Recommended Practice for Railroad Transportation of Line Pipe

API RECOMMENDED PRACTICE 5L1

SIXTH EDITION, JULY 2002

American Petroleum Institute

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Upstream Segment

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FOREWORD

Suggested revisions are invited and should be submitted to the standardization manager, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

its given in 4.3 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 rivet heads, nails, 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.

Such damage, called transit fatigue, has been reported in pipe with diameter-to-thickness ratios as low as 12.5 and, even though transit fatigue does not appear to be grade related, it has been reported on pipe in 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 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 lim-

b. Abrasions or peening: These result from rubbing or pounding action against some protrusion, such as weld reinforcement of adjacent pipe or a rivet head in the car bottom or side wall. This condition may also be followed by the initiation of fatigue cracks at the damaged areas during transit.

c. Longitudinal fatigue cracks: Longitudinal fatigue cracks can be initiated in the pipe by vertical vibrations and forces, repeated many times during long rail trips. These fatigue cracks are the result of a combination of static and cyclic stresses produced by the static load of upper layers of pipe and a cyclic load caused by the vertical movement of the transportation equipment. Fatigue cracks are often associated with local abrasion or denting but may arise with no apparent surface damage.

This Recommended Practice 5L1 is under jurisdiction of the Standardization of Tubular Goods of the American Petroleum Institute.

Line pipe shipped by rail is loaded either in gondola cars or on flatcars. In either case, the loading practice shall be designed to assure that pipe, when transported under normal conditions by all rail carriers involved, will arrive at the destination undamaged.

These supplementary recommendations have resulted from experience of the shippers of line pipe showing that damage to pipe during rail shipments consists of three principal types:

a. End damage: Pipe end damage can result from longitudinal shifting of the load into the end of the car body or the pipe pile on an adjacent car.

CONTENTS

General Rules Governing the Loading of Pipe on Open Top Cars

[1]Association of American Railroads, 50 F Street, N.W., Washington, D.C. 20001

Unless otherwise specified, the most recent editions or revisions of the following publications form a part of this recommended Practice:

API

Spec 5L Specification for Line Pipe

AAR[1]

General Rules Governing the Loading of Commodities on Open Top Cars

General Rules Governing the Loading of Pipe on Open

ence to which these supplementary recommendations apply.

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

2 References

practices are prescribed by the Association of American Railroads (AAR) as referenced in the next section.

The recommendations given herein are supplementary to the AAR loading practices. If any recommendations are in conflict with AAR loading practices, those of AAR shall govern.

Note: If the AAR loading rules are not applicable to the railroad transportation of line pipe in the country of origin, the basic loading practice shall be as prescribed in the applicable nationally recognized loading rules and requirements for the type of railroad cars used in the country of origin and that document becomes the refer-

diameter to thickness (D/t) ratios of 50 or 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.

1.2 BASIC RULES AND REQUIREMENTS

Certain minimum mandatory rules governing the loading

1 Scope

1.1 GENERAL

The recommendations provided herein apply to the transportation on railcars of API Specification 5L steel line pipe in sizes 2 3/8 and larger in lengths longer that single random. The recommendations of Section 4 concerned with load stresses are exclusively applicable to API line pipe having

conform to the stress requirements for bearing strips, and the location of separator strips should be directly above the bottom bearing strips. For single or double overhanging loads using separator strips, such strips shall also be used on the

bearing members within approximately 1/2 in. for pipe of sizes 6 5/8 – 16 exclusive, and within approximately 1/4 in. for pipe of sizes 16 and larger or for any pipe having a D/t ratio of 50 or more. The blocking used for leveling shall be firmly attached to the bearing members.

3.3 SEPARATOR STRIPS

Horizontal separator strips shall be used when the pipe is not nested. The number and width of separator strips shall

Where AAR stipulates greater dimensions: Pipe size ≥ 6 float-ing loads, and pipe size ≥ 20 in. loads other than floating. Strip height shall not exceed strip width. A minimum of four bearing strips shall be used, and an even number of bearing strips should be used for each pipe stack. Bearing strips shall be evenly spaced (see 4.5 and 4.6 for bearing-strip requirements for pipe with D/t ratios of 50 or more).

The bearing strips shall be aligned so that the load on individual bearing members is not excessive. All intermediate bearing members should be level with respect to the end may contact the sides of the car. Blocking, where required because of uneven car sides, should be introduced between car sides and stakes, and firmly attached to stakes.

The thickness of the bearing strips shall be sufficient to prevent the pipe from touching the bed or protrusions thereon, but in no case less than 2-in. (50 mm) nominal thickness and 4-in. (100 mm) nominal width. Furthermore, the following situations shall require 2-in. (50 mm) nominal thickness and 6-in. (150 mm) nominal width for bearing strips, except

stripping or humping. Cars that have metallic protrusions on the bed or sides (such as bent or torn parts) that would require excessive thickness of bearing strips or of side stakes to prevent contact of the protrusion with the pipe during shipment shall not be used.

3.2 BEARING STRIPS AND BLOCKING

Metallic bearing strips are prohibited. Side protection shall be provided for pipe shipped in gondola cars where the pipe

3 General Requirements (For All Pipe Sizes 2 3/8 And Larger)

3.1 RAILCAR CONDITION

Cars used to ship pipe shall be reasonably free of all foreign materials, particularly those of such size and hardness that could damage pipe during shipment by abrasion or that could contribute to movement of the pipe in the car during overhanging portion, and this portion shall be steel banded, regardless of the D/t ratio. Overhanging shall not exceed the

3.7 BANDING AND TYING-DOWN

Emphasis should be placed on minimizing load shifting

end gates and each end of the pipe to facilitate handling.

3.6 END PROTECTION (GONDOLAS)

If any of the pipe ends are closer than 5 ft (1.5 m) to the end of the car, a minimum of 1 in. (25 mm) nominal thickness rough lumber, or its equivalent, shall be securely attached to the end of the car to prevent the pipe ends from contacting the end gates. Permanently wood-lined end gates are considered suitable for end protection. At the time of loading, a minimum clearance of 1 ft (0.3 m) shall be provided between the

[illegible]

horizontal stripping is used for straight filler metal weld seam pipe (SAW and GMAW), the weld seam shall be positioned at 45 degrees, ± 5 degrees, from vertical. Pipe with a straight filler metal weld seam (SAW and GMAW) shall be positioned with the seam at 0 or 180 degrees (in other words, 12 or 6 o'clock position) when nested, in order to prevent pipe-to-weld seam contact. Furthermore, weld seams should be oriented to avoid contact with steel banding straps.

slings that will prevent surface damage. Where fork lifts are used, the fork ends shall be rounded or properly padded to minimize damage to the pipe.

3.5 PIPE WITH FILLER METAL WELD SEAMS

Pipe with filler metal weld seams (SAW and GMAW) shall be positioned or padded in such a manner that the weld does not contact either the blocking or the adjacent pipe. When

bronze, and any copper alloy shall be excluded). They shall also have sufficient width and depth to fit the internal curvature of the pipe. Elastomeric aprons shall be attached to pipe hooks to protect the pipe ends unless pipe ends are provided with adequate end protectors. 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 handled by loose lifts, all necessary precautions should be taken during handling to prevent pipe damage, and consideration should be given to selection of

requirements in 4.6 and 4.7.

3.4 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, copper,

occurrence of longitudinal fatigue cracks. The following recommendations adhere to the philosophy of setting a maximum allowable static load stress, using a g factor of 1.5 to account for expected cyclic stresses.

4.2 STATIC LOAD STRESS

The static load stress, σ_s, is calculated from the equation:

$$\sigma_s = 0.2\sqrt{D}\,\frac{(nL)}{B}\,\frac{D}{t}\,\ln\left(\frac{D}{2t}\right) \text{ for USC units}$$

appropriately marked and set aside for further inspection.

4 Load Stresses (For Pipe With D/t ≥ 50)

4.1 GENERAL

For pipe having D/t ratio of 50 or larger, consideration should be given to both the static and dynamic forces that act upon the pipe during rail shipment, in order to minimize the

[illegible]

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 pretransit damage.

3.8.2 Unloading

Pipe damage detected during transit or unloading should be promptly reported to the carrier and/or manufacturer and

are used, adequate padding shall be used at points of contact with pipe.

3.8 INSPECTION

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

3.8.1 Loading

[illegible] be placed on minimizing load shifting and subsequent damage to the pipe by unitizing the entire load, or specific portions thereof, with steel bands of at least 1 in. (25 mm) width. The bands should be properly spaced, of sufficient number, and properly tensioned to reduce the tendency of the pipe to move separately from the unitized load itself.

While tie-down bands may be advantageous for some loads, rail handling or humping may loosen or break tie-down bands. Where flat tie-down bands are used, they shall have a minimum width of 1 in. (25 mm). Where wire rope or chains

$$\sigma_s = 9.05 \times 10^{-4}\sqrt{D}\,\frac{(nL)}{B}\,\frac{D}{t}\,\ln\left(\frac{D}{2t}\right) \text{ for SI Units}$$

[illegible]

obtained from Figure 1 is found along the abscissa. The ordinate of the intersection of this value with the proper nL/B curve represents the calculated static load stress.

where

k_2 (USC units) = 1

k_2 (SI units) = 3.28.

To use Figure 2, the value of

$$k_1\sqrt{D}\frac{D}{t}ln\left(\frac{D}{2t}\right)$$

where

k_1 (USC units) = 0.2

k_1 (SI units) = 0.04

for pipe sizes 16 and larger, with various wall thicknesses within the scope of this recommended practice.

Figure 2 is a chart for the calculation of stresses for commonly obtained k_2nL/B factors.

mate tensile strength (UTS).

4.4 GRAPHICAL DETERMINATION OF STATIC LOAD STRESS

Figure 1 is a chart for obtaining the equation factor

$$k_1\sqrt{D}\,\frac{D}{t}\,ln\left(\frac{D}{2t}\right)$$

[illegible]

$ln\left(\frac{D}{2t}\right)$ = natural logarithm of $\frac{D}{2t}$.

4.3 MAXIMUM STATIC LOAD STRESS

The static load stress, σ_s, shall not exceed 0.4 times the specified minimum yield strength (SMYS) for grades less than Grade X52. For grades X52 and higher, the static load stress shall not exceed 0.3 times the specified minimum ulti-

rows in the pipe load, whether provided with separator strips or nested,

L = maximum length of individual pipe, ft (m),

B = effective number of bearing strips. Dimensions of bearing strips shall comply with 3.2,

D = specified OD of pipe, in. (mm),

t = specified wall thickness, in. (mm).

4.7 DOUBLE OVERHANGING LOADS

For double overhanging loads on cars 52 ft (15,8 m) and longer in which the overhang exceeds the requirements of

$$B = \frac{(\sigma_s \max)t}{\quad} \text{ for SI units}$$

4.6 BEARING STRIP PLACEMENT

Bearing strips shall be spaced approximately symmetrically about the center of the pipe stack in order to provide uniform load distribution.

The distance from pipe ends to end-bearing strips shall be as shown in Table 1.

where σs max is the maximum static load stress from 4.3. Fractional values of B must always be rounded up to the next whole number.

$$B = \frac{(\sigma_s \max)t}{0.2\,nL\,D^{3/2}\,ln\left(\frac{D}{2t}\right)} \text{ for USC units}$$

$$9.05 \times 10^{-4}\,nL\,D^{3/2}\,ln\left(\frac{D}{2t}\right)$$

stress, extra bearing strips shall be added, or wedges shall be provided on the end bearing strips.

As an alternative, 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 required may be reduced to not less than one-half the number of flat bearing strips calculated in accordance with the preceding requirements.

An alternative method for calculating the minimum number of flat bearing strips (B) is to use the following equation.

Note: For pipe of strength levels in excess of Grade X60, use the maximum stresses permitted for X60.

4.5 BEARING STRIPS

The minimum number of flat bearing strips for single railcars shall be the number required to limit the stress to the maximum allowable as set forth in 4.3 and 4.4.

If the calculated static load stress ss is equal to or greater than (B - 1) / B times the maximum allowable static load

[illegible]

The horizontal lines appearing on Figure 2 represent the maximum static load stresses permitted under fatigue conditions using a g factor of 1.5. These values are limited to the lesser of 0.4 times specified minimum yield strength (SMYS) or 0.3 times specified minimum ultimate tensile strength (UTS). If the value exceeds those permitted for the grade of line pipe involved, additional bearing strips shall be provided or the stacking height reduced.

where

n = Stacking load factor, which is the number of

Note: While the k_2nL/B curves are plotted for the most common situations, intermediate k_2nL/B values may be interpolated. Any values not shown on the curves may be calculated from the formula in 4.2

as set forth in 4.1 through 4.5, except that if the end bearing strips are either contoured or wedge blocked, the number of bearing strips may be reduce by 2. In the case of double overhanging loads of long pipe on cars 52 ft (15,8 m) and longer, the end bearing strips should be located as close to the ends of the cars as possible and shall be no more than 18 ft (5,5 m) from the ends of the pipe. The remaining strips should be approximately evenly spaced.

4.6, the number of flat bearing strips shall be 1.4 times the number required to limit the stress to the maximum allowable

Table 1 – Distance From Pipe Ends to End-Bearing Strips

Pipe Size	Minimum Distance	Maximum Distance
< 16	1.5 OD	5 ft (1,5 m)
16 to 30, incl.	1.5 OD	6 ft (1,8 m)
> 30	4 ft (1,2 m)	6 ft (1,8 m)

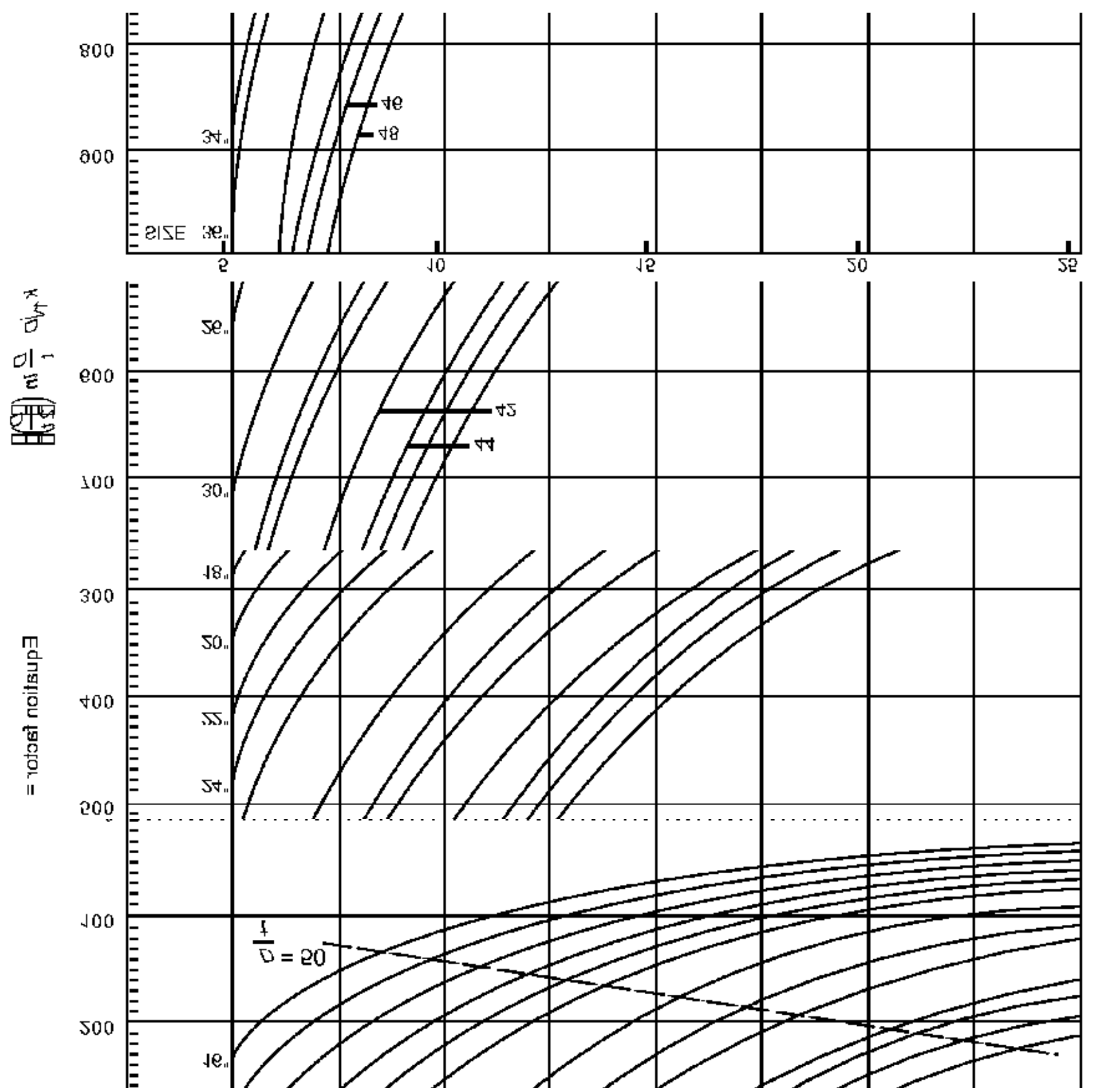

Figure 1—Chart for Determination of Equation Factor

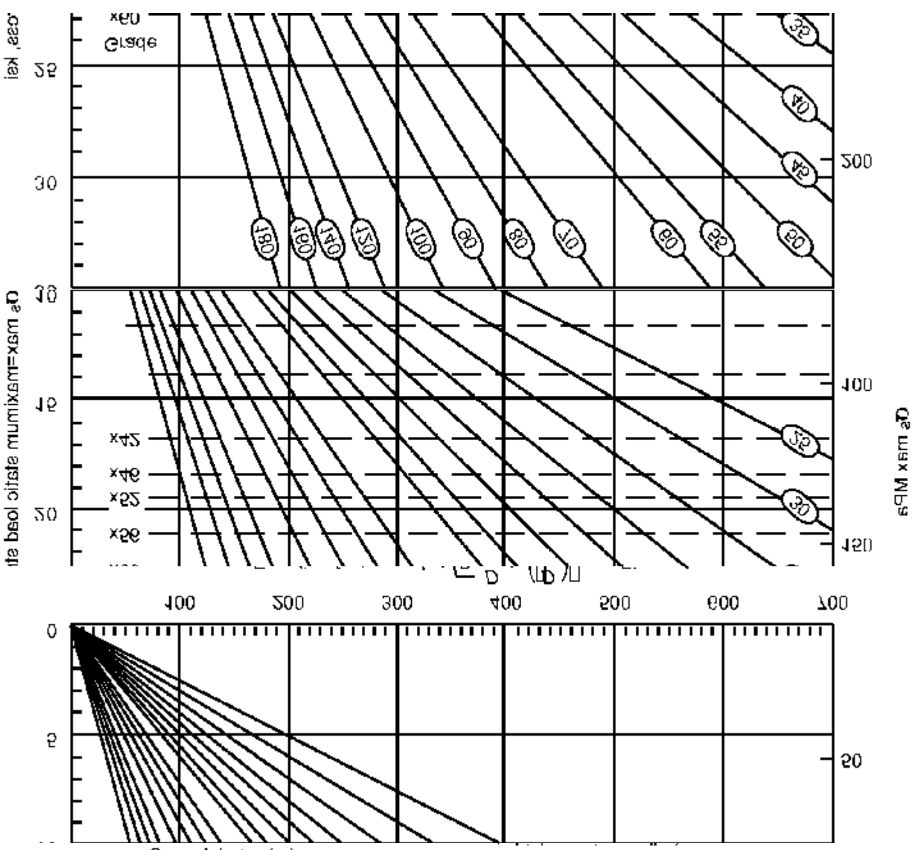

Figure 2—Static Load Stress Calculation Chart

B = Effective no. of bearing strips

D = Diameter of pipe in. (mm)

t = Wall thickness, in. (mm)

σ_s = Static load stress psi (MPa)

n = Stacking load factor

L = Length of pipe, ft (m)

Maximum allowable fatigue stress based on 0.40 times yield strength or 0.30 times tensile strength (whichever is smaller). This assumes a "g" factor of 1.5.

$$\sigma_s = 8.05\times10^{-4}\sqrt{D}\,\frac{B}{(nL)}\,\frac{t}{D}\ln\left(\frac{2t}{D}\right) \text{ for SI units}$$

$$\sigma_s = 0.2\sqrt{D}\left(\frac{B}{nL}\right)\frac{t}{D}\ln\left(\frac{2t}{D}\right) \text{ for USC units}$$

Equation factors = $x\sqrt{D}\,\frac{t}{D}\ln\left(\frac{2t}{D}\right)$ see Figure 1

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