Attachment 4

LTS PROGRAM
CONFIRMATORY ANALYSIS
OF SONGS 1
PIPING AND PIPE SUPPORTS

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ABSTRACT

A series of confirmatory piping and pipe support analyses have been performed to ensure that the criteria and methodology employed by Southern California Edison Company (the licensee) in seismically upgrading the San Onofre Nuclear Generating Station, Unit 1 (SONGS 1), are acceptable. Four piping systems--SI-51, SI-04, SI-158, and a run of SI-51 tubing--were subjected to confirmatory finite element analysis. These analyses were performed to the requirements of the USNRC Systematic Evaluation Program (SEP) guidelines and current industry practice. In addition, the run of tubing was subjected to a confirmatory hand calculation. Supports for the SI-51 and SI-04 systems, a total of 50 supports, were also analyzed. Results of the confirmatory finite element analyses were compared with those of the licensee. Results were compared for the tubing between the finite element analysis and the hand calculation. The conclusion was drawn that the criteria and methodology employed by the licensee in analyzing the piping and pipe supports of SONGS 1 meet the requirements and are acceptable.

ACKNOWLEDGMENTS

This report is a product of the efforts of several people. S. L. Morton wrote the first draft of the report and did much of the piping analysis. Much of the pipe support analysis was done by V. B. Call and C. Edgar. B. J. Quintana provided invaluable technical assistance.

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LTS PROGRAM

CONFIRMATORY ANALYSIS

OF SONGS 1

PIPING AND PIPE SUPPORTS

1. INTRODUCTION

A confirmatory analysis of the piping and supports at the San Onofre Nuclear Generating Station Unit 1 (SONGS 1) was requested by the Nuclear Regulatory Commission (NRC). This analysis was performed in an effort to verify a portion of the SONGS 1 Long Term Service Seismic Reevaluation Program,[a] (Reference 1) specifically, the analysis techniques utilized by the SONGS 1 piping and support analysts for the LTS Program. Three Safety Injection System (SIS) piping models and one SIS tubing model were selected to represent the wide variety of pipe sizes incorporated in the plant. The four pipe sections chosen for detailed examination were SI-51, SI-04, SI-158, and SI-51 (tubing). Emphasis was placed on modeling techniques, accuracy, loading conditions, and pipe and support stresses. This report summarizes the confirmatory analyses performed on the four models and associated supports. It also provides a comparison of results for the analyses done by EG&G and by the licensee, Southern California Edison Co.

a. Hereafter referred to as the LTS Program.

2. PIPING SYSTEM DESCRIPTION

Information pertaining to the details of these piping systems was provided by the licensee. Much of it was verified by independent line walkdowns by the author. The information provided contained the latest as-built pipe dimensions, pipe specifications, valve weights, response spectra, seismic and thermal anchor movements, detailed pipe support drawings, and other miscellaneous data required to perform the independent piping analyses.

SIS problem SI-51 includes the piping between feedwater pumps FWS-G-3A and FWS-G-3B and the six-inch branch piping from this line to the containment sphere. Figures 1 through 6 are computer model plots defining problem SI-51. The non-safety related piping included in this analysis, shown in these computer plots, was provided to include its effects on the safety related piping. SIS problem SI-04 includes the piping between pump SIS-G-50A and feedwater pump FWS-G-3A. Computer model plots, Figures 7 through 9, describe the problem in more detail. SIS problem SI-158, seen in Figures 10 through 13, is a small model which includes six-inch piping from the containment sphere penetration B-1B to the cold leg of reactor coolant loop C. Finally, tubing problem SI-51 is defined in Figures 14 and 15. The tubing runs from flow transmitter SIS-FT-912 to valve 870E-3/4"-T57 (on the SI-51 piping).

Tables 1 through 4 list the significant pipe data and material specifications utilized in the analyses described in this summary. Design and service conditions are also included in these tables.

Various service levels were analyzed. This included deadweight, pressure, thermal expansion, thermal anchor movements, and the inertial and anchor motions due to the 0.67 g modified Housner response spectra earthquake. These analyses were performed utilizing the ASME Code Class 2 rules (Reference 2) as specified by the SEP Guidelines (Reference 3) and compared to the stresses calculated by the licensee.

3. PIPING SYSTEM SEISMIC ANALYSES

All four finite element analyses were performed using the program NUPIPE-II, a proprietary program developed by Quadrex Corporation. NUPIPE-II capabilities are briefly described in Appendix A. Idaho National Engineering Laboratory (INEL) program module V4AGINL was utilized for these analyses.

The piping system data, drawings, and response spectra necessary for these analyses were provided by the licensee. The following assumptions based on experience and engineering judgment were employed where information was missing or incomplete:

1. All components meet the dimensional requirements of the standards listed in Table NC-3132-1 of the ASME Code.

2. The requirements of the ASME Code, Section III, Subarticle NC-3640 are satisfied. This subarticle deals with ensuring adequate wall thickness of the components for the Design Pressure at the Design Temperature. Since the change in design requirements involves the seismic load case only and pressure stress has been included in the seismic analyses, an explicit check for adequate wall thickness was deemed unnecessary.

3. The only thermal mode assumed was the normal operating mode.

A summary of weight and center of gravity information for all valves on the four safety injection piping models is contained in Table 5. This table also includes the face-to-face dimension for each of the valves.

The four models were analyzed for weight, thermal expansion plus thermal anchor movements, earthquake, and seismic anchor motion (SAM) loads. All were analyzed in accordance with the SEP Guidelines (Reference 3). Details of the analyses not specified in this document were in accord with standard EG&G piping analysis practice. These details were at a level not controlled explicitly by the regulatory process. There is one exception to this. EG&G SAM load generation methodology involves envelopment of structural motion displacements in the area of the support to obtain SAM values. These are then applied individually, with the results combined by square root of the sum of the squares (SRSS) combination. Preliminary result comparisons showed significant differences between EG&G and utility SAM stresses. This initiated an investigation to identify the source of the differences. A different SAM load generation methodology is used by the licensee. SAM values are obtained by interpolation between appropriate structural motion displacements, with either algebraic or absolute value combination of loadings depending on the location and direction of the supports. The basis for this methodology was evaluated, and it was found acceptable. There are a sufficient number of points on the structural steel model with associated SAM data to allow interpolation for support point attachment SAMs. Algebraic combination of specified directions and locations is based on a study of the motion of the buildings which concluded that these particular directions and locations move in phase. Absolute summation of the remainder is conservative. The licensee's methodology was adopted in the EG&G analyses in order to prevent the potential masking of other sources of discrepancy.

An additional analysis was done for the SI-51 tubing model. The second analysis of the SI-51 tubing was done according to the alternate calculation methodology allowed by the licensee's small-bore piping criteria. This methodology was found to predominate in the small-bore piping calculations audited. It consists of an equivalent static analysis based on a simply supported beam calculation.

PVRC damping spectra obtained from the licensee's structural analyses were appropriately enveloped for each particular piping model and used for the earthquake load case in these analyses. These enveloped response spectra curves are shown in Figures 16 through 27. The spectra were applied in all three directions simultaneously and the results were combined using the square-root sum of the squares (SRSS) method. All seismic anchor movements were applied and combined using the licensee's methodology, as discussed above.

Microfiche copies of the finite element analyses are contained in Appendix B. The small-bore piping hand calculation is contained in Appendix C.

4. PIPING ANALYSIS RESULT COMPARISONS

The piping finite element analyses were performed per the requirements of the SEP guidelines and the ASME Class 2 equations specified there. The results obtained from the loadings previously described were used to calculate the piping stresses. The small-bore piping hand calculation was performed using the methodology found to predominate in the audits of small-bore piping calculations. Allowable stresses, per the SEP guidelines, were 2.4Sh for the equivalent of Class 2 piping and 1.8Sh for the equivalent of Class 1 piping. Except for a small length of pipe near the reactor coolant loop, the piping analyzed is the equivalent of Class 2 piping.

Although calculated stresses were compared to allowable stresses, the focus of this work was a comparison of stresses as calculated by EG&G and the licensee to ensure that the stress calculation criteria and methodology employed by the licensee is acceptable. Some differences in methodology were found. Different techniques were initially used to combine seismic anchor motion (SAM) loads. This is discussed in detail in Section 3 of this report. The licensee's technique was found acceptable and adopted in the EG&G analyses to prevent the differences in this methodology from masking any other differences which may have existed. Other differences in methodology were found. This includes differences in valve and reducer modeling techniques and anchor point stiffness calculations. These are discussed in the following paragraphs.

As is common industry practice, all modes of vibration with natural frequencies under 33 Hz were included in the dynamic analyses. The effects of the higher frequency modes, the "missing mass effect" were automatically included in the results by the NUPIPE-II program. Tables 6 through 9 show the first ten modes of vibration for each of the piping models. The SI-51 model was calculated to have 52 natural frequencies below 33 Hz with rod hangers modeled rigidly and 50 without rod hangers. The SI-04 model displayed 42 natural frequencies under 33 Hz with rigid rod hangers and

43 without rod hangers. The SI-158 model, which has no rod hangers, had 13 natural frequencies under 33 Hz. The SI-51 tubing model exhibited 17 natural frequencies below 33 Hz.

Comparisons of stress results are presented in Tables 10 through 13. The first column of each table identifies the EG&G node point and the licensee's data point at which stresses are compared. The EG&G node point (the first number) can be used to locate the point under consideration in the plots of the models (Figures 1 through 15). The next two columns identify the type of component being analyzed and its associated stress intensification factor (SIF). The remaining six columns are divided into two sets, one for the seismic inertia plus normal operating load (SI) stress, and one for the seismic anchor motion load (SAM) stress. This separation allowed a clear identification of the source of any differences in stress results. There are three columns for each type of stress. The first is for stresses from the EG&G analysis, the second for the licensee's stresses, and the third for the percent difference between the two sets of results, with the average value used listed in the percentage column header. This type of comparison was chosen because it emphasized the most significant differences, those in the areas of maximum stress, and because it allows a comparison of results among the models.

Stress results comparisons were limited to points in the models with SIF greater than 1.0, and at support points in the straight runs of piping, since these represent local stress maxima. Due to the large size of the SI-51 model, stress results were compared only in areas of maximum stress, which were found to be in the same areas of the model in both sets of results. These areas were found in the vicinity of both feedwater pump nozzles and in the vicinity of the branch point for the west side 6-in. line running to containment. Stress result comparisons were presented for all of the SI-04 model except for nodes 5 through 60 and those nodes associated with boundary condition piping (non-safety related), where the comparison yielded identical trends to those presented. All stress result comparisons are presented for the SI-158 model.

Comparison of stress results for the SI-51 analyses shows close agreement (see Table 10). The EG&G stresses are based on as-built data and standard practice at EG&G with the following exceptions. The rod hanger support at node 145 (Figure 3) was given full credit for vertical support. Although not in agreement with the as-built condition, this reflects the licensee's decision to upgrade the rod hanger to a full vertical support (typically done by adding a bumper near the rod hanger to restrain uplift of the piping). This modification to EG&G's SI-51 model was done to obtain an identical support configuration with the licensee's model. A two element reducer model was used in the EG&G analysis, each element having the section properties of the attached piping. This is in contrast with standard EG&G practice, which is to use a single element with the section properties of the smaller of the attached pipes, and to increase the stress on the large end of the reducer to reflect the larger pressure stress there. This practice is known to be overly conservative, and the refined two element model is used at EG&G in cases where the standard model indicates an overstress.

There were also instances of EG&G common practice different from the licensee's which were not changed. In EG&G common practice, anchor stiffness is based on the associated pipe section properties, while the licensee uses a single fixed value. These are the default procedures found in the two computer analysis codes used. EG&G valve element stiffnesses are based on a factored stiffness for the equivalent piping element, while the licensee's are based on the associated pipe element with a doubled wall thickness. Valve masses are distributed differently, although the center of gravity of the valve and total mass are the same. EG&G uses a single mass for both the valve body and the operator; the licensee uses a separate mass for each. Since the valve models are included only to simulate the effect of the valves on the piping, these differences are negligible. Centerline offsets for axial supports are modeled by EG&G but not by the licensee.

Differences in common practice between EG&G and the licensee had no significant effect on the stress results, as indicated in Table 10. Extremely close agreement was obtained, with the maximum difference appearing in the area of tee components. These differences are attributed to the accumulation of the differences in stiffness along each portion of the piping that terminates at the tee.

The results of the SI-04 analyses did not compare as favorably as those for the SI-51 analyses (see Table 11). The EG&G model was strictly as-built. This resulted in two differences between EG&G's and the licensee's models. The vertical support at node 265 (Figure 9) in the EG&G model was located at the position corresponding to node 260 in the licensee's model. The reducer between nodes 335 and 340 of the EG&G model was modeled as 14 in. long in the EG&G model, and 7 in. long in the licensee's model. In both cases, the EG&G model was closer to the as-built configuration, but both variations in the licensee's models were within IE Bulletin 79-14 tolerances. The same differences in common practice found in the SI-51 models were also found. Reducer model refinements made in EG&G's SI-51 analysis were not made in the SI-04 analysis.

Since the differences in stress results for the SI-04 analyses were larger than those for the SI-51 analyses, an attempt was made to isolate the cause. The EG&G SI-04 model was modified to duplicate the licensee's support configuration, valve and reducer models, and anchor stiffnesses. Stress results from analysis of the modified model were compared with no improvement seen. The location of stress variation was different, but the degree and number of variations were the same. The models were closely compared and found to be as near to identical as could be obtained using different analysis computer codes.

The source of differences in stress results was found in a contrast between the SI and SAM stress comparisons for the SI-04 analyses. The agreement in stresses is much better for the SAM load. This indicates that the discrepancies affect the dynamic analyses more strongly than the static analyses. Differences in SAM stress greater than 10% occur only in reducers and elbows. This is not anomalous for the reducers, which are modeled differently, but it indicates that elbow element stiffness formulations differ slightly. The effect of this small variation is negligible for the static (SAM) analyses, but can be significant in the dynamic (SI) stress results. Such variations would have little effect on the calculation of the lower frequency modes of vibration, which are more accurately defined than the higher frequency modes in dynamic analysis. This characteristic makes the effect of minor variations in elbow stiffness on stress results dependent on the frequency content of the response spectra used in the dynamic analysis. Response spectra with relatively more excitation in the low frequencies, such as the SI-51 spectra, generate resultant stresses with larger contribution from the low frequency modes. The effects of the elbow stiffness variation are attenuated, and the stresses compare closely. The SI-04 spectra, having relatively less low frequency excitation, generate resultant stresses with relatively more contribution from the higher frequency modes. The effect of the elbow stiffness variation is emphasized, and the stress comparison is less favorable.

The existance of small variations in elbow stiffness formulation is not particularly harmful in seismic analysis, because the effects of the variation are concentrated in the calculation of the higher frequency response. Seismic events are essentially low frequency events, a result of the fact that high frequency motion is rapidly attenuated in transmission through the ground. Large seismic stresses are therefore associated with low frequency response, where the variation in elbow stiffness is not significant. This can be seen in a comparison between the maximum stresses calculated in the SI-51 and SI-04 analyses. The average maximum SI-51 analysis stress, which is in the range of the SEP guidelines allowable stress, is 2.6 times larger than the SI-04 average maximum stress.

A comparison of stresses for the SI-158 analyses are presented in Table 12. Good agreement is indicated. These results compliment the conclusions drawn in the discussion of the SI-51 and SI-04 results.

For an overall comparison, the differences in stress for all entries of Tables 10 through 13 were averaged for the seismic inertia and SAM stresses. On the average, EG&G seismic inertia stresses were 1.0 ksi higher, and the SAM stresses differed by less than 0.1 ksi. The difference in seismic inertia stress can be attributed to differences in spectral definition. EG&G spectra were limited to 30 points, while the licensee's spectra contained 160 points. In performing the reduction, envelopment criteria were imposed, which would result in a marginally higher stress calculated using the reduced spectra.

A comparison between finite element calculated stresses and allowable stresses showed the EG&G analyses and the licensee's analyses to be in exact agreement in terms of a conclusion of adequacy. SI-04 and SI-158 are acceptable with good margin. SI-51 had two components with stresses that exceeded allowable stresses. Both were reducers located on the discharge side of the feedwater pumps. This indicates that the licensee's criteria and methodology produce comparable results to those of the SEP guidelines. Supports have been added to the SI-51 piping to reduce stresses to acceptable levels.

A comparison between stresses calculated for the SI-51 tubing model using finite element analysis and hand calculations showed the hand calculation to be conservative. The maximum finite element analysis stress was 14.5 ksi, versus a hand calculated maximum stress of 71.8 ksi. According to the hand calculation, the tubing is severely overloaded. According to the finite element analysis (which is more accurate, and hence controls the conclusion concerning adequacy of the tubing), the tubing is acceptable to the SEP guideline limits with large margin.

Based on the detailed comparison of the results of three piping system finite element analyses, the criteria and methodology used by the licensee in analyzing piping were found to be in keeping with the SEP guidelines and current industry practice and are acceptable. The comparison of the confirmatory finite element analysis for the tubing with the confirmatory hand calculation showed the hand calculation to be conservative and acceptable.

5. PIPE SUPPORT ANALYSIS RESULT COMPARISONS

Pipe support analyses were performed per the requirements of the SEP guidelines and current industry practice. Hand calculations were predominately used. Nominal stresses were calculated based on the loads supplied by the confirmatory piping analyses and nominal member section properties. Loads on catalog components were compared to vendor supplied allowable loads. Detailed finite element stress analyses were used in cases not amenable to hand calculation. Weight and thermal loads were considered for normal operating loads. Thermal loads were included only if they increased the resultant stress. Seismic inertia and seismic anchor motion loads were combined by the square root of the sum of the squares method, and then added and subtracted to the normal operating loads to obtain the range of loads used in calculating the seismic stress. In cases where the support geometry or loading was too complex for hand analysis, detailed finite element stress analyses were performed. The resulting stresses were compared to allowable stresses defined in the SEP guidelines.

All supports on safety related piping of the SI-51 and SI-04 models were analyzed. Since this led to the analysis of some 50 supports, analyses of the SI-04 supports were not performed. The analyses are contained in Appendix D. The supports for the SI-51 and SI-158 piping were then ranked according to decreasing stress ratio. The stress ratio for a support is defined to be the maximum ratio of calculated to allowable stress for all components of the support. Hence the support with the highest stress ratio is the most highly loaded relative to its allowable load. The licensee was requested to similarly rank the supports of both systems and to identify the supports with the largest stress ratio. For each piping system, the five supports with the largest stress ratio according to the EG&G analyses and the five according to the licensee's analyses were merged into a list. The lists were reviewed and found to contain a representative sample of the types of components found in pipe supports. The calculations supporting the stress ratios appearing on both lists were then subjected to a detailed comparison. The purpose of the comparison was to determine if the criteria and methodology applied by the licensee were acceptable.

Results of the comparison between support calculations are presented for the SI-51 piping supports in Table 13, and for the SI-158 supports in Table 14. Several differences in stress ratio were found, as indicated and discussed in the tables. No application of unacceptable criteria or methodology was found. Supports identified as overloaded by the EG&G analysis had either been forwarded to the support design group for modification, or shown to be acceptable by analysis of an improved support configuration. As noted in Section 4 of this report, supports were added to the SI-51 piping to reduce loads on the feedwater pump nozzles. Loads used in the licensee's support analyses were taken from the analysis of the piping with the improved support configuration. In some cases, the presence of added supports reduced loads on nearby supports, so that some of the supports identified as unacceptable in the EG&G analysis were shown acceptable under the reduced loading in the licensee's analysis.

Based on detailed comparison of the results of 14 supporting analyses, the criteria and methodology used by the licensee in analyzing pipe supports were shown to be in keeping with the SEP guidelines and current industry practice and are acceptable.

6. CONCLUSION

Four confirmatory finite element analyses and one confirmatory hand calculation were performed for piping systems. Pipe supports of two of the systems were subjected to confirmatory analysis. Results of the confirmatory analyses were compared to corresponding results of the licensee's analyses. The confirmatory hand calculation results were compared to the results of a confirmatory finite element analysis. Based on the comparisons, the licensee's criteria and methodologies for analyzing piping and pipe supports were found in keeping with the SEP guidelines and current industry practice and are acceptable.

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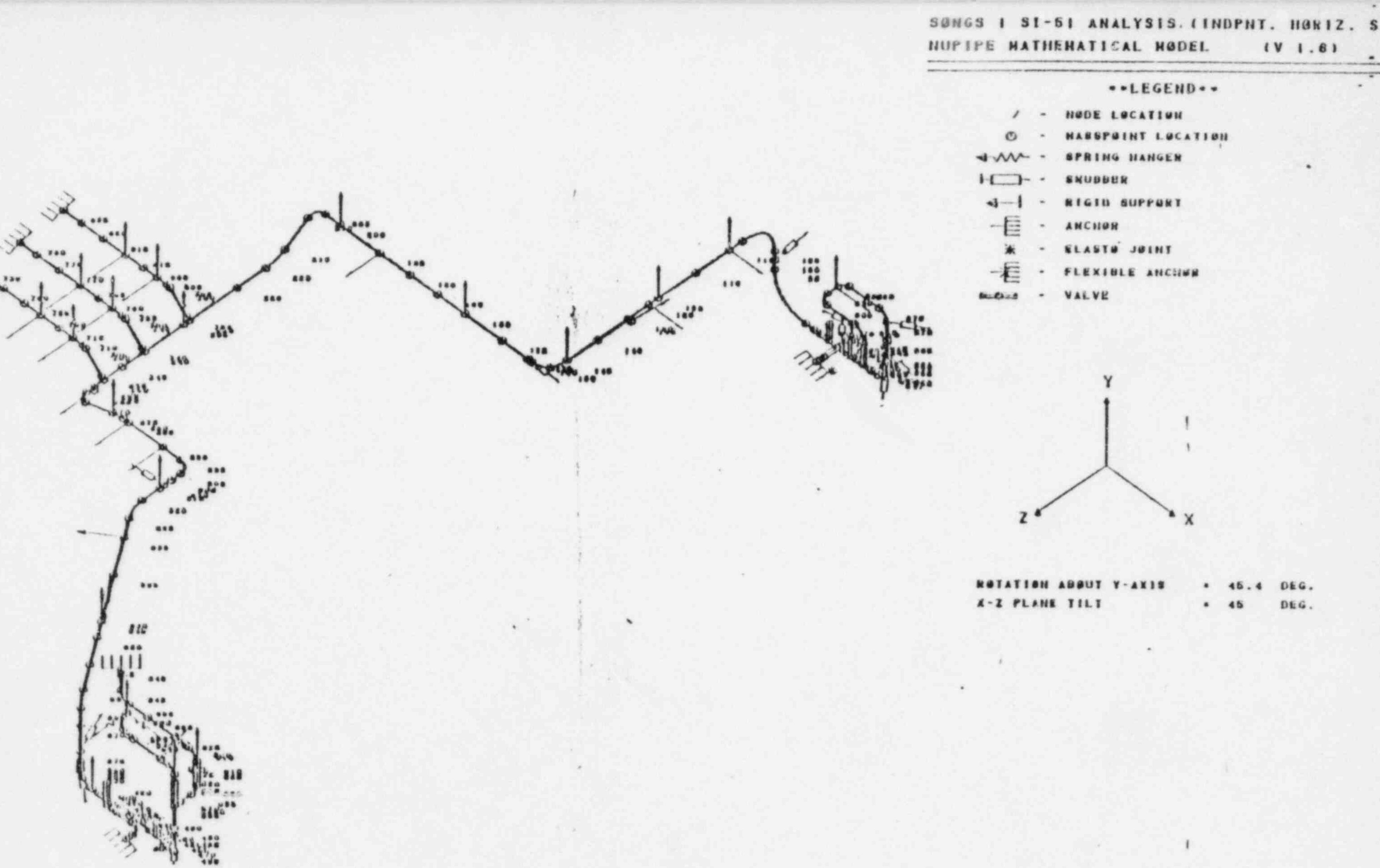

Figure 1. Isometric of the SI-51 computer model.

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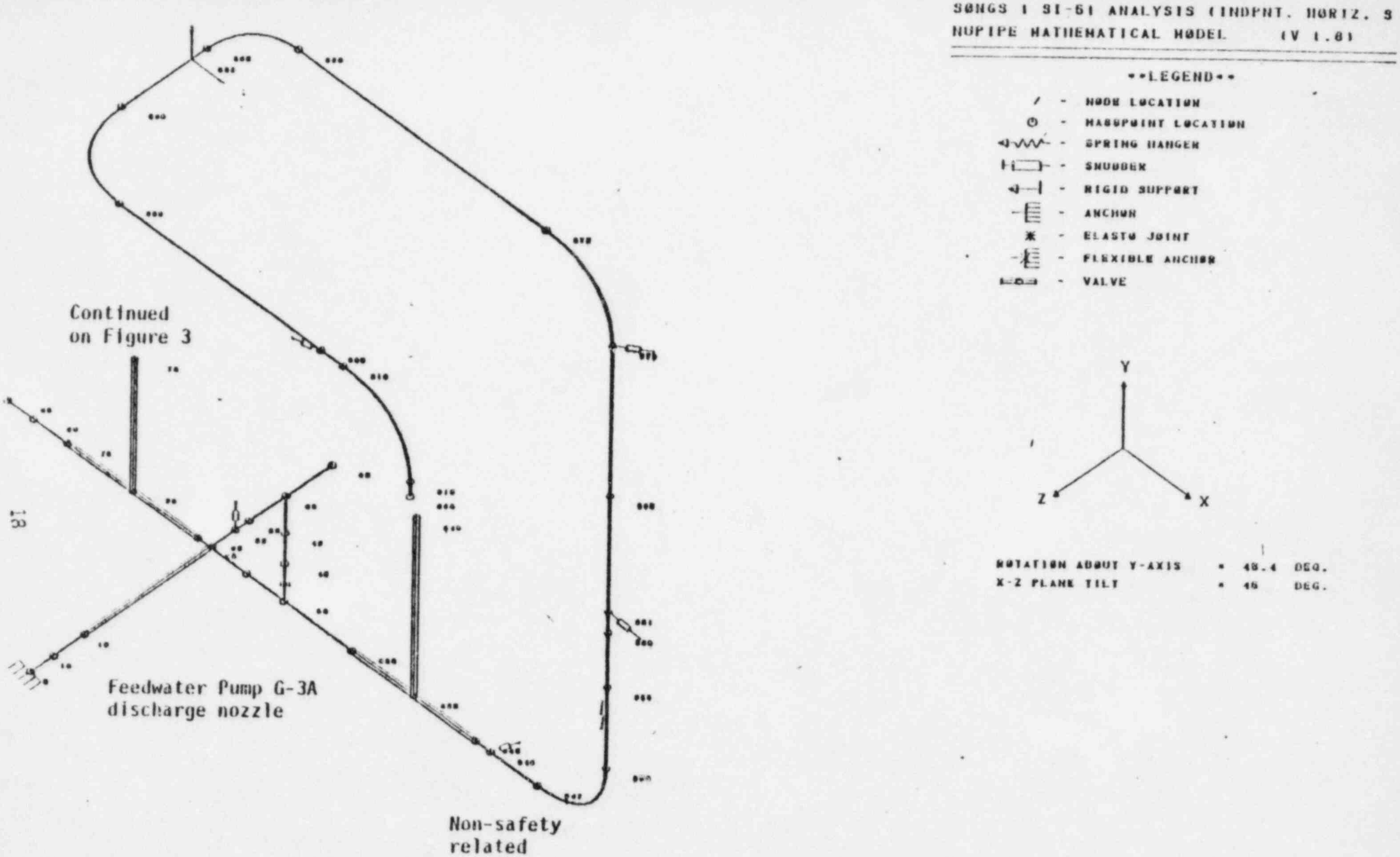

Figure 2. Partial isometric of the SI-51 computer model.

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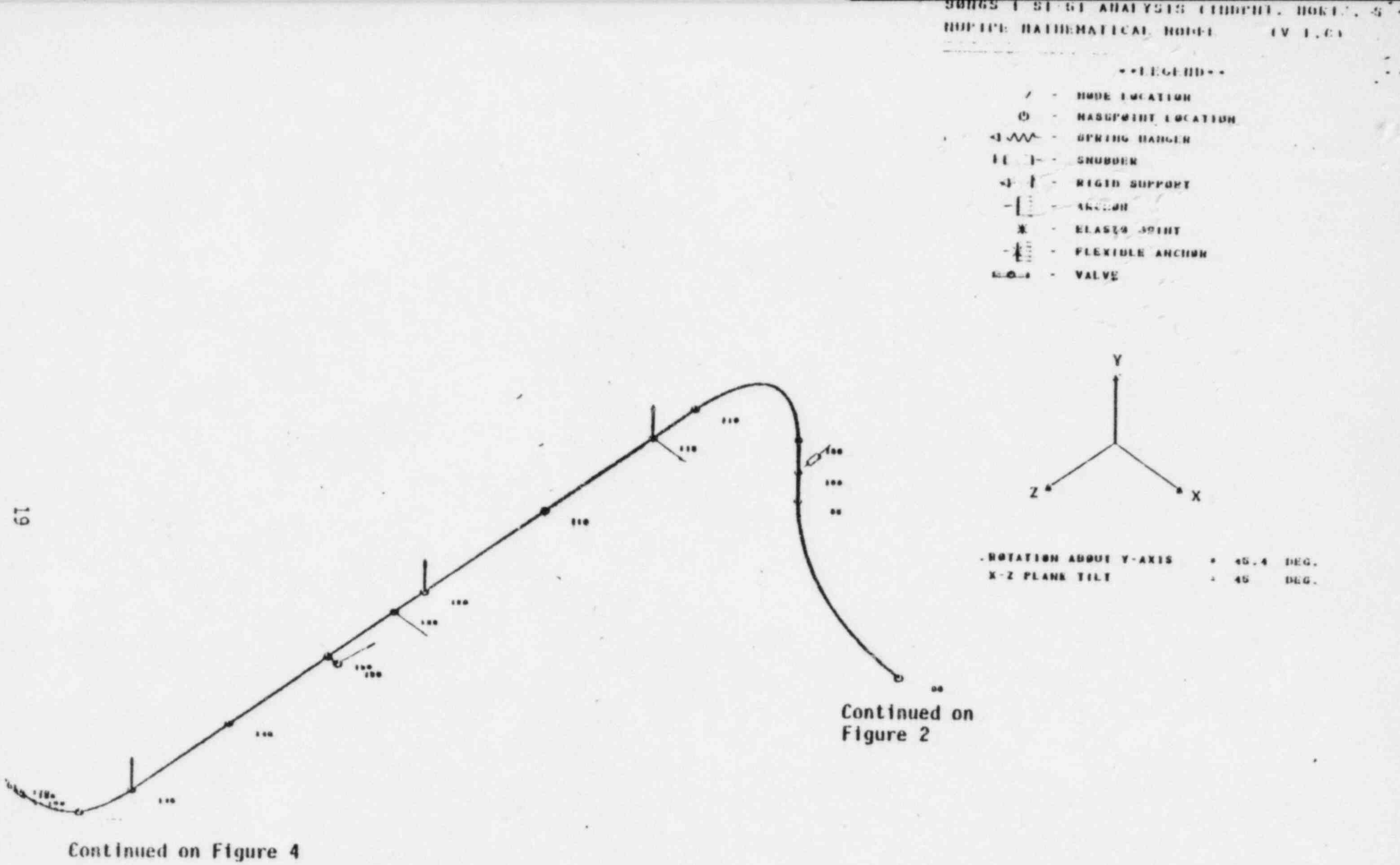

Figure 3. Partial isometric of the SI-51 computer model.

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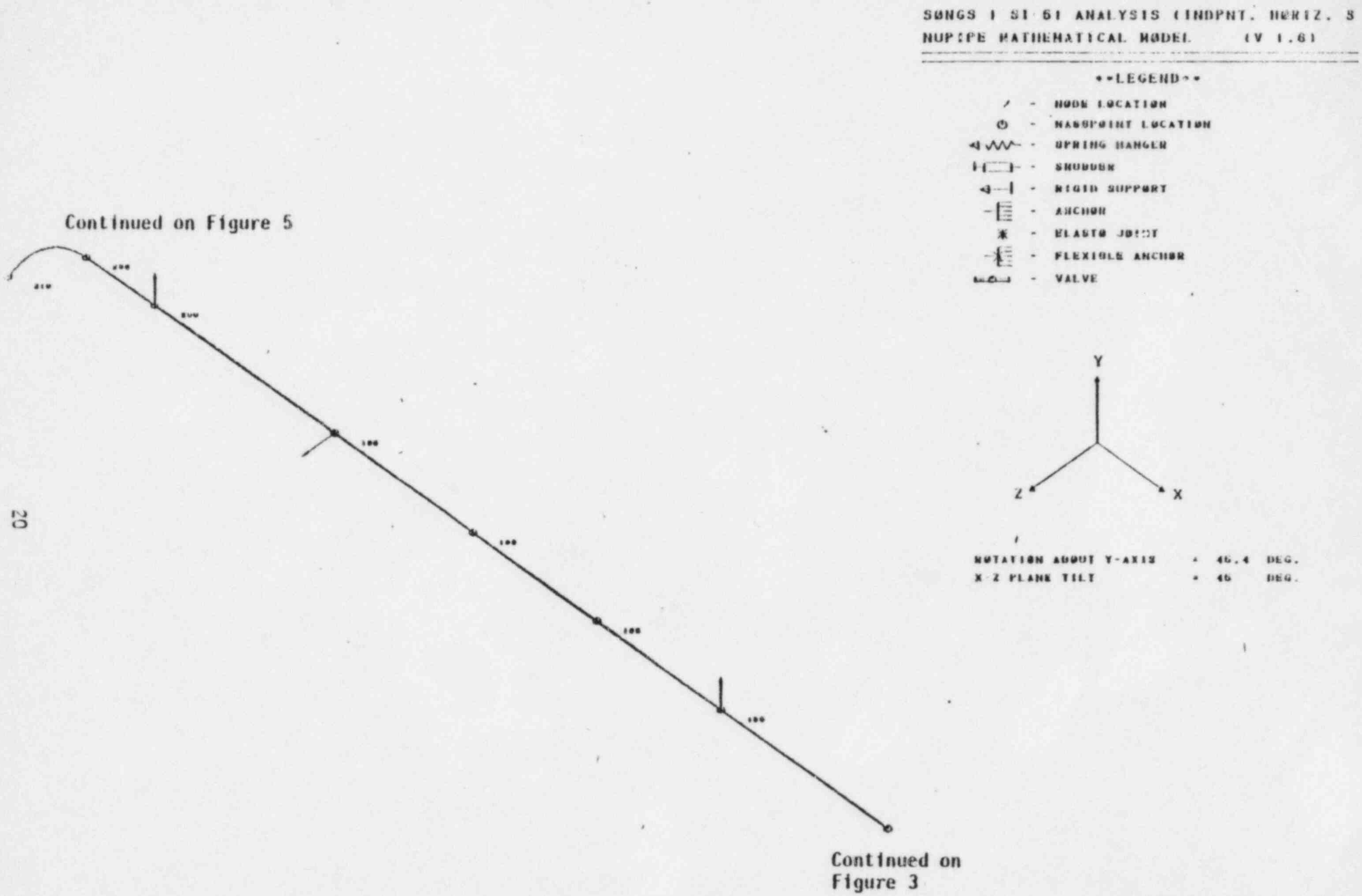

Figure 4. Partial isometric of the SI-51 computer model.

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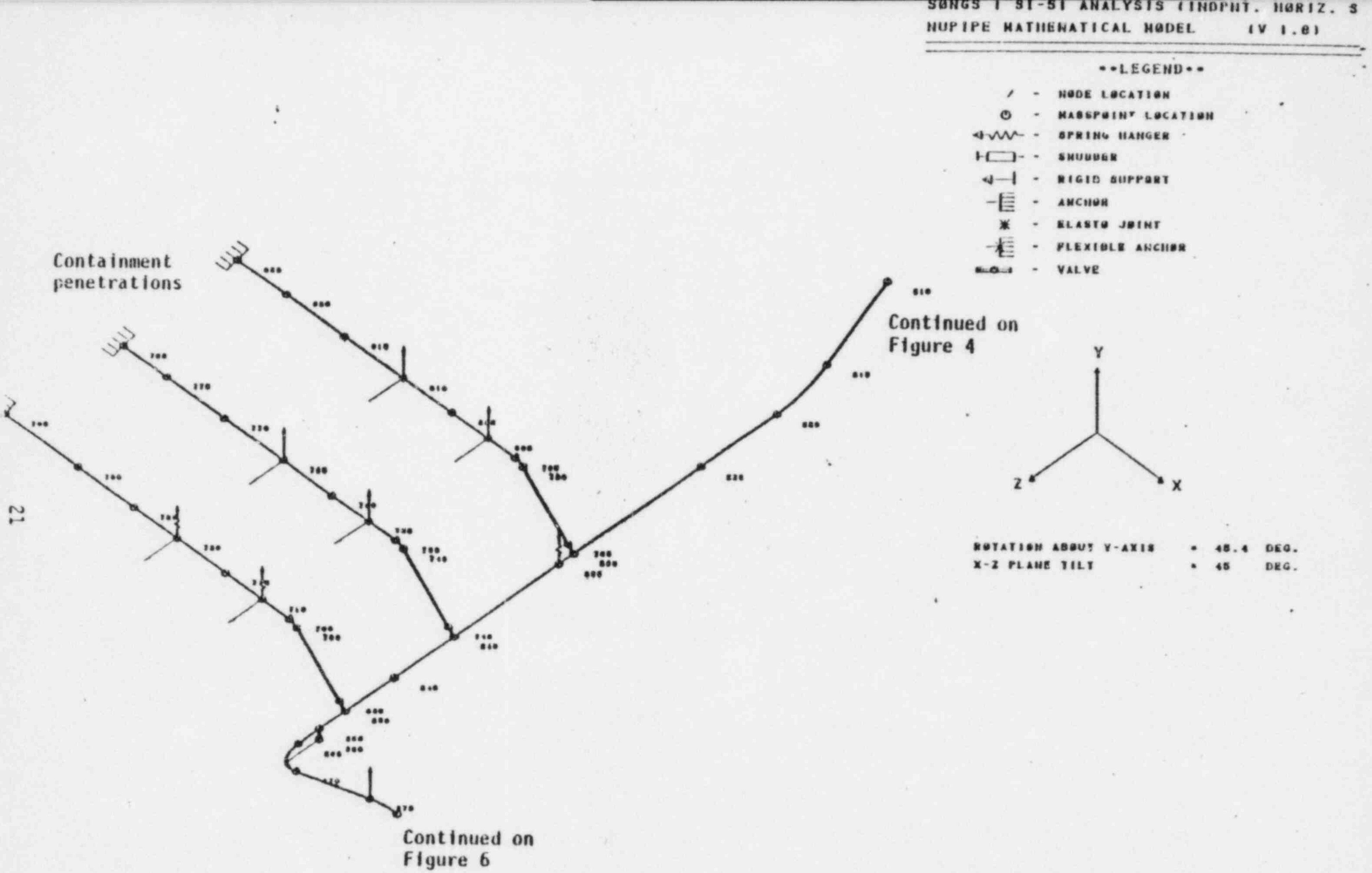

Figure 5. Partial isometric of the SI-51 computer model.

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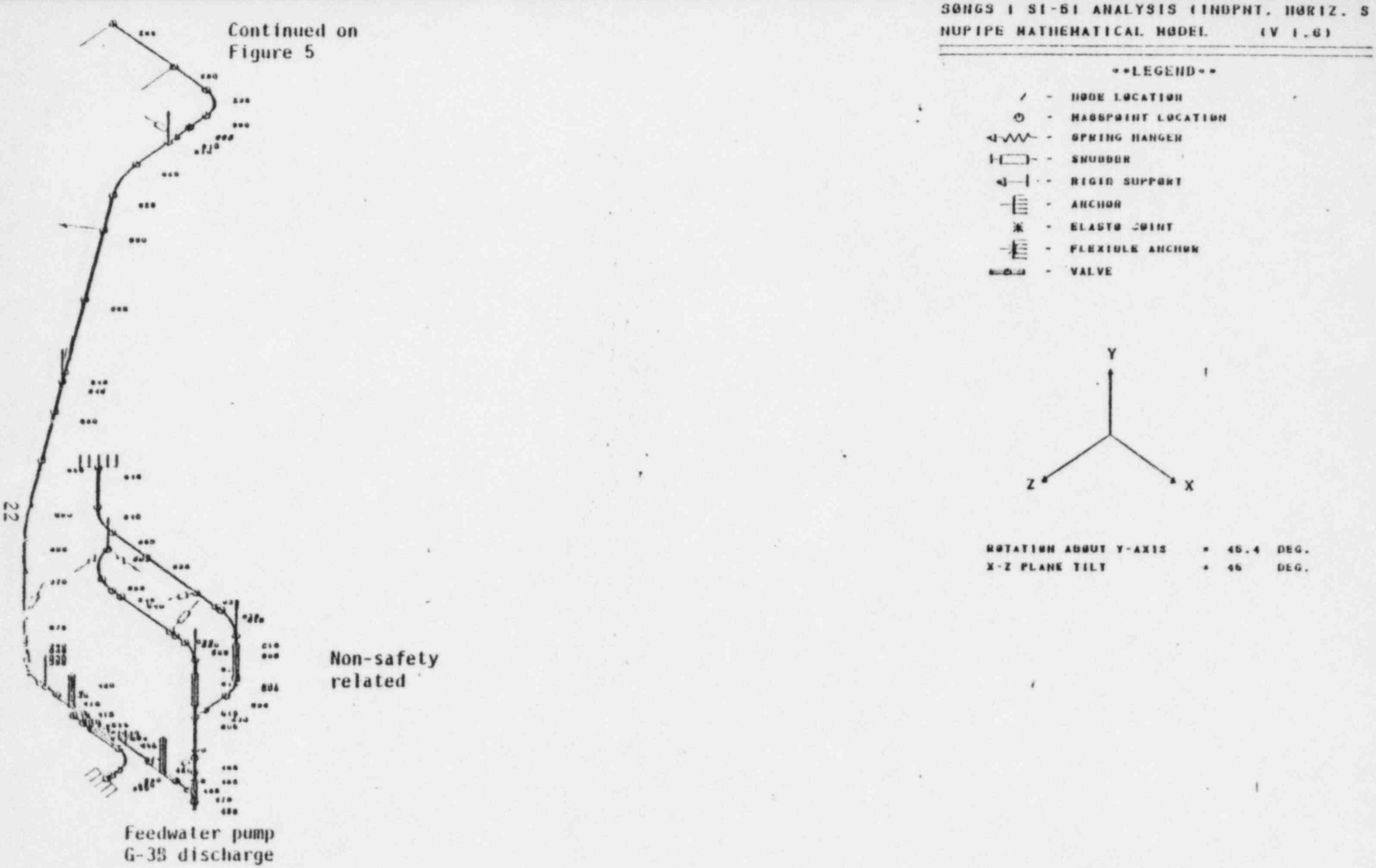

Figure 6. Partial isometric of the SI-51 computer model.

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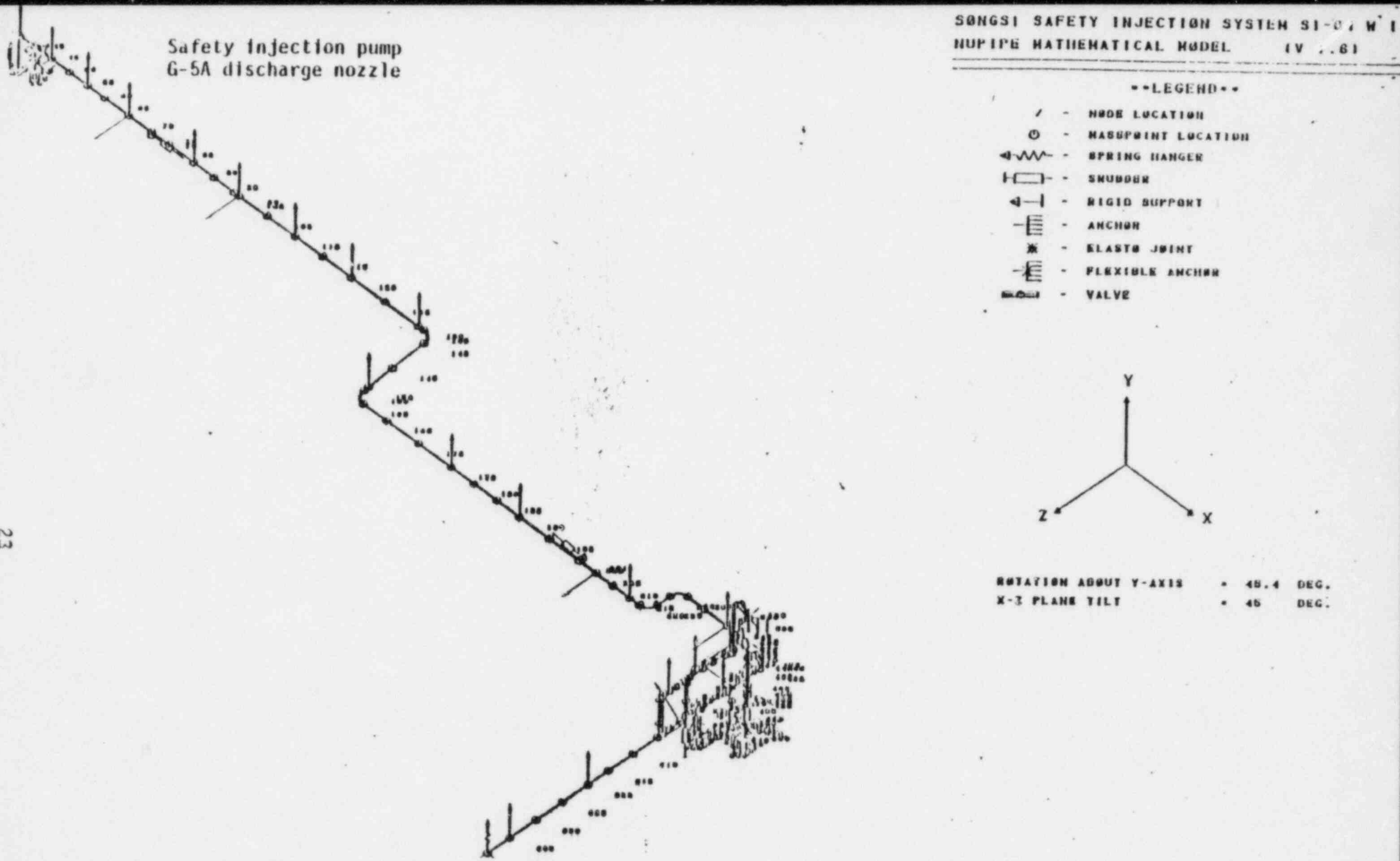

Figure 7. Isometric of the SI-04 computer model.

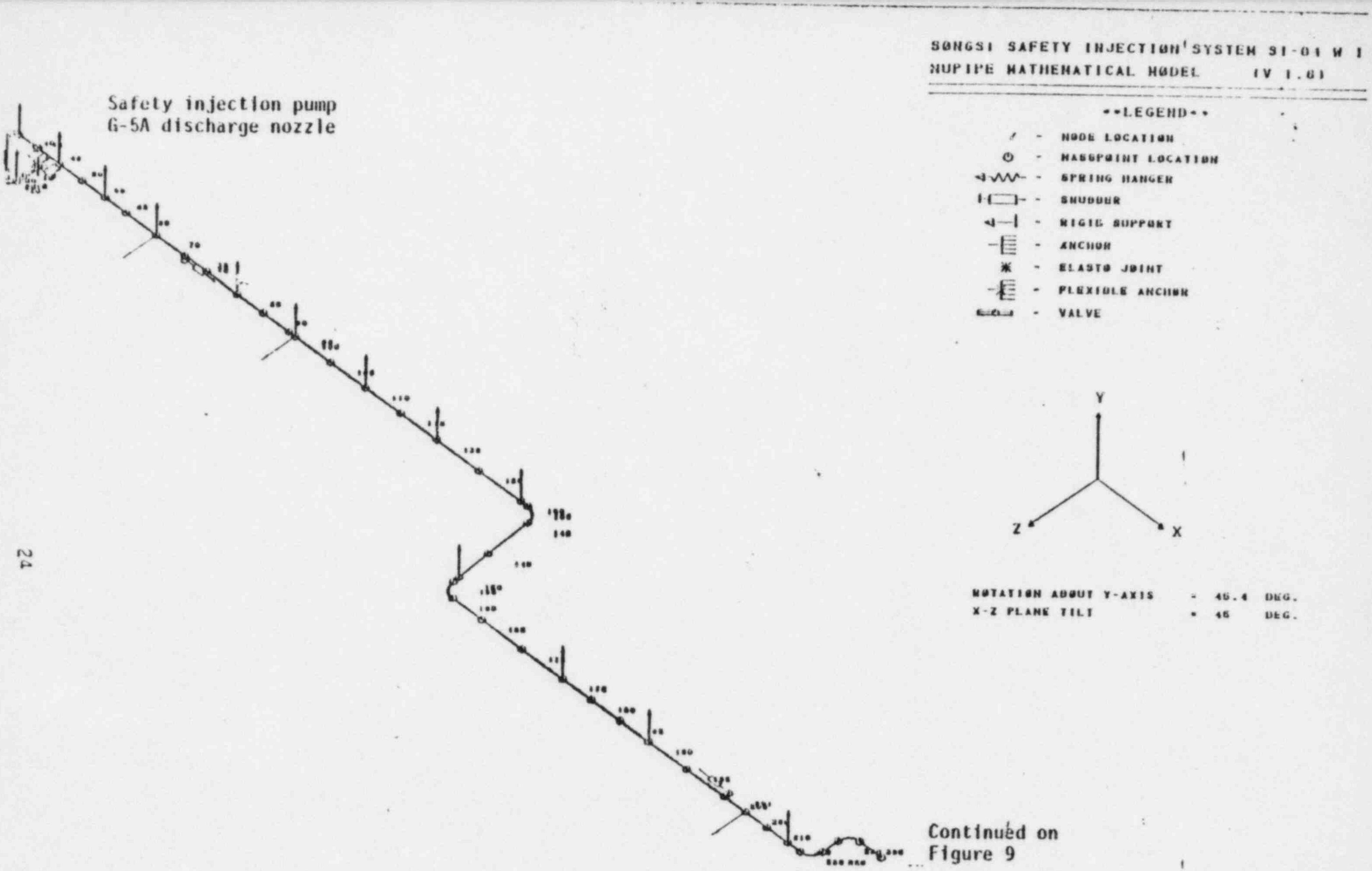

Figure 8. Partial isometric of the SI-04 computer model.

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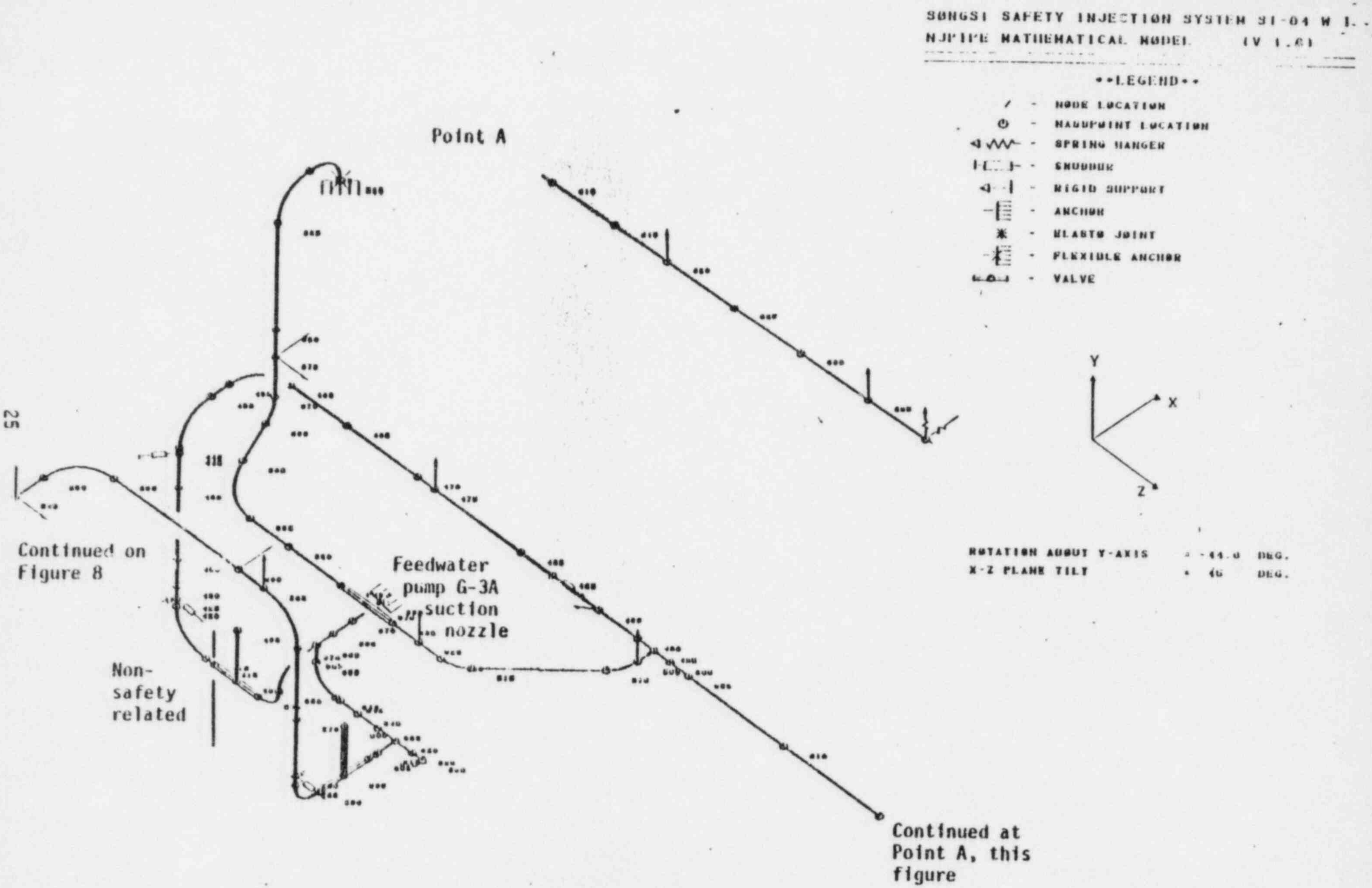

Figure 9. Partial isometric of the SI-04 computer model.

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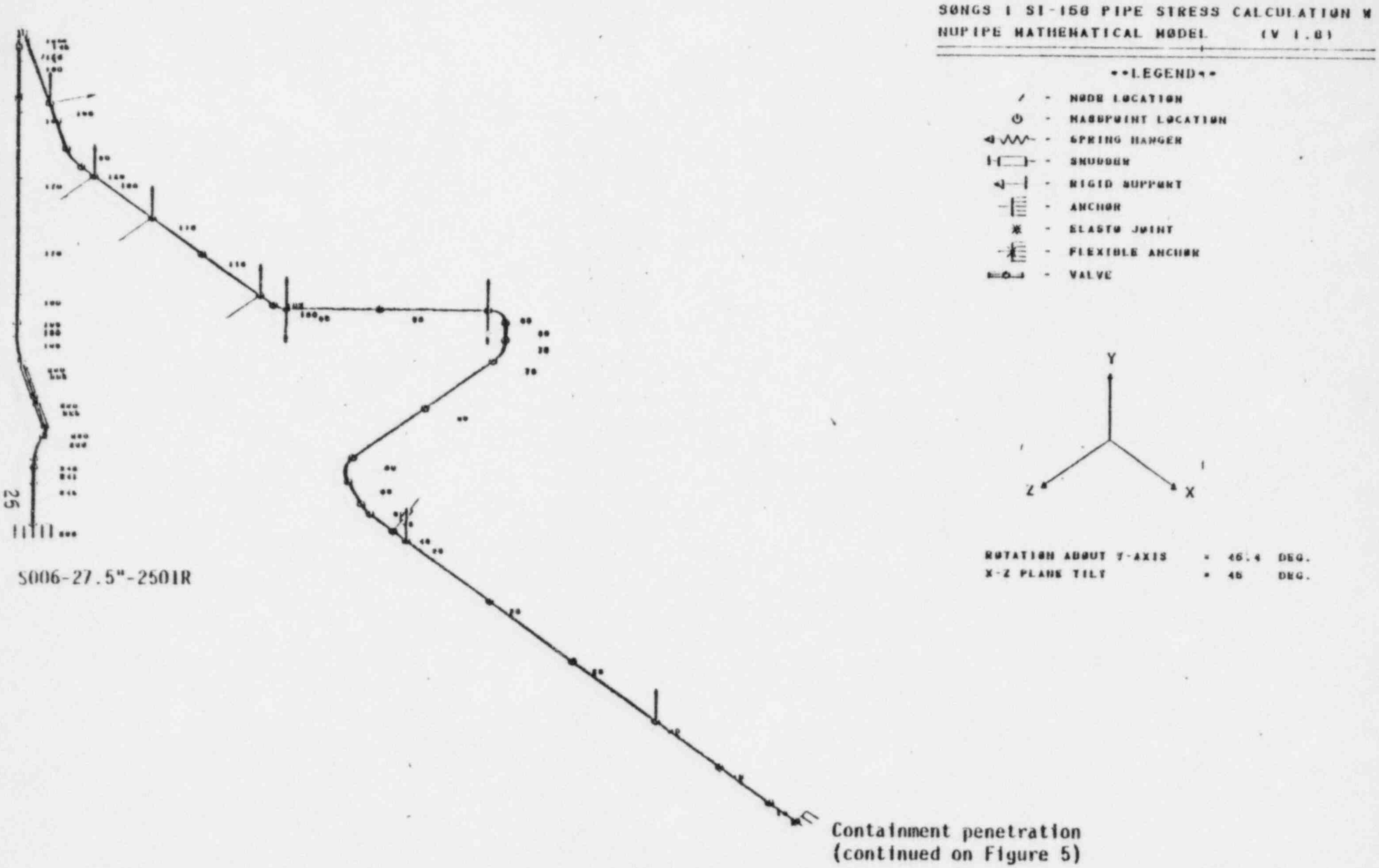

Figure 10. Isometric of the SI-158 computer model.

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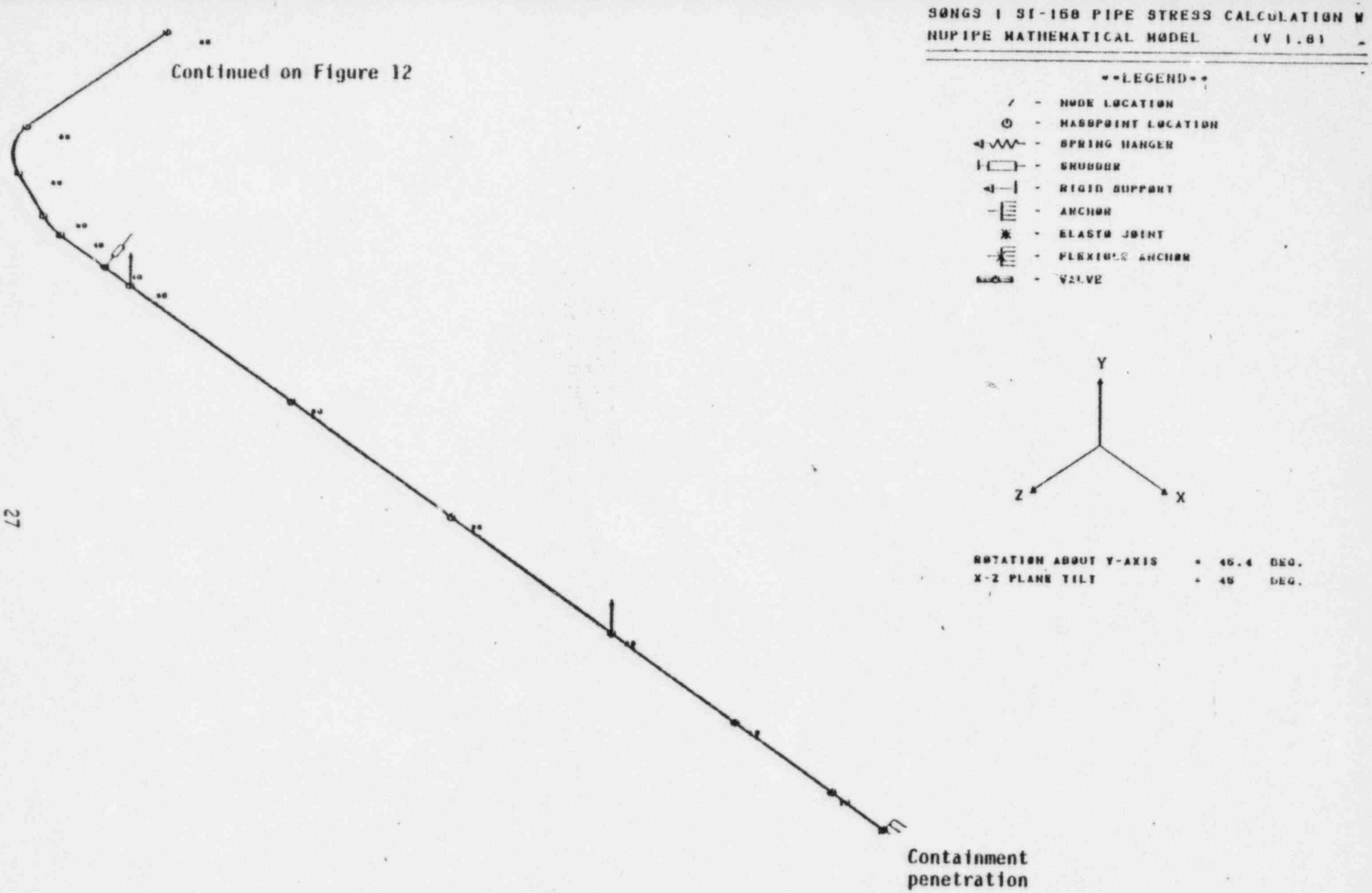

Figure 11. Partial isometric of the SI-158 computer model.

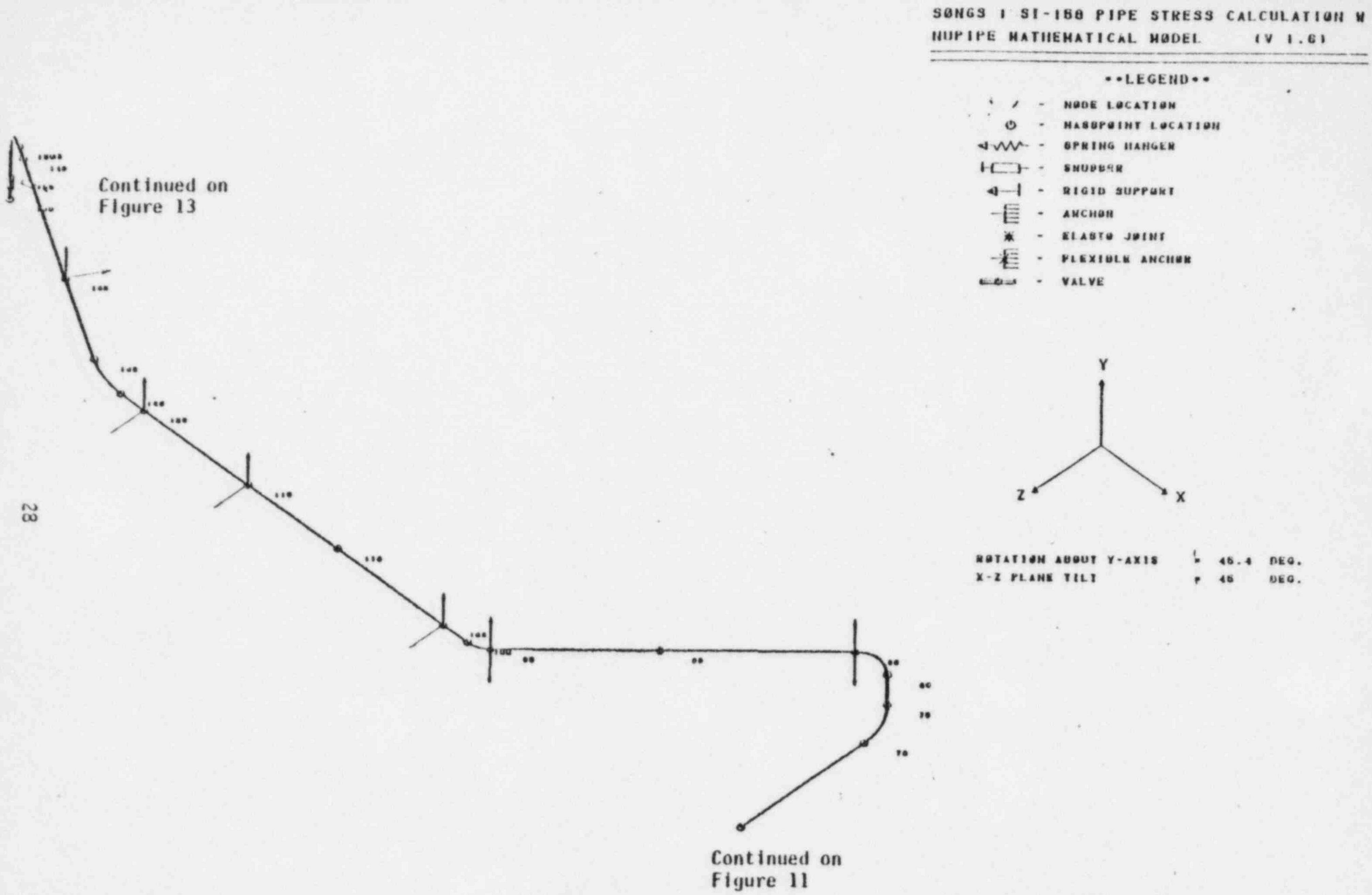

Figure 12. Partial isometric of the SI-158 computer model.

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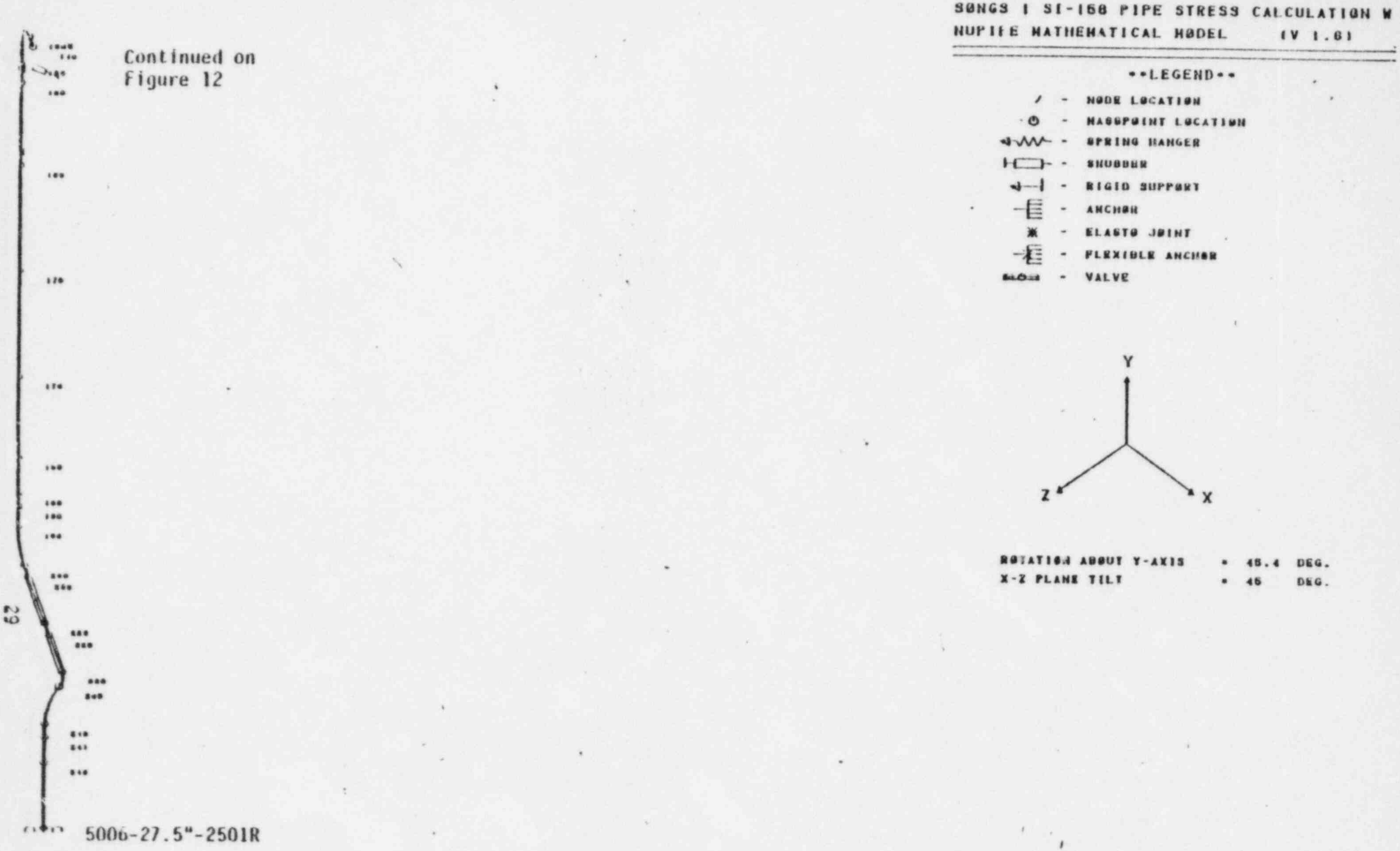

Figure 13. Partial isometric of the SI-158 computer model.

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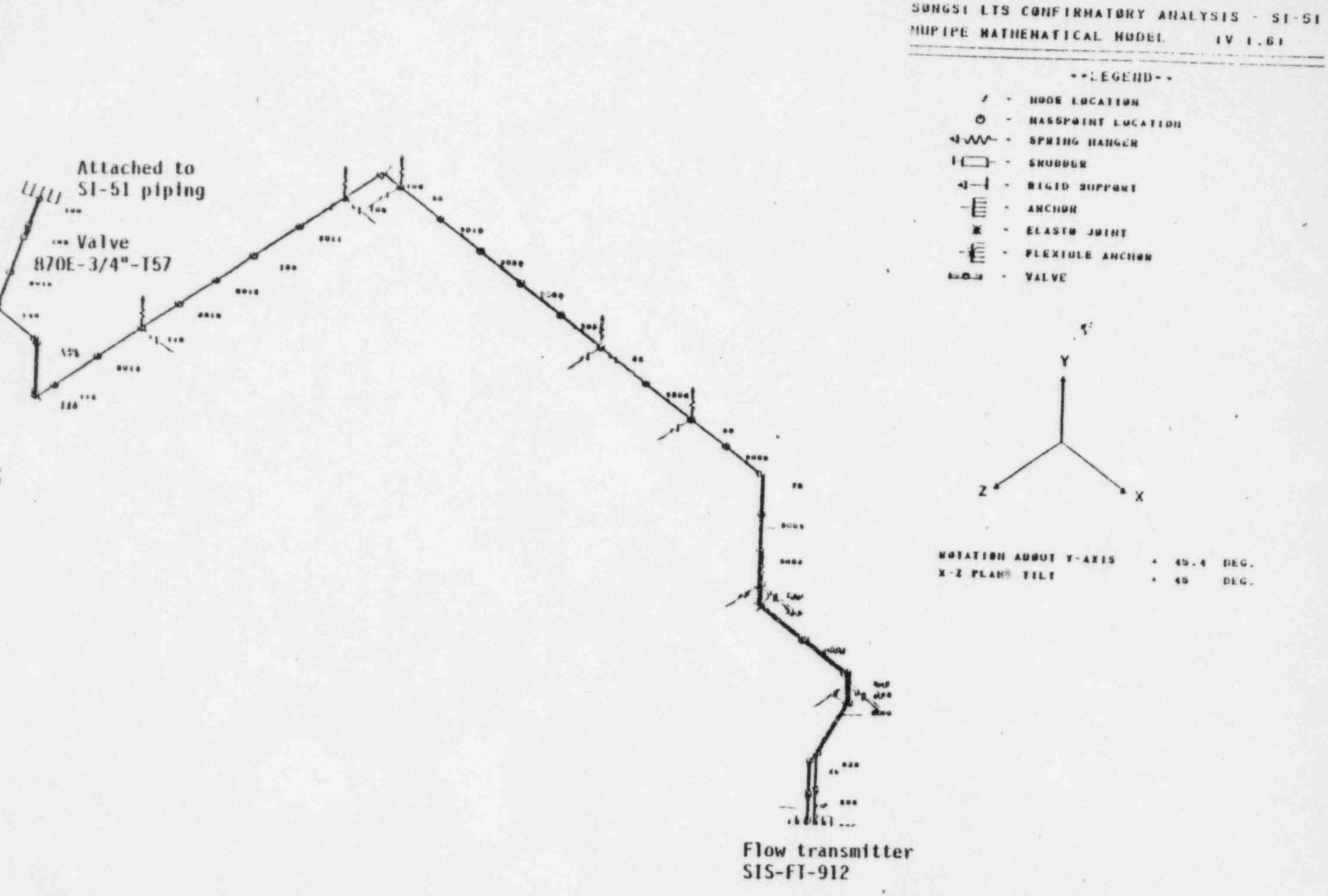

Figure 14. Isometric of the SI-51 tubing computer model.

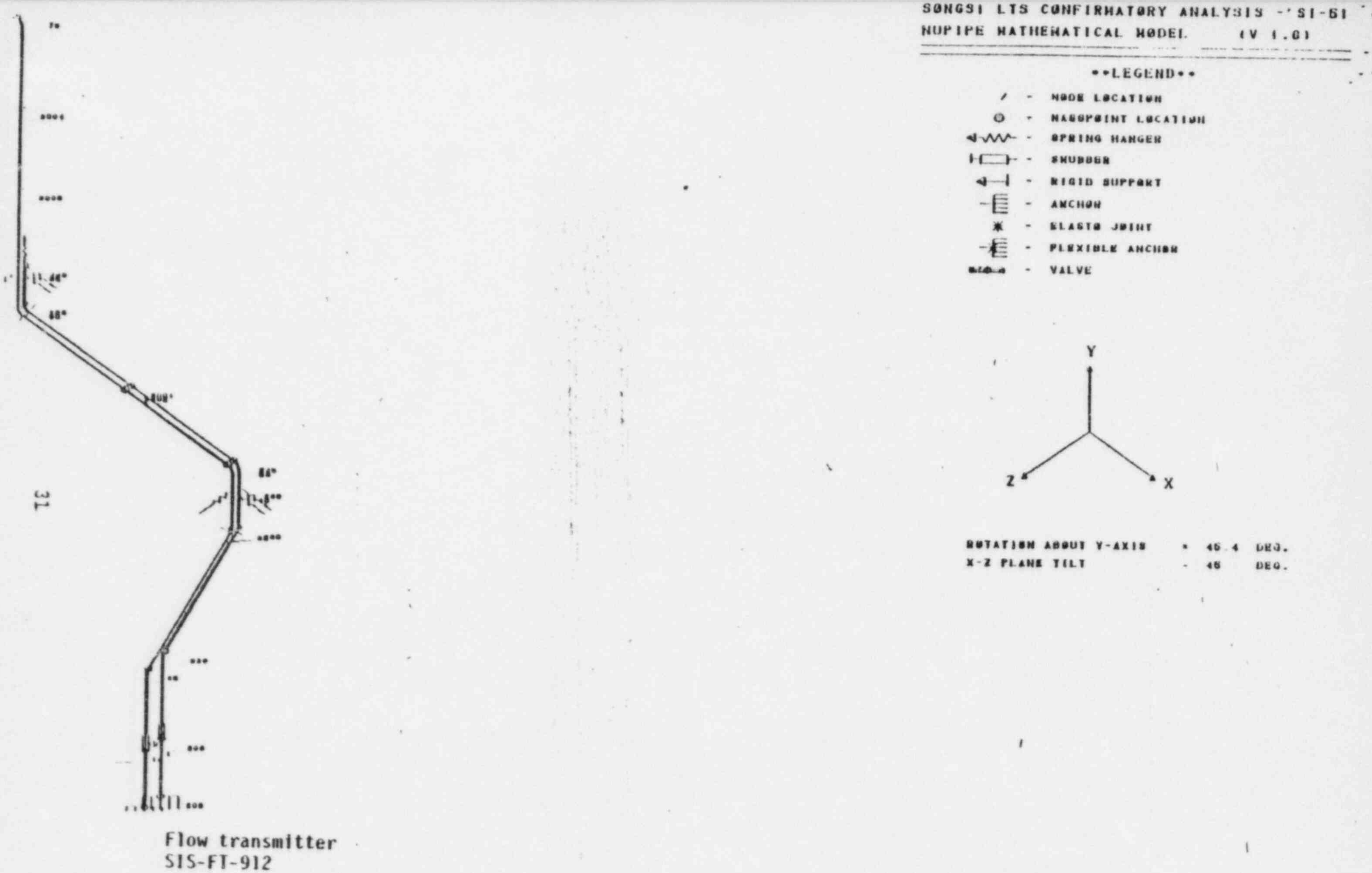

Figure 15. Partial isometric of the SI-51 tubing computer model.

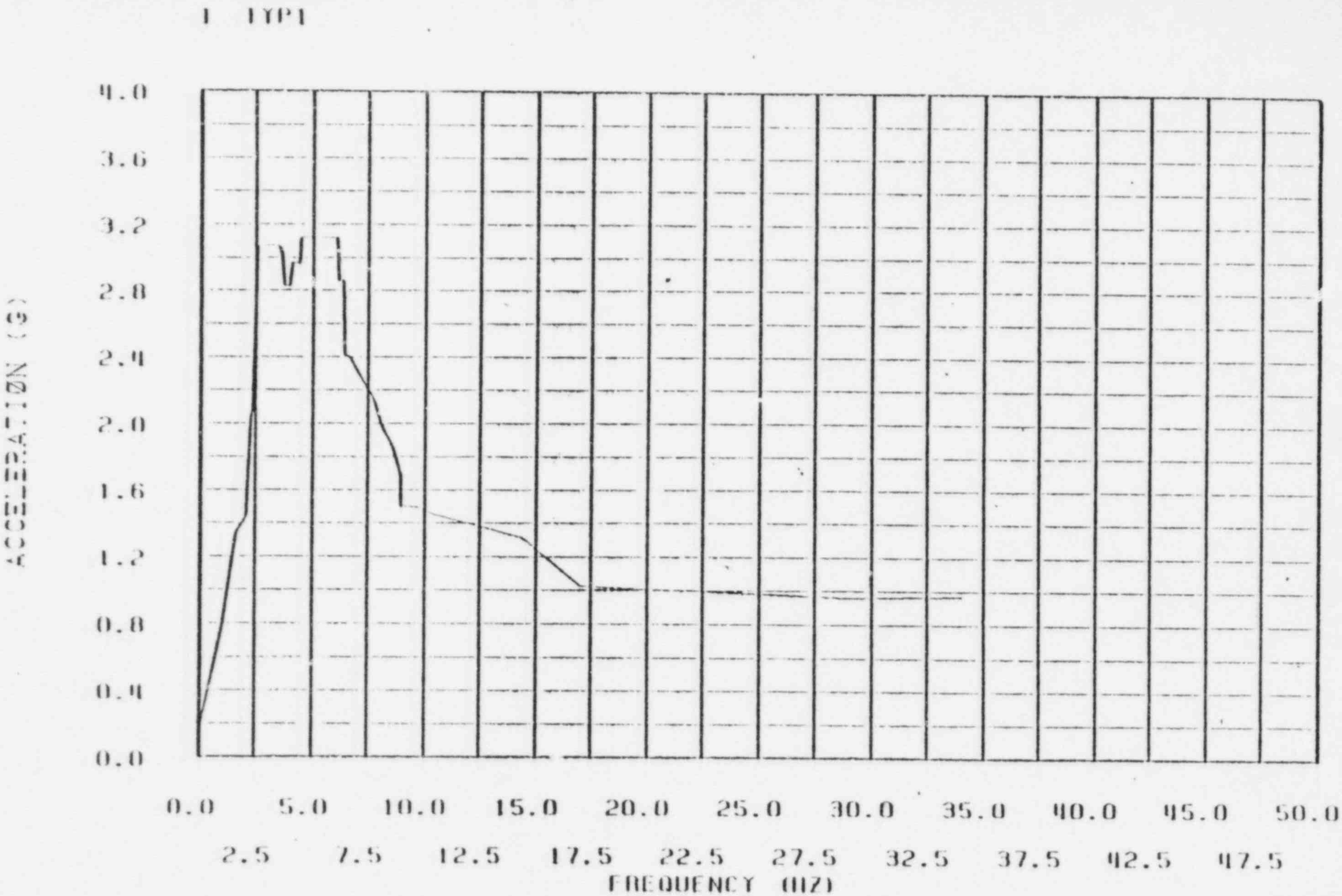

Figure 16. North-South response spectrum for SI-51.

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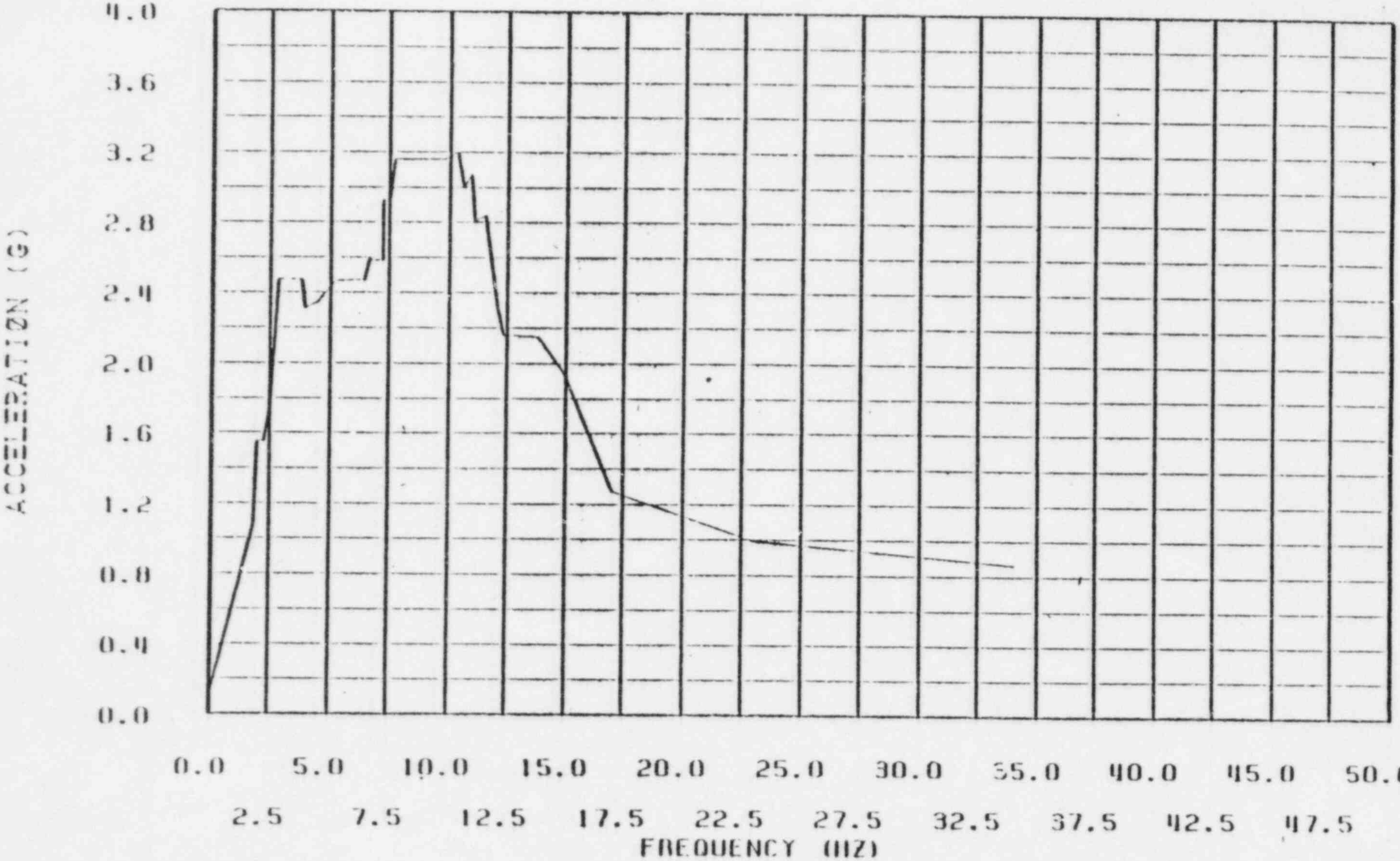


Figure 17. Vertical response spectrum for SI-51.

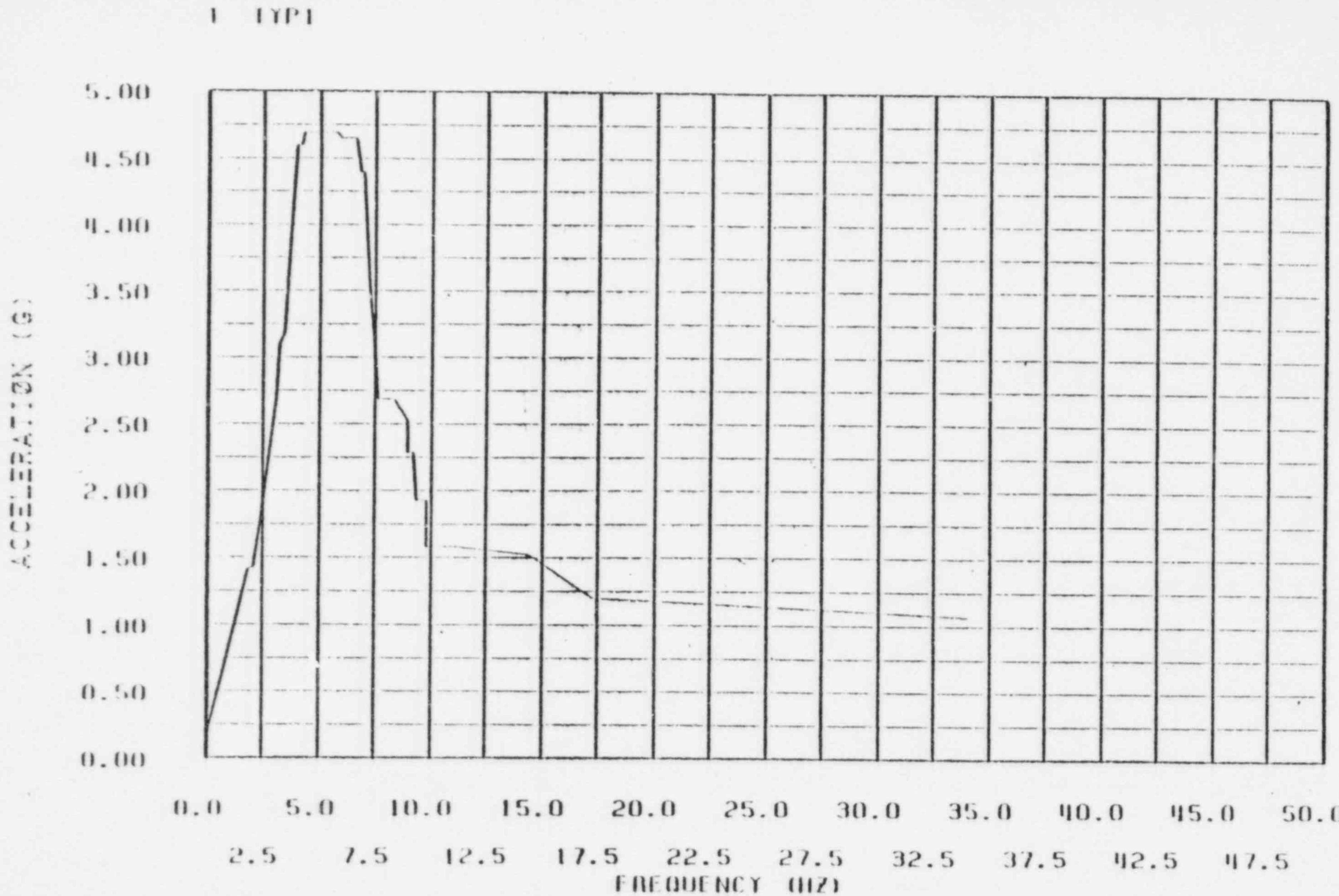


Figure 18. East-West response spectrum for SI-51.

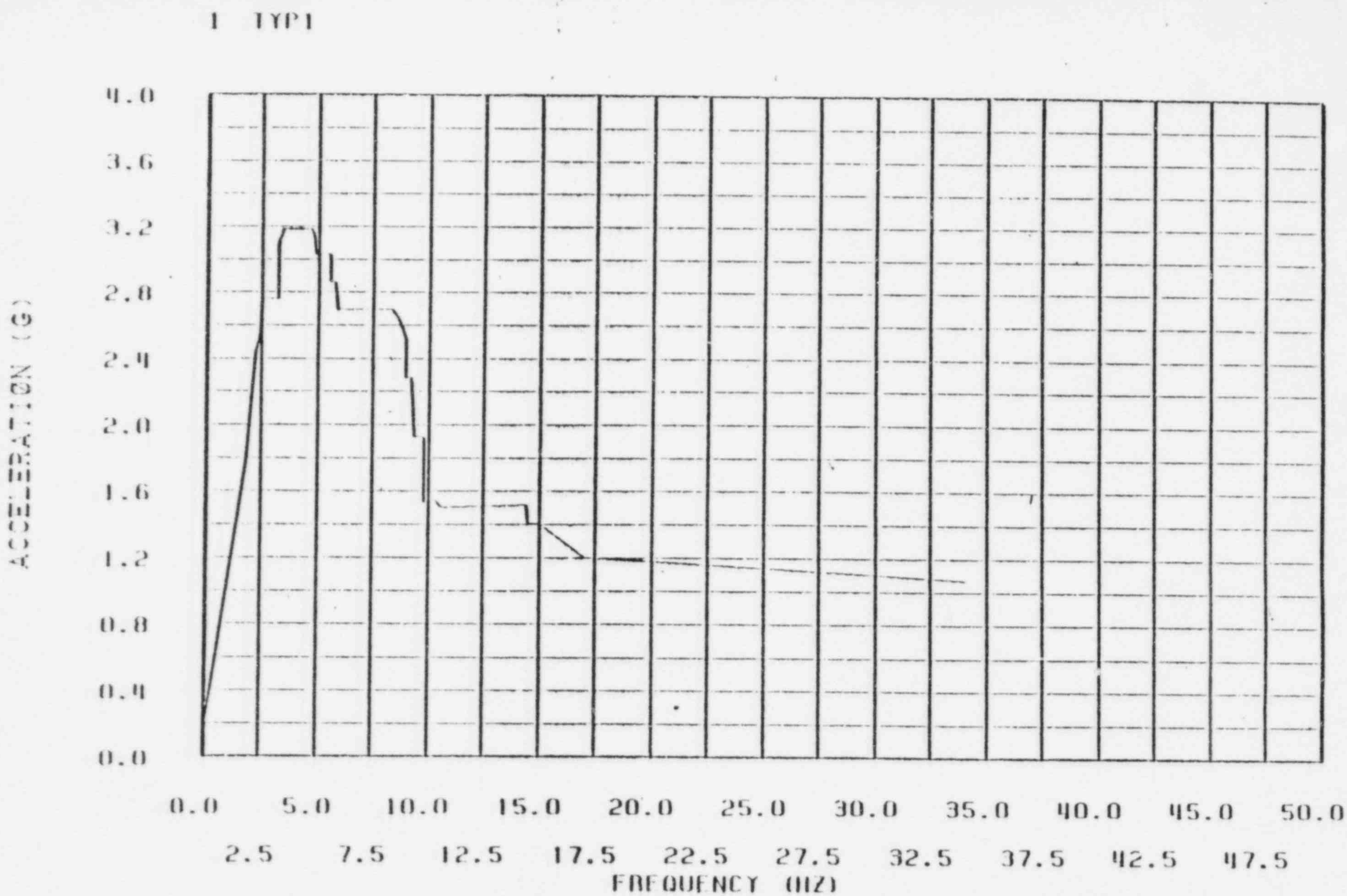


Figure 19. North-South response spectrum for SI-04.

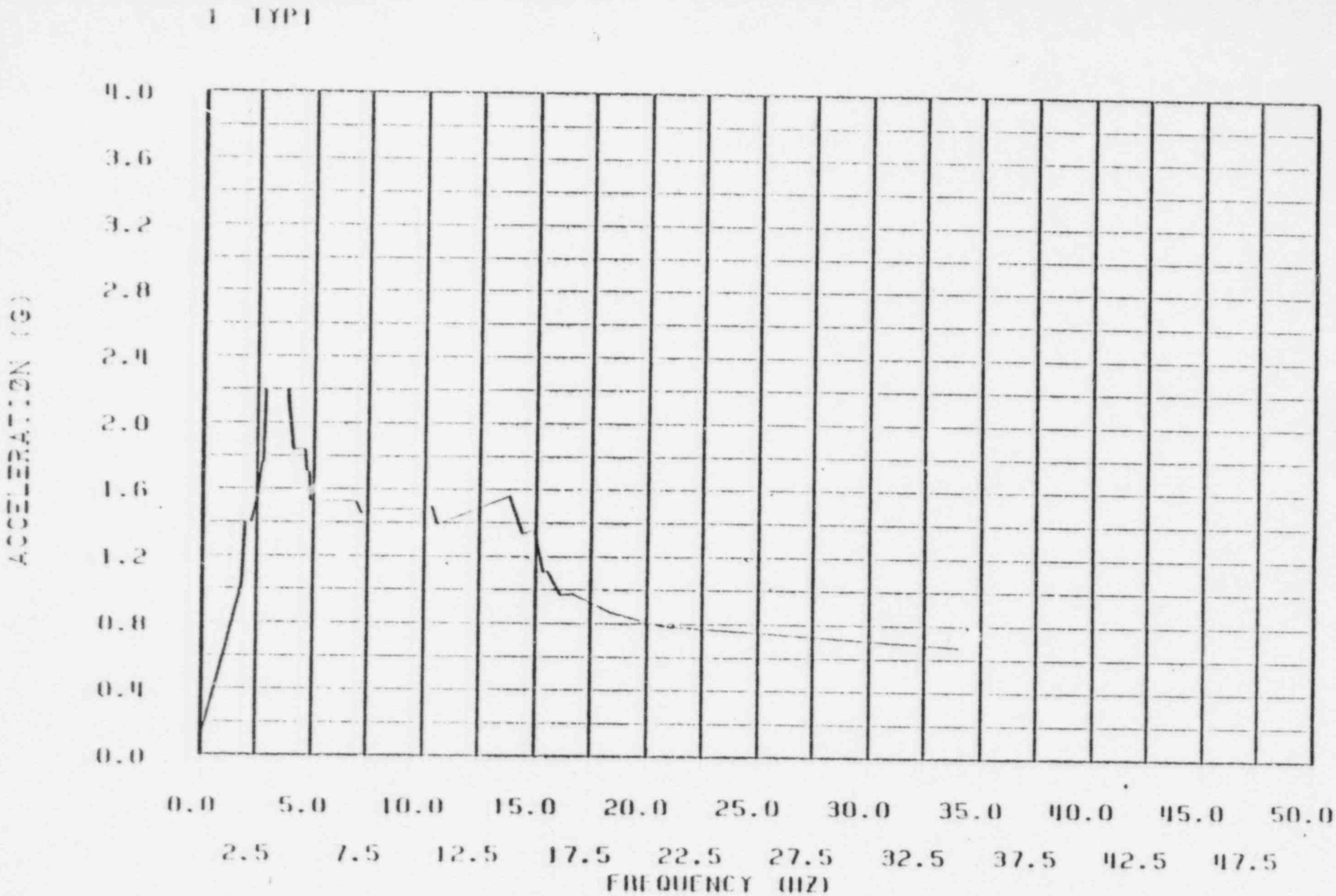


Figure 20. **Vertical response spectrum for SI-04.**

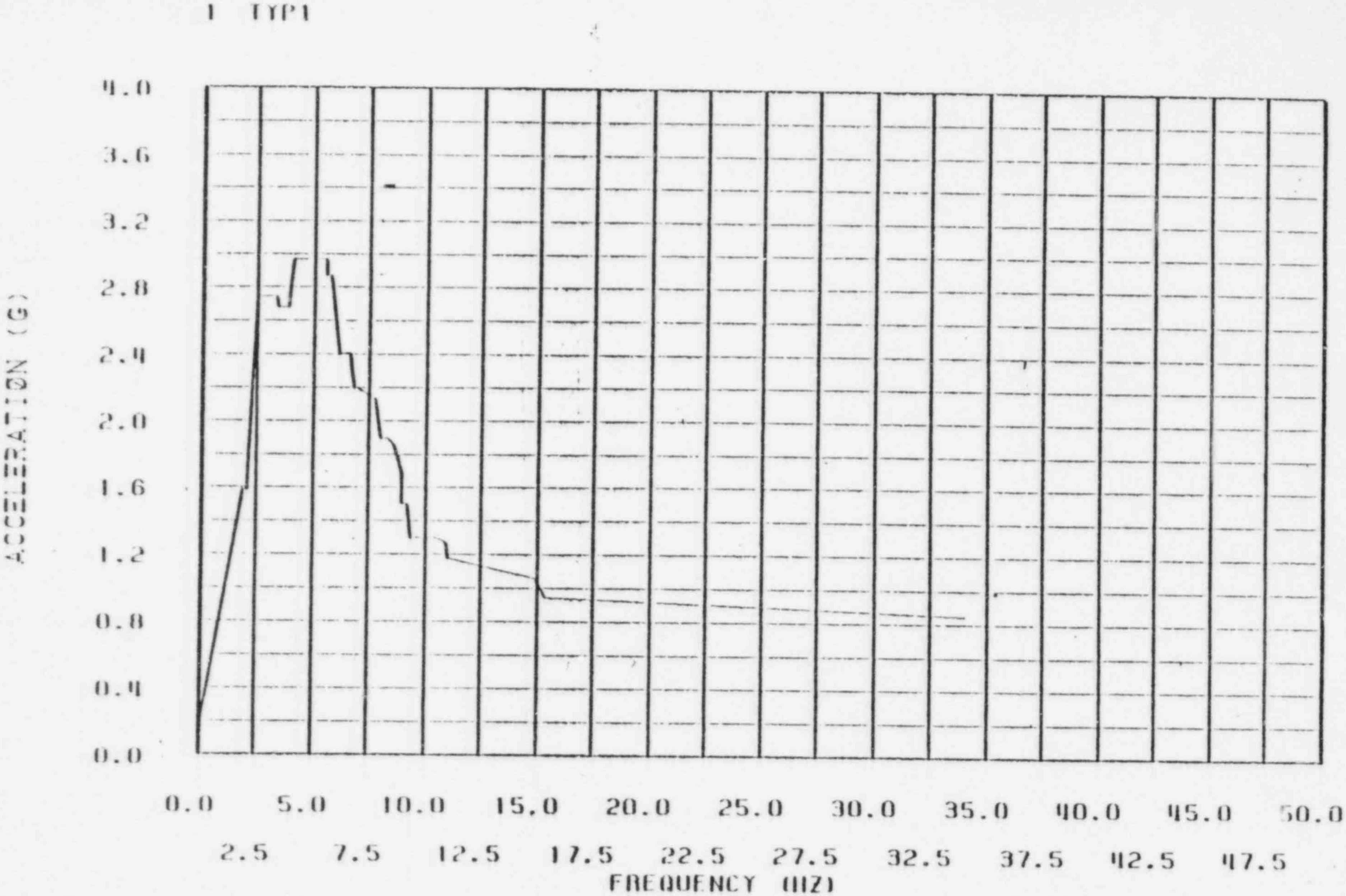


Figure 21. East-West response spectrum for SI-04.

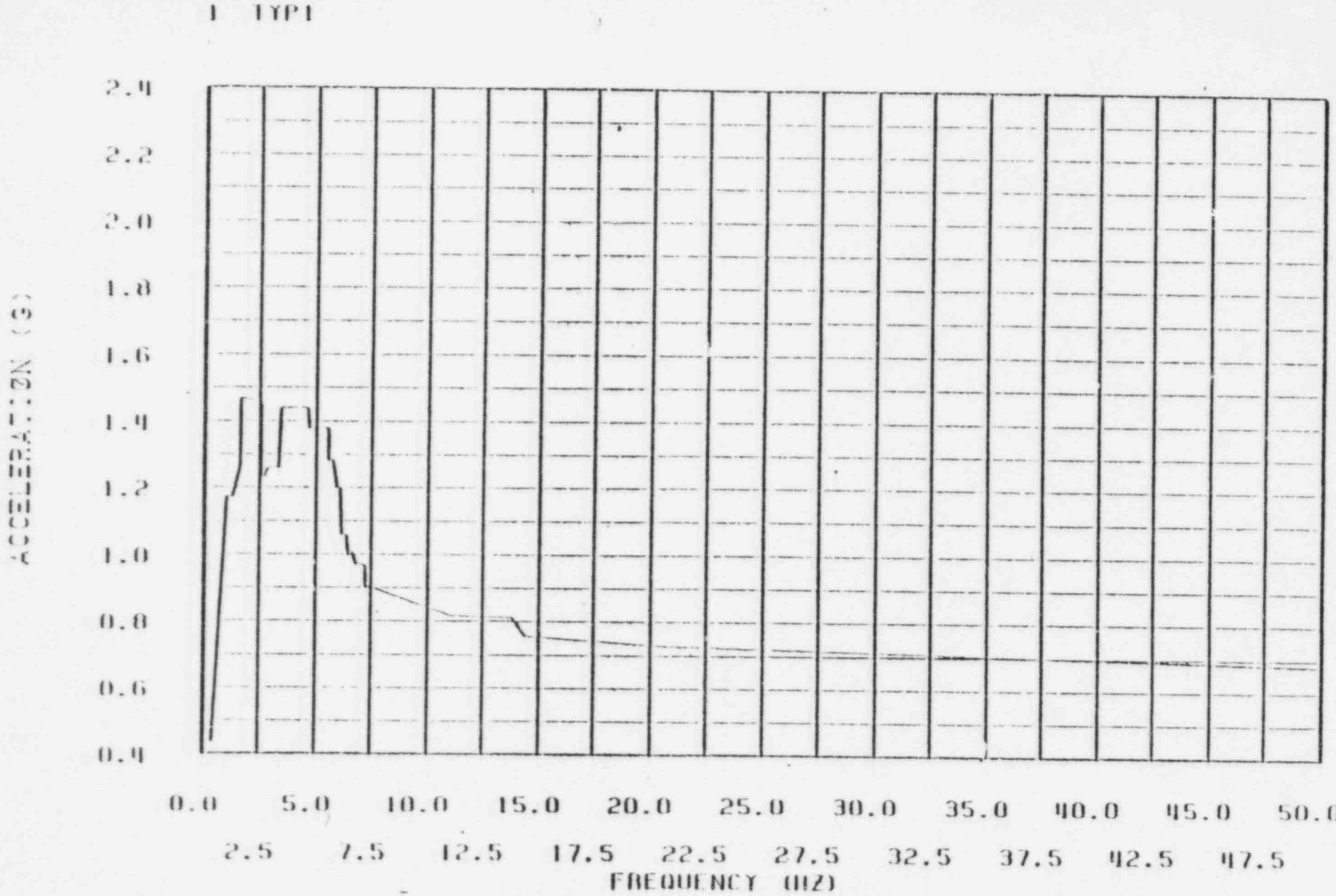


Figure 22. North-South response spectrum for SI-158.

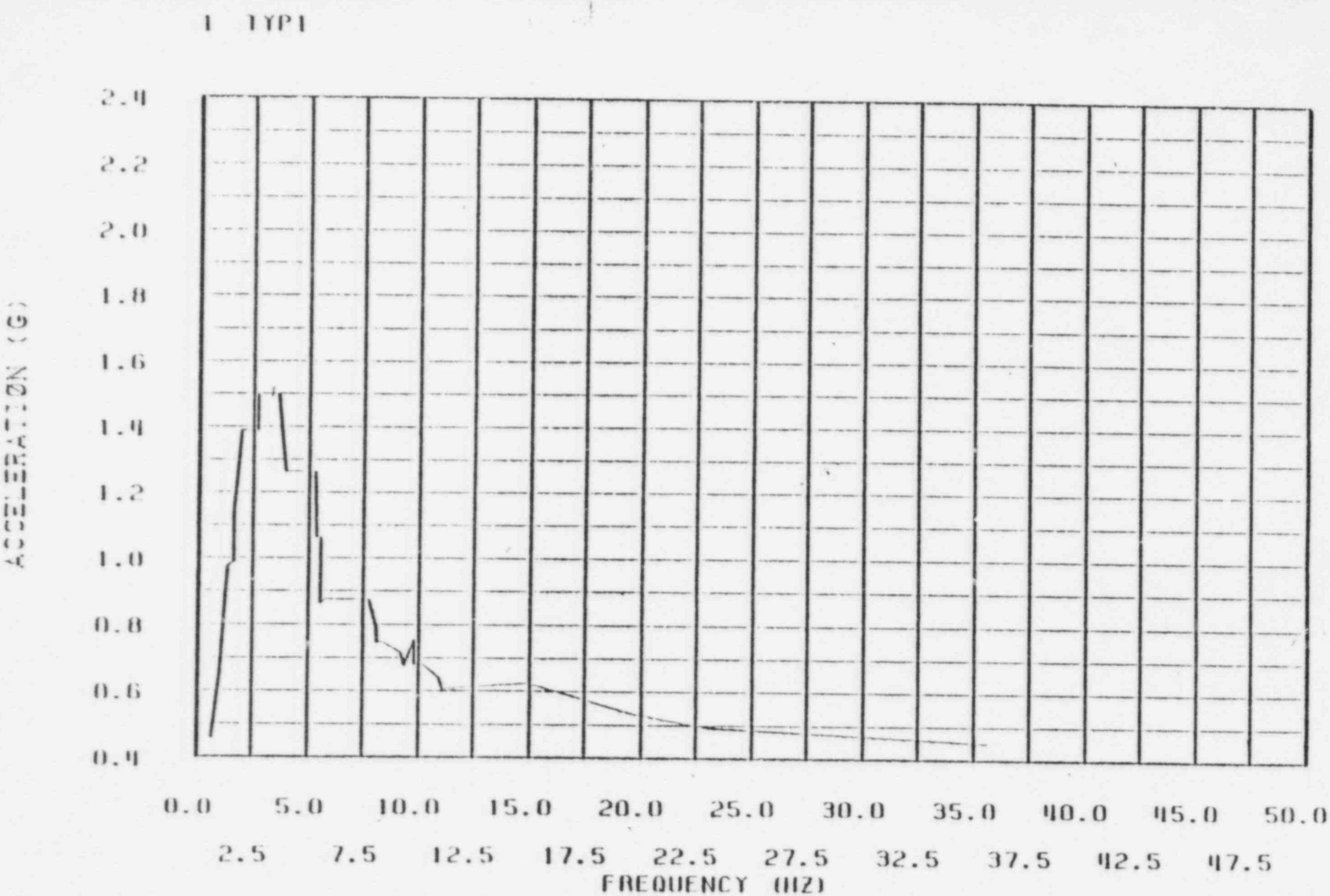


Figure 23. Vertical response spectrum for SI-158.

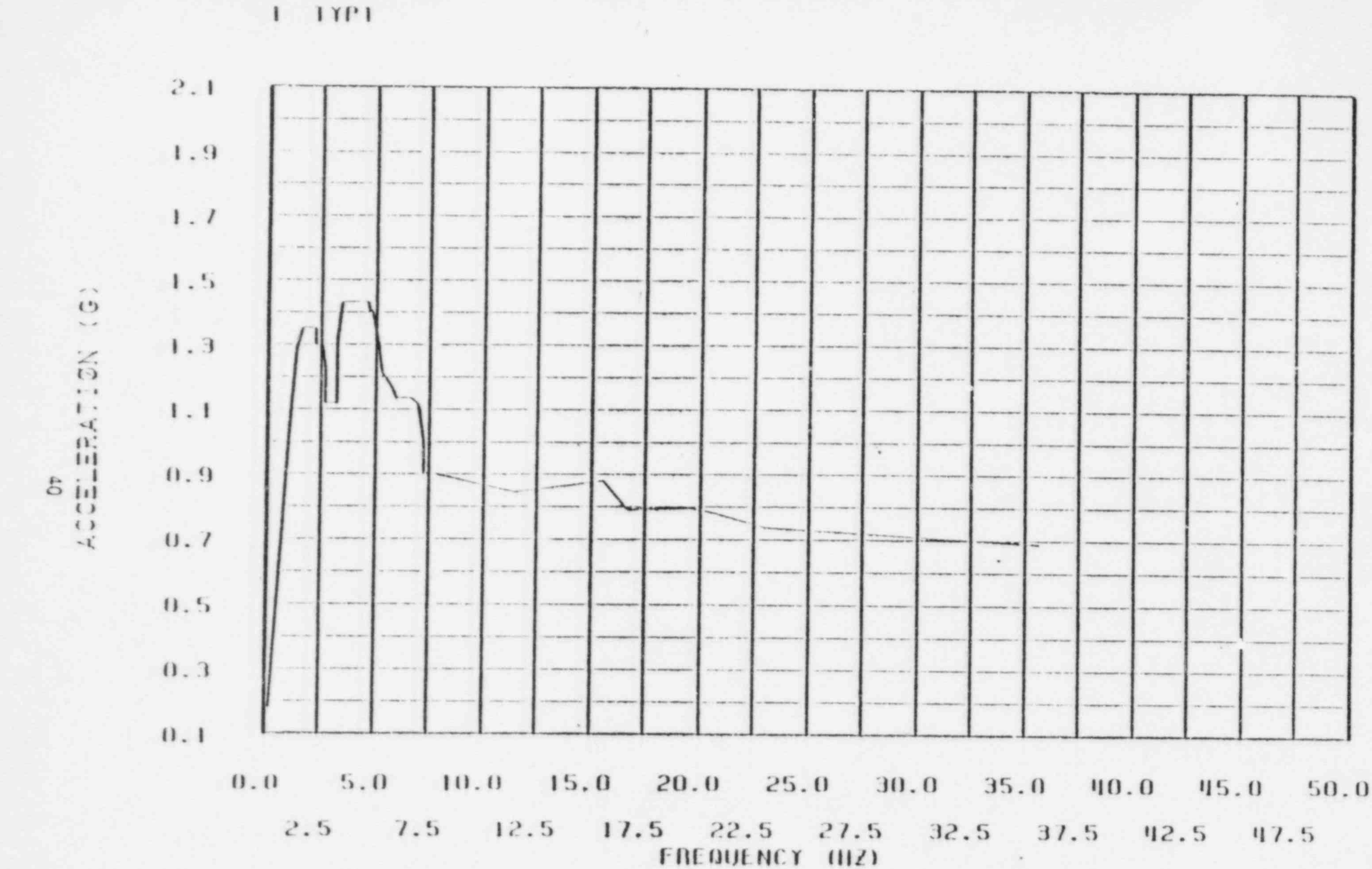


Figure 24. East-West response spectrum for SI-158.

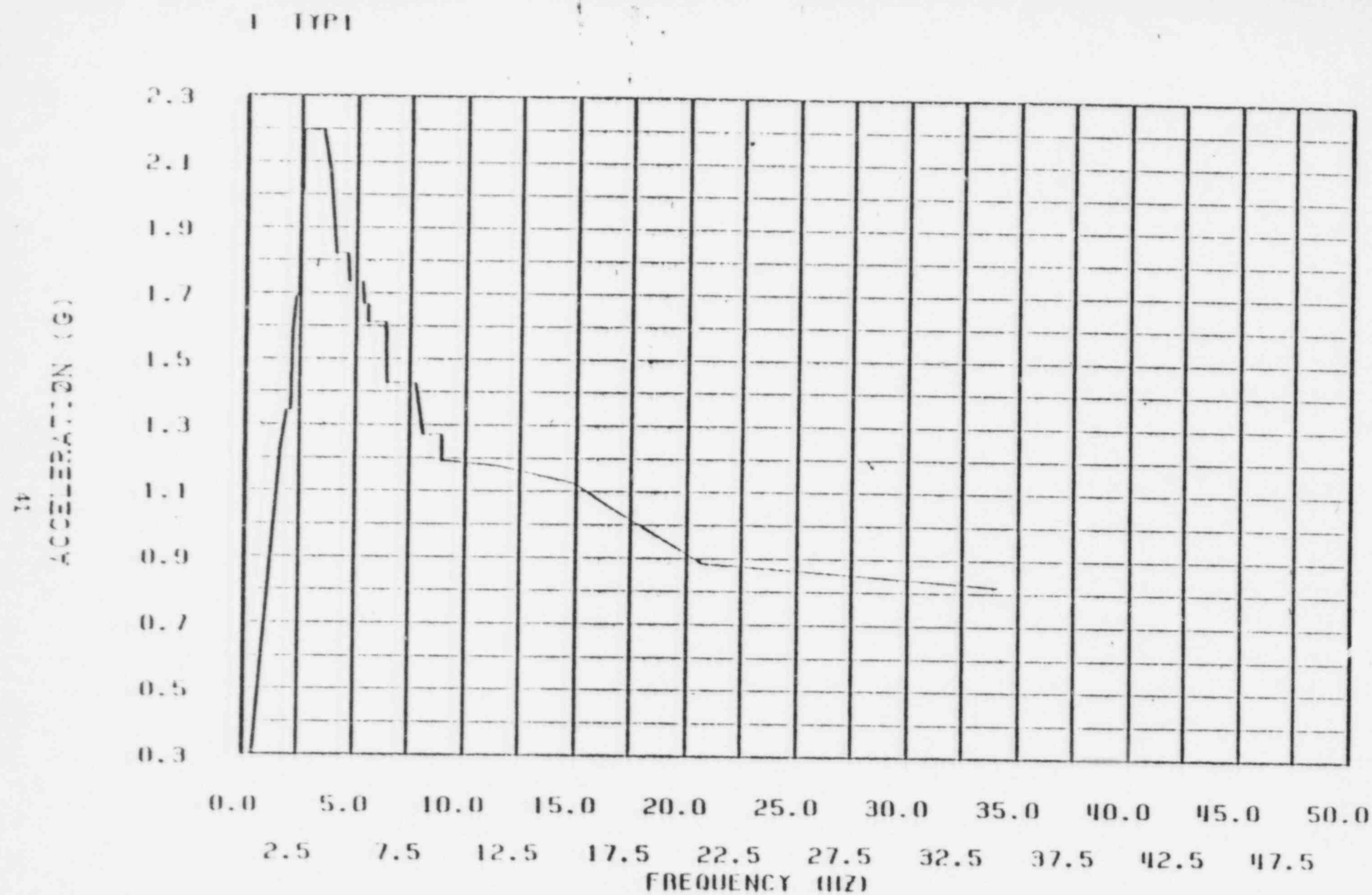


Figure 25. North-South response spectrum for SI-51 tubing.

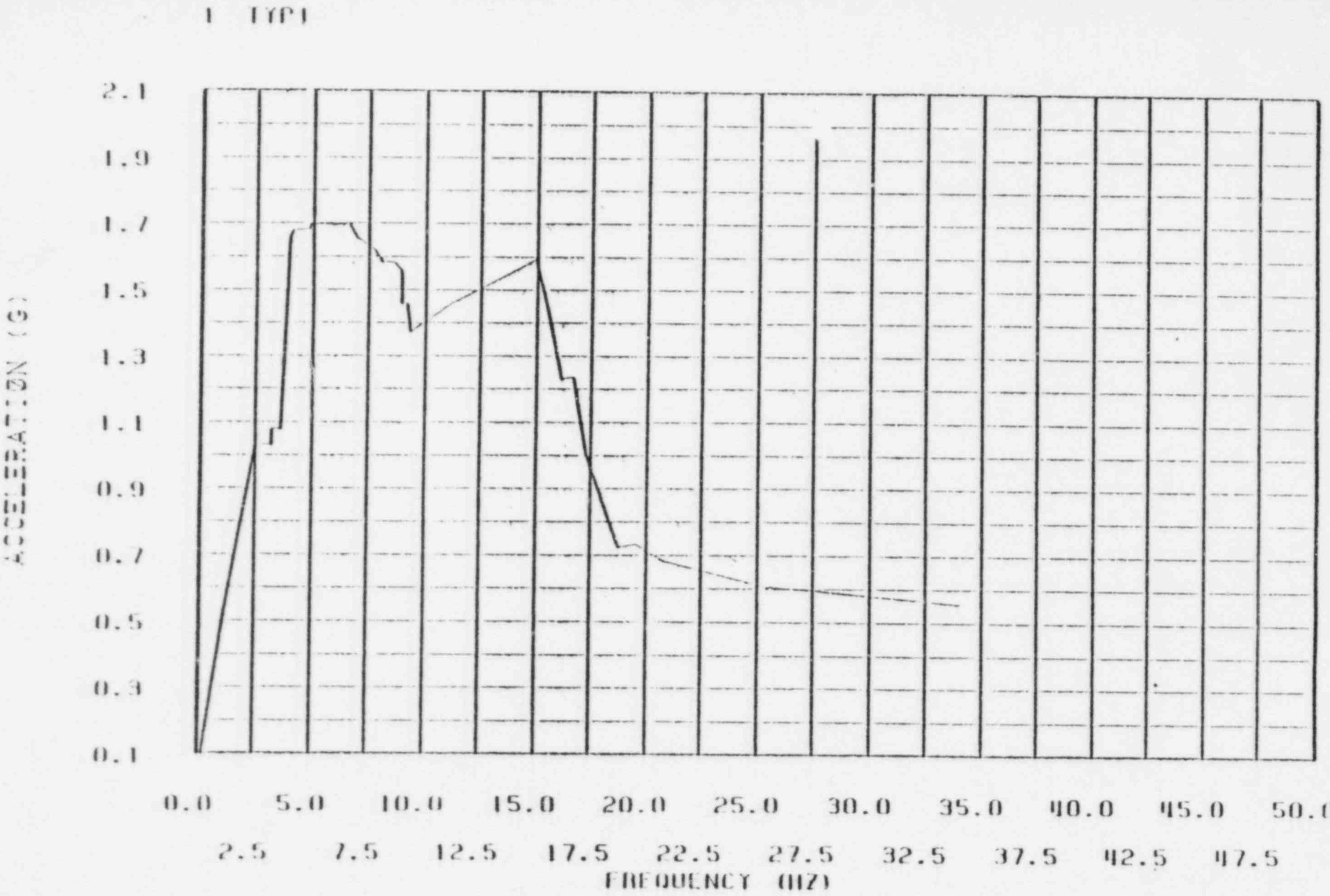


Figure 26. Vertical response spectrum for SI-51 tubing.

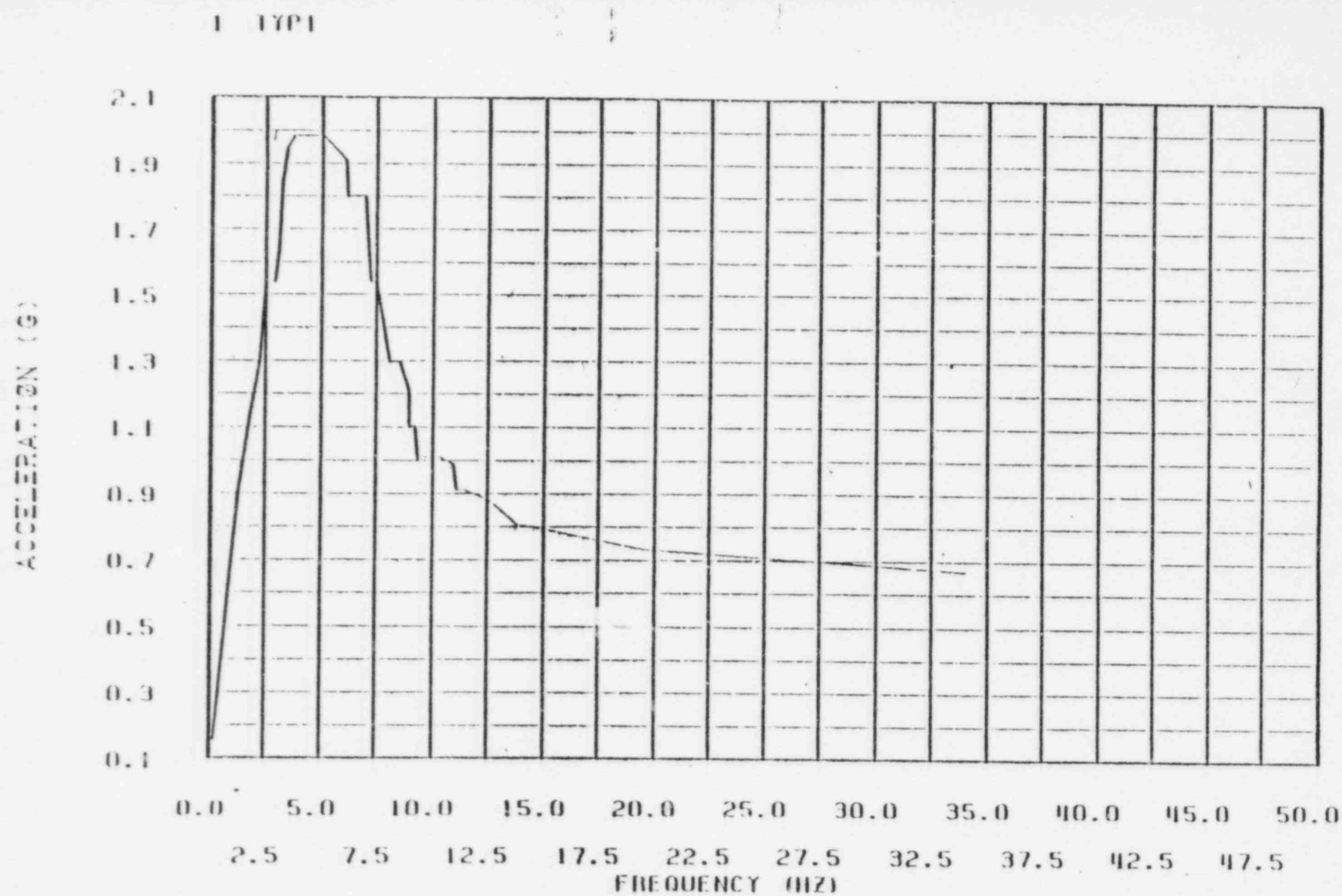


Figure 27. **East-West response spectrum for SI-51 tubing.**

TABLE 1. PIPE DATA AND MATERIAL SPECIFICATIONS--SIS PROBLEM SI-51

Line number	6006-6-150IR 6007-6-150IR 6008-6-150IR	319-12-EG 320-12-EG	6004-14-150IR 6005-14-150IR	319-10-EG 320-10-EG
OD (inches)	6.625	12.75	14.0	10.75
Thickness (inches)	0.432	0.687	0.58	0.593
Weight[a] (lb/ft)	39.86	140.12	139.27	101.97
Material	A312, TP-316	A106-B	A312, TP-316	A106-B
E_{cold} (10^6 psi)	28.3	27.9	28.3	27.9
S_h (psi)	18800	15000	18800	15000
Design temperature (°F)	120	340	120	340
Operating temperature (°F)	120	340	120	340
Design pressure (psi)	900	1350	900	1350
Operating pressure (psi)	900	1350	900	1350

a. Includes weight of pipe, contents, and insulation.

TABLE 2. PIPE DATA AND MATERIAL SPECIFICATIONS--SIS PROBLEM SI-04

Line number	6002-16-151R	318-14-GG	338-8-GG
OD (inches)	16.0	14.0	8.625
Thickness (inches)	0.375	0.375	0.322
Weight[a] (lb/ft)	141.68	122.38	50.24
Material	A312, TP-304	A53-B	A53-B
E_{cold} (10^6 psi)	28.3	27.9	27.9
S_h (psi)	18600	15000	15000
Design temperature (°F)	120	340	95
Operating temperature (°F)	120	340	95
Design pressure (psi)	140	360	360
Operating pressure (psi)	140	360	360

a. Includes weight of pipe, contents, and insulation.

TABLE 3. PIPE DATA AND MATERIAL SPECIFICATIONS--SIS PROBLEM SI-158

Line number	6007-6-1501R	6007-6-2501R
OD (inches)	6.625	6.625
Thickness (inches)	0.432	0.718
Weight[a] (lb/ft)	39.86	60.46
Material	SA312, TP-316	SA312, TP-316
E_{cold} (10^6 psi)	28.3	28.3
S_h (psi)	18800	18800
Design temperature (°F)	120	570
Operating temperature (°F)	120	570
Design pressure (psi)	900	900
Operating pressure (psi)	900	900

a. Includes weight of pipe, contents, and insulation.

TABLE 4. PIPE DATA AND MATERIAL SPECIFICATIONS--SIS PROBLEM SI-51 TUBING

OD (inches)	0.375
Thickness (inches)	0.049
Weight[a] (lb/ft)	0.2
Material	316 SST
E_{cold} (10^6 psi)	28.3
S_h (psi)	18800
Design temperature (°F)	120
Operating temperature (°F)	120
Design pressure (psi)	900
Operating pressure (psi)	900

a. Includes weight of pipe, contents, and insulation.

TABLE 5. PIPING SYSTEM VALVE DESCRIPTIONS

Model	Valve	Weight (lb_f)	Face-to-Face Dimension (in.)
SI-51	HV851A & B	2960/2338[a]	35
	HV852A & B	2160/2338	33
	12-600-222	1463/-	33
SI-04	862-12-C42	750/-	27.5
	HV-853A	2550/1275	33
	HV-854A	2210/1105	30
	14-300-438	1473/737	32.5
	861A-16-G42	1053/527	16
SI-158	MOV-850C	801/393	21
	867C-6-C58	259/-	17
SI-51 Tubing	870E-3/4"-T5	5/-	5
	SIS-FT-912 iso valve	9/0	2

a. The first number is the weight of the valve body and the second is the weight of the valve stem.

TABLE 6. SUMMARY OF FIRST TEN NATURAL FREQUENCIES AND PERIODS OF VIBRATION--SIS MODEL SI-51

	W Rods		W/O Rods	
Mode	f (Hz)	T (second)	f (Hz)	T (second)
1	4.739	0.211	4.455	0.225
2	5.518	0.181	5.147	0.194
3	5.794	0.173	5.794	0.173
4	7.731	0.129	6.111	0.164
5	8.298	0.121	7.645	0.131
6	8.355	0,120	8.271	0.121
7	9.127	0.110	8.380	0.119
8	9.805	0.102	8.805	0.114
9	10.697	0.094	9.465	0.106
10	11.037	0.091	10.464	0.096

TABLE 7. SUMMARY OF FIRST TEN NATURAL FREQUENCIES AND PERIODS OF VIBRATION--SIS MODEL SI-04

	W Rods		W/O Rods	
Mode	f (Hz)	T (second)	f (Hz)	T (second)
1	1.024	0.977	1.024	0.976
2	3.277	0.305	3.219	0.311
3	4.545	0.220	3.639	0.275
4	5.364	0.186	4.545	0.220
5	7.209	0.139	5.364	0.187
6	7.433	0.135	7.209	0.138
7	7.585	0.132	7.437	0.134
8	8.638	0.116	7.586	0.132
9	8.968	0.112	8.638	0.116
10	9.602	0.104	8.972	0.112

TABLE 8. SUMMARY OF FIRST TEN NATURAL FREQUENCIES AND PERIODS OF VIBRATION--SIS MODEL SI-158

Mode	f (Hz)	T (second)
1	6.288	0.159
2	11.141	0.090
3	13.236	0.076
4	14.010	0.071
5	15.529	0.064
6	16.197	0.062
7	18.456	0.054
8	19.290	0.052
9	20.911	0.048
10	23.716	0.042

TABLE 9. SUMMARY OF FIRST TEN NATURAL FREQUENCIES AND PERIODS OF VIBRATION--SIS MODEL SI-51 TUBING

Mode	f (Hz)	T (second)
1	5.791	0.173
2	9.046	0.110
3	9.202	0.109
4	11.587	0.086
5	12.268	0.082
6	13.815	0.072
7	15.480	0.064
8	18.422	0.054
9	18.584	0.054
10	23.364	0.043

TABLE 10. COMPARISON OF STRESS RESULTS FOR SI-51

Node/DP EG&G/Licensee	Component	SIF EG&G/Licensee	Inertial Stress: Equation 9 — Stress (ksi) EG&G	Inertial Stress: Equation 9 — Stress (ksi) Impell	Inertial Stress: Equation 9 — % Difference Based on Max. Stress (62.5 ksi)	2(SAM) Stress: Equation 10 — Stress (ksi) EG&G	2(SAM) Stress: Equation 10 — Stress (ksi) Licensee	2(SAM) Stress: Equation 10 — % Difference Based on Max. Stress (17.2 ksi)
16/7	Reducer-lrg	3.000	63.9	61.1	4	9.1	9.3	1
15/10	Reducer-sml	3.000	36.5	34.9	3	5.2	5.4	1
20/25	Straight pipe	1.000	12.9	12.2	1	1.5	1.6	1
22/30	Straight pipe	1.000	12.8	12.0	1	1.5	1.6	1
30/36	Tee-run	1.427/1.426	13.9	12.9	2	2.0	2.3	2
50/45	Tee-branch	1.427/1.426	15.4	10.6	8	3.0	3.1	1
	-North run	1.427/1.426	14.4	13.2	2	3.8	3.7	1
	-South run	1.427/1.426	12.5	12.6	0	3.2	3.2	0
55/50	Reducer-lrg	2.000	15.9	12.7	5	5.0	4.8	1
60/55	Reducer-sml	2.000	15.1	12.1	5	4.5	4.2	2
830/300	Straight pipe	1.000	11.3	9.2	3	1.8	1.7	1
80/62	Straight pipe at branch	1.500	10.5	9.5	2	2.6	2.6	0
95/70b	Elbow	1.000	8.2	7.2	2	2.0	1.9	1
105/76a	Elbow	1.000	8.6	8.0	1	1.9	1.8	1
110/76b	Elbow	1.000	8.3	8.6	0	2.3	2.4	1
145/105a	Elbow	1.000	8.8	8.8	0	4.3	4.4	1
180/115	Straight pipe	1.000	11.1	11.0	0	10.1	9.4	4
845/305	Straight pipe near valve	1.000	12.7	9.8	5	1.7	1.7	0
850/310a	Elbow	1.848	16.3	12.2	7	4.9	4.6	2
875/325a	Elbow	1.848	14.2	10.6	6	5.2	4.4	5
885/330a	Elbow	2.423/2.421	12.2	11.0	4	3.7	3.6	1
900/910a	Elbow	1.848	10.4	10.2	0	1.8	1.6	1
915/906a	Elbow	1.848	8.0	7.4	1	0.3	0.1	1
250/156	Branch, West run	2.077	13.2	11.0	4	16.5	17.8	7
700/449	Elbow	1.643	8.8	8.7	0	17.6	16.5	6
425/260	Reducer-sml	2.000	26.4	29.2	4	5.0	5.2	1
430/265	Reducer-lrg	2.000	27.0	28.9	3	5.2	5.8	3
435/350	Tee-Branch	1.427/1.426	29.9	27.5	4	5.2	7.7	14
	-North run	1.427/1.426	21.6	22.6	2	3.8	4.5	4
	-South run	1.427/1.426	35.1	30.4	8	5.3	7.4	12
450/395	Straight pipe	1.000	18.7	17.0	3	2.4	3.0	3
660/355	Tee-branch	1.427/1.426	26.8	23.8	5	2.9	4.8	11
	-South run	1.427/1.426	26.9	24.0	5	2.9	4.5	9
675/370	Elbow	1.848	15.5	15.6	0	3.0	3.5	3
680/380	Elbow	1.848	23.3	21.7	3	4.4	4.2	1
680/380	Reducer-sml	3.000	34.0	31.8	4	7.1	6.8	2
685/382	Reducer-lrg	3.000	50.4	54.8	7	12.6	11.6	6

TABLE 11. COMPARISON OF STRESS RESULTS FOR SI-04

Node/DP EG&G/Licensee	Component	SIF EG&G/Licensee	Inertial Stress: Equation 9 Stress (ksi) EG&G	Inertial Stress: Equation 9 Stress (ksi) Licensee	Inertial Stress: Equation 9 % Difference Based on Max. Stress (23.85 ksi)	2(SAM) Stress: Equation 10 Stress (ksi) EG&G	2(SAM) Stress: Equation 10 Stress (ksi) Licensee	2(SAM) Stress: Equation 10 % Difference Based on Max. Stress (11.05 ksi)
60/70	Straight pipe	1.000	4.4	5.1	3	0.5	0.4	1
70/80	Straight pipe	1.000	5.4	4.7	3	0.7	0.6	1
75/90	Straight pipe	1.000	4.5	3.8	3	0.6	0.6	0
85/100	Straight pipe	1.000	7.4	7.5	0	1.6	1.5	1
100/110	Straight pipe	1.000	10.4	10.5	0	0.8	0.8	0
110/120	Straight pipe	1.000	8.0	7.9	0	0.7	0.7	0
120/130	Straight pipe	1.000	12.3	12.5	1	0.6	0.6	0
130/140	Straight pipe	1.000	5.2	3.3	8	1.4	1.4	0
135/145	Elbow	3.227/3.225	11.6	7.6	17	4.8	4.9	1
140/145	Elbow	3.227/3.225	14.2	11.0	13	5.0	5.0	0
145/150	Straight pipe	1.000	7.2	5.7	6	1.6	1.6	0
150/153	Straight pipe	1.000	8.8	7.2	7	1.9	2.0	1
155/155	Elbow	3.227/3.225	19.3	15.7	15	5.8	5.5	3
160/155	Elbow	3.227/3.225	15.4	12.4	13	4.1	4.2	1
175/165	Straight pipe	1.000	23.5	16.2	31	5.5	5.4	1
190/175	Straight pipe	1.000	14.7	14.3	2	6.1	6.0	1
200/190	Straight pipe	1.000	10.5	9.2	5	1.9	1.9	0
205/200	Straight pipe	1.000	13.4	12.4	4	1.9	2.1	2
215/210	Straight pipe	1.000	6.7	7.1	2	3.9	3.8	1
220/215	Elbow	3.227/3.225	11.1	12.0	4	11.2	10.9	3
225/215	Elbow	3.227/3.225	11.9	11.6	1	8.2	7.7	5
230/220	Elbow	3.227/3.225	15.0	13.4	7	8.6	8.3	3
235/220	Elbow	3.227/3.225	14.2	12.0	9	9.1	9.2	1
250/225	Elbow	3.227/3.225	14.7	13.8	4	7.5	8.0	5
255/225	Elbow	3.227/3.225	11.7	11.2	2	6.9	7.7	7
265/230	Elbow	3.227/3.225	10.1	5.4	20	8.2	7.2	9
270/230	Elbow	3.227/3.225	9.8	5.9	16	5.6	6.8	11
285/235	Elbow	4.229/4.232	13.5	8.1	23	7.3	6.1	11
290/235	Elbow	4.229/4.232	16.8	9.2	32	6.3	6.6	3
320/245	Tee-branch	2.539/2.538	13.4	9.4	17	4.6	5.0	4
	-North run		12.5	8.9	15	4.6	5.0	4
335/247	Reducer-lrg	2.000	11.5	7.0	19	3.9	3.1	7
340/247	Reducer-sml	2.000	10.2	7.2	13	3.3	3.6	3
346/255	Elbow	3.851/3.841	16.8	11.0	24	6.2	6.1	1
350/255	Elbow	3.851/3.841	19.0	13.1	25	6.3	5.8	5
360/260	Tee-branch	2.317/2.316	13.5	9.9	15	3.8	3.9	1
	-East run		14.2	11.7	10	3.6	4.0	4
	-North run		14.2	12.5	7	1.9	2.0	1
370/270	Reducer-lrg	2.000	19.2	24.2	21	5.0	6.9	17
375/270	Reducer-sml	2.000	20.5	13.1	30	5.0	3.2	16
385/285	Elbow	3.851/3.841	20.9	17.0	16	3.1	2.6	5
390/285	Elbow	3.851/3.841	20.2	14.5	24	3.2	1.6	14
390/290	Elbow	3.851/3.841	20.2	14.5	24	3.2	1.6	14
395/290	Elbow	3.851/3.841	14.7	16.5	18	2.9	1.8	10

TABLE 12. COMPARISON OF STRESS RESULTS FOR SI-158

Node/DP EG&G/Licensee	Component	SIF EG&G/Licensee	Inertial Stress: Equation 9 — Stress (ksi) EG&G	Inertial Stress: Equation 9 — Stress (ksi) Licensee	Inertial Stress: Equation 9 — % Difference Based on Max. Stress (13.1 ksi)	2(SAM) Stress: Equation 10 — Stress (ksi) EG&G	2(SAM) Stress: Equation 10 — Stress (ksi) Licensee	2(SAM) Stress: Equation 10 — % Difference Based on Max. Stress (6.75 ksi)
5/1000	Straight pipe	1.000	5.5	6.0	4	2.2	3.1	13
20/1030	Straight pipe	1.000	4.4	3.6	6	0.2	0.2	0
35/1090	Straight pipe	1.000	5.1	4.3	6	0.8	1.0	3
40/1100	Straight pipe	1.000	4.9	4.1	6	1.0	1.1	1
45/C10B	Elbow	1.643	4.4	3.8	5	0.8	0.6	3
50/C10A	Elbow	1.643	4.2	3.6	5	0.6	0.6	0
55/C9B	Elbow	1.643	4.1	3.3	6	1.0	1.5	7
60/C9A	Elbow	1.643	4.3	3.4	7	1.2	2.0	15
70/C8B	Elbow	1.643	4.2	3.4	6	1.6	1.2	6
75/C8A	Elbow	1.643	4.2	3.5	5	1.2	0.9	4
80/C7B	Elbow	1.643	4.2	3.6	5	0.8	1.0	3
85/C7A	Elbow	1.643	4.2	3.8	3	0.8	1.6	12
95/C6B	Elbow	1.643	4.3	4.0	2	1.2	1.1	1
100/C6A	Elbow	1.643	4.2	3.9	2	1.2	1.1	1
105/1270	Straight pipe	1.000	4.1	3.6	4	0.8	0.6	3
115/1290	Straight pipe	1.000	4.0	3.7	2	0.6	0.8	3
120/1320	Straight pipe	1.000	4.2	4.4	2	1.2	1.2	0
125/C5B	Elbow	1.000	4.3	4.4	1	1.2	1.2	0
130/C5A	Elbow	1.000	4.5	4.4	1	1.4	1.3	1
135/1360	Straight pipe	1.000	4.6	4.8	2	2.0	1.7	4
140/1350	Run @ branch	1.500/2.100[a]	5.2	6.2	8	3.4	4.2	12
145/C4B	Elbow	1.643	5.6	5.7	1	4.0	3.6	6
150/C4A	Elbow	1.643	5.9	6.4	4	4.6	4.2	6
155/1430	Straight pipe	1.000	5.5	6.2	5	3.0	2.6	6
160/1440	Straight pipe	1.000	5.5	5.9	3	3.0	2.6	6
165/1460	Straight pipe	1.000	4.9	5.3	3	1.8	1.9	1
195/C3B	Elbow	1.643	6.2	7.8	12	8.1	6.8	19
200/C3A	Elbow	1.643	5.[illegible]	8.1	18	7.0	6.5	7
205/V2C	Straight pipe	1.000	5.7	7.5	14	3.8	3.7	1
230/1700	Elbow	1.099	9.2	10.6	11	3.8	2.7	16
235/1704	Elbow	1.099	9.6	10.9	10	4.0	2.8	18
235/1705	Elbow	1.099	9.6	11.3	13	4.0	2.9	16
240/1706	Elbow	1.099	10.0	12.5	19	4.6	3.2	21
250/1717	Straight pipe	1.000	12.7	13.5	6	4.0	2.8	18

a. The EG&G analyst assumed a full penetration weld in place below the fillet weld per common nuclear grade weld practice. The licensee's analyst conservatively asssumed that only the visible weld could be credited. This led to the difference in SIF.

TABLE 13. COMPARISON OF STRESS RATIO RESULTS FOR SI-51 SUPPORTS

Support ID	Type	Node/DP	Component	Stress Ratio EG&G	Stress Ratio Licensee	Notes
SI-05-0320-H013	snubber	22/30	anchor bolt	1.6	--	1
SI-05-6005-H006	strut	260/157	clamp	0.3	0.9	2
SI-02-6005-H005	snubber	375/225	snubber	1.8	1.8	3
SI-06-6005-H004	snubber	380/230	clamp	1.8	1.0	4
SI-06-0319-H007	snubber	485/537	anchor bolt	2.0	0.9	5
SI-05-0320-H017	spring hanger	855/310	spring hanger	0.86	0.87	
SI-05-0320-H011	snubber	861-315	anchor bolt	0.64	0.96	6

1. The supports added to SI-51 made the snubber unnecessary and it was removed.

2. Based on the shape and dimensions recorded in the field, the EG&G analyst concluded the clamp was part of the snubber assembly originally installed. The licensee's analyst made note of the discrepancy, but used the load rating for the clamp associated with the strut assembly that replaced the snubber. This was conservative.

3. The support had been turned over to the licensee's design group for modification to increase load capacity.

4. The EG&G analyst used the published catalog load rating. The licensee's analyst contacted the manufacturer and obtained an increased load rating for the clamp.

5. Supports added to the piping in the vicinity of this support reduced the loads on it to acceptable levels.

6. Supports added to the piping in the vicinity of this support increased its loads.

TABLE 14. COMPARISON OF STRESS RATIO RESULTS FOR SI-158 SUPPORTS

Support ID	Type	Node/DP	Component	Stress Ratio EG&G	Stress Ratio Licensee	Notes
SI-01-6007-H005	strut	35/1090	clamp	0.23	0.21	
SI-01-6007-H30I	guide	105/1270	baseplate	0.70	0.96	1
SI-01-6007-H00E	snubber	155/1430	baseplate	0.33	0.34	
SI-01-6007-H00D	snubber	160/1440	baseplate	0.52	0.39	2
SI-01-6007-H00D	snubber	165/1460	anchor bolts	0.29	0.93	3
SI-01-6007-H008	spring hanger	180/1500	spring hanger	0.78	0.79	
SI-01-6007-H00A	spring hanger	240/1710	spring hanger	0.72	0.58	4

1. The EG&G analyst did a finite element analysis, the licensee's analyst a simple beam calculation. Both are acceptable.

2. The EG&G analyst did a simple beam calculation, the licensee's analyst a finite element analysis. Both are acceptable.

3. The licensee's analysis was based on factoring the results of a previous analysis to account for different loads. In the previous analysis support loads had been increased to account for the possibility of support dynamic response. Current criteria ensure support rigid response, so that support loads need not be increased.

4. Different hot loads were used. EG&G's hot load was based on design drawings, because the hot load hanger setting was not recorded during walkdown. The licensee's load was based on the current setting.

APPENDIX A

DESCRIPTION OF COMPUTER CODE

APPENDIX A

COMPUTER PROGRAM DESCRIPTION

The NUPIPE-II computer program performs linear elastic analysis of three-dimensional piping systems subject to thermal, deadweight, seismic, and other static and dynamic loads. The NUPIPE-II program is also designed to perform stress and fatigue analyses in accordance with the ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components, 1974 Edition through the Summer 1975 Addenda; and the ANSI B31.1 Code, 1967 and Summer 1973 versions. NUPIPE-II may also be utilized to assure compliance with later piping code requirements provided the analyst takes into consideration any possible changes. Piping systems of more than one classification can be analyzed.

NUPIPE-II utilizes the finite element method of analysis with special features incorporated to accommodate specific requirements of piping system analysis. In accordance with the finite element method, the continuous piping is mathematically idealized as an assembly of elastic structural members connnecting discrete nodal points. Nodal points are placed in such a manner as to isolate particular types of piping elements, such as straight runs of pipe, elbows, valves, etc., for which force-deformation characteristics can be categorized. Nodal points are also placed at all discontinuities, such as piping supports, concentrated weights, branch lines, and changes in cross-section. System loads such as weights, equivalent thermal forces, and earthquake inertia forces are applied at the nodal points. For the deadweight and dynamic time-history and response spectra analyses, distributed weight properties of the piping as well as concentrated weights, such as valves, pumps, or snubbers, can be considered. A lumped mass model of the piping system is used for all dynamic analyses. Both translational and rotational degrees-of-freedom may be considered.

For further information concerning NUPIPE-II capabilities or analytical procedures, contact Applied Mechanics Branch of EG&G Idaho, Inc.

APPENDIX B

MICROFICHE OF COMPUTER OUTPUT

NOTE: MICROFICHE OF COMPUTER OUTPUT (PAGES B-2 TO 5) ARE AVAILABLE IN THE PUBLIC DOCUMENT ROOM and LOCAL PUBLIC DOCUMENT ROOM

From Page B2 TO

B5 - are

Microfiche

Eqn 9 Calculation

1) $M_a = [M_x^2 + M_y^2 + M_z^2]^{1/2}$ (wt moment)

2) $M_b = [M_x^2 + M_y^2 + M_z^2]^{1/2}$ (seismic moment)

3 Seismic stress = $\dfrac{.75(SIF)(M_A + M_b)}{(1000)Z}$

4 Total = pressure + seismic

Eqn 10 calculation

1) $M = [M_x^2 + M_y^2 + M_z^2]^{1/2}$

2) Stress = $\dfrac{(SIF)M}{(1000)Z}$

Calculation of stresses where NUPIPE SIF couldn't be specified correctly.

Run AFBX, 85/11/19

ST-51 Reducer Eqn 10 Stress Calc.

Node	Do	tn	Mx	2# SOM My	2# SOM Mz	M	SIF	Z	Stress
10	10.75	0.593	131672	78174	81845	173599	3.0	45.54	11.4
15	12.75	0.687	120461	67557	81845	160549	3.0	74.6	6.5
55	12.75	0.687	55315	132010	130576	193806	2.0	74.6	5.2
60	14.00	0.580	55315	117403	119653	176591	2.0	78.79	4.5
425	14.00	0.580	156079	81079	104412	209938	2.0	78.79	5.3
430	12.75	0.687	156079	102013	108110	215599	2.0	74.6	6.8
650	12.75	0.687	99558	160767	49925	193080	3.0	74.6	7.8
655	10.75	0.593	91926	178497	49925	206670	3.0	45.54	13.6

II-51 Reducer Eqn 9 Stress Calc

			Weight				MHE						Stress		
[illegible]	D_o	t_m	M_x	M_y	M_z	M_a	M_x	M_y	M_z	M_b	SIF	Z	pressure	seismic	Total
10	10.75	0.593	91243	11362	41066	100701	638256	889946	267671	1123459	3.0	45.54	6.12	60.48	66.6
15	12.75	0.687	79473	15565	41066	90600	578214	730136	267761	964085	3.0	74.6	6.26	31.97	38.2
55	12.75	0.687	1667	28636	23390	37012	183875	258082	281021	423544	2.0	74.6	6.26	9.26	15.5
60	14.00	0.580	1667	25719	10605	27870	183875	160739	279413	371105	2.0	78.79	8.15	7.60	15.7
425	14.00	0.580	307	11919	64274	76292	240782	487463	456774	709962	2.0	78.79	8.15	14.85	23.0
410	12.75	0.687	307	12268	120776	121398	240782	442524	460840	682631	2.0	74.6	6.26	16.17	22.4
620	12.75	0.687	18100	8113	18493	27119	325042	776047	256654	879675	3.0	74.6	6.26	27.35	33.6
685	10.75	0.593	14599	11013	18493	26108	326425	862564	256654	957303	3.0	45.54	6.12	48.58	54.7

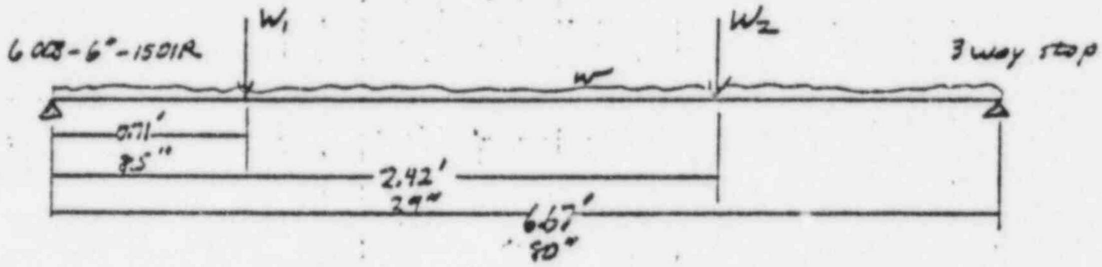
APPENDIX C

SMALL-BORE PIPING HAND CALCULATION

A small bore piping calculation will be done for the SI-51 tubing. Stress results will be compared to those for a finite element analysis of the piping.

By inspection, the critical span is the terminating span at the connection to 6008-6"-1501R.

N-S Dir



W_1 - small hand valve - assume 5 #

W_2 - out of plane span, 1.17' long

$w = (0.2 \text{ \#/ft})(1.17') = 0.23\#$

Span properties; 3/8 SST tubing

$D_o = 3/8" = 0.375"$
$t_n = 0.049"$

$$I = \frac{1}{4}\pi\left[\left(\frac{.375}{2}\right)^4 - \left(\frac{.375}{2} - 0.049\right)^4\right]$$

$I = 6.817\text{-}4 \text{ in}^4$
$S = 2(6.817\text{-}4)/0.375 = 3.636\text{-}3 \text{ in}^3$

acceleration -

$a_{NS}|_{peak} = 2.196\ g$

eq. wt: $w = (0.2 \text{ \#/ft})(1 \text{ ft}/12 \text{ in})(2.196+1g) = 0.053 \text{ \#/in}$

$W_1 = (5)(3.196) = 15.980$

$W_2 = (.23)(3.196) = 0.735$

C-2

Two HP41C programs (see attachment) are used to solve the simply supported beam for:

w:

```
WEIGHT/IN?
            .0330    RUN
LENGTH?
          80.0000    RUN
MODULUS?
         3.636-03    RUN
 X?
           8.5000    RUN
FB= 4,429.4211
                     RUN
 X?
          29.0000    RUN
FB= 10,779.2984
                     RUN
 X?
          47.0000    RUN
FB= 11,66[illegible]
```

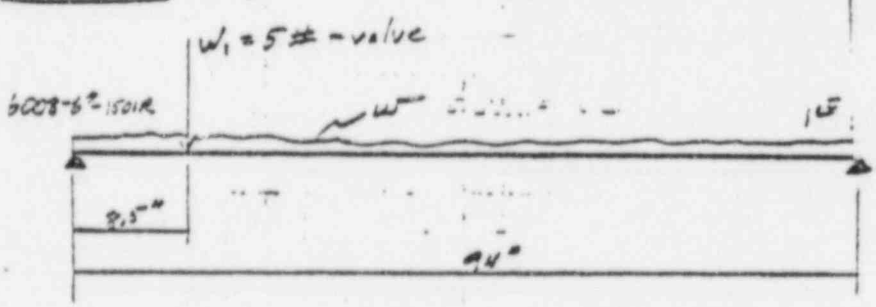
w_1:

```
L=?
          80.0000    RUN
A=?
           8.5000    RUN
F=?
          15.9800    RUN
S=?
         3.636-03    RUN
R1= 14.2321
                     RUN
R2= 1.6979
                     RUN
SA= 33,387.8860
                     RUN
 X=?
          29.0000    RUN
SX= 23,815.8784
                     RUN
 X=?
          47.0000    RUN
SX= 18,673.4[illegible]
```

w_2:

```
L=?
          80.0000    RUN
A=?
          29.0000    RUN
F=?
            .7350    RUN
S=?
         3.636-03    RUN
R1= 0.4686
                     RUN
R2= 0.2664
                     RUN
SA= 3,737.1597
                     RUN
 X=?
           8.5000    RUN
SX= 1,095.3744
                     RUN
 X=?
          40.0000    RUN
SX= 3,[illegible]
```

E-W Dir



acceleration:

$$-a_{E-W}\Big|_{max} = 1.984\ g$$

equivalent wt:

$$w = (0.2\ \#/ft)(1\ ft/12in)(1.984g)$$
$$w = 0.033\ \#/in$$

$$W_1 = (5)(1.984) = 9.920\ \#$$

Using the same solution scheme:

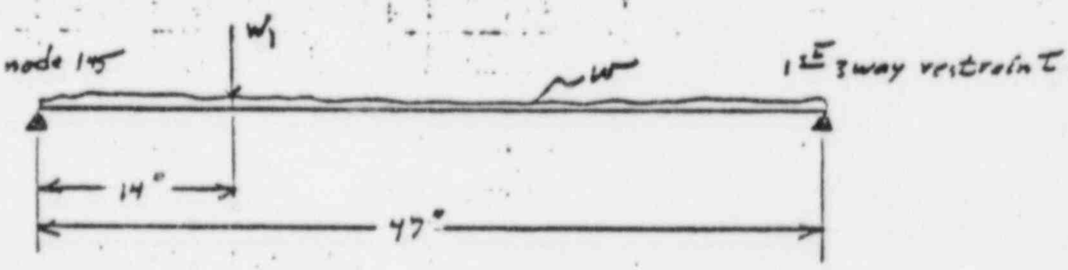
w:

```
        XEQ "DSS"
WEIGHT/IN?
          .0330    RUN
LENGTH?
        94.0000    RUN
MODULUS?
      3.636-03     RUN
 X?
         8.5000    RUN
FB= 3,297.9579
                   RUN
 X?
         9.0000    CLX
        47.0000    RUN
FB= 10,024.3399
```

W_1:

```
        XEQ "FSS"
L=?
        94.0000    RUN
A=?
         8.5000    RUN
F=?
         7.0000    CLX
          .0000    CLX
         9.9200    RUN
S=?
      3.636-03     RUN
R1= 9.0230
                   RUN
R2= 0.8970
                   RUN
SA= 21,093.3221
                   RUN
 X=?
        47.0000    RUN
SX= 11 [illegible]
```

Vertical Dir



acceleration:

$a_v|_{max} = 1.698$

equivalent wt:

$w = (0.2)(1/12)(1.698) = 0.0283$ #/in

$W_1 = (0.2)(1.5)(1.698) = 0.509$ #

Using the same solution scheme:

w:

```
            XE1 DSS
WEIGHT/IN?
        .0283   RUN
LENGTH?
      47.0000   RUN
MODULUS?
     3.636-03   RUN
 X?
      14.0000   RUN
FB= 1,797.9373
                RUN
 X?
      23.5000   RUN
FB= 2,149.1577
```

w_1:

```
            XE0 FSS
L=?
      47.0000   RUN
A=?
      14.0000   RUN
F=?
        .5090   RUN
S=?
     3.636-03   RUN
R1= 0.3574
                RUN
R2= 0.1516
                RUN
SA= 1,376.0621
                RUN
 X=?
      23.5000   RUN
SX= 979.9270
```

Load combinations

N-S Dir

Location	9.5	29.0	40.0
w	4429	10799	11661
w_1 (+ wt)	33388	23815	18678
w_2	342	3737	2931
total	38159	38351 (limit)	33270

E-W Dir

Location	9.5	47.0
w	3298	10024
w_1	21093	11595
total	24391 (limit)	21619

Vertical Dir.

Location	14.0	23.5
W	1798	2149
W_1	1376	980
total	3174	3129
	limit	

Combined Stress

IIF : For socket welded fittings $i = 2.1$

$$\sigma = (0.75)(2.1)\left[38351^2 + 24391^2 + 3174^2\right]^{1/2}$$

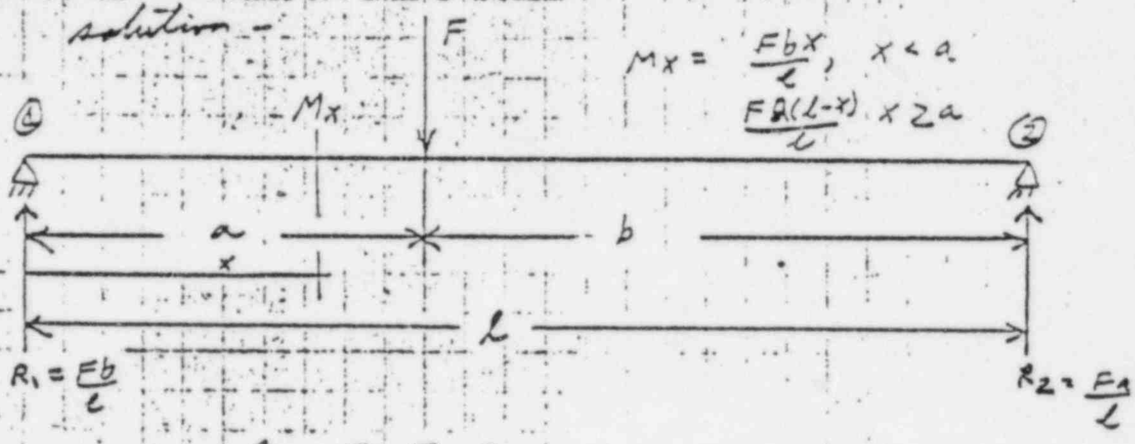
$\sigma = 71758$ psi N.G.

The piping is cold, so no thermal stress calculation was required.

SS solution -

$M_x = \frac{Fbx}{l}, \quad x < a$

$\frac{Fa(l-x)}{l}, \quad x \geq a$



given: l, a, F, I, S

needed: R_1, R_2, $F_b(x)$

Register	Contents
0	l
1	a
2	F
3	I
4	S
5	b
6	X

```
PRP "SS"

01+LBL "SS"
02 XEQ "INP"
03 RCL 02
04 RCL 05
05 *
06 RCL 00
07 /
08 "R1= "
09 ARCL X
10 PROMPT
11 RCL 02
12 RCL 01
13 *
14 RCL 00
15 /
16 "R2= "
17 ARCL X
18 PROMPT
19 RCL 02
20 RCL 05
21 *
22 RCL 01
23 *
24 RCL 00
25 /
26 RCL 04
27 /
28 "SA= "
29 ARCL X
30 PROMPT
31 SF 01
```

RCL 01 / RCL 00

```
32+LBL 01
33 " X=?"
34 PROMPT
35 STO 06
36 RCL 01
37 X>Y?
38 GTO 02
39 RCL 00
40 RCL 06
41 -
42 RCL 02
43 *
44 RCL 01
45 *
46 RCL 00
47 /
48 GTO 03

49+LBL 02
50 RCL 02
51 RCL 05
52 *
53 RCL 06
54 *
55 RCL 00
56 /

57+LBL 03
58 RCL 04
59 /
60 "SX= "
61 ARCL X
62 PROMPT
63 GTO 01
64 END
```

```
PRP "INP"

01+LBL "INP"
02 " L=?"
03 PROMPT
04 STO 00
05 " A=?"
06 PROMPT
07 STO 01
08 " F=?"
09 PROMPT
10 STO 02
11 " S=?"
12 PROMPT
13 STO 04
14 RCL 00
15 RCL 01
16 -
17 STO 05
18 END
```

DSS- Moment calculation for uniformly loaded SS beam.

$$M(x) = \frac{wx}{2}(l-x)$$

$$f_b = \frac{M(x)}{S}$$

```
01+LBL "DSS"
02 "WEIGHT/IN?"    ← unit wt.
03 PROMPT
04 STO 01
05 "LENGTH?"       ← beam length
06 PROMPT
07 STO 02
08 "MODULUS?"      ← S (units?)
09 PROMPT
10 STO 03
11+LBL 01
12 " X?"           ← X
13 PROMPT
14 STO 04
15 RCL 01
16 *
17 2
18 /
19 RCL 02
20 RCL 04
21 -
22 *
23 RCL 03
24 /
25 "FB= "          → f_b(x)
26 ARCL X
27 PROMPT
28 GTO 01
```

APPENDIX D

PIPING SUPPORT CALCULATIONS

Support summary Sheet for II-51

Support	Node/O.P	Stress Ratio	Page
S2-05-0320-H013	22/30	1.60	D-5
-H014	25/35	0.67	D-5
S2-05-6004-H010	85/65	0.86	D-5
-H012	100/75	0.22	D-6-7
-H007	115/81	0.09	D-7-9
-H006	120/85	—	D-9
-H001	125/90	0.15	D-9-10
-H014	135/95	0.50	D-10-11
-H003	145/100	—	D-12
-H005	170/110	0.57	D-12-13
S1-02-6004-H002	180/215	0.69	D-13-14
-H006	195/120	0.79	D-15
-H001	200/125	0.77	D-16
-H003	235/145	0.76	D-16-19
S1-02-6005-H006	260/157	0.33	D-20
-H003	275/165	0.15	D-20-21
-H005	285/175	0.47	D-22
-H001	290/177	0.67	D-22-24
-H008	310/196	0.19	D-25-26
-H002	315/195	0.80	D-27
-H004	330/205	0.44	D-28
—	340/210	—	D-29
—	345/215	—	D-30
S1-06-6005-H005	375/225	1.82	D-30
-H004	380/230	1.78	D-30-31
-H003	405/250	0.79	D-32-34
S1-06-0319-H004	445/390	0.78	D-35
-H007	485/537	1.98	D-35-37
-H006	490/577	0.81	D-38
SI-06-0323-H013	520/560	—	D-39
-H005	675/375	0.86	D-39
SI-02-6008-H001	710/455	0.06	D-39
-H002	720/460	0.05	D-40-42
SI-02-6006-H001	755/425	0.17	D-43
-H002	765/430	0.06	D-43
SI-02-6007-H001	800/405	0.21	D-43
-H002	810/410	0.05	D-43
—	376/—	—	D-43
SI-05-0720-H017	855/310	9.37	D-43
-H016	855/312	0.63	D-44-45
-H011	861/315	0.66	D-46
-H009	870/320	0.17	D-47

Support Summary Sheet For II SI (cont'd)

	page
Loads	D-48-53
Standard component tables	
Lugs	D-55-59
Spring hangers	D-60
Sway struts	D-61-63
Snubbers	D-64-65
HP-41C Programs –	D-54, D-66

Support Summary Sheet for SI-158

Support	Node/D.P.	Stress Ratio	Page
SI-01-6007-H00L	20/1020	0.17	D-156-159
-H00K	35/1090	0.47	D-153-155
-H00J	40/1100	0.28	D-150-152
-H30I	105/1270	0.70	D-107-149
-H30H	115/1290	0.84	D-95-106
-H30G	120/1320	0.20	D-94
-H30F	135/1360	0.34	D-85-93
-H00E	155/1430	0.33	D-83-84
-H00D	160/1440	0.52	D-80-82
-H00C	165/1460	0.88	D-77-79
-H00B	180/1500	0.78	D-72-76
-H00A	240/1710	0.72	D-67-71

Loads D-160-

Node 221 / d.p 30 / SI-05-0720-H013 / Snubber

Based on a review of the design and the calculations in the FCR, this support design is controlled by the anchor bolt capacity. As a first pass, assume that the bolt closest to the snubber ℄ carries the full load. (9193#),

the bolt is a 1" Super Kwik, @ 6½" embedment.

$F_a = 22948/4 = 5737$

$F_v = 19413/4 = 4853$

$\left(\frac{9193}{5737}\right) = 1.60$ NG

The reduced factor of safety cannot be applied because all bolts are in tension. A detailed analysis would not show sufficient load redistribution to pass the design.

Node 25 / d.p. 35 / SI-05-0720-H014 / Spring hanger

Per the spring hanger table, $u = 0.67$

Node 85 / d.p 65 / SI-05-6574-H010 / Spring Hanger

Per the spring hanger Table, $u = .0.86$

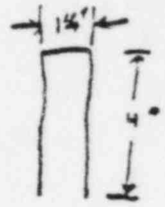
Node 100 / dp 75 / SI-05-6004-H012 / Snubber

The snubber, from rear bracket to pipe clamp, has been qualified in the snubber table. This leaves:

a) lugs attach weld

b) bracket attach weld

a) **Lugs:** the lugs are 1¼" × 4" on the pipe surface, 4 total, with a ¼" fillet weld as shown:



Area of weld:

$A = 1/4\,(1\tfrac{1}{4} + 2 \cdot 4)$

$A = 2.313\ \text{in}^2$

The load is at an angle, with the following direction cosines:

Snubber: $\bar{S} = (.7024, .6135, -.7244)$

pipe : $\bar{P} = (0, 1.0, 0)$

The axial load is:

$F_{axial} = F_{sn}\,(\bar{S} \cdot \bar{P})$

$F_{axial} = 5028\,(0.6135) = 3085\ \text{lb}$

$F_{trans} = \sqrt{F_{sn}^2 - F_{axial}^2} = 3971\ \text{lb}$

Per the lug calculation, u = 0.22 OK

6. Bracket attach weld

The weld pattern is a 5" sq. with 1/2" fillet

$A = 1/2\,(5)(4) = 10^{in^2}$

Since the column is ∥ the pipe,

$F_a = F_{trans}/10^{in^2} = 738\,psi$ OK

$f_v = F_{axial}/10^{in^2} = 573\,psi$ OK

Node 115 / dp. 81 / SI-05-6004-H007 / guide

there are six elements to be analyzed

1) The horizontal W6x15 x 1'2¼" beams
2) The attachment weld to the vertical beams
3) The vertical W6x15 x 2'7" beams
4) The attachment weld of the vertical beams to the W10x29 beam running N-S (secondary steel)
5) The N-S W10x29 beam (secondary steel)
6). Main beam EHR-1923

see end of Appendix for listing of the program

1) Horizontal beam -

L=?	14.13	RUN
a=?	7.07	RUN
F=?	11.20	RUN
S=?	9.72	RUN
M=15.59		RUN
R0= 5.61		RUN
R1= -2.83		RUN
Y0= 2.84		RUN

The load is 16.9 K vertical, applied mid-span.

$L = 1'2\tfrac{1}{8}" = 14.13"$ area = 4.43
$a = L/2 = 7.07"$
$F = 16.9$
$S = 9.72$

2KSI stresses are acceptable - OK

The shear is

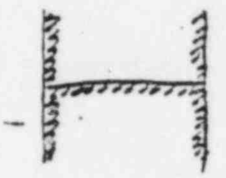
$f_v = 5.61/4.43 = 1.27\,ksi$ - OK

Node 115

9/

2.) attachment weld, horizontal to vertical beam.

The weld pattern:



1/4" fillet weld; This compares to $t_w = 1/4$, $t_F = 1/4"$. Since the weld section is nearly identical to the beam section, and the beam stresses were so low, the weld is acceptable based on comparison with the beam.

3) Vertical beam

The load is a horizontal 1.3K applied 31'11" − 30'6" = 17" from the top. The span is 2'7" − 3" = 28". This is in combination with an axial load of 5.61K

```
L=?       XEQ "FF"
          28.00    RUN
A=?
          17.00    RUN
F=?
          6.78     RUN
S=?
          9.72     RUN
R1= 2.29
                   RUN
R2= 4.41
                   RUN
S1= -.91
                   RUN
SA= 2.78
                   RUN
SL= -2.88
                   RUN
X=?
```

L = 28
a = 17
F = 6.7
S = 9.72

The fixed-fixed assumption gives a maximum bending stress of 2.8 KSI and a maximum shear of 4.41 / 4.43 = 1.0 KSI. The axial stress is 5.61 / 4.43 = 1.27 KSI

The beam is acceptable.

4) attachment weld, vertical beam to secondary steel.

The attachment weld is identical to that above, and the applied loads are as low. The weld is acceptable.

Node 115

5) The W-10X29 N-S secondary steel.

Since the ℄ of the support is within 2' of the main steel (EHP-B23), local stresses are the only concern. The installation of gusset plates to support the flanges of this beam alleviate any concern in this area — acceptable.

Node 120/ dp. 95/ SI-05-6004-H006/ rod hanger

Rod hangers were given no credit for seismic analysis (piping done with & w/o rod hangers). The are not in the scope of the support analysis.

Node 125/ dp. 90/ II-05-6004-H001/ lateral

There are 5 elements to be analyzed,

1) The vertical C5 X 6.7 X 1' 2½" beams contacting the pipe

2) The attachment welds of these beams to the next element (3)

3) The horizontal C5 X 6.7 X 3' 2¾" beams attaching the vertical beams (2) to the column (5)

4) The attachment welds of item (3) to column E-3

---

1) The vertical C beams will be analyzed as fixed fixed with a mid span load

L=?	14.50	RUN
a=?	7.25	RUN
F=?	6.10	RUN
S=?	3.00	RUN

? = 3.05
? = 3.05
? = ?
? = ?
? = ?

$L = 1'2\frac{1}{2}" = 14.5"$
$a = L/2 = 7.25"$
$F = 6.1$ KSI
$S = 3$ in^3 (Str., AISC, 8th, p 1-77)
Area = 1.97 in^2

The bending stress, 3.7 KSI, is acceptable.

$f_v = 3.1/1.97 = 1.6$ KSI, OK.

Node 125

2) The attachment weld is a 1/4 fillet on the inside of the C section, which has $t_w = 7/16"$ $t_f = 5/16"$. Based on the low stresses calculated for the vertical C beams and the similarity of sections here and there, the weld is acceptable. Deficiencies noted in NCR-S01-P-4229 do not affect this conclusion.

3) The horizontal C beams will be analyzed as a column. They are sufficiently short that buckling need not be considered.

$$f_t = F_a = 3.25/1.97 = 1.62 \text{ ksi, OK.}$$

4) The attachment weld to the column consists of two 1/4" fillet welds 12.8" long loaded in shear.

$$A = (1/4)(2)(12.8) = 6.4 \text{ in}^2$$

$$f_v = 6.1/6.4 = 0.9 \text{ ksi} \quad OK.$$

Node 135 / dp. 95 / SI-05-6004-H014 / axial strut

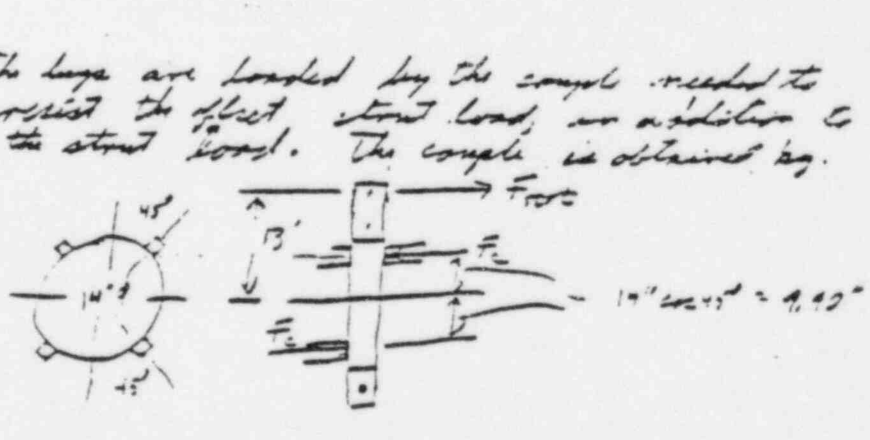
There are 4 elements to be analyzed:

1) lugs on the pipe

2) The strut assy

3) attachment weld of the strut to column E-3

1) The lugs are loaded by the couple needed to resist the offset strut load, in addition to the strut load. The couple is obtained by:



Node 175 from the piping analysis:

$$\overline{DCOS}_{pipe} = (0, 0, 1)$$

$$\overline{DCOS}_{strut} = (.102, 0.000, -.995)$$

The strut load is 12.5 K.

$$\therefore F_{str} = (.995)(12.5) = 12.4 \text{ K}$$

the load ⊥ to the pipe, $F_\perp$, is

$$F_\perp = (.102)(12.5) = 1.3 \text{ K}$$

A moment equation gives:

$$2(9.90'') F_c = (9.9+16) F_{str}$$

$$F_c = \frac{(9.9+16)}{2(9.9)} 12.4 = 16.3 \text{ K}$$

The total load on the lug is

$$F_c + F_{str} = 12.4 + 16.3 = 28.7 \text{ K}$$

Per the lug calculation u = 0.50 OK

2) Strut Assy.

Per the strut table u = 0.42 OK

3) The attachment weld is a 5/8" weld in a 7 5/8 X 5" rectangular pattern. It is subjected to a 12.4 K normal and a 1.3 K shear load.

$$A = 2(5/8)[7\,5/8 + 5] = 15.8 \text{ in}^2$$

$$F_\perp = 12.4/15.8 = 0.8 \text{ KSI}$$

$$F_v = 1.3/15.8 = 0.1 \text{ KSI}, \text{ OK.}$$

Node 145 / dp 100 / II-05-6004-H003 / Rod Hanger

This support has been upgraded to full-vertical restraint. The new design is not available for analysis.

Node 170 / dp 110 / II-02-6004-H005 / Snubber

There are 3 elements needing analysis:

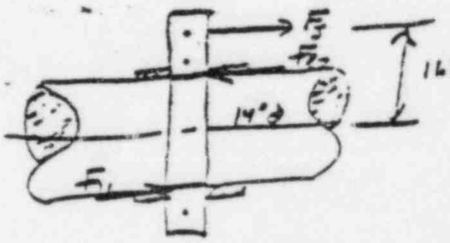
1) Lugs on the pipe

2) The snubber assy

3) attachment weld of snubber assy to col. E-5

1) Attachment Lugs.

Based on the photographs, the lugs will be assumed to share the load and be configured as shown



$7" \, F_{\ell 2} = 11.81" \, F_3$

$F_{\ell 2} = \frac{11.81}{7} (10.2) = 17.2 \, k$

$F_{\ell 1} = F_{\ell 2} + F_3 = 10.2 + 17.2 = 27.4 \, k$

Per the lug table, $u = 0.37$ OK

2) Snubber - Per the snubber table $u = 0.57$

Node 170

3) Attachment weld of snubber ass'y
From the ITT Grinnell Catalog PH81, the bracket on a 201 shock suppressor has dimensions of 4½"x3". (Note that the bracket was left when the PSA-10 was substituted.

$P = 10.2K$

$A = .2(4½+3) ¼ = 3.8 in^2$

$f_a = 10.2/3.8 = 2.7$ KSI OK. (< 21.9)

Node 150 / DP 115 / II-02-600*-H002 / Horiz. Strut

There are 5 elements needing evaluation.

1) the strut assy (which is evaluated in the strut table)
2) the attachment weld, strut ass'y to plate
3) the attachment weld, plate to tube steel
4) the 4x4x¼x11" tube steel
5) the attachment weld, tube steel to W18x45 beam

1) strut ass'y - per the strut assy table:

$u = 0.69$

Node 130

- 2) the attachment weld, strut ass'y to plate

this weld is 2 parallel 1/4" throat by 4½" welds

F = 10.6

A = 2(1/4)(4½) = 2.3 in²

F_v = 10.6/2.3 = 4.6 KSI OK

3) the attachment weld, plate to tube

this weld pattern is 2 parallel 1/4 fillet welds, 4" long

F = 10.6K

A = 2(1/4)(4) = 2 in²

F_a = 10.6/2 = 5.3 KSI

F_A = 23.9 KSI − u = 0.22 OK

4) Tube Steel.

Since the tube steel is too short for concern about buckling, its area, 3.59 in², in comparison to the weld area ensures its adequacy. OK

5) attachment weld, tube steel to W18x45.

this weld is identical to the weld at the other end of the tube, and is adequate by comparison OK

Node 195 / dp 120 / II-02-6004-H006 / Horiz. strut

Three elements need analysis:

1) the strut assembly

2) the attachment weld to Column B-6

1) The Strut Ass'y -

Per the strut ass'y table u = 0.79

2) The attachment weld, strut ass'y to col. B-6

For a 211, size 2 strut ass'y, the base plate is 4½" × 3". For a 3/8" fillet weld, all around,

$A = 3/8\ (2)(4\tfrac{1}{2} + 3) = 5.63\ in^2$

$P = 1.2K$

$F_v = 1.2/5.63 = 1.6\ K$ OK

Node 200 / dp 125 / SI-02-6004-H001 / strut

This support is identical to SI-02-6004-H002 and will be qualified by comparison. The max. load is 11.8K, vs 10.6K. The controlling component for H002 is the strut, with F/F = 0.69. for this strut

$$F/F = (0.69)\frac{(11.8)}{(10.6)} = 0.77 < 1.0 \text{ OK}$$

Node 235 / dp 145 / SI-02-6004-H003 / vertical guide

There are 7 parts to be analyzed:

1) the bumper column – W 4x13x 10 13/16" beam (E)
2) the double C3X4.1, c-c 1'-8" beam (54)
3) the std. components: 7/8" nuts, #140, 7/8" rod (12) eye nuts (#290, part 7), #66, welded beam attach (Δ), #3, the washer plate (item 60)
4) the W8x15x 5'4" beam (item B; envelopes item A and appurtenances)
5) attach weld to ∠4x4x7/8"x4"
6) ∠ 4x4x7/8"x4" (items C)
7) attach weld, items C to support steel
8) attach weld, beam attach to beam

1) W4x13x10 13/16" beam

This beam is too short to buckle.

$A = 3.83''^2$ (AISC, 8th)

$f_a = 3.0/3.8 \sim 0.8$ ksi, negligible OK

2) double C3x4.1, CC 1'8" beam

```
L=?
      20.000   RUN
A=?
      10.000   RUN
F=?
       5.800   RUN
S=?
       2.200   RUN
```

L = 20"
A = 10"
F = 5.8K
S = 2*(1.1) = 2.2 (AISC, 8th)

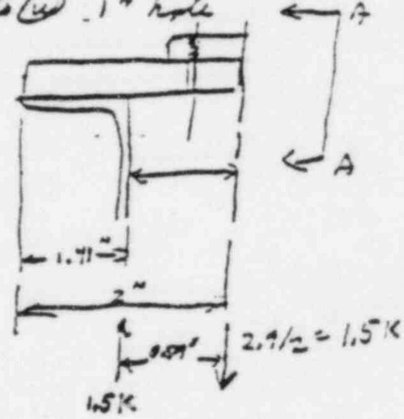
Node 235 $F = 17.1\ ksi < 40.6$ OK - 0.32

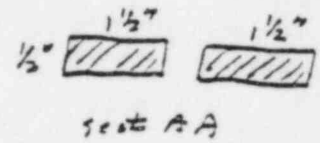
3) Standard components - load is 2.9K

item #	catalog #	descr	rating	
5	—	7/8" nuts	qual. by rod	
12	140	7/8" rod	3.8	OK 0.76
7	290	eye nuts	3.8	OK 0.76
1	66	welded beam attach	3.8	OK 0.76

Catalog is ITT Grinnel Catalog PH 71

The washer plate, has no load rating; it's a 4x4x1/2 plate w 1" hole





$I = \frac{1}{12} b h^3$

$I = 2\left[\frac{1}{12}(1\tfrac{1}{2})(\tfrac{1}{2})^3\right]$

$I = 0.031$

$$F_b = \frac{[(0.29)(1.5)][\tfrac{1}{2}(\tfrac{1}{2})]}{0.031} = 7.1\ ksi < 40.6$$

OK - 0.17

Perhaps an overkill, but remember the Hyatt-Regency skyway in K.C.

4) W 8x15 x 5'9" beam

```
L=?
        69.000    RUN
a=?
        34.500    RUN
F=?
         2.900    RUN
S=?
        11.800    RUN
R1= 1.450
```

$L = 69"$

$a = 69/2 = 34.5$ (concentrated)

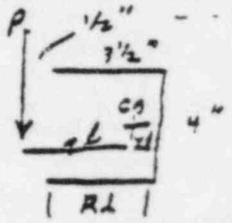
$F = 2.9$

$S = 11.8$ (AISC 8th)

$F = 4.2\ ksi < 40.6$ OK - 0.10

Node 275

5) Attach weld, beam to clip



$t = 1/4"$

from p4-80, AISC, 8th

$$D = \frac{P}{C\,C_1\,l}$$

D = min. reqd throat, 16th
P = applied load. K = 2.9/2 = 1.5 K
C = coefficient from table XXIII (p 4-80) for of
R = 3½/4 = 0.88
for R = 0.88, x = 0.25
xl = (0.25)(4) = 1"
al = 4" - xl = 3"
a = 0.75

C = 1.27
C_1 = 0.86 (p 4-74)

$$D = \frac{1.5}{(1.27)(0.86)\,4"} = 0.343 \Rightarrow 1$$

D/t = 1/16 / 1/4 = 0.25 OK - 0.25

6) < 4x4x 3/8" x 4

2 plates, area 4 x 3/8" has A = 3"

F_v = 2.9/3 = 1.0 ksi < 24.4 OK 0.04

7) attach weld, clip to beam -

Based on item 5, weld is OK, but: check shear

A = 2 (1/4)[(2)(3½) + 4] = 2.75

F_v = 2.9/2.75 = 1.05 < 24.4 ksi OK 0.04

Node 235

3) attach weld, beam attach to beam

from ITT Gr. P.471 for #6, 7/8 beam attach, the welds are 2½"

$A = (2\frac{1}{2})(2)(1/4) = 1.25"$

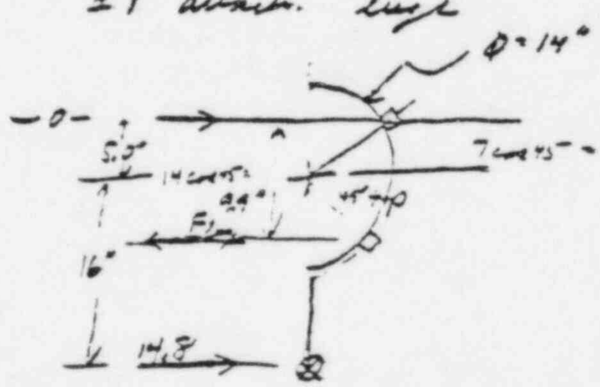
$f_v = 2.9/1.25" = 2.3K < 23.9$ OK 0.10

Node 260 / OP 157 / II-02-3005-H006 / strut

There are elements to be analyzed:

1) Attachment lugs
2) Pipe clamp - Bergen Patterson (assumed) 16" dia by 1½x5 stock
3) B.P. No. 2200-75 strut
4) attach. weld, weld end to plate (this envelopes all loadings in the strut)

1) attach. lugs



ΣM_0:

$F_{lug} = \frac{(16-5)\,14.8}{9.9"} = 16.4$

from the lug calc. $f/F = 0.52$ OK

2) Pipe clamp. Based on dimensions, this is a Bergen - Patterson part No. 2036. (catalog dated 12/20/74)

$F = 37.6$ KSI

$f = 5.8 < 37.6$ OK - 0.15

Node 260

3) B P - No. 2200-30 strut

from strut calc, OK 0.49

4) from the B.P. catalog, the welds are 7 5/8" long

$A = 1/4\ (7\,5/8) = 1.906\ in^2$

$f_v = 14.8/1.906 = 7.8\ ksi < 22.9$ OK – 0.33

Node 275 / dp 165 / II-02-6005-H003 / vertical guide

there are 4 elements to be analyzed:

1) the TS 4x4x 3/8 x 31.5" horizontal member
2) attachment weld of horizontal to vertical members
3) W6x25 x 1'7 1/2 vertical members
4) attach. weld of vertical member to structural steel.

the downward shim design is acceptable by inspection – the load is transferred directly to structural steel.

1) TS 4x4x 3/8 x 31.5" long

```
         31.500   RUN
  A=?
         12.000   RUN
  F=?
          3.200   RUN
  S=?
          5.350   RUN
R1= 2.161
R2= 1.039
S1= -2.751
S2= 2.996
```

L = 31.5"
a = 12"
F = 3.2
S = 5.35 (AISC 8th, p 1-91)

$f_b = 2.8 < 40.6$ OK 0.07

F_v = A ≈ 5.09
$f_v = 3.2/5.08 = 0.6 \sim 0$

Node 275

2) attachment weld 1/4" fillet all around

Based on TS 4x4x1/4 section $S = 4.11\ in^3$ (AISC, 8th)

$$F = 2.8\ \frac{(5.75)}{(4.11)} = 3.65 < 27.9 \quad OK\ \underline{0.13}$$

3) W6 x 25 vertical member

From AISC, 8th; $A = 7.34\ in^2$; $S = 16.7\ in^3$

$$F_a = 3.2/7.3 \sim 0$$

$$F_b = (2.8)\frac{(5.75)}{(16.7)} = 0.9 \sim 0 \quad \underline{OK}$$

4) attach weld, vertical member to civil steel - 1/4" fillet on flanges & web.

Consider the flanges only.

$$b_f = 6.08"$$
$$t_f = 0.455"$$
$$d = 6.38"$$

$$I = 2\left\{\left[\tfrac{1}{2}(6.38 - 0.455)\right]^2 [6.08)(0.455)\right]$$

$$I = 48.6$$

$$F_b = (2.8)(5.75)\left(\frac{\frac{1}{2}(6.38)}{48.6}\right) = 1.0 < 27.9\ KSI$$

OK 0.04

Node 285 / dp 175 / 1I-02-6005-H005 / strut

There are 2. elements to be analyzed

1.) Strut, Fig 211, size #3, cc - 3'6 13/16"
2) attach. weld to civil steel.

1) Sway Strut

From the sway strut calcs, . OK 0.47

2. Attach. weld: from the ITT Gr. PH 71 catalog, the weld is 3" long.

$A = 2(3)(3/8) = 2.25 \ in^2$

$f = 5.5/2.25 = 2.5 \ ksi < 27.9$

OK 0.10

Node 290 / DP 177 / 1I-02-6005-H001 / Lat. guide

There are elements to be analyzed

1) the W6x25 vertical member
2) the attach weld to the horiz member
3) the W6x25 horizontal member
4) the attach to civil steel.

1) W6x25 vertical member

$M = (1.2(4) + 1.7) \ 19.2 = 146.4 \ K\text{-}in$

from AISC 8th, $A = 7.34$, $S = 16.7$

$F_b = \frac{146.4}{16.7} = 8.8 < 40.6 \ ksi$ OK .0.22

$F_x = 19.2/7.34 = 2.6 < 27.4$ OK 0.11

Node 290

2) The connection weld

The weld is $t = 5/16$, all around, for eq. thickness of 5/8" – this compares to $t_w = 5/16$, $t_f = 7/16$. Since the weld has a much beefier section, use same stress

$$F = 8.8 < 23.9 \quad \underline{OK \quad 0.37}$$

3) The W8x25 horiz. member.

Treat as a contiguous member & evaluate the intermediate weld only. The basic member will see the max moment applied by the vert member, so OK for vert. is OK for horiz. member. Also check for web crippling

Assume only flange welds contribute

$$d = 6.38$$
$$b_f = 6.08$$

$$I = 2[1/2(6.38 - 0.25)]^2 (6.08)(0.25)$$
$$I = 28.6$$

$$F = \frac{(8.8)(16.7)(6.38/2)}{28.6} = 16.4 < 23.9 \quad OK \quad 0.69$$

Web Crippling (AISC, 8th, p 5-47)

$$A_{st} = \frac{P_{bf} - F_{yc}\, t\,(t_b + 5k)}{F_{yst}}$$

F_{yc} = col F_y = 36
F_{yst} = stiff F_y = 36
k = 13/16 (p1-29)
P_{bf} = flange force

$$P_{bf} = 4/3\,(8.8/6.38) = 1.9$$

$t = 5/16$
$t_b = 7/16$

$$A_{st} = \frac{1.9 - 36(5/16)(7/16 + 5(13/16))}{36}$$

$$A_{st} = -1.35 < 0 \quad \text{no need for stiffener}$$

Node 290

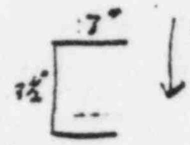
4) The attachment to civil steel

load: from Roark, 5th, p 103;

The max reaction force for an SS beam @ intermediate moment is M_o/l

$R = 146.4 / (2'4"+4"+1'2") = 2.9K$

use table XXIV of AISC, 8th (p 4-80), for clips weld on horizontal member.



$P = 2.9/2 = 1.5K$

$D = \frac{P}{C C_1 l}$, = 16th t needed

P = applied load (½ total - 2 clips)

$C_1 = 0.86$ (p 4-78)

a = 1.0 (concentric)

$k = 3/3½ = 0.857$

$C = 0.885$

$l = 3.5"$

$D = \frac{1.5}{(0.885)(0.86)(3.5)} = 0.56$

t = 5/16, OK 0.56/5 = 0.11

for clips weld on civil steel,

$A = 2(5/16)(3) = 1.125$

$F = 2.9/1.125 = 1.1 < 21.9$ OK 0.05

for the clips

$A = 2(½)(3) = 3$

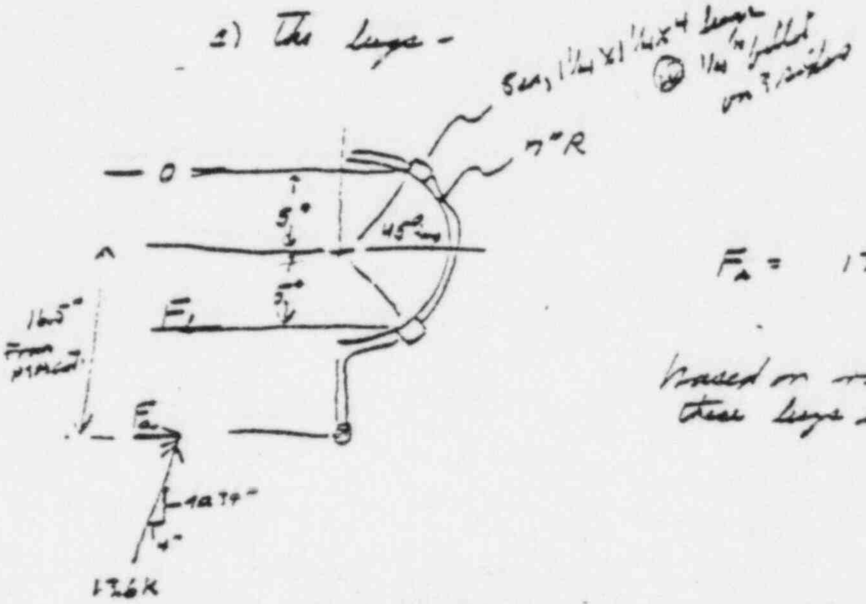
$F = 2.9/3 = 1.0 < 40.6$ OK 0.03

Node 310 / dp 146 / II-02-6005-H005 / snubber

There are elements to be analyzed

1) the lugs
2) the pipe clamp
3) the snubber
4) the clevis attach to civil steel

1) the lugs -



$F_A = 13.6 \frac{(4)}{40.34} = 0.6K$

based on review of the lug calc, these lugs are negligibly loaded.

OK - 0.0

2) The pipe clamp

from 4/20/79 PSA catalog,

for θ = arctan (4/40.34) = 5.5°

F = 45.4 K @5°:

F = 13.6 < 45.4 OK 0.30

3) The snubber

same catalog, F = 72.4K

F = 13.6 < 72.4 OK 0.19

Node 310

4) The attach to civil steel

If the box section is assumed to be built up of full pen welded 1/2" plates,

$A = 4(7)(1/2) = 14 \text{ in}^2$

$F = 126/14 = 0.971 K < 23.9$ OK 0.04

Node 315 / dp 195 / II-02-6005-H-002 / strut

there are 6 elements to be analyzed:

1) the strut
2) attach weld to W6X15 horizontal member
3) W6X15 horiz. member
4) attach weld to vert member
5) vert. W4X13 member
6) attach weld to civil steel.

1) the strut.

Per the sway strut calculation. OK - 0.80

2) attach weld to W6X15 horizontal member

1/4" all around on 4 1/2 x 3 plate

$A = 2(1/4)(4\tfrac{1}{2}+3) = 3.75 \text{ in}^2$

$F = 9.4/3.75 = 2.5 \text{ KSI} < 23.9$ OK 0.11

3) W6X15 horiz. member

```
        28.000   RUN
A=?
        14.000   RUN
F=?
         9.400   RUN
S=?
         9.720   RUN
R1= 4.700
R2= 4.700
S1= -3.385
```

$L = 28"$
$a = 14$
$F = 9.4$
$S = 9.72$ (AISC, 8th, p1-28)

$f_b = 3.4 < 40.6$ OK 0.08

$A = 4.43$
$f_v = 9.4/4.43 = 2.1 < 24.4$ OK 0.09

Node 315

4) attach. weld to W4X13 member

for W4X13, $t_f = 1/4$, $t_w = 3/4$. Since the flange makes predominant contribution to I, use W4X13 I for weld section. I = 1.90

$$F_b = (3.4)\frac{(4.72)}{(1.90)} = 17.4 < 23.9 \quad \underline{OK \ 0.73}$$

for W4X13, d = 4.16, b_f = 4.06

$$A = 1/4\ (2(4.06) - 4.16) = 3.07\ in^2$$

$$F_a = 4.7/3.07 = 1.53\ Ksi < 23.9 \quad \underline{OK \ 0.06}$$

interaction $0.73 + 0.06 = \underline{0.79} < 1$ OK

5) W4X13 member

same stress as calc'd for 4) above:

$$F_b = 17.4 < 40.6 \quad \underline{OK \ 0.43}$$

A = 3.83 in²

$$F_a = 4.7/3.83 = 1.2 < 40.6 \quad OK \ 0.03$$

interaction - 0.46 OK

6) attach weld to emb'd steel

This weld is enveloped by item 4). The only difference is that the web has a 5/16" weld vs 1/4" for item 4

OK 0.79

Node 330 / dp 205 / II-06-6005-H008 / strut

This support has 4 elements to analyze

1) Clamp
2) strut
3) clevis
4) attach weld to civil steel

1) Clamp. -

for 1¼ × 5" stock, B.P (see photo) strut hooked to 3" od strut, @ adjustment, have a BP 2200-30 strut -

for 1¼ × 5" stock, 3 bolt, have BP # 2600

For 14" - F = 326 K

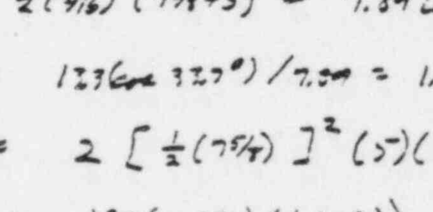
F = 123 < 326 OK 0.35

2 & 3 - strut & clevis

B.P. 2200-30 assy. includes strut & clevis:

Per the strut table OK 0.44

4) attach. weld to civil steel



7⅝" × 5" × 5/16" weld

$A = 2(5/16)(7⅝ + 5) = 7.89\ in^2$

$F_a = 123(\cos 33.7°) / 7.89 = 1.40$ ksi

$I = 2\left[\tfrac{1}{2}(7⅝)\right]^2 (5)(5/16) = 45.4$

$F_b = \dfrac{123(\sin 33.7)(\tfrac{1}{2}(7⅝))}{45.4} = 0.6$

$F = F_a + F_b = 2.0$ ksi < 27.9 OK 0.08

F_v negligible OK

D-23

Node 340 / dp 2101 — Snubber

This support has elements to be analyzed:

1) lugs
2) clamp -
3) snubber assy
4)

can't find matching clamp
check base web to missing

Node 345/ dp 215/ — / rod hgr.

Analysis not necessary — piping adequate w/o rod hanger contribution.

Node 375/ dp 225 / II-06-6005-H005 / snubber

Per the snubber table F/F = 1.82 **NG.**

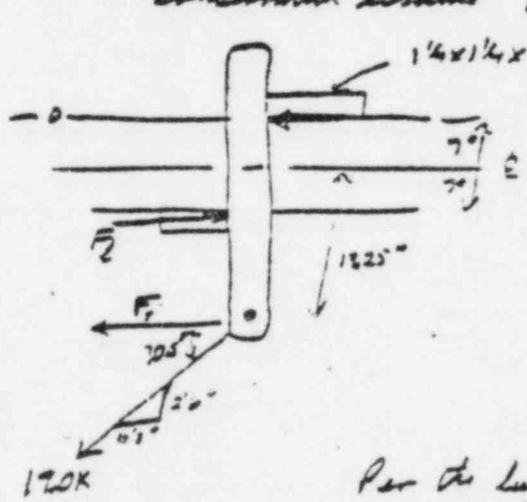
Node 380 / dp 230 / II-06-6005-H004 / snubber

This support has elements to be analyzed

1) lugs
2) snubber assy
3) bracket attach weld
4) plate
5) anchor bolts

1. lugs.

conservative assume w.c. lug orientation:



ΣM_o :

$F_2 = (19.0)(\cos 30)\ \frac{(13.25+7)}{7}$

$F_2 = 47.4K$

Per the lug calc OK 0.82

Node 330

2) Snubber assy.

Per the snubber table. OK - 1.11

Since the snubber was oriented off the ⊥ to the pipe ℄, load rating on the clamp needs checked:

$$\theta = \sin^{-1}\left[\frac{2'4"}{3'0\frac{1}{4}"}\right] = 50.8°$$

per the Pac. Sci data:

θ	F
45	7435
50.8	6907 =
60	6070

for faulted F=1.55 (6907) = 10706

F/F = 19/10.7 = 1.78 NG

Node 405 / dp 250 / SI-06-6005-H003 / vert guide

This support has 6 features to be analyzed:

1) W6X15X2'7" top horiz member
2) attach weld to vertical members
3) W6X15X2'4 vert members
4) attach weld to baseplate
5) baseplate
6) anchor bolts.

the bottom horiz. member will be enveloped by analysis of top horiz. member

1) W6X15X 2'7" top horiz member

for W6X15:

$D = 6.28$
$b_f = 4.03$
$t_w = 1/4$
$t_f = 3/8$
$A = 4.74$
$S = 10.2$
$k = 3/4$

$L = 2'7" + 6.28" = 37.28"$
$A \sim 1/2 L = 16.64$
$F = 29.4$
$S = 10.2$

$f_b = 12.0 < 40.6 ksi$ OK 0.30

$f_v = 14.7 / 4.74 = 3.1 < 24.4 ksi$ OK 0.13

Check for web crippling:

$$A_{st} \sim \frac{P_{bf} - F_{yc} t (t_b + 5k)}{F_{yst}}$$

$F_{yc} = F_{yst} = 36$ ksi
$k = 0.75"$
$P_{bf} = (4/3)\ 29.4 = 39.2$
$t = 1/4$
$t_b = 1/16$ assumed contact zone

Node 405

$A_{st} = \frac{39.2 - 36(1/4)(1/16 + 5(3/4))}{36}$

$A_{st} = 0.136\ in^2$

the 2 3/8 × 2½ × 5½" plates have

$A = (2)(3/8)(2½) = 1.875 > 0.136$ OK 0.07

2 attach weld to vertical members.

the weld throat, 1/4", 1:1 ratio of weld to flange/web and t_p = 3/4 t_w = 1/4 allows using the calc'd beam stress for the weld

f_b = 12.0 < 23.9 OK 0.50

f_v = 3.1 < 23.9 OK 0.13

3) vertical member -

same section as the horizontal member, same moment:

f_b = 12 < 40.6 OK 0.3

$f_a = f_{v(2)}$ = 3.1 < 40.6 OK 0.08

interaction: 0.30 + 0.08 = 0.38 OK

4) attach weld to baseplate

same as 3 above, but applied to (2)

f_b = 12.0 < 23.9 OK 0.50

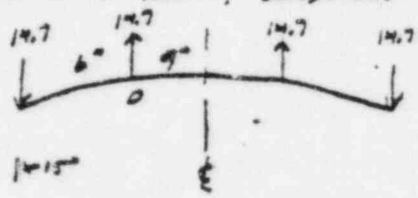
$f_a = f_{v(2)}$ = 3.1 < 23.9 OK 0.13

interaction: 0.50 + 0.13 = 0.63 OK

Node 405

5) Baseplate

treat as a beam and use symmetry.



$M_0 = 14.7(6) = 88.2$ k-in

$S = \frac{1}{1.5}\left[\frac{1}{12}(14)(1)^3\right] = 2.33$

$F_b = 88.2/2.33 = 37.9$

$F_b = (1.88)(0.75)(36) = 50.76$ <u>OK 0.75</u>

$F_v = 14.7/12 = 1.3 < 24.4 =$ <u>OK 0.05</u>

6) Anchor bolts:

1¼ CEB, min embed 6" - F = 19K

$F = 14.7/2 = 7.4 < 19$ <u>OK 0.39</u>

Node 445 / dp 790 / SI-06-0319-H004 / SPR HGR

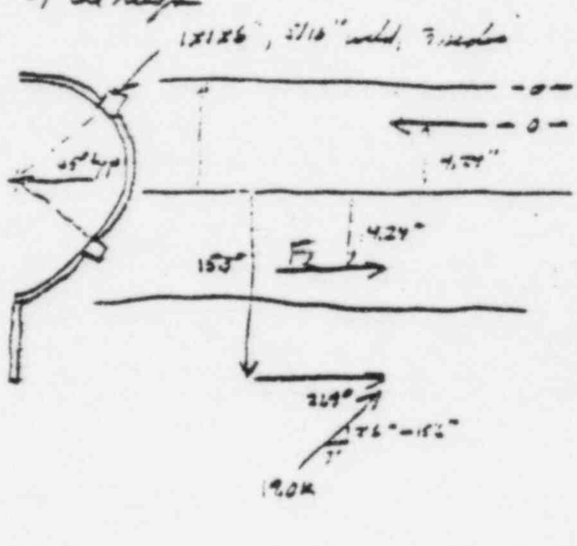
Per the spring hanger table - OK - 0.78

Node 455 / dp 577 / SI-06-0319-H007 / snubber

there are features to be analyzed:

1) The lugs
2) the clamp
3) the snubber assy
4) clevis attach weld
5) the plate
6) the snubber bolts.

1) The lugs



$F_2 = (19.0)(\cos 22.9)\frac{(15.5 - 4.24)}{2(4.24)}$

$F_2 = 41.0K$

From the lug calc. OK 0.57

2) The clamp

for a PSC-24-120, @ load @ 68.1°; F = 1.557(1.904) = 21.5K

F = 19.0 < 21.5 OK 0.88

3) the snubber assy.

from the snubber table, OK - 0.26

Node 485

4) Clevis attach weld

The weld pattern, based on an anchor std bracket, is a 7"×7" × 5/16" weld pattern.

$A = 5/16\,(7+7)(2) = 8.75\ in^2$
$I = 2\,(\tfrac{1}{2}(7))^2\,(7)(5/16) = 88.6$
$S = 88.6/((\tfrac{1}{2})(7)) = 19.7$

$F_a = (19)(\cos 21.9)\,/\,8.75 = 2.0\ ksi$

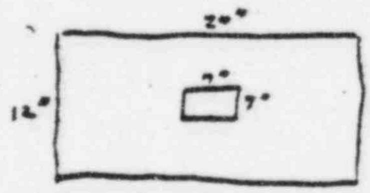
$F_b = (19)(\sin 21.9)(4.8)/19.7 = 1.73$

$F_v = (19)(\sin 21.9)\,/\,8.75 = 0.810$

$F = [(2.0+1.73)^2 + .81^2]^{1/2} = 3.8 < 28.9$ OK 0.16

5) The plate

pull-out load - assume 1S - uniform central pressure



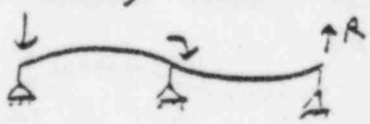
From Roark, 5th, p 386, fig 1c

$a = 24$ $\quad a = b$
$b = 12$ $\quad a_1/b = 0.58 - 0.6$
$a_1 = 7$ $\quad b_1/b = 0.58 - 0.6$
$b_1 = 7$ $\quad \beta = .6$

$\sigma_{max} = \sigma_0 = \frac{\beta W}{t^2} = \frac{(0.6)(19\cos 21.9)}{(3/4)^2}$

$\sigma_b = 18.8\ ksi$

bending load: assume supported by outer bolts only:



$R = [19(\sin 21.9)(4.8)]/24"$
$R = 0.3K$
$M = (0.3)(12) = 3.5\ in\text{-}K$
$S = \frac{1}{(6)(3/4)}\,(12)(3/4)^3 = 13.5$

$\sigma_b = 3.5/13.5 = 0.3$

$F_b = 18.8 + 0.3 = 19.1 < 40.6$ OK 0.47

Node 435

Anchor bolts: for 1¼" CEB @ 5¾ embedment in 2ksi concrete $F_t = 1/4(19.0) = 4.8K$
$F_v = 1/4(36.75) = 9.2K$

assume central bolts carry pull-out

$F = 19.0/2 = 9.5 > 4.8$ NG 1.98

need a detailed plate analysis, all bolts will be in tension, so FOS=2 is NG, Node 410 / dp 537 / II-05-0TA-H006 / Snubber

This support has features to be analyzed:

1) lugs
2) clamp
3) snubber assy.
4) clevis attach
5) baseplate
6) anchor bolts.

1) lugs

assume full axial load on 1x1x6 lugs

$F = (17.7K)\left[\frac{5'4\frac{1}{16}"}{6'6\frac{5}{16}"}\right] = 14.5K$

per the lug calc OK - 0.32

2. clamp

The clamp is a PSA-35 loaded at an angle of

$\theta = \sin^{-1}\left[\frac{5'4\frac{1}{16}"}{6'6\frac{5}{16}"}\right] = 55°$

from the PSA catalog, $F = (1.55)(14.7) = 22.8K$

$f/F = 17.7/22.8 = 0.78$

3. snubber assy'

per the snubber table OK - 0.24

4, 5, 6 - Base attach - clevis attach, baseplate, anchor bolts.

Per FCR-X-41-747-5 stress ratio with a load of 19.0K is 0.87.

∴ OK: $0.87\left(\frac{17.7}{19.0}\right) = 0.81$

Node 520/dp 500 / 1I-06-0327-H013/ rod hanger

The piping was designed to function seismically w/o this support - analysis not needed.

Node 675/dp 375/ 1I-06-0719-H005/ spr hgr

From the spring hanger Table. OK 0.86

Node 710 / dp 455 / 1I-02-6008-H001 / guide

This support is identical to support at node 720 (dp 460), except the loads differ:

	Loads Node 710	Loads Node 720
Horizontal	1.7	1.6
Vertical	2.5	1.4

The maximum increase in load gives a factor of 1.1

The maximum stress ratio @ node 720 is 0.06

Therefore $u = 1.1\,(0.5) = 0.6$

Node 720 / dp 460 / SI-02-6003-H002 / guide

There are 6 elements to be analyzed:

1) The horizontal W4X13 x 1'2¾" beam restraining uplift

2) attachment weld, item 1 to the vertical W4X13 x 2'4" sides of the box

3) The vertical W4x13 x 0'-5" beams transferring horizontal loads to item (4)

4) the vertical W4X13x 2'4" beams comprising the sides of the box

5) attachment weld, item 4 to item 6

6) the 4" sch 40 pipes resisting down loading. (welds hold in place & do not see the load)

1) This W4X13x 1'2¾" beam will be modeled Fixed-fixed with a central uplift load.

```
-L=?
        14.750    RUN
A=?
         7.375    RUN
F=?
         1.400    RUN
S=?
         5.460    RUN
P1= 0.700
P2= 0.700
S1= -0.473
SA= 0.473
SL= -0.473
```

$\ell = 1'2¾" = 14.75"$

$a = ½\ell = 7.375"$

$F = 1.4$

$S = 5.46\ in^3,\ A = 3.83\ in^2$ (AISC, 8th, p 1-25)

$f_v = 0.7 / 3.83 = 0.2\ KSI < 24.4$ 0.01 OK

$f_b = 0.5\ KSI < 40.6$ OK 0.01

Node 720

2) Attach weld, element (2) to element (3)

The weld is a 1/4" fillet on web & both flanges. this compares to a beam section with $t_w = 1/4$, $t_f = 3/8"$. For bending, can assume flange controls section properties : use beam stress

$F_b = 0.5\,KSI < 23.9$ OK 0.02

3) Vertical W4X13 beams used as compression members.

This element will be analyzed using 1.15.5.2 of AISC, 8th, p 5-47, this section makes provisions for local web buckling due to local compression loading from an attached beam in bending.

$F_{yc} = F_{yst} = 36$ KSI
$k = 17/16"$
$P_{bf} = 4/3\,(1.6) = 2.1$ KSI
$t = 0.28$
$t_b = 1/32"$ (estimated width of line of contact between pipe and beam)

$$A_{st} = \frac{P_{bf} - F_{yc}\,t\,(t_b + 5k)}{F_{yst}}$$

$$A_{st} = \frac{(2.1) - (36)(0.28)(1/32 + 5(17/16))}{36}$$

$A_{st} = -1.1\ in^2$

since $A_{st} < 0$, no web stiffener is needed.

4) vertical W4 X13 X 2'4" box sides.

L=?		
	28.000	RUN
A=?		
	18.600	RUN
F=?		
	1.600	RUN
S=?		
	5.460	RUN

F1= 0.420
F2= 1.180
F1= -0.614
F2= 0.316
F = -1.216

Analyze as a F-F beam, $F_a = 0.3$ KSI (see element 2) with a transverse load of 1.8K applied (31'-5 5/16") - (29'-10 3/4") = 18.56" above the base.

$L = 2'4" = 28$
$a = 18.6"$
$F = 1.6K$
$S = 5.46"$

Node 720

$F_v = 619 / 7.83 = 0.3\ KSI < 24.4$

All stresses are very low - OK. 0.01

5) attachment weld, item 4 to item 6.

Same as Item 2, use beam stress:

$F_b = 1.3 < 23.9$ OK 0.05

6) 4" sch 40 pipe

The pipe is too short to buckle

$F_a = 1.43 / 3.17 = 0.4 \sim 0.0$ OK

Node 755 / DP 425 / SI-02-6006-H001 / guide
765 430 -6006-H002
800 405 -6007-H001
810 410 -6007-H002

These 4 supports are identical to SI-02-6008-H002, they will be evaluated by comparing loads, as was done for node 710

Node	Load Horiz	Vert	Factor	F/F	
720	1.6	1.4	1.0	0.05	
755	1.5	4.7	3.4	0.17	OK
765	1.8	0.9	1.2	0.06	OK
800	1.8	5.8	4.2	0.21	OK
810	1.6	1.2	1.0	0.05	OK

Node 846 / dp — / — / snubber

This snubber, inclined to ground on the east end FW horiz. piping, has no design available.

Node 855 / dp 710 / SI-05-0320-H017 / spring hanger

Per the spring hanger table - OK 0.87

Node 855 / dp 3121 ⊕ - 05 - 0320 - H016 ℓ Snubber.

This support has features to be evaluated:

1) lugs
2) clamp
3) snubber assy
4) attach weld for clevis
5) plate
6) anchor bolts

1) lugs -

Lugs are on snubber ℄:
Pac. sci clamp has 15.5" ℄ offset

$$F_{lug} = [7.2 \sin(45°)]\left[\frac{6 - 15.5}{12}\right] = 9.5K$$

per the lug calculation - OK 0.28

2) Clamp

the std. PSC clamp for the application @ 45° has $F = 1.55(18) = 27.9$

$$F = 7.3 < 27.9 \quad \text{OK} \quad 0.26$$

3) snubber assy.

per the snubber table - OK 0.10

4) the plate -

assume a SS plate @ central pt load:

$$F = 7.2 \sin 47° = 5.3K$$

dimensions 22" x 20"
7" x 7" contact pressure

Node 555

using Roark, 5th, fig 1c p 386:

$W = 5.3$
$a_1/b = 7/20 = 0.35 \sim 0.4$
$b_1/b = 7/20 = 0.35 \sim 0.4$
$a/b = 22/20 = 1.10 \sim 1.0$
$\beta = 0.84$

$$\sigma_b \sim \frac{\beta W}{t^2} = \frac{(0.84)(5.3)}{(3/4)^2} = 7.9\,ksi$$

$f_b = 7.9 < 40.6$ OK 0.20

5) The anchor bolts -

for 1" CEB, 4½" emb.:
$F_t = 14{,}000/4 = 3.5K$
$F_v = 27.4/4 = 6.8K$

pull out load: $F_t = \frac{1}{4}(5.3) = 1.3K$

bending: assume bending moment taken by opposite bolts:

$$F = \frac{(7.2\cos 47.2)(4.8)}{((22^2+20^2)^{1/2})} = 0.8K$$

total: $F_t = 1.3 + 0.8 = 2.1 < 3.5$ OK 0.60

shear: $F_v = \frac{1}{4}(7.2\sin 47.2) = 1.32 < 6.8$ OK 0.19

interaction: $(0.6^2 + 0.19^2)^{1/2} = 0.63 < 1$ OK 0.63

Node 861 / dp 315 / II - 05 - 0720 - H011 / snubber

Three elements need analysis:

1) the clamp
2) the snubber
3) the attachment structure (clevis, frame, baseplate)

1) The clamp -

use a 12" ϕ PSA-35 clamp w

$$\theta = \sin^{-1}\left[\frac{20'7\frac{1}{2}" - 16'6"}{5'7"}\right] = 42.8°$$

from PSA catalog:

$$F = (1.55)(18.0) = 27.9$$

$$f/F = 6.2/27.9 = 0.22 \text{ ok}$$

2) the snubber -

per the snubber table, OK - 0.07

3) the attachment structure

Review of FCR X-41-763-5 showed it applicable, except that an F03-2 was used on the anchor bolt. Correction for this gives $f/F = (0.745)(2) = 1.49$ with a 14 K snubber load.

$$f/F = (1.49)\left(\frac{6.2}{14.0}\right) = \underline{0.66}$$

Node 3701 / dp 320 / SI-05-0720-H009 / snubber

There are 3 elements to be evaluated:

1) clamp
2) snubber assy
3) clevis attach weld

1) The clamp - the std -120 PSC clamp for the -35 snubber, @ θ = 90°, has F = (1.55) 50. = 77.5

F = 12.5 < 77.5 OK 0.16

2) The snubber

Per the snubber table OK 0.17

3) The clevis attach weld:

for a 7"x7" x 5/16" weld,

$A = 5/16 (7+7) 2 = 8.75''$

$S = \frac{1}{1/2(7)} (1/2(7))^2 (7(5/16)) = 9.84$

The snubber is offset from ⊥ by atan$\left(\frac{4.6''}{7-1''}\right) = 37.4°$

$f_a = 12.6 (\cos 37.4) / 8.75 = 1.2 < 40.6$ OK 0.03

$f_b = 12.6 (\sin 37.4)(4.3) / 9.84 = 3.4 < 40.6$ OK 0.08

interaction: 0.08 + 0.03 = OK 0.11

SI-51 Support Loads (ABUR, 10/15/85; ADOQ, 10/15/85)

node	dir	wt	T	$(SSE^2+SAM^2)^{1/2}$	'Level A, B'	'Level D'
22	Y	—	—	9193	—	±9193
100	Z	—	—	5028	—	±5028
115	X	133	1176	5439	(133, 1304)	(-5306, 6748)
115	Y	3311	-931	7843	(2380, 3311)	(-5463, 11154)
120	Y	1784	182	4161	(1784, 1966)	(-2777, 5727)
125	X	247	-1476	4910	(-1189, 247)	(-6099, 5157)
135	Z	-312	-179	12215	(-312, -133)	(-12527, 12082)
145	Y	2482	263	7499	2745	(-5017, 10244)
170	X	—	—	12673	—	±12673
180	Y	2393	-175	7663	2393	(-4945, 10556)
195	Z	-483	1524	8175	(-483, 1041)	(-9658, 9216)
200	Y	4143	-317	7717	4143	(-3891, 11860)
235	Y	1223	364	4238	1587	(-3015, 5825)
260	Z	-200	-1860	12691	-2060	(-14757, 12491)
275	Y	3648	249	6854	3897	(-3206, 10751)
285	Z	540	-252	4960	540	(-4672, 5500)
290	Z	28	1565	17623	1593	(-17595, 19216)
310	Z	—	—	13605	—	±13605
315	Y	2890	287	6167	3177	(-3277, 9344)
330	Z	-282	-109	12916	-391	(-13307, 12634)
340	Z	—	—	16713	—	±16713
345	Y	3374	-2132	9712	3374	(-8470, 13086)
375	Z	—	—	40189	—	±40189
380	Z	—	—	18987	—	±18987
405	Y	4141	689	24560	4830	(-20419, 29390)
485	Z	—	—	18970	—	±18970
490	Z	—	—	17653	—	±17653
520	Y	5550	-404	16504	5550	(-13358, 22054)
575	Z	—	—	10576	—	±10576
610	Y	4155	-471	8910	4155	(-5226, 13065)
625	Z	—	—	17552	—	±17552
710	Y	481	-72	1980	481	(-1571, 2461)
710	Z	134	51	1525	185	(-1391, [illegible])

SI-51 Support Loads (cont'd)

node	dir	wt	T	$(SSE^2 + SAM^2)^{1/2}$	'Level A,B'	'Level D'
720	Y	255	-59	1165	255	(-969, 1429)
720	Z	-36	7	1536	-36	-1572
755	Y	1419	142	3059	1611	(-1640, 4670)
755	Z	85	336	1119	421	(-1034, 1540)
765	Y	143	-8	784	143	(-649, 427)
765	Z	-28	-44	1704	-72	(-1776, 1676)
800	Y	1593	-150	4228	1593	(-2755, 5821)
800	Z	84	603	1095	687	(-1011, 1782)
810	Y	90	-103	1137	(-13, 90)	(-1150, 1227)
810	Z	-18	-107	1599	-125	(-1727, 1581)
846	Ξ	—	—	6362	—	±6362
855	I	—	—	7251	—	±7251
861	Ξ	—	—	6206	—	±6206
870	I	—	—	12533	—	±12533
886	X	313	670	16572	983	(-16199, 17495)
886	Y	1398	-1156	3352	1398	(-3110, 4750)

85/10/16. NUPIPE-III. NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1

SONGS I ST-51 ANALYSIS IMPELL SAMS

NODE	TYPE	REACTIONS (LBS OR IN-LBS)	DIRECTION
645	MOMENT	697796.	Z COORD
[illegible]	FORCE	18240.	X COORD
[illegible]	FORCE	5830.	Y COORD
[illegible]	FORCE	30654.	Z COORD
[illegible]	MOMENT	430673.	X COORD
[illegible]	MOMENT	1036303.	Y COORD
[illegible]	MOMENT	226376.	Z COORD
710	FORCE	1980.	Y COORD
710	FORCE	1525.	Z COORD
720	FORCE	1165.	Y COORD
720	FORCE	1536.	Z COORD
735	FORCE	8683.	X COORD
735	FORCE	582.	Y COORD
735	FORCE	919.	Z COORD
735	MOMENT	7212.	X COORD
735	MOMENT	74875.	Y COORD
735	MOMENT	33169.	Z COORD
755	FORCE	3059.	Y COORD
755	FORCE	1119.	Z COORD
765	FORCE	784.	Y COORD
765	FORCE	1704.	Z COORD
780	FORCE	2522.	X COORD
780	FORCE	425.	Y COORD
780	FORCE	1077.	Z COORD
780	MOMENT	5683.	X COORD
780	MOMENT	84181.	Y COORD
780	MOMENT	24797.	Z COORD
800	FORCE	4228.	Y COORD
800	FORCE	1095.	Z COORD
810	FORCE	1137.	Y COORD
810	FORCE	1599.	Z COORD
825	FORCE	5980.	X COORD
825	FORCE	453.	Y COORD
825	FORCE	1010.	Z COORD
825	MOMENT	3789.	X COORD
825	MOMENT	80401.	Y COORD
825	MOMENT	25672.	Z COORD
856	FORCE	6362.	INCLINED
855	FORCE	7251.	INCLINED
861	FORCE	6206.	INCLINED
870	FORCE	12533.	INCLINED
880	FORCE	16512.	X COORD
885	FORCE	3352.	Y COORD
905	FORCE	3935.	INCLINED
930	FORCE	105.	X COORD
930	FORCE	2542.	Y COORD
930	FORCE	35.	Z COORD

SONGS 1 SI-51 ANALYSYS IMPELL SAHS

SUPPORT REACTIONS FOR LOAD COMBINATION CASE NO. 27

SSE + SAHS (SRSS IS W AND W/O ROD HANGERS)

NODE	TYPE	REACTIONS (LBS OR IN-LBS)	DIRECTION
1	FORCE	21270.	X COORD
1	FORCE	8876.	Y COORD
1	FORCE	15402.	Z COORD
1	MOMENT	691290.	X COORD
1	MOMENT	1022028.	Y COORD
1	MOMENT	277081.	Z COORD
22	FORCE	9193.	Y COORD
100	FORCE	5028.	INCLINED
115	FORCE	5539.	X COORD
115	FORCE	7853.	Y COORD
120	FORCE	4161.	Y COORD
125	FORCE	4910.	X COORD
135	FORCE	12215.	INCLINED
145	FORCE	7499.	Y COORD
170	FORCE	12673.	X COORD
180	FORCE	7663.	Y COORD
155	FORCE	8175.	Z COORD
200	FORCE	7717.	Y COORD
235	FORCE	4238.	Y COORD
260	FORCE	12691.	Z COORD
275	FORCE	6854.	Y COORD
265	FORCE	4960.	Z COORD
290	FORCE	17623.	Z COORD
310	FORCE	13605.	INCLINED
315	FORCE	6167.	Y COORD
330	FORCE	12916.	INCLINED
340	FORCE	16713.	INCLINED
345	FORCE	9712.	Y COORD
375	FORCE	40189.	INCLINED
380	FORCE	18987.	INCLINED
405	FORCE	24560.	Y COORD
485	FORCE	18970.	INCLINED
490	FORCE	17653.	INCLINED
520	FORCE	16504.	Y COORD
535	FORCE	10596.	INCLINED
560	FORCE	81.	X COORD
560	FORCE	4531.	Y COORD
560	FORCE	179.	Z COORD
610	FORCE	8918.	Y COORD
625	FORCE	17552.	INCLINED
655	FORCE	14477.	X COORD
655	FORCE	4060.	Y COORD
655	FORCE	8122.	Z COORD
655	MOMENT	347296.	X COORD
656	MOMENT	174143.	Y COORD

SUPPORT REACTIONS FOR LOAD CASE NO. 2

THERMAL EXPANSION NORMAL OPERATION

NODE	TYPE	REACTION (LBS OR INCH-LBS)	DIRECTION
[illegible]	FORCE	-1047.	X COORD
[illegible]	FORCE	1944.	Y COORD
[illegible]	FORCE	95.	Z COORD
[illegible]	MOMENT	87302.	X COORD
[illegible]	MOMENT	59479.	Y COORD
[illegible]	MOMENT	[illegible]	Z COORD
115	FORCE	1176.	X COORD
115	FORCE	-731.	Y COORD
120	FORCE	182.	Y COORD
[illegible]	FORCE	-1434.	X COORD
[illegible]	FORCE	[illegible]	INCLINED
[illegible]	FORCE	[illegible]	Y COORD
[illegible]	FORCE	[illegible]	Y COORD
[illegible]	FORCE	[illegible]	Z COORD
[illegible]	FORCE	-317.	Y COORD
[illegible]	FORCE	[illegible]	Y COORD
[illegible]	FORCE	[illegible]	Z COORD
[illegible]	FORCE	[illegible]	Y COORD
[illegible]	FORCE	[illegible]	Z COORD
[illegible]	FORCE	[illegible]	Y COORD
[illegible]	FORCE	287.	Y COORD
[illegible]	FORCE	-109.	INCLINED
[illegible]	FORCE	-2132.	Y COORD
[illegible]	FORCE	[illegible]	Y COORD
[illegible]	FORCE	[illegible]	Y COORD
[illegible]	FORCE	-10.	X COORD
[illegible]	FORCE	-722.	Y COORD
[illegible]	FORCE	4.	Z COORD
[illegible]	[illegible]	-71.	[illegible]
[illegible]	FORCE	301.	X COORD
[illegible]	FORCE	-1262.	Y COORD
[illegible]	FORCE	-36.	Z COORD
[illegible]	MOMENT	-2110.	X COORD
[illegible]	MOMENT	-19148.	Y COORD
[illegible]	MOMENT	[illegible]	Z COORD
[illegible]	FORCE	[illegible]	X COORD
[illegible]	FORCE	[illegible]	Y COORD
[illegible]	FORCE	-2070.	Z COORD
[illegible]	MOMENT	[illegible]	X COORD
[illegible]	MOMENT	[illegible]	Y COORD
[illegible]	MOMENT	-3111.	Z COORD
710	FORCE	-73.	Y COORD
710	FORCE	91.	Z COORD
720	FORCE	-49.	Y COORD
[illegible]	FORCE	[illegible]	[illegible]
[illegible]	FORCE	[illegible]	X COORD
[illegible]	FORCE	[illegible]	Y COORD
[illegible]	FORCE	[illegible]	Z COORD
[illegible]	MOMENT	-121.	X COORD
[illegible]	MOMENT	[illegible]	Y COORD
[illegible]	MOMENT	[illegible]	Z COORD
[illegible]	FORCE	[illegible]	[illegible]
[illegible]	FORCE	[illegible]	Z COORD
[illegible]	FORCE	[illegible]	Y COORD
[illegible]	FORCE	[illegible]	[illegible]
[illegible]	FORCE	-135.	X COORD
[illegible]	FORCE	[illegible]	Y COORD
[illegible]	FORCE	[illegible]	Z COORD
[illegible]	MOMENT	[illegible]	X COORD
[illegible]	MOMENT	-1211.	Y COORD
[illegible]	MOMENT	[illegible]	Z COORD
800	FORCE	-140.	Y COORD
800	FORCE	-61.	Z COORD
810	FORCE	-103.	Y COORD
810	FORCE	[illegible]	[illegible]
[illegible]	FORCE	1127.	X COORD
[illegible]	FORCE	[illegible]	Y COORD
[illegible]	FORCE	[illegible]	Z COORD
[illegible]	MOMENT	-1441.	X COORD
[illegible]	MOMENT	3369.	Y COORD
[illegible]	MOMENT	[illegible]	Z COORD
[illegible]	FORCE	-179.	X COORD
[illegible]	FORCE	-1156.	Y COORD
730	FORCE	-103.	Y COORD
730	FORCE	-1202.	Y COORD
730	FORCE	1.	Z COORD

PAGE ##   05/10/15.   NUPIPE-II, NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1.9.1

SONGS 1 SI-51 ANALYSIS IMPELL SAMS (INDPNT. HORIZ. SPECTRA)

SUPPORT REACTIONS FOR LOAD CASE NO. 1

WEIGHT PLUS EXTERNAL FORCES

NODE	TYPE	REACTION (LBS OR IN-LBS)	DIRECTION
4	FORCE	-497.	X COORD
4	FORCE	1773.	Y COORD
4	FORCE	-238.	Z COORD
4	MOMENT	109983.	X COORD
4	MOMENT	-4998.	Y COORD
4	MOMENT	-30494.	Z COORD
119	FORCE	133.	X COORD
[illegible]	[illegible]	[illegible]	[illegible]

HP 41C code for Load conditions

Combines pipe support loads by:
Level A,B min = min (W, W+T)
max = max (W, W+T)

Total min = Level A,B min − SEISMIC
max = Level A,B max + SEISMIC

```
PRP "LCOM"

01+LBL "LCOM"
02 " WT?"          <---- Wt
03 PROMPT
04 STO 01
05 STO 02
06 "  T?"          <---- Thermal
07 PROMPT
08 ST+ 02
09 RCL 01
10 RCL 02
11 X>Y?
12 X<>Y
13 STO 03
14 X<>Y
15 STO 04
16 "A,MN= "
17 ARCL 03
18 PROMPT          ----> A, MN =  Level A,B, min
19 "A,MX= "
20 ARCL 04
21 PROMPT          ----> A, MX =  Level A,B, max
22 "SEIS?"
23 PROMPT
24 ST- 03
25 ST+ 04
26 "D,MN= "
27 ARCL 03
28 PROMPT          ----> D, MN =  Level D, min
29 "D,MX= "
30 ARCL 04
31 PROMPT          ----> D, MX =  Level D, max
32 END
```

LUGS

The following data has been gathered from the support analyses:

Node / AP	Force	∥ direction length (L_2)	both sides welded?	⊥ dir length (L_1)	weld throat
100/75	121 K	4"	✓	1 1/4"	1/4"
175/95	23.7 K	4"	✓	1 1/4"	1/4"
170/110	13.7	2"	✓	2"	1/4"
	13.7	4"	✓	1 1/4	1/4"
200/157	31.4	4	✓	1 1/4	5/16 (use 1/4)
330/270	47.4	4	✓	1 1/4	5/16
495/577	41.0	6	✓	1"	5/16
490/537, 846/	14.5	6	✓	1"	5/16
855/312	9.5	6	✓	1"	1/4"

LUGS

ASME Code Case N-318-2 shall be used, (4/12/84), but only σ_m stresses will be checked

1.0 Limitations

1.1 fillet welds ok

1.2 - must pt - cold piping

1.3 $\beta_1 \leq 0.5$, $\beta_2 < 0.5$, $\beta_1\beta_2 \leq 0.075$

$\beta_1 = L_1/r$, $\beta_2 = L_2/r$

L_1 = width of plate r = mean pipe radius, L_2 = length of plate

for D_o = 14.0, t_n = 0.58 (p = 900 psi)
12.75, t_n = 0.69

$r = (D_o - t_n)/2$ = 6.710
= 6.030

Node	L_1	β_1	r	L_2	β_2	$\beta_1\beta_2$	
100	1¼	0.19	6.71	4 → 2.65	0.59	0.111	NG
135	1¼	0.19	6.71	4 → 2.65	0.59	0.111	NG
170	2	0.30	6.71	2 → 1.68	0.30	0.89	NG
	1¼	0.19	6.71	4 → 2.65	0.59	0.111	NG
260	1¼	0.19	6.71	4 → 2.65	0.59	0.111	NG
380	1¼	0.19	6.71	4 → 2.65	0.59	0.111	NG
485	1	0.17	6.03	6 → 2.66	0.89	0.133	NG
490	1	0.17	6.03	6 → 2.66	0.89	0.133	NG
855	1	0.17	6.03	6 → 2.66	0.89	0.133	NG

100: try $L_2 = 0.5r = 3.35$, but $\beta_1\beta_2 = 0.095 > 0.075$
so $L_2 = 0.075r/\beta_1 \approx 2.65"$

135: same as 100

170 use $L_2 = 0.05r/\beta_1 = 1.68$ for 2" L^2
same as 100 for 4" L^2

260 same as 100
380 — " " "
485 - try $L_2 = 0.5r \cong 3.35$, $\beta_1\beta_2 = 0.075$ ok
855 - use 485 results
490 - try $L_2 = 0.5r = 3.01$ $\beta_1\beta_2 = 0.085$ NG.
try $L_2 = .075r/\beta_1 = (.075)(6.03)/.17 = 2.66$

LUBS

1.4 $\sqrt{rt} = \sqrt{(6.71)(0.58)} = 1.97'' \rightarrow$ 14.5/1.97 = 22 evenly spaced allowed: OK

1.5 $D_o/t = 14/0.58 = 25 < 100$

2.0 $r = 6.71''/6.03''$
$t = 0.58''/0.69''$
$D_o = 14''/12.75''$
$\gamma = r/t = 11.569/8.779$
B_1, B_2 from p1
L_1, L_2 from p1

$K_1 = 3.6$ for fillet weld

$M_L = M_N = M_T = Q_1 = W = 0$

$Q_2 \neq 0$, load

3.0

$S_{m1} = Q_2/2L_2L_b$

$L_b = \min(L_1, t) = \min(L_1, 0.58)$ for 14", $= \min(L_1, 0.69)$, for 12"

Node	Q_2	L_2	L_b	S_{mL}
100	12.1	2.65	0.58	3.94 ksi
135	29.7	2.65	0.58	9.74
170	13.7	1.68	0.58	7.03
	13.7	2.65	0.58	4.46
260	31.4	2.65	0.58	10.21
330	47.4	2.65	0.58	15.42
485	41.0	2.66	0.69	11.17
490	14.5	2.66	0.69	3.95
855	9.5	2.66	0.69	2.06

$S_{n1} = Q_2/2L_2L_b = S_{mL}$

$S_{m1}^{**} = S_{mL}$

3.0 - for eqn 9 & special reqmts only

$$(NC-9)\qquad \underbrace{\frac{B_1 P_{max} D_o}{2 t_m} + B_2 \frac{M_A + M_B}{Z}}_{\sigma_p} + S_{ML} \le \min(3.0 S_m, 2 S_y)$$

σ_p is the standard piping output stress - for straight pipe, the 0.75i form of the equation (which will be used here) gives identical results

for T_p 316 @ 120°F, S_m = 18,800 psi
S_y = 27,536 psi

min ($3 S_m$, $2 S_y$) = 56.4 (i.e. $3 S_y$)

Node	σ_p	S_{ML}	$\sigma_p + S_{ML}$	< 56.4 ksi?	S_{ML} < 18.8 ksi
100	8.8	3.94	12.7	OK-0.22	OK 0.21
135	9.5	9.74	23.2	OK 0.41	OK 0.50
170	9.1	7.03	16.1	OK-0.29	OK 0.37
170	9.1	4.46	13.6	OK-0.24	OK 0.24
260	17.5	10.21	29.3	OK 0.52	OK 0.21
380	12.6	15.42	29.6	OK 0.52	OK 0.82
485	12.8	16.17	30.0	OK-0.53	OK 0.57
490	14.3	3.95	18.3	OK 0.32	OK 0.21
555	13.5	2.06	15.6	OK 0.28	OK 0.11

$S_{ML}^{**} \le 2.5 S_y \Rightarrow$ since $S_{ML}^{**} = S_{ML} = S_{ML} < 2.0 S_y$, satisfied by the above

$Q_2^{**}/2L_2L_3 \le S_y$:

since $Q_2^{**} = Q_2$, this is equivalent to

$S_{ML} < \sigma_y$

3.2 - stat requirements for fillet welds.

(7) $\frac{2Q_2^{**}}{A_W} \leq 2S_y \leq 56.4$ ksi

$Q_2^{**} = Q_2$, A_W = fillet weld throat area

$A_W = t\,(n_1 L_1 + n_2 L_2)$

t - throat size
n_1 = # L_1 sides welded
n_2 = # L_2 " "

(8) $\{4\,[\,Q_2^{**}/A_W\,]^2\}^{1/2} \leq S_y$

since $Q_2^{**} = Q_2$, this reduces to

$2Q_2/A_W \leq S_y$

if this is satisfied, (7) is automatically satisfied

node	Q_2	n_1	L_1	n_2	L_2	A_W	$2Q_2/A_W$	$< S_y = 18.8$?
100	12.1	1	1.25	2	2.65	6.55	3.7	OK - 0.20
135	28.7	1	1.25	2	2.65	6.55	8.76	OK - 0.47
171	13.7	1	2.0	2	1.68	5.36	5.11	OK - 0.27
	13.7	1	1.25	2	2.65	6.55	4.18	OK 0.22
260	31.4	1	1.25	2	2.65	6.55	9.59	OK 0.51
380	47.4	1	1.25	2	2.65	6.55	7.24	OK 0.39
485	41.0	1	1.00	2	3.35	7.70	10.65	OK 0.57
490	14.5	1	1.0	2	3.06	4.91	5.90	OK 0.31
855	9.5	1	1.0	2	3.35	7.70	2.47	OK 0.13

Spring hanger table

Support No.	Node/dp	Type [Grinnell]	Loads Hot	Loads Max	Stress Ratio
SI-05-0320-H014	25/35	Fig B-268, #16, 'B'	6500	9750	0.67
SI-05-6004-H010	85/65	" , #14 'B'	4491	5200	0.86
SI-06-0319-H004	475/390	Fig 268, #17, 'B'	10100	13000	0.78
SI-06-0319-H005	675/375	" , #10, 'F'	1458	1690	0.86
SI-05-0320-H017	855/310	Fig 82, #14 'F'	4500	5200	0.87

Stress Ratio = hot load / max load

Max Loads taken from ITT Grinnell PH 71 catalog

SI-51 Sway Strut Analysis

Node / DP	Support No.	Length	Load	Part No. / size	Allowable Length	Allowable Load (normal)	Comment
135/45	SI-05-6004-H014	3'8¾"	12527	2200-30	78"	30000	OK-0.42
180/115	SI-02-6004-H002	4'10¼"	10556	C-211/#21	120"	15400	(1) OK-0.69
195/120	SI-02-6004-H006	5'7"	9216.	211/#2	120"	11630	OK - 0.79
200/125	SI-02-6004-H001	4'10¼"	11860	C-211/#1	120"	15400	(1) OK-0.77
260/157	SI-02-6005-H006	4'-1"	14751	2200-30	78"	30000	OK - 0.49
285/175	SI-02-6005-H005	4'-5½"	5500	211/#2	120"	11630	OK - 0.47
315/195	SI-02-6005-H002	2'-4½"	9344	C-211/#2	120"	11630	OK - 0.80
330/205	SI-02-6055-H008	3'-9"	13307	2200-30	78"	30000	OK - 0.44

MJB 5/12/95

MJQ 2/15/86

SWAY STRUT NOTES:

1) The given allowable for these struts is for a length of 10', where buckling would clearly govern. Because of this, a buckling calculation will be used to establish capacity. This is attached.

MJR 4/12/85

SWAY STRUT ANALYSIS -

Struts @ nodes 180 & 200 are C-211, size 1 Grinnel sway struts 4'10" long loaded to 10556 and 16, respectively. the capacity of these supports will be assessed in terms of the buckling load, and shear of the bolts.

Buckling - based on a pinned-pinned, 2" sch 160 pipe, 4'10" long.

2" sch 160 pipe: $A = 2.190^{-2}$, $I = 1.162^{-4}$

$$r = \sqrt{I/A} = \sqrt{\frac{1.162}{2.190}} = 0.728''$$

K = 1.0 (pin-pin, p 5-124, AISC, 8th)

$$\frac{Kl}{r} = \frac{58}{.728} = 79.625 < 200$$

Assume $F_y = 36$ KSI

$$C_c = \sqrt{\frac{2\pi^2(29\times10^6)}{(36\times10^3)}} \qquad \text{1.5-1, AISC, 8th}$$

$C_c = 126.1$

$Kl/r < C_c$:

$$F_a = \frac{\left[1 - \frac{79.625^2}{2(126.1)^2}\right]36}{\frac{5}{3} + \frac{3(79.625)}{8(126.1)} - \frac{(79.625)^3}{8(126.1)^3}}$$

$F_a = 15,797$

strut @ node 180 [illegible], @ 200, o.k.

note: use 1.33 seismic factor. $F_a = 1.33(15,797) = 21,010$

$F_a < F_a$ @ node 180

ST-51 SNUBBER LOAD

Node/dp	Length	Load (lb)	Support No.	Manuf.	Model No.	Allow. Length	Load Rating	Comments
22/30	1.5'	1193	ST-05-0320-H013	Pacific Scientific	PSA-3	4.5'	11,700	OK
180/75	4.5'	5028	ST-05-6004-H012	Pacific Scientific	PSA-10	4.6'	22,100	OK
170/110	3.8'	12673	ST-02-6004-H005	Pac Sci	PSA-10	4.6'	22100	OK-057
310/196	7.6'	13605	ST-02-6005-H008	Pac. Sci.	PSA-35	10.0'	72450	OK
340/210	8.4'	16113	ST-06-6005-H001	Pac. Sci.	PSA-35	10.0'	72450	OK
375/225	3.0'	10189	ST-06-6005-H005	Pac. Sci.	PSA-10	4.6'	22100	NG-1.82
380/230	5.2'	18987	ST-06-6055-H004	Pac Sci	PSA-10	4.6'	17114 (1)	NG-1.11
455/537	3.2'	18970	ST-06-0314-H007	Pac. Sci	PSA-35	10.0'	72450	OK
490/538	6.5'	17653	ST-06-0315-H006	Pac Sci	PSA-35	10.0'	72450	OK
535/570	7.8'	10596	ST-06-0323-H006	Pac. Sci.	PSA-35	10.0'	72450	OK
625/315	4.0'	17552	ST-06-0315-H010	Pac Sci.	PSA-35	10.0'	72450	OK
846/307	6.5'	6362	ST-05-6004-H009	Pac. Sci.	PSA-10	4.6'	15459 (2)	0.41-OK
855/312	5.5'	7251	ST-05-0320-H016	Pac. Sci.	PSA-35	10.0'	72450	OK
861/	5.6'	6206	ST-05-032-H011	Pac Sci	PSA-35	10.0'	72450	OK
870/320	7.2'	12533	ST-05-0320-H004	Pac Sci	PSA-35	10.0'	72450	OK

II-51 Snubber Table Notes

1) The buckling load, away from simple compression failure (short columns), is controlled by the following relationships:

$$P_1 = K_1 / l_1^2$$
$$P_2 = K_2 / l_2^2$$

for the same snubber $K_1 = K_2$:

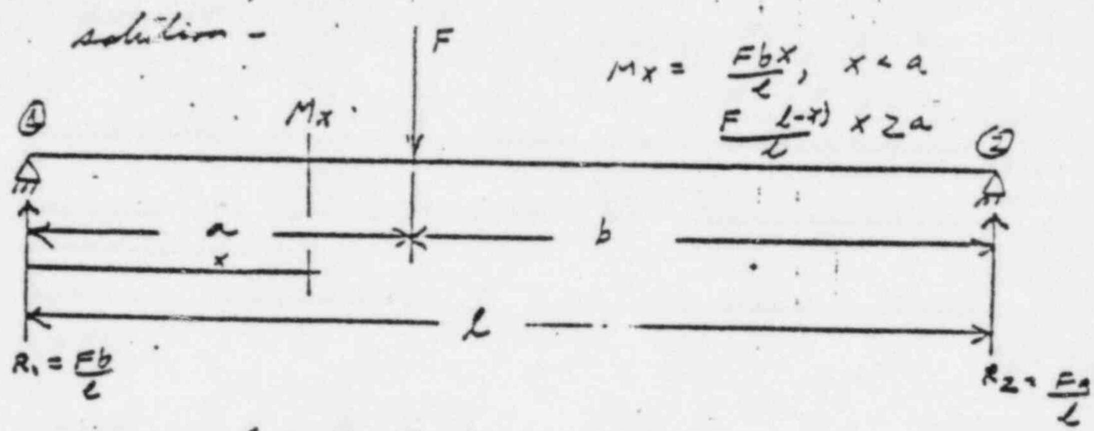
$$P_1 / P_2 = (l_2 / l_1)^2$$

$$P_1 = (22100)(4.6/5.2)^2 =$$

2) Same as above:

$$P_1 = (22100)(4.6/5.5)^2 = 15459$$

SS solution -



$M_x = \frac{Fbx}{l}, \; x < a$

$\frac{F(l-x)}{l} \; x \geq a$

given: l, a, F, I, S

needed: R_1, R_2, $F_b(x)$

Register	Contents
0	l
1	a
2	F
~~3~~	~~I~~
4	S
5	b
6	X

```
PRP "SS"

01+LBL "SS"
02 XEQ "INP"
03 RCL 02
04 RCL 05
05 *
06 RCL 00
07 /
08 "R1= "
09 ARCL X
10 PROMPT
11 RCL 02
12 RCL 01
13 *
14 RCL 00
15 /
16 "R2= "
17 ARCL X
18 PROMPT
19 RCL 02
20 RCL 05
21 *
22 RCL 01
23 *
24 RCL 00
25 /
26 RCL 04
27 /
28 "SA= "
29 ARCL X
30 PROMPT
31 SF 01
```

```
32+LBL 01
33 "  X=?"
34 PROMPT
35 STO 06
36 RCL 01
37 X>Y?
38 GTO 02
39 RCL 00
40 RCL 06
41 -
42 RCL 02
43 *
44 RCL 01
45 *
46 RCL 00
47 /
48 GTO 03

49+LBL 02
50 RCL 02
51 RCL 05
52 *
53 RCL 06
54 *
55 RCL 00
56 /

57+LBL 03
58 RCL 04
59 /
60 "SX= "
61 ARCL X
62 PROMPT
63 GTO 01
64 END
```

```
PRP "INP"

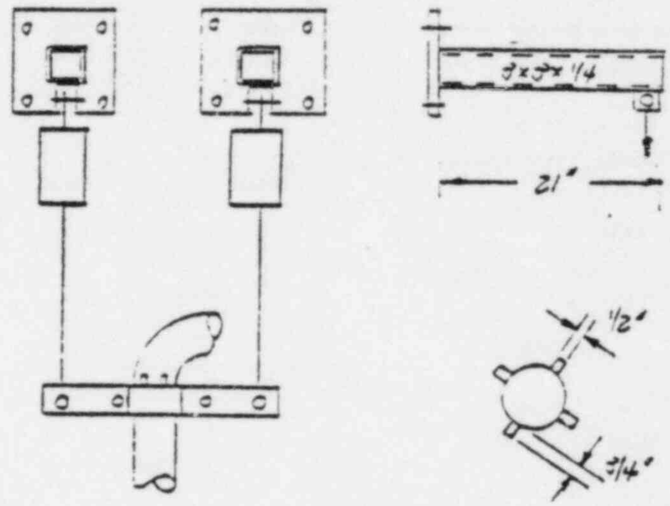
01+LBL "INP"
02 "  L=?"
03 PROMPT
04 STO 00
05 "  A=?"
06 PROMPT
07 STO 01
08 "  F=?"
09 PROMPT
10 STO 02
11 "  S=?"
12 PROMPT
13 STO 04
14 RCL 00
15 RCL 01
16 -
17 STO 05
18 END
```

NCL 51
4
NC-DC

SI-01-6007-H00A

LOADS:

$|W+P_d| = 1050$ lb.



CONSIDER LUGS: 1/2" x 3/4" x 1" Long

Shear: $\sigma_v = \dfrac{1050}{4(1/2)(1)} = 525$ psi $< 14,400$ psi

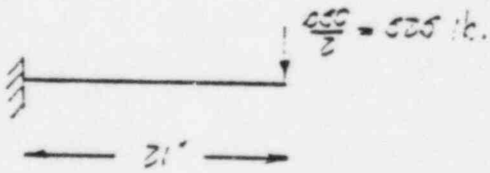
CONSIDER SPRING HANGER & CLEVISES:

Assume Grinnell parts —

Part	Allowable Load (lb.)
290	1810
140	1810
66	1810
(2) B-268, Fig. C Size 7	1064

Actual loads are less than allowables.

CONSIDER 3x3x1/4 TUBING: (use longest beam)

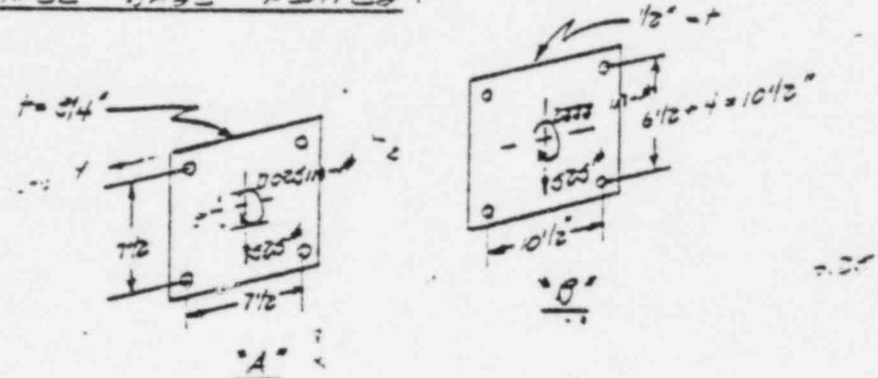


$A = 2.59$ in^2
$S =$ [illegible] in^3

shear: $\sigma_v = \frac{525}{2.59} = 203$ psi < 14,400 psi

Bending: $\sigma_b = \frac{525(21)}{2.10} = 5250$ psi < 23,760 psi

CONSIDER BASE PLATES:



use "PLATE" program —

Bending: $\sigma_{b_{max}} = 12,882$ psi for plate "A" < 23,760 psi

$\sigma_{b_{max}} = 8,697$ psi for plate "B" < 23,760 psi

Tension: $\sigma_t = \frac{525}{[9-2(3/4)](3/4)} = 93$ psi < 21,600 psi

shear: $\sigma_v = \frac{525}{4(1\frac{1}{2})(\frac{1}{2})} = 175$ psi < 14,400 psi

CONSIDER BOLTS:

For plate "A" →

Tension: $P = \frac{11025}{(7.5)(2)} = 735$ lb/bolt

shear: $P = \frac{525}{4} = 131$ lb/bolt

For plate "B" →

Tension: $P = \frac{2222}{(10^1/2)(2)} = 138$ lb/bolt

Shear: $P = \frac{525}{4} = 131$ lb/bolt

These loads appear reasonable for the respective bolt sizes, however, allowables are unknown.

CONSIDER WELDS:

Lugs to pipe → 3/16" fillet, both sides

Shear: $\sigma_v = \frac{525}{.707(3/16)(8)(1)} = 495$ psi

Clevis to tubing → 1/4" fillet, both sides

Tension: $\sigma_t = \frac{525}{.707(1/4)(2)(1^1/4)} = 1188$ psi.

Tubing to plate → 1/4" fillet, all around

Shear: $\sigma_v = \frac{525}{.707(1/4)(6)} = 495$ psi

Bending: $\sigma_b = \frac{525(21)}{.707(1/4)(6)(3)} = 3,465$ psi

CONSIDER RISER CLAMP:

For a Grinnell #3 40 clamp, allowable load = 3450 lbs > 1050 lbs.

∴ This support is acceptable.

PLATE "A"

	03	2.25	2.25	
	04	3.75	3.75	
	05	2.25	5.25	
	06	3.75	3.75	
	07	7.5	7.5	
	08	7.5	7.5	
	09	3675	-3675	
	10	6.52E-10	6.52E-10	
	14	1.12E+06	1.12E+06	
11	ω_{xx}	-.0007	.00003	
12	ω_{yy}	-.0007	.00019	
13	ω_{xy}	-4.72E-15	3.53E-15	
14	M_{xx}	1046.55	-97.86	
15	M_{yy}	984.07	-223.60	
17	M_{xy}	-3.70E-09	2.76E-09	**TOTAL**
18	σ_x	11,163.23	-1043.79	12,207
19	σ_y	10,495.73	-2385.04	12,882
20	σ_{xy}	-3.95E-08	2.95E-08	6.90E-08

PLATE "B"

03	3.75	3.75	
04	5.25	5.25	
05	3.75	6.75	
06	5.25	5.25	
07	10.5	10.5	
08	10.5	10.5	
09	963	-963	
10	1.12E-09	1.12E-09	
14	3.32E+05	3.32E+05	
ω_{xx}	-.0007	.00007	
ω_{yy}	-.0006	.0003	
ω_{xy}	-1.14E-14	-2.64E-14	
M_{xx}	284.50	-46.87	
M_{yy}	272.44	-89.95	
M_{xy}	-2.65E-09	-6.14E-09	TOTAL
σ_x	6,827.90	-1,124.83	7,952.73
σ_y	6,538.67	-2,158.73	8,697.40
σ_{xy}	-6.3E-08	-1.47E-07	2.10E-07

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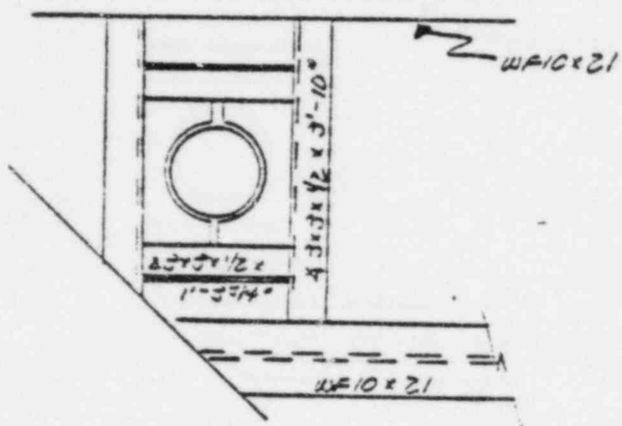
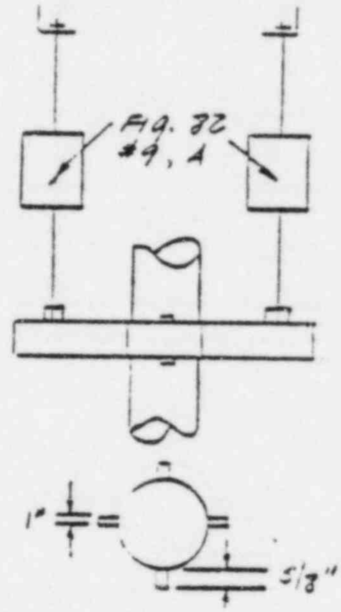
Loads: $|W + P_d + T| = 2040$ lbs.





CONSIDER LUGS: 5/8" × 1" × 1" long

Shear: $\sigma_v = \dfrac{2040}{4(1)(1)} = 510$ psi $<$ 14,400 psi

CONSIDER CLAMP:

For a Grinnell HS 40 clamp with 5/8" bolts, allowable load = 3450 lbs > 2040 lbs.

CONSIDER SPRING HANGERS & CLEVISES:

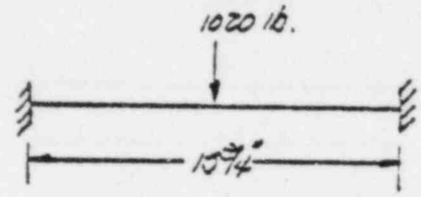
Assume Grinnell parts —

Part	Allowable Load (lbs)
290	2710
140	2710
(2) 82, Type A #9	2040/2042

Actual loads ≤ allowables

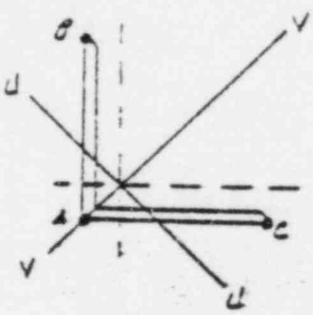
CONSIDER ∠ 3 x 3 x 1/2 x 1'-3 3/4":

Consider as a fixed-fixed beam w/ loads applied at center —



shear: $\sigma_v = \frac{1020/2}{2.75} = 185$ psi < 14,400 psi

bending: $a = 2.75\ in^2$ $\quad I_x = I_y = 2.22\ in^4$
$x_o = y_o = 0.932$ in $\quad r_u = 0.584$ in



$I_u = 2.75(.584)^2 = 0.938\ in^4$

$I_v = 2(2.22) - .938 = 3.502\ in^4$

$v_A = -1.318$ $\quad v_B = 1.478$ $\quad v_C = 1.478$
$u_A = 0.$ $\quad u_B = -2.796$ $\quad u_C = 2.796$

$M_u = \frac{-.707(1020)(15\,3/4)}{8} = -1420$ in-lb

$M_v = \frac{.707(1020)(15\,3/4)}{8} = 1420$ in-lb.

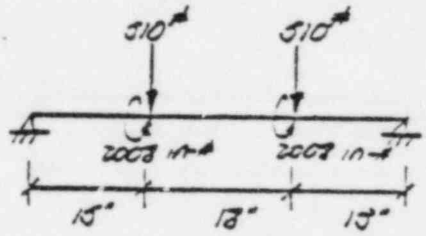
$\sigma_A = \frac{-1420(-1.318)}{.938} = 1995$ psi < 21,600 psi

$\sigma_B = \frac{-1420(1.478)}{.938} + \frac{1420(-2.796)}{3.502} = 3371$ psi < 21,600 psi

$\sigma_C = \frac{-1420(1.478)}{.938} + \frac{1420(2.796)}{3.502} = -1104$ psi < 21,600 psi

CONSIDER ∠ 3×3×1/2 × 3'-10" :

consider as a fixed-fixed beam with loads applied as shown —



shear: $\sigma_v = \dfrac{\dfrac{2(510)(31)^2\left[(3)(15)+31\right]}{463}}{2.75} = 223$ psi < 14,400 psi

Bending: $M_{max} = \dfrac{2(510)(15)(31)^2}{46^2} = 6949$ in-lb

$M_u = -.707(6949) = -4913$ in-lb

$M_v = .707(6949) = 4913$ in-lb

$\sigma_A = -\dfrac{4913(-1.318)}{.938} = +6903$ psi < 21,600 psi

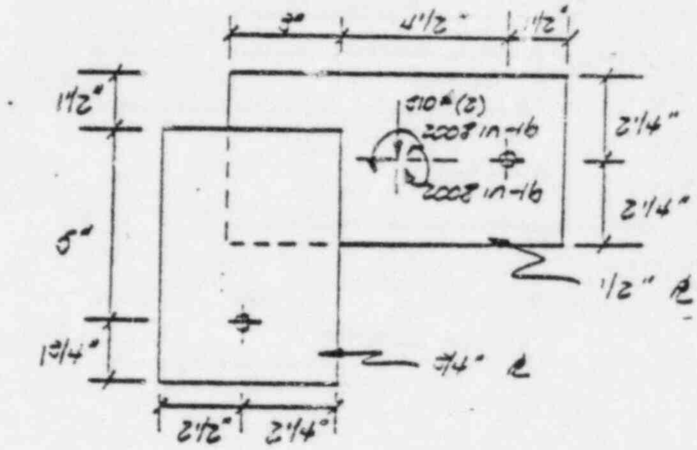
$\sigma_B = -\dfrac{4913(1.478)}{.938} + \dfrac{4913(-2.796)}{3.502} = 11,664$ psi < 21,600 psi

$\sigma_C = -\dfrac{4913(1.478)}{.938} + \dfrac{4913(2.796)}{3.502} = -3819$ psi < 21,600 psi

Torsion: $J = \frac{1}{3}\left[3(1/2)^3 + (3-1/2)(1/2)^3\right] = 0.229$ in^4

$\tau = \dfrac{Tc}{J} = \dfrac{2(2008)(1/2)}{.229} = 8769$ psi < 14,400 psi

CONSIDER BASE PLATE:



$419 \text{ lb.} = \frac{2(510)(3)}{6.75} - \frac{2008}{7.5}$

2008 in-lb $\quad \frac{2008}{7.5} + \frac{2(510)(2.25)}{6.75} = 334 \text{ lb.}$

For 1/2" PL —

Shear: $\sigma_V = \frac{334}{(4\tfrac{1}{2} - 3/4)(1/2)} = 445 \text{ psi} < 14{,}400 \text{ psi}$

Torsion: $\tau = \frac{2008(1/2)(3)}{4\tfrac{1}{2}(1/2)^3} = 5355 \text{ psi} < 14{,}400 \text{ psi}$

For 3/4" PL —

Shear: $\sigma_V = \frac{419}{2(1\tfrac{3}{4})(3/4)} = 160 \text{ psi} < 14{,}400 \text{ psi}$

Tension: $\sigma_t = \frac{419}{(4\tfrac{3}{4} - 1)(3/4)} = 150 \text{ psi} < 21{,}600 \text{ psi}$

Bending: $\sigma_b = \frac{2008(3/4/2)}{4\tfrac{3}{4}(3/4)^3/12} = 4509 \text{ psi} < 27{,}000 \text{ psi}$

CONSIDER BOLTS:

For 3/4" Fig. 5-34 Philips –

Shear = 834 lb < 16,516/5 = 3303 lb. allowable

Tension = $\frac{2008}{4.25}$ = 472 lb. < 17,675/5 = 3535 lb. allow

For 1" Hilti bolt –

Shear = 419 lb. < 26879/5 = 5376 lb. allowable

Tension = 472 lb. < 14,000/5 = 2800 lb. allow.

CONSIDER WELDS:

∠ 3×3×1/2 to ∠ 3×3×1/2 – 3/16" Fillet

Shear: $\sigma_V = \frac{1020/2}{.707(3/16)(12)} = 321$ psi

Bending: $\sigma_b = \frac{1020(15\,3/4)/2}{.707(3/16)\left[\frac{4(3)(3)+(3)^2}{6}\right]} = 2020$ psi

Total: 2341 psi

∠ 3×3×1/2 to anchor – 3/16" Fillet

Shear: $\sigma_V = \frac{\frac{2(510)(31)^2}{423}\left[3(15)+31\right]}{.707(3/16)(12)} = 786$ psi

Bending: $\sigma_b = \frac{6949}{.707(3/16)\left[\frac{4(3)(3)+(3)^2}{6}\right]} = 6589$ psi

Torsion: $\tau = \frac{2(2008)}{.707(3/16)\left[\frac{(3+3)^4-6(3)^2(3)^2}{12(3+3)}\right]} = 2693$ psi

Total: 10,068 psi

∴ This support appears acceptable.

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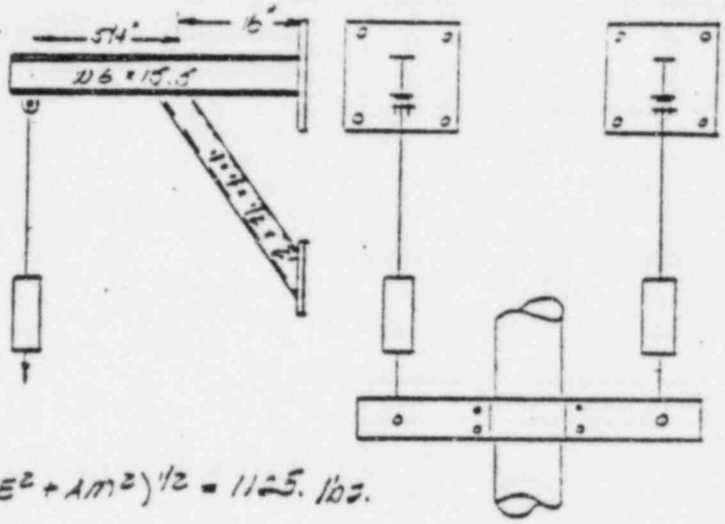


LOADS:

$$|W + P_d| + (SSE^2 + AM^2)^{1/2} = 1125.\ lbs.$$

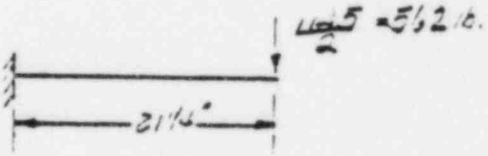
CONSIDER SNUBBERS AND CLEVISES:

For PSA-3, allowable load = 6000 lbs. Level A-B
= 10,380 lbs. Level C-D

∴ Imposed load is below allowables

CONSIDER HORIZONTAL WIDE FLANGE:

conservatively consider WF as a cantilever beam w/out bracing —



A = 4.56
I = 10.0

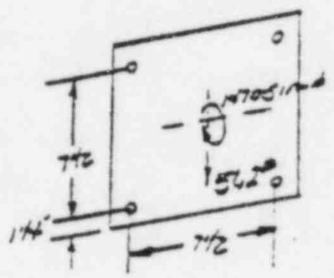
shear: $\sigma_V = \dfrac{562}{4.56} = 123\ psi < 14{,}400\ psi$

bending: $\sigma_b = \dfrac{562\,(21\,1/4)}{10} = 1194\ psi < 23{,}760\ psi$

<u>CONSIDER LUGS:</u> 3/4" × 1" × 2" Long

Shear: $\sigma_v = \dfrac{1125}{4(1)(2)} = 141$ psi < 14,400 psi

<u>CONSIDER BASE PLATES:</u> 3/4" × 10" × 10"



Bending: Conservatively consider plate as a simply supported beam with moment applied at center –

$\sigma_b = \dfrac{11943\,(3/4/2)}{7\tfrac{1}{2}(3/4)^3/12} = 16986$ psi < 23,760 psi

Shear: $\sigma_v = \dfrac{562}{4(1\tfrac{1}{4})(3/4)} = 150$ psi < 14,400 psi

Tension: $\sigma_t = \dfrac{562}{[10-2(3/4)](3/4)} = 88$ psi < 21,600 psi

<u>CONSIDER BOLTS:</u>

Tension: $P_T = \dfrac{11943}{7\tfrac{1}{2}(3)} = 796$ lb/bolt

Shear: $P_v = \dfrac{693}{4} = 173$ lb/bolt

Although the type of anchor bolt is unknown these loads appear reasonable for 3/4" bolts.

CONSIDER WELDS:

clevis to WF → 1/4" fillet, all around

Tension: $\sigma_t = \frac{562}{.707(1/4)(2.25)(4)} = 353$ psi

WF to plate → 1/4" fillet, all around

Shear: $\sigma_v = \frac{562}{2(5.46)(.707)(1/4)} = 291$ psi

Bending: $\sigma_b = \frac{11943}{.707(1/4)(6)(5.995)} = 1879$ psi

CONSIDER RISER CLAMP:

Assume a 6" Grinnell HS 40 riser clamp:

Allowable load = 3450 lbs. > 1125 lbs.

∴ This support is acceptable.

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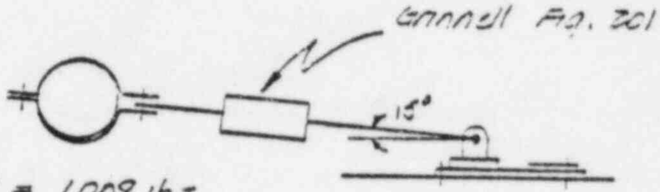


LOADS: $|W+P_d| + (SSE^2 + AM^2)^{1/2} = 1008$ lbs.

CONSIDER SNUBBER, CLAMP, CLEVIS:

For Grinnell Fig. 201 assembly, the allowable load = 10,350 lbs. > 1008 lbs.

CONSIDER WELDS:

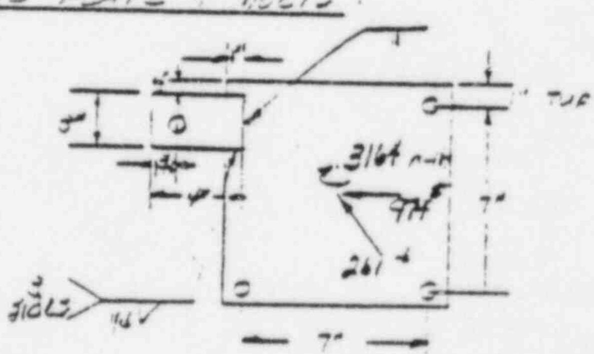
clevis plate to base plate — 5/16" fillet all around

shear: $\sigma_v = \dfrac{1008 \cos 15}{.707(5/16)(10)} = 441$ psi

Tension: $\sigma_t = \left[\dfrac{(1008 \cos 15)(3\,1/4)}{5} + 1010 \sin 15\right] \dfrac{1}{.707(5/16)(10)}$

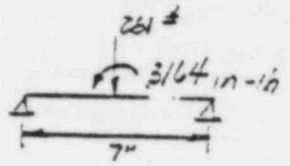
$= 405$ psi

CONSIDER BASE PLATE + BOLTS:



First, consider main plate as if there existed a rigid connection in upper left corner:

Bending:

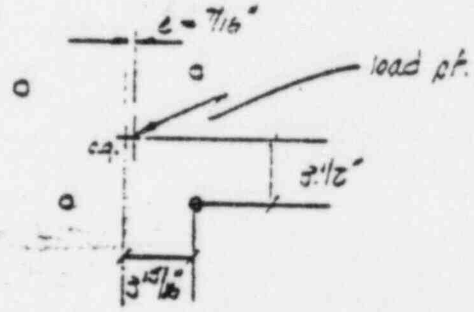


$$\sigma_b = \left[3164 + \frac{261(7)}{4}\right]\frac{(1/2 \cdot 1/2)}{7(1/2)^3/12} = 12414 \text{ psi} < 23{,}760 \text{ psi}$$

Tension: $$\sigma_t = \frac{974}{[9 - 2(3/4)]\,1/2} = 260 \text{ psi} < 21{,}600 \text{ psi}$$

Shear: $$\sigma_v = \frac{974}{4(1)(1/2)} = 487 \text{ psi} < 14{,}400 \text{ psi}$$

2. Second, consider bolt loads taking into account eccentric bolt pattern:



Since c.g. of bolt pattern is so close to point of loading, ignore eccentricity and consider safety factor in doing so.

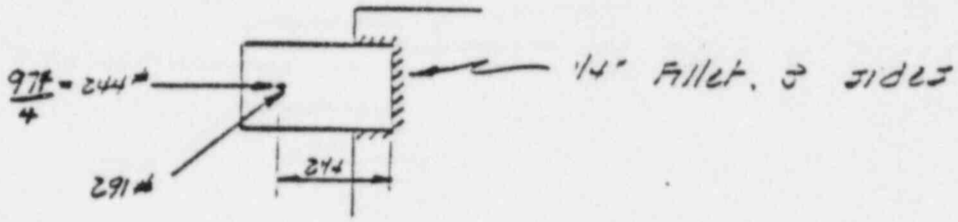
Shear : $$\sigma_v = \frac{974}{4} = 244 \text{ lb/bolt}$$

Tension: $$\sigma_t = \frac{261}{4} + \frac{3164}{2(7)} = 291 \text{ lb/bolt}$$

For 3/4" Hilti Kwik Bolts the ultimate shear load is 13,257 lb. and the ultimate tensile load is 7155 lb.

Although the allowable loads for the other 3/4" bolts are unknown, the imposed loads are so small that they are deemed acceptable.

3. Consider joint of extension plate to main plate:



$$\sigma = \left[\frac{244 + 291}{5} + \frac{291(2\frac{1}{4})}{1^2[(2)(3)+1]/3(1+3)} \right] \frac{1}{.707(\frac{1}{4})} = 6956 \text{ psi}$$

∴ This support is acceptable.

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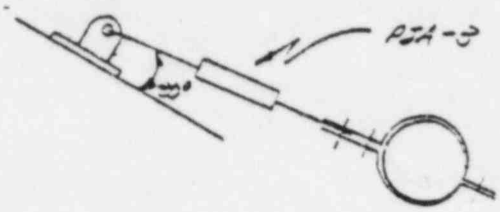
LOADS:



$|W + P_d + T| + (SSE^2 + AM^2)^{1/2}$

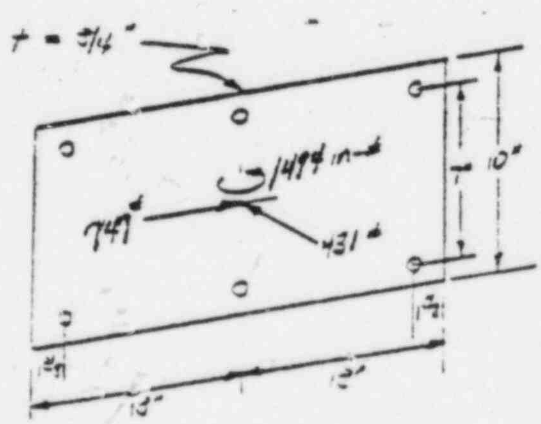
$= 862$ lbs.

CONSIDER SNUBBER, CLAMP, CLEVIS:

Assume all Pacific Scientific PSA-3 parts:

Allowable load = 6000 lbs Level A + B
10,380 lbs Level C + D

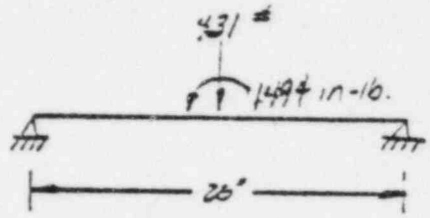
CONSIDER BASE PLATE:



Tension: $\sigma_t = \frac{747}{[10 - 2(9/16)](3/4)} = 119$ psi < 21,600 psi

Shear: $\tau_v = \frac{747}{4(1\,7/8)(3/4)} = 131$ psi < 14,400 psi

Bending: Conservatively ignore inside bolts and consider plate as a simply supported beam with moment and axial applied at center —



$$\sigma_b = \frac{Mc}{I} = \left[\frac{431(26)}{4} + 1494\right]\frac{(3/4/2)}{7(3/4)^3/12} = 6546 \text{ psi} < 23{,}750 \text{ psi}$$

CONSIDER BOLTS:

Shear: $\frac{747}{6} = 125$ lb / bolt

Tension: consider corner bolts only –

$$\frac{1494}{2(26)} + \frac{431}{4} = 136 \text{ lb / bolt}$$

∴ Although bolt type is unknown, these loads appear acceptable for 3/4" concrete anchors.

CONSIDER WELDS:

Clevis plate to base plate – 1/4" fillet all around

Shear: $\sigma_v = \frac{747}{.707(1/4)(10)} = 423$ psi

Tension: $\sigma_t = \frac{431 + 1494/5}{.707(1/4)(10)} = 413$ psi

∴ This support is acceptable.

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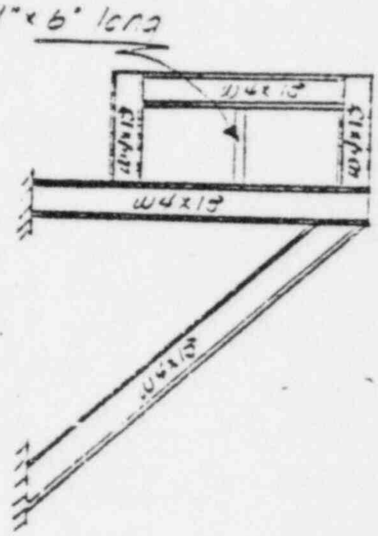

LOADS:

Y-dir. $|W+P_d+T| = 1036$ lbs

$|W+P_d+T| + (SSE^2+AM^2)^{1/2} = 1645$ lbs.

Inc. $|W+P_d+T| = 105$ lbs.

$|W+P_d+T| + (SSE^2+AM^2)^{1/2} = 442$ lbs.

Utilize computer program "FRAME" to find reactions in structural members: Analyze for worst load combinations

CONSIDER W4x13 MEMBERS: $A = 3.83\ in^2$,. $S = 5.46\ in^3$

Tension: $\sigma_t = \frac{1825}{3.83} = 477$ psi < 21,600 psi

Compression: $C_c = 126$

$$\frac{Kl}{r} = \frac{2(42)}{1.0} = 84 < 126$$

$$F_a = \frac{\left[1 - \frac{(84)^2}{2(126)^2}\right] 36{,}000}{\frac{5}{3} + \frac{3(84)}{8(126)} - \frac{(84)^3}{8(126)^3}} = 14{,}397 \text{ psi}$$

Level D = 28010 psi

$\sigma_a = \frac{1834}{3.83} = 479$ psi < 14,397 psi

Shear: $\sigma_v = \frac{1162}{3.83} = 303$ psi < 14,400 psi

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Bending: $\sigma_b = \frac{3984}{5.46} = 726 \text{ psi} < 23{,}760 \text{ psi}$

<u>CONSIDER 1¼ × 4 × 6 ℓ</u> :

Tension: $\sigma_t = \frac{586}{5.0} = 117 \text{ psi} < 21{,}600 \text{ psi}$

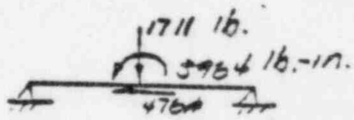
Shear: $\sigma_v = \frac{266}{5} = 53 \text{ psi} < 14{,}400 \text{ psi}$

Bending: $\sigma_b = \frac{789\,(1\tfrac{1}{4}/2)}{4(1\tfrac{1}{4})^2/12} = 757 \text{ psi} < 27000 \text{ psi}$

<u>CONSIDER BASE PLATES</u>:

Analyze plates as simply supported beam with loads applied at center:

Top plate:

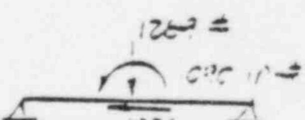


Bending: $\left[3984 + \frac{1711\,(20)}{4}\right]\frac{(1/2)}{17(1)^2/12} = 4418 \text{ psi} < 27000 \text{ psi}$

Tension: $\sigma_t = \frac{476}{[21 - 2(1\tfrac{3}{8})](1)} = 26 \text{ psi} < 21{,}600 \text{ psi}$

Shear: $\tau_v = \frac{476}{4(2)(1)} = 60 \text{ psi} < 14{,}400 \text{ psi}$

Bottom plate:



Bending: $\left[1090 + \frac{1269(13)}{4}\right]\frac{(1\frac{1}{2}/2)}{13(\frac{1}{2})^3/12} = 9626 \text{ psi} < 27000 \text{ psi}$

Tension: $\sigma_t = \frac{1326}{[16 - 2(\frac{13}{16})]\frac{1}{2}} = 184 \text{ psi} < 21{,}600 \text{ psi}$

Shear: $\sigma_v = \frac{1326}{4(1\frac{1}{2})(\frac{1}{2})} = 111 \text{ psi} < 14{,}400 \text{ psi}$

CONSIDER ANCHOR BOLTS:

At top anchor:

Shear: $\sigma_v = \frac{476}{4} = 116 \text{ lb/bolt}$

Tension: $\sigma_t = \frac{1711}{4} + \frac{3964}{2(17)} = 544 \text{ lb/bolt}$

These loads appear reasonable for 1/4" concrete anchors.

At bottom anchor:

Shear: $\sigma_v = \frac{1326}{4} = 332 \text{ lb/bolt}$

Tension: $\sigma_t = \frac{1269}{4} + \frac{1090}{2(13)} = 359 \text{ lb/bolt}$

These loads appear reasonable for 3/4" concrete anchors.

CONSIDER WELDS:

Wide to base plate: 5/16" Fillet

Tension: $\sigma_t = \frac{\frac{1711}{2} - \frac{3964}{4}}{.707(\frac{5}{16})(4)} = 3432 \text{ psi}$

Shear: $\sigma_v = \dfrac{1326}{.707(3/16)(2)(2\,3/4)} = 1819$ psi

W4×13 to W4×13: 1/4" Fillet

Shear: $\sigma_v = \dfrac{1724}{.707(1/4)(2)(2\,3/4)} = 1773$ psi

Tension: $\sigma_T = \dfrac{\frac{1162}{2} + \frac{2734}{4}}{.707(1/4)(4)} = 1789$ psi

℄ 1 1/4 × 4 × 6 to W4×13: 5/16" Fillet

Shear: $\sigma_v = \dfrac{266}{.707(5/16)(8)} = 151$ psi

Tension: $\sigma_t = \dfrac{586 + 789/1\,1/4}{.707(5/16)(8)} = 689$ psi

Total 840 psi

∴ This support appears acceptable. However, it should be noted that additional loading will be imposed by the other piping supported by this structure. This additional loading will probably <u>not</u> overstress the structure.

Revised loadings of (1482, 496) vs the original loads of (1645 vs 496) required analysis. Since the vertical load decreased the same % as the horizontal load increased & is ~3 times the horizontal, and would contribute more to the stress in the limiting element, the support has the same stress ratio - OK.

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JOINT NUMBER	COORDINATES X	Y	Z	DISPLACEMENT - RESTRAINTS - ROTATIONS X	Y	Z	X	Y	Z
1	0.000	0.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
2	9.500	0.000	0.000						
3	7.000	0.000	0.000						
4	19.500	0.000	0.000						
5	25.750	0.000	0.000						
6	33.000	0.000	0.000						
7	3.000	-10.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
8	30.000	5.000	0.000						
9	13.000	10.000	0.000						
10	25.750	10.000	0.000						
11	19.500	[illegible]	0.000						
12	3.000	[illegible]	0.000						
13	25.500	5.000	0.000						

MEMBER TYPE	SECTION AREA	MODULUS OF ELASTICITY	THERMAL EXP. COEFFICIENT	AREA MOMENT OF INERTIA Z AXIS	Y AXIS	TORSIONAL RIGIDITY	UNIT WEIGHT	REFERENCE VECTOR FOR X AXIS X1	X2	X3
1	1.5000	.293E+08	0.	12.3930	[illegible]	.166E+07	.2836	0.0000	0.0000	1.0000
2	5.0000	.293E+08	0.	.5?10	[illegible]	.292E+08	.2836	0.0000	0.0000	1.0000

MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT
1	2	1	5.000	[illegible]	2	2	1	[illegible]	4.235	5	4	1	10.500	11.381
3	13	1	10.000	10.625	4	[illegible]	1	[illegible]	5.190	4	13	2	5.000	7.075
12	11	1	15.?00	11.321	5	[illegible]	1	[illegible]	5.190	13	11	2	[illegible]	7.075
11	10	1	5.250	5.650	6	8	1	[illegible]	5.419	6	7	1	42.420	45.986
10	5	1	5.250	5.650	8	9	1	5.000	5.419					

TOTAL STRUCTURAL WEIGHT 1?7.692 CENTER OF GRAVITY X = 16.42311, Y = -2.00451, Z = 0.00000

THE STIFFNESS MATRIX FOR ?6 EQUATIONS REQUIRES 9?7 STORAGE LOCATIONS

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SEISMIC LOADS

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	MOMENT APPLIED ABOUT THE X AXIS	Y AXIS	Z AXIS
8	0.	-.1645E+04	0.	0.	0.	0.
9	.4420E+03	0.	0.	0.	0.	0.

JOINT	DISPLACEMENTS IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	ROTATIONS ABOUT THE X AXIS	Y AXIS	Z AXIS
1	0.	0.	0.	0.	0.	0.
2	.7692E-14	-.1360E-02	0.	0.	0.	-.4633E-04
3	.1398E-03	-.[illegible]E-02	0.	0.	0.	-.1589E-04
4	.2303E-03	-.1085E-02	0.	0.	0.	-.1395E-04
12	.[illegible]E-03	-.[illegible]E-02	0.	0.	0.	-.7156E-04
5	.3415E-03	-.1360E-02	0.	0.	0.	-.3036E-04
13	.[illegible]E-03	-.1374E-02	0.	0.	0.	-.4[illegible]E-04
11	.[illegible]E-03	-.1303E-02	0.	0.	0.	-.5179E-04
6	.4533E-03	-.1554E-02	0.	0.	0.	-.[illegible]E-04
10	.8319E-03	-.12[illegible]E-02	0.	0.	0.	-.3631E-04
8	.[illegible]E-03	-.1461E-02	0.	0.	0.	-.3899E-04
7	0.	0.	0.	0.	0.	0.
9	.[illegible]E-03	-.2485E-02	0.	0.	0.	-.3462E-04

MEMBER I	J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE X AXIS	Y AXIS	TORSION	BENDING MOMENTS ABOUT THE X AXIS I END	J END	Y AXIS I END	J END
1	2	.1769E+04	0.	.3117E+03	0.	.3035E+04	.2240E+04	0.	0.
2	3	.1765E+04	0.	.1157E+03	0.	.2240E+04	.5646E+03	0.	0.
3	4	.1712E+04	0.	.1627E+03	0.	.7544E+03	-.9153E+03	0.	0.
3	12	-.1445E+03	0.	-.3167E+01	0.	.1704E+03	.2015E+03	0.	0.
4	5	.1722E+04	0.	.4526E+03	0.	-.1305E+03	-.3365E+04	0.	0.
4	13	.1164E+03	0.	-.1272E+02	0.	-.4557E+02	-.2245E+02	0.	0.
12	11	-.3167E+01	0.	-.1560E+03	0.	.2014E+03	-.1535E+04	0.	0.
5	6	.1724E+04	0.	-.1162E+04	0.	-.3365E+04	.2738E+04	0.	0.
13	11	.3109E+03	0.	-.1232E+02	0.	-.2255E+02	.5607E+02	0.	0.
11	10	-.1542E+03	0.	-.1235E+03	0.	-.1356E+04	-.5356E+03	0.	0.
6	8	-.1635E+03	0.	.4574E+03	0.	.2640E+04	-.2477E+03	0.	0.
6	7	-.1826E+04	0.	.4214E+02	0.	.1964E+03	-.1093E+04	0.	0.
10	9	-.1643E+03	0.	-.1739E+03	0.	-.5389E+03	.3248E+03	0.	0.
8	9	-.1629E+03	0.	.1543E+02	0.	-.2477E+03	-.3246E+03	0.	0.

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	-.1769E+04
1	DISPLACEMENT IN THE Y DIRECTION	.3117E+03
1	ROTATION ABOUT THE Z AXIS	.3633E+04
7	DISPLACEMENT IN THE X DIRECTION	.1267E+04
7	DISPLACEMENT IN THE Y DIRECTION	.1386E+04
7	ROTATION ABOUT THE Z AXIS	.1690E+04

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SEISMIC LOADS

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	MOMENTS APPLIED ABOUT THE X AXIS	Y AXIS	Z AXIS
5	0.	-.1445E+04	0.	0.	0.	0.
13	-.4420E+03	0.	0.	0.	0.	0.

JOINT	DISPLACEMENTS IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	ROTATIONS ABOUT THE X AXIS	Y AXIS	Z AXIS
1	0.	0.	0.	0.	0.	0.
2	.3263E-04	-.1277E-03	0.	0.	0.	-.4123E-04
3	.6812E-04	-.1364E-03	0.	0.	0.	-.4911E-04
4	.1556E-03	-.1623E-03	0.	0.	0.	-.5137E-04
12	.4751E-03	-.2773E-03	0.	0.	0.	-.4497E-04
5	.2234E-03	-.1168E-02	0.	0.	0.	-.2069E-04
13	.3724E-03	-.6723E-03	0.	0.	0.	-.1137E-04
11	.4279E-03	-.6633E-03	0.	0.	0.	-.4446E-04
6	.7613E-03	-.1142E-02	0.	0.	0.	-.6653E-05
10	.4731E-03	-.1045E-02	0.	0.	0.	-.2621E-04
9	.3234E-03	-.1120E-02	0.	0.	0.	-.1669E-04
7	0.	0.	0.	0.	0.	0.
8	.4193E-03	-.1217E-02	0.	0.	0.	-.1963E-04

MEMBER I	J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE Y AXIS	Z AXIS	TORSION	BENDING MOMENTS ABOUT THE Z AXIS I END	J END	Y AXIS I END	J END
1	2	.4763E+03	0.	.4607E+03	0.	.3654E+04	.1551E+04	0.	0.
2	3	.1163E+03	0.	.4607E+03	0.	.1351E+04	-.2423E+03	0.	0.
3	4	.5479E+03	0.	.3113E+03	0.	.1223E+04	-.1070E+04	0.	0.
3	12	-.2474E+03	0.	-.2779E+03	0.	-.1913E+04	.1257E+04	0.	0.
4	5	.1373E+04	0.	.3254E+03	0.	-.2110E+03	-.3555E+04	0.	0.
4	13	.4047E+03	0.	-.2654E+03	0.	-.7017E+03	.5395E+03	0.	0.
12	11	-.2773E+03	0.	.2424E+03	0.	.1247E+04	-.1288E+04	0.	0.
5	6	.1373E+04	0.	-.1021E+04	0.	-.3155E+04	.1608E+04	0.	0.
13	11	.4045E+03	0.	.1764E+03	0.	.3395E+03	-.3423E+03	0.	0.
11	10	-.1006E+03	0.	-.1624E+03	0.	-.1630E+04	-.7756E+03	0.	0.
6	8	-.1478E+03	0.	.1009E+03	0.	.4295E+03	.4252E+03	0.	0.
6	7	-.1432E+04	0.	.4314E+02	0.	.6700E+03	-.4615E+03	0.	0.
10	9	-.1065E+03	0.	-.1628E+03	0.	-.7755E+03	.7911E+02	0.	0.
8	9	-.1428E+03	0.	.1009E+03	0.	.4352E+03	-.7911E+02	0.	0.

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	-.6603E+03
1	DISPLACEMENT IN THE Y DIRECTION	.4607E+03
1	ROTATION ABOUT THE Z AXIS	.3654E+04
7	DISPLACEMENT IN THE X DIRECTION	.1172E+04
7	DISPLACEMENT IN THE Y DIRECTION	.1164E+04
7	ROTATION ABOUT THE Z AXIS	.9514E+03

SEISMIC LOADS

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	MOMENT APPLIED ABOUT THE X AXIS	Y AXIS	Z AXIS
13	0.	.1145E+04	0.	0.	0.	0.
8	.4420E+03	0.	0.	0.	0.	0.

DISPLACEMENTS IN THE / ROTATIONS ABOUT THE

JOINT	X DIRECTION	Y DIRECTION	Z DIRECTION	X AXIS	Y AXIS	Z AXIS
1	0.	0.	0.	0.	0.	0.
2	-.3074E-04	.1210E-03	0.	0.	0.	.4233E-04
3	-.6533E-04	.3115E-03	0.	0.	0.	.5007E-04
4	-.1473E-03	.6780E-03	0.	0.	0.	.4011E-04
12	-.4547E-03	.1285E-03	0.	0.	0.	.4456E-04
5	-.1955E-03	.2030E-02	0.	0.	0.	.2046E-04
13	[illegible]	.1053E-02	0.	0.	0.	.1703E-04
11	-.4273E-03	.6133E-02	0.	0.	0.	.5734E-04
6	-.2434E-03	.1120E-02	0.	0.	0.	.1670E-04
10	-.4113E-03	.1136E-02	0.	0.	0.	.2597E-04
8	-.3234E-03	.1164E-02	0.	0.	0.	.1604E-04
7	0.	0.	0.	0.	0.	0.
9	-.2346E-03	.1208E-02	0.	0.	0.	.7712E-05

MEMBER FORCES

MEMBER I	J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE A AXIS	B AXIS	TORSION	BENDING MOMENTS ABOUT THE A AXIS I END	A AXIS J END	B AXIS I END	B AXIS J END
1	2	-.6327E+03	0.	-.4758E+03	0.	-.3965E+04	-.1555E+04	0.	0.
2	3	-.6058E+03	0.	-.4758E+03	0.	-.1585E+04	.3179E+03	0.	0.
3	4	-.5331E+03	0.	-.1064E+03	0.	-.1314E+04	.1935E+04	0.	0.
3	12	.1564E+03	0.	.1503E+03	0.	.1031E+04	-.1272E+04	0.	0.
4	5	-.1020E+04	0.	.1909E+03	0.	.1733E+04	.7305E+03	0.	0.
4	13	.4503E+03	0.	.5096E+02	0.	.2023E+03	-.3253E+02	0.	0.
12	11	.2463E+03	0.	.1445E+03	0.	-.1272E+04	.4752E+03	0.	0.
5	6	-.1020E+04	0.	.1509E+03	0.	.7305E+03	-.2717E+03	0.	0.
13	11	.4603E+03	0.	.5096E+02	0.	-.3253E+02	-.2673E+03	0.	0.
11	10	.3373E+03	0.	-.6607E+03	0.	.2679E+03	.3708E+04	0.	0.
6	8	.6283E+03	0.	.1047E+03	0.	.1657E+03	-.2579E+03	0.	0.
6	7	.1022E+04	0.	-.1141E+02	0.	-.1374E+03	.7954E+03	0.	0.
10	9	.3373E+03	0.	.3703E+03	0.	.3700E+04	-.1426E+04	0.	0.
8	9	.9203E+03	0.	-.3372E+03	0.	-.2579E+03	.1426E+04	0.	0.

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	.6620E+03
1	DISPLACEMENT IN THE Y DIRECTION	-.4755E+03
1	ROTATION ABOUT THE Z AXIS	-.3566E+04
7	DISPLACEMENT IN THE X DIRECTION	-.1125E+04
7	DISPLACEMENT IN THE Y DIRECTION	-.1169E+04
7	ROTATION ABOUT THE Z AXIS	-.7954E+03

SEISMIC LOADS

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	MOMENT APPLIED ABOUT THE X AXIS	Y AXIS	Z AXIS
13	0.	.37450E+04	0.	0.	0.	0.
13	-.44207E+03	0.	0.	0.	0.	0.

JOINT	DISPLACEMENTS IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	ROTATIONS ABOUT THE X AXIS	Y AXIS	Z AXIS
1	0.	0.	0.	0.	0.	0.
2	-.77131E-04	.12552E-02	0.	0.	0.	.47438E-04
3	-.12471E-03	.12386E-02	0.	0.	0.	.67041E-04
4	-.10791E-03	.13672E-02	0.	0.	0.	.52696E-04
12	-.89665E-03	.17578E-02	0.	0.	0.	.71168E-04
5	-.77390E-03	.12321E-02	0.	0.	0.	.30055E-04
13	-.67005E-03	.13377E-02	0.	0.	0.	.40971E-04
11	-.87405E-03	.11671E-02	0.	0.	0.	.14465E-04
6	-.44597E-03	.14311E-02	0.	0.	0.	.35378E-04
10	-.61211E-03	.13590E-02	0.	0.	0.	.37085E-04
8	-.63845E-03	.15765E-02	0.	0.	0.	.12635E-04
7	0.	0.	0.	0.	0.	0.
9	-.80335E-03	.15204E-02	0.	0.	0.	.22711E-04

MEMBER I	J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE Y AXIS	Z AXIS	TORSION	BENDING MOMENTS ABOUT THE Z AXIS I END	J END	Y AXIS I END	J END
1	2	-.17111E+04	0.	-.33372E+03	0.	-.39443E+04	-.26746E+04	0.	0.
2	3	-.17111E+04	0.	-.33372E+03	0.	-.22746E+04	-.93935E+03	0.	0.
3	4	-.12228E+04	0.	-.25391E+03	0.	-.80538E+03	.17612E+04	0.	0.
3	12	.39441E+02	0.	.26139E+02	0.	-.24115E+02	-.31635E+03	0.	0.
4	5	-.16711E+04	0.	.31918E+03	0.	[illegible]	.54605E+03	0.	0.
4	13	[illegible]	0.	-.36641E+03	0.	-.32131E+03	.62957E+03	0.	0.
12	13	.16156E+02	0.	-.26656E+02	0.	-.21603E+03	.62238E+03	0.	0.
5	6	-.15231E+04	0.	.53188E+03	0.	.14351E+03	-.12015E+04	0.	0.
13	11	.44471E+03	0.	.23441E+03	0.	.12391E+03	-.64635E+03	0.	0.
11	10	.25148E+03	0.	-.66551E+03	0.	-.18901E+02	.34668E+04	0.	0.
6	8	.45948E+03	0.	-.25315E+03	0.	-.84431E+03	.41491E+03	0.	0.
6	7	.14271E+04	0.	-.56725E+02	0.	-.55722E+03	.90160E+03	0.	0.
10	9	.26151E+03	0.	.97981E+03	0.	.34601E+04	-.16745E+04	0.	0.
8	9	.57961E+03	0.	-.25188E+03	0.	.41562E+03	.16745E+04	0.	0.

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	.17111E+04
1	DISPLACEMENT IN THE Y DIRECTION	-.33372E+03
1	ROTATION ABOUT THE Z AXIS	-.39443E+04
7	DISPLACEMENT IN THE X DIRECTION	-.12745E+04
7	DISPLACEMENT IN THE Y DIRECTION	-.13111E+04
7	ROTATION ABOUT THE Z AXIS	-.90306E+03

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SI-01-6007-H30G

Loads:

Y-dir. $|W + P_d + T| = 636$ lbs.

$|W + P_d + T| + (SSE^2 + AM^2)^{1/2} = 705$ lbs.

Lat.-dir. $|W + P_d + T| = 151$ lbs.

$|W + P_d + T| + (SSE^2 + AM^2)^{1/2} = 288$ lbs.

This support is essentially the same as SI-01-6007-H30F and the loads applied here are significantly less than those utilized in the analysis of SI-01-6007-H30F. Therefore, this support appears acceptable with the same comments as given for SI-01-6007-H30F.

SI-01-6007-H30.4

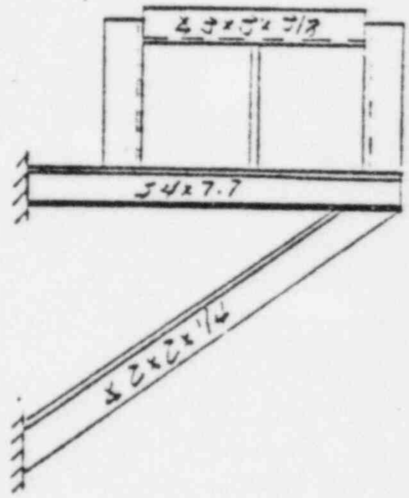
LOADS:

Y-Dir. $|W+P_d+T| = 198$ lb.

$|W+P_d+T| + (SSE^2+AM^2)^{1/2} = 347$ lb.

Z-Dir. $|W+P_d+T| = 106$ lb.

$|W+P_d+T| + (SSE^2+AM^2)^{1/2} = 272$ lb.



utilize computer program "FRAME" to find reactions in structural members: Analyze for worst load combinations

CONSIDER S4x7.7 MEMBER $\quad A = 2.26\ in^2, \quad S = 3.04\ in^3$

Tension: $\sigma_t = \frac{551}{2.26} = 244$ psi $< 21{,}600$ psi

Compression: $C_c = 126$

$\frac{KL}{r} = \frac{2(18)}{0.581} = 61.96 < 126$

$$F_a = \frac{\left[1 - \frac{(61.96)^2}{2(126)^2}\right] 36{,}000}{\frac{5}{3} + \frac{3(61.96)}{8(126)} - \frac{(61.96)^3}{8(126)^3}} = 17{,}235 \text{ psi}$$

Level D = 32,402 psi

$\sigma_a = \frac{553}{2.26} = 245$ psi $< 17{,}235$ psi

Shear: $\sigma_v = \frac{332}{2.26} = 147$ psi $< 14{,}400$ psi

Bending: $\sigma_b = \frac{1549}{3.04} = 510$ psi $< 23{,}760$ psi

CONSIDER ∠ 2×2×1/4 :

Tension: $\sigma_t = \frac{470}{.938} = 501$ psi $< 21{,}600$ psi

Compression: $C_c = 126$

$\frac{KL}{r} = \frac{2(25.5)}{.609} = 83.74 < 126$

$$F_a = \frac{\left[1 - \frac{(83.74)^2}{2(126)^2}\right] 36{,}000}{\frac{5}{3} + \frac{3(83.74)}{8(126)} - \frac{(83.74)^3}{8(126)^3}} = 14{,}926 \text{ psi}$$

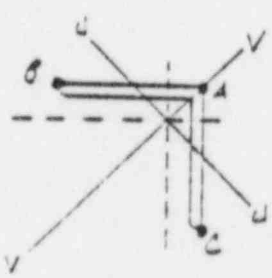
Level D = 28.061 psi

$\sigma_a = \frac{466}{.938} = 497$ psi $< 14{,}926$ psi

Shear: σ_v = negligible

Bending: $a = .938\ in^2$ $\quad I_x = I_y = 0.347\ in^4$

$x_0 = y_0 = 0.592$ in $\quad r_u = 0.391$ in.



$I_u = a r_u^2 = .938(.391)^2 = 0.143\ in^4$

$I_v = 2(.348) - .143 = 0.553\ in^4$

$v_A = -0.837$ $\quad v_B = 0.577$ $\quad v_C = 0.577$

$u_A = 0.$ $\quad u_B = -1.414$ $\quad u_C = 1.414$

$M_u = -.707(18) = -13$ in-lb

$M_v = .707(18) = 13$ in-lb

$\sigma_A = \frac{-13(-.837)}{.143} = -76$ psi $< 21{,}600$ psi

$\sigma_B = -\frac{13(.577)}{.143} + \frac{13(-1.414)}{.553} = 86$ psi $< 21{,}600$ psi

$\sigma_C = -\frac{13(.577)}{.143} + \frac{13(1.414)}{.553} = -42$ psi $< 21{,}600$ psi

<u>CONSIDER ∠ 3×3×3/8 :</u>

Tension: $\sigma_t = \frac{253}{2.11} = 120$ psi $< 21{,}600$ psi

Compression: Negligible

Shear: $\sigma_v = \frac{253}{2.11} = 120$ psi $< 14{,}400$ psi

Bending: $a = 2.11\ in^2$ $\qquad I_x = I_y = 1.76$
$x_o = y_o = 0.888$ $\qquad r_u = 0.587$

$I_u = 2.11(.587)^2 = 0.727\ in^4$

$I_v = 2(1.76) - .727 = 2.793\ in^4$

$v_A = -1.256$ $\qquad v_B = 0.865$ $\qquad v_C = .865$
$u_A = 0$ $\qquad u_B = -2.121$ $\qquad u_C = 2.121$

$M_u = -.707(584) = -413$ in-lb.

$M_v = .707(584) = 413$ in-lb

$\sigma_A = -\frac{413(-1.256)}{.727} = -714$ psi $< 21{,}600$ psi

$\sigma_B = -\frac{413(.865)}{.727} + \frac{413(-2.121)}{2.793} = 800$ psi $< 21{,}600$ psi

$\sigma_C = -\frac{413(.865)}{.727} + \frac{413(2.121)}{2.793} = -188$ psi $< 21{,}600$ psi

CONSIDER ⌀ 1/2 × 2 × 7 1/2 :

Tension : $\sigma_t = \frac{202}{1/2(2)} = 202$ psi < 21,600 psi

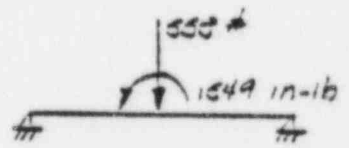
Shear : $\sigma_v = \frac{120}{1/2(2)} = 120$ psi < 14,400 psi

Bending : $\sigma_b = \frac{276(1/2/2)}{2(1/2)^3/12} = 3312$ psi < 27,000 psi

CONSIDER BASE PLATES :

Analyze plates as if simply supported beams with loads applied at center

Top plate :



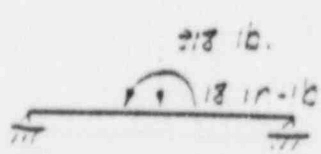
Bending : $\left[1549 + \frac{553(15)}{4}\right]\frac{(3/8/2)}{4(3/8)^3/12} = 38643$ psi

F_b (Level D) = 1.88(.75)(36,000) = 50,760 psi > 38,643 psi

Tension : $\sigma_t = \frac{186}{[4 - 1\,1/4](3/8)} = 180$ psi < 21,600 psi

Shear : $\sigma_v = \frac{186}{2(1\,1/2)(3/8)} = 165$ psi < 14,400 psi

Bottom plate :



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bending: $\left[18 + \frac{313(9)}{4}\right]\frac{(1\frac{1}{2}/2)}{6(1\frac{1}{2})^3/12}$ = 2934 psi < 27,000 psi

Tension: $\sigma_t = \frac{345}{[6 - 1/2](1/2)}$ = 125 psi < 21,600 psi

shear: $\sigma_v = \frac{345}{2(1\frac{1}{2})(1/2)}$ = 230 psi < 14,400 psi

CONSIDER ANCHOR BOLTS:

At top anchor:

shear: $\sigma_v = \frac{186}{2}$ = 93 lb/bolt

Tension: $\sigma_t = \frac{553}{2} + \frac{1549}{15}$ = 380 lb/bolt

These loads appear reasonable for 1/4" concrete anchors.

minimum edge dist = 1 5/8 − 1/8 = 1 1/2"

At bottom anchor:

shear: $\sigma_v = \frac{345}{2}$ = 173 lb/bolt

Tension: $\sigma_t = \frac{313}{2} + \frac{17}{6}$ = 162 lb/bolt

These loads appear reasonable for 1/2" concrete anchors.

CONSIDER WELDS:

S4×7.7 to base plate: 1/4" fillet

Tension : $\sigma_t = \dfrac{\frac{553}{2} + \frac{1549}{4}}{.707(1/4)(2\,5/8)} = 1431$ psi

Shear : $\sigma_v = \dfrac{186}{.707(1/4)(2)(2\,1/2)} = 210$ psi

4 2×2×1/4 to base plate: 1/4" Fillet

Tension : $\sigma_t = \dfrac{318}{.707(1/4)(8)} = 225$ psi

Shear : $\sigma_v = \dfrac{345}{.707(1/4)(8)} = 244$ psi

Bending: $\sigma_b = \dfrac{18}{(.707)(1/4)\left[\dfrac{4(2)(2)+(2)^2}{6}\right]} = 31$ psi

Total 500 psi

4 3×3×3/8 to S4×7.7 : 1/4" Fillet

Tension : $\sigma_t = \dfrac{253}{.707(1/4)(12)} = 119$ psi

Shear : $\sigma_v = \dfrac{185}{.707(1/4)(12)} = 87$ psi

Bending: $\sigma_b = \dfrac{584}{(.707)(1/4)\left[\dfrac{4(3)(3)+(3)^2}{6}\right]} = 441$ psi

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Total: 647 psi

℄ 1/2 × 2 × 7 1/2 to S4 × 7.7 :

Tension: $\sigma_t = \frac{202}{.707(1/4)(5)} = 229$ psi

Shear: $\sigma_v = \frac{170}{.707(1/4)(5)} = 138$ psi

Bending: $\sigma_b = \frac{276/1.2}{.707(1/4)(2)} = 1561$ psi

Total: 1929 psi

∴ This support appears acceptable with the most critical stresses occurring in the 3/8" base plate. Although a very conservative approach was taken for the plate analysis, it should be considered that loads due to adjacent piping will also be imposed upon this structure.

The loads have been revised:

	Vert.	Horiz.
old load	442	235
new load	347	272
% of old load	79%	116%

The calculation was reviewed, and the baseplate found to control the design. Since a frame analysis was used to run permutations of the possible ± load combinations results were used to predict the effect of the load change on the baseplate loads and stresses. This was conservatively bounded by multiplying the ratio of increase by the maximum stress ratio:

$$f/F = (1.16)(0.72) = 0.84$$

SI-01-FC07-H30F

JOINT NUMBER	X	Y	Z	DISPLACEMENT X	DISPLACEMENT Y	DISPLACEMENT Z	RESTRAINTS – ROTATIONS X	Y	Z
1	0.000	0.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
2	5.000	0.000	0.000						
3	7.000	0.000	0.000						
4	15.000	0.000	0.000						
5	19.000	0.000	0.000						
6	23.000	0.000	0.000						
7	0.000	-25.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
8	23.000	4.500	0.000						
9	23.000	9.000	0.000						
10	19.000	9.000	0.000						
11	15.000	9.000	0.000						
12	7.000	9.000	0.000						
13	15.000	4.500	0.000						

MEMBER TYPE	SECTION AREA	MODULUS OF ELASTICITY	THERMAL EXP. COEFFICIENT	AREA MOMENT OF INERTIA A AXIS	B AXIS	TORSIONAL RIGIDITY	UNIT WEIGHT	REFERENCE VECTOR FOR A AXIS A1	A2	A3
1	2.2000	.290E+08	0.	6.0000	.7640	.784E+07	.2230	0.0000	0.0000	1.0000
2	.9380	.290E+08	0.	.3480	.3460	.234E+05	.2830	0.0000	0.0000	1.0000
3	2.1100	.290E+08	0.	1.7600	1.7600	.111E+07	.2830	0.0000	0.0000	1.0000
4	1.0000	.290E+08	0.	.0210	.3330	.933E+06	.2830	0.0000	0.0000	1.0000

MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT
1	2	3	5.000	3.198	2	3	1	2.000	1.276	3	4	1	8.000	5.117
3	12	3	9.000	5.374	4	5	1	4.000	2.556	4	13	4	4.500	1.274
12	11	3	8.000	4.777	5	6	1	4.000	2.558	13	11	4	4.500	1.274
11	10	3	4.000	2.389	6	8	1	4.500	2.687	6	7	2	33.971	9.018
10	9	3	4.000	2.389	8	9	3	4.500	2.697					

TOTAL STRUCTURAL WEIGHT 46.577 CENTER OF GRAVITY X = 13.21699, Y = .71055, Z = 0.00000

THE STIFFNESS MATRIX FOR 66 EQUATIONS REQUIRES 987 STORAGE LOCATIONS

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SEISMIC LOADS

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	FORCES APPLIED IN THE Y DIRECTION	FORCES APPLIED IN THE Z DIRECTION	MOMENT APPLIED ABOUT THE X AXIS	MOMENT APPLIED ABOUT THE Y AXIS	MOMENT APPLIED ABOUT THE Z AXIS
12	0.	.4420E+03	0.	0.	0.	0.
4	.2350E+03	0.	0.	0.	0.	0.

JOINT	DISPLACEMENTS IN THE X DIRECTION	DISPLACEMENTS IN THE Y DIRECTION	DISPLACEMENTS IN THE Z DIRECTION	ROTATIONS ABOUT THE X AXIS	ROTATIONS ABOUT THE Y AXIS	ROTATIONS ABOUT THE Z AXIS
1	0.	0.	0.	0.	0.	0.
2	-.1427E-06	.7757E-04	0.	0.	0.	.2681E-04
3	-.1998E-06	.1356E-03	0.	0.	0.	.3024E-04
4	-.1246E-04	.4247E-03	0.	0.	0.	.3389E-04
12	-.1109E-03	.1428E-03	0.	0.	0.	.2047E-04
5	-.1980E-04	.5404E-03	0.	0.	0.	.2406E-04
13	-.3540E-04	.4465E-03	0.	0.	0.	-.6588E-05
11	-.9772E-04	.4683E-03	0.	0.	0.	.5041E-04
6	-.2513E-04	.6179E-03	0.	0.	0.	.1475E-04
10	-.9124E-04	.6327E-03	0.	0.	0.	.1170E-04
8	-.5100E-04	.6364E-03	0.	0.	0.	.5567E-05
7	0.	0.	0.	0.	0.	0.
9	-.8461E-04	.6550E-03	0.	0.	0.	.2651E-05

MEMBER I	MEMBER J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE A AXIS	AVERAGE SHEAR FORCE B AXIS	TORSION	BENDING MOMENTS ABOUT THE A AXIS I END	BENDING MOMENTS ABOUT THE A AXIS J END	BENDING MOMENTS ABOUT THE B AXIS I END	BENDING MOMENTS ABOUT THE B AXIS J END
1	2	-.1871E+01	0.	-.1837E+03	0.	-.1405E+04	-.4662E+03	0.	0.
2	3	-.1871E+01	0.	-.1837E+03	0.	-.4862E+03	-.1149E+03	0.	0.
3	4	-.1066E+03	0.	-.1345E+03	0.	-.6186E+03	.4575E+03	0.	0.
3	12	.4916E+02	0.	.9876E+02	0.	.4999E+03	-.3693E+03	0.	0.
4	5	-.1037E+03	0.	.5839E+01	0.	.4453E+03	.4220E+03	0.	0.
4	13	.1464E+03	0.	.2956E+01	0.	.1217E+02	-.1131E+01	0.	0.
12	11	.9876E+02	0.	-.4916E+02	0.	-.3693E+03	.4340E+01	0.	0.
5	6	-.1037E+03	0.	.5839E+01	0.	.4220E+03	.3986E+03	0.	0.
13	11	.1464E+03	0.	.2956E+01	0.	-.1131E+01	-.1443E+02	0.	0.
11	10	.1017E+03	0.	-.1495E+03	0.	-.1609E+02	.7460E+03	0.	0.
6	8	.2525E+03	0.	.1333E+03	0.	.4040E+03	-.1959E+03	0.	0.
6	7	.3601E+03	0.	-.5756E+00	0.	-.5395E+01	.1416E+02	0.	0.
10	9	.1017E+03	0.	.2525E+03	0.	.7460E+03	-.2619E+03	0.	0.
8	9	.2525E+03	0.	-.1017E+03	0.	-.1958E+03	.2619E+03	0.	0.

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	.1871E+01
1	DISPLACEMENT IN THE Y DIRECTION	-.1637E+03
1	ROTATION ABOUT THE Z AXIS	-.1405E+04
7	DISPLACEMENT IN THE X DIRECTION	-.2369E+03
7	DISPLACEMENT IN THE Y DIRECTION	-.2563E+03
7	ROTATION ABOUT THE Z AXIS	-.1416E+02

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SEISMIC LOADS

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	MOMENT APPLIED ABOUT THE X AXIS	Y AXIS	Z AXIS
12	0.	.4420E+03	0.	0.	0.	0.
11	-.2350E+03	0.	0.	0.	0.	0.

JOINT	DISPLACEMENTS IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	ROTATIONS ABOUT THE X AXIS	Y AXIS	Z AXIS
1	0.	0.	0.	0.	0.	0.
2	-.4316E-04	.9554E-04	0.	0.	0.	.3769E-04
3	-.5903E-04	.1771E-03	0.	0.	0.	.4613E-04
4	-.1215E-03	.5917E-03	0.	0.	0.	.5141E-04
12	-.6127E-03	.1765E-03	0.	0.	0.	.6549E-04
5	-.1451E-03	.7784E-03	0.	0.	0.	.4348E-04
13	-.1431E-03	.6230E-03	0.	0.	0.	.5029E-04
11	-.6193E-03	.6543E-03	0.	0.	0.	.5482E-04
6	-.1590E-03	.9517E-03	0.	0.	0.	.4471E-04
10	-.6135E-03	.6645E-03	0.	0.	0.	.4045E-04
8	-.4016E-03	.9697E-03	0.	0.	0.	.5375E-04
7	0.	0.	0.	0.	0.	0.
9	-.6384E-03	.5977E-03	0.	0.	0.	.3336E-04

MEMBER I	J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE A AXIS	B AXIS	TORSION	BENDING MOMENTS ABOUT THE A AXIS I END	J END	B AXIS I END	J END
1	2	-.5527E+03	0.	-.9668E+02	0.	-.1500E+04	-.1017E+04	0.	0.
2	3	-.5527E+03	0.	-.9668E+02	0.	-.1017E+04	-.6236E+03	0.	0.
3	4	-.5095E+03	0.	-.1009E+03	0.	-.5196E+03	.2366E+03	0.	0.
3	12	-.4100E+01	0.	-.4316E+02	0.	-.3040E+03	.8443E+02	0.	0.
4	5	-.3918E+03	0.	-.1011E+03	0.	.5521E+03	.1479E+03	0.	0.
4	13	.2019E+03	0.	-.1177E+03	0.	-.2655E+03	.2641E+03	0.	0.
12	11	-.4316E+02	0.	.4100E+01	0.	.8443E+02	.5163E+02	0.	0.
5	6	-.3918E+03	0.	.1011E+03	0.	.1478E+03	-.2565E+03	0.	0.
13	11	.2019E+03	0.	.1173E+03	0.	.2641E+03	-.2037E+03	0.	0.
11	10	.7415E+02	0.	-.1978E+03	0.	-.2121E+03	.5789E+03	0.	0.
6	8	.2442E+03	0.	-.7415E+02	0.	-.2693E+03	.6435E+02	0.	0.
6	7	.4692E+03	0.	-.2897E-01	0.	.1279E+02	.1377E+02	0.	0.
10	9	.7415E+02	0.	.2442E+03	0.	.5789E+03	-.3980E+03	0.	0.
8	9	.2442E+03	0.	-.7415E+02	0.	.6435E+02	.3980E+03	0.	0.

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	.5527E+03
1	DISPLACEMENT IN THE Y DIRECTION	-.9668E+02
1	ROTATION ABOUT THE Z AXIS	-.1500E+04
7	DISPLACEMENT IN THE X DIRECTION	-.3177E+03
7	DISPLACEMENT IN THE Y DIRECTION	-.3453E+03
7	ROTATION ABOUT THE Z AXIS	-.1377E+02

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SEISMIC LOADS

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	MOMENT APPLIED ABOUT THE X AXIS	Y AXIS	Z AXIS
5	0.	-.4420E+03	0.	0.	0.	0.
9	.2350E+03	0.	0.	0.	0.	0.

JOINT	DISPLACEMENTS IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	ROTATIONS ABOUT THE X AXIS	Y AXIS	Z AXIS
1	0.	0.	0.	0.	0.	0.
2	.4203E-04	-.9320E-04	0.	0.	0.	-.3695E-04
3	.5980E-04	-.1033E-03	0.	0.	0.	-.4782E-04
4	.1199E-03	-.4139E-03	0.	0.	0.	-.5334E-04
12	.6164E-03	-.3821E-03	0.	0.	0.	-.6242E-04
5	.1505E-03	-.6966E-03	0.	0.	0.	-.4134E-04
13	.3799E-03	-.6134E-03	0.	0.	0.	-.5585E-04
11	.6229E-03	-.4133E-03	0.	0.	0.	-.4660E-04
6	.1910E-03	-.9560E-03	0.	0.	0.	-.3940E-04
10	.6267E-03	-.7704E-03	0.	0.	0.	-.4274E-04
8	.4192E-03	-.9599E-03	0.	0.	0.	-.5428E-04
7	0.	0.	0.	0.	0.	0.
9	.6295E-03	-.9597E-03	0.	0.	0.	-.4251E-04

MEMBER I	J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE A AXIS	B AXIS	TORSION	BENDING MOMENTS ABOUT THE A AXIS I END	J END	B AXIS I END	J END
1	2	.5505E+03	0.	.9850E+02	0.	.1549E+04	.1057E+04	0.	0.
2	3	.5505E+03	0.	.9850E+02	0.	.1057E+04	.8549E+03	0.	0.
3	4	.5007E+03	0.	.1071E+03	0.	.5500E+03	-.3068E+03	0.	0.
3	12	.8660E+01	0.	.4960E+02	0.	.3097E+03	-.1385E+03	0.	0.
4	5	.5002E+03	0.	.1101E+03	0.	-.3088E+03	-.7492E+03	0.	0.
4	13	.2989E+01	0.	.5339E+00	0.	.1947E+01	-.4557E+00	0.	0.
12	11	.4980E+02	0.	-.8606E+01	0.	-.1385E+03	-.6466E+02	0.	0.
5	6	.5002E+03	0.	-.3319E+03	0.	-.7492E+03	.5794E+03	0.	0.
13	11	.2989E+01	0.	.3339E+00	0.	-.4557E+00	-.2658E+01	0.	0.
11	10	.5034E+02	0.	-.1159E+02	0.	-.7252E+02	-.2614E+02	0.	0.
6	8	-.1159E+02	0.	.1847E+03	0.	.5042E+03	-.2468E+03	0.	0.
6	7	-.4664E+03	0.	.3478E+03	0.	-.5797E+01	-.1761E+02	0.	0.
10	9	.5034E+02	0.	.1159E+02	0.	-.2614E+02	.2624E+02	0.	0.
8	9	-.1159E+02	0.	-.5034E+02	0.	-.2468E+03	-.2024E+02	0.	0.

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	-.5505E+03
1	DISPLACEMENT IN THE Y DIRECTION	.9850E+02
1	ROTATION ABOUT THE Z AXIS	.1549E+04
7	DISPLACEMENT IN THE X DIRECTION	.1155E+03
7	DISPLACEMENT IN THE Y DIRECTION	.3435E+03
7	ROTATION ABOUT THE Z AXIS	.1761E+02

SEISMIC LOADS

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	FORCES APPLIED IN THE Y DIRECTION	FORCES APPLIED IN THE Z DIRECTION	MOMENT APPLIED ABOUT THE X AXIS	MOMENT APPLIED ABOUT THE Y AXIS	MOMENT APPLIED ABOUT THE Z AXIS
5	0.	-.4420E+03	0.	0.	0.	0.
13	-.2350E+03	0.	0.	0.	0.	0.

DISPLACEMENTS IN THE / ROTATIONS ABOUT THE

JOINT	X DIRECTION	Y DIRECTION	Z DIRECTION	X AXIS	Y AXIS	Z AXIS
1	0.	0.	0.	0.	0.	0.
2	-.1343E-07	-.6113E-04	0.	0.	0.	-.2807E-04
3	-.2550E-07	-.1418E-03	0.	0.	0.	-.3193E-04
4	.1119E-04	-.4269E-03	0.	0.	0.	-.3562E-04
12	.1146E-03	-.1494E-03	0.	0.	0.	-.1720E-04
5	.2413E-04	-.5586E-03	0.	0.	0.	-.3192E-04
13	-.1415E-02	-.4369E-03	0.	0.	0.	.4330E-05
11	.1325E-03	-.4269E-03	0.	0.	0.	-.4239E-04
6	.3706E-04	-.6241E-03	0.	0.	0.	-.9438E-05
10	.1343E-03	-.5576E-03	0.	0.	0.	-.2398E-04
8	.6363E-04	-.6256E-03	0.	0.	0.	-.6095E-05
7	0.	0.	0.	0.	0.	0.
9	.1355E-03	-.6270E-03	0.	0.	0.	-.1180E-04

MEMBER I	MEMBER J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE A AXIS	AVERAGE SHEAR FORCE B AXIS	TORSION	BENDING MOMENTS ABOUT THE A AXIS I END	A AXIS J END	B AXIS I END	B AXIS J END
1	2	-.2416E+00	0.	.1955E+03	0.	.1454E+04	.5260E+03	0.	0.
2	3	-.2416E+00	0.	.1655E+03	0.	.5260E+03	.1530E+03	0.	0.
3	4	.9187E+02	0.	.1408E+03	0.	.6491E+03	-.4777E+03	0.	0.
3	12	-.4466E+02	0.	-.9211E+02	0.	-.4941E+03	.3349E+03	0.	0.
4	5	.2120E+03	0.	[illegible]	0.	-.2020E+03	-.1023E+04	0.	0.
4	13	.6440E+02	0.	-.1201E+03	0.	-.2757E+03	.2646E+03	0.	0.
12	11	-.9211E+02	0.	.4466E+02	0.	.3349E+03	-.2237E+02	0.	0.
5	6	.2120E+03	0.	-.2367E+03	0.	-.1623E+04	-.7675E+02	0.	0.
13	11	.6440E+02	0.	.1159E+03	0.	.2648E+03	-.2522E+03	0.	0.
11	10	.2276E+02	0.	-.1983E+02	0.	-.2745E+03	-.1952E+03	0.	0.
6	8	-.1983E+02	0.	-.2278E+02	0.	-.8914E+02	.1336E+02	0.	0.
6	7	-.3477E+03	0.	.5944E+03	0.	.1239E+02	-.1800E+02	0.	0.
10	9	.2276E+02	0.	-.1983E+02	0.	-.1952E+03	-.1159E+03	0.	0.
8	9	-.1983E+02	0.	-.2278E+02	0.	.1336E+02	.1159E+03	0.	0.

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	.2416E+00
1	DISPLACEMENT IN THE Y DIRECTION	.1855E+03
1	ROTATION ABOUT THE Z AXIS	.1454E+04
7	DISPLACEMENT IN THE X DIRECTION	.2348E+03
7	DISPLACEMENT IN THE Y DIRECTION	.2565E+03
7	ROTATION ABOUT THE Z AXIS	.1800E+02

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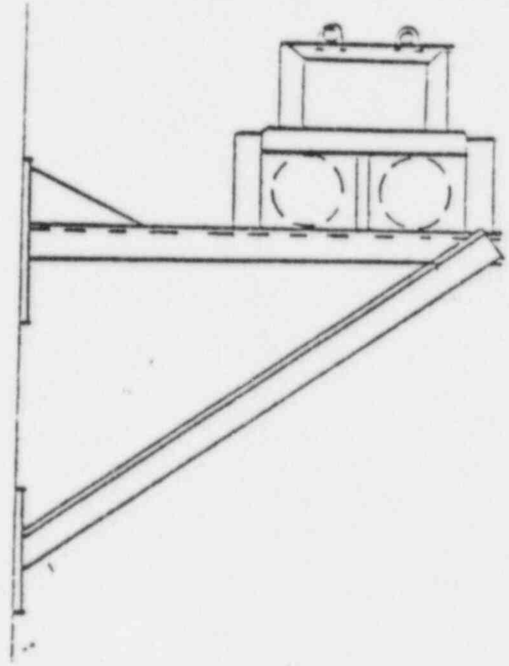
SI-01-6007-H30I

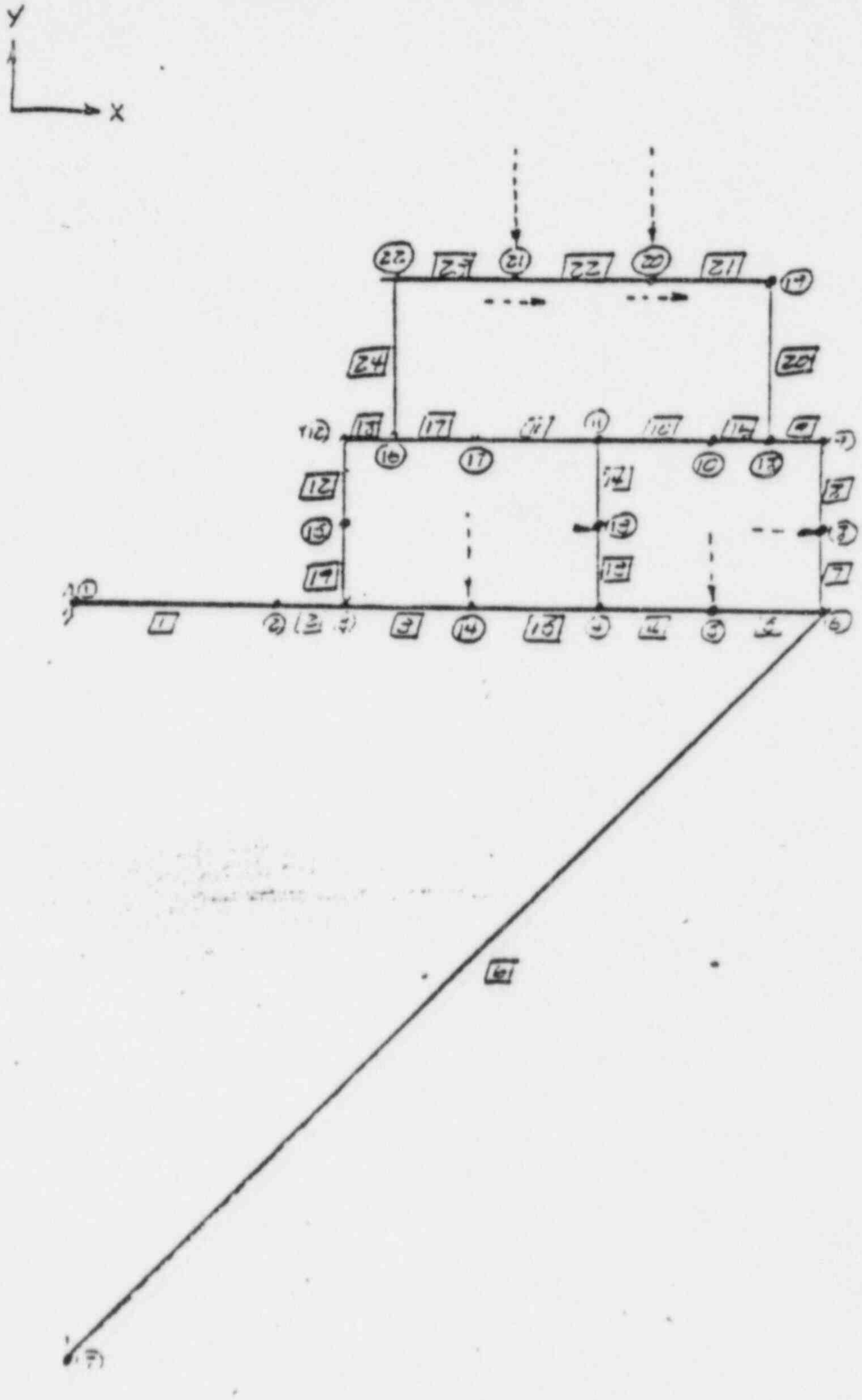


Load equation $|W + Pd + T| + (SSE^2 + AM^2)^{1/2}$

Load Case	Load Description	Node	X-Force lbs	Y-Force lbs	Z-Force lbs
1	−X	5	628.0	0	0
1	+X	13	915.0	0	0
1	+X	20	100	0	0
1	+X	21	100	0	0
2	−X	13	−656.0	0	0
2	−X	15	−1460.0	0	0
2	−X	20	−100	0	0
2	−X	21	−100	0	0
3	−Y	[illegible]	0	[illegible]	0
3	−Y	[illegible]	0	[illegible]	0
3	−Y	20	0	100.0	0
3	−Y	21	0	[illegible]	0
4	−Y	14	0	[illegible]	0
4	−Y	5	0	[illegible]	0
4	−Y	20	0	[illegible]	0
4	−Y	21	0	[illegible]	0

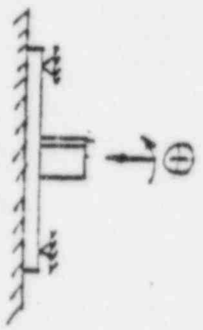
Utilize computer program "Frame" to find resulting structure members.

Frame Model



Consider Base Plates

Analyze plates as if simply supported beams with displacements allowed only in positive X-direction and loads applied at center.



Top plate $A = 4(3/8) = 1.50\ in^2$

$S = 1/12(4)(3/8)^3/(3/16) = 0.094\ in^3$

$l = 14$

Bottom plate $A = 6(1/2) = 3.00\ in^2$

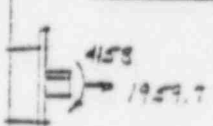
$S = 1/12(6)(1/2)^3/(1/4) = 0.250\ in^3$

$l = 6"$

Consider bending in top plate

Load Case	X - Reaction lbs	Y - Reaction lbs	Moment React. lb-INS	Load Type
1	-2251	-532.7	-1425	+X
2	3352	688.2	587.8	-X
3	291.3	-585.4	-2733	-Y
4	-550.9	732.3	3871	-Y

Combine Load case 1&3

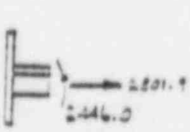


X-React = -2251 - 291.3 = -1959.7

Moment React = -1425 - 2733 = -4158

$T_b = \left[\frac{1959.7}{4}(14) + 4158\right]\frac{1}{0.094} = 117,201.6\ psi$

Combine Load cases 1&4



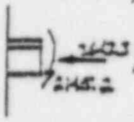
X-React = -2251 - 550.9 = -2801.9 lbs

Moment = -1425 + 3871 = 2446.0 in-lb

$T_b = \left[\frac{(2801.9)(14)}{4} - 2446\right]\frac{1}{0.094} = 130,347.3\ psi$

Combine Load cases 2 & 3

$X\text{-React} = 3352 + 291.3 = 3643.3$

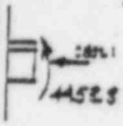


$\text{Moment React} = 587.8 - 2733 = -2145.2$

$\sigma_b = \frac{2145.2}{0.094} = 22,821.3$

Combine Load cases 2 & 4

$X\text{-React} = 3352 - 550.9 = 2801.1$



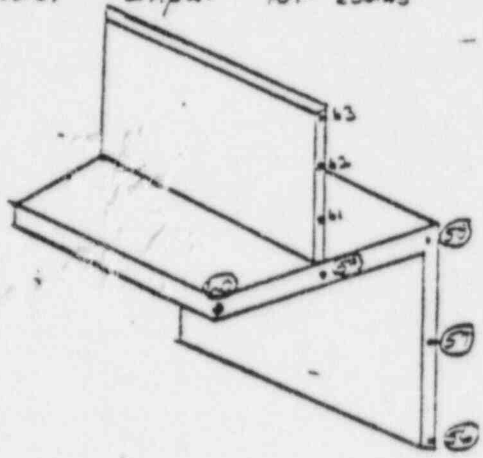
$\text{Moment React} = 587.8 + 3871 = 4458.8$

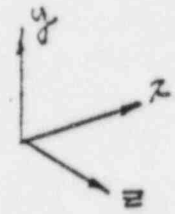
$\sigma_b = \frac{4458.8}{0.094} = 47,434.0 \text{ psi}$

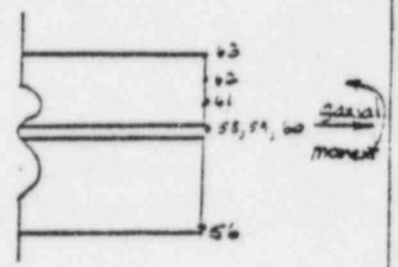
The combination of load cases 1 and 3 and the combination of load cases 1 and 4 give the largest bending stresses in the plate. Idealizing the base plate as a simply supported beam gave very high stresses so a finite element model and SUPERSAP were used to determine more realistic stresses.

The stresses for the plate were determined for two load cases. Load case 1 is the combination of cases 1 & 3 and load case 2 is the combination of cases 1 & 4 above.

Super Sap Model Input for Loads







Load Case 1

Axial load = 2251 - 291.3 = 1959.7 lbs

Moment = -1425 - 2733 = -4158 lb-in

$\frac{1959.7}{4}$ = 489.9 lbs $\frac{489.9}{2}$ = 245.0 lbs

$\frac{-4158 \text{ lb-in}}{3 \text{ lb}}$ = 1386 lbs ...

Node	X-Force	Y-Force	Z-Force
56	0	0	1631.0
57	0	0	489.1
58	0	0	-896.1
59	0	0	489.9
60	0	0	245

56 ⇒ 245.0 + 1386 = 1631.0

57 ⇒ 489.9

58 ⇒ 489.9 - 1386 = - 896.1

59 ⇒ 489.9

60 ⇒ 245

Load Case 2

Axial load = 2251 + 550.9 = 2801.9

Moment = -1425 + 3871 = 2446.0

$\frac{2801.9}{4} = 700.5$ $\frac{700.5}{2} = 350.2$

$\frac{2446.0}{3} \frac{lb\text{-}in}{in} = 815.3$ lbs (couple force)

Node	X-Force	Y-Force	Z-Force
56	0	0	1165.5
57	0	0	700.5
58	0	0	-114.8
59	0	0	700.5
60	0	0	350.2

Node

56 350.2 + 815.3 = 1165.5

57 700.5 =

58 700.5 - 815.3 = -114.8

59 700.5

60 350.2

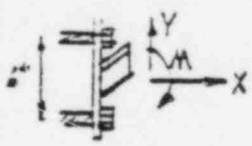
Loading the SUPERSAP model with the loads given on pages 3 and 4 give plate bending stresses to be approximately 35.5 KSI in the area just below the angle.

Bending stress = 35.5 KSI ≤ allowable = 50.76 KSI = 0.75 (36)(1.88) for level D.

The upper base plate is subjected to larger loads than the lower base plate; therefore the lower base plate will not be checked for bending.

<u>Check Anchor Bolts in lower base plate</u>

X = 291.3 + 635.9 = 927.2 Y = 319.6 + 688.2 = 1007.8 lbs



M = 353.1 + 127.1 = 480.2 lb-in

Maximum tension = $\frac{927.2}{2} + \frac{480.2}{6}$ = **543.6 lbs/bolt**

Maximum shear = $\frac{1007.8}{2}$ = **503.9 lbs/bolt**

<u>Check Anchor Bolts in upper base plate</u>

Maximum tension (from super sap) = -261.7 + 1367.0 + 731.2 + 187.5 + 247.7 = **2272 lbs/bolt**

Maximum shear (from frame) = $\frac{732.3}{2} + \frac{688.2}{2}$ = **710.3 lbs/bolt**

Check ∠ 3 x 3 x 1/2

Tension:

(⊕X + ⊕Y member 1)

Axial Force = 550.9 + 2251 = 2801.9

$f_t = \frac{2801.9}{2.75} = 1019 \text{ psi} \le 21{,}000 = 0.6(36)$

Compression:

$C_c = 126.1$ p. 5-77 AISC

$\frac{Kl}{r} = \frac{(2.0)(18)}{0.584} = 61.64 < 126.1$

$F_a = (17{,}270$ p. 5-74 AISC$)(1.88$ level D$) = 32{,}470$ psi

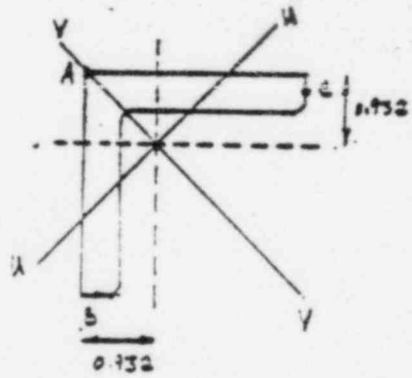
(⊕X + ⊕Y member 1)

Axial force = 3352 + 291.3 = 3643 lbs

$f_a = \frac{3643}{2.75} = 1325$ psi

$f_a = 1325 \text{ psi} \le F_a = 32470$

Bending:



Moment = [illegible]
= [illegible] - 557.8
= 4459 lb-in

Area = 2.75 $\qquad I_x = I_y = $ [illegible]

$x_0 = y_0 = 0.932 \qquad r_\lambda = 0.584$

$I_\lambda = A r_\lambda^2 = 2.75(0.584)^2 = 0.938 \text{ in}^4$

$I_u + I_v = I_\lambda + I_y$

$I_v = 2($[illegible]$) - 0.938 = 3.502 \text{ in}^4$

$V_A = $ [illegible] $\quad V_B = 0.803 \quad V_C = 0.803$

$u_A = 0 \qquad u_B = -2.121 \quad u_C = 2.121$

$M_\lambda = -.707(4459) = -3.152$

$M_v = 0.707(4459) = -3152$

$T_A = \frac{M_\lambda V_A}{I_\lambda} - \frac{M_v u_A}{I_v} = \frac{-3152(\text{[illegible]})}{0.938} = $ [illegible] psi

$T_B = \frac{-3152(0.803)}{0.938} - \frac{3152(-2.121)}{3.502} = -4607$ psi

$T_C = \frac{-3152(0.803)}{0.938} - \frac{3152(\text{[illegible]})}{3.502} = -4607$ psi

$f_b \max = 4607 \text{ psi} \le F_b \text{ minimum} = 0.6(36)(1.88) = $ [illegible] psi

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Shear:

Force = 688.2 + 732 = 1420 lbs
θX + θY

shear area = (3)(1/2) = 1.5 in²

$f_V = \frac{1420 \text{ lb}}{1.5 \text{ in}^2} = 947 \text{ psi} \leq (0.4)(36)(1.88) = 27,070 \text{ psi}$

$f_V = 947 \text{ psi} \leq F_V = 27,070 \text{ psi}$

Check ∠ 2 x 2 x 3/4

Tension:

Force = (θX + θY member 6)

Force = 937 + 432 = 1369 lbs.

$f_t = \frac{1369}{1.36} = 1007 \text{ lbs} \leq F_t = 40,600 \text{ lbs}$

Compression:

Force = (θX + θY member 6)

Force = 729 + 819 = 1548 lbs

$f_a = \frac{1548}{1.36} = 1138 \text{ psi}$

$C_c = 126$ p. 5-77 AISC

$\frac{Kl}{r} = \frac{2.0(31)}{0.394} = 157.4 > 126$

$F_a = 5,878 (1.88) = 11,051 \text{ psi}$
p. 5-74 AISC

$f_a = 1138 \leq F_a = 11,05 \text{ psi}$

Bending:

Moment = (⊕ X + ⊕ Y member 6)

Moment = 161.6 + 34.7 = 196.3

$A = 1.36$ $I_x = I_y = 0.479$

$x_o = y_o = 0.636$ $r_u = 0.389$

$I_u = 1.36(0.389)^2 = 0.206$

$I_v = 2(0.479) - 0.206 = 0.752$

$v_A = -0.899$ $v_B = 0.515$ $v_C = 0.515$

$u_A = 0.0$ $u_B = -1.414$ $u_C = 1.414$

$m_u = -0.707(196.3) = -138.9$ lb-in

$m_v = 0.707(196.3) = 138.9$ lb-in

$$T_A = \frac{-138.9(-0.899)}{0.206} = 605.7 \text{ psi}$$

$$T_B = \frac{-138.9(0.515)}{0.206} + \frac{138.9(-1.414)}{0.752} = -608 \text{ psi}$$

$$T_C = \frac{-138.9(0.515)}{0.206} + \frac{138.9(1.414)}{0.752} = -86 \text{ psi}$$

$F_{b\,min} = 0.6(36)(1.88) = 40,600$

$f_{b\,max} = 608$ psi $\leq F_{b\,minimum} = 40,600$

Shear:

Force = (⊕ X + ⊕ Y member 6)

Force = 5.9 + 2.1 = 7.9 lbs

shear area = [illegible] = 0.75 in²

$f_v = \frac{7.9}{0.75} = 10.5$ psi $\leq$ (0.4)(36,000 ... [illegible])

$f_v = 10.5 \leq F_v = 27,000$ psi

Check ∠ 3×3×3/8

Tension:

Force = ΣX+ΣY member 19

Force = 629 + 681 = 1310 lbs

$f_t = \frac{1310}{2.11} = 621$ psi $F_t = 0.6(36,000)(1.84) = 40,300$

$f_t = 621$ psi $\leq F_t = 40,300$ psi

Compression:

$C_c = 126$ p.5-16 AISC

$\frac{KL}{r} = \frac{2.0(12)}{0.587} = 40.9 < 126$ [The K=1.0 which is conservative [illegible] length [illegible] [illegible]]

$F_a = 19,120$ psi$(1.83) = 35,[illegible]$

Force = (ΣX + ΣY members 12+[illegible])

Force = 662 + 522 = 1184 lbs

$f_a = \frac{1184}{2.11} = 561$ psi

$f_a = 561 \leq F_a = 35,[illegible]$

Shear:

Force = ΣX + ΣY member 19

Force = 1966 + 208 = 2174 lbs

Shear area = (3)(3/8) = 1.125 in²

$f_v = \frac{2174 \text{ lb}}{1.125 \text{ in}^2} = 1,944$ psi

$F_v = 0.4(36)(1.83) = [illegible]$ psi

$f_v = 1944$ psi $\leq F_v = [illegible]$ psi

Bending:

Moment = 9X + 9Y guide & [illegible] manse-8
Moment = 3049 + 421 = 3470 lb-in

$a = 2.11\ in^2$ $\qquad I_x = I_y = 1.76\ in^4$
$x_0 = y_0 = 0.555$ $\qquad r_u = 0.587\ in$

$I_u = 2.11\ (0.587)^2 = 0.727\ in^4$

$I_v = 2(1.76) - 0.727 = 2.793\ in^4$

$u_A = -1.256$ $\qquad u_B = 0.[illegible]$ $\qquad u_C = 0.[illegible]$

$v_A = 0.0$ $\qquad v_B = -[illegible]$ $\qquad v_C = [illegible]$

$M_u = -0.707(3470) = -3100$

$M_v = 0.707(3470) = 3100$

$f_A = \frac{-3100(-1.256)}{0.727} = 3623$

$f_B = -\frac{3100(0.[illegible])}{0.727} + \frac{[illegible]}{2.793} = -4043$

$f_C = \frac{-3100(0.[illegible])}{0.727} + \frac{3100([illegible])}{2.793} = -[illegible]4$

f_b maximum $= 4043 \leq F_b$ minimum $= 40,500$

<u>Check Plate 1/2 x 2 x 7 1/2</u>

Tension: Force = 395 lbs

$f_t = \frac{395}{2(.5)} = 395\ psi$

$f_t = 395\ psi \leq F_t = 40,500\ psi$

Compression:

Force = 358 lbs $\qquad f_a = \frac{358\ lbs}{2(.5)\ in^2} = 358\ psi$

$I = \frac{1}{12}(2)(.5)^3 = 0.0208 \qquad r = \sqrt{\frac{I}{A}} = \sqrt{[illegible]} = 0.[illegible]3$

$KL/r = \frac{[illegible]}{0.1443} = 103.[illegible]$ $C_c = 126$

$F_a = (12,482)(1.88) = 23,466$

$f_a = 358 \leq 23,466 = F_a$

Bending:

Moment = (8% + 8% [illegible] Moment at member 3)

Moment = 1354 + 1575 = [illegible] in-lb

$f_b = \frac{([illegible])(1/4)}{0.0208} = 35,240$

$F_b = (0.75)(36,000)(1.88) = 50,760$

$f_b = 35,240 \leq F_b = 50,760$

Check Welds

Welds are at least 1/4" fillet weld and are all around unless noted otherwise.

Weld Capacity per inch of weld = 0.707(1/4)(23,940 #/in²) = 4,231 #/in

Connection of 2x2x3/8 ⇒ length = 2[2+2+[illegible]−[illegible]] = [illegible]5"

3x3x3/8 ⇒ length = 2[3+3−3/8−3/8] = 10.5

3x3x1/2 ⇒ length = 2[3+3−1/2−1/2] = 14.0"

Minimum weld strength = 9.5(4,231 #/in) = 40,195 lbs

Minimum weld strength = 40,195 lbs ≫ to any member force.

FRAME OUTPUT

Pages 14 thru 29

SI-01-6JG7-0301

JOINT NUMBER	COORDINATES X	Y	Z	DISPLACEMENT - RESTRAINTS - X	Y	Z	ROTATIONS X	Y	Z
1	0.000	0.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
2	5.000	0.000	0.000						
3	7.000	0.000	0.000						
4	15.000	0.000	0.000						
5	19.000	0.000	0.000						
6	23.000	0.000	0.000						
7	0.000	-25.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
8	23.000	4.500	0.000						
9	23.000	9.000	0.000						
10	19.000	9.000	0.000						
11	15.000	9.000	0.000						
12	7.000	0.000	0.000						
13	15.000	4.500	0.000						
14	11.000	[illegible]	0.000						
15	7.000	4.500	0.000						
16	9.000	9.000	0.000						
17	13.000	9.000	0.000						
18	21.000	9.000	0.000						
19	21.000	26.000	0.000						
20	19.500	23.001	3.000						
21	13.[illegible]	23.[illegible]	3.000						
22	9.000	23.001	0.000						

MEMBER TYPE	SECTION AREA	MODULUS OF ELASTICITY	THERMAL EXP. COEFFICIENT	AREA MOMENT OF INERTIA A AXIS	B AXIS	TORSIONAL RIGIDITY	UNIT WEIGHT	REFERENCE VECTOR FOR A AXIS A1	A2	A3
1	[illegible]	.290E+08	0.	2.2240	2.2260	.252E+07	.2830	0.0000	1.0000	0.0000
2	1.[illegible]	.290E+08	0.	.9390	.9390	.714E+06	.2830	0.0000	0.0000	1.0000
3	2.1100	.290E+08	0.	1.7630	1.7603	.111E+07	.2830	0.0000	0.0000	1.0000
4	1.0000	.290E+08	0.	.2100	.3330	.433E+06	.2830	0.0000	0.0000	1.0000

MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT
1	2	3	5.000	3.[illegible]	2	3	1	2.000	1.[illegible]	3	[illegible]	1	4.000	3.11[illegible]
3	1[illegible]	3	4.500	2.[illegible]	1[illegible]	4	1	4.000	3.11[illegible]	1[illegible]	1[illegible]	3	4.000	[illegible].60[illegible]
[illegible]	[illegible]	1	4.000	3.11[illegible]	[illegible]	13	4	4.[illegible]	1.[illegible]	12	16	3	9.220	5.535
[illegible]	[illegible]	1	4.000	3.113	1[illegible]	11	4	4.[illegible]	1.[illegible]	16	17	3	1.000	.597
1[illegible]	22	3	11.000	4.234	[illegible]	7	4	[illegible]	13.[illegible]	6	8	3	4.500	2.68[illegible]
11	10	3	4.000	2.[illegible]	11	17	4	[illegible]	3.[illegible]	22	21	2	1.500	.53[illegible]
9	9	3	4.500	2.[illegible]	1[illegible]	18	4	2.000	1.154	21	20	2	9.000	3.464
[illegible]	18	3	2.000	1.194	19	19	2	11.000	4.234	20	19	2	1.500	.533

TOTAL STRUCTURAL WEIGHT — 73.221 — CENTER OF GRAVITY X = 13.05412, Y = 2.80666, Z = 0.00000

THE STIFFNESS MATRIX FOR 120 EQUATIONS REQUIRES 2226 STORAGE LOCATIONS

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POSITIVE X LOADING

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X-DIRECTION	Y DIRECTION	Z DIRECTION	MOMENT APPLIED ABOUT THE X-AXIS	Y-AXIS	Z-AXIS
8	.6380E+03	0.	0.	0.	0.	0.
13	.9150E+03	0.	0.	0.	0.	0.
20	.1000E+03	0.	0.	0.	0.	0.
21	.1000E+03	0.	0.	0.	0.	0.

JOINT	DISPLACEMENTS IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	ROTATIONS ABOUT THE X AXIS	Y AXIS	Z AXIS
1	0.	0.	0.	0.	0.	0.
2	.1411E-03	.1043E-03	0.	0.	0.	.2339E-05
3	.1976E-03	.6526E-05	0.	0.	0.	-.1178E-04
14	.2831E-03	-.1132E-03	0.	0.	0.	-.1139E-04
15	.6293E-03	.1077E-03	0.	0.	0.	-.1075E-03
4	.3686E-03	-.8213E-03	0.	0.	0.	-.1015E-03
12	.8949E-04	.1461E-03	0.	0.	0.	-.1681E-03
5	.4250E-03	-.8571E-03	0.	0.	0.	-.8163E-04
13	.1923E-02	-.5168E-03	0.	0.	0.	-.[illegible]
16	.2128E-02	-.2098E-03	0.	0.	0.	-.1636E-03
6	.4814E-03	-.1296E-02	0.	0.	0.	-.1532E-03
11	.2112E-02	-.[illegible]	0.	0.	0.	-.2811E-04
17	.2115E-02	-.[illegible]	0.	0.	0.	-.1156E-03
22	.4518E-02	-.1848E-03	0.	0.	0.	-.1475E-03
7	0.	0.	0.	0.	0.	0.
8	.1391E-02	-.1306E-02	0.	0.	0.	-.2095E-03
10	.2180E-02	-.[illegible]	0.	0.	0.	-.8493E-04
21	.4582E-02	-.3634E-03	0.	0.	0.	[illegible]
9	.2184E-02	-.1321E-02	0.	0.	0.	[illegible]
18	.2184E-02	-.1057E-02	0.	0.	0.	[illegible]
20	.4580E-02	-.8675E-03	0.	0.	0.	[illegible]
19	.4876E-02	-.1082E-02	0.	0.	0.	[illegible]

MEMBER I	J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE A AXIS	B AXIS	TORSION	BENDING MOMENTS ABOUT THE A AXIS I END	J END	B AXIS I END	J END
1	2	.2251E+04	-.5327E+03	0.	0.	0.	0.	.1425E+04	-.1[illegible]E+04
2	3	.2251E+04	-.5327E+03	0.	0.	0.	0.	-.1259E+04	-.2[illegible]E+04
3	14	.1704E+04	-.1025E+02	0.	0.	0.	0.	-.3916E+03	-.4326E+03
3	15	.5224E+03	0.	.5466E+03	0.	.1912E+04	-.5475E+03	0.	0.
14	4	.1704E+04	-.1025E+02	0.	0.	0.	0.	-.4326E+03	-.4737E+03
15	12	-.5224E+03	0.	-.5466E+03	0.	-.5475E+03	.1912E+04	0.	0.
4	5	.1125E+04	-.3680E+02	0.	0.	0.	0.	.1056E+04	-.4155E+03
4	13	-.3577E+03	0.	.[illegible]E+03	0.	.1531E+04	-.1674E+04	0.	0.
12	16	.6286E+03	0.	.4203E+03	0.	.1912E+04	-.1962E+04	0.	0.
5	6	.1125E+04	-.3680E+03	0.	0.	0.	0.	-.4155E+03	-.1082E+04
13	11	-.3577E+03	0.	-.[illegible]E+03	0.	-.1679E+04	.4293E+03	0.	0.
16	11	.4542E+03	0.	-.4[illegible]E+03	0.	-.2451E+04	-.2601E+04	0.	0.
16	22	.8970E+02	0.	.5246E+02	0.	.4883E+03	-.5281E+03	0.	0.
6	7	-.7242E+03	0.	-.6825E+01	0.	-.1616E+03	.3630E+02	0.	0.
6	8	-.1647E+03	0.	.6266E+03	0.	-.2645E+04	-.7765E+03	0.	0.
11	16	.1106E+03	0.	-.3[illegible]E+02	0.	.8356E+03	.6750E+03	0.	0.
11	17	.4542E+03	0.	-.4[illegible]E+03	0.	-.1455E+03	.2601E+04	0.	0.
22	21	.9240E+02	0.	-.8510E+02	0.	-.3261E+03	-.3935E+03	0.	0.
8	9	-.1647E+03	0.	-.1143E+02	0.	-.7765E+03	-.7191E+03	0.	0.
10	18	.1140E+03	0.	-.3[illegible]E+02	0.	.8356E+03	.1025E+04	0.	0.
21	20	-.1598E+01	0.	-.8510E+02	0.	-.3535E+03	.4138E+03	0.	0.
9	18	.1143E+02	0.	-.1649E+03	0.	-.7151E+03	-.3803E+03	0.	0.
18	19	-.8970E+02	0.	.1076E+03	0.	.[illegible]E+03	-.5463E+03	0.	0.
20	19	-.1076E+03	0.	-.8510E+02	0.	.4138E+03	-.5463E+03	0.	0.

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	-.2251E+04
4	DISPLACEMENT IN THE Y DIRECTION	-.5532E+03

1 ΦX

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1	ROTATION ABOUT THE Z AXIS	-.1425E+04
2	DISPLACEMENT IN THE X DIRECTION	.4980E+03
2	DISPLACEMENT IN THE Y DIRECTION	.5327E+03
3	ROTATION ABOUT THE Z AXIS	-.3650E+02

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0

SI-01-6007-11301
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3,2.11,29000000,.0.,1.76,1.76,1110000,.0.283,0,.0,.1.
4,1.00,29000000,.0.,0.216,0.333,433060,.0.283,0,.0,.1.
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3,14,1
14,4,1
4,5,1
5,6,1
6,7,2
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8,9,3
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18,16,3
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4,1[illegible],4
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18,1[illegible],2
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22,16,2
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5,0,19,.0,.7.
6,0,23,.0,.3.
7,[illegible],.0,-25,.0,.1,1,1,1,1,1
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9,0,23,.[illegible],.1.
10,0,19,.[illegible],.0.
11,0,15,.[illegible],.0.
12,0,7,.0,.6.
13,0,1[illegible],.4.[illegible],0.
14,0,11,.6,.0.
15,0,7,.4.5,0.
16,0,4,.4,.0.
17,0,10,.9,.0.
18,0,21,.9,.0.
19,0,21,.20,.0.
20,0,16,.0,.2[illegible],.0.
21,0,10,.[illegible],26,.0.
22,0,9,.20,.0.
POSITIVE X LOADING
2,8,0,0,438,.0,.0,.0,.0,.0.
2,1[illegible],0,0,415,.0,.0,.0,.0,.0.
2,2[illegible],0,[illegible],10,.0,.0,.0,.0,.0.
2,21,0,[illegible],106,.0,.0,.0,.0,.0.

16.23.19.UCL[illegible], [illegible]. [illegible]107,      [illegible].640KLNS.
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ST-01-6007-H301

JOINT NUMBER	COORDINATES X	Y	Z	DISPLACEMENT - RESTRAINTS X	Y	Z	ROTATIONS X	Y	Z
1	0.000	0.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
2	5.000	0.000	0.000						
3	7.000	0.000	0.000						
4	15.000	0.000	0.000						
5	19.000	0.000	0.000						
6	23.000	0.000	0.000						
7	6.000	-25.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
8	23.000	4.500	0.000						
9	23.000	9.000	0.000						
10	19.000	9.000	0.000						
11	15.000	9.000	0.000						
12	7.000	0.000	0.000						
13	15.000	4.500	0.000						
14	11.000	0.000	0.000						
15	7.000	4.500	0.000						
16	9.000	9.000	0.000						
17	10.000	9.000	0.000						
18	21.000	9.000	0.000						
19	21.000	20.000	0.000						
20	19.000	20.000	0.000						
21	10.000	20.000	0.000						
22	9.000	20.000	0.000						

MEMBER TYPE	SECTION AREA	MODULUS OF ELASTICITY	THERMAL EXP. COEFFICIENT	AREA MOMENT OF INERTIA A AXIS	B AXIS	TORSIONAL RIGIDITY	UNIT WEIGHT	REFERENCE VECTOR FOR A AXIS A1	A2	A3
1	2.3500	.2900E+08	0.	2.2210	2.2210	.6[illegible]E+07	.2830	0.0000	1.0000	0.0000
2	1.3600	.2900E+08	0.	.4790	.4790	.3140E+06	.2830	0.0000	0.0000	1.0000
3	2.1100	.2900E+08	0.	1.7600	1.7600	.1115E+07	.2830	0.0000	0.0000	1.0000
4	1.6000	.2900E+08	0.	.2100	.3[illegible]0	.4535E+06	.2830	0.0000	0.0000	1.0000

MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT
1	2	1	5.000	3.[illegible]	2	3	1	2.000	1.[illegible]	3	14	1	4.000	3.113
3	15	1	4.500	2.[illegible]	15	4	1	4.000	3.113	15	12	3	4.500	2.[illegible]
4	5	1	4.000	3.115	4	13	4	4.500	1.274	12	16	3	9.220	5.105
5	6	1	4.000	3.113	13	11	4	4.500	1.274	16	17	3	1.000	.553
1[illegible]	22	2	11.000	4.234	2	7	2	2[illegible].[illegible]	1[illegible].0[illegible]	6	8	3	4.500	2.683
11	10	3	4.000	2.369	11	1[illegible]	2	[illegible].000	2.982	22	21	2	1.000	.633
8	9	3	4.500	2.657	10	18	2	2.000	1.194	21	20	2	9.000	3.464
9	18	3	2.000	1.194	18	19	2	11.000	4.234	20	19	2	2.000	.577

TOTAL STRUCTURAL WEIGHT 71.221 CENTER OF GRAVITY X = 13.05917, Y = 2.[illegible], Z = 0.00000

THE STIFFNESS MATRIX FOR 120 EQUATIONS REQUIRES [illegible] STORAGE LOCATIONS

NEGATIVE X LOADING

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	MOMENT APPLIED ABOUT THE X AXIS	Y AXIS	Z AXIS
13	-.6560E+03	0.	0.	0.	0.	0.
15	-.1860E+04	0.	0.	0.	0.	0.
20	-.1800E+03	0.	0.	0.	0.	0.
21	-.1000E+03	0.	0.	0.	0.	0.

JOINT	DISPLACEMENTS IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	ROTATIONS ABOUT THE X AXIS	Y AXIS	Z AXIS
1	0.	0.	0.	0.	0.	0.
2	-.2101E-03	.1088E-03	0.	0.	0.	.8366E-04
3	-.2942E-03	.3874E-03	0.	0.	0.	.1580E-03
14	-.3687E-03	.9024E-03	0.	0.	0.	.1642E-04
15	-.2019E-02	.3668E-03	0.	0.	0.	.4451E-03
4	-.4433E-03	.1134E-02	0.	0.	0.	.5619E-04
12	-.2409E-03	.3461E-03	0.	0.	0.	.3532E-03
5	-.4942E-03	.1561E-02	0.	0.	0.	.4416E-04
13	-.1777E-02	.1129E-02	0.	0.	0.	.2363E-03
16	-.2239E-02	.7354E-03	0.	0.	0.	.1218E-03
6	-.5432E-03	.1558E-02	0.	0.	0.	.1118E-03
11	-.2225E-02	.1111E-02	0.	0.	0.	.3030E-04
17	-.2232E-02	.8442E-03	0.	0.	0.	.9837E-04
22	-.4373E-02	.7112E-03	0.	0.	0.	.1259E-03
7	0.	0.	0.	0.	0.	0.
8	-.1328E-02	.1624E-02	0.	0.	0.	.2074E-03
10	-.2267E-02	.1245E-02	0.	0.	0.	.5624E-04
21	-.4377E-02	.6682E-03	0.	0.	0.	.8113E-04
9	-.2166E-02	.1650E-02	0.	0.	0.	.1464E-03
18	-.2196E-02	.1404E-02	0.	0.	0.	.1023E-03
20	-.4376E-02	.1558E-02	0.	0.	0.	.6662E-04
19	-.4312E-02	.1428E-02	0.	0.	0.	.1365E-03

MEMBER I	J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE A AXIS	B AXIS	TORSION	BENDING MOMENTS ABOUT THE B AXIS I END	J END	A AXIS I END	J END
1	2	-.3352E+04	.6882E+03	0.	0.	0.	0.	-.5718E+03	[illegible]
2	3	-.3352E+04	.6882E+03	0.	0.	0.	0.	.2843E+04	[illegible]
3	14	-.1486E+04	.4017E+03	0.	0.	0.	0.	-.2772E+04	-.1141E+04
3	15	-.2809E+03	0.	-.1866E+04	0.	-.7001E+04	.1396E+04	0.	0.
14	4	-.1486E+04	.4071E+03	0.	0.	0.	0.	-.1141E+04	.4900E+03
15	12	.2864E+03	0.	.6646E+01	0.	.1294E+04	.1369E+04	0.	0.
4	5	-.1618E+04	.3352E+03	0.	0.	0.	0.	-.8641E+02	.4769E+02
9	12	-.1251E+02	0.	-.4674E+03	0.	-.1354E+04	.7582E+03	0.	0.
12	16	-.2781E+03	0.	.2454E+02	0.	.1309E+04	.6621E+03	0.	0.
5	6	-.1016E+04	.3352E+03	0.	0.	0.	0.	.4765E+03	.3131E+04
13	11	-.1251E+02	0.	.1866E+03	0.	.3866E+03	-.8144E+02	0.	0.
16	17	.8856E+02	0.	.1935E+03	0.	.1393E+04	.1199E+04	0.	0.
16	22	-.8865E+02	0.	-.9460E+02	0.	-.5306E+03	.5100E+03	0.	0.
6	7	.5370E+03	0.	.2031E+01	0.	.8117E+02	.1271E+02	0.	0.
6	8	.3529E+03	0.	-.3166E+03	0.	-.1566E+04	-.1876E+03	0.	0.
11	19	.2752E+03	0.	.2860E+03	0.	.1800E+03	-.8142E+03	0.	0.
11	17	.8856E+02	0.	.1935E+03	0.	-.2315E+03	-.1199E+04	0.	0.
22	21	-.9460E+02	0.	.8829E+02	0.	.5100E+03	.3797E+03	0.	0.
8	9	.3529E+03	0.	-.3866E+03	0.	-.1870E+03	.1525E+04	0.	0.
10	18	.2752E+03	0.	.2666E+03	0.	-.9142E+03	-.1446E+04	0.	0.
21	20	.2357E+01	0.	.8825E+02	0.	.3393E+03	-.4622E+03	0.	0.
9	18	.3866E+03	0.	.3529E+03	0.	.1525E+04	.2196E+03	0.	0.
18	19	.8825E+02	0.	-.1025E+03	0.	-.8267E+03	.5327E+03	0.	0.
20	19	.1025E+03	0.	.8825E+02	0.	-.4622E+03	-.5327E+03	0.	0.

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	.3352E+04
	DISPLACEMENT IN THE Y DIRECTION	.6669E+03

2 θx

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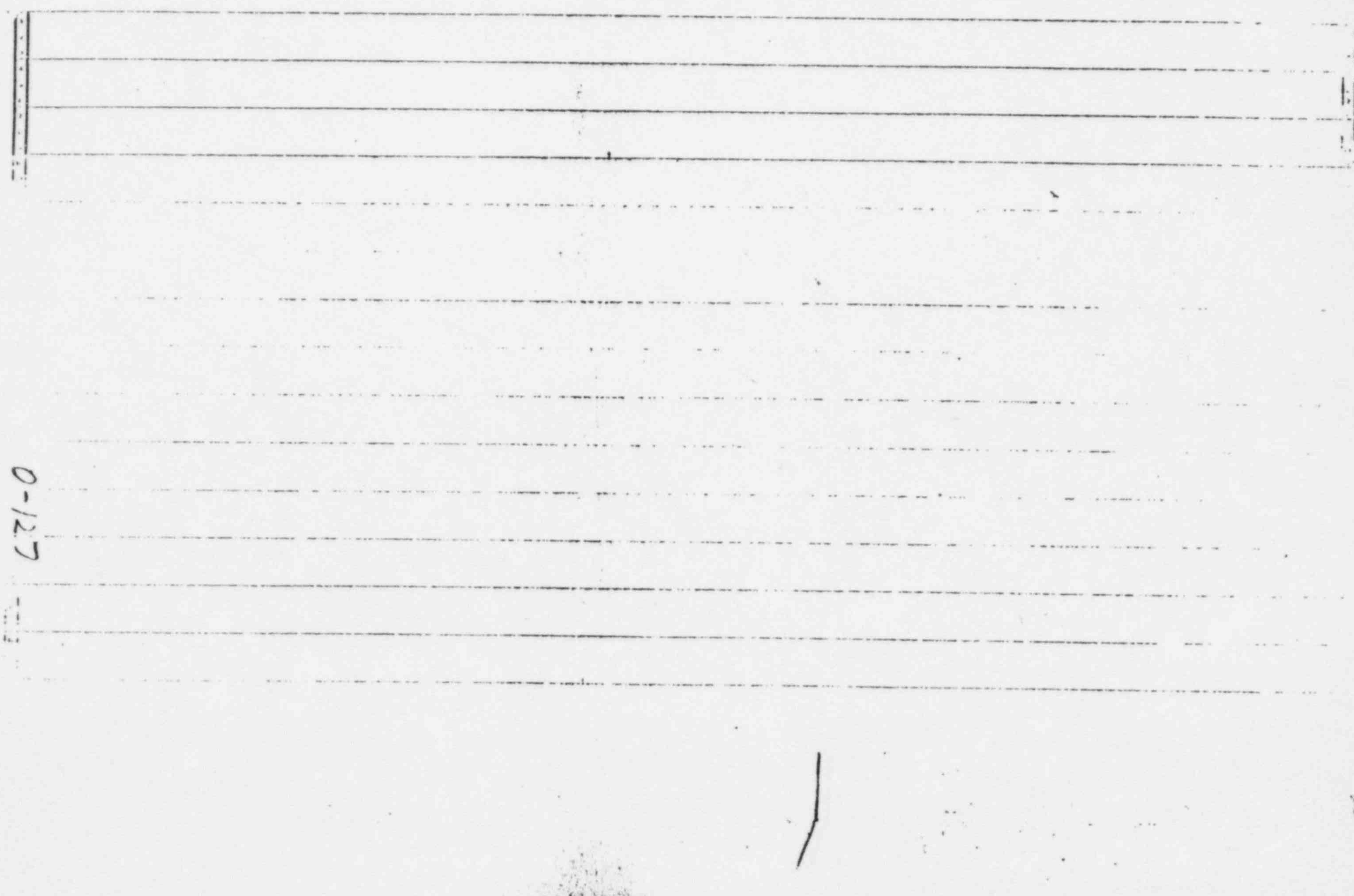
1	ROTATION ABOUT THE Z AXIS	.[illegible]E+03
1	DISPLACEMENT IN THE X DIRECTION	-.6559E+03
1	DISPLACEMENT IN THE Y DIRECTION	-.6862E+02
1	ROTATION ABOUT THE Z AXIS	-.1271E+02



0-127

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0

51-01-6907-H301
24,22,1.2.4
1.2.75.24000000..0..2.22,2.22,2570006,.0.283,0,.1,.0,
2.1.36.24000000..0..0.479,0.479,714000..0.283,0..0..1.
3.2.11.24000000..0..1.76,1.76,1110000,.0.283,0,.0..1,
4.1.00.29003000..0..0.210,0.333,933000..0.283,0..0..1.
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2.3.1
3.14.1
14.4.1
3.5.1
5.6.1
6.7.2
6.8.3
8.9.3
9.10.3
10.11.3
10.11.3
11.17.3
17.16.3
16.17.3
12.15.3
15.5.3
4.13.4
13.11.4
18.19.2
19.20.2
20.21.2
21.22.2
22.16.2
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2.0.9..9..0.
3.0.7..9..0.
4.0.13..0..0.
5.0.19..0..0.
6.0.23..0..9.
7.0.15.0..-25..0..1.1.1.1.1.1
8.0.23..4.5.0.
9.0.23..9..0.
10.0.19..9..0.
11.0.15..9..0.
12.0.7..0....
13.0.15..4.5,0.
14.0.11..0..0.
15.0.7..4.5,0.
16.0.9..9..0.
17.0.10..9..0.
18.0.21..9..0.
19.0.21..20..0.
20.0.19.2.22..0.
21.0.10.2.20..0.
22.0.9..20..0.
POSITIVE X LOADING
2.8.0.0.63m..0..0..0..0..0.
2.13.0.0.91..0..0..3..0..0.
2.20.0.0.101..0..0..0..6..0.
2.21.0.0.101..0..0..5..0..0.

16.22.42.UCLT, (1), HSLP1DT,       3.64DKLNS.
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ST-01-6037-6301

JOINT NUMBER	COORDINATES X	Y	Z	DISPLACEMENT - RESTRAINTS - ROTATIONS X	Y	Z	X	Y	Z
1	0.000	0.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
2	5.000	0.000	0.000						
3	7.000	0.000	0.000						
4	15.000	0.000	0.000						
5	19.000	0.000	0.300						
6	23.000	0.000	0.000						
7	0.000	-25.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
8	23.000	4.500	0.000						
9	23.000	9.000	0.000						
10	19.000	9.000	0.000						
11	15.000	9.000	0.000						
12	7.000	0.000	0.000						
13	15.000	4.500	0.000						
14	11.000	0.000	0.000						
15	7.000	4.500	0.000						
16	9.000	9.000	0.000						
17	10.000	9.000	0.000						
18	21.000	9.000	0.000						
19	21.000	20.000	0.000						
20	19.500	20.000	0.000						
21	16.500	20.000	0.000						
22	9.000	20.000	0.000						

MEMBER TYPE	SECTION AREA	MODULUS OF ELASTICITY	THERMAL EXP. COEFFICIENT	AREA MOMENT OF INERTIA Z AXIS	Y AXIS	TORSIONAL RIGIDITY	UNIT WEIGHT	REFERENCE VECTOR FOR X AXIS A1	A2	A3
1	2.1800	.290E+08	0.	2.2200	2.2200	.250E+07	.2630	0.0000	1.0000	0.0000
2	1.3600	.290E+08	0.	.4790	.4750	.314E+06	.2630	0.0000	0.0000	1.0000
3	2.1100	.290E+08	0.	1.7600	1.7600	.111E+07	.2530	0.0000	0.0000	1.0000
4	1.0000	.290E+08	0.	.2100	.3330	.533E+06	.2830	0.0000	0.0000	1.0000

MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT
1	2	1	5.000	3.141	2	3	1	2.000	1.551	3	14	1	4.000	3.113
3	15	3	4.500	2.667	14	4	1	4.000	3.113	15	12	3	4.500	2.667
4	5	1	4.000	3.113	4	13	4	4.500	1.274	12	16	3	9.220	5.535
5	6	1	4.000	3.113	13	11	4	4.500	1.274	16	11	3	1.000	.553
16	22	2	11.000	4.234	6	7	6	25.571	13.615	6	8	3	4.500	2.667
11	16	3	4.000	2.389	11	17	3	5.000	2.986	22	21	2	1.500	.577
8	9	3	4.500	2.667	16	16	3	2.000	1.194	21	20	2	9.000	3.464
9	18	3	2.000	1.194	18	19	2	11.000	4.234	20	15	2	1.500	.577

TOTAL STRUCTURAL WEIGHT 71.221 CENTER OF GRAVITY X = 12.65413, Y = 2.46666, Z = 0.00000

THE STIFFNESS MATRIX FOR 120 EQUATIONS REQUIRES 2220 STORAGE LOCATIONS

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POSITIVE Y LOADING

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	MOMENTS APPLIED ABOUT THE X AXIS	Y AXIS	Z AXIS
17	0.	.7050E+03	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.
20	0.	.1000E+03	0.	0.	0.	0.
21	0.	.1000E+03	0.	0.	0.	0.

JOINT	DISPLACEMENTS IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	ROTATIONS ABOUT THE X AXIS	Y AXIS	Z AXIS
1	0.	0.	0.	0.	0.	0.
2	-.1626E-04	.3412E-03	0.	0.	0.	.5660E-04
3	-.2557E-04	.3215E-03	0.	0.	0.	.3440E-04
14	-.3861E-04	.3103E-03	0.	0.	0.	.2379E-04
15	-.3316E-03	.5689E-03	0.	0.	0.	.3272E-03
4	-.3116E-04	.3556E-03	0.	0.	0.	-.3831E-03
12	.1694E-04	.6136E-03	0.	0.	0.	.3105E-04
5	-.9284E-04	.6449E-03	0.	0.	0.	-.2166E-04
13	-.2067E-03	.3461E-03	0.	0.	0.	.4743E-04
16	-.2283E-03	.3958E-03	0.	0.	0.	.1643E-04
6	-.1143E-03	.6115E-03	0.	0.	0.	.7654E-06
11	-.3141E-03	.5235E-03	0.	0.	0.	-.2013E-04
17	-.3273E-03	.6135E-03	0.	0.	0.	.5206E-05
22	-.2800E-03	.8268E-03	0.	0.	0.	.1584E-05
7	0.	0.	0.	0.	0.	0.
8	-.2610E-03	.6351E-03	0.	0.	0.	.2520E-04
10	-.3627E-03	.6525E-03	0.	0.	0.	-.1073E-04
21	-.2793E-03	.8326E-03	0.	0.	0.	.5113E-05
9	-.2986E-03	.6366E-03	0.	0.	0.	.5584E-05
18	-.3130E-03	.6429E-03	0.	0.	0.	-.8664E-05
20	-.2750E-03	.7114E-03	0.	0.	0.	-.2134E-04
19	-.2343E-03	.6336E-03	0.	0.	0.	-.2243E-04

MEMBER I	J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE A AXIS	B AXIS	TORSION	REACTION MOMENTS ABOUT THE A AXIS I END	A AXIS J END	B AXIS I END	B AXIS J END
1	2	-.2913E+03	-.5854E+02	0.	0.	0.	0.	.2135E+04	-.1531E+03
2	3	-.2913E+03	-.5854E+02	0.	0.	0.	0.	-.1438E+03	-.1326E+04
3	14	-.4594E+03	.7634E+02	0.	0.	0.	0.	-.9673E+03	-.6617E+03
3	15	.6618E+03	0.	.1681E+03	0.	.3573E+03	-.3693E+03	0.	0.
14	[illegible]	-.4594E+03	.7639E+02	0.	0.	0.	0.	-.6617E+03	-.3562E+03
15	[illegible]	-.6617E+03	0.	-.1681E+03	0.	-.3582E+03	.3573E+03	0.	0.
4	[illegible]	-.4225E+03	.1458E+03	0.	0.	0.	0.	-.2140E+03	.6518E+02
4	12	.6942E+02	0.	-.3653E+02	0.	-.1578E+03	.8345E+01	0.	0.
12	1	.6825E+03	0.	.2857E+02	0.	.3973E+03	.2076E+03	0.	0.
12	[illegible]	-.4225E+03	.1456E+03	0.	0.	0.	0.	.6518E+02	.6526E+03
13	11	.6942E+02	0.	-.2653E+02	0.	.8345E+01	.1745E+03	0.	0.
16	17	.1493E+03	0.	-.5643E+02	0.	.8665E+02	.6507E+03	0.	0.
16	22	.9310E+02	0.	.1876E+02	0.	.1215E+03	-.8504E+02	0.	0.
6	7	.4324E+03	0.	-.2061E+01	0.	-.3465E+02	.3531E+02	0.	0.
6	[illegible]	.1736E+03	0.	-.1312E+03	0.	-.6177E+03	-.2732E+02	0.	0.
11	10	.1124E+03	0.	.3659E+02	0.	.1232E+03	-.1662E+03	0.	0.
11	17	.1493E+03	0.	.1403E+03	0.	.3104E+02	-.6507E+03	0.	0.
22	21	.1678E+02	0.	-.5710E+02	0.	-.8504E+02	.6056E+02	0.	0.
8	9	.1736E+03	0.	-.1312E+03	0.	-.2732E+02	.5631E+03	0.	0.
10	18	.1124E+03	0.	.3693E+02	0.	-.1662E+03	-.3021E+03	0.	0.
21	20	.1878E+02	0.	.2905E+01	0.	.6656E+02	.3441E+02	0.	0.
4	16	.1312E+03	0.	.1738E+03	0.	.5631E+03	.2154E+03	0.	0.
18	19	.1029E+03	0.	-.1836E+02	0.	-.8649E+02	.1199E+03	0.	0.
20	19	.1878E+02	0.	.1025E+03	0.	.3441E+02	-.1199E+03	0.	0.

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	.2913E+03
	DISPLACEMENT IN THE Y DIRECTION	-.5854E+02

3 OY

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3	ROTATION ABOUT THE Z AXIS	-.2753E+04
3	DISPLACEMENT IN THE X DIRECTION	-.2913E+03
3	DISPLACEMENT IN THE Y DIRECTION	-.5196E+03
3	ROTATION ABOUT THE Z AXIS	-.3531E+02

0

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SI-81-6007-N301
24,32,1.2.0
1.2.75,29000000..0..2.22,2.22,2570000..0.283,0..1..0.
2.1.36,29001000..0..0.479,0.479,714063..0.283,0..0..1.
3.2.11.29000000..0..1.76,1.76,110000..0.283,0..0..1.
4.1.00.29000000..0..0.214.0.333.933000..0.283.0..0..1.
1.2.1
2.3.1
3.14.1
14.5.1
4.5.1
5.6.1
6.7.2
6.8.3
8.9.3
9.14.3
10.11.3
10.11.3
11.17.3
11.[illegible].3
16.1[illegible].3
12.1[illegible].3
15.[illegible].3
[illegible]
15.11.4
18.1[illegible].2
1[illegible].2[illegible].2
2[illegible].21.2
21.[illegible].2
[illegible].11.2
1.[illegible]
2.6.[illegible]..6.
3.6.7..0..0.
4.0.15..0..6.
5.0.19..0..[illegible].
6.0.23..0..[illegible].
7.F.11.[illegible]
8.0.[illegible]3..9.[illegible]
9.0.[illegible]3..[illegible]..0.
10.0.19..[illegible]..6.
11.[illegible].1[illegible]..[illegible]..0.
12.[illegible].7..0..0.
1[illegible].[illegible].1[illegible]..4.[illegible].0.
14.0.11..[illegible]
15.0.7..4.5.0.
16.0.9..[illegible]..6.
17.0.10..[illegible]..3.
18.0.21..9..3.
19.0.21..26..0.
20.0.19.[illegible].2[illegible]..0.
21.0.10.5.2[illegible]..0.
22.0.9..20..0.
POSITIIVE X LOADING
2.0.0.0.L3H..0..6..6..0..0.
2.1[illegible].0.[illegible]..0..3..0..0..0.
2.2[illegible].0.[illegible].10[illegible]..6..0..6..0..0.
2.21.0.0.101..0..0..[illegible]..0..6.

16.24.0[illegible], [illegible]. H-[illegible]7.        0.64[illegible]ALUS.
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ST-01-6307-N231

JOINT NUMBER	COORDINATES X	Y	Z	DISPLACEMENT - RESTRAINTS - ROTATIONS X	Y	Z	X	Y	Z
1	0.000	0.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
2	3.000	0.000	0.000						
3	7.000	0.000	0.000						
4	15.000	0.000	0.000						
5	19.000	0.000	0.000						
6	23.000	0.000	0.000						
7	0.000	-25.000	0.000	FIXED	FIXED	FIXED	FIXED	FIXED	FIXED
8	23.000	4.500	0.000						
9	23.000	9.000	0.000						
10	19.000	9.000	0.000						
11	15.000	9.000	0.000						
12	7.000	0.000	0.000						
13	15.000	4.500	0.000						
14	11.000	0.000	0.000						
15	7.000	4.500	0.000						
16	9.000	9.000	0.030						
17	16.000	9.000	0.000						
18	21.000	5.000	0.000						
19	[illegible]	20.000	0.000						
20	14.500	20.000	0.000						
21	[illegible]	20.000	0.000						
22	9.000	20.000	0.000						

MEMBER TYPE	SECTION AREA	MODULUS OF ELASTICITY	THERMAL EXP. COEFFICIENT	AREA MOMENT OF INERTIA A AXIS	B AXIS	TORSIONAL RIGIDITY	UNIT WEIGHT	REFERENCE VECTOR FOR A AXIS A1	A2	A3
1	2.3266	.290E+08	0.	2.2200	2.2200	.[illegible]E+07	.2830	0.0000	1.0000	0.0000
2	1.3700	.290E+08	0.	.4790	.4790	.314E+06	.2830	0.0000	0.0000	1.0000
3	2.1100	.290E+08	0.	1.7600	1.7600	.111E+07	.2830	0.0000	0.0000	1.0000
4	1.0000	.290E+08	0.	.2100	.3330	.533E+06	.2830	0.0000	0.0000	1.0000

MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT	MEMBER		TYPE	LENGTH	WEIGHT
1	2	1	3.000	3.491	2	3	1	2.000	1.163	3	14	1	4.000	3.113
3	15	3	4.500	2.667	14	4	1	4.000	3.113	15	12	3	4.500	2.683
4	5	1	4.000	3.113	4	13	4	4.500	1.274	12	16	3	4.225	2.505
5	6	1	4.000	3.113	13	11	4	4.500	1.274	16	11	3	1.003	.593
10	22	2	11.000	4.234	6	7	1	25.471	19.632	6	8	3	4.500	2.663
11	16	3	4.030	2.389	11	17	2	5.000	2.988	22	21	2	1.500	.533
6	9	3	4.500	2.657	13	18	2	2.000	1.194	21	20	2	4.000	3.564
4	16	3	2.000	1.194	16	19	2	11.000	4.234	20	19	2	1.500	.533

TOTAL SECTIONAL WEIGHT 71.221 CENTER OF GRAVITY X = 13.05012, Y = 2.00006, Z = 0.00000

THE STIFFNESS MATRIX FOR 120 EQUATIONS REQUIRES [illegible] STORAGE LOCATIONS

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NEGATIVE Y LOADING

CONCENTRATED LOADS

JOINT	FORCES APPLIED IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	MOMENT APPLIED ABOUT THE X AXIS	Y AXIS	Z AXIS
14	0.	-.8630E+03	0.	0.	0.	0.
5	0.	-.2750E+03	0.	0.	0.	0.
20	0.	-.1000E+03	0.	0.	0.	0.
21	0.	-.1000E+03	0.	0.	0.	0.

JOINT	DISPLACEMENTS IN THE X DIRECTION	Y DIRECTION	Z DIRECTION	ROTATIONS ABOUT THE X AXIS	Y AXIS	Z AXIS
1	0.	0.	0.	0.	0.	0.
2	.3454E-04	-.5142E-03	0.	0.	0.	-.1505E-03
3	.4835E-04	-.8271E-03	0.	0.	0.	-.1422E-03
14	.8639E-04	-.1231E-02	0.	0.	0.	-.6985E-04
15	.5809E-03	-.8458E-03	0.	0.	0.	-.1082E-03
4	.1244E-03	-.1345E-02	0.	0.	0.	.1025E-04
12	.1401E-03	-.8686E-03	0.	0.	0.	-.3466E-04
5	.1612E-03	-.1254E-02	0.	0.	0.	.3316E-04
13	.2379E-03	-.1284E-02	0.	0.	0.	-.4682E-04
16	.4392E-03	-.5684E-03	0.	0.	0.	-.3749E-04
6	.1960E-03	-.1146E-02	0.	0.	0.	.1017E-04
11	.4311E-03	-.1[illegible]E-02	0.	0.	0.	-.2573E-04
17	.4262E-03	-.1120E-02	0.	0.	0.	-.4[illegible]E-04
22	.5746E-03	-.1013E-02	0.	0.	0.	-.2568E-04
7	0.	0.	0.	0.	0.	0.
8	.2789E-03	-.1161E-02	0.	0.	0.	-.3445E-04
10	.4107E-03	-.1211E-02	0.	0.	0.	.1439E-04
21	.6137E-03	-.1166E-02	0.	0.	0.	-.6[illegible]E-04
9	.3498E-03	-.1182E-02	0.	0.	0.	-.3[illegible]E-04
18	.4555E-03	-.118[illegible]E-02	0.	0.	0.	.9942E-05
20	.5[illegible]E-03	-.1211E-02	0.	0.	0.	-.[illegible]
19	.6477E-03	-.1214E-02	0.	0.	0.	-.66[illegible]E-04

MEMBER I	J	AVERAGE AXIAL FORCE	AVERAGE SHEAR FORCE A AXIS	B AXIS	TORSION	BENDING MOMENTS ABOUT THE A AXIS I END	J END	B AXIS I END	J END
1	2	.5509E+03	.7323E+03	0.	0.	0.	0.	-.3673E+04	-.3[illegible]E+03
2	3	.5509E+03	.7323E+03	0.	0.	0.	0.	-.2059E+03	.1[illegible]E+04
3	14	.7583E+03	.4222E+03	0.	0.	0.	0.	.4014E+03	.2050E+04
3	15	-.3102E+03	0.	-.2076E+03	0.	-.8535E+03	.8008E+02	0.	0.
14	4	.7583E+03	-.4418E+02	0.	0.	0.	0.	.2090E+04	.3228E+03
15	12	.3162E+03	0.	.2075E+03	0.	.8008E+02	-.8535E+03	0.	0.
4	5	.1233E+03	-.4563E+02	0.	0.	0.	0.	.4662E+03	.2773E+03
4	13	.3952E+03	0.	.2611E+02	0.	.1335E+03	.2095E+02	0.	0.
12	16	-.3473E+03	0.	-.1352E+03	0.	-.8535E+03	.3933E+03	0.	0.
5	6	.1333E+03	-.3206E+03	0.	0.	0.	0.	.2773E+03	-.1005E+04
13	11	.1982E+03	0.	.2511E+02	0.	.2066E+02	-.5158E+02	0.	0.
16	17	-.1848E+03	0.	.2052E+03	0.	.5476E+03	.3189E+03	0.	0.
16	22	-.1016E+03	0.	-.2271E+02	0.	-.1942E+03	.1155E+03	0.	0.
6	7	-.8117E+03	0.	.4666E+01	0.	.6557E+02	-.3493E+02	0.	0.
6	8	-.2856E+03	0.	.1138E+03	0.	.9212E+03	.1001E+03	0.	0.
11	10	-.1598E+03	0.	-.1867E+03	0.	-.8194E+03	-.3536E+02	0.	0.
11	17	-.1848E+03	0.	.2052E+03	0.	.7277E+03	-.3184E+03	0.	0.
22	21	-.2271E+02	0.	.1010E+03	0.	.1155E+03	-.3592E+02	0.	0.
8	9	-.2850E+03	0.	.1825E+03	0.	.1001E+03	-.7209E+03	0.	0.
10	18	-.1598E+03	0.	-.1866E+03	0.	-.3536E+02	.2566E+03	0.	0.
21	20	-.2271E+02	0.	.5[illegible]E+00	0.	-.3849E+02	-.4454E+02	0.	0.
9	19	-.1825E+03	0.	-.3850E+03	0.	-.7265E+03	-.1505E+03	0.	0.
18	19	-.9904E+02	0.	.2271E+02	0.	.1457E+03	-.1046E+03	0.	0.
20	19	-.2271E+02	0.	-.5564E+02	0.	-.4454E+02	.1046E+03	0.	0.

JOINT NUMBER	RESTRAINT CONDITION	REACTION
1	DISPLACEMENT IN THE X DIRECTION	-.8509E+03
1	DISPLACEMENT IN THE Y DIRECTION	.3933E+03

4 θY

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1	ROTATION ABOUT THE Z AXIS	.3871E+04
3	DISPLACEMENT IN THE X DIRECTION	.2509E+03
3	DISPLACEMENT IN THE Y DIRECTION	.6051E+02
3	ROTATION ABOUT THE Z AXIS	.3493E+02

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51-01-6207-0301
24,2,1,2,0
1,2,75,24000000..0..2.22,2.22,2.70000,.0.283,C..1..0,
2,1,56,24600000..0..0.435,0.435,714000.,0.283,0..0..1,
3,2,11,24000000..0..1.76,1.76,110000,.0.283,0..0..1,
4,1,00,24000000..0..0.210,0.333,033003..0.283,0..0..1,
1,2,1
2,3,1
3,14,1
14,4,1
4,5,1
5,6,1
6,7,2
6,8,3
8,9,3
9,10,3
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
1,F1,0..F...1,1,1,1,1,1
2,[illegible]
3,0,7..,.3.
4,[illegible]
5,0,14..[illegible]
6,0,23..0..1.
7,F1,0..-3..0..1,1,1,1,1,1
8,0,23..4.5.0.
5,0,23..4..[illegible]
10,0,14..[illegible]..0.
11,0,15..9..0.
12,[illegible]
13,0,12..4..[illegible]..0.
14,0,11..[illegible]..0.
15,0,7..4.5.[illegible]
16,0,9..9..0.
17,0,10..4..0.
18,0,21..4..0.
19,0,21..20..0.
20,0,14..[illegible]2...0.
21,0,10..[illegible]20..0.
22,0,4..[illegible]0..0.
POSITIVE W LOADING
2,6,0,0,63..0..0..0..0..0.
2,1[illegible],0,0,91..0..0..0..0..0.
2,2,0,3,0,10..0..0..0..0..0.
2,21,0,0,100..0..0..0..0..0.

16.24.55.DEL? . [illegible], HSLF197.        3.64[illegible]S.
```

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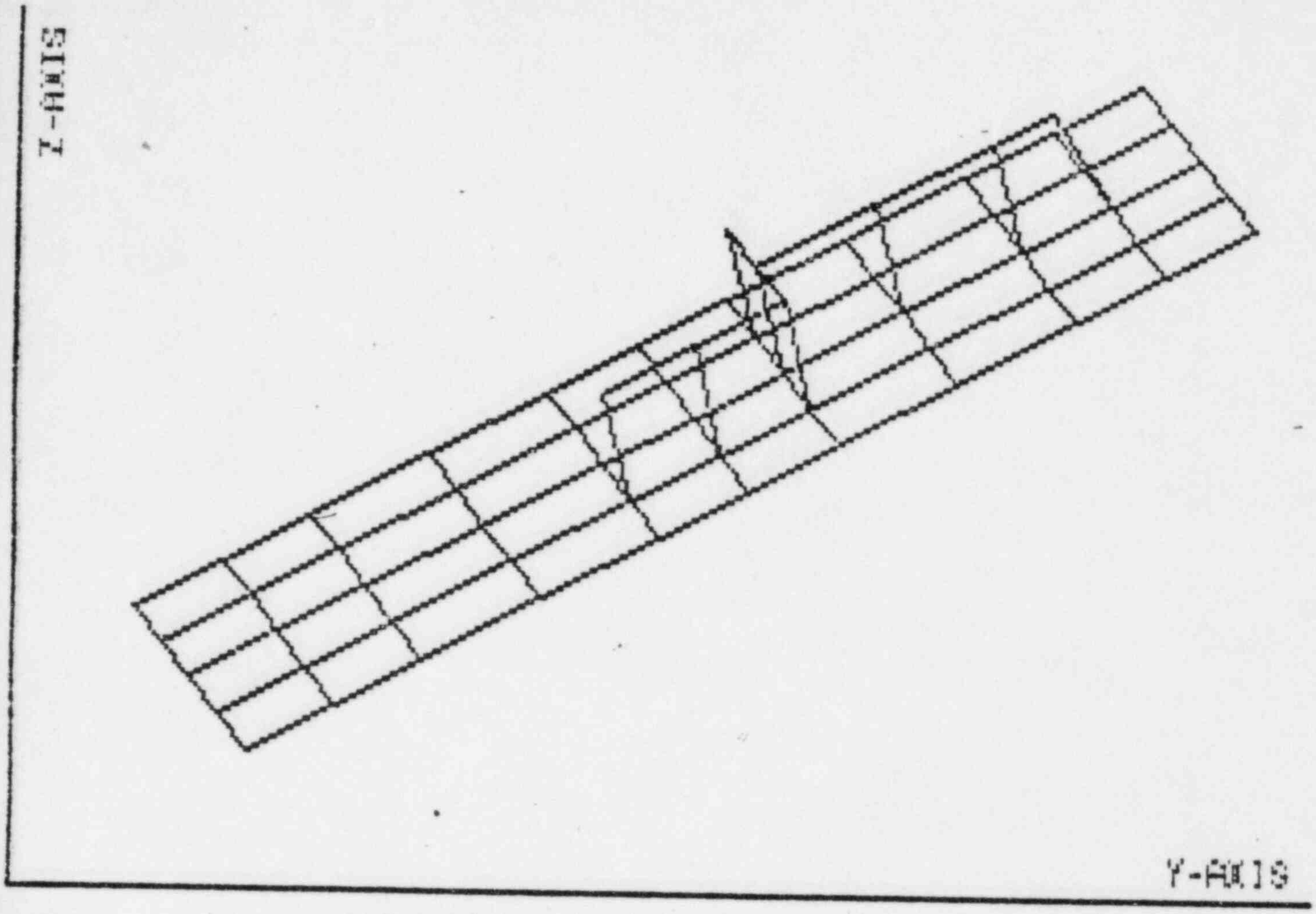
SUPERSAP OUTPUT

Pages 31 thru 42


Z-AXIS
Y-AXIS

Write fault error writing device PRN
Abort, Retry, Ignore? A

[C:\] >>TYPE CLINT1.L
1**** SUPERSAP ANALYSIS VERSION: 7.1
RELEASED: 7/30/85

DATE: June 11, 1986
TIME: 08:08:30
INPUT FILE.............CLINT1

BASE PLATE WITH GUSSET

1**** CONTROL INFORMATION

NUMBER OF NODE POINTS	(NUMNP)	=	63
NUMBER OF ELEMENT TYPES	(NELTYP)	=	2
NUMBER OF LOAD CASES	(LL)	=	2
NUMBER OF FREQUENCIES	(NF)	=	0
GEOMETRIC STIFFNESS FLAG	(GEOSTF)	=	0
ANALYSIS CODE	(NDYN)	=	0
SOLUTION MODE	(MODEX)	=	0
NUMBER OF ITERATION VECTORS	(NAD)	=	0
EQUATIONS PER BLOCK	(KEQB)	=	0
TAPE10 SAVE FLAG	(N10SV)	=	0
NODAL DEFLECTION PRINTING	(DEFPCH)	=	0
OVERALL MATRIX PRINTING	(GENPRT)	=	0
ELEMENT MATRIX PRINTING	(ELPRT)	=	0
WEIGHT AND C.G. FLAG	(IWTCG)	=	0
BANDWIDTH MINIMIZATION FLAG	(MINBND)	=	0
FILE FORMAT FLAG	(IPLT)	=	0
NUMBER OF RESPONSE SPECTRA	(NRSC)	=	0
GRAVITATIONAL CONSTANT	(GRAV)	=	3.8640E+02
TOTAL BLANK COMMON	(MTOT)	=	23000

BANDWIDTH MINIMIZATION SPECIFIED

1**** NODAL DATA

NODE NO.	BOUNDARY CONDITION CODES DX	DY	DZ	RX	RY	RZ	NODAL POINT COORDINATES X	Y	Z	T
1	0	1	1	0	0	0	.000E+00	.000E+00	.000E+00	.000E+00
2	0	0	0	0	0	0	1.000E+00	.000E+00	.000E+00	.000E+00
3	0	0	0	0	0	0	2.000E+00	.000E+00	.000E+00	.000E+00
4	0	0	0	0	0	0	3.000E+00	.000E+00	.000E+00	.000E+00
5	0	1	1	0	0	0	4.000E+00	.000E+00	.000E+00	.000E+00
6	0	0	0	0	0	0	.000E+00	1.500E+00	.000E+00	.000E+00
7	0	0	0	0	0	0	1.000E+00	1.500E+00	.000E+00	.000E+00
8	0	0	0	0	0	0	2.000E+00	1.500E+00	.000E+00	.000E+00
9	0	0	0	0	0	0	3.000E+00	1.500E+00	.000E+00	.000E+00
10	0	0	0	0	0	0	4.000E+00	1.500E+00	.000E+00	.000E+00
11	0	0	0	0	0	0	.000E+00	3.000E+00	.000E+00	.000E+00
12	0	0	0	0	0	0	1.000E+00	3.000E+00	.000E+00	.000E+00
13	0	0	0	0	0	0	2.000E+00	3.000E+00	.000E+00	.000E+00
14	0	0	0	0	0	0	3.000E+00	3.000E+00	.000E+00	.000E+00
15	0	0	0	0	0	0	4.000E+00	3.000E+00	.000E+00	.000E+00
16	0	0	0	0	0	0	.000E+00	[illegible]	.000E+00	.000E+00
17	0	0	0	0	0	0	1.000E+00	[illegible]	.000E+00	.000E+00
18	[illegible]	[illegible]	0	0	0	0	2.000E+00	[illegible]	[illegible]	.000E+00
19	[illegible]	0	0	0	0	0	3.000E+00	[illegible]	[illegible]	.000E+00

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[illegible]	0	0	0	0	0	0	4.000E+00	[illegible]	.000E+00	.000E+00
21	0	0	0	0	0	0	.000E+00	7.000E+00	.000E+00	.000E+00
22	0	0	0	0	0	0	1.000E+00	7.000E+00	.000E+00	.000E+00
23	0	0	0	0	0	0	2.000E+00	7.000E+00	.000E+00	.000E+00
24	0	0	0	0	0	0	3.000E+00	7.000E+00	.000E+00	.000E+00
25	0	0	0	0	0	0	4.000E+00	7.000E+00	.000E+00	.000E+00
26	0	0	0	0	0	0	.000E+00	8.500E+00	.000E+00	.000E+00
27	0	0	0	0	0	0	1.000E+00	8.500E+00	.000E+00	.000E+00
28	0	0	0	0	0	0	2.000E+00	8.500E+00	.000E+00	.000E+00
29	0	0	0	0	0	0	3.000E+00	8.500E+00	.000E+00	.000E+00
30	0	0	0	0	0	0	4.000E+00	8.500E+00	.000E+00	.000E+00
31	0	0	0	0	0	0	.000E+00	1.000E+01	.000E+00	.000E+00
32	0	0	0	0	0	0	1.000E+00	1.000E+01	.000E+00	.000E+00
33	0	0	0	0	0	0	2.000E+00	1.000E+01	.000E+00	.000E+00
34	0	0	0	0	0	0	3.000E+00	1.000E+01	.000E+00	.000E+00
35	0	0	0	0	0	0	4.000E+00	1.000E+01	.000E+00	.000E+00
36	0	0	0	0	0	0	.000E+00	1.200E+01	.000E+00	.000E+00
37	0	0	0	0	0	0	1.000E+00	1.200E+01	.000E+00	.000E+00
38	0	0	0	0	0	0	2.000E+00	1.200E+01	.000E+00	.000E+00
39	0	0	0	0	0	0	3.000E+00	1.200E+01	.000E+00	.000E+00
40	0	0	0	0	0	0	4.000E+00	1.200E+01	.000E+00	.000E+00
41	0	0	0	0	0	0	.000E+00	1.400E+01	.000E+00	.000E+00
42	0	0	0	0	0	0	1.000E+00	1.400E+01	.000E+00	.000E+00
43	0	0	0	0	0	0	2.000E+00	1.400E+01	.000E+00	.000E+00
44	0	0	0	0	0	0	3.000E+00	1.400E+01	.000E+00	.000E+00
45	0	0	0	0	0	0	4.000E+00	1.400E+01	.000E+00	.000E+00
46	0	0	0	0	0	0	.000E+00	1.550E+01	.000E+00	.000E+00
47	0	0	0	0	0	0	1.000E+00	1.550E+01	.000E+00	.000E+00
48	0	0	0	0	0	0	2.000E+00	1.550E+01	.000E+00	.000E+00
49	0	0	0	0	0	0	3.000E+00	1.550E+01	.000E+00	.000E+00
50	0	0	0	0	0	0	4.000E+00	1.550E+01	.000E+00	.000E+00
51	0	1	1	0	0	0	.000E+00	1.700E+01	.000E+00	.000E+00
52	0	0	0	0	0	0	1.000E+00	1.700E+01	.000E+00	.000E+00
53	0	0	0	0	0	0	2.000E+00	1.700E+01	.000E+00	.000E+00
54	0	0	0	0	0	0	3.000E+00	1.700E+01	.000E+00	.000E+00
55	0	1	1	0	0	0	4.000E+00	1.700E+01	.000E+00	.000E+00
56	0	0	0	0	0	0	3.000E+00	7.000E+00	2.000E+00	.000E+00
57	0	0	0	0	0	0	3.000E+00	8.500E+00	2.000E+00	.000E+00
58	0	0	0	0	0	0	3.000E+00	1.000E+01	2.000E+00	.000E+00
59	0	0	0	0	0	0	2.000E+00	1.000E+01	2.000E+00	.000E+00
60	0	0	0	0	0	0	1.000E+00	1.000E+01	2.000E+00	.000E+00
61	0	0	0	0	0	0	2.000E+00	1.200E+01	2.000E+00	.000E+00
62	0	0	0	0	0	0	2.000E+00	1.400E+01	2.000E+00	.000E+00
63	0	0	0	0	0	0	2.000E+00	1.500E+01	2.000E+00	.000E+00

1**** THIN PLATE/SHELL ELEMENTS

NUMBER OF ELEMENTS = 47
NUMBER OF MATERIALS = 1

1**** MATERIAL PROPERTIES

MATERIAL I.D. NUMBER = 1
WEIGHT DENSITY = 2.8400E-01
MASS DENSITY = 7.[illegible]99E-04

Cxxx ALPHA(x)	Cxyy ALPHA(y)	Cxs	Cyy	Cys	Css
3.137E+07	9.556E+06	.000E+00	3.137E+07	.000E+00	1.115E+07
.000E+00	.000E+00				

1**** ELEMENT LOAD MULTIPLIERS

	CASE A	CASE B	CASE C	CASE D

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PRES	.000E+00	.000E+00	.000E+00	.000E+00
TEMP	.000E+00	.000E+00	.000E+00	.000E+00
X-DIR	.000E+00	.000E+00	.000E+00	.000E+00
Y-DIR	.000E+00	.000E+00	.000E+00	.000E+00
Z-DIR	.000E+00	.000E+00	.000E+00	.000E+00

1**** ELEMENT CONNECTIVITY DATA

ELEM NO.	NODE I	NODE J	NODE K	NODE L	NODE O	MAT'L INDEX	AVERAGE THICKNESS	NORMAL PRESSURE.	TEMP. DIFFERENCE	TEMP. GRADIENT
1	1	2	7	6	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
2	6	7	12	11	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
3	11	12	17	16	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
4	16	17	22	21	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
5	21	22	27	26	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
6	26	27	32	31	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
7	31	32	37	36	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
8	36	37	42	41	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
9	41	42	47	46	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
10	46	47	52	51	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
11	2	3	8	7	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
12	7	8	13	12	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
13	12	13	18	17	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
14	17	18	23	22	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
15	22	23	28	27	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
16	27	28	33	32	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
17	32	33	38	37	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
18	37	38	43	42	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
19	42	43	48	47	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
20	47	48	53	52	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
21	3	4	9	8	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
22	8	9	14	13	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
23	13	14	19	18	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
24	18	19	24	23	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
25	23	24	29	28	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
26	28	29	34	33	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
27	33	34	39	38	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
28	38	39	44	43	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
29	43	44	49	48	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
30	48	49	54	53	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
31	4	5	10	9	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
32	9	10	15	14	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
33	14	15	20	19	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
34	19	20	25	24	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
35	24	25	30	29	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
36	29	30	35	34	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
37	34	35	40	39	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
38	39	40	45	44	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
39	44	45	50	49	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
40	49	50	55	54	0	1	3.750E-01	.000E+00	.000E+00	.000E+00
41	24	29	57	56	0	1	5.000E-01	.000E+00	.000E+00	.000E+00
42	29	34	58	57	0	1	5.000E-01	.000E+00	.000E+00	.000E+00
43	34	33	59	58	0	1	5.000E-01	.000E+00	.000E+00	.000E+00
44	33	32	60	59	0	1	5.000E-01	.000E+00	.000E+00	.000E+00
45	33	38	61	59	0	1	5.000E-01	.000E+00	.000E+00	.000E+00
46	38	43	62	61	0	1	5.000E-01	.000E+00	.000E+00	.000E+00
47	43	48	63	62	0	1	5.000E-01	.000E+00	.000E+00	.000E+00

1**** BOUNDARY ELEMENTS

NUMBER OF ELEMENTS = 20

1**** ELEMENT LOAD MULTIPLIERS

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CASE A	CASE B	CASE C	CASE D
.000E+00	.000E+00	.000E+00	.000E+00

1**** ELEMENT CONNECTIVITY DATA

ELEMENT NUMBER	NODE N	----DIRECTION I	J	K	NODES--- L	CODES KD	KR	SPECIFIED TRANSLATION	SPECIFIED ROTATION	SPRING RATE
1	1	2	3	2	7	1	0	.0000E+00	.0000E+00	1.000E+10
2	2	3	4	3	8	1	0	.0000E+00	.0000E+00	1.000E+10
3	3	4	5	4	9	1	0	.0000E+00	.0000E+00	1.000E+10
4	4	5	6	5	10	1	0	.0000E+00	.0000E+00	1.000E+10
5	5	6	7	6	11	1	0	.0000E+00	.0000E+00	1.000E+10
6	6	2	3	2	7	1	0	.0000E+00	.0000E+00	1.000E+10
7	7	3	4	3	8	1	0	.0000E+00	.0000E+00	1.000E+10
8	8	4	5	4	9	1	0	.0000E+00	.0000E+00	1.000E+10
9	9	5	6	5	10	1	0	.0000E+00	.0000E+00	1.000E+10
10	10	6	7	6	11	1	0	.0000E+00	.0000E+00	1.000E+10
11	46	2	3	2	7	1	0	.0000E+00	.0000E+00	1.000E+10
12	47	3	4	3	8	1	0	.0000E+00	.0000E+00	1.000E+10
13	48	4	5	4	9	1	0	.0000E+00	.0000E+00	1.000E+10
14	49	5	6	5	10	1	0	.0000E+00	.0000E+00	1.000E+10
15	50	6	7	6	11	1	0	.0000E+00	.0000E+00	1.000E+10
16	51	2	3	2	7	1	0	.0000E+00	.0000E+00	1.000E+10
17	52	3	4	3	8	1	0	.0000E+00	.0000E+00	1.000E+10
18	53	4	5	4	9	1	0	.0000E+00	.0000E+00	1.000E+10
19	54	5	6	5	10	1	0	.0000E+00	.0000E+00	1.000E+10
20	55	2	3	2	7	1	0	.0000E+00	.0000E+00	1.000E+10

1**** BANDWIDTH MINIMIZATION

MINBND (BANDWIDTH CONTROL PARAMETER) = 1

1**** EQUATION NUMBERS AFTER MINIMIZATION

OLD NODE	NEW NODE	DX	DY	DZ	RX	RY	RZ
1	47	273	0	0	274	275	276
2	54	313	314	315	316	317	318
3	59	343	344	345	346	347	348
4	62	361	362	363	364	365	366
5	63	367	0	0	368	369	370
6	46	267	268	269	270	271	272
7	53	307	308	309	310	311	312
8	58	337	338	339	340	341	342
9	60	349	350	351	352	353	354
10	61	355	356	357	358	359	360
11	45	261	262	263	264	265	266
12	52	301	302	303	304	305	306
13	55	319	320	321	322	323	324
14	56	325	326	327	328	329	330
15	57	331	332	333	334	335	336
16	44	255	256	257	258	259	260
17	48	277	278	279	280	281	282
18	49	283	284	285	286	287	288
19	50	289	290	291	292	293	294
20	51	295	296	297	298	299	300
21	39	225	226	227	228	229	230
22	40	231	232	233	234	235	236
23	41	237	238	239	240	241	242
24	42	243	244	245	246	247	248
25	43	249	250	251	252	253	254
[illegible]	[illegible]	183	184	185	186	187	188
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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29	37	213	214	215	216	217	218
30	38	219	220	221	222	223	224
31	26	147	148	149	150	151	152
32	27	153	154	155	156	157	158
33	28	159	160	161	162	163	164
34	30	171	172	173	174	175	176
35	31	177	178	179	180	181	182
36	18	99	100	101	102	103	104
37	19	105	106	107	108	109	110
38	22	123	124	125	126	127	128
39	24	135	136	137	138	139	140
40	25	141	142	143	144	145	146
41	12	63	64	65	66	67	68
42	13	69	70	71	72	73	74
43	15	81	82	83	84	85	86
44	16	87	88	89	90	91	92
45	17	93	94	95	96	97	98
46	6	27	28	29	30	31	32
47	7	33	34	35	36	37	38
48	9	45	46	47	48	49	50
49	10	51	52	53	54	55	56
50	11	57	58	59	60	61	62
51	1	1	0	0	2	3	4
52	2	5	6	7	8	9	10
53	3	11	12	13	14	15	16
54	4	17	18	19	20	21	22
55	5	23	0	0	24	25	26
56	36	207	208	209	210	211	212
57	35	201	202	203	204	205	206
58	29	165	166	167	168	169	170
59	23	129	130	131	132	133	134
60	21	117	118	119	120	121	122
61	20	111	112	113	114	115	116
62	14	75	76	77	78	79	80
63	8	39	40	41	42	43	44

BANDWIDTH BEFORE RESEQUENCING = 200
BANDWIDTH AFTER RESEQUENCING = 60

1**** NODAL LOADS (STATIC) OR MASSES (DYNAMIC)

NODE NUMBER	LOAD CASE	X-AXIS FORCE	Y-AXIS FORCE	Z-AXIS FORCE	X-AXIS MOMENT	Y-AXIS MOMENT	Z-AXIS MOMENT
56	1	.000E+00	.000E+00	1.631E+03	.000E+00	.000E+00	.000E+00
57	1	.000E+00	.000E+00	4.891E+02	.000E+00	.000E+00	.000E+00
58	1	.000E+00	.000E+00	-5.961E+02	.000E+00	.000E+00	.000E+00
59	1	.000E+00	.000E+00	4.899E+02	.000E+00	.000E+00	.000E+00
60	1	.000E+00	.000E+00	2.450E+02	.000E+00	.000E+00	.000E+00
56	2	.000E+00	.000E+00	1.166E+03	.000E+00	.000E+00	.000E+00
57	2	.000E+00	.000E+00	7.005E+02	.000E+00	.000E+00	.000E+00
58	2	.000E+00	.000E+00	-1.148E+02	.000E+00	.000E+00	.000E+00
59	2	.000E+00	.000E+00	7.005E+02	.000E+00	.000E+00	.000E+00
60	2	.000E+00	.000E+00	3.502E+02	.000E+00	.000E+00	.000E+00

1**** ELEMENT LOAD MULTIPLIERS

LOAD CASE	CASE A	CASE B	CASE C	CASE D
1	.000E+00	.000E+00	.000E+00	.000E+00
2	.000E+00	.000E+00	.000E+00	.000E+00

1**** STIFFNESS MATRIX PARAMETERS

MINIMUM NON-ZERO DIAGONAL ELEMENT = D-147 [illegible]

MAXIMUM DIAGONAL ELEMENT = [illegible]
MAXIMUM/MINIMUM = 3.4380E+04
AVERAGE DIAGONAL ELEMENT = 5.1471E+08
DENSITY OF THE MATRIX = 9.7054E+00

!!!! WARNING: MODEL MAY LACK SUFFICIENT BOUNDARY CONSTRAINT OR HAVE STIFFNESS COMPATIBILITY PROBLEM. SEE NODE AND/OR ELEMENTS ASSOCIATED WITH DOF: 367

1**** STATIC ANALYSIS

LOAD CASE = 1

DISPLACEMENTS/ROTATIONS(DEGREES) OF UNRESTRAINED NODES

NODE NUMBER	X- TRANSLATION	Y- TRANSLATION	Z- TRANSLATION	X- ROTATION	Y- ROTATION	Z- ROTATION
1	7.5513E-05	.0000E+00	.0000E+00	-8.3870E-02	-7.5470E-03	.0000E+00
2	7.4615E-05	3.0517E-06	-3.9594E-08	-7.9535E-02	4.4196E-03	.0000E+00
3	7.2321E-05	1.3882E-05	-5.6844E-08	-9.2985E-02	2.5964E-03	.0000E+00
4	6.8430E-05	1.5813E-05	-4.8831E-08	-9.7218E-02	-1.2544E-03	.0000E+00
5	6.3944E-05	.0000E+00	.0000E+00	-1.1112E-01	1.3236E-02	.0000E+00
6	6.6940E-05	1.4989E-06	-1.9985E-08	1.1664E-01	-1.3266E-02	.0000E+00
7	6.7131E-05	8.0463E-06	1.1384E-07	1.3462E-01	6.1206E-03	.0000E+00
8	6.7755E-05	1.4682E-05	6.0398E-08	1.5059E-01	3.4324E-03	.0000E+00
9	6.8697E-05	1.8306E-05	1.5410E-07	1.6607E-01	-3.8463E-03	.0000E+00
10	6.7541E-05	2.0528E-05	1.9399E-08	1.7983E-01	2.4630E-02	.0000E+00
11	5.7904E-05	-5.9457E-07	7.0921E-03	4.1799E-01	-6.5306E-02	.0000E+00
12	5.8336E-05	7.9346E-06	8.0348E-03	4.4697E-01	-4.6935E-02	.0000E+00
13	5.8039E-05	1.5985E-05	8.8589E-03	4.9001E-01	-4.7492E-02	.0000E+00
14	5.7671E-05	2.3855E-05	9.7226E-03	5.3440E-01	-4.8040E-02	.0000E+00
15	5.6549E-05	3.3111E-05	1.0441E-02	5.7752E-01	-2.6397E-02	.0000E+00
16	3.7536E-05	-5.4195E-06	2.3276E-02	4.5537E-01	-8.8704E-02	.0000E+00
17	3.8301E-05	7.0626E-06	2.5030E-02	4.7064E-01	-1.1902E-01	.0000E+00
18	3.8791E-05	2.1810E-05	2.7244E-02	5.0498E-01	-1.3942E-01	.0000E+00
19	3.4713E-05	3.2992E-05	2.9694E-02	5.4319E-01	-1.4663E-01	.0000E+00
20	3.0019E-05	4.6564E-05	3.2286E-02	5.7229E-01	-1.7079E-01	.0000E+00
21	1.0457E-05	-8.2026E-06	3.2969E-02	7.5868E-02	-7.5139E-02	.0000E+00
22	1.0965E-05	2.7003E-06	3.4752E-02	5.3917E-02	-1.3805E-01	.0000E+00
23	1.2523E-05	1.7921E-05	3.7571E-02	1.7758E-02	-2.0027E-01	.0000E+00
24	1.4051E-05	6.4847E-05	4.0732E-02	-1.0176E-02	-1.5021E-01	-8.2065E-03
25	1.3614E-05	3.3323E-05	4.3196E-02	-3.3827E-02	-1.6293E-01	.0000E+00
26	-1.8224E-06	-4.9731E-06	3.1759E-02	-1.6248E-01	-4.0510E-02	.0000E+00
27	-2.0584E-06	-3.4259E-06	3.2702E-02	-1.9144E-01	-6.1819E-02	.0000E+00
28	1.4579E-06	-1.5520E-06	3.3771E-02	-2.4750E-01	-5.0274E-02	.0000E+00
29	1.8184E-05	-2.0326E-06	3.4828E-02	-3.0059E-01	-8.5296E-02	-9.3271E-04
30	3.3180E-05	-1.8027E-06	3.7006E-02	-3.4364E-01	-1.5011E-01	.0000E+00
31	3.3332E-06	5.7971E-07	2.5953E-02	-2.6483E-01	-2.5059E-02	.0000E+00
32	2.1467E-06	-7.5196E-06	2.6499E-02	-2.7226E-01	-3.2807E-02	1.3332E-03
33	6.6379E-06	-2.9818E-05	2.7145E-02	-2.7257E-01	-3.7891E-02	4.8288E-04
34	1.9920E-05	-6.2273E-05	2.7855E-02	-2.6711E-01	-4.4397E-02	3.5423E-03
35	2.4578E-05	-3.7201E-05	2.8735E-02	-2.9649E-01	-5.0492E-02	.0000E+00
36	3.8638E-05	4.7638E-07	1.6061E-02	-2.9234E-01	-3.3672E-02	.0000E+00
37	3.9945E-05	-2.0388E-05	1.6649E-02	-2.9080E-01	-3.1449E-02	.0000E+00
38	4.1833E-05	-5.8857E-05	1.7149E-02	-2.9259E-01	-2.3716E-02	-2.5914E-04
39	3.5792E-05	-4.5567E-05	1.7521E-02	-3.0511E-01	-2.0352E-02	.0000E+00
40	3.1761E-05	-4.9984E-05	1.7325E-02	-3.2709E-01	-1.6928E-02	.0000E+00
41	6.6597E-05	-2.5551E-06	5.4718E-03	-3.3967E-01	-9.5778E-03	.0000E+00
42	6.5598E-05	-1.1926E-05	6.3570E-03	-3.4820E-01	-9.4111E-03	.0000E+00
43	5.7740E-05	-2.0507E-05	7.1[illegible]E-03	-3.1621E-01	-1.0551E-02	-5.9027E-04
44	5.1098E-05	-2.7705E-05	6.6844E-03	-3.2715E-01	7.7503E-02	.0000E+00
45	4.9092E-05	-7.5534E-05	6.0728E-03	-3.[illegible]	4.1147E-[illegible]	.0000E+00
46	7.1643E-05	-1.5620E-06	-9.9439E-08	-1.[illegible]	-1.0776E-[illegible]	.0000E+00
47	[illegible]	[illegible]	1.3136E-07	-1.3627E-01	4.[illegible]	.0000E+00

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
49	6.7034E-05	-1.3217E-05	1.3771E-07	-1.3141E-01	-3.0252E-03	.0000E+00
50	6.4717E-05	-2.1531E-05	-4.3229E-09	-1.1766E-01	1.2376E-02	.0000E+00
51	7.0901E-05	.0000E+00	.0000E+00	7.7456E-02	-6.7262E-03	.0000E+00
52	7.0284E-05	5.0086E-07	-3.7655E-08	7.3018E-02	4.1326E-03	.0000E+00
53	7.3275E-05	-4.6900E-07	-5.2957E-08	8.0059E-02	5.5229E-04	.0000E+00
54	7.4915E-05	-7.0656E-06	-3.9822E-08	7.6066E-02	-3.5310E-03	.0000E+00
55	7.0702E-05	.0000E+00	.0000E+00	8.2799E-02	7.8392E-03	.0000E+00
56	-3.8813E-03	8.7603E-03	4.1320E-02	.0000E+00	-9.7533E-02	-4.9196E-02
57	-2.6934E-03	8.8224E-03	3.4630E-02	.0000E+00	-6.9517E-02	-4.9043E-02
58	-1.3760E-03	9.0114E-03	2.7836E-02	-2.6341E-01	-3.6446E-02	-5.3863E-02
59	-1.3540E-03	9.8431E-03	2.7172E-02	-2.9225E-01	-3.6261E-02	-2.9844E-02
60	-1.3402E-03	1.0179E-02	2.6524E-02	-2.9661E-01	.0000E+00	-1.3363E-02
61	-7.2988E-04	9.9061E-03	1.7116E-02	.0000E+00	-2.0348E-02	-1.1807E-02
62	-3.8531E-04	9.8051E-03	7.1377E-03	.0000E+00	-1.3912E-02	-9.1500E-03
63	-2.3707E-04	9.7494E-03	2.2417E-03	.0000E+00	-1.0683E-02	-8.3267E-03

1**** STATIC ANALYSIS

LOAD CASE = 2

DISPLACEMENTS/ROTATIONS(DEGREES) OF UNRESTRAINED NODES

NODE NUMBER	X- TRANSLATION	Y- TRANSLATION	Z- TRANSLATION	X- ROTATION	Y- ROTATION	Z- ROTATION
1	2.3013E-04	.0000E+00	.0000E+00	-1.0089E-01	-6.7391E-03	.0000E+00
2	2.2547E-04	2.7920E-05	-4.7799E-08	-9.6000E-02	5.5063E-03	.0000E+00
3	2.1783E-04	4.0426E-05	-6.9134E-08	-1.1308E-01	3.3616E-03	.0000E+00
4	2.0733E-04	4.1564E-05	-5.9749E-08	-1.1893E-01	-1.4011E-03	.0000E+00
5	1.9637E-04	.0000E+00	.0000E+00	-1.3623E-01	1.6325E-02	.0000E+00
6	2.0803E-04	1.5211E-05	-2.6173E-08	1.3923E-01	-1.3672E-02	.0000E+00
7	2.0788E-04	2.9342E-05	1.3670E-07	1.6247E-01	7.5409E-03	.0000E+00
8	2.0981E-04	4.2856E-05	7.3145E-08	1.8314E-01	4.4464E-03	.0000E+00
9	2.1229E-04	4.7352E-05	1.8878E-07	2.0320E-01	-4.5716E-03	.0000E+00
10	2.0976E-04	4.3657E-05	2.4792E-08	2.2123E-01	3.0486E-02	.0000E+00
11	1.9321E-04	1.7400E-05	8.4995E-03	5.0304E-01	-3.4833E-02	.0000E+00
12	1.9333E-04	3.2275E-05	9.7175E-03	5.4146E-01	-6.0949E-02	.0000E+00
13	1.9280E-04	4.6696E-05	1.0787E-02	5.9721E-01	-6.1532E-02	.0000E+00
14	1.9203E-04	6.0386E-05	1.1908E-02	6.5493E-01	-6.2351E-02	.0000E+00
15	1.8931E-04	7.6542E-05	1.2852E-02	7.1126E-01	-3.5461E-02	.0000E+00
16	1.5802E-04	1.4213E-05	2.8081E-02	5.5496E-01	-1.1931E-01	.0000F+00
17	1.5857E-04	3.5893E-05	3.0404E-02	5.7641E-01	-1.5550E-01	.0000E+00
18	1.5846E-04	6.0972E-05	3.3289E-02	6.2131E-01	[illegible]	.0000E+00
19	1.3133E-04	8.1016E-05	3.6486E-02	6.7255E-01	-1.9124E-01	.0000E+00
20	1.4324E-04	1.0531E-04	3.9873E-02	7.1373E-01	-2.2071E-01	.0000E+00
21	1.1106E-04	1.4620E-05	4.0126E-02	1.0567E-01	-1.9726E-01	.0000E+00
22	1.1112E-04	3.3408E-05	4.2567E-02	8.3943E-02	-1.8263E-01	.0000E+00
23	1.1230E-04	6.1304E-05	4.6262E-02	3.4976E-02	-2.3063E-01	.0000E+00
24	1.1200E-04	1.3807E-04	5.0494E-02	9.9955E-03	-2.1191E-01	-7.2166E-03
25	1.1557E-04	9.3081E-05	5.3975E-02	-1.3227E-02	-2.2546E-01	.0000E+00
26	9.1919E-05	2.3161E-05	3.9074E-02	-1.8070E-01	-6.9259E-02	.0000E+00
27	9.0254E-05	2.6186E-05	4.0572E-02	-2.1244E-01	-9.5674E-02	.0000E+00
28	9.1905E-05	3.3088E-05	4.2228E-02	-2.7554E-01	-8.1547E-02	.0000E+00
29	1.1223E-04	5.3588E-05	4.3973E-02	-3.3680E-01	-1.3932E-01	-2.2367E-03
30	1.3949E-04	2.9536E-05	4.7222E-02	-3.8968E-01	-2.1765E-01	.0000E+00
31	1.0316E-04	2.8140E-05	3.2215E-02	-3.2235E-01	-5.3515E-02	.0000E+00
32	1.0547E-04	1.8837E-05	3.3316E-02	-3.3505E-01	-6.3619E-02	4.0612E-03
33	1.1601E-04	-1.2749E-05	3.4637E-02	-3.3319E-01	-8.0091E-02	1.9717E-03
34	1.3866E-04	-6.9577E-05	3.5047E-02	-3.1477E-01	-8.3725E-02	9.6583E-03
35	1.5048E-04	-3.9947E-05	3.7643E-02	-3.5675E-01	-9.3326E-02	.0000E+00
36	1.6745E-04	1.0760E-05	2.0059E-02	-3.5403E-01	-9.3970E-02	.0000E+00
37	1.7750E-04	-2.7125E-05	2.1094E-02	-3.7663E-01	-9.7110E-02	.0000E+00
38	1.8416E-04	-9.5716E-05	2.3026E-02	[illegible]	-4.3771E-02	2.2217E-04
39	1.7989E-04	-7.0634E-05	2.2677E-02	[illegible]	[illegible]	.0000E+00
40	1.7633E-04	-7.4294E-05	2.3677E-02	[illegible]	-4.7914E-02	.0000E+00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
42	2.2009E-04	-3.4248E-05	8.0659E-03	-3.9115E-01	-7.5593E-02	.0000E+00
43	2.1133E-04	-6.5270E-05	9.0472E-03	-4.0688E-01	-2.0541E-02	-1.2651E-03
44	2.0573E-04	-6.1199E-05	8.7442E-03	-4.2250E-01	4.1352E-02	.0000E+00
45	2.0415E-04	-6.8986E-05	8.1160E-03	-4.3362E-01	4.5497E-02	.0000E+00
46	2.3389E-04	-1.4322E-05	-1.4557E-08	-1.3272E-01	-1.3317E-02	.0000E+00
47	2.3307E-04	-2.6473E-05	1.5178E-07	-1.5974E-01	6.3831E-03	.0000E+00
48	2.3148E-04	-2.9151E-05	4.3625E-08	-1.7679E-01	-2.0178E-03	-1.6344E-03
49	2.2904E-04	-4.4428E-05	1.8332E-07	-1.7202E-01	-3.3457E-03	.0000E+00
50	2.2578E-04	-4.7614E-05	-2.8071E-09	-1.5684E-01	1.6728E-02	.0000E+00
51	2.4888E-04	.0000E+00	.0000E+00	9.8292E-02	-8.3237E-03	.0000E+00
52	2.4390E-04	-2.1942E-03	-4.7906E-08	9.3309E-02	5.5363E-03	.0000E+00
53	2.3878E-04	-3.1157E-05	-6.8396E-08	1.0347E-01	1.1000E-03	.0000E+00
54	2.3129E-04	-3.5238E-05	-5.2179E-08	9.9493E-02	-4.3175E-03	.0000E+00
55	2.1997E-04	.0000E+00	.0000E+00	1.0903E-01	1.0589E-02	.0000E+00
56	-6.0584E-03	9.3827E-03	5.1109E-02	.0000E+00	-1.6621E-01	-5.2373E-02
57	-4.7268E-03	1.0013E-02	4.3721E-02	.0000E+00	-1.3524E-01	-5.9463E-02
58	-2.6699E-03	1.0351E-02	3.6082E-02	-2.9649E-01	-8.6540E-02	-1.1019E-01
59	-2.6367E-03	1.2302E-02	3.4677E-02	-3.7505E-01	-6.9184E-02	-7.3964E-02
60	-2.6155E-03	1.3152E-02	3.3345E-02	-3.8567E-01	.0000E+00	-3.5587E-02
61	-1.2582E-03	1.2534E-02	2.1962E-02	.0000E+00	-3.5504E-02	-2.2903E-02
62	-6.1831E-04	1.2492E-02	9.1994E-03	.0000E+00	-2.5467E-02	-1.7095E-02
63	-3.4156E-04	1.2432E-02	2.9223E-03	.0000E+00	-1.9546E-02	-1.5583E-02

1**** THIN PLATE/SHELL ELEMENT STRESSES

ELEMENT NO.	CASE (MODE)	-- MEMBRANE STRESS COMPONENTS -- SM11	SM22	SM12	--- BENDING STRESS COMPONENTS -- SB11	SB22	SB12
1	1	-6.501E+00	1.249E+01	2.172E+01	-2.690E+03	-1.392E+04	9.108E+02
1	2	-2.444E+01	1.535E+02	8.675E+01	-3.236E+03	-1.674E+04	1.140E+03
2	1	2.906E+00	-2.043E+01	1.778E+01	-4.379E+03	-2.073E+04	-3.369E+03
2	2	1.580E+01	5.425E+01	5.256E+01	-5.291E+03	-2.509E+04	-4.537E+03
3	1	5.492E+00	-3.951E+01	4.629E+00	-1.048E+03	-1.763E+03	-1.748E+03
3	2	1.169E+01	6.631E+00	8.842E+00	-1.321E+03	-2.457E+03	-2.388E+03
4	1	3.154E+00	-5.100E+01	-2.121E+01	1.351E+03	1.925E+04	-2.590E+02
4	2	4.822E+00	-1.362E+01	-3.757E+01	1.549E+03	2.281E+04	-4.504E+02
5	1	-4.891E+00	-2.947E+01	-2.464E+01	6.736E+02	1.537E+04	2.552E+03
5	2	-2.132E+01	6.349E+00	-2.712E+01	7.699E+02	1.866E+04	2.957E+03
6	1	-2.083E+00	1.348E+01	-5.456E+00	3.951E+02	5.913E+03	9.109E+02
6	2	2.812E+00	-2.207E+01	6.335E+01	5.910E+02	8.537E+03	6.600E+02
7	1	-1.315E+01	-9.799E+01	4.511E+01	7.598E+01	1.127E+03	-3.332E+02
7	2	-1.807E+01	-4.646E+02	1.058E+02	-1.172E+02	1.702E+03	-2.525E+02
8	1	1.731E+01	4.461E+01	-1.944E+01	4.123E+02	6.027E+02	-1.410E+03
8	2	3.767E+01	-1.977E+02	-6.633E+01	4.829E+02	8.749E+02	-1.454E+03
9	1	-2.168E+00	8.542E+01	-1.730E+01	-2.951E+03	-1.268E+04	3.636E+03
9	2	1.122E+01	4.588E+01	-9.576E+01	-3.719E+03	-1.599E+04	5.046E+03
10	1	-5.002E+00	5.737E+01	-4.235E+00	-2.614E+03	-1.235E+04	-4.585E+02
10	2	-3.222E+01	1.726E+02	-9.412E+01	-3.278E+03	-1.530E+04	-1.267E+03
11	1	-2.408E+01	4.552E-01	2.472E+01	-5.009E+03	-1.598E+04	3.047E+0[illegible]
11	2	-7.882E+01	1.359E-01	4.999E+01	-6.[illegible]88E+03	-1.936E+04	5.540E+[illegible]
12	1	3.997E+00	1.422E+01	1.308E+01	-3.966E+03	-2.271E+04	-2.210E+03
12	2	4.396E+01	7.366E+01	3.348E+01	-4.[illegible]2E+03	-2.763E+04	-2.887E+03

13	2	3.260E+01	1.395E+02	2.761E+01	-1.841E+03	-1.953E+03	-3.803E+03
14	1	1.287E+01	-5.611E+01	1.755E+01	2.747E+03	2.222E+04	-2.471E+03
14	2	1.978E+01	-9.683E+00	3.532E+01	2.983E+03	2.637E+04	-3.134E+03
15	1	-7.262E-01	-2.477E+02	5.774E+00	2.704E+03	1.703E+04	5.689E+03
15	2	-5.986E+01	-3.605E+02	3.877E+01	3.051E+03	2.027E+04	6.709E+03
16	1	2.447E+01	-3.055E+02	-7.901E+01	1.441E+03	3.782E+03	4.716E+02
16	2	2.467E+01	-5.067E+02	8.516E+00	2.018E+03	6.308E+03	-1.241E+02
17	1	1.470E+00	-3.034E+02	-1.354E+02	4.398E+02	1.047E+03	5.598E+02
17	2	2.950E+01	-9.259E+02	-1.789E+02	5.226E+02	1.915E+03	1.356E+03
18	1	1.673E+01	3.442E+02	-1.463E+02	2.995E+03	1.872E+03	-1.178E+03
18	2	8.611E+01	1.953E+02	-3.496E+02	3.847E+03	2.475E+03	-1.228E+03
19	1	-3.228E+01	3.506E+02	7.426E+01	-1.801E+03	-1.200E+04	3.132E+03
19	2	-2.523E+01	4.162E+02	-6.445E+01	-2.380E+03	-1.531E+04	4.400E+03
20	1	6.552E+00	-4.417E+01	6.902E+01	-4.811E+03	-1.458E+04	-1.961E+02
20	2	-9.894E+01	-5.248E+00	1.091E+00	-6.231E+03	-1.874E+04	-3.077E+02
21	1	-3.653E+01	2.076E+01	1.499E+01	-5.866E+03	-1.779E+04	4.578E+02
21	2	-1.007E+02	4.922E+01	1.985E+01	-7.167E+03	-2.171E+04	5.686E+02
22	1	3.101E+01	7.560E+01	-1.305E+01	-7.789E+03	-2.473E+04	-2.725E+03
22	2	8.101E+01	1.874E+02	-3.709E+01	-9.542E+03	-3.025E+04	-3.524E+03
23	1	-3.508E+01	9.795E+01	-1.144E+01	-5.902E+02	-7.407E+02	-3.461E+03
23	2	-4.245E+01	2.403E+02	-2.114E+01	-8.835E+02	-1.255E+03	-4.513E+03
24	1	2.620E+01	2.106E+02	1.932E+02	1.037E+04	2.780E+04	-2.914E+03
24	2	1.069E+01	4.193E+02	3.029E+02	1.176E+04	3.304E+04	-3.891E+03
25	1	1.567E+01	-8.300E+02	2.333E+02	6.579E+03	1.955E+04	9.419E+03
25	2	-4.652E+01	-1.103E+03	4.660E+02	6.435E+03	2.288E+04	1.133E+04
26	1	1.961E+02	-7.967E+02	-1.580E+02	-2.253E+03	-9.418E+02	-1.296E+02
26	2	1.478E+02	-1.590E+03	-1.523E+01	-2.831E+03	2.778E+02	-1.136E+02
27	1	8.592E+01	-6.364E+01	3.552E+01	2.902E+02	1.464E+03	1.168E+03
27	2	9.169E+01	-5.831E+02	1.266E+02	5.500E+02	3.134E+03	2.188E+03
28	1	-6.200E+01	3.918E+02	1.241E+02	3.009E+03	1.398E+03	2.369E+03
28	2	-6.127E+01	2.727E+02	3.089E+02	3.425E+03	2.364E+03	3.684E+03
29	1	1.148E+00	4.105E+02	-5.493E+01	-1.470E+03	-1.219E+04	-2.078E+03
29	2	4.033E+01	5.229E+02	9.884E+01	-1.854E+03	-1.576E+04	-2.295E+03
30	1	-1.372E+01	-2.490E+01	-1.094E+02	-4.741E+03	-1.485E+04	3.681E+01
30	2	-1.357E+02	2.886E+01	-7.246E+01	-6.106E+03	-1.929E+04	-2.206E+01
31	1	-1.657E+01	2.175E+02	-6.143E+01	-3.540E+03	-1.859E+04	-2.177E+02
31	2	-4.215E+01	5.137E+02	-1.565E+02	-4.335E+03	-2.280E+04	-2.390E+02
32	1	2.150E+01	1.818E+02	-1.702E+01	-5.375E+03	-1.584E+04	[illegible]
32	2	4.687E+01	4.096E+02	-5.394E+01	-6.571E+03	-2.177E+04	[illegible]
33	1	-3.868E+01	1.722E+02	-1.069E+01	-1.590E+02	-1.722E+02	[illegible]
33	2	-5.378E+01	3.434E+02	-1.331E+01	-2.719E+02	-5.642E+02	[illegible]
34	1	4.241E+01	1.477E+02	-1.375E+02	7.146E+03	2.345E+04	[illegible]
34	2	3.459E+01	3.746E+02	-3.012E+02	8.625E+03	[illegible]	[illegible]

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[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
35	2	1.785E+01	-1.426E+03	-2.949E+02	2.752E+03	2.370E+04	-2.790E+03
36	1	8.369E+00	-9.220E+02	1.156E+02	-4.541E+03	-3.919E+03	4.791E+03
36	2	7.029E+00	-1.860E+03	1.700E+02	-5.158E+03	-3.286E+03	5.950E+03
37	1	1.936E+01	3.426E-01	1.795E+02	3.971E+02	1.747E+03	6.739E+02
37	2	3.539E+01	-2.837E+02	3.055E+02	9.129E+02	4.023E+03	6.456E+02
38	1	-2.304E+01	2.299E+02	2.101E+01	5.079E+02	5.757E+02	2.599E+03
38	2	-3.326E+01	1.347E+02	5.898E+01	6.015E+02	8.111E+02	4.040E+03
39	1	1.589E+01	2.768E+02	2.372E+01	-3.189E+03	-1.364E+04	-2.874E+03
39	2	4.448E+01	3.321E+02	1.059E+02	-4.236E+03	-1.795E+04	-3.318E+03
40	1	-1.584E+01	2.629E+02	4.460E+01	-2.858E+03	-1.376E+04	8.690E+02
40	2	-5.134E+01	5.337E+02	1.655E+02	-3.780E+03	-1.813E+04	1.073E+03
41	1	8.807E+02	3.087E+03	2.030E+03	-3.692E+02	-2.276E+03	-1.420E+03
41	2	1.355E+03	3.032E+03	3.233E+03	-6.170E+02	-1.760E+03	-1.573E+03
42	1	8.482E+02	-1.320E+03	-1.277E+03	-3.102E+02	-8.435E+02	-2.394E+03
42	2	1.766E+03	-1.018E+03	-1.056E+03	-1.999E+03	-6.398E+02	-3.729E+03
43	1	-1.202E+02	1.973E+01	2.731E+01	1.360E+03	-9.740E+01	-2.906E+03
43	2	8.540E+00	5.400E+02	-1.947E+02	2.017E+03	-1.408E+02	-6.458E+03
44	1	-2.493E+01	3.671E+02	3.156E+02	7.459E+02	-1.169E+03	-1.331E+03
44	2	-1.674E+01	4.586E+02	4.941E+02	1.849E+03	-2.371E+03	-3.432E+03
45	1	2.557E+02	3.208E+01	-5.997E+02	5.491E-02	6.612E+00	-7.122E+02
45	2	1.120E+03	1.264E+02	-1.052E+03	1.484E+03	-2.551E+02	-1.439E+03
46	1	-2.847E+02	5.629E+02	-8.963E+02	8.077E+01	2.402E+01	-4.084E+02
46	2	1.218E+02	6.771E+02	-1.547E+03	8.431E+01	-1.740E+02	-7.332E+02
47	1	-5.028E+02	-2.549E+02	1.303E+03	8.424E+01	3.700E+02	-3.213E+02
47	2	-4.114E+02	-2.516E+01	1.265E+03	1.378E+02	6.284E+02	-5.848E+02

1**** BOUNDARY ELEMENT FORCES/MOMENTS

ELEMENT NO.	CASE (MODE)	FORCE	MOMENT
1	1	.0000E+00	.0000E+00
1	2	.0000E+00	.0000E+00
2	1	-3.9594E+02	.0000E+00
2	2	-4.7794E+02	.0000E+00
3	1	-5.6844E+02	.0000E+00
3	2	-6.9134E+02	.0000E+00
4	1	-4.8631E+02	.0000E+00
4	2	-5.9749E+02	.0000E+00
5	1	.0000E+00	.0000E+00
5	2	.0000E+00	.0000E+00
6	1	-1.9985E+02	.0000E+00
6	2	-2.6[illegible]E+02	.0000E+00
7	1	1.1704E+03	.0000E+00
7	2	1.3[illegible]E+03	.0000E+00

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	[illegible]	1	[illegible]	[illegible]
	8	2	7.3145E+02	.0000E+00
	9	1	+1.5410E+03	.0000E+00
	9	2	+1.8875E+03	.0000E+00
	10	1	1.9339E+02	.0000E+00
	10	2	2.4792E+02	.0000E+00
	11	1	-9.9439E+01	.0000E+00
46	11	2	-1.4557E+02	.0000E+00
47	12	1	1.2133E+03	.0000E+00
	12	2	1.5178E+03	.0000E+00
48	13	1	5.6027E+01	.0000E+00
	13	2	4.3625E+02	.0000E+00
49	14	1	+1.3771E+03	.0000E+00
	14	2	+1.8332E+03	.0000E+00
50	15	1	-4.3229E+01	.0000E+00
	15	2	-2.8071E+01	.0000E+00
51	16	1	.0000E+00	.0000E+00
	16	2	.0000E+00	.0000E+00
52	17	1	-3.7635E+02	.0000E+00
	17	2	-4.7906E+02	.0000E+00
	18	1	-5.2957E+02	.0000E+00
53	18	2	-6.8396E+02	.0000E+00
54	19	1	-3.9822E+02	.0000E+00
	19	2	-5.2179E+02	.0000E+00
55	20	1	.0000E+00	.0000E+00
	20	2	.0000E+00	.0000E+00

1**** TEMPORARY FILE STORAGE (MEGABYTES)

UNIT NO. 7	:	.023
UNIT NO. 8	:	.035
UNIT NO. 9	:	.029
UNIT NO. 10	:	.023
UNIT NO. 11	:	.164
UNIT NO. 12	:	.009
UNIT NO. 13	:	.305
UNIT NO. 14	:	.050
UNIT NO. 15	:	.023
UNIT NO. 17	:	.000
TOTAL	:	.659

1**** END OF FILE

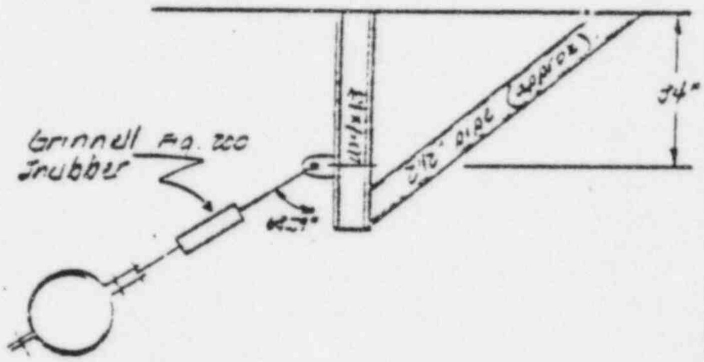
[C: AL30R]

SI-01-6007-H005

LOADS :

$|W+P_d| + (SSE^2+AM^2)^{1/2}$

= 583 lbs.



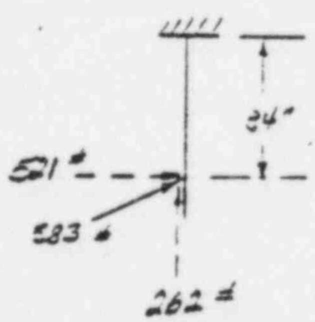
CONSIDER SNUBBER, CLAMP, CLEVISES:

Assume all Grinnell parts: (due to lack of info.)

Part	Allowable Load (lbs.)
200	10,350
295	2,765
66	3,770

∴ All parts are acceptable

CONSIDER VERTICAL WIDE FLANGE:



A = 3.83
S = 5.46
r = 1.00

Tension: F_t = 21,600 psi , Level D = 40,608 psi

$\sigma_t = \frac{262}{3.83}$ = 68 psi < 21,600 psi

Compression: $C_c = 126$

$$\frac{KL}{r} = \frac{2.0(34)}{1.00} = 68 < 126$$

$$F_a = \frac{\left[1 - \frac{(68)^2}{2(126)^2}\right] 36,000}{\frac{5}{3} + \frac{3(68)}{8(126)} - \frac{(68)^3}{8(126)^3}} = 16,631 \text{ psi}$$

Level D = 31,266 psi

$$\sigma_a = \frac{262}{3.83} = 68 \text{ psi} < 16,631 \text{ psi}$$

Shear: $F_v = 14,400$ psi , Level D = 27,072 psi

$$\sigma_v = \frac{521}{3.83} = 136 \text{ psi}$$

Bending: $F_b = .66(36,000) = 23,760$ psi

Level D = 44,669 psi

$$\sigma_b = \frac{521(34)}{5.46} = 3244 \text{ psi} < 23,760 \text{ psi}$$

CONSIDER WELDS:

Clevis to wide flange – 1/4" fillet all around

Tension: $$\sigma_t = \frac{521}{.707(1/4)(4)} = 737 \text{ psi}$$

Shear: $$\sigma_v = \frac{262}{.707(1/4)(4)} = 371 \text{ psi}$$

wide flange to existing large beam – 1/4" fillet all around

Tension: $\sigma_t = \frac{262}{.707(1/4)(21)} = 71$ psi

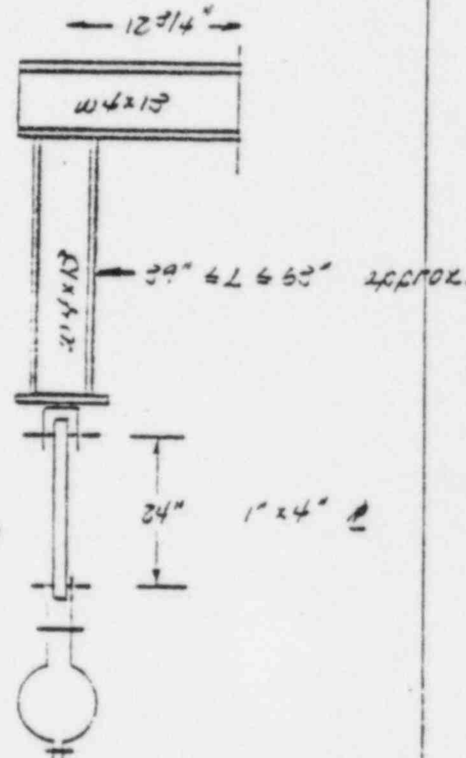
Shear: $\sigma_v = \frac{521}{.707(1/4)(21)} = 140$ psi

Bending: $\sigma_b = \frac{521(34)}{.707(1/4)\left[2(4)(4)+\frac{(4)^2}{3}\right]} = 2684$ psi

TOTAL: 2895 psi

∴ This support is acceptable

SI-01-6007-H002



LOADS:

$|W + P_d| = 686$ lb.

$|W + P_d + T| = 731$ lb.

$|W + P_d - T| + (SSE^2 + AM^2)^{1/2} = 1266$ lbs.

CHECK WIDE FLANGES: $A = 3.83$, $S = 5.46$

Shear: $F_v = .4(36) = 14.4$ ksi

Level D = 27.07 ksi

$\sigma_v = \frac{731}{3.83} = 191$ psi $< 14,400$ psi

$\sigma_v = \frac{1266}{3.83} = 331$ psi $< 27,070$ psi Level D

Bending: $F_b = .66(36) = 23.76$ ksi, Level D = 44.67 ksi

$\sigma_b = \frac{1266(12\,3/4)}{5.46} = 2956$ psi $< 23,760$ psi

Tension: $F_t = .6(36) = 21.6$ ksi, Level D = 40.61 ksi

$\sigma_t = \frac{1266}{3.83} = 330$ psi $< 21,600$ psi

Compression: $C_c = \sqrt{\frac{2\pi^2(29,000)}{36,000}} = 126$

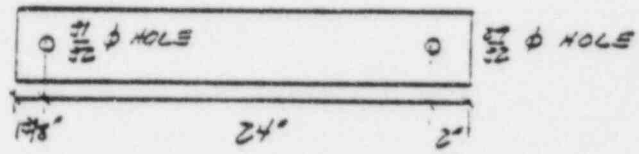
$\frac{KL}{r} = \frac{1.0(53)}{1.00} = 53.0 < 126$

$$F_a = \frac{\left[1 - \frac{63.0^2}{2(126)^2}\right](36{,}000)}{\frac{5}{3} + \frac{3(63.0)}{8(126)} - \frac{(63.0)^3}{8(126)^3}} = 17133 \text{ psi}$$

Level D = 32210 psi

$$\sigma_a = \frac{1266}{3.83} = 330 \text{ psi} < 17133 \text{ psi}$$

CHECK 1" × 4" PL:



Shear: F_v = 14.4 ksi

Level D = 27.07 ksi

$$\sigma_v = \frac{1266}{1(1\tfrac{3}{8})} = 920 \text{ psi} < 14{,}400 \text{ psi}$$

Tension (tear out): F_t = 21.6 ksi, Level D = 40.61 ksi

$$\sigma_t = \frac{1266}{(1)(4 - 31/32)} = 418 \text{ psi} < 21{,}600 \text{ psi}$$

Compression: $C_c = 126$, $r = \sqrt{(2(1^3/12))/(1)(4)} = 0.042$

$$\frac{KL}{r} = \frac{2(24)}{.042} = 1143 > 126 \quad \text{(use 200)}$$

$$F_a = \frac{12\pi^2 E}{23(KL/r)^2} = \frac{12\pi^2(29\times10^6)}{23(200)^2} = 3733 \text{ psi}$$

Level D = 7019 psi

$$\sigma_a = \frac{1266}{2(1)} = 633 \text{ psi} < 3733 \text{ psi}$$

CHECK CLAMP & CLEVISES:

Assume Grinnell parts:

Part No.	Maximum Load (lbs.)
295	5390
66	1090

All parts are acceptable.

CHECK WELDS:

Clevis to 6×6" ℘ → 1/4" Fillet L ≈ 3¾"

$$\sigma_t = \frac{1266}{.707(1/4)(3\frac{3}{4})} = 1910 \text{ psi}$$

& wide Flanges → 1/4" Fillet

$$\sigma_t = \frac{1266}{.707(1/4)(2)(2\frac{3}{4})} = 1302 \text{ psi}$$

$$\sigma_v = \frac{1266}{.707(1/4)(2)(2\frac{3}{4})} = 1302 \text{ psi}$$

$$\sigma_b = \frac{1266(12\frac{3}{4})}{(.707)(4-1/4)(2\frac{3}{4})(1/4)} = 8856 \text{ psi}$$

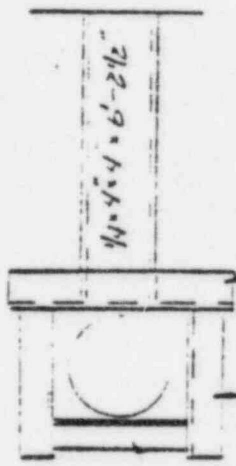
∴ this support is acceptable.

SUPPORT CALCULATIONS

SI-01-6007-H001

LOADS: $|W+P_d+T| = 442$ lbs

$|W+P_d+T| + (SSE^2 + AM^2)^{1/2} = 747$ lbs.



CONSIDER VERTICAL TUBE:

Tension: $F_t = .6(36{,}000) = 21{,}600$ psi

Level D = 40,608 psi

$$\sigma_t = \frac{747}{3.59} = 208 \text{ psi} < 21{,}600 \text{ psi}$$

Compression: $$C_c = \sqrt{\frac{2\pi^2(29\times10^6)}{36{,}000}} = 126$$

$$\frac{Kl}{r} = \frac{2(38\tfrac{1}{2})}{1.51} = 51.0 < 126$$

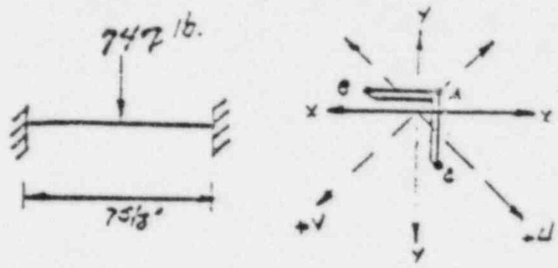
$$F_a = \frac{\left[1-\frac{(51.0)^2}{2(126)^2}\right]36{,}000}{\frac{5}{3} + \frac{3(51)}{8(126)} - \frac{(51)^3}{8(126)^3}} = 18{,}259 \text{ psi}$$

Level D = 34,326 psi

$$\sigma_a = \frac{747}{3.59} = 208 \text{ psi} < 18{,}259 \text{ psi}$$

CONSIDER HORIZONTAL L:

Consider the member as a fixed-fixed beam w/ a concentrated load at center –



Shear: $F_v = .4(36{,}000) = 14{,}400$ psi, Level D = 27,072 psi

$$\sigma_v = \frac{747}{1.19} = 628 \text{ psi} < 14{,}400 \text{ psi}$$

Bending: $F_b = .6(36{,}000) = 21{,}600$ psi, Level D = 40,608 psi

$a = 1.19 \text{ in}^2$ $\qquad I_x = I_y = 0.703 \text{ in}^4$

$x_o = y_o = 0.717$ in. $\qquad r_u = 0.941$ in.

$$I_u = ar_u^2 = 1.19(.941)^2 = 1.054 \text{ in}^4$$

$$I_u + I_v = I_x + I_y \qquad I_v = 2(.703) - 1.054 = 0.352 \text{ in}^4$$

$v_A = -1.014$ $\qquad v_B = 0.754$ $\qquad v_C = +0.754$

$u_A = 0$ $\qquad u_B = -1.768$ $\qquad u_C = 1.768$

$$M_u = -.707(747)(7\tfrac{5}{8})/8 = -503 \text{ in-lb}$$

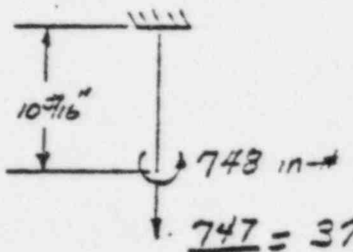
$$M_v = .707(747)(7\tfrac{5}{8})/8 = 503 \text{ in-lb}$$

$$\sigma_A = \frac{M_u v_A}{I_u} + \frac{M_v u_A}{I_v} = \frac{-503(-1.014)}{1.054} = 484 \text{ psi} < 21{,}600 \text{ psi}$$

$$\sigma_B = \frac{-503(.754)}{1.054} + \frac{503(-1.768)}{.352} = -2466 \text{ psi} < 21{,}600 \text{ psi}$$

$$\sigma_C = \frac{-503(.754)}{1.054} + \frac{503(1.768)}{.352} = 2888 \text{ psi} < 21{,}600 \text{ psi}$$

CONSIDER VERTICAL ∠ S :

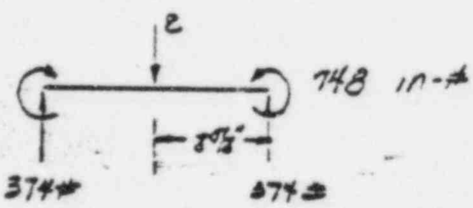


$\frac{747}{2} = 374$ lbs.

Tension: $\sigma_t = \frac{374}{1.19} = 314$ psi < 21,600 psi

Bending: calculations performed for horizontal ∠ 2½ × 2½ × ¼ would apply here also.

CONSIDER CHANNEL :



A = 3.09
S = .564

Shear: $\sigma_v = \frac{374(2)}{3.09} = 242$ psi < 14,400 psi

Bending: Consider half of beam as cantilever —

$\sigma_b = \frac{374(8^5/8) + 748}{0.564} = 7046$ psi < 40,608 psi
Level D

$\sigma_b = \frac{442(1/2)(8^5/8) + 442(7^5/8)/8}{.564} = 4,127$ psi < 21,600 psi

CONSIDER WELDS:

Tube to existing beam: 1/4" fillet

Tension: $\sigma_t = \dfrac{747}{.707(1/4)(4)(3)} = 352$ psi

Horizontal ⊈ to vertical ⊈: 1/4" fillet

Shear: $\sigma_v = \dfrac{747}{.707(1/4)(2)(2 1/2)} = 845$ psi

Bending: $\sigma_b = \dfrac{748}{.707(1/4)\left[\dfrac{4(2 1/2)(2 1/2) + (2 1/2)^2}{6}\right]} = 813$ psi

(See "Design of Welded Structures", Blodgett)

Vertical ⊈ to channel: 1/4" fillet

Bending: same as above calculation

Tension: $\sigma_t = \dfrac{374}{.707(1/4)(4)(2 1/2)} = 212$ psi

Channel to vertical tubing: 3/16" fillet

Tension: $\sigma_t = \dfrac{747}{.707(3/16)(2)(4)} = 704$ psi

Bending: $\sigma_b = \dfrac{748\ (2)}{.707(3/16)(4)(4)} = 705$ psi

∴ This support is acceptable

SONGS 1 SI-158 PIPE STRESS CALCULATION W IMPELL SAMS

SUPPORT REACTIONS FOR LOAD CASE NO. 1

WEIGHT PLUS EXTERNAL FORCES

NODE	TYPE	REACTION (LBS OR IN-LBS)	DIRECTION
5	FORCE	-9.	X COORD
5	FORCE	188.	Y COORD
5	FORCE	-1.	Z COORD
5	MOMENT	15.	X COORD
5	MOMENT	72.	Y COORD
5	MOMENT	-5733.	Z COORD
20	FORCE	408.	Y COORD
35	FORCE	686.	Y COORD
85	FORCE	466.	Y COORD
85	FORCE	1.	INCLINED
95	FORCE	210.	Y COORD
95	FORCE	-41.	INCLINED
105	FORCE	196.	Y COORD
105	FORCE	36.	Z COORD
115	FORCE	198.	Y COORD
115	FORCE	-4.	Z COORD
120	FORCE	209.	Y COORD
120	FORCE	-25.	Z COORD
135	FORCE	10.	Y COORD
135	FORCE	-3.	INCLINED
250	FORCE	39.	X COORD
250	FORCE	-231.	Y COORD
250	FORCE	19.	Z COORD
250	MOMENT	2916.	X COORD
250	MOMENT	-566.	Y COORD
250	MOMENT	1978.	Z COORD

SONGS 1 SI-158 PIPE STRESS CALCULATION W IMPELL SAMS

SUPPORT REACTIONS FOR LOAD CASE NO. 2

THERMAL EXPANSION PLUS ANCHOR MOVEMENTS

NODE	TYPE	REACTION (LBS OR IN-LBS)	DIRECTION
5	FORCE	-178.	X COORD
5	FORCE	-11.	Y COORD
5	FORCE	-46.	Z COORD
5	MOMENT	579.	X COORD
5	MOMENT	-5555.	Y COORD
5	MOMENT	151.	Z COORD
20	FORCE	34.	Y COORD
35	FORCE	45.	Y COORD
85	FORCE	-145.	Y COORD
85	FORCE	54.	INCLINED
95	FORCE	82.	Y COORD
95	FORCE	49.	INCLINED
105	FORCE	6.	Y COORD
105	FORCE	-63.	Z COORD
115	FORCE	-69.	Y COORD
115	FORCE	-102.	Z COORD
120	FORCE	427.	Y COORD
120	FORCE	176.	Z COORD
135	FORCE	-1036.	Y COORD
135	FORCE	-100.	INCLINED
250	FORCE	156.	X COORD
250	FORCE	667.	Y COORD
250	FORCE	-124.	Z COORD
250	MOMENT	-11195.	X COORD
250	MOMENT	-7393.	Y COORD
250	MOMENT	-58093.	Z COORD

191-D

SONGS 1 SI-158 PIPE STRESS CALCULATION W IMPELL SAMS

SUPPORT REACTIONS FOR LOAD COMBINATION CASE NO. 24

SEISMIC PLUS IMPSAMS

NODE	TYPE	REACTIONS (LBS OR IN-LBS)	DIRECTION
5	FORCE	679.	X COORD
5	FORCE	127.	Y COORD
5	FORCE	327.	Z COORD
5	MOMENT	952.	X COORD
5	MOMENT	21449.	Y COORD
5	MOMENT	7365.	Z COORD
20	FORCE	305.	Y COORD
35	FORCE	535.	Y COORD
40	FORCE	563.	INCLINED
65	FORCE	403.	Y COORD
85	FORCE	306.	INCLINED
95	FORCE	100.	Y COORD
95	FORCE	373.	INCLINED
105	FORCE	83.	Y COORD
105	FORCE	602.	Z COORD
115	FORCE	149.	Y COORD
115	FORCE	166.	Z COORD
120	FORCE	169.	Y COORD
120	FORCE	137.	Z COORD
135	FORCE	446.	Y COORD
135	FORCE	393.	INCLINED
155	FORCE	862.	INCLINED
160	FORCE	1010.	INCLINED
165	FORCE	1125.	Y COORD
250	FORCE	1653.	X COORD
250	FORCE	705.	Y COORD
250	FORCE	1733.	Z COORD
250	MOMENT	81452.	X COORD
250	MOMENT	77906.	Y COORD
250	MOMENT	72249.	Z COORD

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