Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels

API RECOMMENDED PRACTICE 5LW
SECOND EDITION, DECEMBER 1996

EFFECTIVE DATE, MARCH 1, 1997

American Petroleum Institute

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Exploration and Production Department

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FOREWORD

Recommended Practice 5LW shall become effective on the date printed on the cover but may be used voluntarily from the date of distribution. This recommended practice is under the jurisdiction of the Subcommittee on Standardization of Tubular Goods of the American Petroleum Institute. Line pipe shipments on inland and marine waterways should be designed to assure that the pipe will arrive at the destination undamaged. The minimum mandatory rules in force for such shipments shall be followed. The rules of governing regulatory agencies shall be considered as basic, with the recommendations given herein as supplementary thereto. These supplementary recommendations are the result of line pipe shippers' experience that damage to the pipe during shipment can consist of three principal types as follows:

a. End damage: End damage to pipe can occur during loading and unloading, or from a longitudinal load shift against a bulkhead or an adjacent pipe.
b. Abrasions or peening: These result from a rubbing or pounding action against some protrusion such as the weld reinforcement of the adjacent pipe. This condition may result in initiation of fatigue cracks at the damaged areas during transit.
c. Longitudinal fatigue cracks: These are initiated in the pipe by vertical cyclical forces with no apparent local abrasion or denting. Fatigue cracks result from a combination of static and cyclic stresses produced by the weight of upper layers of pipe and/or other cargo giving a static load, and a cyclic load caused by the vertical movement.

Such damage, called *transit fatigue*, has been reported in pipe with diameter-to-thickness ratios as low as 12.5 and in line pipe grades from Grades B through X70. (See T.V. Bruno, "How To Prevent Transit Fatigue To Tubular Goods," *Pipe Line Industry*, July 1988, pp. 31-34.) Cracks have been found at three general locations: along the edge of submerged-arc welds; in the pipe base metal at areas of denting, metal-to-metal contact, or abrasion; and at the pipe ends.

The variables that influence transit fatigue include the magnitude of the static stress, the number and magnitude of the cyclic stresses, the size of the contact area, the nature of the bearing surface, the degree of surface damage, and the ambient environment. The stress limits given in 3.3 of this document are intended to keep static and cyclic stresses to levels sufficiently low to avoid transit fatigue. However, contact with hard surfaces, such as nailheads, bolts or other debris, steel stanchions, wire cables, and so forth, can lead to transit fatigue even when stresses are properly controlled. Corrosive atmospheres such as might be encountered in humid coastal or industrial areas can accelerate fatigue damage.

Transit fatigue generally causes multiple cracks emanating from the area of surface contact. A distinctive feature of transit fatigue is that cracks will usually be found at both the inside and outside surfaces.

Adherence to the recommendations herein should prevent transit fatigue cracking. It is also important to note that poor loading or shipping practices may lead to serious damage that may result in pipeline leaks or ruptures.

Suggested revisions are invited and should be submitted to the director of the Exploration and Production Department, American Petroleum Institute, 1220 L Street, N.W., Washington, DC. 20005.

CONTENTS

Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels

1 SCOPE

The recommendations in this document apply to transportation of API Specification 5L steel line pipe by ship or barge on both inland and marine waterways unless the specific requirement of a paragraph in this document references only marine or only inland waterway transport. *Inland waterways* are defined as those waterways with various degrees of protection, such as rivers, canals, intracoastal waterways, and sheltered bays. These waterways can be fresh or salt water but are usually traversed by barges. *Marine waterways are* defined as waterways over open seas with limited or no protection from wind, current, waves, and the like. These areas are normally traversed by sea-going vessels. These recommendations apply to steel line pipe that is 2⅜ inch outside diameter (OD) and larger. An exception is that the recommendations of Section 3 as concerned with load stresses are exclusively applicable to API line pipe having diameter-to-thickness (*D/t*) ratios of 50 and more. However, pipe with *D/t* ratios well below 50 may suffer fatigue in transit under some circumstances, as noted in the foreword.

These recommendations cover coated or uncoated pipe, but they do not encompass loading practices designed to protect pipe coating from damage. These recommendations are not applicable to pipe-laying vessels or supply vessels. They must be considered as supplementary to the existing rules of governing agencies.

These recommendations are supplemental to shipping rules for the convenience of purchasers and manufacturers in the specification of loading and shipping practices and are not intended to inhibit purchasers and manufacturers from using other supplemental loading and shipping practices by mutual agreement.

2 GENERAL REQUIREMENTS

2.1 Vessel Condition

Cargo compartments should be reasonably free from any foreign objects or material likely to cause either physical damage, contamination, or chemical reaction with the pipe.

The bilge pumping system shall be in working order to remove standing water from the cargohold.

2.2 Shipping Space

Pipe may be laid longitudinally or athwart the vessel to make the best use of available space. A clearance of 1 foot must be left between the ends of the pipe and the vessel (or other cargo) to facilitate unloading. Dimensions of hatchways should be large enough to allow the pipe to pass in a horizontal position unless special precautions are taken.

2.3 Handling Equipment

When end hooks are used for handling pipe, they shall be designed to prevent end damage and should be lined in the area of land (bevel face) contact with a cushioning material (for example, a nonmetallic material such as rubber or a metallic material such as aluminum, but brass or copper shall be excluded). These hooks shall also have sufficient width and depth to fit the internal curvature of the pipe. Rubber aprons should be attached to pipe hooks to protect the pipe ends unless adequate end protectors are used. Lifting shall be carried out in such a manner that impact loads sufficient to cause local denting or out-of-roundness of pipe body or pipe ends will not occur. When the pipe is loaded by loose lifts, all necessary precautions shall be taken during loading and unloading to prevent surface or other damage to the pipe.

2.4 Stacking Arrangement

2.4.1 STOWAGE

When stacking, one should consider the maximum weight that the bottom layer of pipe can withstand before deformation will occur. Short lengths should be placed on the top of the stack.

Pipe in the hold of a vessel during marine shipments shall be cantline stowed.

Cantline stowage shall be defined as stowage without separator strips (for example, nesting or pyramid fashion) but including wood blocking every other tier on both sides of the hull as illustrated in Figure 1. If the top tier is a partial load, separator strips shall be used to secure additional blocking, which is used to secure the top tier of pipe.

For inland waterway transit, pipe may be cantline stowed, or separator strips may be used between successive tiers of pipe.

Loaded pipe shall not contact the sides or bottom of the vessel. However, each length of pipe shall be in contact throughout its entire length with all adjacent pipe or blocking, and precautions should be taken to minimize any lateral movement.

Pipe with filler metal weld seams (SAW and GMAW) shall be positioned or padded in such a manner that the weld does not contact the blocking or adjacent pipe. When horizontal stripping (permissible only for transportation on inland waterways) is used to load straight filler metal weld seam pipe (SAW and GMAW), the weld seam shall be positioned at 45 degrees, ±5 degrees, from vertical. When nested, pipe with a straight filler metal weld seam (SAW and GMAW) shall be positioned with the seam at 0 degrees (in other words, 12 o'clock).

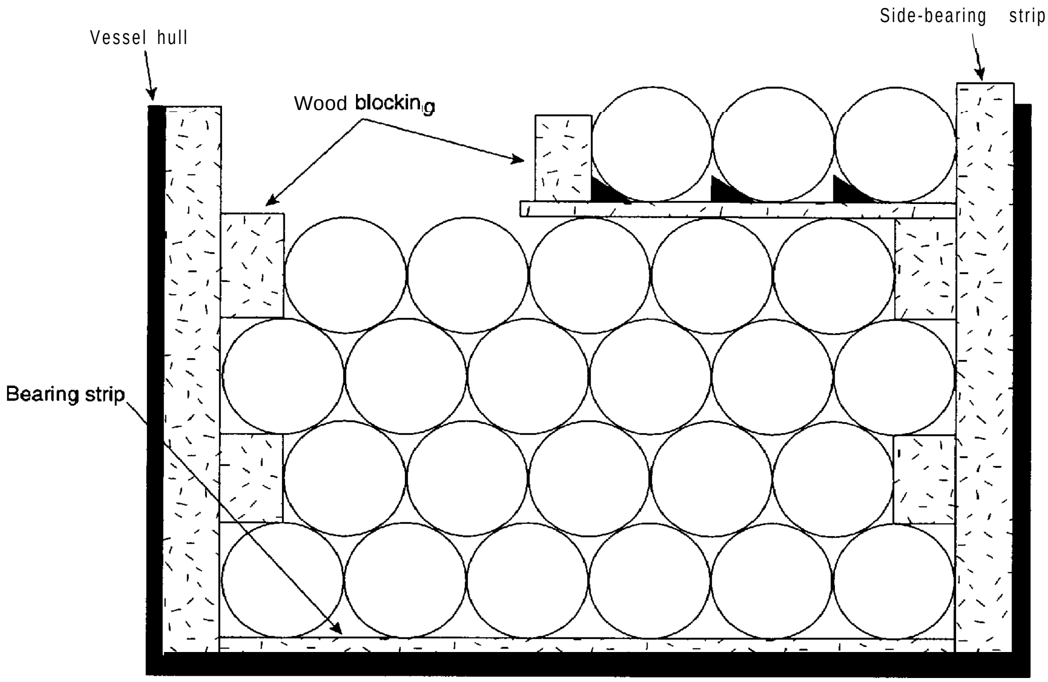

Figure 1—Cantline Stowage

2.4.2 LOADING ON DECK

The pipe shall be placed on a horizontal surface, and the building of a wooden floor is recommended to eliminate contact of the pipe with metallic protrusions and to compensate for inclined planes. There shall be a sufficient number of stanchions for the pipe to rest against. If the stanchions are metallic, wood or rubber strips shall be interposed between them and the pipe. Stowing cables or chains shall be isolated from any contact with pipe through a protection medium such as rubber strips. During transportation, the tension of stowing cables or chains should be checked daily.

2.5 Bearing and Separator Strips

Wood-bearing and separator strips shall be a minimum size of 1 inch x 2 inches. Metallic-bearing strips are prohibited. Bearing strips shall be used to keep the bottom layer of pipe above the hold bottom. The spacing of these strips should be as small as necessary but no greater than 4 feet unless stress concentration calculations from Section 3 allow wider spacing to be used. For any loading arrangement, however, at least 4 bearing strips per pipe stack must be used. For inland waterway shipments, horizontal separator strips may be used when the pipe is not nested. These horizontal strips should be located directly above the bottom bearing strips.

Additional blocking, if necessary, shall be used to minimize lateral movement of pipe.

2.6 Side Protection

To prevent stress concentrations, wooden side-bearing strips or wood blocking shall be provided so that contact with the hull of the vessel or any protrusion is prevented.

2.7 Inspection

Purchaser's inspector shall have access to loading and unloading facilities, with reasonable advance notice of loading and unloading.

2.7.1 LOADING

Damaged pipe shall not be loaded on board. If damaged pipe is detected on board, it should be noted on the bill of lading and the pipe marked by the carrier to indicate pre-transit damage.

2.7.2 UNLOADING

Pipe damage detected during transit or unloading should be promptly reported to the carrier and/or manufacturer and appropriately marked and set aside for further inspection.

3 LOAD STRESSES

3.1 General

In order to minimize the possibility of fatigue damage on pipe having a *D/t* ratio of 50 or more (as described in the foreword), consideration shall be given to both the static and dynamic forces that act upon the pipe during transportation. The following recommendations use the philosophy of setting a maximum static load stress. The dynamic stress induced in the pipe is dependent on the height of the waves, the speed of the vessel, the length of the vessel, the response of the vessel to the water surface, and the location of the pipe along the axis of the vessel. The calculations to arrive at this stress commonly include a g factor of 0.4 to account for possible dynamic stresses. Other g factors not less than 0.2 can be used by agreement among the parties involved.

3.2 Static Load Stress

Static load stress is calculated from the equation:

$$\sigma_S = 0.426\,\frac{D^2}{t}\,n\left[\frac{0.152\,(L - BW)}{B} + 1\right]$$

Where:

σ_s = static load stress in psi.
n = number of tiers.
D = specified OD of pipe in inches.
t = specified wall thickness in inches.
L = specified length of pipe in feet.
W = width of bearing strips in feet.
B = effective number of flat bearing strips. As an alternative to flat strips, bearing strips contoured to contact the pipe for a minimum included angle of 30 degrees may be used. If such contoured strips are used, the number of bearing strips calculated for flat strips may be reduced to not less than ½ as calculated above.

Note: The preceding calculations assume that each length of pipe is in contact throughout its entire length with all adjacent pipe or blocking.

3.3 Maximum Static Load Stress

3.3.1 For inland-waterway transit, the static load stress shall not exceed the specified minimum yield strength of the pipe.

3.3.2 For marine shipments, the static load stress shall not exceed the specified minimum yield strength of the pipe divided by $(1 + g)$, where g is as given in 3.1.

3.4 Graphical Solution

Figure 2 is a chart for obtaining the factor 0.426 D^2/t for 16-inch OD and larger pipe of various wall thicknesses within the scope of this recommended practice.

Figure 3 is a chart for the calculation of stresses for commonly obtained

$$n\left[\frac{0.152\,(L - BW)}{B} + 1\right]$$

factors.

The value of 0.426 D^2/t obtained from Figure 2 is found along the abscissa (horizontal axis) in Figure 3. The ordinate of the intersection of this value with the proper

$$n\left[\frac{0.152\,(L - BW)}{B} + 1\right]$$

line represents the calculated static load stress.

Note: While the lines

$$n\left[\frac{0.152\,(L - SW)}{B} + 1\right]$$

are plotted for the most common situations, intermediate values may be interpolated. Any values not shown on the lines may be calculated from the formula in 3.2.

3.5 Nomographic Solutions

Charts similar to that shown in Figure 4 may be developed from the formulas given in 3.4 for a selected g factor, a fixed number of bearing strips, a minimum width of bearing strip, and a fixed length of pipe for ease in determining the permissible number of tiers stacked on the bottom layer for various grades, diameters, and wall thicknesses of pipe.

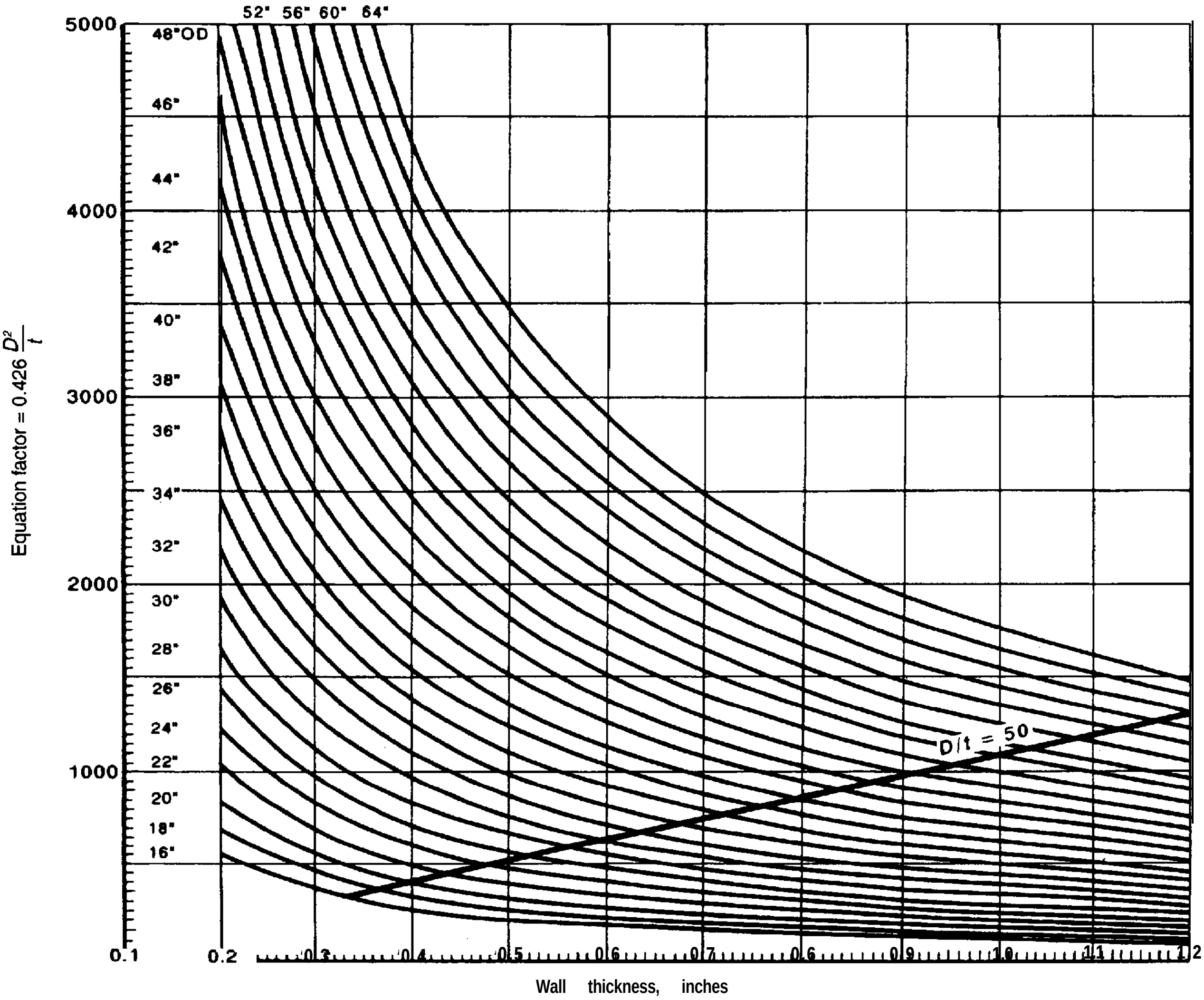

Figure 2—Chart for Determination of Equation Factor

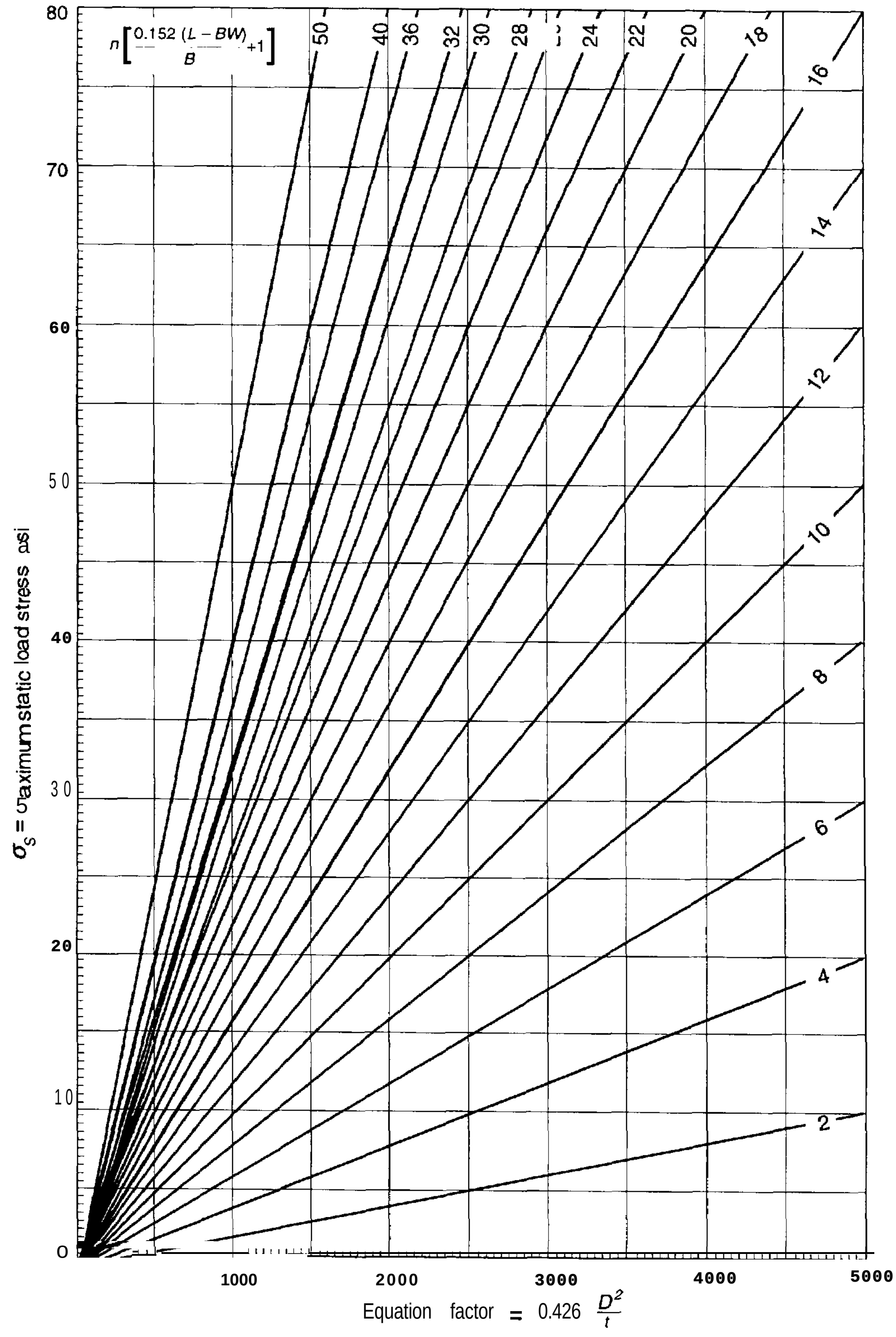

Figure 3-Static Load Stress Calculation Chart

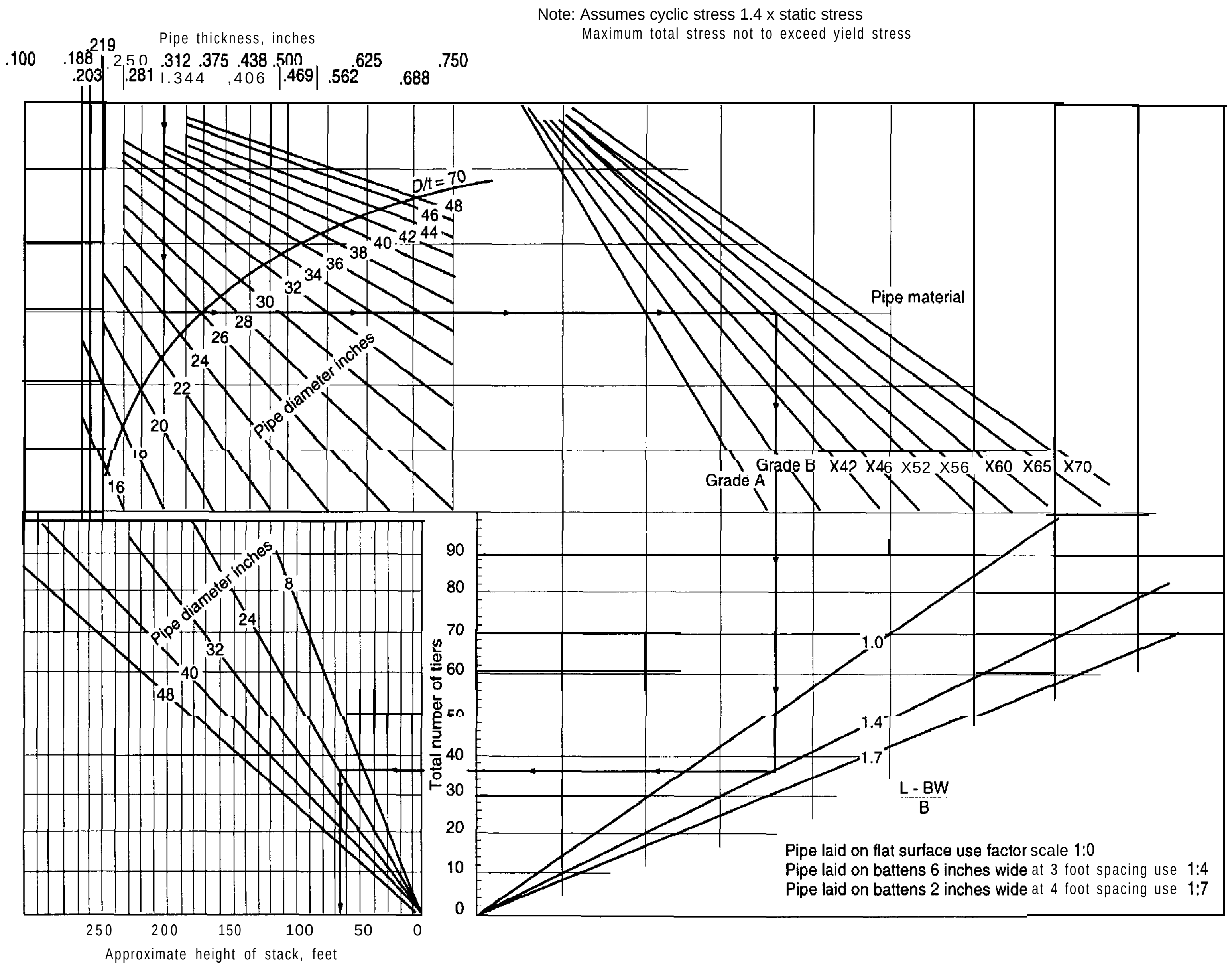

Figure 4-Example of Nomograph for Permissible Number of Tiers Based on a G Factor of .04 (See 3.5)

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