Attachment 2

SUMMARY OF OYSTER CREEK UNIT 1
CRD RETURN LINE PIPING REANALYSIS

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INTRODUCTION

Audit calculations to verify the original analysis and new calculations using current ASME Code and Regulatory Guide Standards were previously performed on the Oyster Creek Unit 1 CRD return line. Information subsequently received provided as-built information of the piping system per the NRC's I&E Bulletin 79-14. This updated information typically reflected pipeline dimensional changes, valve weights and dimensions, and pipe support variations. After incorporating this updated information into the NUPIPE-II finite element structural model, a "current criteria" analysis was then repeated using the method and procedures described in Reference 1. The results of the analysis using the updated configurations are described below. This supplement should be used in conjunction with the Reference 1 report.

CRD Return Line Analysis

A simplified plot of the CRD return line piping model is shown in Figure 1. Figures 2 through 7 show various sections of the piping model. It should be remembered that the dimensions shown on these plots are approximate and are intended only to give an indication of scale. Two CRD return line piping models were analyzed. One model reflected the entire system as shown in the figures with all supports incorporated. The second model reflected the deletion of 17 rod or pipe rest supports which are capable of providing nonlinear restraint. It is believed that deleting these types of supports generally produces a conservative stress analysis of the piping. Two 1-inch branch lines were included in the updated models which were not present in the Reference 1 analysis.

The analytical assumptions made for the CRD return line are:

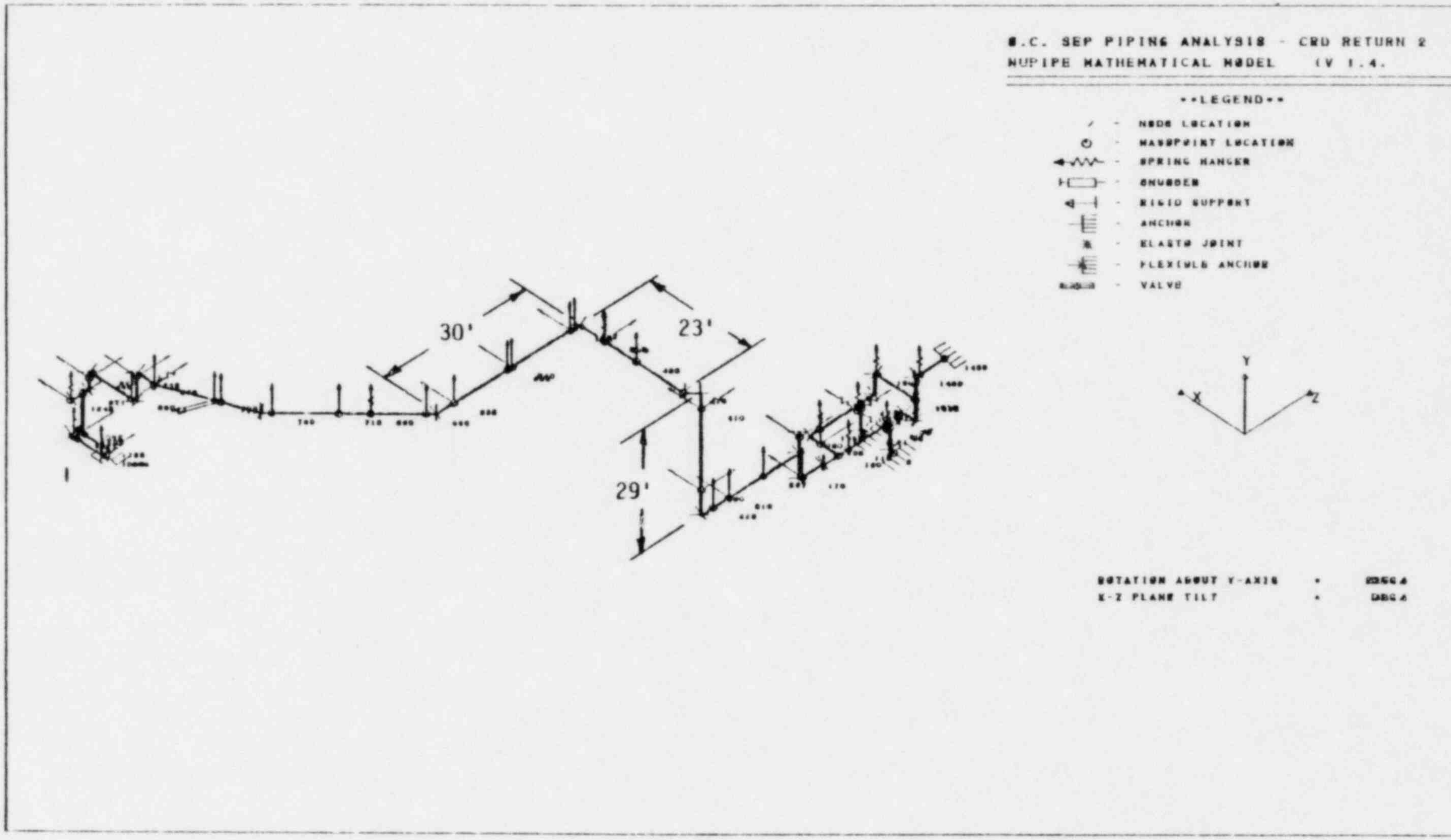

Figure 1. Simplified plot of CRD return line piping model.

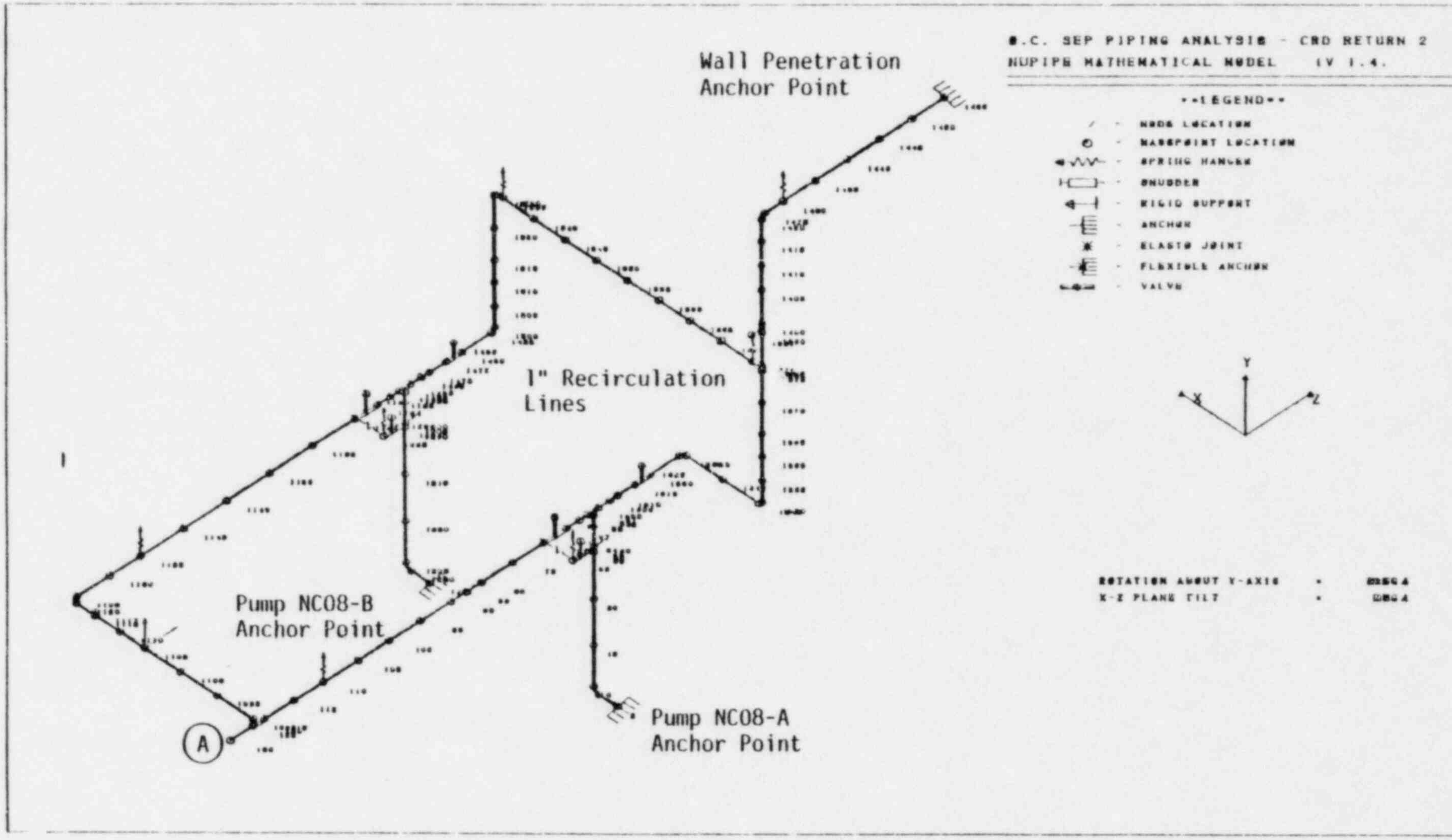

Figure 2. Enlarged plot of CRD piping near pump anchors and 1" recirculation lines.

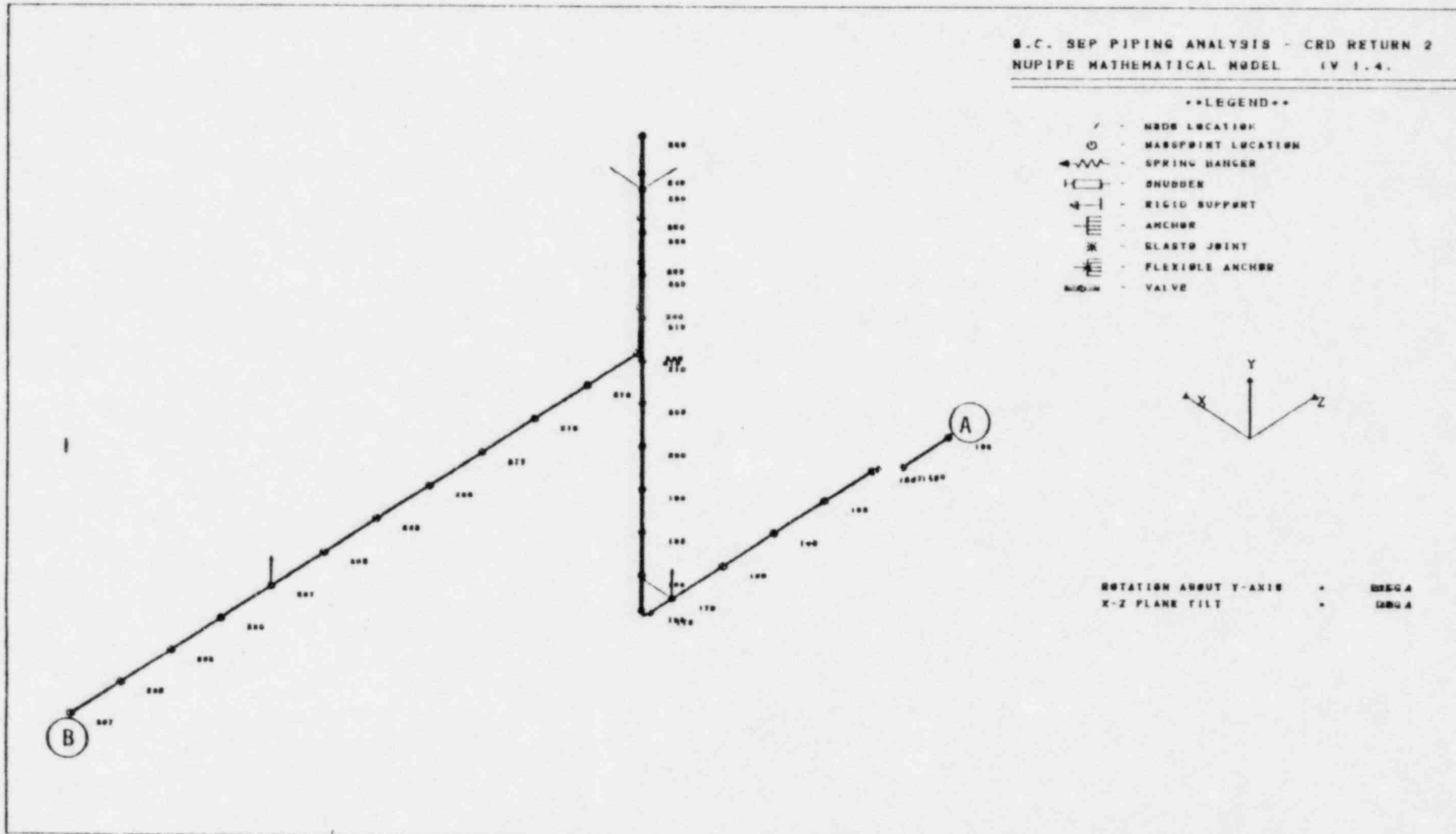

Figure 3. Enlarged plot of CRD piping.

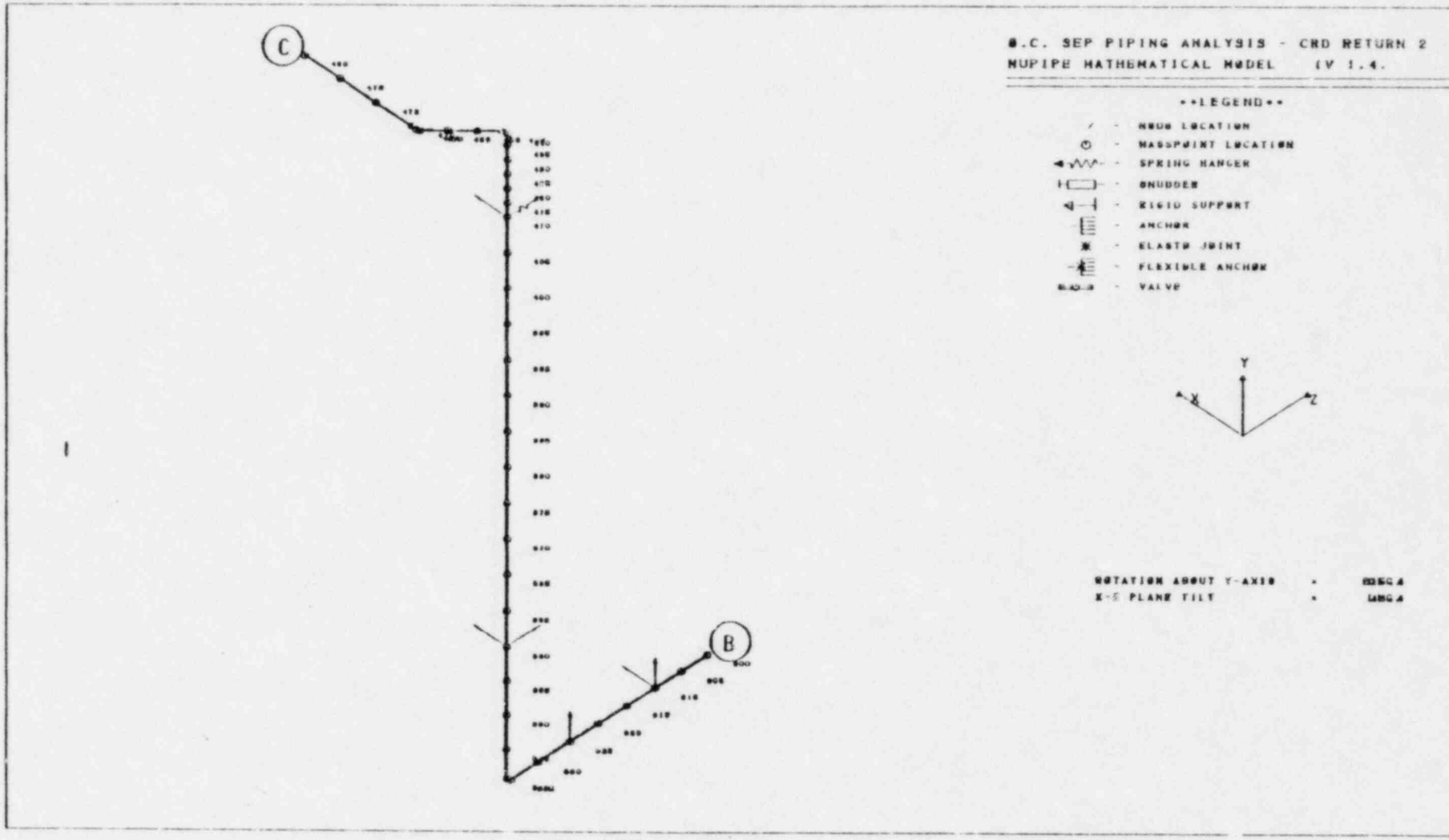

Figure 4. Enlarged plot of CRD piping.

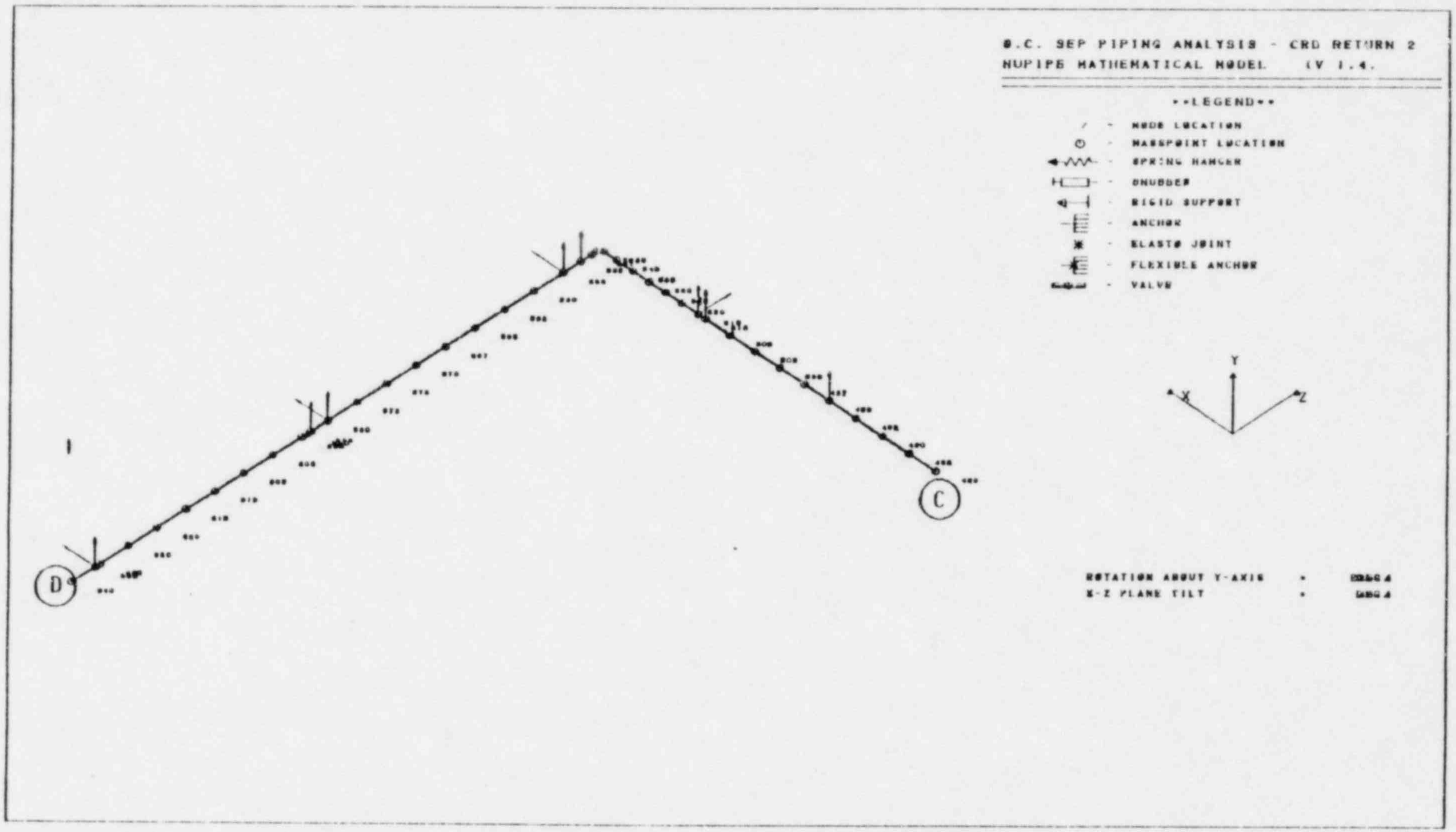

Figure 5. Enlarged plot of CRD piping.

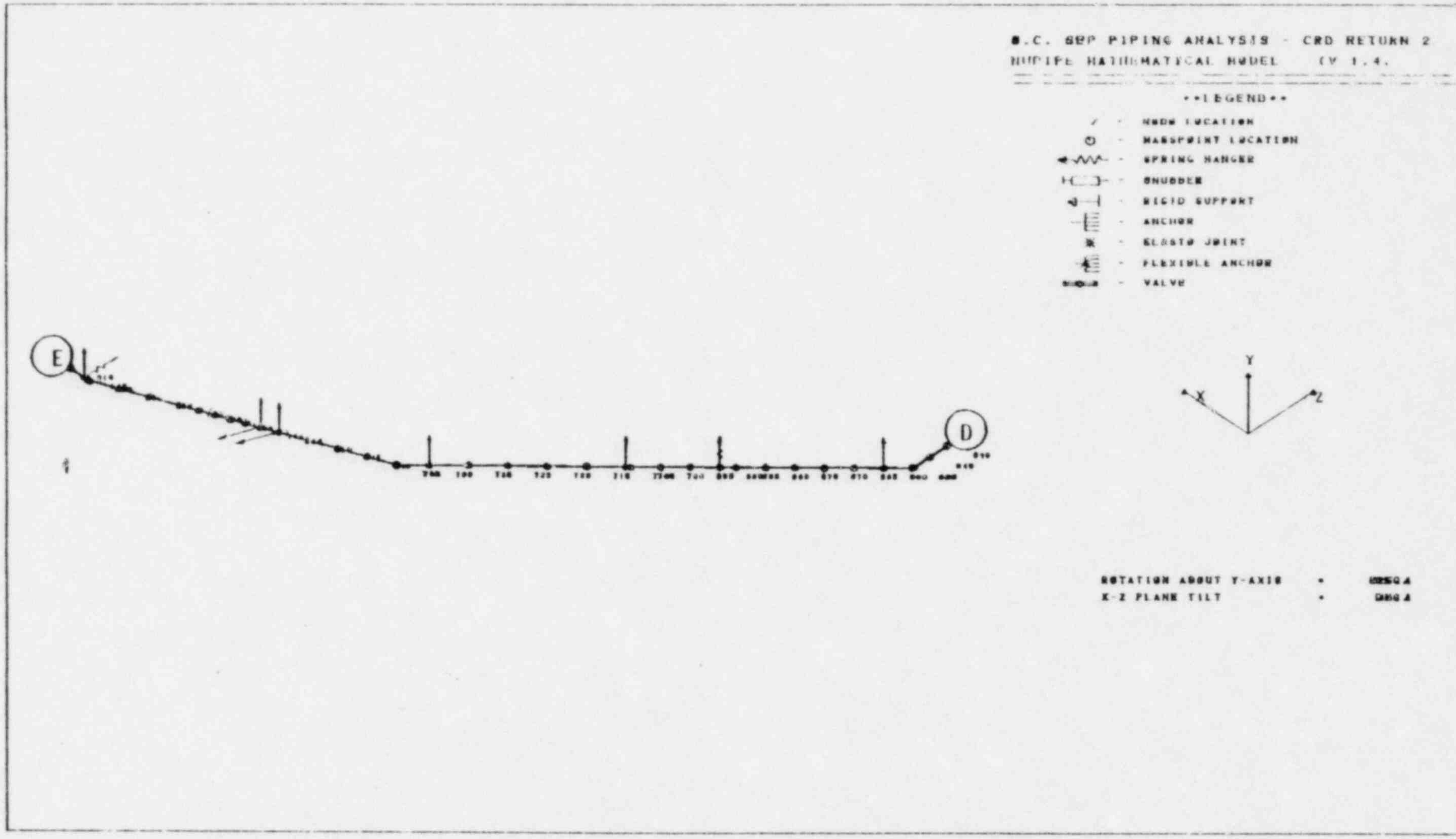

Figure 6. Enlarged plot of CRD piping.

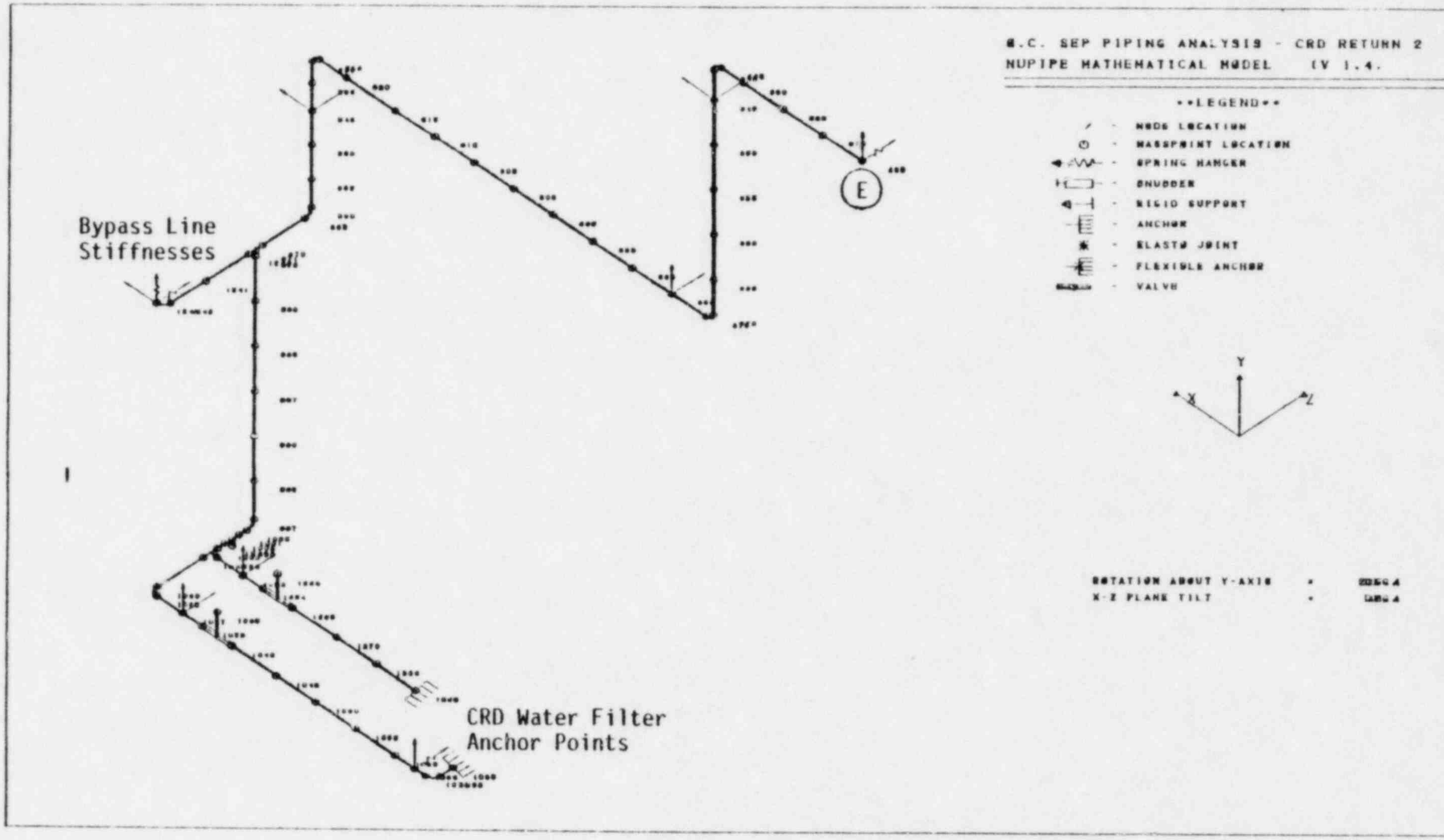

Figure 7. Enlarged plot of CRD piping.

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

b. The requirements of the ASME Code, Section III, Subarticle N:-3540 are satisfied.

The as-built drawing also shows three additional lines branching off of the subject portion of the CRD piping. The effects of these lines on the system behavior were taken into account by including translational stiffnesses at the branch points.

Since the original analysis was performed, the NRC has recommended site specific response spectra for Oyster Creek. It is a narrower spectra having a zero-period acceleration (ZPA) of 0.165 g. On this basis, the response spectra for the CRD return line listed in Reference 1 were scaled down by the ratio of 0.165 g/0.22 g.

Table 1 lists the first ten natural frequencies for both the updated models and those frequencies listed in Reference 1. A comparison between the frequencies previously determined and the updated configuration with all supports incorporated indicates that the updated piping system has higher frequencies. This was expected due to the increased number of supports. Of course, as indicated in Case 4, the frequencies decreased because of the deletion of the seventeen nonlinear supports.

A comparison of ASME Code, Class 2, Equation 9, primary stress results is shown in Table 2. This table compares results at similar points between the various models. With the exception of the 1-inch piping, the stresses for the updated model are significantly lower than those for the original model. This is due to the additional support information which was incorporated into the model. There was a slight increase in the stresses shown in Case 4. This was expected due to the lower frequencies calculated for Case 4. As shown in the table, stresses at several points along the

TABLE 1. COMPARISON OF FIRST TEN NATURAL FREQUENCIES FOR OYSTER CREEK UNIT 1 CRD RETURN PIPING

Mode	Case 1 Frequencies (Hz)	Case 2 Frequencies (Hz)	Case 3 Frequencies (Hz)	Case 4 Frequencies (Hz)
1	1.67	1.66	2.93	2.16
2	1.94	1.88	3.22	2.63
3	2.52	1.96	3.54	3.23
4	2.72	2.16	3.92	3.44
5	2.86	2.54	4.42	3.61
6	3.84	2.74	4.52	3.81
7	4.22	3.12	4.76	3.99
8	4.92	3.76	4.91	4.16
9	5.16	4.89	5.26	4.90
10	5.54	4.90	6.05	4.97

NOTES:

a. Case 1 -- original model, with all supports incorporated, as reported in Reference 1.

Case 2 -- original model, without rod and pipe rest supports incorporated, as reported in Reference 1.

Case 3 -- updated model with all supports incorporated.

Case 4 -- updated model without rods and pipe rest supports incorporated.

TABLE 2. COMPARISON OF ASME, CLASS 2, EQUATION 9, STRESS VALUES--"CURRENT" SSE

Node	Imposed Stress (ksi) Case 1	Case 2	Case 3	Case 4	Allowable Stress (ksi)	Comment
2 (5)	33.6	35.2	31.2	22.4	42.0	Pump Anchor
10	50.0	52.9	27.1	22.3	42.0	Socket Weld Elbow End
335	61.9	56.7	11.5	26.2	42.0	Socket Weld Elbow End
340	62.0	56.6	11.9	27.3	42.0	Socket Weld Elbow End
410	44.4	42.6	8.54	10.4	42.0	Support Point
445	51.4	37.9	8.35	9.58	42.0	Straight Pipe
755	42.1	45.9	4.88	5.27	42.0	Support Point
1085	3.64	3.78	3.21	3.45	42.0	Filter Anchor
1231 (1230)	25.1	28.1	19.3	19.7	42.0	Pump Anchor
1285 (1290)	3.91	3.96	3.26	3.30	42.0	Filter Anchor
1310	---	---	54.6	46.2	42.0	Socket Weld 2x1 Reducer End
1375	---	---	46.8	51.3	42.0	Socket Weld 1x1x1 Tee End
1390	---	---	34.5	44.1	42.0	Socket Weld Valve End
1455	---	---	43.0	54.2	42.0	Wall Anchor
1470	---	---	36.7	43.9	42.0	Socket Weld 2x1 Reducer End

NOTES:

a. Case situations defined in Table 1.

b. For the analysis of the updated model, it was necessary to change some of the node numbers. The node numbers used in the original analysis are shown in parentheses.

c. Allowable stress is 2.4 S_h.

d. Equation 9 stresses include the effects of pressure, weight, and SSE.

1-inch piping exceed the allowable limit. These stresses were primarily caused by significant north-south movements during the seismic event. The SSE analysis results showed a maximum deflection of approximately five inches. The 1-inch piping was not included in the scope of the original analysis. Therefore, no results are available for comparison.

Table 3 presents a comparison of support loads. This table lists seismic loads for all models. Since the support configuration has been altered from the Reference 1 analysis, a comparison of loads provides little useful information. As mentioned previously, two models were used for analysis purposes. One model incorporated all supports while the other model deleted all rod and pipe rest supports. A common assumption is made that the piping experiences these types of support restraints until the dynamic imposed loads (such as seismic loads) exceed the initial (weight plus thermal) imposed loads. However, this assumes that the weight and thermal analyses are exact, which should not be expected. By making the two types of analyses described herein, the actual situation regarding piping stresses is probably bounded and the potential of support failure due to impact loading can be minimized through adequate engineering procedures. It was not within the scope of the analysis to determine the structural adequacy of the CRD return piping supports. However, it should be noted that the spring hanger at node 470 has the potential for bottoming out. The seismic analysis results show a vertical deflection at that location of approximately two inches for Case 4.

Table 4 predicts the anchor loads for all models. Again, since the support configuration has been altered, a comparison of anchor loads provides little useful information. Also, it was not within the scope of the analysis to determine anchor adequacy.

TABLE 3. SUPPORT LOAD SUMMARY--CRD RETURN PIPING--SEISMIC LOADS ONLY

Node	Direction	Loads (kip) Case 1	Case 2	Case 3	Case 4
35	Y	---	---	0.061	---
110	Y	0.442	---	0.198	---
170	X	0.543	0.466	0.205	0.224
	Y	0.279	0.326	0.030	0.130
230	X	0.092	0.132	0.085	0.139
	Z	0.743	0.755	0.162	0.373
287	Y	---	---	0.047	---
310 (295)	X	0.138	0.167	0.103	0.137
	Y	0.991	0.865	0.171	0.404
325	Y	---	---	0.246	---
360	X	0.230	0.249	0.081	0.092
	Z	0.857	0.835	0.186	0.268
410	X	0.610	0.577	0.129	0.151
	Z	0.725	0.596	0.143	0.166
495	Y	0.912	---	0.078	---
510	Y	---	---	0.053	---
515 (510)	Y	0.564	0.251	0.007	0.193
	Z	0.676	0.575	0.184	0.199
552 (551)	Y	0.089	---	0.099	---
555	X	---	---	0.123	0.133
	Y	---	---	0.107	0.125
580	X	0.747	0.782	0.047	0.059
	Y	0.240	0.291	0.022	0.045
585	Y	0.163	---	0.036	---
635	X	1.100	1.050	0.181	0.342
	Y	0.049	0.332	0.018	0.027
660	Y	0.092	---	0.007	---
690	Y	---	---	0.006	---
	LAT	---	---	0.101	---
710	Y	---	---	0.014	0.042
	LAT	---	---	0.076	0.208
730	Y	0.137	---	0.015	---
752 (755)	Y	0.085	0.652	0.033	0.178
	LAT	1.82	1.73	0.691	0.638

TABLE 3. (Continued)

Node	Direction	Loads (kip) Case 1	Case 2	Case 3	Case 4
755 (755)	Y	0.085	0.652	0.039	0.164
	LAT	1.82	1.73	0.484	0.430
805	Y	0.067	0.132	0.038	0.0
	Z	0.334	0.318	0.059	0.103
845	X	0.385	0.350	0.216	0.357
	Z	0.051	0.054	0.016	0.014
880 (900)	Y	0.046	0.112	0.043	0.035
	Z	0.072	0.091	0.016	0.016
945	X	0.085	0.086	0.042	0.065
	Z	0.083	0.091	0.030	0.029
1027 (1025)	Y	0.102	0.103	0.023	0.026
	Z	0.064	0.056	0.010	0.011
1065	Y	0.049	0.059	0.004	0.005
	Z	0.012	0.011	0.0	0.0
1105	Y	0.233	0.190	0.074	0.091
	Z	0.689	0.537	0.233	0.287
1135	Y	0.144	---	0.084	---
1235	Y	---	---	0.143	---
1252 (1250)	Y	0.155	0.167	0.091	0.108
	Z	0.059	0.058	0.010	0.011
1430	Y	---	---	0.275	---
1535	Y	---	---	0.131	---
1575	Y	---	---	0.124	---

NOTES:

a. Case situations defined in Table 1.

b. Node numbers explained in Table 2.

c. Directions listed are in the global coordinate system. "X" implies a force in the global X direction. "LAT" implies a force perpendicular to the pipe axis in the horizontal plane of a pipe segment that is not oriented parallel to any of the global axes.

TABLE 4. ANCHOR LOAD SUMMARY--CRD RETURN PIPING--SEISMIC LOADS ONLY

Node	Direction	Loads (kip or in.-kip) Case 1	Case 2	Case 3	Case 4
2 (5)	X	0.334	0.302	0.236	0.143
	Y	0.101	0.127	0.233	0.158
	Z	0.313	0.505	0.075	0.088
	XX	4.84	7.65	0.726	1.02
	YY	4.39	3.52	4.87	3.73
	ZZ	33.5	34.8	18.9	12.7
1085	X	0.078	0.095	0.010	0.014
	Y	0.021	0.025	0.002	0.003
	Z	0.006	0.007	0.001	0.001
	XX	0.147	0.186	0.031	0.037
	YY	0.380	0.463	0.051	0.070
	ZZ	0.059	0.072	0.027	0.032
1231 (1230)	X	0.234	0.211	0.132	0.091
	Y	0.059	0.091	0.169	0.080
	Z	0.079	0.127	0.024	0.040
	XX	1.33	1.74	0.272	0.533
	YY	4.81	4.24	3.35	3.74
	ZZ	24.3	27.7	11.0	11.2
1285 (1290)	X	0.069	0.075	0.023	0.031
	Y	0.020	0.023	0.012	0.014
	Z	0.009	0.009	0.001	0.001
	XX	0.217	0.231	0.119	0.140
	YY	0.174	0.179	0.016	0.023
	ZZ	0.386	0.442	0.167	0.203
1455	X	---	---	0.164	0.177
	Y	---	---	0.021	0.115
	Z	---	---	0.068	0.068
	XX	---	---	0.418	5.62
	YY	---	---	8.94	9.97
	ZZ	---	---	0.887	0.989

NOTES:

a. Case situations defined in Table 1.

b. Node numbers explained in Table 2.

c. Directions listed are in the global coordinate system. "X" implies a force in the global X direction. "XX" implies a moment about the global X axis.

Special Considerations

The as-built information utilized in this analysis was supplied by MPR Associates, Inc., the utility's engineering consultant, along with comments regarding the original CRD return line analysis. These comments and a discussion of their review are contained in Appendix A.

Conclusions

The results previously discussed show that the maximum stresses of the CRD return line exceed ASME Code allowables for SSE loadings. These high stress values are caused by the seismic response of the piping in the area of the 1-inch recirculation lines. Consideration should be given to reasonable methods of reducing the seismic stresses.

Reference

1. M. E. Nitzel, "Summary of the Oyster Creek Unit 1 Piping Calculations Performed for the Systematic Evaluation Program," EGG-EA-5211, July 1980.

APPENDIX A