Georgia Power Company
230 Peachtree Street
Post Office Box 4545
Atlanta, Georgia 30303
Telephone 404 522-6060

TK

Georgia Power

Power Supply Engineering and Services

79 JUL 3 A 8:49

USNRC REG. ATLANTA

June 26, 1979

United States Nuclear Regulatory Commission
Office of Inspection and Enforcement
Region II - Suite 3100
101 Marietta Street
Atlanta, Georgia 30303

REFERENCE:
RII: RFR, III
50-321
50-366

ATTENTION: Mr. J. P. O'Reilly

Gentlemen:

In our letter to you dated April 25, 1979, concerning IE Bulletin 79-07, we indicated that the review of the seismic computer codes used by General Electric was incomplete. The following are the results of the completed review.

Unit 1

The seismic analysis of General Electric supplied piping for Hatch Unit 1 was performed by EDS Nuclear, Inc. The PISOL and/or SUPERPIPE computer programs were used by EDS Nuclear for the seismic piping analysis. A description of these programs and the verification procedure used by EDS Nuclear is presented in Attachment 1.

Unit 2

The SAP4 and SAP4G computer programs were used by General Electric for the seismic piping analysis on Hatch Unit 2. A description of these programs and the verification procedure is presented below.

SAP Verification

Program Description

SAP4 and SAP4G are versions of the SAP program, which was originally developed for General Electric by F. A. Peterson and K. J. Bathe of the Engineering Analysis Corporation at Berkeley. The SAP program is a general purpose structure program used to perform static and dynamic analysis of mechanical and piping components by the finite element method.

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Georgia Power

U. S. Nuclear Regulatory Commission
ATTN: Mr. James P. O'Reilly
Page Two
June 26, 1979

Verification

All GE production versions of SAP are verified using a special benchmark problem that exercises all the important features of the program. The benchmark problem has been analyzed for the effects of constraint of free end, distributed forces, and is dynamically analyzed to determine mode shapes and natural frequencies used to predict dynamic response of the benchmark program using the response spectra and time history integration methods. The predicted frequencies, mode shapes, and loads were compared to the corresponding SAP predictions. The SAP program prediction had to be consistent with those of ANSYS before SAP was qualified for production use. In order to test unique features of SAP that cannot be compared to the results of another program, a special problem is devised which has an equivalent computer or manually calculated solution. Before any new versions of SAP is verified, for production application, the benchmark problem is reanalyzed to verify that the program changes have not changed predictions or reduced their accuracy.

As shown above and in our letter dated April 25, 1979, none of the methods described in item one of the Bulletin were used in any of the computer programs for the seismic analysis of safety related pipe at Plant Hatch.

Very truly yours,

R. W. Staffa

R. W. Staffa
Manager of Quality Assurance

JAB/bg
Attachment

589 078

ATTACHMENT 1

Description of the Verification

Procedure Used by

EDS Nuclear, Inc.,

for the Computer Programs Used for

the Seismic Analysis of

General Electric Company

Supplied Piping

589 079

EDS NUCLEAR INC.
220 MONTGOMERY ST. • SAN FRANCISCO, CALIFORNIA 94104 • (415) 544-8000

April 19, 1979

General Electric Company, Inc.
175 Curtner Avenue
San Jose, California 95125

ATTENTION: Mr. Ed Swain
Mail Code 760

SUBJECT: Input for IE Bulletin No. 79-07 Request
EDS Seismic Piping Programs

Gentlemen:

As discussed in our March 16, 1979 letter to you, the EDS seismic piping programs have always combined both the modal and directional responses by square root sum of the squares and/or absolute summation. However, per your April 18, 1979 letter, we are providing the enclosed summary for your use in responding to item (3) of IE Bulletin No. 79-07 relative to the benchmarking EDS has performed for its seismic piping programs.

If you have any questions on the enclosed information, please do not hesitate to contact the undersigned.

Very truly yours,

EDS NUCLEAR INC.

John McCarthy

John B. McCarthy
Manager
Piping Analysis Division

JBM/m
Enclosures

589 080

7908080574

SUMMARY OF
PIPING BENCHMARK PROBLEMS
FOR
EDS SEISMIC PIPING PROGRAMS

589 081

INTRODUCTION

EDS has utilized the EDS proprietary programs PISOL and SUPERPIPE for the seismic analysis of safety related piping systems. The PISOL and SUPERPIPE programs analyze arbitrary, three-dimensional piping systems for seismic excitation using the dynamic analysis technique known as the response spectrum mode superposition method. In this technique, the 2-D or 3-D earthquake excitation is characterized by acceleration response spectra, and the total response of the system is evaluated as a square root sum of the squares and/or absolute summation combination of the response of the significant natural modes of vibration of the system. These procedures and therefore the seismic analyses performed by EDS are in compliance with NRC requirements for these analyses.

In addition, SUPERPIPE has time history analysis capability. To date, this option has not been used for the seismic piping analysis of any safety related piping systems on operating plants or plants under construction.

PROGRAM VERIFICATION METHODS

EDS has performed extensive program verification for both piping programs. This verification is a combination of any or all of the following methods:

1. Comparison to ASME Benchmark Problems
2. Benchmark Problems Utilizing EDS Programs and Other Industry Programs
3. Comparison to Hand Calculations
4. Comparison Between EDS Programs and Versions

A partial summary of work performed in each of these four methods is provided below:

1. Comparison to ASME Benchmark Problems

   EDS has benchmarked both PISOL and SUPERPIPE against the ASME Benchmark Problem 1. This problem is described in the ASME publication, "Pressure Vessel and Piping 1972, Computer Programs Verification." This publication utilized the ANSYS and WESTDYN programs. The PISOL comparison as submitted for the ASME Committee on Computer Technology is enclosed in the attachment titled, "ASME BENCHMARK PROBLEM NO. 1 - PISOL VERIFICATION."

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2. Benchmark Problems Utilizing EDS Programs and Other Industry Programs

EDS has benchmarked both PISOL and SUPERPIPE against other programs available to the industry. Several such studies have been performed. In our most recent effort, a series of benchmark tests were conducted to compare SUPERPIPE against the following piping analysis programs: PISOL, NUPIPE, PIPESD, and ADLPIPE. Prior to this, EDS performed benchmarks against John Blume's PIPESD and the Bechtel Power Corporation's ME-101 program. In addition, PISOL has been verified by independent analysis by the Bechtel Power Corporation of San Francisco utilizing their proprietary program.

Examples of such benchmarks are shown in the attachments, "PISOL/PIPESD COMPARISON," "PISOL/ME-101 COMPARISON," and "SUPERPIPE/ME-101 COMPARISON."

3. Comparison to Hand Calculations

For certain seismic options, hand calculations have been performed and compared to computer results. In the seismic area, the simplified models are typically cantilever and single span configurations.

4. Comparison Between EDS Programs and Versions

The most common benchmark method utilized by EDS is to compare results from one version to another. Such comparisons are used to show program modifications are properly performing while not impacting other options within the program. These comparisons are described and maintained within the quality assurance files of the program.

Benchmarks are also made between the PISOL and SUPERPIPE programs. An example of this is shown in the attachment, "SUPERPIPE VERIFICATION AND COMPARISON SUMMARY."

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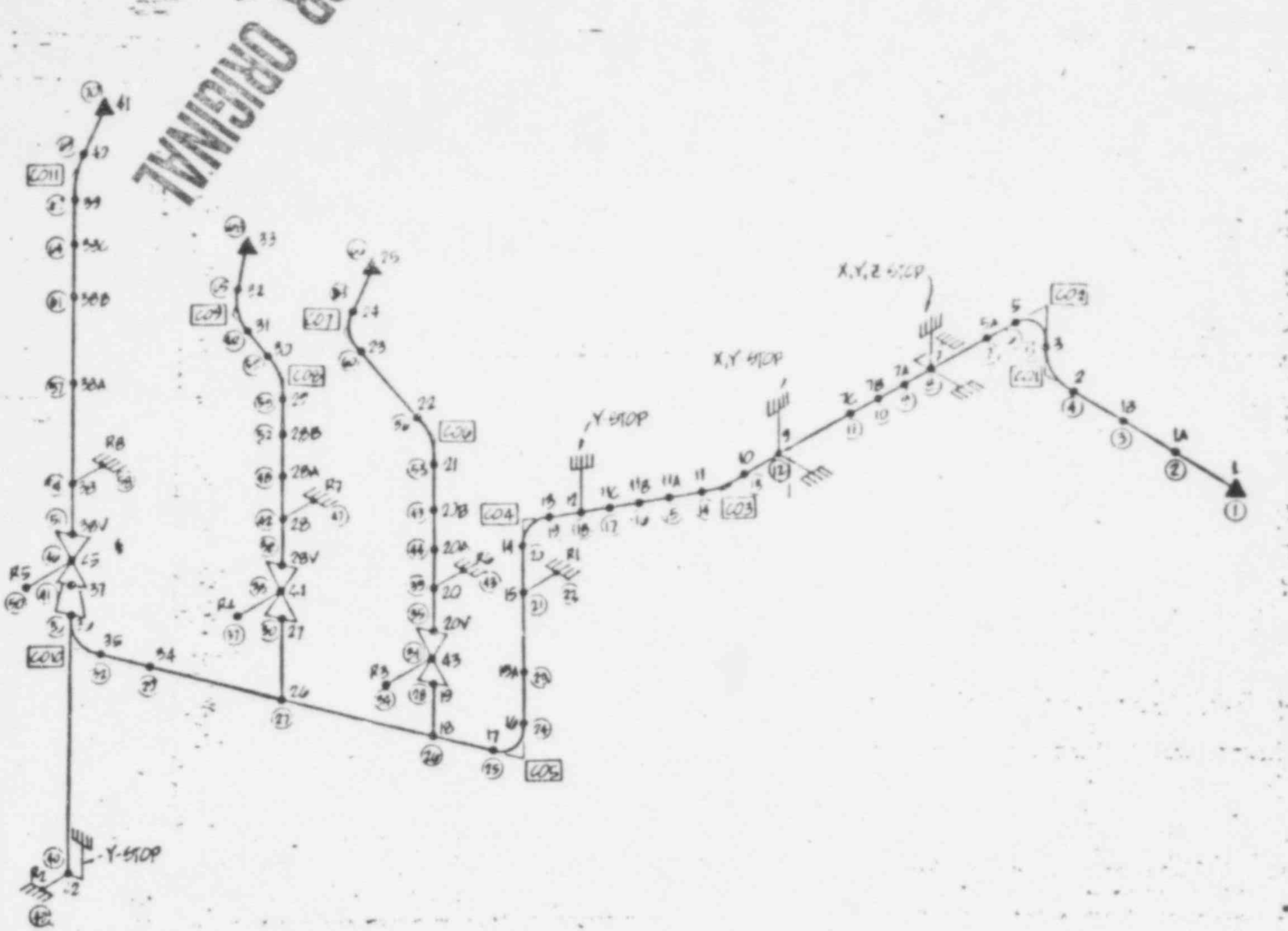
PISOL/PIPESD COMPARISON

589 084



NOTES:

1. X = PISOL NODE NAME
2. (X) = PIPSD NODE NAME
3. [XX] = CURVED MEMBER NAME

EDS NUCLEAR

PISOL / PIPSD COMPARISON

NTS RMD SMT

589 085

PISOL/PIPE SD COMPARISON

MODEL 1

Number of Degrees of Freedom = 167

FREQUENCIES

Mode	PISOL (1/SC)	PIPE SD (1/SC)
1.	4.806	4.807
2.	9.415	9.416
3.	10.083	10.083
4.	11.361	11.361
5.	12.950	12.950
6.	14.356	14.356
7.	15.397	15.398
8.	15.478	15.480
9.	16.488	16.488
10.	16.871	16.872
11.	17.497	17.505
12.	18.593	18.594
13.	19.058	19.058
14.	19.971	19.971
15.	23.859	23.878
16.	28.802	28.803
17.	31.280	31.280

DISPLACEMENTS (x + y Eq.)

Joint (PISOL/PIPESD)	PISOL (in) X	Y	Z	PIPESD (in) X	Y	Z
1B/3	.0007	.0169	.0014	.0007	.0169	.0014
7B/10	.0257	.0230	.0003	.0257	.0030	.0003
11/14	.0095	.0081	.0013	.0095	.0081	.0013
20B/49	.1016	.0225	.0767	.1016	.0225	.0767
38B/61	.3063	.0004	.1730	.3062	.0004	.1729
R4/37	.3896	.0173	.2112	.3894	.0173	.2111

MOMENTS (x + y Eq.)

Member (PISOL/PIPESD)	PISOL (ft-lb) X	Y	Z	PIPESD (ft-lb) X	Y	Z
1B/2S	98.8	26.7	84.8	98.8	26.7	84.8
3C/7S	82.3	472.1	360.2	82.3	472.1	360.2
CO3/3C	229.7	156.8	412.9	229.6	156.8	412.7
9B/29S	13.5	94.4	142.0	13.5	94.4	141.9
19B/49S	32.9	87.7	124.4	32.9	87.7	124.4

STRESSES (X+Y Eq)

Member (PISOL/PIPESD)	PISOL (psi)	PIPE SD (psi)
1B/2S	187.7	187.7
3C/7S	846.8	846.8
C03/3C	1450.7	1449.7
9B/29S	1190.7	1190.1
19B/49S	1756.5	1756.1

REACTIONS (X+Y Eq)

Joint (PISOL/PIPESD)	PISOL (lb)			PIPE SD (lb)		
	X	Y	Z	X	Y	Z
1/1	71.9	85.[illegible]	43.9	72.	86.	44.
7/8	182.4	97.7	471.0	182.	98.	471.
12/18	0.0	1403.2	0.0	0.	1403.	0.
33/68	96.6	599.8	62.4	97.	600.	62.
41/70	59.6	14.9	39.2	60.	15.	39.

DISPLACEMENTS

Joint (PISOL/PIPESD)	PISOL (in) X	PISOL (in) Y	PISOL (in) Z	PIPESD (in) X	PIPESD (in) Y	PIPESD (in) Z
1B/3	.0017	-.0310	.0033	.0016	-.0298	.0031
7B/10	.0023	-.0155	.0000	.0022	-.0173	.0000
11/14	-.0006	.0007	-.0001	-.0006	.0012	-.0001
20B/49	-.0018	-.0054	-.0006	-.0014	-.0052	-.0011
38B/61	.0201	-.0006	-.0107	.0203	-.0006	-.0103
R4/37	.0184	-.0048	-.0099	.0186	-.0046	-.0098

MOMENTS

Member (PISOL/PIPESD)	PISOL (ft-lb) X	PISOL (ft-lb) Y	PISOL (ft-lb) Z	PIPESD (ft-lb) X	PIPESD (ft-lb) Y	PIPESD (ft-lb) Z
1B/2S	-208.6	-55.0	-28.4	199.5	53.2	19.9
3C/7S	-1.1	-29.3	447.5	10.3	-27.9	417.8
CO3/3C	-68.1	4.0	8.3	-76.4	28.2	6.9
9B/29S	0.3	-6.1	17.0	0.6	-5.0	15.8
19B/49S	2.0	3.4	-7.3	2.1	2.8	-7.6

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STRESSES

Member (PISOL/PIPESD)	PISOL (psi)	PIPE SD (psi)
1B/2S	307.3	293.0
3C/7S	633.4	591.7
C03/3C	100.5	142.4
9B/29S	125.7	115.5
19B/49S	93.8	94.5

REACTIONS

Joint (PISOL/PIPESD)	PISOL (lb)			PIPE SD (lb)		
	X	Y	Z	X	Y	Z
1/1	-10.9	307.8	-2.9	-10.5	305.3	-2.6
7/8	13.3	663.3	-6.8	13.2	666.6	-6.3
12/18	0.0	1007.5	0.0	0.0	1010.0	0.0
33/68	-6.3	94.0	2.7	-6.1	92.5	2.7
41/70	-2.8	22.8	1.5	-2.7	26.7	1.8

589 090

ASME BENCHMARK PROBLEM NO. 1
PISOL VERIFICATION

A PROBLEM ON DYNAMIC ANALYSIS OF A THREE-DIMENSIONAL STRUCTURE

PROBLEM DESCRIPTION

The problem description and data used in its solution can be found on pages 1 2, and 3 of Benchmark Problem No. 1.

SOLUTION

The solution listed in TABLE 1 represents a portion of the modal response analysis of the lumped-mass system described in the mathematical model (FIGURE 1) and in Benchmark Problem No. 1. The solution to the problem was found using PISOL1A, a program developed by EDS Nuclear Inc. for the seismic analysis of arbitrary three-dimensional piping systems, and was obtained using a CDC 6600 computer. The solution is based on a lumped-mass model consisting of 42 dynamic degrees of freedom with each of the displacement degrees of freedom at each of the 14 lumped masses represented. Details of the complete solution have been documented and are available upon request from EDS Nuclear Inc., 220 Montgomery, San Francisco, CA 94104.

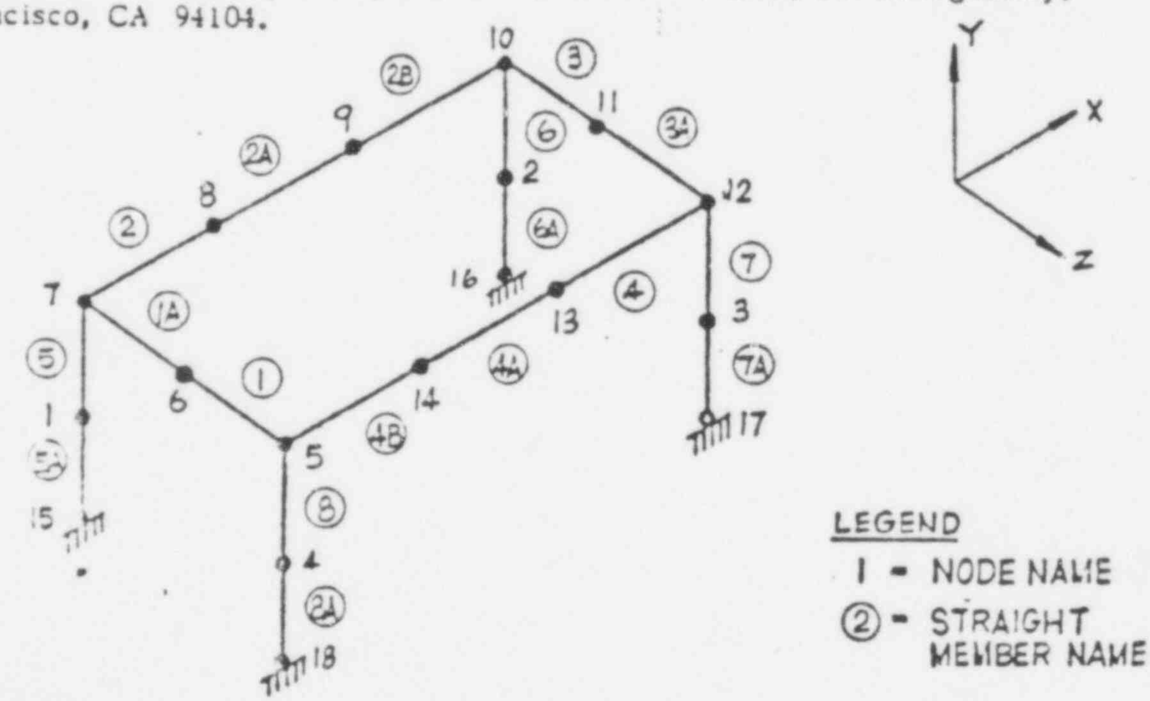

FIGURE 1 PICTORIAL REPRESENTATION OF MATHEMATICAL MODEL

589 092

RESULTS

The results of the frequency analysis using PISOL1A are excerpted from the output and are tabulated in TABLE 1.

TABLE 1

CALCULATED AND MEASURED FREQUENCIES AND DIRECTIONS OF PRINCIPLE EXCITATION

MEASURED(1)		ANSYS RESULTS		PISOL1A RESULTS	
Resonant Frequency cps	Excitation Direction	Resonant Frequency cps	Excitation Direction	Resonant Frequency cps	Excitation(2) Direction
110	X	112	X	111	X
117	Z	116	Z	116	Z
134	X, Z	138	X, Z	137	None
214	Y, Z	218	Y, Z	216	None
359	X	---	--	---	--
382	Y	404	Y	405	Y
416	Y	423	Y	422	Y
---	--	452	Z	453	Z
553	Z	554	Z	550	Z
697	Y	736	Y	735	Y
821	X, Y	762	X	758	X
853	Y	853	X	855	X
---	--	894	X, Y	893	Y
885	X	---	--	893	X
898	X, Y	910	X, Y	909	None

(1) Crede, C. E., "Shock and Vibration Concepts in Engineering Design," Prentice Hall, Inc., Englewood Cliffs, N.J.

(2) No significant participation factor means the maximum directional participation factor for a given frequency is less than 0.025% of the maximum directional participation factor for any frequency.

589 093

SUPERPIPE VERIFICATION AND COMPARISON SUMMARY

589 094

SUPERPIPE VERIFICATION AND COMPARISON SUMMARY

SUPERPIPE contains capabilities that many other piping programs do not have. Therefore, the comparison of SUPERPIPE with other piping programs is limited to an evaluation of forces, moments and displacements. Two piping problems were selected for a comparison between SUPERPIPE, PISOL and PIPESD. The first problem used for comparison is the ASME Benchmark Problem No. 6. This piping model is used for an evaluation of static analyses results only. A relative comparison of the significant portions of the results is contained in tables 1 and 2. Figure 1 is a pictorial representation of the mathematical model used in making the analyses.

The second piping problem selected for comparison is the same problem that appears in the SUPERPIPE mini-manual. This piping system is used because it is realistic and will exercise most of the standard features in any piping program. The relative comparison of results from the SUPERPIPE mini-manual problem includes both static and dynamic (response spectrum) analyses results. The relative comparisons of the SUPERPIPE mini-manual results are contained in tables 3 through 9. Figure 2 contains a pictorial representation of the mathematical model for problem number 2.

The piping problems used in evaluating SUPERPIPE were selected on the basis of credibility within the piping industry and overall capability. The slight variance of values contained in the summaries is attributable to the different method of solution that each program uses and does not represent errors in analyses.

COMPUTER RUNS

SUPERPIPE MINI-MANUAL SAMPLE PROBLEM

PISOL3A ASME BENCHMARK PROBLEM NO. 6

SUPERPIPE ASME BENCHMARK PROBLEM NO. 6

SUPERPIPE CLASS 1 SAMPLE PROBLEM (LOAD CASES)

SUPERPIPE CLASS 1 SAMPLE PROBLEM (STRESS REPORT)

PIPESD MINI-MANUAL SAMPLE PROBLEM (LOAD CASES)

PISOL3A(STATIC)	"	"	THESE RUNS CONSTITUTE A COMPLETE CLASS TWO ANALYSIS ON THE PISOL SERIES OF PROGRAMS
PISOL1A(DYNAMIC)	"	"	
PISOL7B(STRESS)	"	"	
SUPSUM	"	"	
PLOT	"	"	
TINIT	"	"	
PAX2A	"	"	

589 096

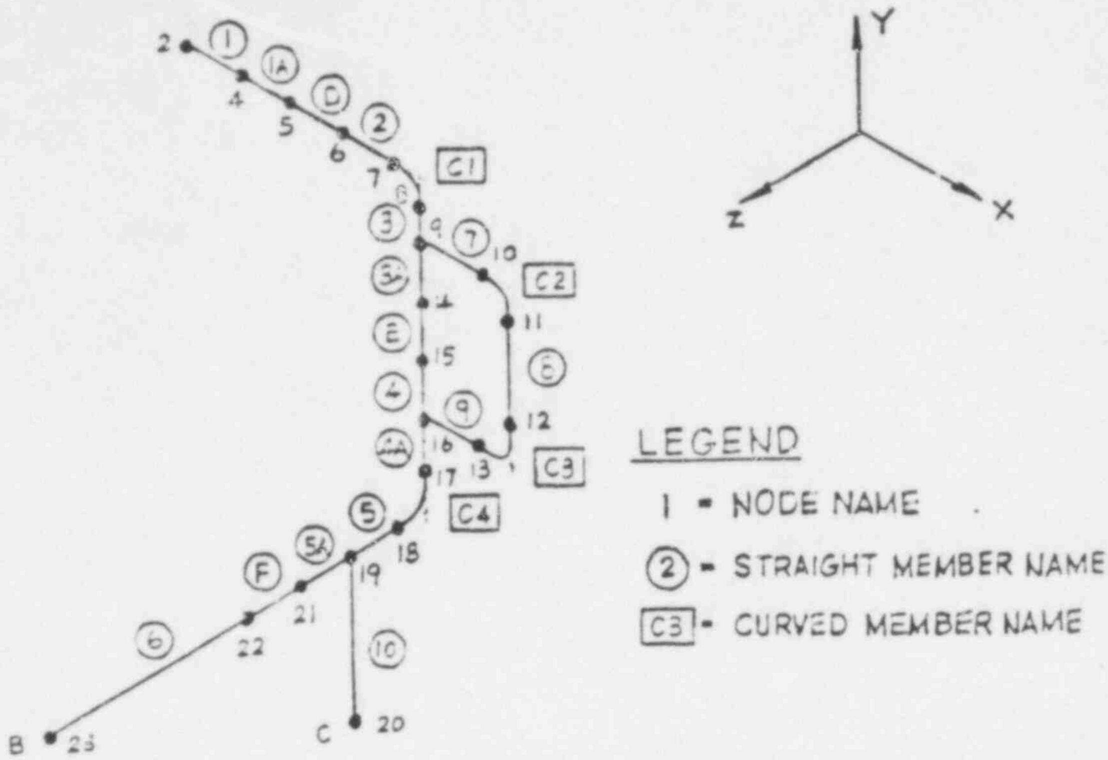

FIGURE 1 PICTORIAL REPRESENTATION OF MATHEMATICAL MODEL

TABLE 1 ANCHOR REACTIONS
(lb., in. - lb.)

Reaction Component

Node	Solution by	F_x	F_y (1)	F_z	M_x	M_y	M_z
2	ANSYS	-49	3	144	10	-33	-20
	WESTDYN	-49	4	144	10	-34	-20
	PISOL3A	-49	3	144	10	-33	-20
	SUPERPIPE	-49	4	148	12	-35	-19
20	ANSYS	286	713	1985	66572	1442	-16591
	WESTDYN	287	837	1981	66516	1407	-16599
	PISOL3A	286	731	1983	66545	1439	-16591
	SUPERPIPE	288	762	2044	67527	1432	-16693
23	ANSYS	-238	-513	-2129	-13678	11357	-221
	WESTDYN	-238	-469	-2126	-13173	11382	-210
	PISOL3A	-237	-496	-2127	-13729	11358	-221
	SUPERPIPE	-240	-528	-2192	-14339	11388	-199

(1) Variation in F_y due to differences in weight distribution algorithm in ANSYS, WESTDYN, and PISOL3A.

589 097

TABLE 2 NODE POINT DISPLACEMENTS

(in., rad.)

Displacement Component

Node	Solution by	U_x	U_y	U_x	ϕ_x	ϕ_y	ϕ_z
4	ANSYS	.049	-.002	-.144	-.0010	.0033	.0020
	WESTDYN	.050	-.004	-.145	-.0010	.0034	.0020
	PISOL3A	.049	-.003	-.144	-.0010	.0033	.0020
	SUPERPIPE	.049	-.004	-.148	-.0012	.0035	.0019
9	ANSYS	.147	.063	-.256	-.0015	.0013	.0017
	WESTDYN	.147	.063	-.258	-.0016	.0013	.0017
	PISOL3A	.147	.063	-.256	-.0015	.0013	.0017
	SUPERPIPE	.146	.060	-.256	-.0018	.0014	.0016
12	ANSYS	.201	.037	-.231	-.0019	.0007	.0017
	WESTDYN	.201	.037	-.232	-.0020	.0007	.0016
	PISOL3A	.201	.027	-.232	-.0020	.0007	.0017
	SUPERPIPE	.200	.034	-.236	-.0022	.0007	.0016
16	ANSYS	.186	.011	-.218	-.0019	.0003	.0016
	WESTDYN	.187	.011	-.218	-.0020	.0004	.0016
	PISOL3A	.187	.011	-.218	-.0019	.0003	.0016
	SUPERPIPE	.185	.008	-.221	-.0022	.0004	.0016
19	ANSYS	.185	.028	-.172	-.0044	-.0020	.0002
	WESTDYN	.185	.028	-.172	-.0044	-.0020	.0002
	PISOL3A	.185	.028	-.172	-.0044	-.0020	.0002
	SUPERPIPE	.184	.028	-.172	-.0047	-.0020	.0002

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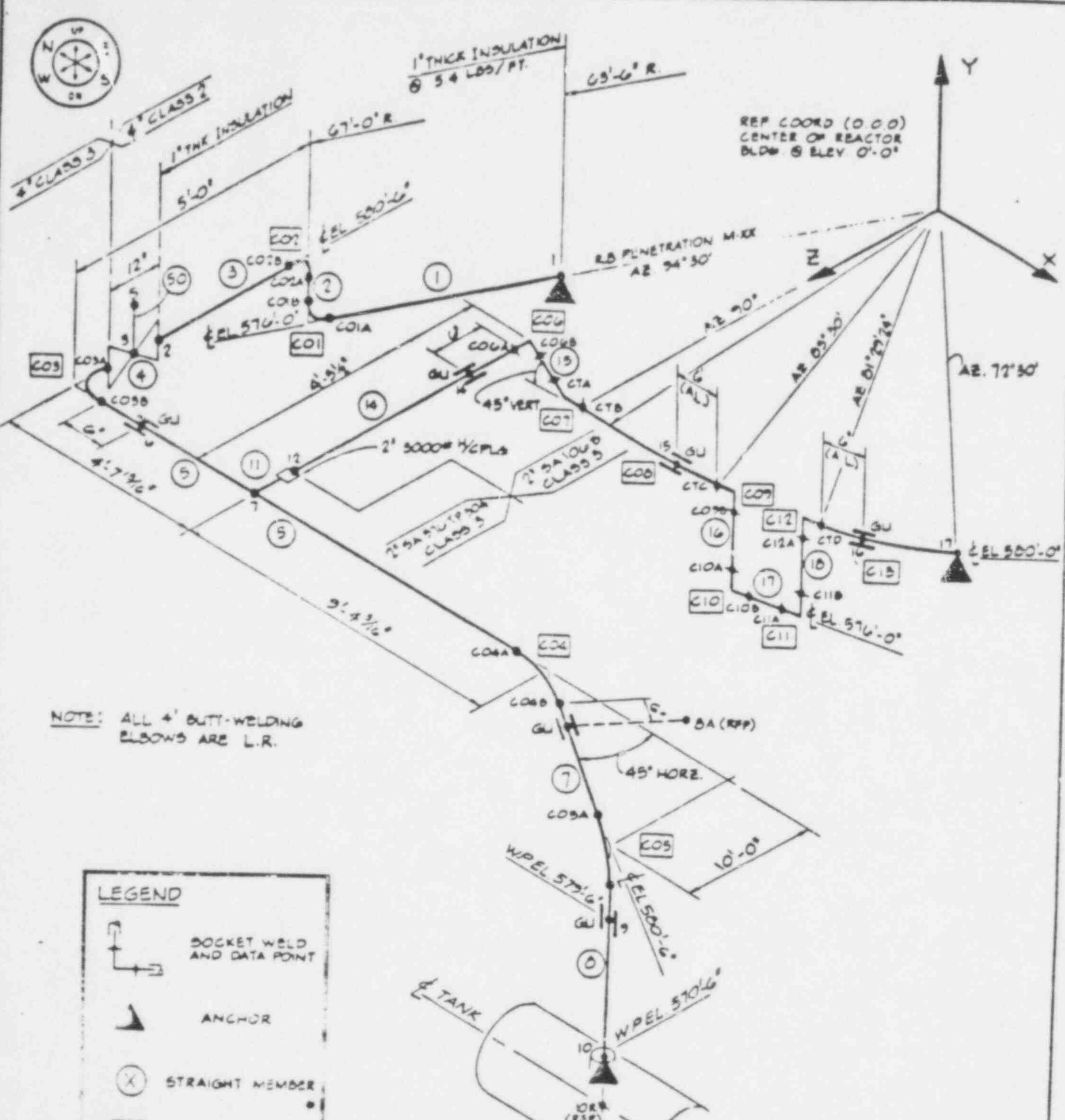


Fig. 2A
SUPERPIPE MATH MODEL

POOR ORIGINAL

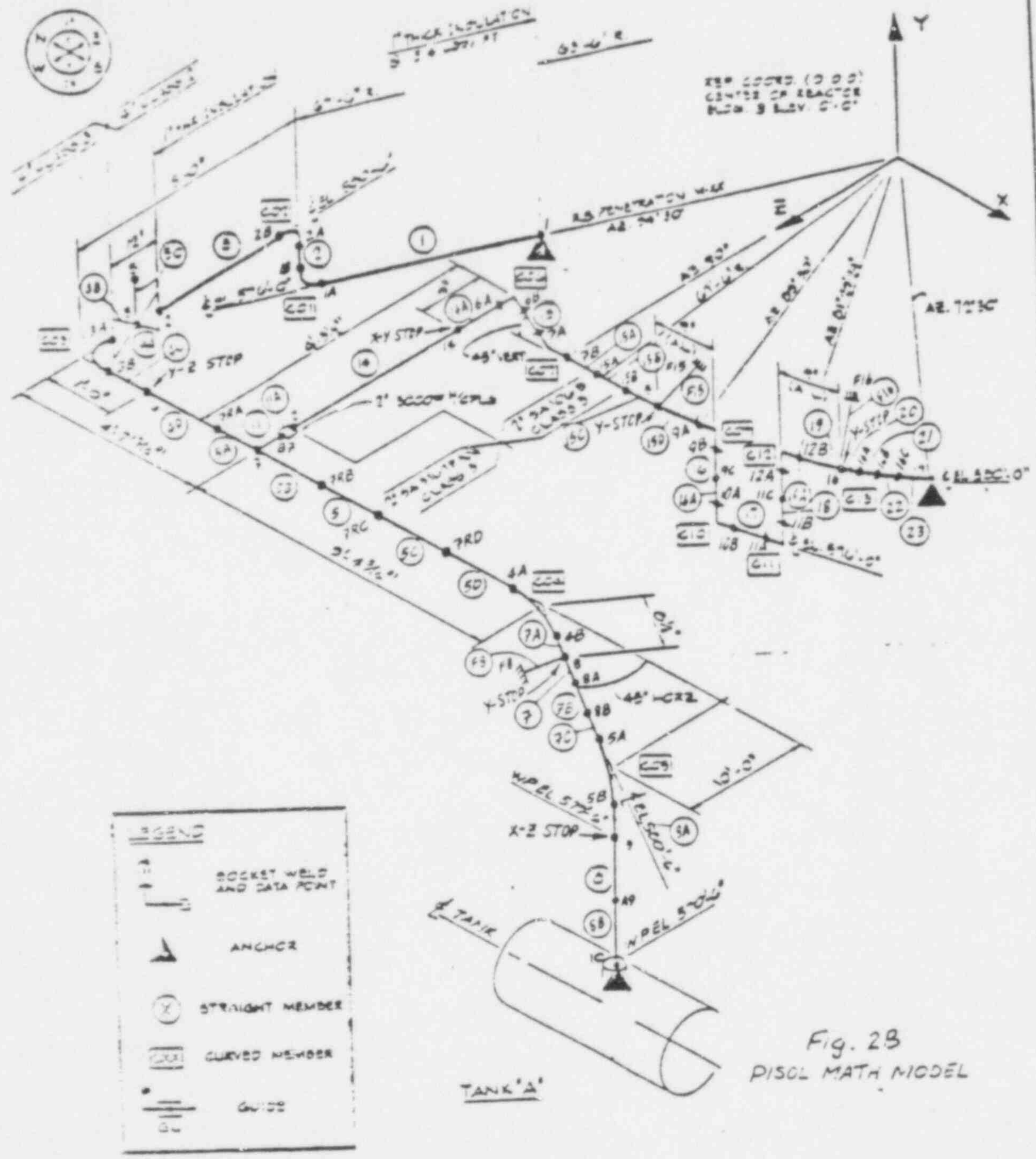


Fig. 2B
PISOL MATH MODEL

POOR ORIGINAL

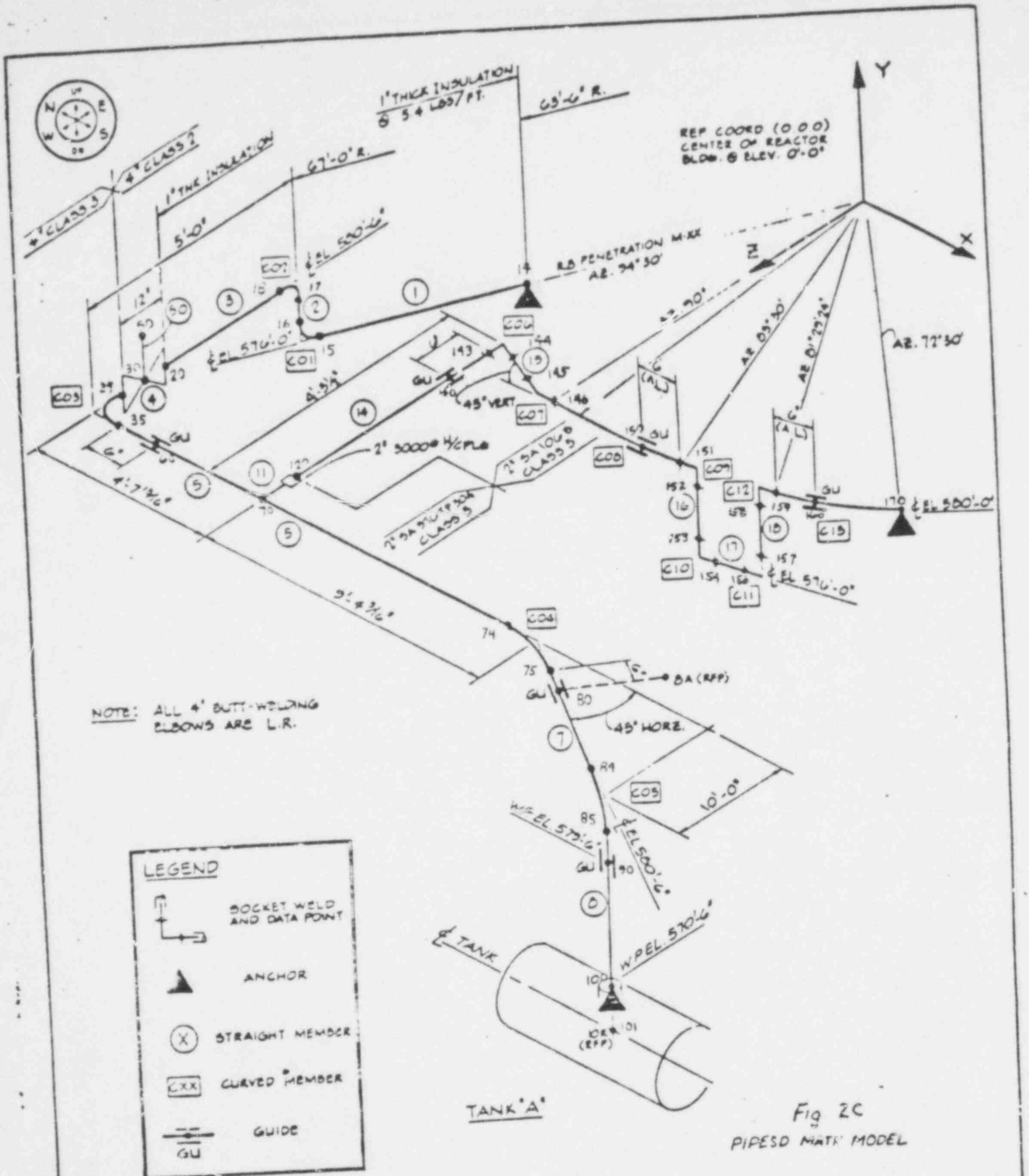


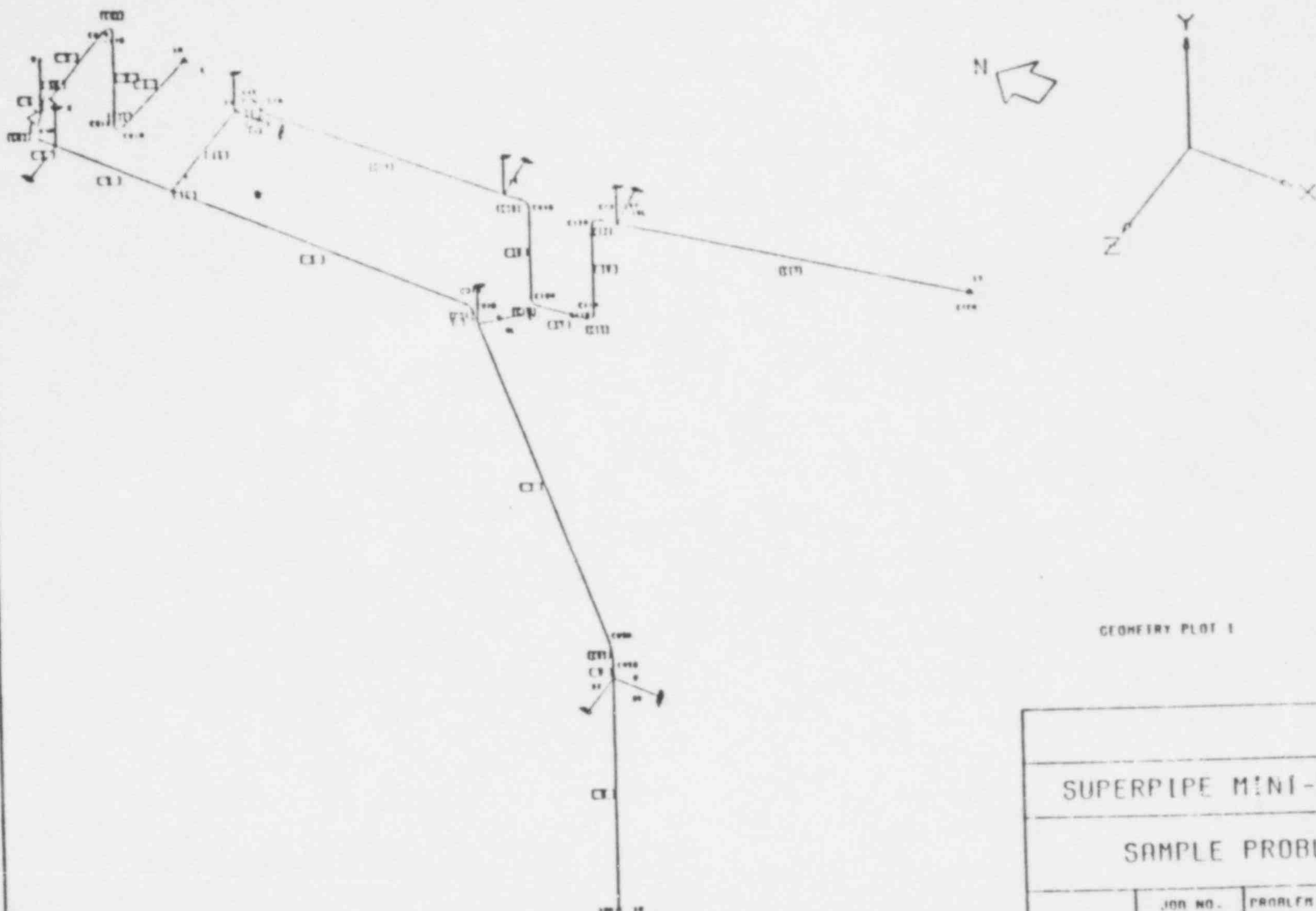
Fig 2C
PIPESD MATH MODEL

POOR ORIGINAL

589 101

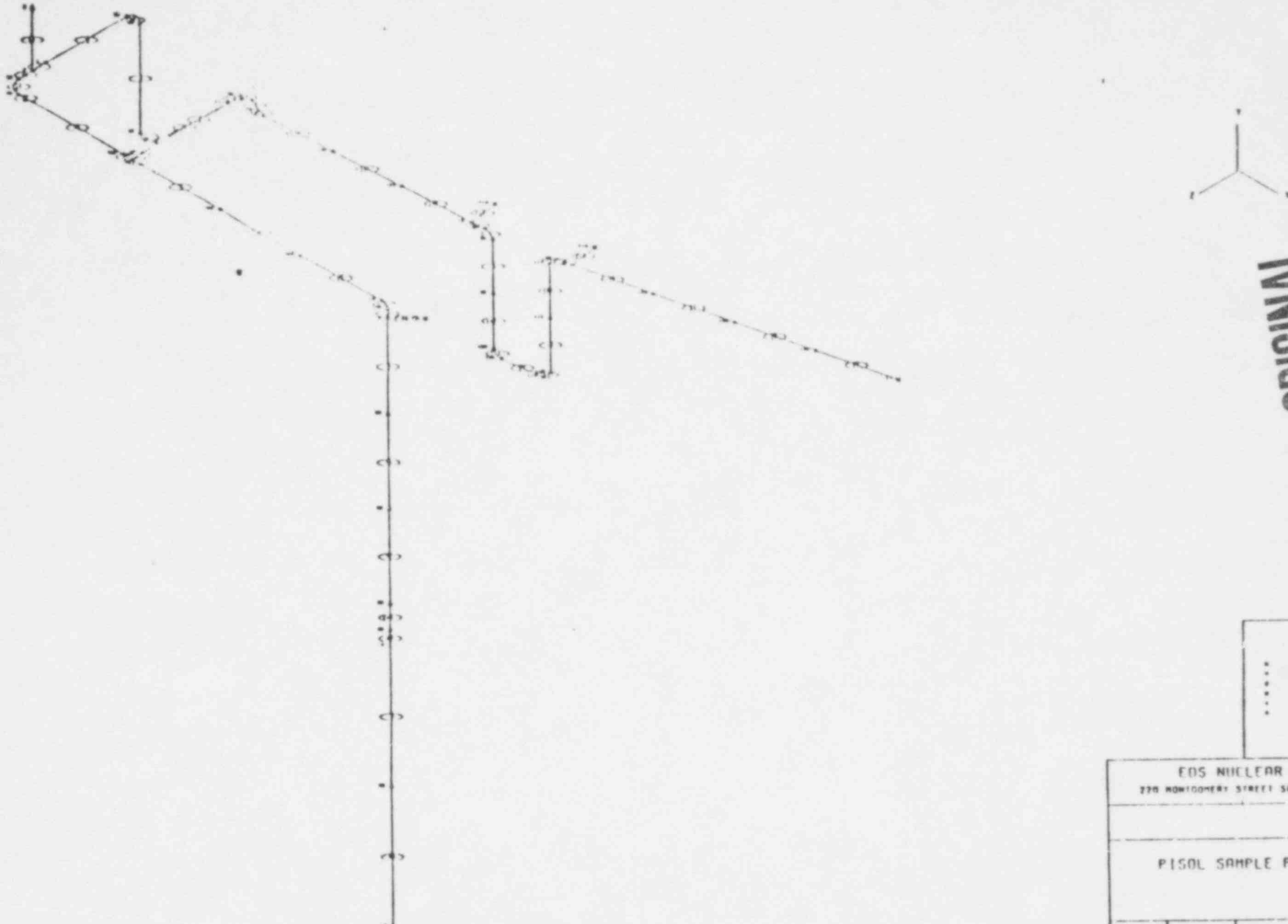
POOR ORIGINAL

589 102



GEOMETRY PLOT 1

SUPERPIPE MINI-MANUAL			
SAMPLE PROBLEM			
	JOB NO. XXXXXXX	PROBLEM NO. SP-01	BY SAO
	PLOT NO.	DATE 05/09/77	TIME 16.41.52.



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LEGEND

- X-SUPPORT
- Y-SUPPORT
- Z-SUPPORT
- ANCHOR
- OTHER SUPPORT
- NO SUPPORT

EDS NUCLEAR INC.
220 MONTGOMERY STREET SAN FRANCISCO

PISOL SAMPLE PROBLEM

5-9-77	602-240	TRIAL 2	0

TABLE 3
MINI-MANUAL SAMPLE PROBLEM
MEMBER END FORCES AND MOMENTS
THERMAL EXPANSION ANALYSIS
(lb., in - lb)

Node	Solution by	F_x	F_y	F_z	M_x	M_y	M_z
1	SUPERPIPE	385	257	-232	-6527	12324	2051
	PISOL	386	258	-233	-6532	12356	2064
	PIPSD	388	259	-233	-6518	12388	2085
C02B	SUPERPIPE	402	257	-201	5041	1369	10947
	PISOL	403	258	-202	5058	1380	10968
	PIPESD	405	259	-202	5077	1405	11016
6	SUPERPIPE	201	49	175	2923	-4669	1961
	PISOL	202	49	172	2941	-4669	1968
	PIPESD	202	50	183	2994	-4619	1966
C04A	SUPERPIPE	613	-133	17	1884	1919	4806
	PISOL	607	-133	17	1891	1921	4801
	PIPESD	638	-141	17	1885	1921	4991
9	SUPERPIPE	45	-21	-16	263	1147	-1490
	PISOL	46	-20	-16	266	1136	-1476
	PIPESD	46	-23	-18	276	1272	-1628
12	SUPERPIPE	-42	32	-412	169	10749	887
	PISOL	-40	32	-405	161	10657	896
	PIPESD	-42	33	-436	159	11752	949
14	SUPERPIPE	-42	-26	100	169	-4777	-310
	PISOL	-40	-25	97	161	-4601	-293
	PIPESD	-42	-25	95	169	-4701	-312
C06B	SUPERPIPE	89	52	42	2690	-2668	-325
	PISOL	86	50	40	2593	-2566	-312
	PIPESD	85	49	42	2661	-2656	-316
CTC	SUPERPIPE	95	6	-10	106	434	1672
	PISOL	90	5	-10	109	377	1609
	PIPESD	90	-5	-10	109	420	1599
C10B	SUPERPIPE	95	6	-8	313	380	-2928
	PISOL	90	5	-8	-295	325	-2736
	PIPESD	90	5	-8	-301	367	-2745

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TABLE 4
MINI-MANUAL SAMPLE PROBLEM
MEMBER END FORCES AND MOMENTS
DEAD WEIGHT ANALYSIS
(lb., in - lb)

Node	Solution by	F_x	F_y	F_z	M_x	M_y	M_z
	SUPERPIPE	23	181	-5	-87	196	4948
1	PISOL	29	192	-4	-145	138	6043
	PIPESD	23	182	-5	-88	200	4988
	SUPERPIPE	23	43	-3	184	-24	-423
C02B	PISOL	29	16	-2	107	-58	-552
	PIPESD	23	44	-3	186	-24	-428
	SUPERPIPE	3	108	1	-1037	91	2295
6	PISOL	2	79	0	-1054	175	2306
	PIPESD	3	114	1	1091	92	2414
	SUPERPIPE	7	-1	-96	-672	-1132	56
C04A	PISOL	6	0	-97	-610	-990	35
	PIPESD	7	-1	-99	-688	-1171	66
	SUPERPIPE	117	18	9	34	-621	1321
9	PISOL	154	16	8	29	-570	1187
	PIPESD	119	19	9	26	-628	1258
	SUPERPIPE	-1	-7	-4	-52	110	-337
12	PISOL	-1	-17	-4	-44	103	-403
	PIPESD	0	-8	-4	-51	122	-387
	SUPERPIPE	-1	24	3	-52	-40	238
14	PISOL	-1	23	2	-44	-32	234
	PIPESD	0	24	3	-51	-41	210
	SUPERPIPE	-10	14	1	43	20	6
C06B	PISOL	-10	13	1	38	17	-1
	PIPESD	-10	14	0	24	4	4
	SUPERPIPE	3	28	-1	30	6	174
CTC	PISOL	2	26	-1	25	4	146
	PIPESD	3	27	-1	27	5	174
	SUPERPIPE	3	2	-1	3	3	-37
C10B	PISOL	2	-1	-1	4	1	-32
	PIPESD	3	1	0	4	2	-53

TABLE 5

MINI-MANUAL SAMPLE PROBLEM

MEMBER END FORCES AND MOMENTS

SEISMIC ANALYSIS

(lb., - in - lb)

Node	Solution by	F_x	F_y	F_z	M_x	M_y	M_z
1	SUPERPIPE	7	22	15	555	353	730
	PISOL	7	28	19	726	409	912
C02B	SUPERPIPE	5	5	9	294	366	133
	PISOL	16	17	6	458	246	632
6	SUPERPIPE	26	30	24	200	453	410
	PISOL	29	32	24	220	478	461
C04A	SUPERPIPE	29	19	18	149	231	366
	PISOL	28	21	20	158	233	391
9	SUPERPIPE	13	4	3	152	264	357
	PISOL	13	5	4	149	311	373
12	SUPERPIPE	9	35	6	30	163	165
	PISOL	8	38	6	32	178	191
14	SUPERPIPE	7	5	7	30	97	1217
	PISOL	7	6	9	32	106	1325
C06B	SUPERPIPE	7	4	6	914	764	22
	PISOL	10	6	6	992	823	20
CTC	SUPERPIPE	6	3	31	1211	56	193
	PISOL	8	4	24	1219	52	252
C10B	SUPERPIPE	6	3	2	56	97	76
	PISOL	7	4	2	60	100	108

TABLE 6

MINI-MANUAL SAMPLE PROBLEM

NODE POINT DISPLACEMENTS

THERMAL EXPANSION ANALYSIS

(in., rad.)

Node	Solution By	U_x	U_y	U_z	$Ø_x$	$Ø_y$	$Ø_z$
C02A	SUPERPIPE	-.169	.068	-.074	-.00214	-.00302	.00252
	PISOL	-.1687	.0675	-.0742	-.002140	-.003041	.002504
	PIPESD	-.169	.068	-.075	-.00215	-.00305	.00250
C02B	SUPERPIPE	-.201	.077	-.074	.00060	-.00306	.00195
	PISOL	-.2004	.0772	-.0741	.000606	-.003072	.001944
	PIPESD	-.308	.030	-.075	.00061	-.00309	.00193
2	SUPERPIPE	-.308	.030	-.031	.00174	-.00266	..00077
	PISOL	-.3081	.0294	-.0307	.001744	-.002668	.00762
	PIPESD	-.309	.030	-.031	.00174	-.00261	.00066
3	SUPERPIPE	-.324	.019	-.023	.00175	-.00257	.00069
	PISOL	-.3239	.0188	-.0235	.001755	-.002586	.000679
	PIPESD	-.324	.019	-.024	.00178	-.00261	.00066
C03A	SUPERPIPE	-.339	.009	-.016	.00174	-.00248	.00060
	PISOL	-.3391	.0083	-.0162	.001747	-.002489	.000596
	PIPESD	-.340	.008	-.017	.00175	-.00251	.00058
C03B	SUPERPIPE	-.342	.000	-.002	.00166	-.00045	.00007
	PISOL	-.3423	-.0001	-.0020	.001681	-.000459	.000076
	PIPESD	-.343	.000	-.002	.00168	-.00049	.00006
7	SUPERPIPE	-.282	-.006	.001	.00072	-.00009	-.00020
	PISOL	-.2821	-.0064	.0017	.000729	-.000088	-.000202
	PIPESD	-.282	-.007	.004	.00071	-.00018	-.00021
12	SUPERPIPE	-.279	-.002	-.005	.00059	-.00165	-.00017
	PISOL	-.2794	-.0031	-.0015	.000598	-.001652	-.000173
	PIPESD	-.280	-.004	-.000	.00064	-.00094	-.00020
CTC	SUPERPIPE	.137	-.014	-.027	-.00159	.00215	-.00262
	PISOL	.1435	-.0137	-.0272	-.001506	.002024	-.002515
	PIPESD	.140	-.014	-.028	-.00129	.00218	-.00252
C09B	SUPERPIPE	.131	-.025	-.029	-.00159	.00215	-.00263
	PISOL	.1374	-.0244	-.0288	-.001538	.001989	-.002682
	PIPESD	.134	-.025	-.031	-.00132	.00214	-.00268

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TABLE 7

MINI-MANUAL SAMPLE PROBLEM

NODE POINT DISPLACEMENTS

DEAD WEIGHT ANALYSIS

(in., rad.)

Node	Solution by	U_x	U_y	U_z	ϕ_x	ϕ_y	ϕ_z
C02A	SUPERPIPE	-.002	-.012	.001	-.00007	-.00002	.00002
	PISOL	-.0032	-.0148	.0014	-.000084	-.000002	.000052
	PIPESD	.002	.012	.001	.0009	-.00002	.00004
C02B	SUPERPIPE	-.002	-.011	.000	-.00014	-.00001	-.00001
	PISOL	-.0034	-.0139	.0007	-.000182	.000012	.000033
	PIPESD	.002	.011	.000	-.00013	-.00001	-.00001
2	SUPERPIPE	-.003	-.002	.000	-.00030	.00000	-.00005
	PISOL	-.0027	-.0050	.0007	-.000334	.000030	.000009
	PIPESD	-.003	-.003	.000	.0003	.00000	-.00005
3	SUPERPIPE	-.002	-.002	.000	-.00031	.00000	-.00006
	PISOL	-.0025	-.0030	.0007	-.000347	.000031	.000007
	PIPESD	-.002	-.002	.000	-.00031	.00000	-.00006
C03A	SUPERPIPE	-.002	-.000	.000	-.00031	-.00001	.00006
	PISOL	-.0023	-.0008	.0007	-.000353	-.000033	.000005
	PIPESD	-.002	.000	.000	.00031	-.00001	.00006
C03B	SUPERPIPE	-.002	.001	.000	-.00019	.00004	-.00020
	PISOL	-.0021	.0009	.0004	-.000243	.000059	-.000134
	PIPESD	-.002	.001	.000	.0002	-.00004	-.00021
7	SUPERPIPE	-.002	-.016	-.001	.00014	.00001	-.00033
	PISOL	-.0021	-.0139	-.0016	.000098	.000018	-.000311
	PIPESD	.002	-.027	-.001	.00015	.00001	-.00035
12	SUPERPIPE	-.002	-.015	-.001	.00019	.00000	-.00034
	PISOL	-.0021	-.0133	-.0016	.000156	.000003	-.000319
	PIPESD	-.002	-.015	-.001	.00018	.00000	-.00035
CTC	SUPERPIPE	-.002	.001	.000	.00004	-.00004	.00008
	PISOL	-.0020	.0005	.0004	.000005	-.000036	.000071
	PIPESD	-.002	.001	.000	.00004	-.00004	.00005
C09B	SUPERPIPE	-.002	.001	.000	-.00004	-.00004	.00008
	PISOL	-.0018	.0007	.0005	-.000002	-.000036	.000061
	PIPESD	-.002	.000	.000	.00023	-.00004	.00004

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TABLE 8

MINI-MANUAL SAMPLE PROBLEM

NODE POINT DISPLACEMENTS

SEISMIC ANALYSIS

(in., rad.)

Node	Solution by	U_x	U_y	U_z	ϕ_x	ϕ_y	ϕ_z
C02A	SUPERPIPE	.011	.002	.002	.00005	.00012	.00025
	PISOL	.0139	.0024	.0029	.000060	.000156	.000318
C02B	SUPERPIPE	.011	.002	.003	.00005	.00018	.00023
	PISOL	.0146	.0025	.0021	.000053	.000229	.000294
2	SUPERPIPE	.0004	.0003	.0002	.00006	.00022	.00026
	PISOL	.0051	.0030	.0032	.000066	.000287	.000309
3	SUPERPIPE	.003	.003	.002	.00006	.00022	.00026
	PISOL	.0034	.0032	.0032	.000067	.000289	.000311
C03A	SUPERPIPE	.001	.003	.003	.00006	.00022	.00026
	PISOL	.0017	.0034	.0032	.000068	.000289	.000309
C03B	SUPERPIPE	.001	.002	.001	.00007	.00021	.00026
	PISOL	.0005	.0018	.0016	.000075	.000261	.000302
7	SUPERPIPE	.001	.010	.008	.00012	.00012	.00015
	PISOL	.0005	.0112	.0091	.000128	.000126	.000164
12	SUPERPIPE	.001	.010	.008	.00014	.00010	.00015
	PISOL	.0006	.0115	.0091	.000153	.000102	.000162
CTC	SUPERPIPE	.001	.000	.001	.00950	.00026	.00115
	PISOL	.0015	.0004	.0015	.010426	.000275	.001240
C09B	SUPERPIPE	.004	.001	.030	.00951	.00026	.00115
	PISOL	.0041	.0006	.0334	.010543	.000285	.001280

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TABLE 9
MINI-MANUAL SAMPLE PROBLEM
CALCULATED FREQUENCIES
DYNAMIC ANALYSIS

Frequency (CPS)

Mode	SUPERPIPE	PISOL	PIPESD
1	5.950	5.939	5.48
2	12.897	13.466	13.65
3	15.360	15.351	15.08
4	18.250	17.757	18.02
5	19.449	19.376	19.07
6	22.350	22.048	19.47
7	22.638	22.568	21.71
8	25.629	25.338	22.28
9	28.781	26.927	28.20
10	29.616	28.174	29.38
11	30.561	30.015	30.09

PISOL/ME-101 COMPARISON

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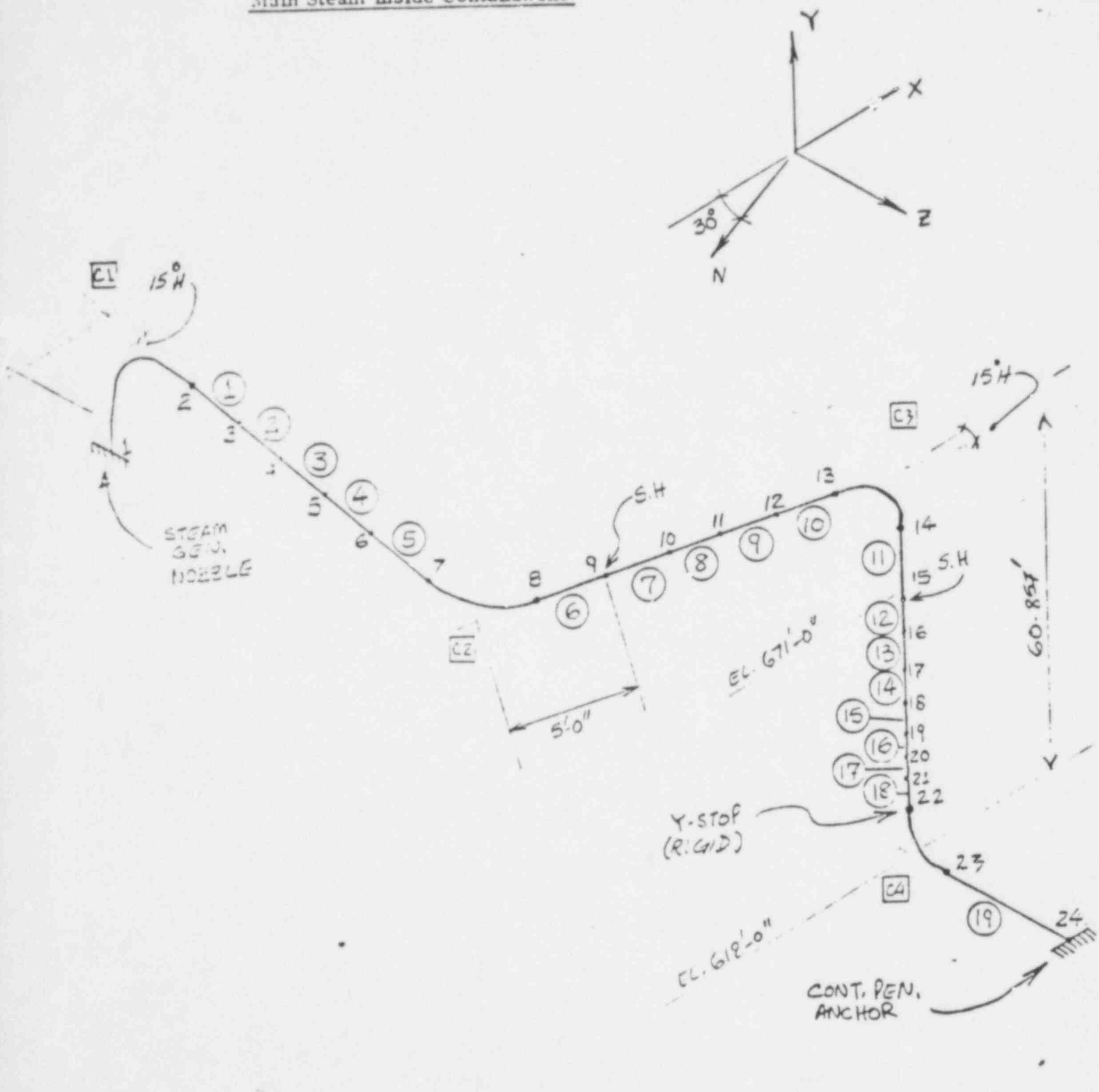
Main Steam Inside Containment



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POOR ORIGINAL

PISOL/ME-101 COMPARISON

MODEL: Main Steam Inside Containment

Number of Degrees of Freedom = 65
(Excluding Restraints)

FREQUENCIES (Cycles/Sec)

MODE NO.	PISOL	ME-101
1	1.680	1.680
2	2.842	2.843
3	3.394	3.395
4	9.586	9.588
5	10.895	10.898
6	19.377	19.382

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X + Y EARTHQUAKE

DISPLACEMENTS (INCHES)

JOINT ID	PISOL			ME-101		
PISOL/ME-101	X	Y	Z	X	Y	Z
5/5	0.459	0.328	0.105	0.447	0.324	0.103
10/10	0.972	0.359	0.292	0.941	0.353	0.294
20/20	0.242	0.000	0.191	0.235	0.000	0.191
22/23B	0.036	0.000	0.024	0.035	0.000	0.024

MOMENTS (FT.-LB.)

MEMBER ID	PISOL			ME-101		
PISOL/ME-101	X	Y	Z	X	Y	Z
C1/1	228750	48174	109948	223715	47581	108285
4/5	38137	86278	27884	38715	84712	27167
8/11	34448	59441	20186	35225	57733	19725
19/24	152854	57642	136511	147964	58749	137018

STRESSES (PSI)

MEMBER ID PISOL/ME-101	PISOL	ME-101
C1/1	4794	4693
4/5	996	982
8/11	725	713
19/24	2155	2126

REACTIONS (LBS)

JOINT ID	PISOL			ME-101		
PISOL/ME-101	X	Y	Z	X	Y	Z
1/1	8245	4580	6250	8166	4590	6527
22/23B	0	25364	0	0	25438	0
24/24	5377	25422	4401	5349	25521	4510

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