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J. Phillip Bayne
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August 13, 1984
IPN-84-29

Director of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. Steven A. Varga, Chief
Operating Reactors Branch No. 1
Division of Licensing

Subject: Indian Point 3 Nuclear Power Plant
Docket No. 50-286
Appendix R Fire Protection Program

Dear Sir:

As stated in our submittal dated December 13, 1983, IPN-83-99, the Authority and our consultant have undertaken a comprehensive review and re-evaluation of the Indian Point 3 Appendix R compliance program. In the course of the review, two areas have been identified as requiring clarification. The specific areas of concern involve the seismic capability of the reactor coolant pump (RCP) oil spillage collection system and the quality assurance program utilized for the Authority's initial Section III.G review.

By letter dated November 16, 1981, IPN-81-86, the Authority stated that, based on visual examination of the system, there was reasonable assurance that the RCP oil spillage collection system would remain functional, and hence complied with Section III.O of Appendix R, during and after a safe shutdown earthquake. The seismic capability of the oil spillage collection system has been analyzed as part of the ongoing Appendix R activities. The results of the analysis indicate that this system will not fail during an earthquake of .15g (see attached report). The Authority however, has decided to implement additional modifications to further enhance the seismic capability of the collection system.

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The Authority's submittal dated July 1, 1982, IPN-82-49, stated that a quality assurance procedure was adopted for development of the documentation used to prepare the "original" safe shutdown functional flow diagrams. Review of the documentation packets by the Authority's Appendix R Task Force indicates that a formal quality assurance procedure was not utilized for reviews performed by the Authority and our (then) consultant as part of the initial Section III.G review. The installation of Appendix R modifications and the so called "interim fire protection measures" were performed under the appropriate quality assurance program and are unaffected by the Task Force findings. The current Appendix R re-evaluation is being performed in accordance with the appropriate requirements of the Authority's quality assurance program and supercedes the previous efforts.

Should you or your staff have any questions regarding this matter, please contact Mr. P. Kokolakis of my staff.

Very truly yours,

J. P. Bayne
Executive Vice President
Nuclear Generation

cc: Resident Inspector's Office
Indian Point 3
U. S. Nuclear Regulatory Commission
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Buchanan, New York 10511

Attachment A to IPN-84- 29

New York Power Authority
Indian Point 3 Nuclear Power Plant
Docket No. 50-286

EVALUATION OF INDIAN POINT RCP LUBE OIL DRAIN SYSTEM

The reactor coolant pump lube oil drain system at Indian Point Unit 3 is designated a nonseismic category I system and had no specific provisions for seismic design. This system was identified in the Indian Point III System Interaction Study as being a potential missile source to impact Category I instrument lines.

SMA, as a subcontractor to Pickard, Lowe & Garrick, made a simplified evaluation of the lube oil drain lines and drain tank for the Design Basis Earthquake, DBE, of 0.15g. It was concluded that the postulated interactions could not occur on the basis that the drain tank, drain lines and drain line supports would not become a missile at the DBE level of seismic input.

The system interaction study concentrated upon the probability of a missile being dislodged and striking a target. Consideration was not given to missile function. In the case of the lube oil drain system, the system function is to collect leaking pump motor bearing lube oil and transfer the oil to a drain tank. The principal concern is one of fire. The lube oil system was therefore reexamined to assure that it would have a very high probability of performing its intended functions under a DBE of 0.15g.

Lube Oil Drain System Description

The lube oil drain system consists of 2" schedule 40 threaded pipe drain lines that connect a drain tank at elevation 48'-5 1/2" to drip pans mounted on platforms around the pump and pump motor. The lowest elevation drain pan is at the 65'-0" level at about the pump upper bearing location. An additional drain pan is located on a platform around the pump motor at the 70'-0" level. Additional drain piping connects to the pump motor oil cooler and to oil collection pans on the pump motor. The piping is normally empty and the oil level in the drain tank is variable.

Preliminary as-built drawings prepared by NYPA show the drain piping, drain tank and support system layout. The piping layouts for pumps 31 through 34 are similar but not identical. Likewise the support locations are not identical. Most supports are U-bolt clamps or pipe straps rigidly connecting the piping to structural steel members.

Figures 1 and 2 show a typical drain tank and support. Figure 3 shows the two drain lines connecting to the top of the drain tank and Figure 4 shows a typical vertical run of the two drain lines between the drain tank and the pump platform at the 65' elevation. The copper colored line in Figure 3 and 4 connects to the drain pan at elevation 65' and the green line continues on to collect oil from drip pans at the 70' level and at pump motor connections above the 70' level. Typical piping detail between the 70' and 78' platforms is shown in Figures 5, 6 and 7.

Lube oil drain piping for pumps 31, 33 and 34 have three to five supports located above the 70' elevation. Pump 32 lube oil drain piping has only one vertical support at elevation 76'-2".

Basis for Evaluation

NYPA is currently conducting a detailed design and analysis of the RCP lube oil drain system to upgrade it to seismic Category 1 status. The evaluation conducted by SMA is therefore not as detailed as would be done for current designs to rigorous code and licensing requirements. The objective of the evaluation was to determine whether the lube oil piping system would actually fail under a 0.15g earthquake rather than to demonstrate compliance to current licensing criteria. The current system would likely not meet current licensing criteria if standard linear elastic response spectrum analysis methods were employed. If one takes a more objective look at the actual system and loading though, it appears that there is adequate support of the piping to preclude failure at the DBE level.

The approach was to demonstrate that the current system would meet the intent of current licensing criteria using simplified analytical approaches. Support spacing charts developed for threaded piping during the Indian Point III System Interaction Study were utilized to evaluate piping and some simple hand calculations were conducted to demonstrate adeqaute anchorage of the lube oil drain tanks.

The pipe support spacing charts for threaded pipe are included as appendices A, B and C to this report. The charts are based on simple geometric piping systems subjected to equal equivalent static load in three principal directions. In deriving a maximum allowable span for 2" threaded pipe, 1.5 times the peak spectral acceleration for the 5% damped response spectrum at the highest elevation of the system was used as the basis for loading. This is conservative for two reasons. First, the 1.5 factor on peak spectral acceleration is considered an upper bound. Its conservatism is recognized and allowed for equivalent static analysis by the Standard Review Plans, Section 3.7.2 II 1(b). Secondly, spectra for the reactor building internal structure at 81'-6" were used. This is about the highest elevation of the piping system and bounds all lower elevations. Five percent damping was used on the basis that current data accumulation and recommendations by the Pressure Vessel Research Committee, PVRC, support 5% damping for all sizes of piping for frequencies up to 10 Hz. The piping fundamental frequency is expected to be below 10 Hz.

Accounting for the fact that the piping charts in the Appendices are based on equal seismic input in each of three principal directions and the Indian Point structural response is dominated by one direction (NS), it was determined by interpolation of charts in the Appendices that an acceptable straight continuous span length for 2 inch diameter threaded pipe in the empty condition is about 37 feet. This is based upon meeting ASME Class 3 faulted condition stress acceptance criteria. Appendix A details the derivation of the allowable span lengths for continuous span straight sections. Curved and branch total spans may be determined from the charts in Appendix C.

The above criteria were applied to the lube oil drain piping geometry recognizing that the actual geometry is not nearly so simple as the base cases in the Appendices.

Drain piping for pumps 31, 33 and 34 were determined to have spans between supports that would meet the span spacing acceptance criteria of the Appendices. The lube oil drain piping for pump 32 has only one support, a vertical sliding support at about elevation 76'-2" and the unsupport span of piping for loading in the lateral direction will not meet the acceptance criteria established. However, if large deflections are considered, lateral support is provided at elevations 65' and 70' as the piping passes through floor grating. The restraint offered by the floor grating is considered sufficient to keep the piping from sliding off of its only vertical support. The lateral support afforded at these floor levels also supports the piping adequately to prevent failure in a 0.15g earthquake. If these locations are considered to be active supports after taking up the gap between piping and grating, the unsupported spans will meet the pipe support spacing criteria.

The drain tank anchorage was evaluated for adequancy to withstand the 5% damped peak spectral acceleration for the base mat spectra at elevation 46'. The weak link in the tank anchorage was determined to be the 5/16 diameter embedded expansion anchors on the tank legs. Using a safety factor of five on average pull out strength in 3000 psi concrete as an allowable bolt load, the tank anchorage was found to be adequate for the full tank condition.

Pipe supports were not analyzed in detail but were subjectively determined to be adequate on the basis of the small loading that could occur during the DBE. As an example, the empty pipe weighs only 0.415 pounds per foot. The peak spectral accelerations for 5% damping at elevation 81'-6" are 0.55g NS, 0.29g EW and 0.19g V. The vector sum of 1.5 times these values is about 1g. Thus, the average support reactions for a 1g acceleration on a 37' continuous span are less than 16 pounds. The U-bolt clamps and pipe straps used for supports can easily carry much more than this value.

Conclusions

By applying simple analytical approximations and conducting simple hand calculations, it was determined that the current RCP lube oil drain system will not fail during a design basis earthquake of 0.15g. In one instance, the supporting effect of a floor grating had to be considered to reach this conclusion. While mobilization of the floor grating as a support would not normally be considered in a piping system design, the beneficial effect is nevertheless present and should be considered in making estimates of the actual capacity of the system.

APPENDIX A

BASIS FOR SEISMIC SUPPORT SPACING TABLES AND CHARTS

This Appendix presents a discussion of the analytical basis and procedures used for the development of tables and charts which can be employed to make an approximate evaluation of unsupported spans of non-seismic piping. In brief, the basic procedure to use the tables and charts is to first select a maximum allowable length between supports of an "equivalent" straight pipe for the particular pipe size, material, and seismic acceleration from the tables of Appendix B. With this length, and the configuration (one-bend; two-bend, in-plane; etc.) of the pipe being analyzed, the approximate maximum spacing between seismic supports can be selected from the charts of Appendix C. The basis for the tables and charts is as follows.

SPACING TABLES - (APPENDIX B)

The tables of Appendix B are developed for the case of a continuous, straight, horizontal pipe of four equal spans. For this case, where the seismic load is assumed to act as a uniform load over all spans, the maximum bending moment in a span is determined by the relationship:

$$M = 0.107\ G\ w\ \ell_m^2 \qquad (1)$$

where:

- M = bending moment (lb-in.),
- G = seismic acceleration (multiple of gravity), not to be confused with acceleration of gravity, g,
- w = uniform weight distribution of pipe (lb/in),
- ℓ_m = length of pipe span between supports (in).

The acceptance criteria equation is derived from the ASME Code, Section III, Division 1, Nuclear Power Plant Components, Subsection ND, Class 3 components, ND-3600.

$$\frac{PD_o}{4t_m} + \frac{0.75i \ M_A}{Z} + \frac{0.75i \ M_B}{Z} \lesssim 2.4 \ S_h \qquad (2)$$

where:

P	=	Internal design pressure
D_o	=	Outside diameter of pipe
t_m	=	Wall thickness of pipe including corrosion allowance
M_A	=	Moment due to sustained loads
M_B	=	Moment due to occasional loads (DBE, in this case)
Z	=	Section modulus of pipe
i	=	Stress intensification factor from the code
S_h	=	Allowable stress from the Code Appendices

In addition, the product of 0.75i can not be less than 1.0. In the case of straight pipe, i = 1.0, therefore 0.75i = 1.0.

The seismically induced stress, σ_s, for straight pipe is calculated as:

$$\sigma_s = \frac{M_B}{Z} \qquad (3)$$

If the stress σ_s is assumed to be a maximum permissible seismic stress, then the maximum span length between supports that is permissible without exceeding this stress can be obtained by substituting Equation (3) into Equation (1) and solving for ℓ_m:

$$\ell_m = \left[\frac{9.35 \ \sigma_s \ Z}{G \ w}\right]^{1/2} \qquad (4)$$

Thus, if an allowable seismic stress σ_s and the seismic loading (as expressed by the acceleration G) can be selected, the maximum span length can obtained from Equation (4). The allowable stress and seismic loading are discussed further in the following sections.

Allowable Stresses (σ_s)

The allowable seismic stress used in Equation (4) is obtained by subtracting from an allowable total stress, allowances for deadweight stresses and pressure stresses. From the code acceptance criteria, the maximum allowable stress permitted in the pipe is 2.4 S_h. A reasonable approximate allowance for the deadweight stress is 0.1 S_h, based on the normally used spacing for supports of piping systems as expressed in the B31.1 Power Piping code used in the original design of non seismic category piping.

The allowance for pressure stress was selected as 0.5 S_h based on the assumption that the pipe wall thickness was selected on the basis of pressure stress in the hoop direction by the simple relationship:

$$S_h = \frac{PD_o}{2t_m} \tag{5}$$

Since the stress in the longitudinal direction is equal to half the hoop stress, it was assumed that one-half the allowable stress margin in the longitudinal direction is "used" by the pressure in the pipe and the remainder is available for dead load and seismic stresses. Equation (5) above, is a simplification of the B31.1 Code criteria for pipe wall thickness, Paragraph 104, Equation 3, which rearranged, gives:

$$S_h = \frac{P(D_o - 0.8\ t_m)}{2t_m} \tag{6}$$

Since t_m in the pipe for many practical cases does not exceed 0.1 D_o, and is more typically less than this value, the simplified formulation of

Equation (5) is reasonable. Given the approximate nature of the method, the simplified version of the pressure stress formulation of Equation (5) was selected for all schedules and sizes of pipe.

Thus, using the above allowances for dead load and pressure, the maximum permissible seismic stress becomes:

$$\sigma_s = 2.4\ S_h - 0.1\ S_h - 0.5\ S_h = 1.8\ S_h \qquad (7)$$

If equation (7) is substituted into Equation (4), the expression for ℓ_m becomes:

$$\ell_m = \left[\frac{16.83\ S_h\ Z}{G\ w} \right]^{1/2} \qquad (8)$$

The above equation was developed for faulted condition loading only where faulted condition is defined as normal plus SSE loading. Load combinations for the OBE event are not considered in evaluating system interactions.

For the case of threaded piping, a code specified stress intensification factor of 2.3 was applied to account for the possibility of threaded couplings occurring at the point of maximum moment. Considering the stress intensification factor to apply to deadweight and seismic stress, the equation for span length becomes:

$$\ell_m = \left[\frac{9.38\ S_h\ Z}{G\ w} \right]^{1/2} \qquad (9)$$

<u>Seismic Loading</u>

Seismic loading on the piping system is represented by the term G w, Equation (1). The accelerations, G, used in this Appendix for development of tables in Appendix B span from 0.5g to 1.5g in 0.5g increments.

The above values are horizontal accelerations assumed to act in each direction. At lower levels where most of the piping under consideration is located, the peak vertical spectral accelerations are approximately 2/3 of the horizontal peak spectral accelerations. For purposes of developing pipe support tables, vertical accelerations were assumed to be equal to the horizontal values. This is conservative at all elevations. Responses due to the two horizontal and one vertical directions were combined by the square-root-of-the-sum-of-the-squares method to obtain total response. The appropriate acceleration level, G, to be employed in design should be selected as follows. First, select the appropriate floor response spectrum applicable at the points of support of the piping system in question. This step will automatically include the appropriate damping value for the piping. Second, select the acceleration G as a fraction of the peak spectral acceleration of the floor response spectrum. This can be expressed as

$$G = K_s Sa_p \qquad (10)$$

where

K_s = fraction of the peak of the applicable floor response spectrum,

Sa_p = peak (maximum) spectral acceleration of the applicable floor response spectrum.

The value of K_s to be used depends upon the degree of conservatism that is required in the analysis. For final confirmation of seismic design adequacy, the U.S. Nuclear Regulatory Commission requires that a conservative value of K_s = 1.5 be used when an equivalent static coefficient method, such as outlined in this Appendix, is used to verify design and further dynamic analyses are not performed (Reference A-1). When dynamic analyses are used to verify design of piping systems which have been laid out and supported using procedures similar to those portrayed in this report, it has been determined statistically that it can be expected that approximately one line in 50, will be overstressed as determined by dynamic analysis when a coefficent of K_s = 0.6 is used (Reference A-2).

Thus, in using the tables of Appendix B, peak floor response spectral acceleration, Sa_p, for the piping system being evaluated should be determined and multiplied by K_s. For purposes of making field judgements as to the likelihood of failure of Indian Point Unit 3 non seismic piping, a value of K_s equal to unity was used. This is considered to be conservative and to result in a very low probability of exceeding code allowable stress and essentially zero probability of pipe failure.

Table Series B2 was developed for threaded piping assuming a threaded joint at the point of maximum moment. A stress intensification factor of 2.3 from the ANSI B31.1 power piping code was applied at the threaded joint. Table Series B2 may also be used for piping of 2-inch diameter and less, connected by socket welds where maximum moment is assumed to occur at the socket weld. The appropriate stress intensification factor for socket welds is 2.1 and the 2.3 factor used for threaded pipe bounds this value. Also, the allowable stress, S_h, for threaded pipe is 12 ksi based on an assumed material of A-53-Grade A.

Piping materials, sizes, schedule, and allowable stress, S_h, for which tables were developed are summarized in Table A-1.

Support span spacings for schedule 40 piping for 1" and 2" diameters are almost identical to those listed in Table A-1 for schedule 80. The strengthening effect of increased moment of inertia is negated by the increased pipe weight, thus, for all practical purposes, the 1" and 2" diameter support spacing tables apply to both Schedule 40 and Schedule 80 piping.

DESIGN CHARTS FOR VARIOUS PIPE CONFIGURATIONS - (APPENDIX C)

Seismic support spacings in the tables of Appendix B were developed for straight, horizontal pipes continuous over multiple supports. These tables can be used to select maximum span lengths which will keep the stresses in the pipes within prescribed limits. Using these tables, modified by the charts of Appendix C, seismic support spacings can be obtained for other configurations of pipe. Specifically, in Appendix C, normalized, non-dimensional seismic design charts have been prepared for the following four basic configurations:

1. One-bend;
2. Two-bend, in-plane;
3. Two-bend, out-of-plane;
4. Branch connection of equal branch diameter

These configurations are shown in Figure A-1. The basic idea of the charts developed for Appendix C is that they permit evaluation of span spacing (Figure A-1) if l_m (from Appendix B) and the ratios l_2/l_m for one-bend or the ratios l_2/l_m and l_1/l_m for the other configurations are known.

Derivation of the Charts

The charts of Appendix C were derived by computer analysis of selected configurations and orientations. The charts in Appendix C are an extension of previous work where a series of charts were prepared for a large number of pipe sizes, schedules, materials and temperatures. The previous work, however, assumed constant stress intensification factors for all sizes of piping elbows and tees. The charts contained in Appendix C of this report specifically address stress intensification factors for threaded joints and for different pipe sizes. Some of the original work was scaled to more specific conditions being addressed and verification computer analyses were conducted to validate the scaling process. Several general aspects of the derivation of the charts are as follows.

An earthquake in two horizontal directions and a simultaneous vertical earthquake with an acceleration equal to the horizontal acceleration have been considered. Internal moments from these directions have been combined on a square-root-of-the-sum-of-the-squares basis. The two horizontal seismic inertia forces were assumed to be oriented parallel and perpendicular to the horizontal runs of the piping system.

The branch connection fitting assumed in the preparation of Appendix B charts for full penetration butt welded piping is a butt welding tee per ANSI B16.9, as shown in the B31.1 Code, Appendix D and uses a stress intensification factor as follows:

$$i = 0.9/(4.4t_m/r)^{2/3}$$

where

t_m = wall thickness of the tee.

r = mean radius of the tee.

The elbow fitting used is a long radius (R = 1.5 diameter) welding elbow with a stress intensification factor as follows:

$$i = 0.9/(t_m R/r^2)^{2/3}$$

For threaded piping all tee and elbow joints are threaded and a stress intensification factor of 2.3 is used. This factor exceeds stress intensification factors for all tee and elbow fittings except the case of an 8-inch schedule 40 elbow where the stress intensification factor is 2.44. The 2.3 factor for threaded pipe joints was considered sufficiently close to 2.44 for purposes of chart development that a special case was not considered for 8-inch schedule 40 elbows. Some sample cases were conducted to verify that support spans base on i = 2.3 did not result in an elbow overstress condition for 8-inch schedule 40 pipe. In the cases tested, maximum stress always occurred at the support locations and not the elbow when considering threaded joints to exist at or near the pipe supports.

Table A-2 summarizes the stress intensification factors calculated for all sizes of pipe considered. In order to minimize the number of cases to be run, stress intensification factors that bounded those in Table A-2 were utilized. To avoid unnecessary conservatism, the bounding was conducted by pipe size groups. Table A-3 shows the stress intensification factors used in the bounding analyses.

Use of the Charts

In general, the charts are used as follows:

a. Find the maximum length, l_m, from the tables of Appendix B.

b. Obtain the ratio l_2/l_m, for the single bend or the ratios l_1/l_m and l_2/l_m for the other cases by direct calculation.

c. Refer to the charts of Appendix C to obtain l_1/l_m for the single bend or l_3/l_m for the other cases.

d. Calculate l_1 (single bend) or l_3 (other cases) which is the maximum permissible distance to the next seismic support.

As an approximation for large concentrated weights, it is suggested that the concentrated weight be replaced by an equivalent span length of pipe multiplied by 1.5. For example, if a valve weighs 100 lb in a line having a unit weight of 2 lb/in, the effective length is (1.5) (100/2) = 75 in. The coefficient of 1.5 is based on the ratio of maximum moment in a fixed-end beam with load at the center, $Wl/8$, to the same beam uniformly loaded, $Wl/12$, where $W = wl$ and w is the load per unit length of beam.

The tables and charts provided do not consider any intermediate supports and restraints. In developing the tables and charts, it was assumed that the terminal ends of all support configurations were continuous, straight pipes.

REFERENCES

A-1 "Equivalent Static Load Method," U.S. Nuclear Regulatory Commission, Standard Review Plan, Section 3.7.2. II 1.6, June, 1975.

A-2 Stevenson, J. D., "Seismic Design of Small Diameter Pipe and tubing for Nuclear Power Plants," Paper No. 314, 5th World Conference on Earthquake Engineering, Rome, 1973.

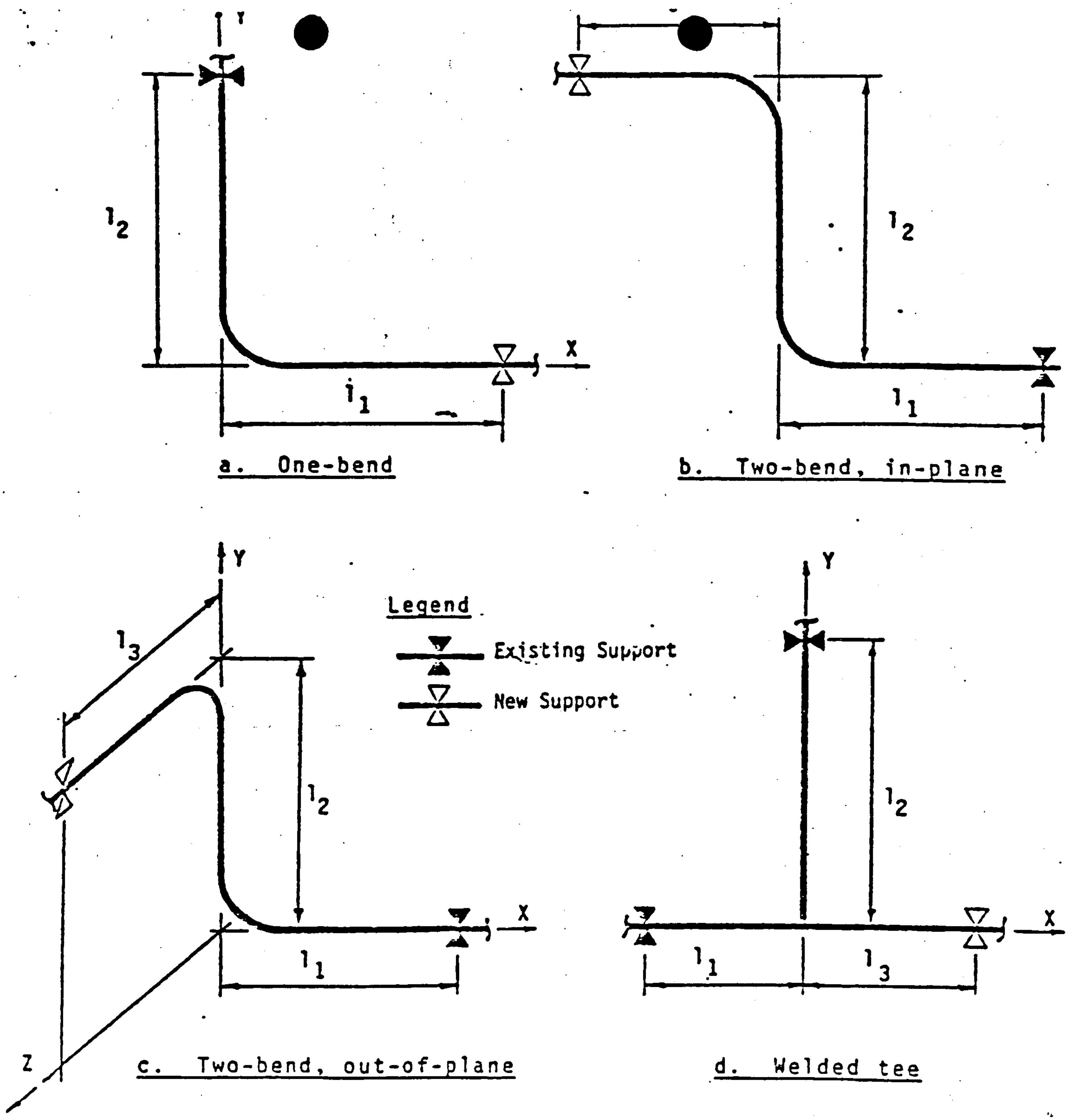


FIGURE A-1 PIPING CONFIGURATIONS

TABLE A-1

APPLICABLE PIPE SIZES

System	Size	Schedule	Material	S_h
Full Penetration Butt Welded Piping	1"	30	Seamless ASTM-106B	15 ksi
↓	2"	80	↓	↓
	3"	40		
	4"	40		
	6"	40		
	8"	40		
Threaded Piping	2"	80	Seamless ASTM-A53 Gr A	12 ksi
↓	2-1/2"	40	↓	↓
	3"	↓		
	4"			
	6"			
	8"			

TABLE A-2

STRESS INTENSIFICATION FACTORS FOR PIPE COMPONENTS

Nominal Pipe Size	Schedule	O.D. (inches)	Stress Intensification Factor		
			Elbow**	Welding Tee	Threaded Joints
1	80	1.315	1.09*	1.0*	2.3
2	80	2.375	1.32*	1.0*	2.3
2-1/2	40	2.875	1.59	1.18	2.3
3	40	3.5	1.78	1.30	2.3
4	40	4.5	1.95	1.45	2.3
6	40	6.625	2.27	1.69	2.3
8	40	8.625	2.44	1.84	2.3

* Stress intensification factor of 2.1 should be used for fittings under 2 inches if socket welds were used.

** Radius of the bend = 1.5 x (nominal pipe diameter)

TABLE A-3

BOUNDING STRESS INTENSIFICATION FACTORS FOR PIPE COMPONENTS

Nominal Pipe Size	Schedule	Bounding Stress Intensification Factor			
		Elbow	Welding Tee	Socket Weld	Threaded Joints
1	80	1.33	1.33	2.3	2.3
2	80	1.33	1.33	2.3	2.3
2-1/2	40	1.8	1.33	N/A	2.3
3	40	1.8	1.33	N/A	2.3
4	40	2.15*	1.66	N/A	2.3
6	40	2.3	1.66	N/A	2.3
8	40	2.3	1.84	N/A	2.3

* This was an existing case from prior work, thus, special cases were not run for i = 1.95 for 4" elbows

APPENDIX B

SPACING TABLES TO DEFINE SPAN LENGTH FOR STRAIGHT PIPE CONFIGURATIONS

The tables in this appendix are organized by:

1. Piping Joint Type
2. Horizontal Input Acceleration Level
3. Pipe Schedule and Geometary

The combination of material and operating temperature defines the allowable stress. The material for full penetration butt welded pipe is assumed to be ASTM A-106 Grade B and the allowable stress, S_h, is constant up to 650°F. Threaded pipe is assumed to be ASTM-A-53 Grade A and the allowable stress is constant up to 300°F. None of these temperature limits are expected to be exceeded for any of the postulated sources. The specific series of tables provided are listed in Table B-1.

In the use of these tables, the appropriate span length, l_m, may be determined for both the empty and full cases. None of the cases considered insulation on the piping. For insulated piping, span spacings may be adjusted by using equation 4 of Appendix A to ratio the support spacing for a new weight, W.

TABLE B-1

SPACING TABLES FOR STRAIGHT PIPE

Table Series	System	Material	S_h, psi	Accel. Levels
B-1	Full Penetration Butt Welds	A 106B	15,000	0.5 to 1.5g
B-2	Threaded Piping (threaded joints in span or near support)*	A 53 Gr. A	12,000	0.5 to 1.5g

*Also used for 1" and 2" diameter piping with socket welds

TABLE SERIES B-1

SYSTEM	FULL PENETRATION BUTT WELDS (No Socket Welds)
MATERIAL	ASTM A106, GRADE B CARBON STEEL, S_h = 15 ksi
CODE	ASME SECTION III, ND3600
HORIZONTAL INPUT ACCELERATION	0.5g to 1.5g

TABLE B1-1

SPACING TABLE TO DEFINE SPAN LENGTH FOR STRAIGHT PIPE
RUNS BASED ON STATIC ANALYSIS USING PEAK SPECTRA ACCELERATION

MATERIAL--A106 C.S.,GR.B
ASME CLASS 2 AND 3
CODE ALLOWABLE STRESS = 15.0KSI
G-HORIZONTAL INPUT ACCELERATION = .5G

NOMINAL IPS SIZE INCHES	DIMENSIONS--INCH OUTSIDE DIAMETER	WALL THICK	WEIGHT LBS PER INCH EMPTY	FULL	SUPPORT SPACING INCHES EMPTY	FULL
1.0	1.315	.179	.181	.207	563.000	526.547
2.0	2.375	.218	.419	.525	789.626	704.945
2.5	2.875	.203	.467	.655	887.310	761.462
3.0	3.500	.216	.631	.698	987.798	828.149
4.0	4.500	.237	[illegible]	1.358	1129.748	919.176
6.0	6.625	.280	1.561	2.626	1385.172	1074.764
8.0	8.625	.322	2.379	4.175	1588.201	1198.321

TABLE B1-2

SPACING TABLE TO DEFINE SPAN LENGTH FOR STRAIGHT PIPE
RUNS BASED ON STATIC ANALYSIS USING PEAK SPECTRA ACCELERATION

MATERIAL--A106 C.S.,GR.B
ASME CLASS 2 AND 3
CODE ALLOWABLE STRESS = 15.00KSI
G-HORIZONTAL INPUT ACCELERATION = 1.0G

NOMINAL PIPE SIZE INCHES	DIMENSIONS--INCH OUTSIDE DIAMETER	WALL THICK	WEIGHT LBS PER INCH EMPTY	FULL	SUPPORT SPACING INCHES EMPTY	FULL
1.0	1.315	.179	.161	.207	358.101	372.325
2.0	2.375	.218	.419	.525	558.356	498.471
2.5	2.875	.203	.463	.655	627.423	538.435
3.0	3.500	.216	.631	.858	658.479	585.590
4.0	4.500	.237	.854	1.358	798.852	649.955
6.0	6.625	.280	1.861	2.626	979.464	759.973
8.0	8.625	.322	2.379	4.179	1123.028	847.341

TABLE B1-3

SPACING TABLE TO DEFINE SPAN LENGTH FOR STRAIGHT PIPE
RUNS BASED ON STATIC ANALYSIS USING PEAK SPECTRA ACCELERATION

MATERIAL--A106 C.S.,GR.B
ASME CLASS 2 AND 3
CODE ALLOWABLE STRESS = 15.0KSI
G-HORIZONTAL INPUT ACCELERATION = 1.56

NOMINAL PIPE SIZE INCHES	DIMENSIONS--INCH OUTSIDE DIAMETER	WALL THICK	WEIGHT LBS PER INCH EMPTY	FULL	SUPPORT SPACING INCHES EMPTY	FULL
1.0	1.315	.179	.161	.207	325.048	304.002
2.0	2.375	.218	.419	.525	455.891	407.000
2.5	2.875	.203	.483	.655	512.289	439.630
3.0	3.500	.216	.631	.898	570.306	478.132
4.0	4.500	.237	.899	1.358	652.260	530.686
6.0	6.625	.280	1.581	2.626	799.729	620.515
8.0	8.625	.322	2.379	4.179	916.946	691.851

<u>TABLE SERIES B-2</u>

SYSTEM	1. 2" OR LESS DIAMETER PIPES WITH SOCKET WELDS 2. THREADED PIPE WITH THREADED COUPLINGS IN SPAN OR NEAR SUPPORTS
MATERIAL	TABLES BASED ON ASTM A53, GRADE A, CARBON STEEL, S_h = 12 ksi
CODE	ASME SECTION III, ND3600
HORIZONTAL INPUT ACCELERATION	0.5g to 1.5g

TABLE B-2-1

SPACING TABLE TO DEFINE SPAN LENGTH FOR STRAIGHT PIPE RUNS BASED ON STATIC ANALYSIS USING PEAK SPECTRA ACCELERATION

MATERIAL-- A53 C.S..GR.A
ASME CLASS 2 AND 3
CODE ALLOWABLE STRESS = 12.00KSI
G-HORIZONTAL INPUT ACCELERATION = .5G

NOMINAL PIPE SIZE INCHES	DIMENSIONS--INCH OUTSIDE DIAMETER	WALL THICK	WEIGHT LBS PER INCH EMPTY	FULL	SUPPORT SPACING INCHES EMPTY	FULL
1.0	1.315	.179	.181	.207	372.512	348.393
2.0	2.375	.218	.419	.525	522.461	466.431
2.5	2.875	.203	.483	.655	587.095	503.827
3.0	3.500	.216	.631	.898	653.583	547.950
4.0	4.500	.237	.895	1.358	747.505	608.179
6.0	6.625	.280	1.581	2.626	516.508	711.125
8.0	8.625	.322	2.379	4.179	1050.844	792.877

TABLE B-2-2

SPACING TABLE TO DEFINE SPAN LENGTH FOR STRAIGHT PIPE
RUNS BASED ON STATIC ANALYSIS USING PEAK SPECTRA ACCELERATION

MATERIAL-- A53 C.S.,GR.A
ASME CLASS 2 AND 3
CODE ALLOWABLE STRESS = 12.00KSI
G-HORIZONTAL INPUT ACCELERATION = 1.0G

NOMINAL PIPE SIZE INCHES	DIMENSIONS--INCH OUTSIDE DIAMETER	WALL THICK	WEIGHT LBS PER INCH EMPTY	FULL	SUPPORT SPACING INCHES EMPTY	FULL
1.0	1.315	.179	.181	.207	263.406	246.351
2.0	2.375	.218	.419	.525	369.436	329.817
2.5	2.875	.203	.483	.655	415.139	356.259
3.0	3.500	.216	.631	.898	462.153	387.459
4.0	4.500	.237	.859	1.358	528.566	430.047
6.0	6.625	.280	1.561	2.626	648.069	502.841
8.0	8.625	.322	2.379	4.179	743.059	560.649

TABLE B-2-3

SPACING TABLE TO DEFINE SPAN LENGTH FOR STRAIGHT PIPE
RUNS BASED ON STATIC ANALYSIS USING PEAK SPECTRA ACCELERATION

MATERIAL-- A53 C.S..GR.A
ASME CLASS 2 AND 3
CODE ALLOWABLE STRESS = 12.00KSI
C-HORIZONTAL INPUT ACCELERATION = 1.5G

NOMINAL PIPE SIZE INCHES	DIMENSIONS--INCH OUTSIDE DIAMETER	WALL THICK	WEIGHT LBS PER INCH EMPTY	FULL	SUPPORT SPACING INCHES EMPTY	FULL
1.0	1.315	.179	.181	.207	215.070	201.145
2.0	2.375	.218	.419	.525	301.643	269.294
2.5	2.875	.203	.483	.655	338.959	290.884
3.0	3.500	.216	.631	.898	377.347	316.359
4.0	4.500	.237	.659	1.358	431.572	351.132
6.0	6.625	.280	1.581	2.626	529.146	410.568
8.0	8.625	.322	2.379	4.179	606.705	457.768

APPENDIX C

CHARTS TO DETERMINE SUPPORT SPACING FOR ONE-BEND; TWO-BEND, IN-PLANE; TWO BEND, OUT-OF-PLANE, AND FULL SIZE OUTLET BRANCH CONNECTION CONFIGURATIONS

The charts are organized by piping system configuration (Figure C-1) and stress intensification factors. In brief, they are used as follows:

In the case of configuration 1, knowing one leg of the run, l_2 the second leg l_1 may be found from the charts as follows:

1. Given material, input acceleration as a function of g level, pipe geometry, determine l_m from the tables (appendix B).

2. Given l_2 as the distance from the last located support to the center of the elbow, determine the ratio l_2/l_m.

3. Enter the charts in Appendix C for configuration 1 and read l_1/l_m on the abscissa.

4. Determine l_1 and locate the next support.

The treatment of configurations 2, 3, and 4 are similar; however, two legs must be known initially, l_2 and l_1. The procedure in these cases is:

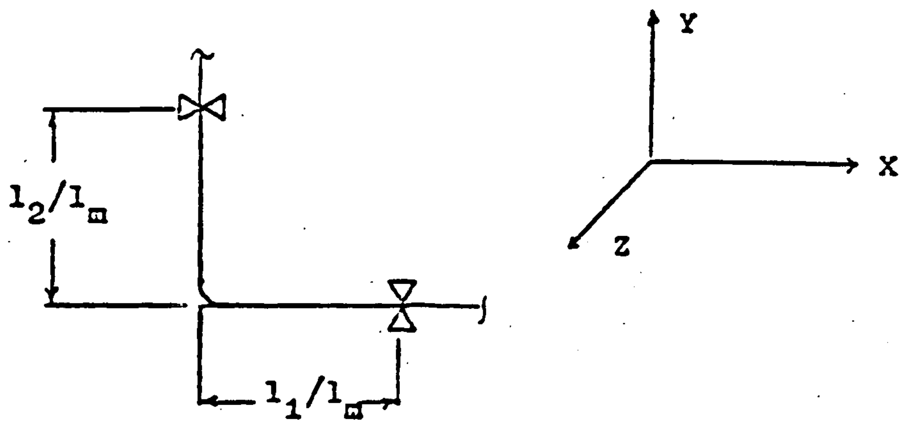
1. Given material, input acceleration, and pipe geometry, determine l_m from the tables (Appendix B).
2. Given l_2 and l_1, determine the ratios l_2/l_m and l_1/l_m.
3. Enter the charts for the appropriate configuration and read l_3/l_m on the abscissa.
4. Determine l_3 as the allowable distance to the next support.

In the manner described above it is possible to sequentially locate seismic support spacings for piping systems. Charts are only shown for the threaded pipe cases. Charts developed for full penetration butt weld cases all indicate more liberal span spacings, thus the charts presented are conservative for evaluation of support spans. It can be seen from the charts that the combination of $l_1 + l_2$ for the single bend in plane case or $l_1 + l_2 + l_3$ for the other cases is always greater than l_m, thus for easy field observations and evaluations, all span combinations were compared to l_m for threaded pipe.

FIGURE C-1

CONFIGURATIONS AND COORDINATE AXES

Configuration 1: One-bend



Configuration 2: Two-bend, in-plane

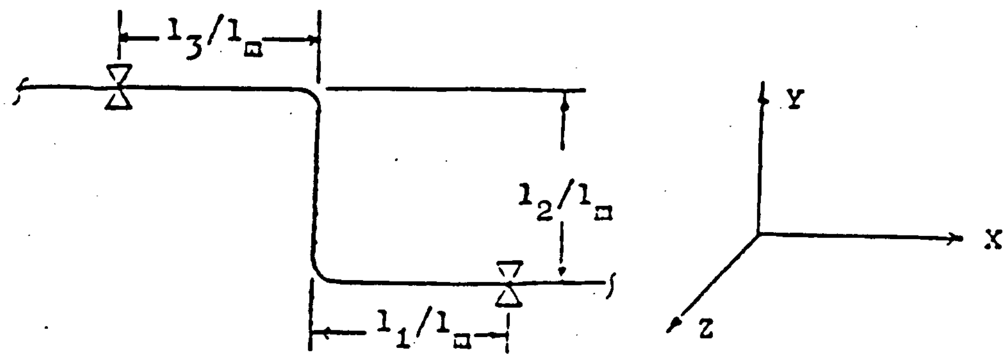
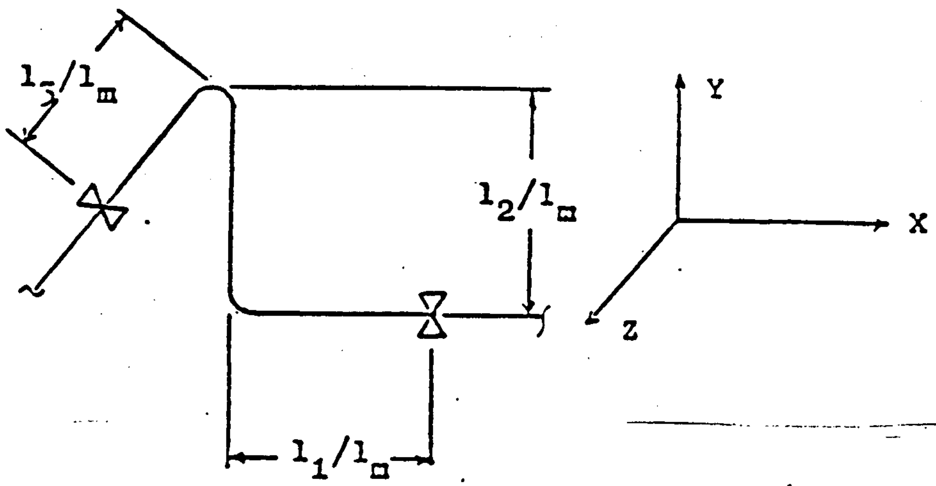


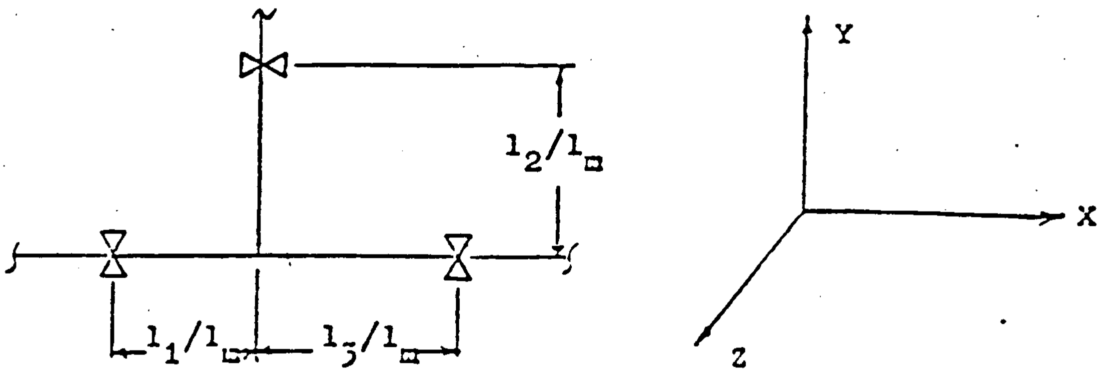
FIGURE C-1 (Continued)

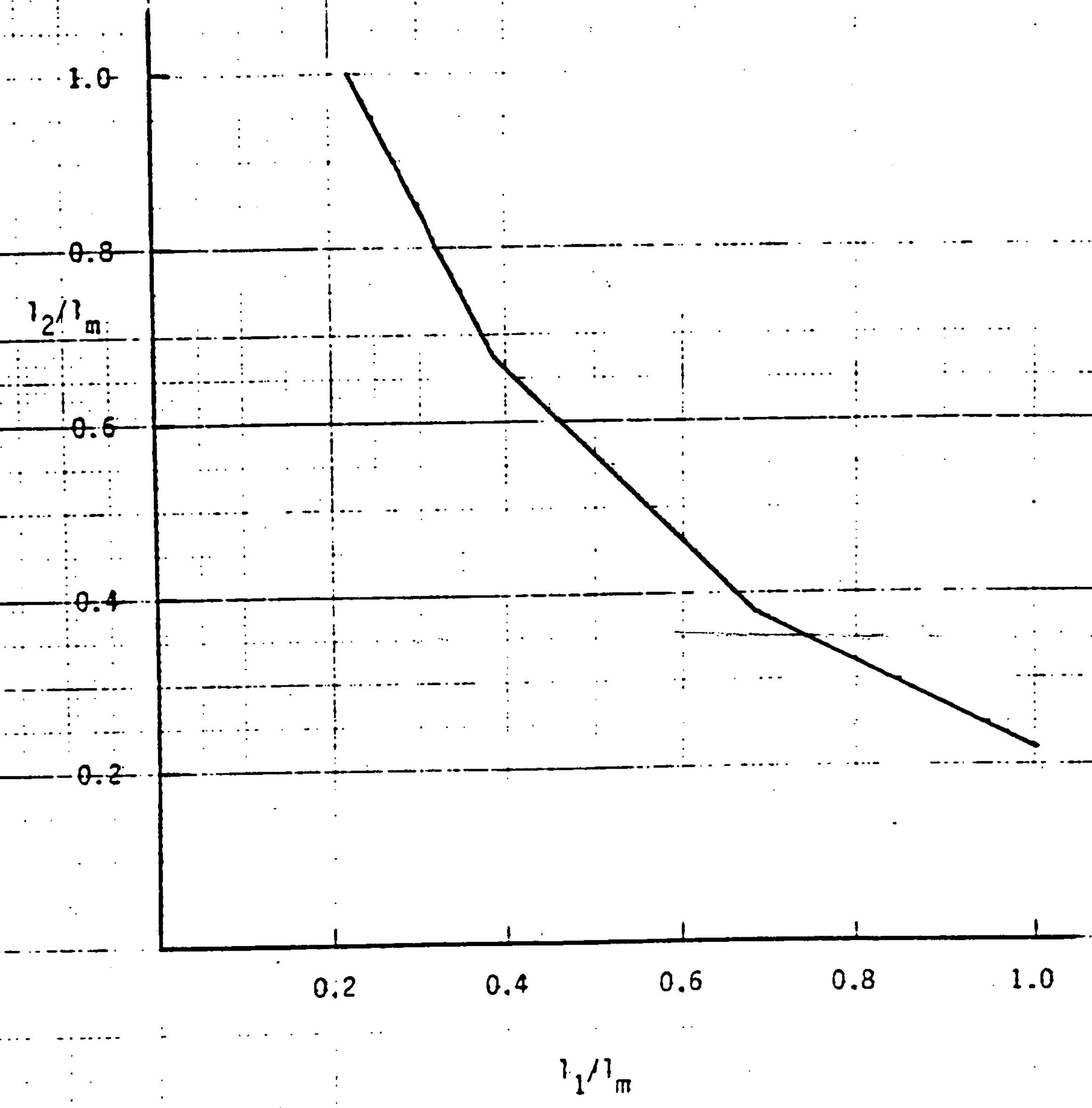
CONFIGURATIONS AND COORDINATE AXES (Continued)

Configuration 3: Two-bend, out-of-plane



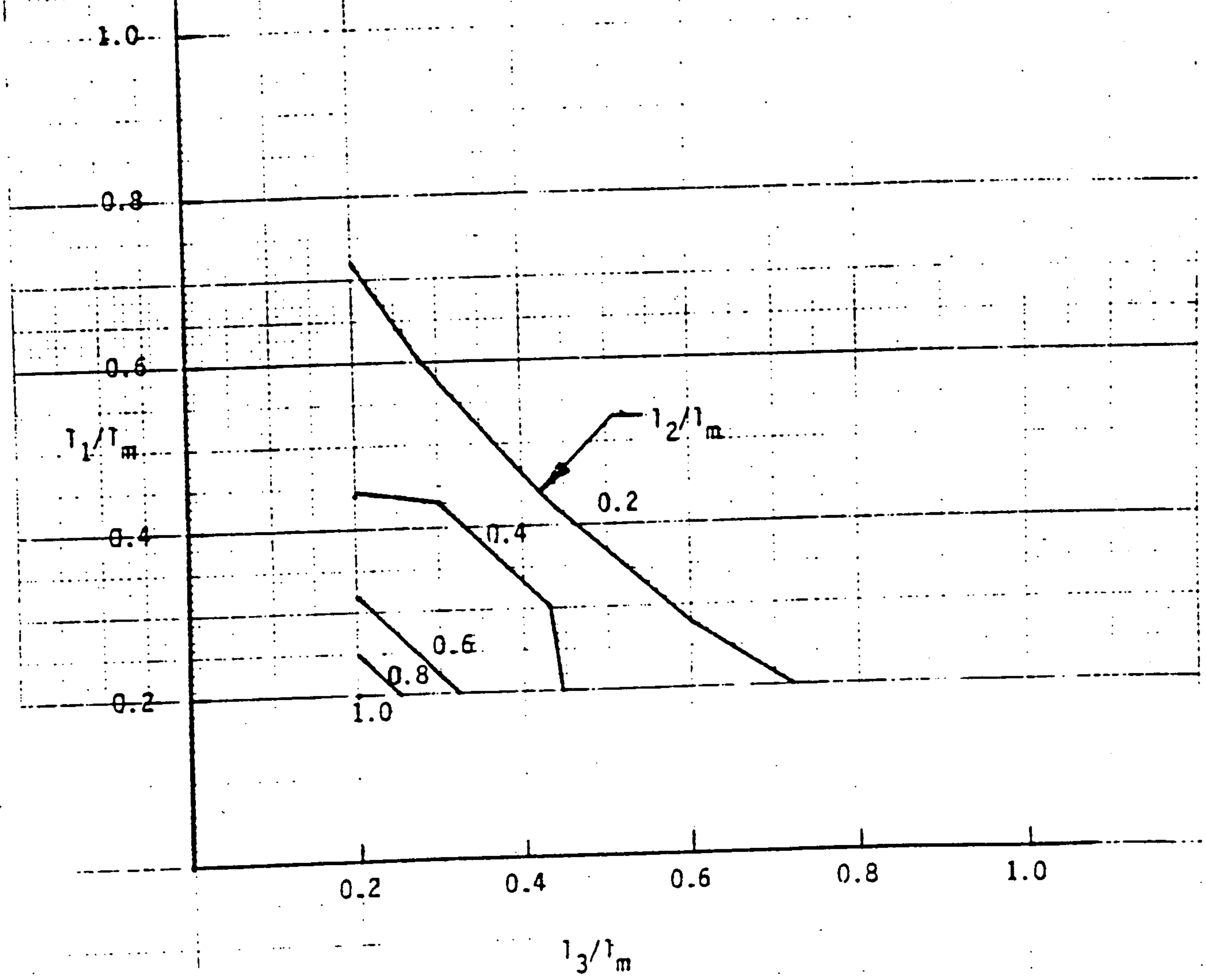
Configuration 4: Welded tee





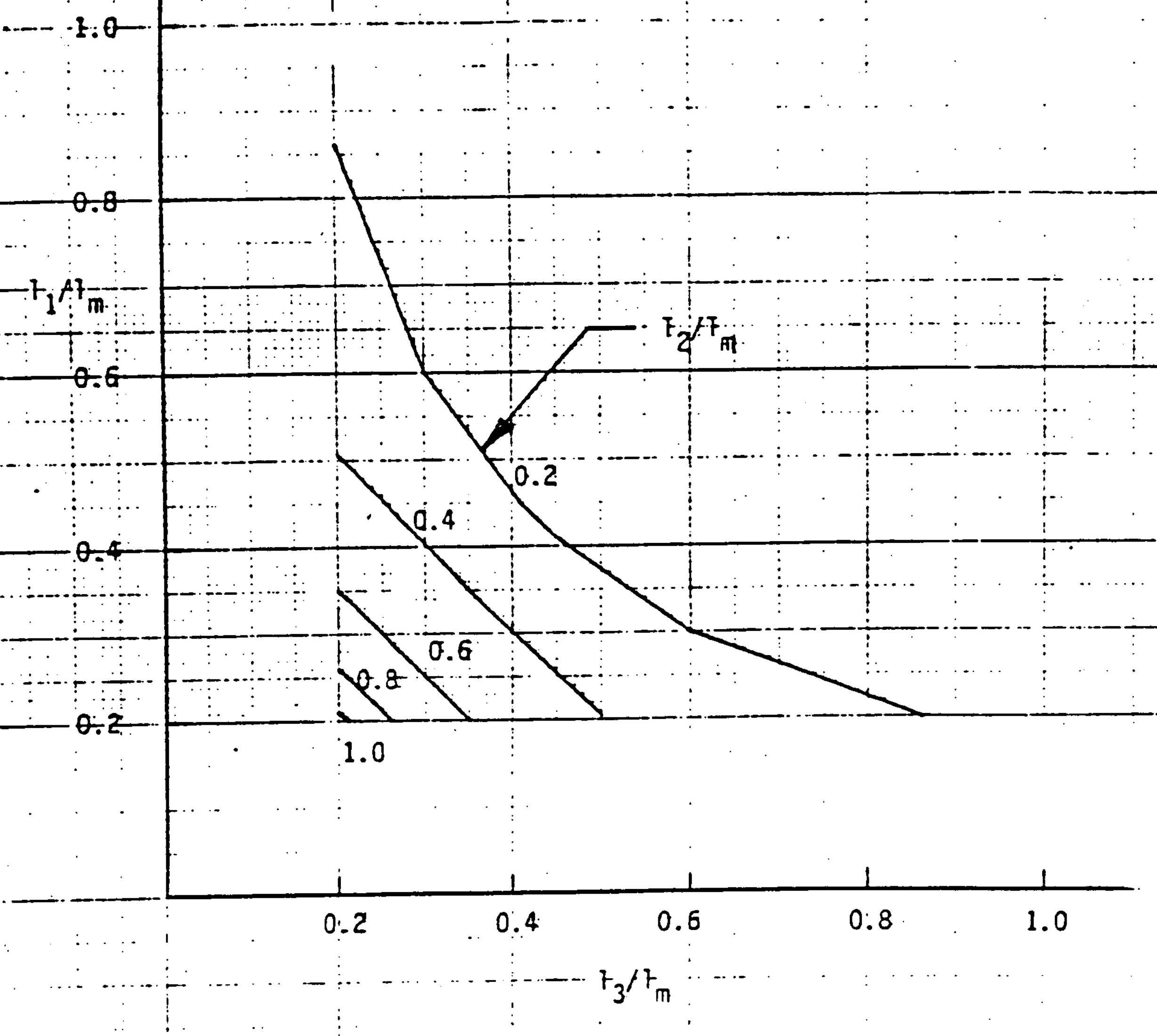
THREADED PIPE - ALL SIZE PIPES (ONE-BEND)

CHART C-1



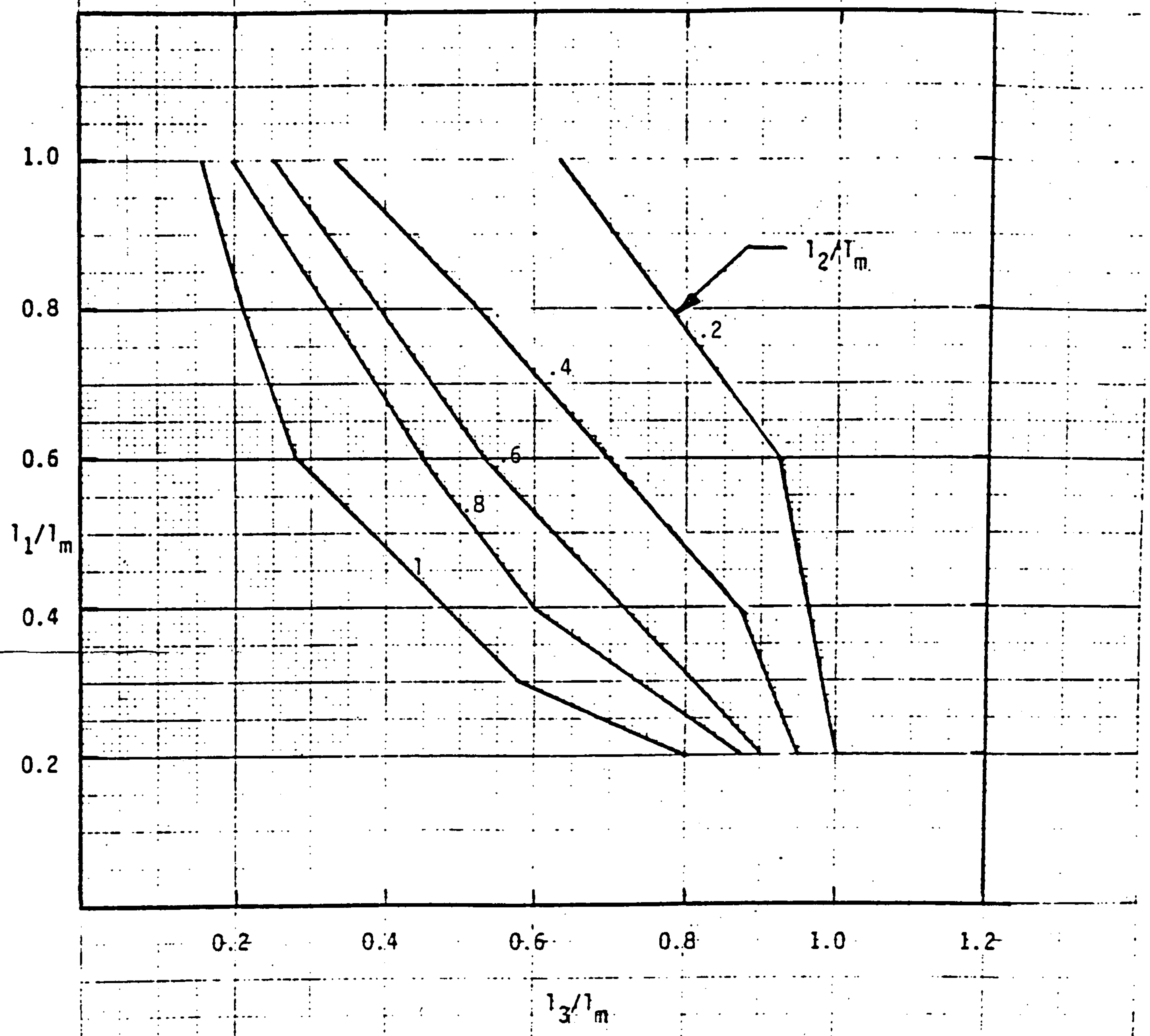
THREADED PIPE - ALL SIZE PIPES (TWO-BEND, IN-PLANE)

CHART C-2



THREADED PIPE - ALL SIZE PIPES (TWO-BEND, OUT-OF-PLANE)

CHART C-3



THREADED PIPE - ALL SIZE PIPES (FULL OUTLET BRANCH CONNECTION)

CHART C-4

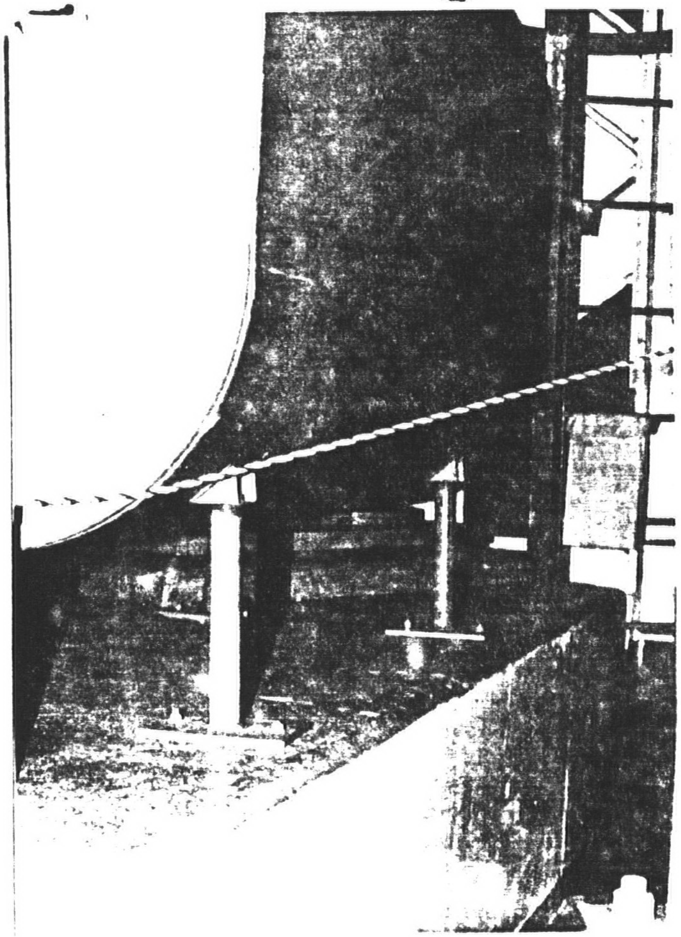


Figure 1

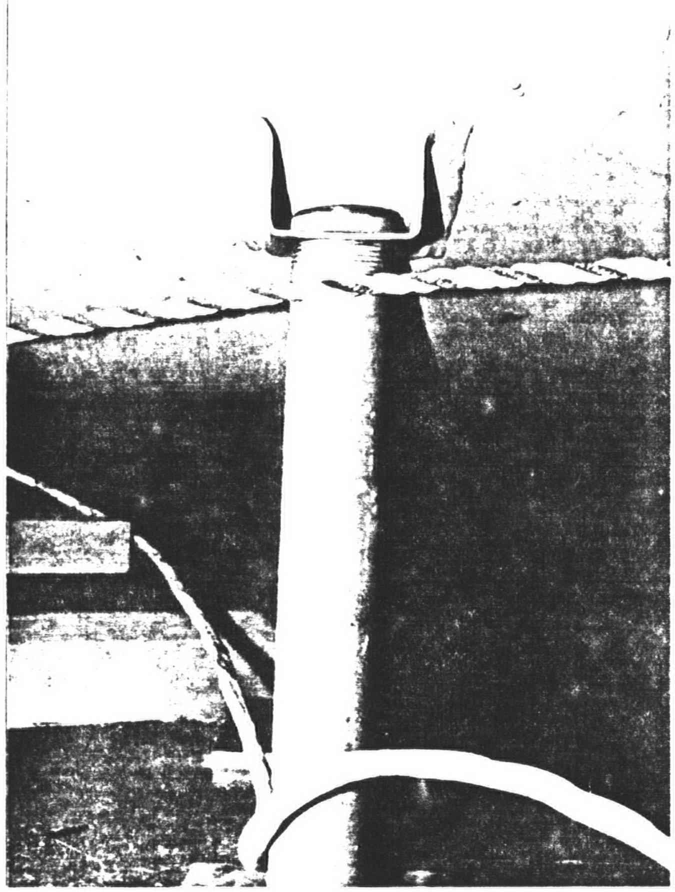


Figure 2

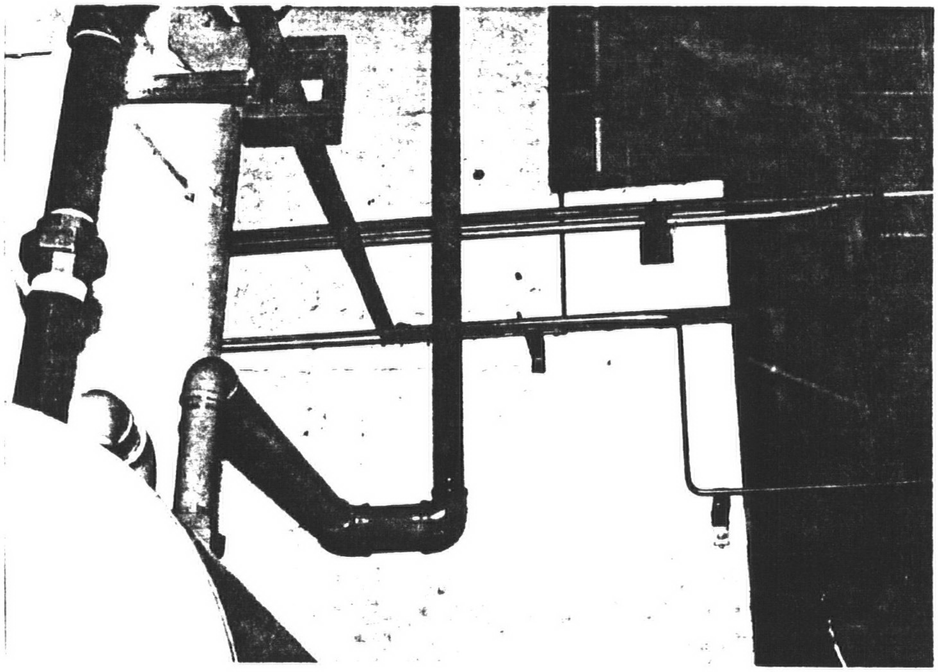


Figure 3

RCS LUBE OIL DRAIN SYSTEM

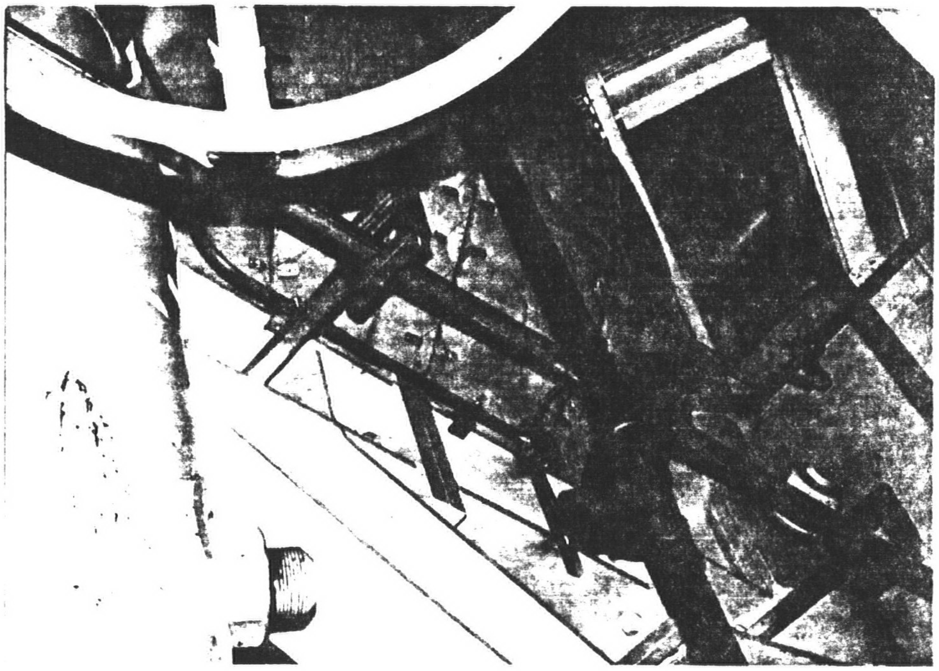


Figure 4

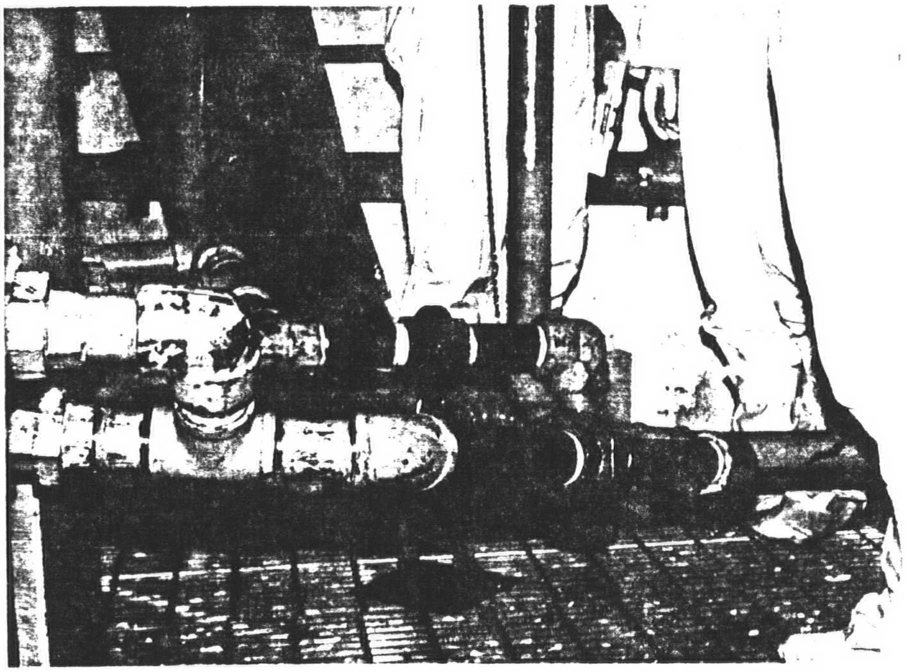


Figure 5

RCS LUBE OIL DRAIN SYSTEM (continued)

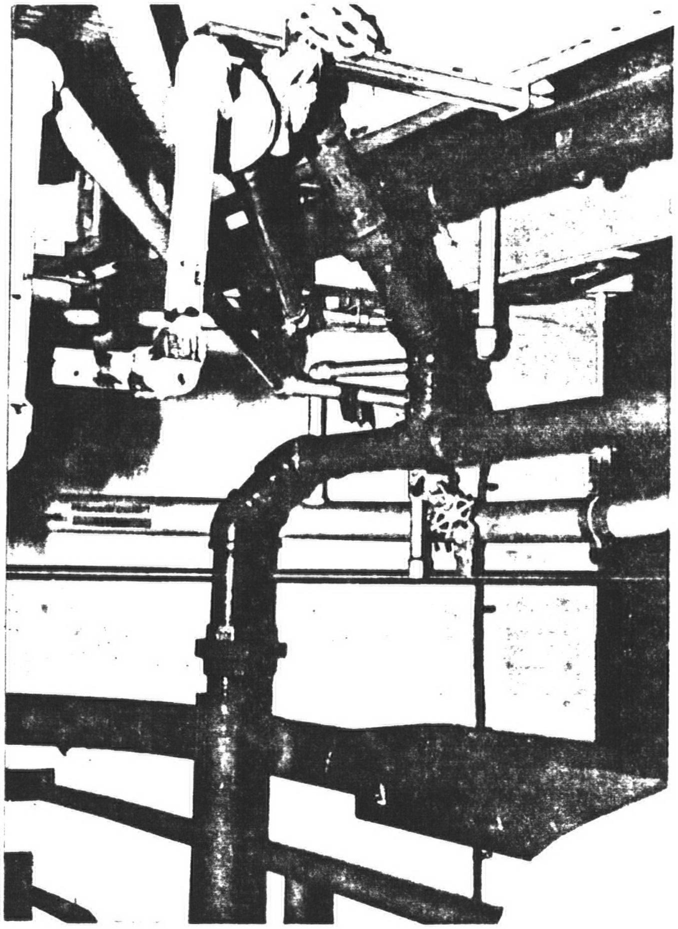


Figure 6

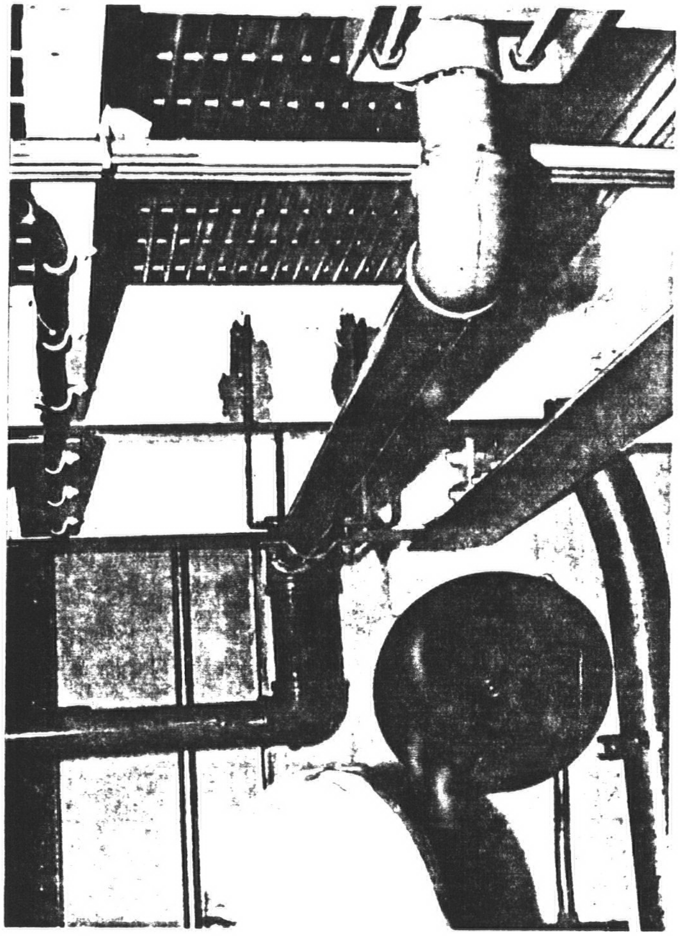


Figure 7

RCS LUBE OIL DRAIN SYSTEM (continued)