet No. 16 Rev. 2
Date 1/13/ By DM

GSF 210.16

Rev	DWG No.	Line No.	Class	Size		Commodity	Vap./Liq.	Description Origin From	Terminus To	Des. PSIG / Oper. PSIG	Des. °F / Oper. °F	Paint / Post Insul.
△	204	326	AA	1½	No	Air	V	Furnishing Line C. Generator No 4	Vent to Outside of Building	50 / Atm	120 / AMB	—
△		327	AA	½"	No	Air	V	Furnishing Line @ Generator	H_2 Bottles Manifold			—
△		328	AA	½" ⅜"	No	Air	V	Generator No 4 Exciter	Vent to Atmos	50 / 30	120 / AMB	—
△		329	AA	1½	N	H_2 & CO_2	V	CO_2, H_2 & H_2 Regu. Generator No. 4	H_2 Vent to Atmos	50 / Atm	120 / AMB	—
△2		330	SC	1"	No	wtr & oil		2 Conns on L.P. Turbine & Condenser	Waste	50 / Atm	120 / AMB	—
△	204 / 201	331	SC	1"	No	Cond	L	H.P Turbine	Cond Awy	50 / Atm	170 / 93	—
△	202	332	WA	4" 6"	No	Water	L	LN 157 WA 8" @ Turbine L.O. Coolers No. 4	Sump Pit	50 / 10	130 / 110	—
△		333	WA	4"	No	Water	L	LN 161 WA 8" @ H_2 Coolers No 4	Sump Pit	50 / 10	100 / 95	—
△1	200	334	AA	¾"	No	Drain	L	Gland Stm. Cond Blower	ATMOS	Atms / Atms	150 / 100	
△2	201	335	SA	1½"	Is	B.F. Water	L	Line 118 SD	Deaerator Heater No. 4-2	25 / 25	254 / 250	—
△	206	336	CCE	1"	No	Sulfuric Acid	L	Acid Delivery Tank No 4	Acid Pump No. 4	50 / Atm	120 / AMB	
△		337	CCE	2"	No	Sulfuric Acid	L	Acid Delivery Tank No 4	Gravel Filled Lime Pit	50 / Atm	120 / AMB	
△		338	CCE	½"	No	Sulfuric Acid	L	Acid Delivery Tank No 4	Oil Trap	50 / Atm	130 / AMB	
△		339	CCE	½"	No	Sulfuric Acid	L	Oil Trap @ Acid Delivery Tank No 4	Over Flow Tank	50 / Atm	130 / AMB	
△		340	CCE	½"	No	Sulfuric Acid	L	Over Flow Tank @ Acid Delivery Tk No 4	Desiccant Tank	50 / Atm	130 / AMB	

△1 | △2 Douglas | △ | △ | △ | △ | △ | △

FORM F-840

APP...

THE FLUOR CORPORATION, LTD

PIPE LINE LIST

JOB NO. 4249

SHEET NO. 7 REV. 1

DATE 4-25-67 BY ...

65-P-210.17

REV	FLOW DIAG. NO.	LINE NO.	CLASS	SIZE	INSUL.	COMMODITY	VAP. LIQ.	DESCRIPTION ORIGIN FROM	TERMINUS TO	DES. PSIG / OPER. PSIG	DES. °F / OPER. °F	REINF. PAD / POST HEAT TREAT
△	206	341	CCE	2"	No	Sulfuric Acid	L	Truck Loading Union	Acid Delivery Tank No. 4	150 / 15	130 / AMB	
△		342										
△	206	343	WA	30"	No	Circulating Water	L	Line 149(F)	Cooling Tower No 4	50 / 25	115 / 90	
△	200	344	SA	½"	No	Cond.	L	From Soot Blower Manifold	Drain.	150 / Atm	200 / 150	
△	200	345	SA	¾"	No	Cond	L	From Soot Blower Manifold	Drain	150 / ATM.	200 / 150	
△	201 202	346	SA	¾" 1"	No	Cond	L	Line 138SA	Heliflow Coolers @ Boiler Feed Water Pumps 4-1,7,15	150 / 65	100 / 93	—
△	200	347	SD	4"	Ih	Sat. Stm Hdr.	V	114 SH 3" Ih @ PCV-1	115 SC 6" Ih @ PCV-8	350 / 275	435 / 415	
△	206	348	WA	2"	No	Service Water	L	LN. 152 WA	Chlorine Injector in LN 187@ @ Cooling Tow. No. 4	150 / 100	100 / 90	
△	200	349	SC	8" ¾"	No	Stm.	V	Line 237 SC & PSV 10 @ Evaporator No. 4	Atmos	Atm. / Atm.	Amb / AMB	
△	200	350	SA	10 8" ¾"	No	Stm & Wtr.	V L	PSV-13(F) @ Deaerator Htr. No. 4	Atmos	Atm. / Atm.	AMB / AMB	
△	200	351	SA	8" ¾" 6"	No	Stm	V	PSV-6 on LN. 115 SC	Atmos	Atm / Atm	AMB / AMB	
△	206	352	AA	¾"	No	Air	V	Exist Air Line @ Cooling Tower #3	Acid Delivery Tank No 4 & Cooling Tower No 4	125 / 30	AMB / AMB	
△	200	353	SD	10" 8" ¾"	No	Stm	V	PSV-5 & PSV-7 on LN. 107SD	Atmos	Atm. / Atm.	AMB / AMB	
△	206	354	WA	3"	No	Wtr	L	Cooling Tower No. 4	LI 442T	Atm / Atm	AMB / AMB	
△	200	355	SC	4" 3" ¾"	No	Stm.	V	PSV-455 on LN 106SJA	Atmos & Drain	Atm. / Atm.	AMB / AMB	

△1 7-6-67 Douglas

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FORM E-640 REV. ... REV.