ASME B31G-2012
(Revision of ASME B31G-2009)

Manual for Determining the Remaining Strength of Corroded Pipelines

Supplement to ASME B31 Code for Pressure Piping

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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Three Park Avenue • New York, NY • 10016 USA

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The next edition of this Manual is scheduled for publication in 2015.

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This Manual was developed under procedures accredited as meeting the criteria for American National Standards. The Standards Committee that approved the Manual was balanced to assure that individuals from competent and concerned interests have had an opportunity to participate. The proposed Manual was made available for public review and comment that provides an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large.

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FOREWORD

It has been recognized within the pipeline industry that some sections of high-pressure pipelines, particularly those with long service histories, may experience corrosion. It has also been recognized, through theoretical analysis, scientific research and testing, and industry operating experience, that some amount of metal loss due to corrosion can be tolerated without impairing the ability of the pipeline to operate safely. In 1984, ASME published the first edition of the B31G Manual for Determining the Remaining Strength of Corroded Pipelines. The B31G document provided pipeline operators with a simplified evaluation method based on the results of analysis and tests. The application of B31G has enabled pipeline operators to reliably determine safe operating pressure levels for pipe affected by corrosion, and to determine whether repairs are necessary in order to continue operating safely.

B31G continued to be reissued by ASME with only minor revisions over time, although other corrosion evaluation methods had evolved since B31G's initial publication. A majority of these other methods are based on the same theoretical model from which the original B31G method was derived, but may offer some refinement in accuracy. Subsequently, an effort was undertaken to update the B31G document to recognize certain other corrosion evaluation methods that have proven sound and that have seen successful use in the pipeline industry. Incorporation of these other methods into a recognized Code document provides the pipeline operator or other user with a formalized framework within which to use such methodologies, as well as a wider range of codified technical options with which to make an evaluation. The 2009 revision of B31G reflected those objectives.

The 2012 edition of B31G was approved by the American National Standards Institute (ANSI) on September 20, 2012.

ASME B31 COMMITTEE
Code for Pressure Piping

(The following is the roster of the Committee at the time of approval of this Standard.)

CORRESPONDENCE WITH THE B31 COMMITTEE

General. ASME Standards are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Standard may interact with the Committee by requesting interpretations, proposing revisions, and attending Committee meetings. Correspondence should be addressed to:

Secretary, B31 Standards Committee
The American Society of Mechanical Engineers
Three Park Avenue
New York, NY 10016-5990

Proposing Revisions. Revisions are made periodically to the Standard to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

Proposing a Case. Cases may be issued for the purpose of providing alternative rules when justified, to permit early implementation of an approved revision when the need is urgent, or to provide rules not covered by existing provisions. Cases are effective immediately upon ASME approval and shall be posted on the ASME Committee Web page.

Requests for Cases shall provide a Statement of Need and Background Information. The request should identify the standard, the paragraph, figure or table number(s), and be written as a Question and Reply in the same format as existing Cases. Requests for Cases should also indicate the applicable edition(s) of the standard to which the proposed Case applies.

Interpretations. Upon request, the B31 Standards Committee will render an interpretation of any requirement of the Standard. Interpretations can only be rendered in response to a written request sent to the Secretary of the B31 Standards Committee.

The request for an interpretation should be clear and unambiguous. It is further recommended that the inquirer submit his/her request in the following format:

Subject:	Cite the applicable paragraph number(s) and the topic of the inquiry.
Edition:	Cite the applicable edition of the Standard for which the interpretation is being requested.
Question:	Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. The inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain proprietary names or information.

Requests that are not in this format may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME Committee or Subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

Attending Committee Meetings. The B31 Standards Committee regularly holds meetings, which are open to the public. Persons wishing to attend any meeting should contact the Secretary of the B31 Standards Committee.

ASME B31G-2012
SUMMARY OF CHANGES

Following approval by the B31 Committee and ASME, and after public review, ASME B31G-2012 was approved by the American National Standards Institute on September 20, 2012.

Changes given below are identified on the pages by a margin note, **(12),** placed next to the affected area.

Page	*Location*	*Change*
2	1.5	In the nomenclature, definition of P_F revised
7	2.3	First sentence revised
9	Table 3-1	In eighth column, second entry revised
	Table 3-1M	In eighth column, second entry revised
10	Table 3-2	In fifth column, second entry revised
11	Table 3-2M	In fifth column, second entry revised
14	Table 3-4	In second column, first entry revised
15	Table 3-4M	In second column, first entry revised
22	Table 3-8	In third column, first entry revised
23	Table 3-8M	In third column, first entry revised

SPECIAL NOTES:

The interpretations to ASME B31G are included in this edition as a separate section for the user's convenience.

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MANUAL FOR DETERMINING THE REMAINING STRENGTH OF CORRODED PIPELINES

1 INTRODUCTION

1.1 Scope

This document is intended solely for the purpose of providing guidance in the evaluation of metal loss in pressurized pipelines and piping systems. It is applicable to all pipelines and piping systems within the scope of the transportation pipeline codes that are part of ASME B31 Code for Pressure Piping, namely: ASME B31.4, Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids; ASME B31.8, Gas Transmission and Distribution Piping Systems; ASME B31.11, Slurry Transportation Piping Systems; and ASME B31.12, Hydrogen Piping and Pipelines, Part PL. Where the term *pipeline* is used, it may also be read to apply to piping or pipe conforming to the acceptable applications and within the technical limitations discussed below.

1.2 Acceptable Applications

The application of this document is limited to the evaluation of wall loss in metal pipe within the following limitations:

(a) metal loss in pipelines located belowground, aboveground, or offshore

(b) metal loss due to external or internal corrosion

(c) metal loss produced by grinding where used to completely remove mechanical damage, cracks, arc burns, manufacturing defects, or other defects from the pipe surface

(d) metal loss in field bends, induction bends, and elbows

(e) metal loss that incidentally affects longitudinal or helical electric seam welds or circumferential electric welds of sound quality and having ductile characteristics, provided workmanship flaws are not present in sufficiently close proximity to interact with the metal loss

(f) metal loss of any depth with respect to the pipe wall, except that due consideration shall be given to the accuracy of measurements and effective corrosion rates when the depth of metal loss exceeds 80% of the actual pipe wall dimension

(g) metal loss in new pipe where allowed by the applicable code of construction

(h) metal loss in pipe material having ductile fracture initiation characteristics [see paras. 1.7(e) and (f)] unless using a Level 3 assessment in accordance with paras. 2.2(b) and 2.4

(i) metal loss in pipe operating at temperatures above ambient within the range of operating temperature recognized by the governing standard, and provided material strength properties at temperature are considered

(j) metal loss in pipe operating at any level of allowable design hoop stress [see paras. 1.4(a) and (b) for additional considerations]

(k) metal loss in pipe where internal pressure is the primary loading [see paras. 1.4(c) and (d) for additional considerations]

1.3 Exclusions

This document does not apply to the following:

(a) crack-like defects or mechanical surface damage not completely removed to a smooth contour by grinding

(b) metal loss in indentations or buckles resulting in radial distortion of the pipe wall larger than 6% of the pipe outside diameter, unless a Level 3 assessment is performed in accordance with para. 2.4

(c) grooving corrosion, selective corrosion, or preferential corrosion affecting pipe seams or girth welds

(d) metal loss in fittings other than bends or elbows

(e) metal loss affecting material having brittle fracture initiation characteristics [see paras. 1.7(e) and (f)] unless a Level 3 assessment is performed in accordance with para. 2.4

(f) pipe operating at temperatures outside the range of operating temperature recognized by the governing standard or operating at temperatures in the creep range

1.4 Additional Considerations

The user is cautioned that additional considerations may apply in certain situations, described below.

(a) Pipe operating at low hoop stress levels due to internal pressure (e.g., less than 25% of SMYS) may be perforated by corrosion without inducing structural material failure. The methods and criteria provided herein do not address failure by perforation.

(b) Pipe affected by general corrosion of the pipe wall (i.e., corrosion-caused wall loss over the entire pipe surface) effectively operates at a greater hoop stress than

the nominal hoop stress based on the original wall dimension. Evaluation of individual deep pits within a generally corroded area should account for the effect of wall loss due to general corrosion.

(c) Under conditions normally encountered in buried pipelines, the hoop stress due to internal pressure is the largest stress and will govern the mode of failure. High longitudinal stresses in tension acting on metal loss having a significant circumferential extent, in unrestrained piping, could change the failure mode from longitudinal to circumferential. The methods and criteria provided herein do not address circumferential failure due to high longitudinal tensile stresses. For such situations, the user should refer to a more comprehensive fitness-for-purpose guidance document, such as API 579-1/ ASME FFS-1–2007, Fitness-for-Service.

(d) Metal loss having a significant circumferential extent and acted on by high longitudinal stresses in compression could be susceptible to wrinkling or buckling. Also, the combination of hoop stress due to internal pressure and longitudinal compression could interact to lower the failure pressure in the metal loss area. The methods and criteria provided herein do not address buckling or wrinkling, or interaction of hoop stress with longitudinal compressive stresses. For such situations, the user should refer to a more comprehensive fitness-for-purpose guidance document, such as API 579-1/ ASME FFS-1.

(12) 1.5 Nomenclature

A = local area of metal loss in the longitudinal plane
A_C = cross-sectional area of Charpy impact specimen
A_0 = local original metal area = Lt
C_V = Charpy V-notched impact absorbed energy
D = specified outside diameter of the pipe
d = depth of the metal loss
E = elastic modulus of steel
L = length of the metal loss
L_e = effective length = $L(\pi/4)$
M = bulging stress magnification factor
$MAOP$ = maximum allowable operating pressure
MOP = maximum operating pressure
P_F = estimated failure pressure = $2S_F t/D$
P_O = operating pressure, may equal MAOP or MOP
P_S = safe operating pressure = P_F/SF
S_F = estimated failure stress level
S_{flow} = flow stress, defined in para. 1.7(b)
S_O = hoop stress at the operating pressure, calculated as $P_O D/2t$
S_{UT} = specified ultimate tensile strength at temperature, may equal SMTS
S_{YT} = specified yield strength at temperature, may equal SMYS
SF = safety factor
$SMTS$ = specified minimum tensile strength at ambient conditions
$SMYS$ = specified minimum yield strength at ambient conditions
t = pipe wall thickness
z = L^2/Dt
z_e = L_e^2/Dt

1.6 Analysis Level

The user may choose to conduct a Level 0, Level 1, Level 2, or Level 3 analysis, depending on the quantity and quality of data available with which to perform an evaluation, and on the desired degree of refinement of the analysis.

(a) A Level 0 evaluation is one that relies on the tables of allowable defect length and depth found in section 3. These tables are carried over without change from earlier editions of ASME B31G and have been supplemented by the addition of tables in metric units. It is intended that a Level 0 evaluation be conducted in the field without the need for performing detailed calculations.

(b) A Level 1 evaluation is a simple calculation that relies on single measurements of the maximum depth and axial extent of metal loss. It is intended that a Level 1 evaluation be conducted in the field by an engineer, corrosion technician, coating inspector, or other individual having appropriate training. A Level 1 evaluation is also suitable for use in prioritizing metal-loss anomalies identified by inline inspection.

(c) A Level 2 evaluation is one that incorporates a greater level of detail than a Level 1 evaluation in order to produce a more accurate estimate of the failure pressure. It typically relies on detailed measurements of the corroded surface profile, accounting for the actual distribution of metal loss, and involves repetitive computations that may be facilitated by the use of computer software or spreadsheets. It is intended that a Level 2 evaluation be conducted by an engineer or technician having appropriate training. A Level 2 evaluation may be suitable for use in prioritizing metal-loss anomalies identified by high-resolution inline inspection.

(d) A Level 3 evaluation is a detailed analysis of a specific flaw in accordance with a user-defined methodology, with full justification for loadings, boundary conditions, material properties, and failure criteria. It is intended that a Level 3 evaluation be conducted by a technical specialist having appropriate expertise in the subject of fitness-for-service assessment.

1.7 Material Properties and Other Data

(a) Specified minimum material properties shall be used when conducting Level 0, Level 1, or Level 2 evaluations for the purpose of determining the need for a repair. Actual material properties from mill test reports (MTRs) or laboratory testing, if known with sufficient

confidence to warrant their usage, may be used with Level 3 evaluations. Statistical representations of material properties may be used with Levels 1, 2, or 3 for purpose of establishing a probability of failure; however, the details of such analyses are outside the scope of this document.

(b) Flow stress is a concept relevant to fracture mechanics and is used in the Level 1, Level 2, and Level 3 evaluations. It is not a property specified in a material grade or finished product standard. Research indicates that it may be defined variously as given below.

(1) S_{flow} for plain carbon steel operating at temperatures below 250°F (120°C) may be defined by $S_{\text{flow}} = 1.1 \times \text{SMYS}$. S_{flow} shall not exceed SMTS.

(2) S_{flow} for plain carbon and low-alloy steel having SMYS not in excess of 70 ksi (483 MPa) and operating at temperatures below 250°F (120°C) may be defined by $S_{\text{flow}} = \text{SMYS} + 10$ ksi (69 MPa). S_{flow} shall not exceed SMTS.

(3) S_{flow} for plain carbon and low-alloy steel having SMYS not in excess of 80 ksi (551 MPa) may be defined by $S_{\text{flow}} = (S_{YT} + S_{UT})/2$, where S_{YT} and S_{UT} are specified at the operating temperature in accordance with the ASME Boiler and Pressure Vessel Code, Section II, Part D; applicable pipe product specification; or room temperature strength multiplied by the temperature derating factor specified by the applicable construction code. Linear interpolation of strength values is allowed between listed temperatures.

(c) This document does not prescribe which definition for flow stress should be used where more than one definition applies. Where more than one definition applies, the various definitions produce acceptable though not necessarily identical results when used with any given evaluation method. It is noted that S_{flow} was defined as 1.1 × SMYS in previous editions of B31G. This definition remains an inherent element of the Level 0 assessment and is recommended with the Level 1 assessment performed in accordance with para. 2.2(a).

(d) Only the specified nominal wall thickness shall be used for the uncorroded wall thickness when conducting a Level 0 evaluation. If known with confidence, the actual uncorroded wall thickness may be used with a Level 1, Level 2, or Level 3 evaluation, with a suitable adjustment of the hoop stress due to internal pressure.

(e) Pipe body material may be considered to have adequate ductile fracture initiation properties for purposes of this Standard if the material operates at a temperature no colder than 100°F (55°C) below the temperature at which 85% shear appearance is observed in a Charpy V-notched impact test.

(f) Electric resistance welded (ERW) seams that have been subjected to a normalizing heat treatment, single and double submerged arc welded seams, and girth welds made using the shielded metal arc, gas metal arc, flux cored arc, and submerged arc processes (manual or automated, and in any combination) are considered to have adequate ductile fracture initiation properties for purposes of this Standard. Other seam and weld types shall be investigated to establish fracture properties before applying methods described herein to metal loss affecting such welds. Consideration shall be given to the disposition of workmanship flaws or manufacturing flaws within a weld or seam that could interact with metal loss due to corrosion.

(g) Some operating conditions, such as low-temperature service, or long-term exposure to sour environments or to very high temperatures, could adversely affect the ductility and fracture toughness properties of some materials. It is the user's responsibility to consider such conditions where necessary before applying methods described herein.

1.8 Evaluation Procedure

Evaluations shall be carried out in accordance with the procedures described in section 2. In addition, the following considerations apply:

(a) Units may be in any self-consistent system. It is the responsibility of the user to determine unitary conversion factors as may be required.

(b) This document makes no recommendation as to which evaluation level and evaluation method to select. All methods described herein have been demonstrated to provide reliable and conservative results when they are applied correctly and within stated limitations. Not all methods give identical numerical results or consistent degrees of conservatism. It is the pipeline operator's responsibility to select an evaluation method, based on experience and judgment, that is consistent with its operating procedures.

(c) Original source reference documents for each methodology are cited. Further references may be found in other documents available in the public domain. While each method can be applied as presented, source documents may provide additional information to the user. The user should consider referring to applicable sources as necessary in order to best implement a given method.

(d) Other evaluation methods may evolve or come into use which were not contemplated by this document. It is not the intention of this document to prohibit their use, but the user of such methods shall be able to demonstrate that the objective of a safe and reliable assessment of metal loss can be achieved.

1.9 Safety Factors and the Meaning of Acceptance

A flaw or anomaly is considered acceptable where the computed failure stress is equal to or greater than the hoop stress at the operating pressure multiplied by a suitable safety factor. There is no single safety factor that is suitable for all types of pipeline construction, for all modes of pipeline operation, or for all types of flaws or anomalies.

This document recommends a minimum safety factor equal to the ratio of the minimum hydrostatic test pressure required for the given type of pipeline construction to the MAOP or MOP, but usually not less than 1.25. Larger factors of safety may be appropriate in some cases, e.g., in locations of greater risk to the public or the environment. Lesser factors of safety may be justified in some circumstances, e.g., for limited periods of time, or where additional procedures are in place to limit modes of operation, or in a remote location having reduced consequences of failure. In establishing the safety factor for a given pipeline segment, the pipeline operator shall give consideration to the accuracy of corrosion depth and length measurements, rates of corrosion growth, the characteristics of the pipe, the reliability of surge control or excess pressure limiting methods, and the presence of external factors that affect risk.

When evaluating anomalies identified by inline inspection, use of larger factors of safety will result in smaller flaws being left in service following field investigation and pipeline repairs. This can increase the reassessment interval to the next inline inspection.

1.10 Software

The use of commercial or proprietary computer software packages, as well as purpose-written programs or spreadsheets, can greatly facilitate Level 1 evaluations, and is practically a necessity for conducting thorough Level 2 and Level 3 evaluations. It is the user's responsibility to verify the accuracy and reliability of all software and spreadsheets, and to train personnel in their correct usage.

Validation of software should include documented evidence that correct results are obtained over the full range of parameters that could reasonably be expected to occur when making evaluations. The following document summarizes the results of burst tests and service failures of line pipe affected by corrosion or artificial metal loss, and which have previously been used for the purpose of validating the evaluation methods presented herein: Kiefner, J. F., Vieth, P. H., and Roytman, I., "Continued Validation of RSTRENG," PRCI Catalog No. L51749, Contract PR 218-9304, Dec. 20, 1996.

Validation may be demonstrated by comparison of calculated results against published benchmark test data such as that found in the above reference, or against results produced by another recognized evaluation method that have been calculated in accordance with this Standard.

Validation of third-party software should also demonstrate that adequate checks or warnings are produced when parameters fall outside ranges that will ensure correct results.

1.11 Accuracy

Consideration should be given to the accuracy of recorded flaw sizes, particularly where indirect methods are used to locate and size the flaws. Methods accounting for uncertainty in indirectly sized flaws include increasing the flaw dimension in order to account for detection tool error, or statistical analysis of the probable flaw sizes or risk of failure.

Metal-loss corrosion anomalies indicated by inline inspection may be evaluated by a Level 1 or Level 2 evaluation method. The user is cautioned against overstating the precision of evaluations applied with flaw dimensions indicated by inline inspection without adequate calibration or verification of actual flaw sizes by investigations carried out in the field.

1.12 Flaw Interaction

The methods described herein are suitable for evaluating isolated areas of metal loss. Corrosion may occur such that multiple areas of metal loss are closely spaced longitudinally or transversely. If spaced sufficiently closely, the metal loss areas may interact so as to result in failure at a lower pressure than would be expected based on an analysis of the separate flaws. The following guideline is suggested with reference to Fig. 1.12-1, based on limited testing and analysis:

(a) Flaws are considered interacting if they are spaced longitudinally or circumferentially from each other within a distance of 3 times the wall thickness ($3t$). Interacting flaws should be evaluated as a single flaw combined from all interacting flaws.

(b) Flaws are considered noninteracting if spaced outside of the above dimensions. Noninteracting flaws should be evaluated as separate flaws.

Care should be exercised when grouping or clustering anomalies indicated by inline inspection for purposes of evaluating interaction during the prioritization process. Consideration should be given to minimum thresholds of metal loss for reliable detection and sizing, minimum thresholds for reporting, and the expected mode of coating failure (e.g., localized failure versus disbondment over large areas). Methods employed for clustering of inline inspection anomalies should be validated by field verification of actual flaw dimensions and spacing.

1.13 Flaw Orientation

Corrosion caused by disbondment of continuous wrapped coatings may exhibit a helical pattern. If the helical pattern lies at an angle less than 45 deg to the pipe axis, the overall length of the corroded area indicated as L_1 in Fig. 1.13-1 shall be considered in the evaluation. If the helical pattern lies at an angle of 45 deg or greater to the pipe axis, it is sufficient to consider the most severe longitudinal section through the corroded area having a length L_2 in Fig. 1.13-1.

Corrosion may occur with a circumferential orientation, e.g., adjacent to a girth weld. It shall be evaluated for safe operating pressure as with corrosion having a helical angle greater than 45 deg to the pipe axis. Evaluation of the circumferential extent of corrosion subject

Fig. 1.12-1 Corrosion Pit Interaction Distances

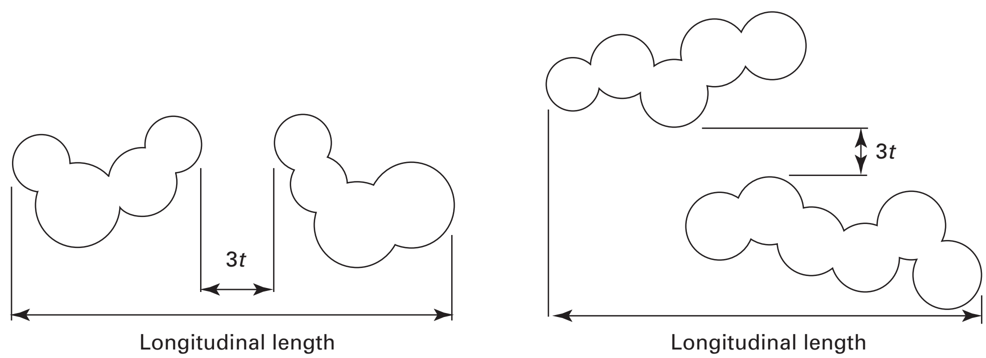
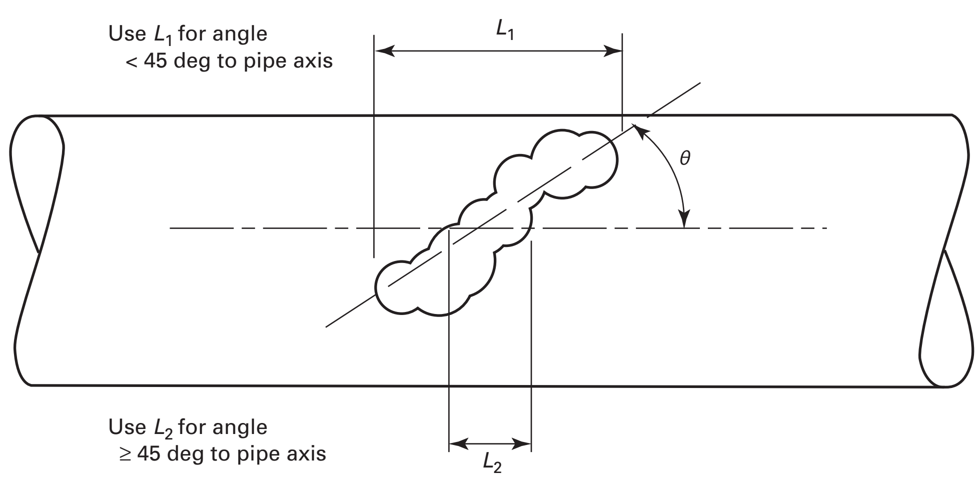


Fig. 1.13-1 Helically Oriented Corrosion Pattern



to high axial pipe stresses is outside the scope of this document. For such situations, the user should refer to a more comprehensive fitness-for-purpose guidance document, such as API 579-1/ASME FFS-1.

2 EVALUATION METHODS

2.1 Level 0 Evaluation

Tables of allowable length of corrosion are found in section 3. The tables are carried over without change from previous editions of B31G and have been supplemented by the addition of tables in metric units. They were calculated from the equations for a Level 1 evaluation in accordance with the original B31G methodology. They provide a ready reference of maximum corrosion lengths for a range of pipe sizes and depths of corrosion. The tables may be used to determine the maximum allowable longitudinal extent of a contiguous area of corrosion or an interacting cluster of metal loss areas.

Evaluations shall be carried out consistent with the procedure described in the following steps:

Step 1. Determine pipe diameter and nominal wall thickness from appropriate records or direct measurement of the pipe.

Step 2. Determine applicable pipe material properties from appropriate records.

Step 3. Clean the corroded pipe surface to bare metal. Care should be taken when cleaning corroded areas of a pressurized pipe.

Step 4. Measure the maximum depth of the corroded area, d, and longitudinal extent of the corroded area, L, as shown in Fig. 2.1-1.

Step 5. Locate the table corresponding to the size of the pipe, D.

Step 6. In the table, locate the row showing a depth equal to the measured maximum depth of the corroded area. If the exact measured value is not listed, choose the row showing the next greater depth.

Step 7. Read across to the column showing the wall thickness of the pipe. If the nominal wall thickness is not listed, use the column for the next thinner wall. The value, L, found at the intersection of the wall thickness column and the depth row is the maximum allowable longitudinal extent of such a corroded area.

Step 8. The metal loss area on the pipe is acceptable if its measured length, L, does not exceed the value of L given in the table.

The tables produce results that may be more conservative than those obtained by performing a Level 1, Level 2, or Level 3 analysis, particularly for operating hoop stress levels less than 72% of SMYS, and also for very long corroded areas. Therefore, the tables may show that a given corroded area is unsuitable for the current operating pressure, while the use of equations given below may show that it is acceptable.

The tables were designed to provide a minimum factor of safety of 1.39 for pipelines operating with a hoop stress of 72% of SMYS. Application of the tables to the evaluation of corrosion in pipelines operating at hoop stress levels greater than 72% of SMYS will result in a factor of safety that is proportionately less.

2.2 Level 1 Evaluation

Level 1 evaluations shall be carried out consistent with the procedure described in the following steps:

Step 1. Determine pipe diameter and nominal wall thickness from appropriate records or direct measurement of the pipe.

Step 2. Clean the corroded pipe surface to bare metal. Care should be taken when cleaning corroded areas of a pressurized pipe.

Step 3. Measure the maximum depth of the corroded area, d, and longitudinal extent of the corroded area, L, as shown in Fig. 2.1-1.

Step 4. Determine applicable pipe material properties from appropriate records.

Step 5. Select an evaluation method and calculate the estimated failure stress, S_F.

Step 6. Define an acceptable safety factor, SF.

Step 7. Compare S_F to $SF \times S_O$.

Step 8. The flaw is acceptable where S_F is equal to or greater than $SF \times S_O$, or where P_F is equal to or greater than $SF \times P_O$.

If the flaw is unacceptable based on Step 8 above, the pressure can be reduced such that it is less than P_F/SF.

(a) Original B31G

$$M = (1 + 0.8z)^{1/2}$$

For $z \leq 20$,

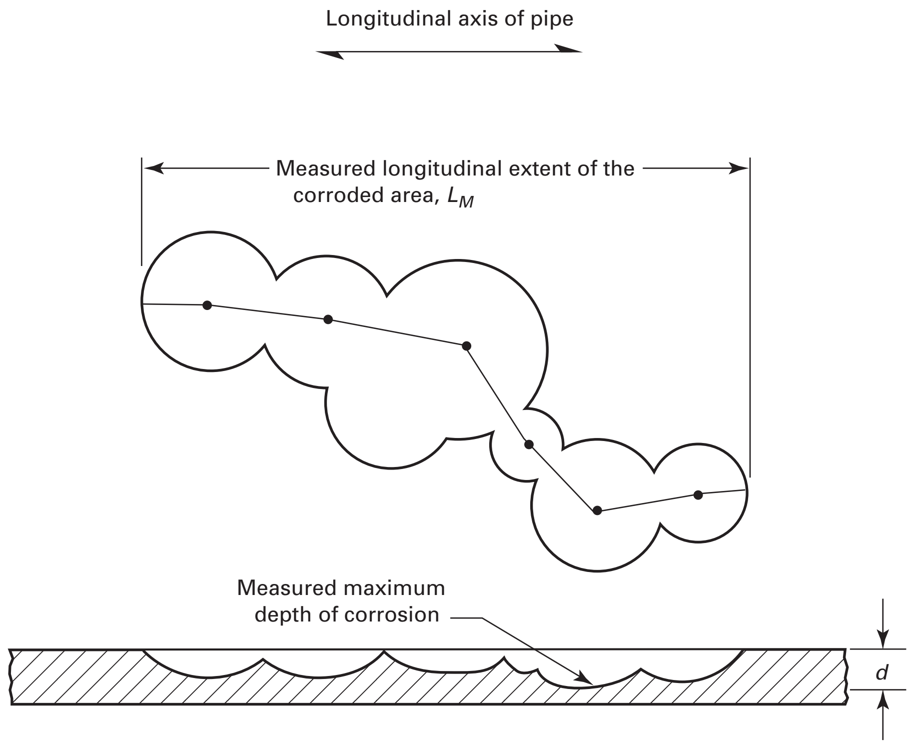
$$S_F = S_{\text{flow}} \left[\frac{1 - \frac{2}{3}(d/t)}{1 - \frac{2}{3}(d/t)/M} \right]$$

For $z > 20$,

$$S_F = S_{\text{flow}}(1 - d/t)$$

Note that previous editions of B31G incorporated a definition for flow stress of $S_{\text{flow}} = 1.1 \times \text{SMYS}$. For consistency in comparison to results obtained from evaluations performed to an earlier edition, use of the same definition for flow stress is recommended.

Fig. 2.1-1 Corrosion Parameters Used in Analysis



[References: ANSI/ASME B31G-1984 and ASME B31G-1991.]

(b) Modified B31G. For $z \leq 50$,

$$M = (1 + 0.6275z - 0.003375z^2)^{1/2}$$

For $z > 50$,

$$M = 0.032z + 3.3$$

$$S_F = S_{\text{flow}} \left[\frac{1 - 0.85(d/t)}{1 - 0.85(d/t)/M} \right]$$

[References: (1) Kiefner, J. F., and Vieth, P. H., "Project PR3-805: A Modified Criterion for Evaluating the Remaining Strength of Corroded Pipe," AGA Catalog No. L51609, Dec. 22, 1989; (2) Kiefner, J. F., and Vieth, P. H., "New Method Corrects Criterion for Evaluating Corroded Pipe," Oil & Gas Journal, Aug. 6 and Aug. 20, 1990.]

(c) API 579 Level 1. The "API 579 Level 1" assessment, when reduced to its simplest form, is of a similar format to the other Level 1 methods presented herein, and therefore qualifies as a Level 1 assessment for purposes of meeting the requirements of this document.

(12) 2.3 Level 2 Evaluation

Level 2 evaluations are performed using what is known as the Effective Area Method. Level 2 evaluations shall be carried out using a procedure similar to the ten steps described for Level 1, except that the Effective Area Method generally requires several measurements of the depth of corrosion or remaining wall thickness throughout the corroded area. The Effective Area Method is expressed as follows:

$$S_F = S_{\text{flow}} \left[\frac{1 - A/A_0}{1 - (A/A_0)/M} \right]$$

The Effective Area Method evaluates, by iteration, all possible combinations of local metal loss, A, with respect to original material, A_0. It requires for input a detailed longitudinal distribution or profile of metal loss. The detailed profile is established by obtaining several measurements of metal loss or remaining wall thickness throughout the metal loss area. Such measurements may be arranged in a grid pattern, or may follow a "river bottom" path through the deepest areas of metal loss. Increments of measurement need not be uniform, subject to limitations of application software. If using a grid pattern, the analysis must be repeated along each meridian to establish the governing solution. For a corroded profile defined by n measurements of depth of corrosion including the end points at nominally full wall thickness, $n!/2(n-2)!$ iterations are required to examine all possible combinations of local metal loss with respect to surrounding remaining material. The local solution resulting in the lowest calculated failure stress shall govern.

Owing to its iterative nature, it is a practical necessity to use a computer program or other algorithmic approach (e.g., a spreadsheet) in order to carry out an evaluation using the Effective Area Method.

The "API 579 Level 2" assessment, when reduced to its simplest form, is equivalent to the Effective Area Method presented herein, and therefore qualifies as a Level 2 assessment for purposes of meeting the requirements of this document. Refer to API 579-1/ASME FFS-1 for detailed instructions.

[References: Same as in para. 2.2(b).]

2.4 Level 3 Evaluation

A Level 3 evaluation typically involves a detailed analysis, such as a finite element analysis of the corroded region. The analysis should accurately consider or account for all factors that could affect the accuracy of results, including loadings including internal pressure and external forces; boundary conditions and constraints; ovality, deformations, misalignments, and discontinuities; material stress–strain characteristics; and effects of the flaw on the overall distribution of loads and stresses. A failure criterion should be developed that considers the strain capacity or fracture resistance characteristics of the material. Similar issues should be considered in developing a suitable safety factor as were described for a Level 1 or Level 2 analysis.

3 TABLES OF ALLOWABLE LENGTH OF CORROSION

The following are applicable to Tables 3-1 through 3-12M:

(a) Metal loss having a maximum depth of 10% of the nominal pipe wall thickness or less is not limited as to allowable length.

(b) Metal loss having a maximum depth exceeding 80% of the nominal pipe wall thickness shall not be evaluated using the tables of allowable length.

Table 3-1 Values of L for Pipe Sizes ≥ NPS 2 and < NPS 6 (12)

Depth, d, in.	Wall Thickness, t, in.							
	0.083	0.109	0.125	0.141	0.154	0.172	0.188	0.218
0.01	1.99	No limit	No limit	No limit	No limit	No limit	No limit	No limit
0.02	0.92	1.94	2.44	2.59	2.71	2.86	2.99	No limit
0.03	0.53	0.85	1.13	1.51	1.94	2.86	2.99	3.22
0.04	0.39	0.60	0.75	0.93	1.11	1.40	1.74	2.74
0.05	0.31	0.47	0.58	0.70	0.82	1.00	1.18	1.62
0.06	0.25	0.39	0.48	0.58	0.66	0.79	0.92	1.21
0.07	. . .	0.33	0.41	0.49	0.56	0.67	0.77	0.99
0.08	. . .	0.28	0.35	0.43	0.49	0.58	0.67	0.84
0.09	. . .	. . .	0.31	0.38	0.43	0.51	0.59	0.74
0.10	. . .	. . .	0.27	0.33	0.39	0.46	0.53	0.66
0.11	. . .	. . .	. . .	0.30	0.35	0.41	0.48	0.60
0.12	. . .	. . .	. . .	. . .	0.31	0.38	0.43	0.55
0.13	. . .	. . .	. . .	. . .	. . .	0.34	0.40	0.50
0.14	. . .	. . .	. . .	. . .	. . .	. . .	0.37	0.46
0.15	. . .	. . .	. . .	. . .	. . .	. . .	0.34	0.43
0.16	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.40
0.17	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.37

Table 3-1M Values of L for Pipe Sizes ≥ 60 mm and < 168 mm O.D. (12)

Depth, d, mm	Wall Thickness, t, mm							
	2.1	2.8	3.2	3.6	3.9	4.4	4.8	5.5
0.3	50.5	No limit	No limit	No limit	No limit	No limit	No limit	No limit
0.5	23.2	49.1	62.0	65.8	68.8	72.7	76.0	No limit
0.8	13.4	21.7	28.7	38.3	49.2	72.7	76.0	81.9
1.0	9.8	15.1	19.0	23.7	28.1	35.6	44.2	69.5
1.3	7.8	11.9	14.7	17.9	20.8	25.3	29.9	41.1
1.5	6.4	9.8	12.1	14.6	16.8	20.1	23.4	30.7
1.8	. . .	8.3	10.3	12.4	14.3	17.0	19.5	25.0
2.0	. . .	7.2	9.0	10.8	12.4	14.7	16.9	21.4
2.3	. . .	. . .	7.9	9.5	11.0	13.0	14.9	18.8
2.5	. . .	. . .	6.9	8.5	9.8	11.6	13.4	16.8
2.8	. . .	. . .	. . .	7.6	8.8	10.5	12.1	15.2
3.0	. . .	. . .	. . .	. . .	8.0	9.6	11.0	13.9
3.3	. . .	. . .	. . .	. . .	. . .	8.7	10.1	12.8
3.6	. . .	. . .	. . .	. . .	. . .	. . .	9.3	11.8
3.8	. . .	. . .	. . .	. . .	. . .	. . .	8.5	10.9
4.1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	10.2
4.3	. . .	. . .	. . .	. . .	. . .	. . .	. . .	9.5

(12) **Table 3-2 Values of *L* for Pipe Sizes ≥ NPS 6 and < NPS 10**

Depth, d, in.	Wall Thickness, t, in.							
	0.083	0.125	0.156	0.188	0.203	0.219	0.250	0.312
0.01	3.32	No limit	No limit	No limit	No limit	No limit	No limit	No limit
0.02	1.53	4.08	4.55	5.00	No limit	No limit	No limit	No limit
0.03	0.88	1.89	3.37	5.00	5.20	5.40	5.77	No limit
0.04	0.65	1.25	1.90	2.91	3.61	4.65	5.77	6.44
0.05	0.51	0.97	1.40	1.97	2.30	2.73	3.86	6.44
0.06	0.42	0.80	1.13	1.54	1.77	2.04	2.67	4.77
0.07	...	0.68	0.96	1.29	1.46	1.66	2.11	3.37
0.08	...	0.59	0.83	1.11	1.25	1.42	1.77	2.68
0.09	...	0.52	0.74	0.98	1.10	1.24	1.54	2.26
0.10	...	0.46	0.66	0.88	0.99	1.11	1.37	1.97
0.11	...	...	0.59	0.80	0.90	1.01	1.24	1.76
0.12	...	...	0.54	0.73	0.82	0.92	1.13	1.60
0.13	...	...	...	0.66	0.75	0.85	1.04	1.46
0.14	...	...	...	0.61	0.69	0.78	0.96	1.35
0.15	...	...	...	0.56	0.64	0.72	0.89	1.26
0.16	...	...	...	...	0.59	0.67	0.83	1.18
0.17	...	...	...	...	...	0.63	0.78	1.10
0.18	...	...	...	...	...	...	0.73	1.04
0.19	...	...	...	...	...	...	0.69	0.98
0.20	...	...	...	...	...	...	0.65	0.93
0.21	...	...	...	...	...	...	...	0.88
0.22	...	...	...	...	...	...	...	0.84
0.23	...	...	...	...	...	...	...	0.80
0.24	...	...	...	...	...	...	...	0.76

Table 3-2M Values of *L* for Pipe Sizes ≥ 168 mm and < 273 mm O.D. (12)

Depth, *d*, mm	Wall Thickness, *t*, mm							
	2.1	3.2	4.0	4.8	5.2	5.6	6.4	7.9
0.3	84.4	No limit	No limit	No limit	No limit	No limit	No limit	No limit
0.5	38.8	103.6	115.7	127.0	No limit	No limit	No limit	No limit
0.8	22.4	48.0	85.6	127.0	132.0	137.1	146.4	No limit
1.0	16.4	31.8	48.1	73.8	91.6	118.1	146.4	163.6
1.3	13.0	24.6	35.5	50.0	58.5	69.3	98.0	163.6
1.5	10.7	20.3	28.7	39.1	44.9	51.7	67.8	121.1
1.8	...	17.3	24.3	32.6	37.1	42.2	53.6	85.5
2.0	...	15.0	21.1	28.2	31.9	36.0	45.0	68.1
2.3	...	13.1	18.7	24.9	28.1	31.6	39.1	57.4
2.5	...	11.6	16.7	22.3	25.1	28.3	34.8	50.2
2.8	...	...	15.0	20.2	22.8	25.6	31.4	44.8
3.0	...	...	13.6	18.4	20.8	23.4	28.7	40.6
3.3	...	...	...	16.9	19.1	21.5	26.4	37.2
3.6	...	...	...	15.5	17.6	19.8	24.4	34.4
3.8	...	...	...	14.3	16.3	18.4	22.7	32.0
4.1	...	...	...	...	15.1	17.1	21.2	29.9
4.3	...	...	...	...	...	15.9	19.8	28.0
4.6	...	...	...	...	...	...	18.6	26.4
4.8	...	...	...	...	...	...	17.5	25.0
5.1	...	...	...	...	...	...	16.4	23.6
5.3	...	...	...	...	...	...	...	22.4
5.6	...	...	...	...	...	...	...	21.3
5.8	...	...	...	...	...	...	...	20.2
6.1	...	...	...	...	...	...	...	19.2

Table 3-3 Values of *L* for Pipe Sizes ≥ NPS 10 and < NPS 16

Depth, *d*, in.	Wall Thickness, *t*, in. 0.156	0.219	0.250	0.307	0.344	0.365	0.438	0.500
0.02	5.80	No limit	No limit	No limit	No limit	No limit	No limit	No limit
0.03	4.29	6.87	7.34	No limit	No limit	No limit	No limit	No limit
0.04	2.41	5.92	7.34	8.14	8.62	8.87	No limit	No limit
0.05	1.78	3.48	4.91	8.14	8.62	8.87	9.72	10.39
0.06	1.44	2.59	3.40	5.77	8.62	8.87	9.72	10.39
0.07	1.22	2.11	2.69	4.13	5.53	6.62	9.72	10.39
0.08	1.06	1.81	2.26	3.30	4.22	4.85	8.37	10.39
0.09	0.94	1.59	1.96	2.80	3.48	3.93	6.10	9.38
0.10	0.84	1.42	1.74	2.45	2.99	3.35	4.92	6.95
0.11	0.75	1.28	1.57	2.19	2.65	2.94	4.18	5.64
0.12	0.68	1.17	1.44	1.98	2.39	2.64	3.67	4.81
0.13	...	1.08	1.32	1.82	2.18	2.40	3.29	4.23
0.14	...	1.00	1.22	1.68	2.01	2.21	2.99	3.80
0.15	...	0.92	1.14	1.56	1.86	2.05	2.75	3.46
0.16	...	0.86	1.06	1.46	1.74	1.91	2.55	3.19
0.17	...	0.80	0.99	1.37	1.64	1.79	2.39	2.97
0.18	...	...	0.93	1.29	1.54	1.69	2.24	2.77
0.19	...	...	0.88	1.22	1.46	1.60	2.12	2.61
0.20	...	...	0.82	1.15	1.38	1.51	2.00	2.47
0.21	...	...	...	1.09	1.31	1.44	1.90	2.34
0.22	...	...	...	1.04	1.25	1.37	1.81	2.23
0.23	...	...	...	0.99	1.19	1.30	1.73	2.12
0.24	...	...	...	0.94	1.13	1.25	1.66	2.03
0.25	...	...	...	...	1.08	1.19	1.59	1.95
0.26	...	...	...	...	1.03	1.14	1.52	1.87
0.27	...	...	...	...	0.99	1.09	1.46	1.80
0.28	...	...	...	...	...	1.05	1.41	1.73
0.29	...	...	...	...	...	1.00	1.35	1.67
0.30	...	...	...	...	...	...	1.31	1.61
0.31	...	...	...	...	...	...	1.26	1.55
0.32	...	...	...	...	...	...	1.21	1.50
0.33	...	...	...	...	...	...	1.17	1.45
0.34	...	...	...	...	...	...	1.13	1.41
0.35	...	...	...	...	...	...	1.09	1.36
0.36	...	...	...	...	...	...	...	1.32
0.37	...	...	...	...	...	...	...	1.28
0.38	...	...	...	...	...	...	...	1.24
0.39	...	...	...	...	...	...	...	1.20
0.40	...	...	...	...	...	...	...	1.16

Table 3-3M Values of L for Pipe Sizes ≥ 273 mm and < 406 mm O.D.

Depth, d, mm	Wall Thickness, t, mm							
	4.0	5.6	6.4	7.8	8.7	9.3	11.1	12.7
0.5	147.4	No limit	No limit	No limit	No limit	No limit	No limit	No limit
0.8	109.1	174.6	186.5	No limit	No limit	No limit	No limit	No limit
1.0	61.3	150.4	186.5	206.7	218.8	225.4	No limit	No limit
1.3	45.2	88.3	124.8	206.7	218.8	225.4	246.9	263.8
1.5	36.5	65.9	86.4	146.6	218.8	225.4	246.9	263.8
1.8	30.9	53.7	68.2	104.8	140.5	168.1	246.9	263.8
2.0	26.9	45.9	57.3	83.9	107.1	123.3	212.7	263.8
2.3	23.8	40.3	49.8	71.0	88.3	99.8	155.0	238.4
2.5	21.3	36.0	44.3	62.1	76.0	85.0	124.9	176.5
2.8	19.2	32.6	40.0	55.5	67.3	74.7	106.1	143.3
3.0	17.3	29.8	36.5	50.4	60.6	67.0	93.1	122.2
3.3	...	27.4	33.6	46.2	55.3	61.0	83.5	107.5
3.6	...	25.3	31.1	42.7	51.0	56.1	76.0	96.5
3.8	...	23.4	28.9	39.7	47.4	52.0	69.9	87.9
4.1	...	21.8	27.0	37.1	44.2	48.5	64.9	81.0
4.3	...	20.3	25.2	34.8	41.5	45.5	60.6	75.3
4.6	...	...	23.7	32.8	39.1	42.9	56.9	70.5
4.8	...	...	22.2	31.0	37.0	40.5	53.7	66.3
5.1	...	...	20.9	29.3	35.1	38.4	50.9	62.7
5.3	...	...	...	27.8	33.3	36.5	48.4	59.4
5.6	...	...	...	26.4	31.7	34.8	46.1	56.6
5.8	...	...	...	25.1	30.2	33.1	44.0	54.0
6.1	...	...	...	23.8	28.8	31.7	42.1	51.6
6.4	...	...	...	...	27.5	30.3	40.3	49.5
6.6	...	...	...	...	26.3	29.0	38.7	47.5
6.9	...	...	...	...	25.1	27.7	37.2	45.7
7.1	...	...	...	...	...	26.6	35.7	44.0
7.4	...	...	...	...	...	25.5	34.4	42.4
7.6	...	...	...	...	...	...	33.2	40.9
7.9	...	...	...	...	...	...	32.0	39.5
8.1	...	...	...	...	...	...	30.8	38.1
8.4	...	...	...	...	...	...	29.7	36.9
8.6	...	...	...	...	...	...	28.7	35.7
8.9	...	...	...	...	...	...	27.7	34.6
9.1	...	...	...	...	...	...	...	33.5
9.4	...	...	...	...	...	...	...	32.4
9.7	...	...	...	...	...	...	...	31.4
9.9	...	...	...	...	...	...	...	30.5
10.2	...	...	...	...	...	...	...	29.6

(12)

Table 3-4 Values of *L* for Pipe Sizes ≥ NPS 16 and < NPS 20

Depth, *d*, in.	Wall Thickness, *t*, in.							
	0.188	0.250	0.312	0.344	0.375	0.438	0.500	0.625
0.02	7.77	No limit	No limit	No limit	No limit	No limit	No limit	No limit
0.03	7.77	8.96	No limit	No limit	No limit	No limit	No limit	No limit
0.04	4.52	8.96	10.01	10.51	10.97	No limit	No limit	No limit
0.05	3.06	6.00	10.01	10.51	10.97	11.86	12.67	No limit
0.06	2.39	4.15	7.41	10.51	10.97	11.86	12.67	No limit
0.07	2.00	3.28	5.23	6.75	8.84	11.86	12.67	14.17
0.08	1.73	2.75	4.17	5.14	6.34	10.21	12.67	14.17
0.09	1.52	2.39	3.51	4.24	5.08	7.44	11.45	14.17
0.10	1.37	2.13	3.07	3.65	4.30	6.00	8.48	14.17
0.11	1.24	1.92	2.74	3.23	3.77	5.10	6.88	13.85
0.12	1.13	1.75	2.48	2.91	3.37	4.47	5.87	10.53
0.13	1.03	1.61	2.27	2.66	3.06	4.01	5.16	8.65
0.14	0.95	1.49	2.10	2.45	2.81	3.65	4.63	7.43
0.15	0.87	1.39	1.96	2.28	2.61	3.36	4.22	6.56
0.16	. . .	1.30	1.83	2.13	2.43	3.12	3.89	5.91
0.17	. . .	1.21	1.72	1.99	2.28	2.91	3.62	5.40
0.18	. . .	1.14	1.62	1.88	2.15	2.74	3.38	4.99
0.19	. . .	1.07	1.53	1.78	2.03	2.58	3.18	4.64
0.20	. . .	1.00	1.44	1.68	1.92	2.45	3.01	4.35
0.21	. . .	. . .	1.37	1.60	1.83	2.32	2.85	4.10
0.22	. . .	. . .	1.30	1.52	1.74	2.21	2.72	3.88
0.23	. . .	. . .	1.24	1.45	1.66	2.11	2.59	3.69
0.24	. . .	. . .	1.18	1.38	1.59	2.02	2.48	3.52
0.25	. . .	. . .	. . .	1.32	1.52	1.94	2.38	3.36
0.26	. . .	. . .	. . .	1.26	1.45	1.86	2.28	3.22
0.27	. . .	. . .	. . .	1.21	1.39	1.79	2.19	3.10
0.28	. . .	. . .	. . .	. . .	1.34	1.72	2.11	2.98
0.29	. . .	. . .	. . .	. . .	1.28	1.65	2.03	2.87
0.30	. . .	. . .	. . .	. . .	1.23	1.59	1.96	2.77
0.31	. . .	. . .	. . .	. . .	. . .	1.53	1.90	2.68
0.32	. . .	. . .	. . .	. . .	. . .	1.48	1.83	2.59
0.33	. . .	. . .	. . .	. . .	. . .	1.43	1.77	2.51
0.34	. . .	. . .	. . .	. . .	. . .	1.38	1.71	2.43
0.35	. . .	. . .	. . .	. . .	. . .	1.33	1.66	2.36
0.36	. . .	. . .	. . .	. . .	. . .	. . .	1.61	2.29
0.37	. . .	. . .	. . .	. . .	. . .	. . .	1.56	2.23
0.38	. . .	. . .	. . .	. . .	. . .	. . .	1.51	2.16
0.39	. . .	. . .	. . .	. . .	. . .	. . .	1.46	2.11
0.40	. . .	. . .	. . .	. . .	. . .	. . .	1.42	2.05
0.41	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.99
0.42	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.94
0.43	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.89
0.44	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.84
0.45	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.80
0.46	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.75
0.47	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.71
0.48	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.67
0.49	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.63
0.50	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.59

Table 3-4M Values of *L* for Pipe Sizes ≥ 406 mm and < 508 mm O.D. (12)

Depth, *d*, mm	Wall Thickness, *t*, mm							
	4.8	6.4	7.9	8.7	9.5	11.1	12.7	15.9
0.5	197.4	No limit	No limit	No limit	No limit	No limit	No limit	No limit
0.8	197.4	227.6	No limit	No limit	No limit	No limit	No limit	No limit
1.0	114.8	227.6	254.2	267.0	278.7	No limit	No limit	No limit
1.3	77.7	152.3	254.2	267.0	278.7	301.2	321.9	No limit
1.5	60.8	105.4	188.2	267.0	278.7	301.2	321.9	No limit
1.8	50.7	83.2	132.9	171.4	224.5	301.2	321.9	359.8
2.0	43.8	69.9	105.8	130.6	161.2	259.5	321.9	359.8
2.3	38.7	60.8	89.3	107.7	129.1	189.1	290.8	359.8
2.5	34.7	54.1	77.9	92.8	109.3	152.4	215.4	359.8
2.8	31.4	48.8	69.6	82.1	95.7	129.5	174.8	351.8
3.0	28.6	44.5	63.0	73.9	85.6	113.6	149.1	267.5
3.3	26.2	41.0	57.8	67.5	77.8	101.8	131.1	219.8
3.6	24.1	37.9	53.4	62.2	71.4	92.7	117.7	188.7
3.8	22.2	35.3	49.7	57.8	66.2	85.3	107.3	166.7
4.1	...	32.9	46.4	54.0	61.7	79.1	98.9	150.1
4.3	...	30.8	43.6	50.7	57.9	73.9	91.9	137.1
4.6	...	28.9	41.1	47.7	54.5	69.5	86.0	126.6
4.8	...	27.1	38.8	45.1	51.5	65.6	80.9	117.9
5.1	...	25.5	36.7	42.8	48.9	62.1	76.4	110.5
5.3	...	...	34.8	40.6	46.4	59.0	72.5	104.2
5.6	...	...	33.0	38.6	44.2	56.2	69.0	98.6
5.8	...	...	31.4	36.8	42.2	53.7	65.8	93.7
6.1	...	...	29.9	35.1	40.3	51.3	63.0	89.4
6.4	...	...	...	33.5	38.6	49.2	60.3	85.5
6.6	...	...	...	32.0	36.9	47.2	57.9	81.9
6.9	...	...	...	30.6	35.4	45.4	55.7	78.7
7.1	...	...	...	...	33.9	43.6	53.6	75.7
7.4	...	...	...	...	32.5	42.0	51.7	72.9
7.6	...	...	...	...	31.2	40.4	49.9	70.4
7.9	...	...	...	...	...	39.0	48.2	68.0
8.1	...	...	...	...	...	37.6	46.5	65.8
8.4	...	...	...	...	...	36.3	45.0	63.7
8.6	...	...	...	...	...	35.0	43.6	61.8
8.9	...	...	...	...	...	33.8	42.2	60.0
9.1	...	...	...	...	...	...	40.9	58.2
9.4	...	...	...	...	...	...	39.6	56.6
9.7	...	...	...	...	...	...	38.4	55.0
9.9	...	...	...	...	...	...	37.2	53.5
10.2	...	...	...	...	...	...	36.1	52.0
10.4	...	...	...	...	...	...	...	50.7
10.7	...	...	...	...	...	...	...	49.3
10.9	...	...	...	...	...	...	...	48.1
11.2	...	...	...	...	...	...	...	46.9
11.4	...	...	...	...	...	...	...	45.7
11.7	...	...	...	...	...	...	...	44.5
11.9	...	...	...	...	...	...	...	43.4
12.2	...	...	...	...	...	...	...	42.4
12.4	...	...	...	...	...	...	...	41.3
12.7	...	...	...	...	...	...	...	40.3

Table 3-5 Values of *L* for Pipe Sizes ≥ NPS 20 and < NPS 24

Depth, *d*, in.	Wall Thickness, *t*, in.							
	0.219	0.250	0.344	0.406	0.469	0.500	0.562	0.625
0.03	9.38	10.02	No limit	No limit	No limit	No limit	No limit	No limit
0.04	8.08	10.02	11.75	No limit	No limit	No limit	No limit	No limit
0.05	4.74	6.70	11.75	12.77	13.72	14.17	No limit	No limit
0.06	3.54	4.64	11.75	12.77	13.72	14.17	15.02	No limit
0.07	2.88	3.66	7.54	12.77	13.72	14.17	15.02	15.84
0.08	2.46	3.08	5.75	8.86	13.72	14.17	15.02	15.84
0.09	2.16	2.68	4.74	6.83	10.21	12.80	15.02	15.84
0.10	1.93	2.38	4.08	5.66	7.94	9.48	14.12	15.84
0.11	1.75	2.15	3.61	4.89	6.61	7.69	10.61	15.49
0.12	1.60	1.96	3.26	4.34	5.73	6.56	8.67	11.77
0.13	1.47	1.80	2.97	3.92	5.09	5.77	7.42	9.67
0.14	1.36	1.67	2.74	3.58	4.60	5.18	6.54	8.31
0.15	1.26	1.55	2.54	3.31	4.22	4.72	5.88	7.34
0.16	1.17	1.45	2.38	3.08	3.90	4.35	5.37	6.61
0.17	1.09	1.36	2.23	2.89	3.64	4.04	4.95	6.04
0.18	...	1.27	2.10	2.72	3.41	3.78	4.61	5.57
0.19	...	1.19	1.99	2.56	3.21	3.56	4.32	5.19
0.20	...	1.12	1.88	2.43	3.04	3.36	4.07	4.87
0.21	...	...	1.79	2.31	2.89	3.19	3.85	4.59
0.22	...	...	1.70	2.20	2.75	3.04	3.65	4.34
0.23	...	...	1.62	2.10	2.63	2.90	3.48	4.13
0.24	...	...	1.55	2.01	2.51	2.77	3.32	3.93
0.25	...	...	1.48	1.92	2.41	2.66	3.18	3.76
0.26	...	...	1.41	1.84	2.31	2.55	3.05	3.61
0.27	...	...	1.35	1.77	2.22	2.45	2.94	3.46
0.28	...	...	...	1.70	2.14	2.36	2.83	3.33
0.29	...	...	...	1.64	2.06	2.27	2.73	3.21
0.30	...	...	...	1.57	1.99	2.19	2.63	3.10
0.31	...	...	...	1.51	1.92	2.12	2.54	2.99
0.32	...	...	...	1.46	1.85	2.05	2.46	2.90
0.33	...	...	...	...	1.79	1.98	2.38	2.81
0.34	...	...	...	...	1.73	1.92	2.31	2.72
0.35	...	...	...	...	1.67	1.86	2.24	2.64
0.36	...	...	...	...	1.62	1.80	2.17	2.56
0.37	...	...	...	...	1.56	1.74	2.11	2.49
0.38	...	...	...	...	...	1.69	2.05	2.42
0.39	...	...	...	...	...	1.64	1.99	2.35
0.40	...	...	...	...	...	1.59	1.93	2.29
0.41	...	...	...	...	...	...	1.88	2.23
0.42	...	...	...	...	...	...	1.83	2.17
0.43	...	...	...	...	...	...	1.78	2.12
0.44	...	...	...	...	...	...	1.73	2.06
0.45	...	...	...	...	...	...	...	2.01
0.46	...	...	...	...	...	...	...	1.96
0.47	...	...	...	...	...	...	...	1.91
0.48	...	...	...	...	...	...	...	1.86
0.49	...	...	...	...	...	...	...	1.82
0.50	...	...	...	...	...	...	...	1.78

Table 3-5M Values of *L* for Pipe Sizes ≥ 508 mm and < 610 mm O.D.

Depth, d, mm	Wall Thickness, t, mm							
	5.6	6.4	8.7	10.3	11.9	12.7	14.3	15.9
0.8	238.1	254.4	No limit	No limit	No limit	No limit	No limit	No limit
1.0	205.1	254.4	298.5	No limit	No limit	No limit	No limit	No limit
1.3	120.5	170.3	298.5	324.3	348.5	359.8	No limit	No limit
1.5	89.8	117.8	298.5	324.3	348.5	359.8	381.5	No limit
1.8	73.3	93.1	191.6	324.3	348.5	359.8	381.5	402.3
2.0	62.6	78.2	146.0	225.2	348.5	359.8	381.5	402.3
2.3	54.9	68.0	120.4	173.5	259.5	325.1	381.5	402.3
2.5	49.1	60.4	103.7	143.8	201.7	240.8	358.6	402.3
2.8	44.4	54.6	91.8	124.3	168.0	195.4	269.5	393.4
3.0	40.6	49.8	82.7	110.2	145.5	166.7	220.2	299.1
3.3	37.3	45.8	75.5	99.5	129.3	146.6	188.5	245.7
3.6	34.5	42.4	69.6	91.0	116.9	131.6	166.1	211.0
3.8	32.0	39.4	64.6	84.1	107.1	119.9	149.4	186.3
4.1	29.7	36.8	60.4	78.3	99.1	110.5	136.4	167.8
4.3	27.7	34.4	56.6	73.3	92.4	102.7	125.8	153.3
4.6	...	32.3	53.4	69.0	86.6	96.1	117.1	141.6
4.8	...	30.3	50.5	65.1	81.6	90.4	109.6	131.8
5.1	...	28.5	47.8	61.7	77.2	85.5	103.3	123.6
5.3	...	...	45.4	58.7	73.3	81.1	97.7	116.5
5.6	...	...	43.2	55.9	69.8	77.1	92.8	110.3
5.8	...	...	41.2	53.4	66.7	73.6	88.4	104.8
6.1	...	...	39.3	51.0	63.8	70.4	84.4	99.9
6.4	...	...	37.5	48.9	61.1	67.5	80.9	95.5
6.6	...	...	35.8	46.9	58.7	64.8	77.6	91.6
6.9	...	...	34.2	45.0	56.4	62.3	74.6	88.0
7.1	...	...	...	43.2	54.3	60.0	71.8	84.6
7.4	...	...	...	41.5	52.3	57.8	69.2	81.6
7.6	...	...	...	39.9	50.4	55.8	66.8	78.7
7.9	...	...	...	38.4	48.7	53.8	64.6	76.1
8.1	...	...	...	37.0	47.0	52.0	62.5	73.6
8.4	...	...	...	...	45.4	50.3	60.5	71.3
8.6	...	...	...	...	43.9	48.7	58.6	69.1
8.9	...	...	...	...	42.4	47.2	56.8	67.0
9.1	...	...	...	...	41.1	45.7	55.1	65.1
9.4	...	...	...	...	39.7	44.3	53.5	63.2
9.7	...	...	...	...	...	42.9	52.0	61.5
9.9	...	...	...	...	...	41.6	50.5	59.8
10.2	...	...	...	...	...	40.3	49.1	58.2
10.4	...	...	...	...	...	...	47.7	56.6
10.7	...	...	...	...	...	...	46.4	55.2
10.9	...	...	...	...	...	...	45.1	53.7
11.2	...	...	...	...	...	...	43.9	52.4
11.4	...	...	...	...	...	...	...	51.1
11.7	...	...	...	...	...	...	...	49.8
11.9	...	...	...	...	...	...	...	48.6
12.2	...	...	...	...	...	...	...	47.4
12.4	...	...	...	...	...	...	...	46.2
12.7	...	...	...	...	...	...	...	45.1

Table 3-6 Values of L for Pipe Sizes ≥ NPS 24 and < NPS 30

Depth, d, in.	Wall Thickness, t, in.							
	0.250	0.312	0.375	0.438	0.469	0.500	0.562	0.625
0.03	10.97	No limit	No limit	No limit	No limit	No limit	No limit	No limit
0.04	10.97	12.26	13.44	No limit	No limit	No limit	No limit	No limit
0.05	7.34	12.26	13.44	14.53	15.03	15.52	No limit	No limit
0.06	5.08	9.07	13.44	14.53	15.03	15.52	16.45	No limit
0.07	4.01	6.41	10.83	14.53	15.03	15.52	16.45	17.35
0.08	3.37	5.10	7.77	12.51	15.03	15.52	16.45	17.35
0.09	2.93	4.30	6.22	9.12	11.19	14.02	16.45	17.35
0.10	2.61	3.76	5.27	7.35	8.70	10.38	15.47	17.35
0.11	2.35	3.35	4.61	6.24	7.24	8.43	11.62	16.96
0.12	2.15	3.04	4.13	5.48	6.28	7.19	9.50	12.90
0.13	1.98	2.79	3.75	4.91	5.58	6.32	8.13	10.60
0.14	1.83	2.57	3.45	4.47	5.04	5.68	7.17	9.10
0.15	1.70	2.39	3.19	4.11	4.62	5.17	6.44	8.04
0.16	1.59	2.24	2.98	3.82	4.27	4.77	5.88	7.24
0.17	1.49	2.10	2.79	3.57	3.98	4.43	5.43	6.61
0.18	1.39	1.98	2.63	3.35	3.74	4.15	5.05	6.11
0.19	1.31	1.87	2.49	3.16	3.52	3.90	4.73	5.69
0.20	1.23	1.77	2.36	2.99	3.33	3.69	4.45	5.33
0.21	...	1.68	2.24	2.85	3.16	3.50	4.21	5.02
0.22	...	1.59	2.13	2.71	3.01	3.33	4.00	4.76
0.23	...	1.51	2.03	2.59	2.88	3.17	3.81	4.52
0.24	...	1.44	1.94	2.48	2.75	3.04	3.64	4.31
0.25	...	...	1.86	2.37	2.64	2.91	3.49	4.12
0.26	...	...	1.78	2.28	2.53	2.79	3.35	3.95
0.27	...	...	1.71	2.19	2.43	2.69	3.22	3.79
0.28	...	...	1.64	2.10	2.34	2.59	3.10	3.65
0.29	...	...	1.57	2.02	2.26	2.49	2.99	3.52
0.30	...	...	1.51	1.95	2.17	2.40	2.88	3.39
0.31	...	...	...	1.88	2.10	2.32	2.78	3.28
0.32	...	...	...	1.81	2.03	2.24	2.69	3.17
0.33	...	...	...	1.75	1.96	2.17	2.61	3.07
0.34	...	...	...	1.69	1.89	2.10	2.53	2.98
0.35	...	...	...	1.63	1.83	2.03	2.45	2.89
0.36	...	...	...	...	1.77	1.97	2.38	2.81
0.37	...	...	...	...	1.71	1.91	2.31	2.73
0.38	...	...	...	...	...	1.85	2.24	2.65
0.39	...	...	...	...	...	1.79	2.18	2.58
0.40	...	...	...	...	...	1.74	2.12	2.51
0.41	...	...	...	...	...	...	2.06	2.44
0.42	...	...	...	...	...	...	2.00	2.38
0.43	...	...	...	...	...	...	1.95	2.32
0.44	...	...	...	...	...	...	1.89	2.26
0.45	...	...	...	...	...	...	...	2.20
0.46	...	...	...	...	...	...	...	2.15
0.47	...	...	...	...	...	...	...	2.09
0.48	...	...	...	...	...	...	...	2.04
0.49	...	...	...	...	...	...	...	1.99
0.50	...	...	...	...	...	...	...	1.94

Table 3-6M Values of L for Pipe Sizes $\geq$ 610 mm and < 762 mm O.D.

Depth, d, mm	Wall Thickness, t, mm							
	6.4	7.9	9.5	11.1	11.9	12.7	14.3	15.9
0.8	278.7	No limit	No limit	No limit	No limit	No limit	No limit	No limit
1.0	278.7	311.4	341.4	No limit	No limit	No limit	No limit	No limit
1.3	186.5	311.4	341.4	368.9	381.8	394.2	No limit	No limit
1.5	129.1	230.5	341.4	368.9	381.8	394.2	417.9	No limit
1.8	102.0	162.8	275.0	368.9	381.8	394.2	417.9	440.7
2.0	85.6	129.6	197.4	317.8	381.8	394.2	417.9	440.7
2.3	74.5	109.3	158.1	231.6	284.2	356.2	417.9	440.7
2.5	66.2	95.5	133.9	186.7	221.0	263.8	392.9	440.7
2.8	59.8	85.2	117.2	158.6	184.0	214.1	295.2	430.9
3.0	54.5	77.2	104.9	139.1	159.4	182.6	241.2	327.6
3.3	50.2	70.8	95.3	124.7	141.6	160.6	206.5	269.1
3.6	46.4	65.4	87.5	113.5	128.1	144.2	182.0	231.1
3.8	43.2	60.8	81.1	104.4	117.3	131.4	163.7	204.1
4.1	40.3	56.9	75.6	96.9	108.5	121.1	149.4	183.8
4.3	37.7	53.4	70.9	90.6	101.2	112.5	137.8	167.9
4.6	35.4	50.3	66.8	85.1	94.9	105.3	128.2	155.1
4.8	33.2	47.5	63.1	80.3	89.4	99.1	120.1	144.4
5.1	31.2	44.9	59.8	76.1	84.6	93.6	113.1	135.4
5.3	...	42.6	56.9	72.3	80.4	88.8	107.0	127.6
5.6	...	40.5	54.2	68.8	76.5	84.5	101.6	120.8
5.8	...	38.5	51.7	65.7	73.0	80.6	96.8	114.8
6.1	...	36.6	49.4	62.9	69.9	77.1	92.5	109.5
6.4	...	...	47.2	60.3	67.0	73.9	88.6	104.7
6.6	...	...	45.2	57.8	64.3	71.0	85.0	100.3
6.9	...	...	43.3	55.5	61.8	68.2	81.7	96.3
7.1	...	...	41.5	53.4	59.5	65.7	78.7	92.7
7.4	...	...	39.9	51.4	57.3	63.3	75.8	89.3
7.6	...	...	38.3	49.5	55.2	61.1	73.2	86.2
7.9	...	...	...	47.7	53.3	59.0	70.7	83.3
8.1	...	...	...	46.1	51.5	57.0	68.4	80.6
8.4	...	...	...	44.4	49.7	55.1	66.2	78.1
8.6	...	...	...	42.9	48.1	53.3	64.2	75.7
8.9	...	...	...	41.4	46.5	51.7	62.2	73.4
9.1	...	...	...	...	45.0	50.0	60.4	71.3
9.4	...	...	...	...	43.5	48.5	58.6	69.3
9.7	...	...	...	...	...	47.0	56.9	67.3
9.9	...	...	...	...	...	45.6	55.3	65.5
10.2	...	...	...	...	...	44.2	53.7	63.7
10.4	...	...	...	...	...	...	52.2	62.0
10.7	...	...	...	...	...	...	50.8	60.4
10.9	...	...	...	...	...	...	49.4	58.9
11.2	...	...	...	...	...	...	48.1	57.4
11.4	...	...	...	...	...	...	...	55.9
11.7	...	...	...	...	...	...	...	54.5
11.9	...	...	...	...	...	...	...	53.2
12.2	...	...	...	...	...	...	...	51.9
12.4	...	...	...	...	...	...	...	50.6
12.7	...	...	...	...	...	...	...	49.4

Table 3-7 Values of L for Pipe Sizes ≥ NPS 30 and < NPS 36

Depth, d, in.	Wall Thickness, t, in.						
	0.250	0.312	0.375	0.438	0.500	0.625	0.688
0.03	12.27	No limit	No limit	No limit	No limit	No limit	No limit
0.04	12.27	13.71	15.03	No limit	No limit	No limit	No limit
0.05	8.21	13.71	15.03	16.24	17.35	No limit	No limit
0.06	5.68	10.14	15.03	16.24	17.35	No limit	No limit
0.07	4.49	7.17	12.10	16.24	17.35	19.40	20.35
0.08	3.77	5.70	8.69	13.99	17.35	19.40	20.35
0.09	3.28	4.81	6.96	10.19	15.68	19.40	20.35
0.10	2.91	4.20	5.89	8.22	11.61	19.40	20.35
0.11	2.63	3.75	5.16	6.98	9.42	18.97	20.35
0.12	2.40	3.40	4.62	6.12	8.04	14.42	20.35
0.13	2.21	3.11	4.19	5.49	7.07	11.85	15.82
0.14	2.04	2.88	3.85	5.00	6.35	10.17	13.07
0.15	1.90	2.68	3.57	4.60	5.78	8.98	11.25
0.16	1.77	2.50	3.33	4.27	5.33	8.09	9.96
0.17	1.66	2.35	3.12	3.99	4.95	7.39	8.98
0.18	1.56	2.21	2.94	3.75	4.63	6.83	8.21
0.19	1.46	2.09	2.78	3.53	4.36	6.36	7.59
0.20	1.38	1.98	2.63	3.35	4.12	5.96	7.07
0.21	...	1.88	2.50	3.18	3.91	5.62	6.63
0.22	...	1.78	2.38	3.03	3.72	5.32	6.26
0.23	...	1.69	2.27	2.89	3.55	5.05	5.93
0.24	...	1.61	2.17	2.77	3.39	4.82	5.64
0.25	...	...	2.08	2.65	3.25	4.61	5.38
0.26	...	...	1.99	2.54	3.12	4.42	5.15
0.27	...	...	1.91	2.44	3.00	4.24	4.94
0.28	...	...	1.83	2.35	2.89	4.08	4.74
0.29	...	...	1.75	2.26	2.79	3.93	4.57
0.30	...	...	1.68	2.18	2.69	3.80	4.41
0.31	...	...	...	2.10	2.60	3.67	4.26
0.32	...	...	...	2.03	2.51	3.55	4.12
0.33	...	...	...	1.96	2.43	3.44	3.99
0.34	...	...	...	1.89	2.35	3.33	3.86
0.35	...	...	...	1.82	2.27	3.23	3.75
0.36	...	...	...	...	2.20	3.14	3.64
0.37	...	...	...	...	2.13	3.05	3.54
0.38	...	...	...	...	2.07	2.96	3.44
0.39	...	...	...	...	2.01	2.88	3.35
0.40	...	...	...	...	1.94	2.81	3.26
0.41	...	...	...	...	...	2.73	3.18
0.42	...	...	...	...	...	2.66	3.10
0.43	...	...	...	...	...	2.59	3.02
0.44	...	...	...	...	...	2.53	2.95
0.45	...	...	...	...	...	2.46	2.87
0.46	...	...	...	...	...	2.40	2.81
0.47	...	...	...	...	...	2.34	2.74
0.48	...	...	...	...	...	2.28	2.68
0.49	...	...	...	...	...	2.23	2.62
0.50	...	...	...	...	...	2.17	2.56
0.51	...	...	...	...	...	...	2.50
0.52	...	...	...	...	...	...	2.44
0.53	...	...	...	...	...	...	2.39
0.54	...	...	...	...	...	...	2.33
0.55	...	...	...	...	...	...	2.28

Table 3-7M Values of *L* for Pipe Sizes ≥ 762 mm and < 914 mm O.D.

Depth, *d*, mm	Wall Thickness, *t*, mm 6.4	7.9	9.5	11.1	12.7	15.9	17.5
0.8	311.6	No limit	No limit	No limit	No limit	No limit	No limit
1.0	311.6	348.1	381.7	No limit	No limit	No limit	No limit
1.3	208.5	348.1	381.7	412.5	440.7	No limit	No limit
1.5	144.3	257.7	381.7	412.5	440.7	No limit	No limit
1.8	114.0	182.0	307.4	412.5	440.7	492.7	517.0
2.0	95.7	144.9	220.7	355.3	440.7	492.7	517.0
2.3	83.2	122.2	176.8	258.9	398.2	492.7	517.0
2.5	74.0	106.7	149.7	208.7	294.9	492.7	517.0
2.8	66.8	95.3	131.0	177.3	239.3	481.8	517.0
3.0	61.0	86.3	117.2	155.6	204.1	366.3	517.0
3.3	56.1	79.1	106.5	139.4	179.5	300.9	401.9
3.6	51.9	73.1	97.8	126.9	161.2	258.4	331.9
3.8	48.3	68.0	90.6	116.8	146.9	228.2	285.8
4.1	45.1	63.6	84.6	108.4	135.4	205.5	252.9
4.3	42.2	59.7	79.3	101.3	125.8	187.8	228.1
4.6	39.6	56.2	74.7	95.1	117.7	173.4	208.6
4.8	37.1	53.1	70.6	89.8	110.8	161.5	192.8
5.1	34.9	50.3	66.9	85.0	104.7	151.3	179.6
5.3	...	47.7	63.6	80.8	99.3	142.7	168.5
5.6	...	45.2	60.6	77.0	94.5	135.1	158.9
5.8	...	43.0	57.8	73.5	90.2	128.4	150.6
6.1	...	40.9	55.2	70.3	86.2	122.4	143.2
6.4	...	...	52.8	67.4	82.6	117.0	136.6
6.6	...	...	50.6	64.6	79.3	112.2	130.7
6.9	...	...	48.4	62.1	76.3	107.7	125.4
7.1	...	...	46.5	59.7	73.4	103.6	120.5
7.4	...	...	44.6	57.5	70.8	99.9	116.0
7.6	...	...	42.8	55.4	68.3	96.4	111.9
7.9	...	...	...	53.4	65.9	93.2	108.1
8.1	...	...	...	51.5	63.7	90.1	104.5
8.4	...	...	...	49.7	61.6	87.3	101.2
8.6	...	...	...	48.0	59.6	84.6	98.1
8.9	...	...	...	46.3	57.7	82.1	95.2
9.1	...	...	...	...	55.9	79.7	92.5
9.4	...	...	...	...	54.2	77.4	89.8
9.7	...	...	...	...	52.5	75.3	87.4
9.9	...	...	...	...	50.9	73.2	85.0
10.2	...	...	...	...	49.4	71.3	82.8
10.4	...	...	...	...	...	69.4	80.7
10.7	...	...	...	...	...	67.6	78.6
10.9	...	...	...	...	...	65.8	76.7
11.2	...	...	...	...	...	64.2	74.8
11.4	...	...	...	...	...	62.5	73.0
11.7	...	...	...	...	...	61.0	71.3
11.9	...	...	...	...	...	59.5	69.6
12.2	...	...	...	...	...	58.0	68.0
12.4	...	...	...	...	...	56.6	66.4
12.7	...	...	...	...	...	55.2	64.9
13.0	...	...	...	...	...	...	63.5
13.2	...	...	...	...	...	...	62.0
13.5	...	...	...	...	...	...	60.6
13.7	...	...	...	...	...	...	59.3
14.0	...	...	...	...	...	...	58.0

(12)

Table 3-8 Values of *L* for Pipe Sizes ≥ NPS 36 and < NPS 42

Depth, *d*, in.	Wall Thickness, *t*, in. 0.250	0.281	0.312	0.375	0.406	0.469	0.562	0.688
0.03	13.44	14.25	No limit	No limit	No limit	No limit	No limit	No limit
0.04	13.44	14.25	15.01	16.46	No limit	No limit	No limit	No limit
0.05	8.99	13.40	15.01	16.46	17.13	18.41	No limit	No limit
0.06	6.22	8.22	11.11	16.46	17.13	18.41	20.15	No limit
0.07	4.92	6.21	7.85	13.26	17.13	18.41	20.15	22.30
0.08	4.13	5.09	6.25	9.52	11.89	18.41	20.15	22.30
0.09	3.59	4.37	5.27	7.62	9.16	13.70	20.15	22.30
0.10	3.19	3.86	4.60	6.46	7.60	10.66	18.94	22.30
0.11	2.88	3.47	4.11	5.65	6.56	8.87	14.23	22.30
0.12	2.63	3.15	3.72	5.06	5.82	7.69	11.63	22.30
0.13	2.42	2.90	3.41	4.59	5.26	6.83	9.95	17.33
0.14	2.24	2.68	3.15	4.22	4.81	6.18	8.78	14.31
0.15	2.08	2.50	2.93	3.91	4.44	5.66	7.89	12.33
0.16	1.94	2.33	2.74	3.65	4.13	5.23	7.20	10.91
0.17	1.82	2.19	2.57	3.42	3.87	4.88	6.65	9.84
0.18	1.71	2.06	2.42	3.22	3.64	4.58	6.18	9.00
0.19	1.60	1.94	2.29	3.04	3.44	4.31	5.79	8.31
0.20	1.51	1.83	2.17	2.89	3.26	4.08	5.45	7.75
0.21	...	1.73	2.06	2.74	3.10	3.87	5.16	7.27
0.22	...	1.64	1.95	2.61	2.95	3.69	4.90	6.85
0.23	...	...	1.85	2.49	2.82	3.52	4.67	6.49
0.24	...	...	1.76	2.38	2.70	3.37	4.46	6.18
0.25	...	...	...	2.28	2.58	3.23	4.27	5.89
0.26	...	...	...	2.18	2.48	3.10	4.10	5.64
0.27	...	...	...	2.09	2.38	2.98	3.94	5.41
0.28	...	...	...	2.00	2.28	2.87	3.79	5.20
0.29	...	...	...	1.92	2.19	2.76	3.66	5.00
0.30	...	...	...	1.84	2.11	2.66	3.53	4.83
0.31	...	...	...	...	2.03	2.57	3.41	4.66
0.32	...	...	...	...	1.95	2.48	3.30	4.51
0.33	...	...	...	...	...	2.40	3.19	4.37
0.34	...	...	...	...	...	2.32	3.09	4.23
0.35	...	...	...	...	...	2.24	3.00	4.11
0.36	...	...	...	...	...	2.17	2.91	3.99
0.37	...	...	...	...	...	2.10	2.83	3.87
0.38	...	...	...	...	...	...	2.74	3.77
0.39	...	...	...	...	...	...	2.67	3.67
0.40	...	...	...	...	...	...	2.59	3.57
0.41	...	...	...	...	...	...	2.52	3.48
0.42	...	...	...	...	...	...	2.45	3.39
0.43	...	...	...	...	...	...	2.38	3.31
0.44	...	...	...	...	...	...	2.32	3.23
0.45	...	...	...	...	...	...	...	3.15
0.46	...	...	...	...	...	...	...	3.07
0.47	...	...	...	...	...	...	...	3.00
0.48	...	...	...	...	...	...	...	2.93
0.49	...	...	...	...	...	...	...	2.87
0.50	...	...	...	...	...	...	...	2.80
0.51	...	...	...	...	...	...	...	2.74
0.52	...	...	...	...	...	...	...	2.68
0.53	...	...	...	...	...	...	...	2.62
0.54	...	...	...	...	...	...	...	2.56
0.55	...	...	...	...	...	...	...	2.50