CERTIFICATE

By Authority Of
THE UNITED STATES OF AMERICA
Legally Binding Document

By the Authority Vested By Part 5 of the United States Code § 552(a) and Part 1 of the Code of Regulations § 51 the attached document has been duly INCORPORATED BY REFERENCE and shall be considered legally binding upon all citizens and residents of the United States of America. *HEED THIS NOTICE*: Criminal penalties may apply for noncompliance.

Document Name: ASME B31G: Manual for Determining the Remaining Strength of Corroded Pipelines

CFR Section(s): 49 CFR 192.485(c)

Standards Body: American Society of Mechanical Engineers

APPROVED

Official Incorporator:
THE EXECUTIVE DIRECTOR
OFFICE OF THE FEDERAL REGISTER
WASHINGTON, D.C.

ASME Code for Pressure Piping, B31
An American National Standard

ASME B31G-1991

(REVISION OF ANSI/ASME B31G-1984)

Manual for Determining the Remaining Strength of Corroded Pipelines

A Supplement to ASME B31 Code for Pressure Piping

AN AMERICAN NATIONAL STANDARD

ASME CODE FOR PRESSURE PIPING, B31

Manual for Determining the Remaining Strength of Corroded Pipelines

A Supplement to ASME B31 Code for Pressure Piping

ASME B31G-1991

(REVISION OF ANSI/ASME B31G-1984)

The American Society of Mechanical Engineers

345 East 47th Street, New York, N.Y. 10017

Date of Issuance: June 27, 1991

The 1991 edition of this Manual will be revised when public comment or Committee actions necessitate the issuance of a new edition, or it will be reviewed and reaffirmed 5 years from the date of approval of this edition. No addenda service is provided with this publication. Written interpretations of the requirements of this Manual will not be issued to the current edition.

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

ASME does not "approve," "rate," or "endorse" any item, construction, proprietary device, or activity.

ASME does not take any position with respect to the validity of any patent rights asserted in connection with any items mentioned in this document, and does not undertake to insure anyone utilizing a standard against liability for infringement of any applicable Letters Patent, nor assume any such liability. Users of a code or standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Participation by federal agency representative(s) or person(s) affiliated with industry is not to be interpreted as government or industry endorsement of this code or standard.

ASME accepts responsibility for only those interpretations issued in accordance with governing ASME procedures and policies which preclude the issuance of interpretations by individual volunteers.

FOREWORD

(This Foreword is not a part of ASME B31G-1991.)

It is recognized by pipeline companies that some sections of high pressure pipelines, particularly those installed a number of years ago, have experienced some corrosion. Where corrosion is found, pipeline operators have been deeply concerned about the need for a method of determining the remaining strength of these corroded areas. If the corrosion does not penetrate the pipe wall, what is the pressure containing capability of the remaining pipe metal in terms of its ability to continue to operate safely at the maximum allowable operating pressure (MAOP) of the pipeline system? Thus, one of the needs of the pipeline industry has been a procedure that will help operators, particularly field personnel, make decisions on existing pipelines, when exposed for any purpose, as to whether any corroded region may be left in service or whether it needs to be repaired or replaced. Such determinations must be based upon sound research and extensive testing in order to provide safe and conservative guidelines on which to base field decisions. The Manual provides procedures to assist in this determination.

Parts 2, 3, and 4 are based on Appendices G-6, G-7, and G-8 of the ASME Guide for Gas Transmission and Distribution Piping Systems, 1983 Edition. They are included in this Manual for use by field operators to determine the remaining strength of corroded pipe. The technology is based on research done in the Columbus laboratories of the Battelle Memorial Institute; specifically, their report *Summary of Research to Determine the Strength of Corroded Areas in Line Pipe,* July 10, 1971.

A revision to the 1984 edition of the Manual was undertaken in 1989. The revision includes a number of clarifications and corrections. The computer program presented in Appendix B and used to produce a printed table of maximum acceptable corrosion lengths for a given pipe diameter, and up to ten wall thicknesses of that diameter, was upgraded.

This Manual was approved by ASME and subsequently by the American National Standards Institute on May 20, 1991.

ASME CODE FOR PRESSURE PIPING, B31

OFFICERS

R. E. Feigel, *Chairman*
L. E. Hayden, Jr., *Vice Chairman*
C. J. Gomez, *Secretary*

COMMITTEE PERSONNEL

P. A. Bourquin, Wolff & Munier International, Hawthorne, New York
A. J. Breugelmans, Lyndhurst, New Jersey
J. D. Byers, Mobil Research & Development, Princeton, New Jersey
J. J. Chappell, Anchor/Darling Valve Co., Williamsport, Pennsylvania
L. F. Clynch, CONOCO Mid-Continental Division, Ponca City, Oklahoma
P. C. DuPernell, Lancaster, New York
R. E. Feigel, Hartford Steam Boiler Inspection and Insurance Co., Hartford, Connecticut
D. M. Fischer, Sargent & Lundy, Chicago, Illinois
P. D. Flenner, Consumers Power Co., Jackson, Michigan
P. H. Gardner, Hercules Inc., Wilmington, Delaware
R. W. Haupt, Pressure Piping Engrg Associates Inc., Foster City, California
L. E. Hayden, Jr., Victaulic Company of America, Easton, Pennsylvania
R. R. Hoffmann, Federal Energy Regulatory Commission, Washington, DC
B. P. Holbrook, Riley Stoker Corp., Worchester, Massachusetts
H. M. Howarth, Trenton, New Jersey
W. B. McGehee, Spring, Texas
A. J. Shoup, Sr., Houston, Texas
G. W. Spohn, III, Dixie Constructors, Inc., Gaffney, South Carolina
H. A. Sosnin, Jenkintown, Pennsylvania
D. H. Wade, Texas Utilities Electric Co., Dallas, Texas

B31.8 GAS TRANSMISSION AND DISTRIBUTION PIPING SYSTEMS SECTION COMMITTEE

A. J. Shoup, Sr., *Chairman,* Houston, Texas
W. B. McGehee, *Vice Chairman,* Spring, Texas
C. J. Gomez, *Secretary,* ASME, New York, New York
W. C. Alexander, Shreveport, Louisiana
R. J. T. Appleby, Exxon Co., USA Thousand Oaks, California
J. E. Beech, Texas Gas Transmission Corp., Owensboro, Kentucky
C. Boshuizen, T. D. Williamson Inc., Tulsa, Oklahoma
L. E. Brooks, Delta Gulf Corp., Shreveport, Louisiana
F. E. Buck, Grove Valve & Regulator Co., Oakland, California
J. S. Chin, ANR Pipeline Co., Detroit, Michigan
W. L. Clayton, Entex Inc., Houston, Texas
P. J. Cory, Bowie, Maryland

R. L. Dean, ConReg Associates, Bellaire, Texas
A. J. Del Buono, CMI-Princeton Inc., Princeton, Kentucky
P. W. Denning, Texas Gas Transmission Corp., Owensboro, Kentucky
M. J. Epperson, Texaco Inc., Bellaire, Texas
J. J. Fallon, Jr., Public Service Electric & Gas Co., Newark, New Jersey
F. R. Fleet, Natural Gas Pipeline Company of America, Lombard, Illinois
M. A. Francis, LTV Steel Tubular Products Co., Youngstown, Ohio
P. R. Goodholm, Visalia, California
J. E. Hansford, Enron Gas Pipeline Operating Co., Houston, Texas
D. J. Hicks, Endeco Engineering Consultants, Tulsa, Oklahoma
D. T. Hisey, ARCO Transportation Alaska, Anchorage, Alaska
M. C. Hocking, Transcontinental Gas Pipe Line, Houston, Texas
E. A. Jonas, Bethlehem, Pennsylvania
J. J. Kieffer, Union Carbide Corp., Tonawanda, New York
J. D. McNorgan, Southern California Gas Co., Los Angeles, California
A. I. Macdonald, Upland, California
R. E. Miller, Columbia Gas Systems Service Corp., Columbus, Ohio
R. A. Mueller, OXY USA Inc., Tulsa, Oklahoma
P. O. Mullens, Phillips Petroleum Co., Bartesville, Oklahoma
D. L. Price, Texas Eastern Gas Pipe Line Co., Harrisburg, Pennsylvania
W. F. Quinn, El Paso Natural Gas Co., El Paso, Texas
A. T. Richardson, Tenneco Gas Transportation Co., Houston, Texas
C. G. Roberts, Williams Brothers Engineering Co., Tulsa, Oklahoma
R. A. Schmidt, Ladish Co., Russelville, Arkansas
B. Taksa, Gulf Interstate Engineering, Houston, Texas
C. J. Tateosian, Walnut Creek, California
A. T. Tyler, Gulf Interstate Engineering Co., Houston, Texas
H. M. Wilkinson, Houston, Texas
G. J. Wolf, Office of Pipeline Safety, U. S. Department of Transportation, Washington, District of Columbia
R. A. Wolf, Transok Inc., Tulsa, Oklahoma
J. M. Wood, Oklahoma Natural Gas Co., Tulsa, Oklahoma
D. W. Wright, Sun Pipe Line Co., Tulsa, Oklahoma
C. C. Wright, Jr., Paola, Kansas
J. S. Zurcher, Panhandle Eastern Pipe Line Co., Houston, Texas

B31 COORDINATING COMMITTEE

D. M. Fischer, *Chairman,* Sargent & Lundy, Chicago, Illinois
C. J. Gomez, *Secretary,* ASME, New York, New York
L. E. Hayden, Jr., Victaulic Company of America, Easton, Pennsylvania
R. R. Hoffmann, Federal Energy Regulatory Commission, Washington, District of Columbia
H. A. Sosnin, Jenkintown, Pennsylvania

B31 FABRICATION AND EXAMINATION TECHNICAL COMMITTEE

P. D. Flenner, *Chairman,* Consumers Power Co., Jackson, Michigan
C. J. Gomez, *Secretary,* ASME, New York, New York
P. C. DuPernell, Lancaster, New York
T. E. Estilow, Newark, Delaware
L. E. Hartsell, Fluor Daniel, Dallas, Texas
D. G. Hopkins, E I duPont de Nemours & Co., Newark, Delaware
A. D. Nance, Evans, Georgia
R. I. Seals, Berkeley, California
H. A. Sosnin, Jenkintown, Pennsylvania

B31 MECHANICAL DESIGN COMMITTEE

R. W. Haupt, *Chairman,* Pressure Piping Engrg Associates Inc., Foster City, California
C. J. Gomez, *Secretary,* ASME, New York, New York
J. P. Breen, O'Donnell & Associates Inc., Pittsburgh, Pennsylvania
A. C. Dzykewicz, Bristol, Rhode Island
J. A. Graziano, Farragut, Tennessee
B. P. Holbrook, Riley Stoker Corp., Worcester, Massachusetts
W. J. Koves, UOP Inc., Des Plaines, Illinois
P. L. Lin, Fluor Engineers Inc., Chicago, Illinois
T. Q. McCawley, Charlotte, North Carolina
E. Michalopoulos, Hartford Steam Boiler Inspection and Insurance Co., Hartford, Connecticut
J. C. Minichiello, ABB Impell Corp., Lincolnshire, Illinois
A. D. Nance, Evans, Georgia
T. W. Pickel, Jr., Martin Marietta Energy Systems Inc., Oak Ridge, Tennessee
E. C. Reed, Babcock & Wilcox Co., Barberton, Ohio
Q. N. Truong, Houston, Texas
G. E. Woods, Kingwood, Texas

B31 CONFERENCE GROUP

M. E. Bajandas, Department of Labor & Human Resources, Hato Ray, Puerto Rico
R. Beaucamp, Department of Labor, Lincoln, Nebraska
J. E. Brennan, Division of Boiler Inspection, Columbus, Ohio
W. E. Brown, State of Kansas, Shawnee Mission, Kansas
G. Bynog, Texas Department of Labor & Standards, Austin, Texas
R. Coomes, Department of Housing, Buildings, and Construction, Frankfort, Kentucky
Z. C. Cordero, Michigan Department of Labor, Lansing, Michigan
J. C. Cvar, Division of Boiler Safety, Dover, Delaware
A. W. Diamond, Department of Labour & Manpower, St. Johns, Newfoundland, Canada
M. P. Fitzpatrick, Department of Labour & Human Resources, Fredericton, New Brunswick, Canada
J. W. Greenawalt, Jr., Oklahoma Department of Labor, Oklahoma City, Oklahoma
G. Grodecki, Ministry of Consumer & Commercial Relations, Toronto, Ontario, Canada
R. D. Herman, Saskatchewan Labour, Regina, Saskatchewan, Canada
D. W. Johansen, Public Service Commission, Jefferson City, Missouri
A. Justin, State of Minnesota, Saint Paul, Minnesota
J. T. Little, Industrial Commission of Arizona, Phoenix, Arizona
W. T. Malloy, Washington Utilities & Transportation Commission, Olympia, Washington
R. G. Marini, New Hampshire Public Utilities Commission, Concord, New Hampshire
I. W. Mault, Labour & Manpower, Winnipeg, Manitoba, Canada
A. W. Meiring, Department of Fire Prevention & Building Safety, Indianapolis, Indiana
E. E. Morgan, Boiler Inspection Section, Denver, Colorado
J. W. Morvant, Office of State Fire Marshal, Baton Rouge, Louisiana
R. F. Mullaney, Boiler & Pressure Vessel Safety Branch, Vancouver, British Columbia, Canada
W. A. Owen, North Dakota Public Service Commission, Bismarck, North Dakota
W. M. Picardo, Department of Consumer & Regulatory Affairs, Washington, District of Columbia
R. Sauve, Government of Quebec, Montreal, Quebec, Canada
P. Sher, Department of Public Utility Control, New Britain, Connecticut
H. E. Shutt, Illinois Commerce Commission, Springfield, Illinois
J. L. Smith, Alberta Department of Labour, Edmonton, Alberta, Canada
R. L. Smith, Public Service Commission, Columbia, South Carolina
M. L. Snow, Jr., Department of Commerce and Insurance, Nashville, Tennessee
E. L. Sparrow, Bureau of Pipeline Safety, Newark, New Jersey
D. Stursma, Iowa State Commerce Commission, Des Moines, Iowa
R. P. Sullivan, Department of Labor, Augusta, Maine
C. W. Thompson, Department of Labor, Little Rock, Arkansas

R. W. Vindich, Department of Labor & Industry, Harrisburgh, Pennsylvania
L. E. Waldrop, Public Service Commission, Montgomery, Alabama
C. H. Walters, Boiler & Elevator Programs, Portland, Oregon
M. W. A. West, Department of Fisheries & Labour, Charlottetown, Prince Edward Island, Canada
T. F. Wickham, Department of Labor, Providence, Rhode Island
R. A. Yeo, Department of Labour and Manpower, Halifax, Nova Scotia, Canada

B31 NATIONAL INTEREST REVIEW GROUP

Aluminum Association — W. W. Pritsky
American Boiler Manufacturers Association — R. J. Fletcher
American Institute of Chemical Engineers — W. C. Carnell
American Iron and Steel Institute — J. R. Pegues
American Petroleum Institute, Division of Refining — H. M. Howarth
American Pipe Fitting Association — J. Thielsch
American Society of Heating, Refrigeration & Air Conditioning Engineers — H. R. Kornblum
American Welding Society — H. A. Sosnin
Chemical Manufacturers Association — D. R. Frikken
Compressed Gas Association — M. F. Melchioris
Copper Development Association — A. Cohn
Ductile Iron Pipe Research Association — T. F. Stroud
Edison Electric Institute — R. L. Williams
International District Heating Association — G. Von Bargen
Manufacturers Standardization Society of the Valve and Fittings Industry — R. A. Schmidt
Mechanical Contractors Association of America — W. E. Maloney
National Association of Plumbing-Heating-Cooling Contractors — R. E. White
National Association of Regulatory Utility Commissioners — D. W. Snyder
National Fire Protection Association — T. C. Lemoff
National Fluid Power Association — H. Anderson
Naval Sea Systems Command — T. W. Hull
Pipe Fabrication Institute — L. Katz
Slurry Transport Association — P. E. Snoek
Society of Ohio Safety Engineers — J. M. Holleran
Valve Manufacturers Association — R. A. Handschumacher

CONTENTS

This page intentionally left blank.

PART 1
INTRODUCTION

1.1 SCOPE

The scope of this Manual includes all pipelines within the scope of the pipeline codes that are part of ASME B31 Code for Pressure Piping, i.e., ASME B31.4, Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohols; ASME B31.8, Gas Transmission and Distribution Piping Systems; and ASME B31.11, Slurry Transportation Piping Systems. Parts 2, 3, and 4 are based on material included in ASME Guide for Gas Transmission and Distribution Piping Systems, 1983 Edition.

This Manual is not applicable to new construction covered under the B31 Code Sections. That is, it is not intended that this Manual be used to establish acceptance standards for pipe that may have become corroded prior to or during fabrication and/or installation.

This Manual is intended solely for the purpose of providing guideline information for the designer/owner/operator. Thus, the specific use of this Manual is the responsibility of the designer/owner/operator.

1.2 LIMITATIONS

(a) This Manual is limited to corrosion on weldable pipeline steels categorized as carbon steels or high strength low alloy steels. Typical of these materials are those described in ASTM A 53, A 106, and A 381, and API 5L. (The current API 5L includes all Grades formerly in API 5LX and 5LS.)

(b) This Manual applies only to defects in the body of line pipe which have relatively smooth contours and cause low stress concentration (e.g., electrolytic or galvanic corrosion, loss of wall thickness due to erosion).

(c) This procedure should not be used to evaluate the remaining strength of corroded girth or longitudinal welds or related heat affected zones, defects caused by mechanical damage, such as gouges and grooves, and defects introduced during pipe or plate manufacture, such as seams, laps, rolled ends, scabs, or slivers.

(d) The criteria for corroded pipe to remain in service presented in this Manual are based only upon the ability of the pipe to maintain structural integrity under internal pressure. It should not be the sole criterion when the pipe is subject to significant secondary stresses (e.g., bending), particularly if the corrosion has a significant transverse component.

(e) This procedure does not predict leaks or rupture failures.

1.3 INITIAL DEVELOPMENT

In the late 1960s, a major long-lines gas transmission pipeline company in conjunction with the Battelle Memorial Institute in Columbus, Ohio, began a research effort to examine the fracture initiation behavior of various kinds of corrosion defects in line pipe. This included determining the relationship between the size of a defect and the level of internal pressure that would cause the defect to leak or rupture. The testing by the gas pipeline company and Battelle demonstrated that there was indeed a possibility of developing methodology and procedures to analyze varying degrees of corrosion of existing pipelines. From this, an operator could make a valid determination as to whether the pipelines could safely remain in service or should be repaired or replaced. As the awareness of this research program grew, other transmission companies began to express considerable interest.

Beginning in the early 1970s, the American Gas Association (AGA) Pipeline Research Committee assumed responsibility for this activity and began developing methods for predicting the pressure strength of line pipe containing various sizes of corrosion defects.

The overall objective of these experiments was to examine the fracture initiation behavior of various sizes of corrosion defects by determining the relationship between the size of a defect and the level of internal pressure that would cause a leak or rupture.

1.4 METHODOLOGY AND RESEARCH PROCEDURES

The procedure contained in this Manual is based upon pressuring actual corroded pipe to failure in an extensive series of full-size tests. Since there was pipe available that had been removed from service and that had sustained corrosion damage, it seemed more logical to test these full-size, actual field specimens, either in place or in a large, full-scale test cell, rather than base these guidelines upon purely laboratory tests using machined defects. Several hundred full-scale pipe tests were conducted on all types of defects to establish general defect behavior. Mathematical expressions to calculate the pressure strength of corroded pipe materials were developed on the basis of these extensive tests. These mathematical expressions, although semiempirical, were founded upon well established principles of fracture mechanics. The basis principle of fracture mechanics is that the resistance of the material to unstable fracturing in the presence of a defect is related to the size of the defect and an inherent metal property called toughness. The tougher the material, the larger the flaw that can be tolerated before failure will occur. Also, the bigger the defect, the lower the pressure at which a leak or rupture will occur. These two features may seem obvious, but they form the basis of fracture mechanics in terms of determining the real strength of pipe containing defects.

During 1970 and 1971, 47 pressure tests were conducted on several pipe sizes to evaluate the effectiveness of the mathematical expressions in determining the strength of corroded areas. The diameter of the pipe material examined ranged from 16 in. through 30 in. and wall thickness varied from 0.312 in. through 0.375 in. The pipe materials have ranged in yield strength from about 25,000 psi for API 5L Grade A-25 to about 52,000 psi for 5LX Grade X-52.

The mathematical expressions developed from the earlier experiments have been modified based on later test results and now provide reliable estimates of the failure pressures for corrosion defects over the range of materials covered in this study. The experiments

on corroded pipe indicated that line pipe steels have adequate toughness and that the toughness is not a significant factor. The failure of blunt corrosion flaws is controlled by their size and the flow stress or yield stress of the material.

Figure 1-1 shows the relationship between the full-size test failures and the criterion for acceptance of corrosion pits in line pipe. The criterion is that they shall withstand a pressure equal to a stress level of 100% of the specified minimum yield stress (SMYS). The Figure is based on an assured parabolic profile of the corroded regions and presents the maximum corrosion depth, divided by the pipe wall thickness, plotted against the corrosion length, divided by the square root of the pipe radius times wall thickness. Each of the data points plotted represents one full-size pipe experiment on corroded pipe, and the number next to the data point represents the stress at failure pressure expressed as percent SMYS. There are only 3 data points (experiments) that failed at pressure levels below 100% SMYS, indicating the lack of severity of corrosion defects in general (note that all three would be rejected by this criterion). The solid line shown on the Figure is the line that identifies failure pressures of less than 100% SMYS. There are a number of data points that are below this line, but all of them represent failures above 100% SMYS. The fact that these are above 100% SMYS simply indicates that the criterion is very conservative.

The acceptable region in the plot is the shaded region below and to the left of the solid line. The Tables in Part 3 are based on corrosion depths and lengths determined by this solid line. Corrosion pits that have depths and lengths that fall above the curve are not acceptable, in accordance with the criteria presented herein, and the operating pressure either has to be reduced, or the corrosion pit removed or repaired.

1.5 HOW TO USE THE MANUAL

Part 2, Determination of Maximum Allowable Longitudinal Extent of Corrosion, sets forth the equations for determining the severity of the corroded areas. It tells the operator how to measure the longitudinal extent and maximum depth of the corroded areas. One can then use Eq. (2) of Part 2 to determine if the corroded area is serious.

However, it is recognized that most field operators will prefer a simpler method of evaluating a corroded area. Therefore, Part 3, Tables for Corrosion Limits, evaluates Eq. (2) and places the results in tabular form. This allows the field operator to make decisions simply by going to a table after measuring the longitudinal extent and maximum depth of the corroded area and making a choice.

Locate the table appropriate for the pipe O.D. and wall thickness. Look down the left column and find the depth of corrosion that is equal to or the next number larger than the measured maximum depth of the corroded area. Read across to the column headed by the wall thickness or next number lower than the pipe's nominal wall thickness to determine the maximum allowable longitudinal extent of the corroded area for the depth of corrosion. If the measured longitudinal extent of the corroded area is equal to or less than the maximum allowable longitudinal extent of the corroded area determined from the Table, the pipe strength is suitable for the present MAOP[1] and is capable of containing a test pressure that will produce a stress of 100% SMYS of the pipe material.

[1]As used in this manual, the term MAOP shall represent maximum steady state operating pressure for pipelines within the scope of ASME B31.4 and ASME B31.11 and maximum allowable operating pressure for pipelines within the scope of ASME B31.8.

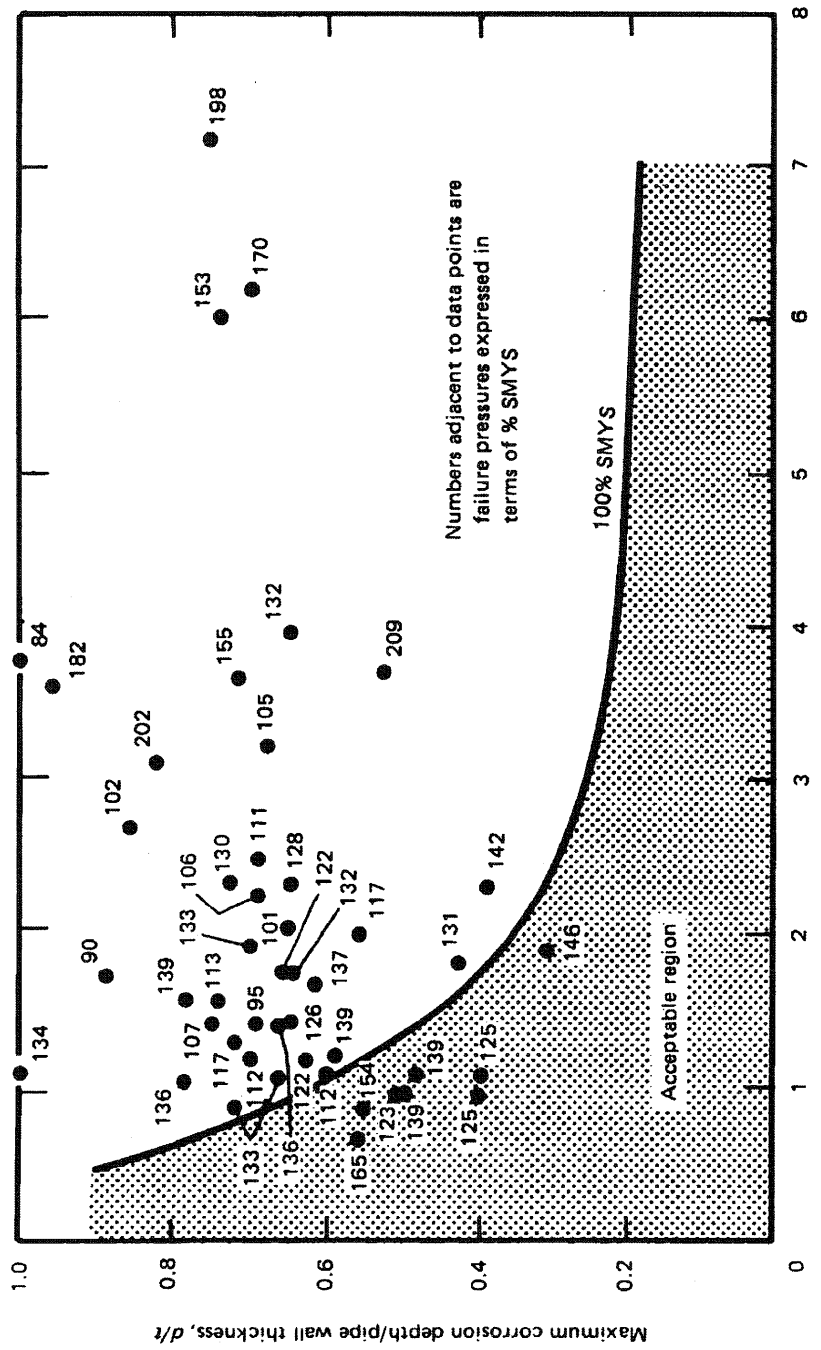

FIG. 1-1 PARABOLIC CRITERIA FOR CLASSIFYING CORROSION DEFECTS ACCORDING TO PREDICTED FAILURE STRESS

The tables produce results which may be more conservative than Eq. (2) of Part 2. The tables could show that the corroded area is unsuitable for the current MAOP, but Eq. (2) may show that it is. Therefore, it is possible for the corroded region to be rejected by the tables, but found suitable by using Eq. (2).

If the tables and Eq. (2) both show the corroded region to be unsuitabe, it may still be possible to establish suitability by one of the methods mentioned in para. 1.7. Another alternative would be to lower the MAOP of the pipeline, if permitted by operating conditions. Part 4 can be used to determine a lower MAOP that has the same safety factor provided by Parts 2 and 3.

Regardless of which alternative is chosen, in all cases where the corroded region is to be left in service, measures should be taken to arrest further corrosion. Such measures should include coating the corroded region and, if indicated, increasing the cathodic protection level.

Figure 1-2 , Procedure for Analysis of Corroded Pipe Strength, shows the steps necessary to proceed through the evaluation of a corroded area on a pipeline in order to determine if any corrective action is needed. The steps shown in the dashed boxes are valid means of determining a safe operating pressure (or MAOP), but the procedures for conducting these steps or the acceptance levels are not in this Manual.

1.6 THE MEANING OF ACCEPTANCE

(a) Any corroded region indicated as acceptable by the criteria of this Manual for service at the established MAOP is capable of withstanding a hydrostatic pressure test that will produce a stress of 100% of the pipe SMYS.

(b) Any corroded region indicated as acceptable for service at a reduced MAOP is capable of withstanding a hydrostatic pressure test at a ratio above the MAOP equal to the ratio of a 100% SMYS test to 72% SMYS operation (1.39:1). If a larger ratio is desired, the reduced MAOP can be adjusted accordingly.

1.7 OTHER MEANS OF DETERMINING SAFE PIPELINE OPERATING PRESSURE

(a) The operator can make a more rigorous analysis of the corroded area to determine the remaining strength by performing a fracture mechanics analysis based upon established principles and practices using the actual profile of the corroded region.

(b) The operator can reestablish the MAOP by a complete hydrostatic pressure test that produces a minimum stress of 100% SMYS, or establish a lower MAOP based on the pressure of a successful test conducted at a lower pressure.

(c) The procedures and acceptance criteria for conducting these alternative acceptance tests, either fracture mechanics analysis or hydrostatic tests, are not included in this Manual.

1.8 COMPUTER PROGRAMS

Appendix A is a BASIC computer program, CRVL.BAS, developed by Mr. Richard L. Seifert and is based on the equations in Parts 2 and 4. It can be used to expedite the evaluation procedure. Several examples of the program output are shown.

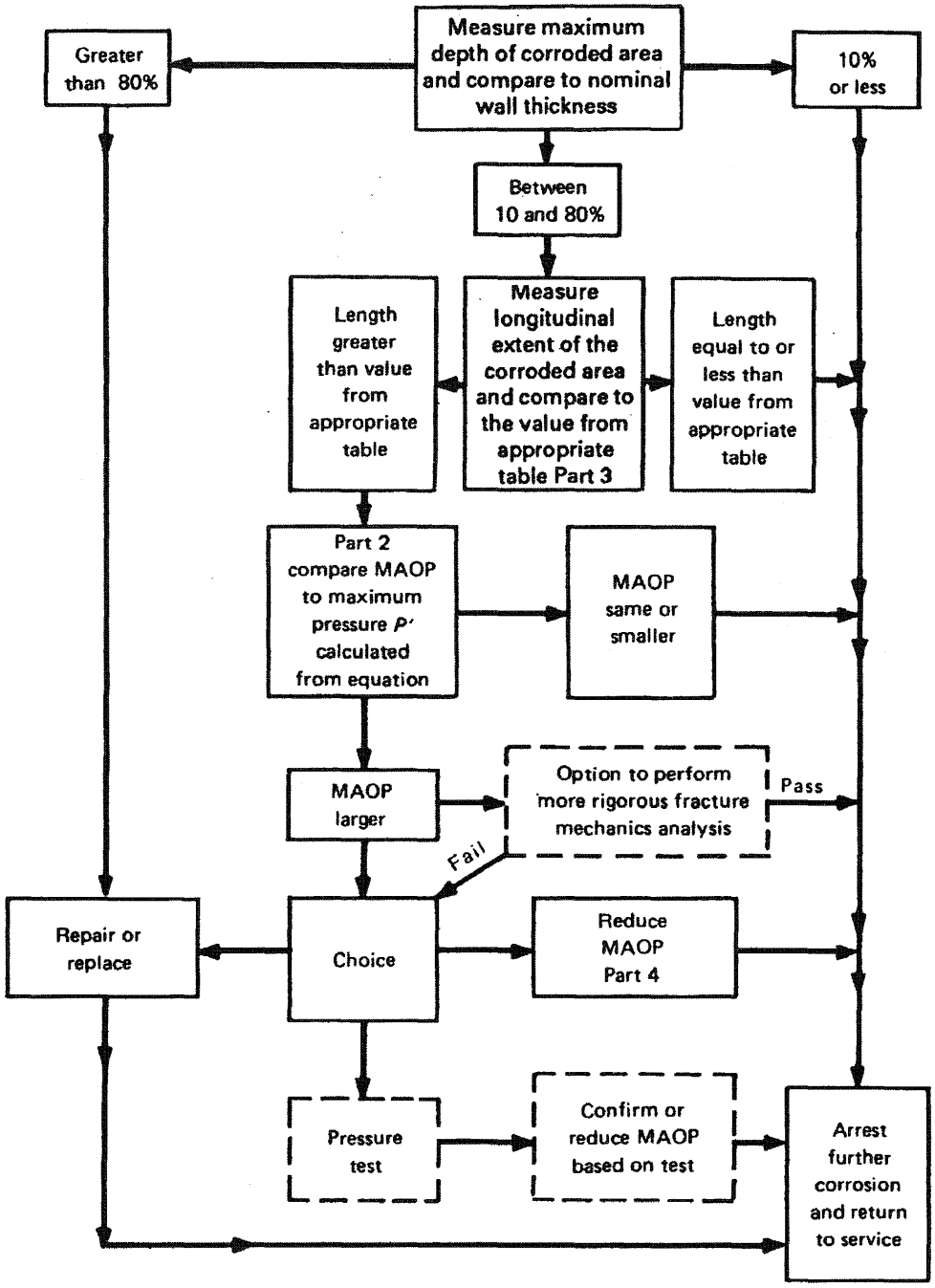

FIG. 1-2 PROCEDURE FOR ANALYSIS OF CORRODED PIPE STRENGTH

Appendix B is a BASIC computer program, CRLGTHU.BAS by Mr. Seifert, which is an upgrade of CRLGTH.BAS, which was contained in the first printing of this Manual. CRLGTH.BAS was used to produce some of the tables in Part 3. It required that the BASIC program be modified slightly each time it was used. The new program CRLGTHU.BAS does not require modification. It will produce a printed table of maximum acceptable corrosion lengths for a given pipe diameter, and up to ten wall thicknesses of that diameter. An example of a printed table by this program is included at the end of Appendix B.

Both CRVL.BAS and CRLGTHU.BAS were written in BASIC for a specific computer/printer combination and can be utilized by most state-of- the-art microprocessors. However, minor modifications may be necessary for use on other equipment or for other purposes.

These computer programs are reproduced herein solely for the convenience of the Manual user, and ASME and the auther make no claims as to their accuracy or effectiveness.

This page intentionally left blank.

PART 2
DETERMINATION OF MAXIMUM ALLOWABLE LONGITUDINAL EXTENT OF CORROSION

The depth of a corrosion pit may be expressed as a percent of the nominal wall thickness of the pipe by:

$$\% \text{ pit depth} = 100d/t \tag{1}$$

where

d = measured maximum depth of the corroded area, in., as shown in Fig. 2-1

t = nominal wall thickness of the pipe, in. Additional wall thickness required for concurrent external loads shall not be included in the calculations.

A contiguous corroded area having a maximum depth of more than 10% but less than 80% of the nominal wall thickness of the pipe should not extend along the longitudinal axis of the pipe for a distance greater than that calculated from:

$$L = 1.12B\sqrt{Dt} \tag{2}$$

(L may also be determined from Tables 3-1 through 3-12 in Part 3.)

where

L = maximum allowable longitudinal extent of the corroded area, in., collinear with L_M in Fig. 2-1

D = nominal outside diameter of the pipe, in.

B = a value which may be determined from the curve in Fig. 2-2 or from:

$$B = \sqrt{\left(\frac{d/t}{1.1\,d/t - 0.15}\right)^2 - 1} \tag{3}$$

except that B may not exceed the value 4. If the corrosion depth is between 10% and 17.5%, use $B = 4.0$ in Eq. (2).

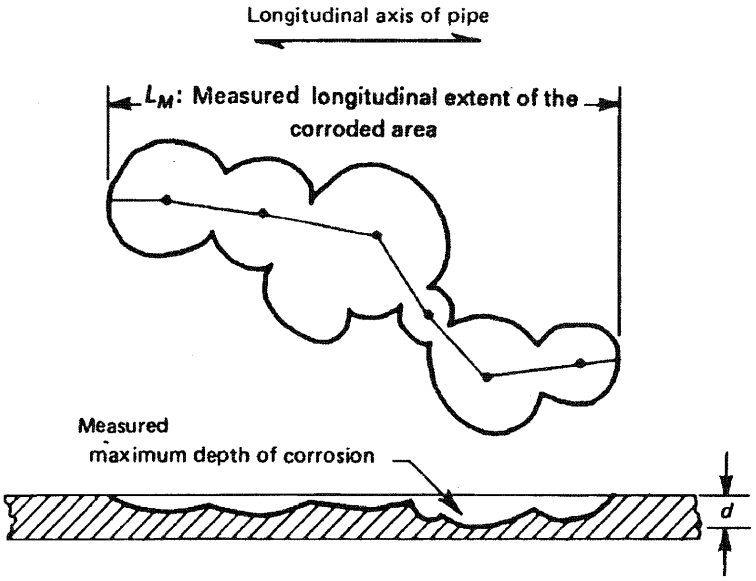

FIG. 2-1 CORROSION PARAMETERS USED IN ANALYSIS

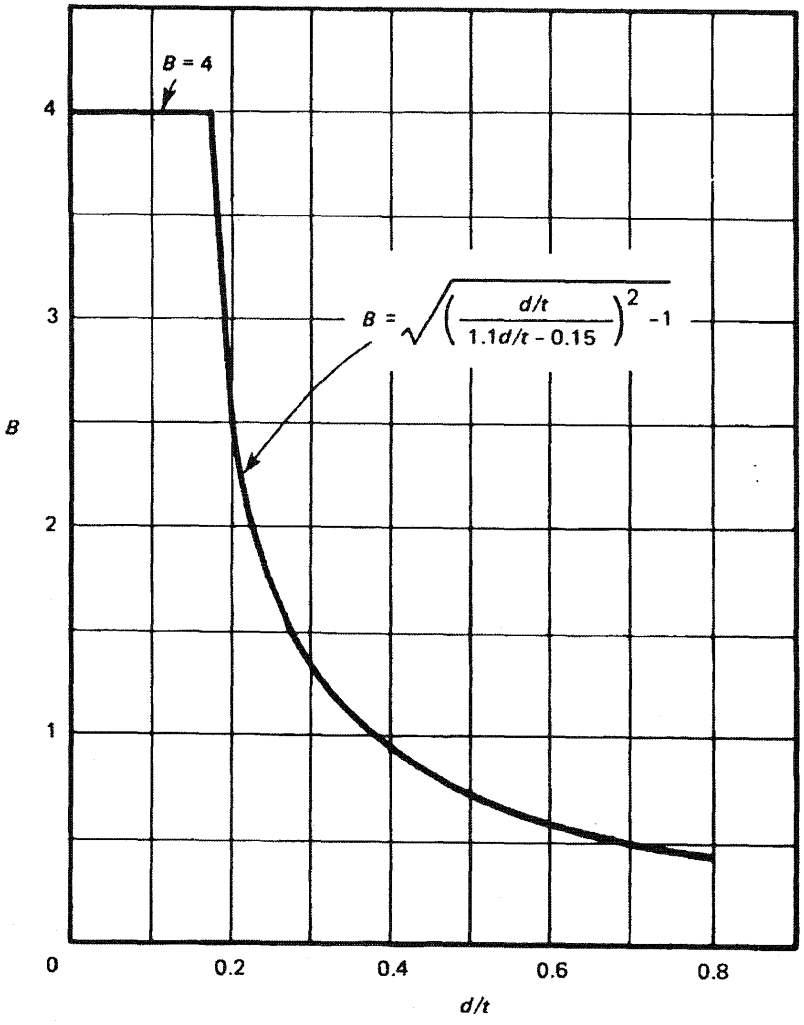

FIG. 2-2 CURVE FOR DETERMINING THE VALUE *B*

This page intentionally left blank.

PART 3
TABLES FOR CORROSION LIMITS

The tables in this Part are calculated from the equations in Part 2. They provide a ready reference of maximum corrosion lengths for a spectrum of pipe diameters, wall thicknesses, and pit depths. These Tables may be used to determine the maximum allowable longitudinal extent of a contiguous area of corrosion as given in Part 2.

(a) The corroded area must be clean to bare metal. Care should be taken when cleaning corroded areas of a pressurized pipeline.

(b) Measure the maximum depth of the corroded area d and the longitudinal extent of the corroded area as shown in Fig. 2-1.

(c) Determine the size (NPS) of the pipe and nominal wall thickness.

(d) Turn to the page in the Table corresponding to the size (NPS) of the pipe.

(e) 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.

(f) Scan 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 depth row is the maximum allowable longitudinal extent of such a corroded area.

(g) The tables in Part 3 produce results which may be more conservative than those obtained from the equations in Part 2. Therefore, the tables could show that a given corroded area is unsuitable for the current MAOP, but the use of the equations in Part 2 may show that it is acceptable.

TABLE 3-1 VALUES OF *L* FOR PIPE SIZES ≥ NPS 2 AND < NPS 6

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	2	.....	.....	.....	.....	.....	.....	.....
0.02	15/16	1 15/16	2 7/16	2 9/16	2 11/16	2 7/8	3	.....
0.03	1/2	7/8	1 1/8	1 1/2	1 15/16	2 7/8	3	3 1/4
0.04	3/8	5/8	3/4	15/16	1 1/8	1 3/8	1 3/4	2 3/4
0.05	5/16	7/16	9/16	11/16	13/16	1	1 3/16	1 5/8
0.06	1/4	3/8	1/2	9/16	11/16	13/16	15/16	1 3/16
0.07	.....	5/16	7/16	1/2	9/16	11/16	3/4	1
0.08	.....	5/16	3/8	7/16	1/2	9/16	11/16	13/16
0.09	.....	.....	5/16	3/8	7/16	1/2	9/16	3/4
0.10	.....	.....	1/4	5/16	3/8	7/16	1/2	11/16
0.11	.....	.....	.....	5/16	3/8	7/16	1/2	5/8
0.12	.....	.....	.....	.....	5/16	3/8	7/16	9/16
0.13	.....	.....	.....	.....	.....	5/16	3/8	1/2
0.14	.....	.....	.....	.....	.....	.....	3/8	7/16
0.15	.....	.....	.....	.....	.....	.....	5/16	7/16
0.16	.....	.....	.....	.....	.....	.....	.....	3/8
0.17	.....	.....	.....	.....	.....	.....	.....	3/8

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
0.010	3 5/16	.....	.....	.....	.....	.....	.....	.....
0.020	1 1/2	4 1/16	4 9/16	5	.....	.....	.....	.....
0.030	7/8	1 7/8	3 3/8	5	5 3/16	5 3/8	5 3/4	.....
0.040	5/8	1 1/4	1 7/8	2 15/16	3 5/8	4 5/8	5 3/4	6 7/16
0.050	1/2	15/16	1 3/8	1 15/16	2 5/16	2 3/4	3 7/8	6 7/16
0.060	7/16	13/16	1 1/8	1 9/16	1 3/4	2 1/16	2 11/16	4 3/4
0.070	.....	11/16	15/16	1 5/16	1 7/16	1 11/16	2 1/8	3 3/8
0.080	.....	9/16	13/16	1 1/8	1 1/4	1 7/16	1 3/4	2 11/16
0.090	.....	1/2	3/4	1	1 1/8	1 1/4	1 9/16	2 1/4
0.100	.....	7/16	11/16	7/8	1	1 1/8	1 3/8	2
0.110	.....	.....	9/16	13/16	7/8	1	1 1/4	1 3/4
0.120	.....	.....	9/16	3/4	13/16	15/16	1 1/8	1 5/8
0.130	.....	.....	.....	11/16	3/4	7/8	1 1/16	1 7/16
0.140	.....	.....	.....	5/8	11/16	13/16	15/16	1 3/8
0.150	.....	.....	.....	9/16	5/8	3/4	7/8	1 1/4
0.160	.....	.....	.....	.....	9/16	11/16	13/16	1 3/16
0.170	.....	.....	.....	.....	.....	5/8	3/4	1 1/8
0.180	.....	.....	.....	.....	.....	.....	3/4	1 1/16
0.190	.....	.....	.....	.....	.....	.....	11/16	1
0.200	.....	.....	.....	.....	.....	.....	5/8	15/16
0.210	.....	.....	.....	.....	.....	.....	.....	7/8
0.220	.....	.....	.....	.....	.....	.....	.....	13/16
0.230	.....	.....	.....	.....	.....	.....	.....	13/16
0.240	.....	.....	.....	.....	.....	.....	.....	3/4

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
0.020	5 13/16	.....	.....	.....	.....	.....	.....	.....
0.030	4 5/16	6 7/8	7 3/8	.....	.....	.....	.....	.....
0.040	2 7/16	5 15/16	7 3/8	8 1/8	8 5/8	8 7/8	.....	.....
0.050	1 3/4	3 1/2	4 15/16	8 1/8	8 5/8	8 7/8	9 3/4	10 3/8
0.060	1 7/16	2 9/16	3 3/8	5 3/4	8 5/8	8 7/8	9 3/4	10 3/8
0.070	1 3/16	2 1/8	2 11/16	4 1/8	5 1/2	6 5/8	9 3/4	10 3/8
0.080	1 1/16	1 13/16	2 1/4	3 5/16	4 3/16	4 7/8	8 3/8	10 3/8
0.090	15/16	1 9/16	1 15/16	2 13/16	3 1/2	3 15/16	6 1/8	9 3/8
0.100	13/16	1 7/16	1 3/4	2 7/16	3	3 3/8	4 15/16	6 15/16
0.110	3/4	1 3/16	1 9/16	2 3/16	2 5/8	2 15/16	4 3/8	5 5/8
0.120	11/16	1 1/16	1 7/16	2	2 3/8	2 5/8	3 11/16	4 13/16
0.130	.....	1	1 5/16	1 13/16	2 3/16	2 3/8	3 5/16	4 1/4
0.140	.....	15/16	1 1/4	1 11/16	2	2 3/16	3	3 13/16
0.150	.....	7/8	1 1/8	1 9/16	1 7/8	2 1/16	2 3/4	3 7/16
0.160	.....	13/16	1 1/16	1 7/16	1 3/4	1 15/16	2 9/16	3 3/16
0.170	.....	3/4	1	1 3/8	1 5/8	1 13/16	2 3/8	2 15/16
0.180	.....	.....	15/16	1 5/16	1 9/16	1 11/16	2 1/4	2 3/4
0.190	.....	.....	7/8	1 1/4	1 7/16	1 5/8	2 1/8	2 5/8
0.200	.....	.....	13/16	1 1/8	1 3/8	1 1/2	2	2 7/16
0.210	.....	.....	.....	1 1/8	1 5/16	1 7/16	1 7/8	2 5/16
0.220	.....	.....	.....	1 1/16	1 1/4	1 3/8	1 13/16	2 1/4
0.230	.....	.....	.....	1	1 3/16	1 5/16	1 3/4	2 1/8
0.240	.....	.....	.....	15/16	1 1/8	1 1/4	1 11/16	2 1/16
0.250	.....	.....	.....	.....	1 1/16	1 3/16	1 9/16	1 15/16
0.260	.....	.....	.....	.....	1 1/16	1 1/8	1 1/2	1 7/8
0.270	.....	.....	.....	.....	1	1 1/16	1 7/16	1 13/16
0.280	.....	.....	.....	.....	.....	1 1/16	1 7/16	1 3/4
0.290	.....	.....	.....	.....	.....	1	1 3/8	1 11/16
0.300	.....	.....	.....	.....	.....	.....	1 5/16	1 5/8
0.310	.....	.....	.....	.....	.....	.....	1 1/4	1 9/16
0.320	.....	.....	.....	.....	.....	.....	1 3/16	1 1/2
0.330	.....	.....	.....	.....	.....	.....	1 3/16	1 7/16
0.340	.....	.....	.....	.....	.....	.....	1 1/8	1 3/8
0.350	.....	.....	.....	.....	.....	.....	1 1/16	1 3/8
0.360	.....	.....	.....	.....	.....	.....	.....	1 5/16
0.370	.....	.....	.....	.....	.....	.....	.....	1 1/4
0.380	.....	.....	.....	.....	.....	.....	.....	1 1/4
0.390	.....	.....	.....	.....	.....	.....	.....	1 3/16
0.400	.....	.....	.....	.....	.....	.....	.....	1 3/16
0.410	.....	.....	.....	.....	.....	.....	.....	.....

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
0.020	7¾	.....	.....	.....	.....	.....	.....	.....
0.030	7¾	8 15/16	.....	.....	.....	.....	.....	.....
0.040	4½	8 15/16	10	10½	11	.....	.....	.....
0.050	3 1/16	6	10	10½	11	11⅞	12 11/16	.....
0.060	2⅜	4⅛	7 7/16	10½	11	11⅞	12 11/16	.....
0.070	2	3¼	5¼	6¾	8 13/16	11⅞	12 11/16	14 3/16
0.080	1¾	2¾	4 3/16	5⅛	6⅜	10 3/16	12 11/16	14 3/16
0.090	1½	2⅜	3½	4¼	5 1/16	7 7/16	11 7/16	14 3/16
0.100	1⅜	2⅛	3 1/16	3⅝	4 5/16	6	8½	14 3/16
0.110	1¼	1 15/16	2¾	3¼	3¾	5⅛	6⅞	13⅞
0.120	1⅛	1¾	2½	2 15/16	3⅜	4½	5⅞	10 9/16
0.130	1 1/16	1⅝	2¼	2 11/16	3 1/16	4	5 3/16	8⅝
0.140	15/16	1½	2⅛	2 7/16	2 13/16	3⅝	4⅝	7 7/16
0.150	⅞	1⅜	1 15/16	2¼	2⅝	3⅜	4¼	6 9/16
0.160	.....	1 5/16	1 13/16	2⅛	2 7/16	3⅛	3⅞	5 15/16
0.170	.....	1 3/16	1 11/16	2	2¼	2 15/16	3⅝	5⅜
0.180	.....	1⅛	1⅝	1⅞	2⅛	2¾	3⅜	5
0.190	.....	1 1/16	1½	1¾	2	2 9/16	3 3/16	4⅝
0.200	.....	1	1 7/16	1 11/16	1 15/16	2 7/16	3	4⅜
0.210	.....	.....	1⅜	1⅝	1 13/16	2 5/16	2⅞	4⅛
0.220	.....	.....	1 5/16	1½	1¾	2 3/16	2 11/16	3⅞
0.230	.....	.....	1¼	1 7/16	1 11/16	2⅛	2 9/16	3 11/16
0.240	.....	.....	1 3/16	1⅜	1 9/16	2	2½	3½
0.250	.....	.....	.....	1 5/16	1½	1 15/16	2⅜	3⅜
0.260	.....	.....	.....	1¼	1 7/16	1⅞	2¼	3¼
0.270	.....	.....	.....	1 3/16	1⅜	1 13/16	2 3/16	3⅛
0.280	.....	.....	.....	.....	1 5/16	1 11/16	2⅛	3
0.290	.....	.....	.....	.....	1 5/16	1⅝	2 1/16	2⅞
0.300	.....	.....	.....	.....	1¼	1 9/16	1 15/16	2¾
0.310	.....	.....	.....	.....	.....	1 9/16	1⅞	2 11/16
0.320	.....	.....	.....	.....	.....	1½	1 13/16	2 9/16
0.330	.....	.....	.....	.....	.....	1 7/16	1¾	2½
0.340	.....	.....	.....	.....	.....	1⅜	1 11/16	2 7/16
0.350	.....	.....	.....	.....	.....	1 5/16	1 11/16	2⅜
0.360	.....	.....	.....	.....	.....	.....	1⅝	2 5/16
0.370	.....	.....	.....	.....	.....	.....	1 9/16	2¼
0.380	.....	.....	.....	.....	.....	.....	1½	2 3/16
0.390	.....	.....	.....	.....	.....	.....	1 7/16	2⅛
0.400	.....	.....	.....	.....	.....	.....	1 7/16	2 1/16
0.410	.....	.....	.....	.....	.....	.....	.....	2
0.420	.....	.....	.....	.....	.....	.....	.....	1 15/16
0.430	.....	.....	.....	.....	.....	.....	.....	1⅞
0.440	.....	.....	.....	.....	.....	.....	.....	1⅞
0.450	.....	.....	.....	.....	.....	.....	.....	1 13/16
0.460	.....	.....	.....	.....	.....	.....	.....	1¾
0.470	.....	.....	.....	.....	.....	.....	.....	1 11/16
0.480	.....	.....	.....	.....	.....	.....	.....	1 11/16
0.490	.....	.....	.....	.....	.....	.....	.....	1⅝
0.500	.....	.....	.....	.....	.....	.....	.....	1 9/16
0.510	.....	.....	.....	.....	.....	.....	.....	.....

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
0.030	9⅜	10	.....	.....	.....	.....	.....	.....
0.040	8 1/16	10	11¾	.....	.....	.....	.....	.....
0.050	4¾	6 11/16	11¾	12¾	13¾	14 3/16	.....	.....
0.060	3 9/16	4⅝	11¾	12¾	13¾	14 3/16	15	.....
0.070	2⅞	3 11/16	7 9/16	12¾	13¾	14 3/16	15	15 13/16
0.080	2 7/16	3 1/16	5¾	8⅞	13¾	14 3/16	15	15 13/16
0.090	2 3/16	2 11/16	4¾	6 13/16	10 3/16	12 13/16	15	15 13/16
0.100	1 15/16	2⅜	4 1/16	5 11/16	7 15/16	9½	14⅛	15 13/16
0.110	1¾	2⅛	3⅝	4⅞	6⅝	7 11/16	10⅝	15½
0.120	1⅝	1 15/16	3¼	4 5/16	5¾	6 9/16	8 11/16	11¾
0.130	1½	1 13/16	3	3 15/16	5 1/16	5¾	7 7/16	9 11/16
0.140	1⅜	1 11/16	2¾	3 9/16	4⅝	5 3/16	6 9/16	8 5/16
0.150	1¼	1 9/16	2 9/16	3 5/16	4 3/16	4¾	5⅞	7 5/16
0.160	1 3/16	1 7/16	2⅜	3 1/16	3⅞	4⅜	5⅜	6⅝
0.170	1 1/16	1⅜	2¼	2⅞	3⅝	4 1/16	4 15/16	6 1/16
0.180	.....	1¼	2⅛	2 11/16	3 7/16	3 13/16	4⅝	5 9/16
0.190	.....	1 3/16	2	2 9/16	3 3/16	3 9/16	4 5/16	5 3/16
0.200	.....	1⅛	1⅞	2 7/16	3 1/16	3⅜	4 1/16	4⅞
0.210	.....	.....	1 13/16	2 5/16	2⅞	3 3/16	3⅞	4 9/16
0.220	.....	.....	1 11/16	2 3/16	2¾	3 1/16	3⅝	4 5/16
0.230	.....	.....	1⅝	2⅛	2⅝	2⅞	3½	4⅛
0.240	.....	.....	1 9/16	2	2½	2¾	3 5/16	3 15/16
0.250	.....	.....	1½	1 15/16	2 7/16	2 11/16	3 3/16	3¾
0.260	.....	.....	1 7/16	1⅞	2 5/16	2 9/16	3 1/16	3⅝
0.270	.....	.....	1⅜	1¾	2¼	2 7/16	2 15/16	3 7/16
0.280	.....	.....	.....	1 11/16	2⅛	2⅜	2 13/16	3 5/16
0.290	.....	.....	.....	1⅝	2 1/16	2¼	2¾	3 3/16
0.300	.....	.....	.....	1 9/16	2	2 3/16	2⅝	3⅛
0.310	.....	.....	.....	1½	1 15/16	2⅛	2 9/16	3
0.320	.....	.....	.....	1 7/16	1⅞	2 1/16	2 7/16	2⅞
0.330	.....	.....	.....	.....	1 13/16	2	2⅜	2 13/16
0.340	.....	.....	.....	.....	1¾	1 15/16	2 5/16	2¾
0.350	.....	.....	.....	.....	1 11/16	1⅞	2¼	2⅝
0.360	.....	.....	.....	.....	1⅝	1 13/16	2 3/16	2 9/16
0.370	.....	.....	.....	.....	1 9/16	1¾	2⅛	2½
0.380	.....	.....	.....	.....	.....	1 11/16	2 1/16	2 7/16
0.390	.....	.....	.....	.....	.....	1⅝	2	2⅜
0.400	.....	.....	.....	.....	.....	1 9/16	1 15/16	2 5/16
0.410	.....	.....	.....	.....	.....	.....	1⅞	2¼
0.420	.....	.....	.....	.....	.....	.....	1 13/16	2 3/16
0.430	.....	.....	.....	.....	.....	.....	1¾	2⅛
0.440	.....	.....	.....	.....	.....	.....	1¾	2 1/16
0.450	.....	.....	.....	.....	.....	.....	.....	2
0.460	.....	.....	.....	.....	.....	.....	.....	1 15/16
0.470	.....	.....	.....	.....	.....	.....	.....	1 15/16
0.480	.....	.....	.....	.....	.....	.....	.....	1⅞
0.490	.....	.....	.....	.....	.....	.....	.....	1 13/16
0.500	.....	.....	.....	.....	.....	.....	.....	1¾
0.510	.....	.....	.....	.....	.....	.....	.....	.....

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
0.030	11	.....	.....	.....	.....	.....	.....	.....
0.040	11	12¼	13⁷⁄₁₆	.....	.....	.....	.....	.....
0.050	7⁵⁄₁₆	12¼	13⁷⁄₁₆	14½	15	15½	.....	.....
0.060	5¹⁄₁₆	9¹⁄₁₆	13⁷⁄₁₆	14½	15	15½	16⁷⁄₁₆	.....
0.070	4	6⁷⁄₁₆	10¹³⁄₁₆	14½	15	15½	16⁷⁄₁₆	17⅜
0.080	3⅜	5⅛	7¾	12½	15	15½	16⁷⁄₁₆	17⅜
0.090	2¹⁵⁄₁₆	4⁵⁄₁₆	6¼	9⅛	11³⁄₁₆	14	16⁷⁄₁₆	17⅜
0.100	2⅝	3¾	5¼	7⅜	8¹¹⁄₁₆	10⅜	15⁷⁄₁₆	17⅜
0.110	2⅜	3⅜	4⅝	6¼	7¼	8⁷⁄₁₆	11⅝	16¹⁵⁄₁₆
0.120	2⅛	3¹⁄₁₆	4⅛	5½	6¼	7³⁄₁₆	9½	12⅞
0.130	2	2¹³⁄₁₆	3¾	4¹⁵⁄₁₆	5⁹⁄₁₆	6⁵⁄₁₆	8⅛	10⅝
0.140	1¹³⁄₁₆	2⁹⁄₁₆	3⁷⁄₁₆	4⁷⁄₁₆	5¹⁄₁₆	5¹¹⁄₁₆	7³⁄₁₆	9⅛
0.150	1¹¹⁄₁₆	2⅜	3³⁄₁₆	4⅛	4⅝	5³⁄₁₆	6⁷⁄₁₆	8¹⁄₁₆
0.160	1⁹⁄₁₆	2¼	3	3¹³⁄₁₆	4¼	4¾	5⅞	7¼
0.170	1½	2⅛	2¹³⁄₁₆	3⁹⁄₁₆	4	4⁷⁄₁₆	5⁷⁄₁₆	6⅝
0.180	1⅜	2	2⅝	3⅝	3¾	4⅛	5⅛	6⅛
0.190	1⁵⁄₁₆	1⅞	2½	3³⁄₁₆	3½	3⅞	4¾	5¹¹⁄₁₆
0.200	1¼	1¾	2⅜	3	3⁵⁄₁₆	3¹¹⁄₁₆	4⁷⁄₁₆	5⁵⁄₁₆
0.210	.....	1¹¹⁄₁₆	2¼	2⅞	3³⁄₁₆	3½	4³⁄₁₆	5
0.220	.....	1⁹⁄₁₆	2⅛	2¹¹⁄₁₆	3	3⁵⁄₁₆	4	4¾
0.230	.....	1½	2¹⁄₁₆	2⁹⁄₁₆	2⅞	3³⁄₁₆	3¹³⁄₁₆	4½
0.240	.....	1⁷⁄₁₆	1¹⁵⁄₁₆	2½	2¾	3¹⁄₁₆	3⅝	4⁵⁄₁₆
0.250	.....	.....	1⅞	2⅜	2⅝	2¹⁵⁄₁₆	3½	4⅛
0.260	.....	.....	1¾	2¼	2½	2¹³⁄₁₆	3⅜	3¹⁵⁄₁₆
0.270	.....	.....	1¹¹⁄₁₆	2³⁄₁₆	2⁷⁄₁₆	2¹¹⁄₁₆	3³⁄₁₆	3¹³⁄₁₆
0.280	.....	.....	1⅝	2⅛	2⁵⁄₁₆	2⁹⁄₁₆	3⅛	3⅝
0.290	.....	.....	1⁹⁄₁₆	2	2¼	2½	3	3½
0.300	.....	.....	1½	1¹⁵⁄₁₆	2³⁄₁₆	2⅜	2⅞	3⅜
0.310	.....	.....	.....	1⅞	2⅛	2⁵⁄₁₆	2¹³⁄₁₆	3¼
0.320	.....	.....	.....	1¹³⁄₁₆	2	2¼	2¹¹⁄₁₆	3³⁄₁₆
0.330	.....	.....	.....	1¾	1¹⁵⁄₁₆	2³⁄₁₆	2⅝	3¹⁄₁₆
0.340	.....	.....	.....	1¹¹⁄₁₆	1⅞	2⅛	2½	3
0.350	.....	.....	.....	1⅝	1¹³⁄₁₆	2¹⁄₁₆	2⁷⁄₁₆	2⅞
0.360	.....	.....	.....	.....	1¾	2	2⅜	2¹³⁄₁₆
0.370	.....	.....	.....	.....	1¹¹⁄₁₆	1¹⁵⁄₁₆	2⁵⁄₁₆	2¾
0.380	.....	.....	.....	.....	.....	1⅞	2¼	2⅝
0.390	.....	.....	.....	.....	.....	1¹³⁄₁₆	2³⁄₁₆	2⁹⁄₁₆
0.400	.....	.....	.....	.....	.....	1¾	2⅛	2½
0.410	.....	.....	.....	.....	.....	.....	2¹⁄₁₆	2⁷⁄₁₆
0.420	.....	.....	.....	.....	.....	.....	2	2⅜
0.430	.....	.....	.....	.....	.....	.....	1¹⁵⁄₁₆	2⁵⁄₁₆
0.440	.....	.....	.....	.....	.....	.....	1⅞	2¼
0.450	.....	.....	.....	.....	.....	.....	.....	2³⁄₁₆
0.460	.....	.....	.....	.....	.....	.....	.....	2⅛
0.470	.....	.....	.....	.....	.....	.....	.....	2⅛
0.480	.....	.....	.....	.....	.....	.....	.....	2¹⁄₁₆
0.490	.....	.....	.....	.....	.....	.....	.....	2
0.500	.....	.....	.....	.....	.....	.....	.....	1¹⁵⁄₁₆
0.510	.....	.....	.....	.....	.....	.....	.....	.....

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
0.030	12¼	.....	.....	.....	.....	.....	.....
0.040	12¼	13 11/16	15	.....	.....	.....	.....
0.050	8 3/16	13 11/16	15	16¼	17⅜	.....	.....
0.060	5 11/16	10⅛	15	16¼	17⅜	.....	.....
0.070	4½	7 3/16	12⅛	16¼	17⅜	19⅜	20⅜
0.080	3¾	5 11/16	8 11/16	14	17⅜	19⅜	20⅜
0.090	3¼	4 13/16	6 15/16	10 3/16	15 11/16	19⅜	20⅜
0.100	2 15/16	4 3/16	5⅞	8 3/16	11⅝	19⅜	20⅜
0.110	2⅝	3¾	5 3/16	7	9 7/16	18 15/16	20⅜
0.120	2⅜	3⅜	4⅝	6⅛	8 1/16	14 7/16	20⅜
0.130	2 3/16	3⅛	4 3/16	5½	7 1/16	11⅞	15 13/16
0.140	2 1/16	2⅞	3⅞	5	6⅜	10 3/16	13 1/16
0.150	1⅞	2 11/16	3 9/16	4⅝	5 13/16	9	11¼
0.160	1¾	2½	3 5/16	4¼	5 5/16	8 1/16	9 15/16
0.170	1 11/16	2⅜	3⅛	4	4 15/16	7⅜	9
0.180	1 9/16	2 3/16	2 15/16	3¾	4⅝	6 13/16	8 3/16
0.190	1 7/16	2 1/16	2¾	3 9/16	4⅜	6⅜	7 9/16
0.200	1⅜	2	2⅝	3⅜	4⅛	5 15/16	7 1/16
0.210	.....	1⅞	2½	3 3/16	3 15/16	5⅝	6⅝
0.220	.....	1 13/16	2⅜	3	3¾	5 5/16	6¼
0.230	.....	1 11/16	2¼	2⅞	3 9/16	5 1/16	5 15/16
0.240	.....	1⅝	2 3/16	2¾	3⅜	4 13/16	5⅝
0.250	.....	.....	2 1/16	2⅝	3¼	4⅝	5⅜
0.260	.....	.....	2	2 9/16	3⅛	4 7/16	5⅛
0.270	.....	.....	1 15/16	2 7/16	3	4¼	4 15/16
0.280	.....	.....	1 13/16	2⅜	2⅞	4 1/16	4¾
0.290	.....	.....	1¾	2¼	2 13/16	3 15/16	4 9/16
0.300	.....	.....	1 11/16	2 3/16	2 11/16	3 13/16	4⅜
0.310	.....	.....	.....	2⅛	2⅝	3 11/16	4¼
0.320	.....	.....	.....	2	2½	3 9/16	4⅛
0.330	.....	.....	.....	1 15/16	2 7/16	3 7/16	4
0.340	.....	.....	.....	1⅞	2⅜	3 5/16	3⅞
0.350	.....	.....	.....	1 13/16	2¼	3¼	3¾
0.360	.....	.....	.....	.....	2 3/16	3⅛	3⅝
0.370	.....	.....	.....	.....	2⅛	3 1/16	3 9/16
0.380	.....	.....	.....	.....	2 1/16	2 15/16	3 7/16
0.390	.....	.....	.....	.....	2	2⅞	3⅜
0.400	.....	.....	.....	.....	1 15/16	2 13/16	3¼
0.410	.....	.....	.....	.....	.....	2¾	3 1/16
0.420	.....	.....	.....	.....	.....	2 11/16	3⅛
0.430	.....	.....	.....	.....	.....	2 9/16	3
0.440	.....	.....	.....	.....	.....	2½	2 15/16
0.450	.....	.....	.....	.....	.....	2 7/16	2⅞
0.460	.....	.....	.....	.....	.....	2⅜	2 13/16
0.470	.....	.....	.....	.....	.....	2 5/16	2¾
0.480	.....	.....	.....	.....	.....	2 5/16	2 11/16
0.490	.....	.....	.....	.....	.....	2¼	2⅝
0.500	.....	.....	.....	.....	.....	2 3/16	2 9/16
0.510	.....	.....	.....	.....	.....	.....	2½
0.520	.....	.....	.....	.....	.....	.....	2 7/16
0.530	.....	.....	.....	.....	.....	.....	2⅜
0.540	.....	.....	.....	.....	.....	.....	2 5/16
0.550	.....	.....	.....	.....	.....	.....	2 5/16
0.560	.....	.....	.....	.....	.....	.....	.....

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
0.030	13 7/16	14 1/4	.....	.....	.....	.....	.....	.....
0.040	13 7/16	14 1/4	15	16 7/16	.....	.....	.....	.....
0.050	9	13 1/8	15	16 7/16	17 1/8	18 7/16	.....	.....
0.060	6 1/4	8 1/4	11 1/8	16 7/16	17 1/8	18 7/16	20 1/8	.....
0.070	4 15/16	6 1/16	7 7/8	13 1/4	17 1/8	18 7/16	20 1/8	22 5/16
0.080	4 1/8	5 1/16	6 1/4	9 1/2	11 7/8	18 7/16	20 1/8	22 5/16
0.090	3 9/16	4 1/8	5 1/4	7 5/8	9 1/16	13 11/16	20 1/8	22 5/16
0.100	3 1/16	3 7/8	4 1/8	6 7/16	7 5/8	10 5/8	18 15/16	22 5/16
0.110	2 7/8	3 7/16	4 1/8	5 5/8	6 9/16	8 7/8	14 1/4	22 5/16
0.120	2 5/8	3 1/8	3 1/4	5 1/16	5 11/16	7 11/16	11 5/8	22 5/16
0.130	2 7/16	2 7/8	3 7/16	4 9/16	5 1/4	6 11/16	9 15/16	17 5/16
0.140	2 1/4	2 11/16	3 1/8	4 1/4	4 11/16	6 1/16	8 1/4	14 5/16
0.150	2 1/16	2 1/2	2 15/16	3 15/16	4 7/16	5 11/16	7 7/8	12 5/16
0.160	1 15/16	2 5/16	2 1/4	3 5/8	4 1/8	5 1/4	7 1/16	10 15/16
0.170	1 11/16	2 1/16	2 9/16	3 7/16	3 7/8	4 7/8	6 5/8	9 11/16
0.180	1 11/16	2 1/16	2 7/16	3 1/4	3 5/8	4 9/16	6 1/16	9
0.190	1 5/8	1 15/16	2 5/16	3 1/16	3 7/16	4 5/16	5 11/16	8 5/16
0.200	1 1/2	1 11/16	2 1/16	2 7/8	3 1/4	4 1/16	5 7/16	7 1/4
0.210	.....	1 1/4	2 1/16	2 1/4	3 1/8	3 7/8	5 1/16	7 1/4
0.220	.....	1 1/8	1 15/16	2 5/8	2 15/16	3 11/16	4 7/8	6 7/8
0.230	.....	.....	1 7/8	2 1/2	2 13/16	3 1/2	4 11/16	6 1/2
0.240	.....	.....	1 1/4	2 3/8	2 11/16	3 1/8	4 7/16	6 1/16
0.250	.....	.....	.....	2 1/4	2 9/16	3 1/4	4 1/4	5 7/8
0.260	.....	.....	.....	2 1/16	2 1/2	3 1/8	4 1/8	5 5/8
0.270	.....	.....	.....	2 1/16	2 1/8	3	3 15/16	5 7/16
0.280	.....	.....	.....	2	2 5/16	2 7/8	3 11/16	5 1/16
0.290	.....	.....	.....	1 15/16	2 1/16	2 1/4	3 11/16	5
0.300	.....	.....	.....	1 7/8	2 1/8	2 11/16	3 1/2	4 11/16
0.310	.....	.....	.....	.....	2	2 9/16	3 7/16	4 11/16
0.320	.....	.....	.....	.....	1 15/16	2 1/2	3 5/16	4 1/2
0.330	.....	.....	.....	.....	.....	2 1/8	3 1/16	4 1/8
0.340	.....	.....	.....	.....	.....	2 1/16	3 1/8	4 1/4
0.350	.....	.....	.....	.....	.....	2 1/4	3	4 1/8
0.360	.....	.....	.....	.....	.....	2 1/16	2 15/16	4
0.370	.....	.....	.....	.....	.....	2 1/8	2 11/16	3 7/8
0.380	.....	.....	.....	.....	.....	.....	2 1/4	3 1/4
0.390	.....	.....	.....	.....	.....	.....	2 11/16	3 11/16
0.400	.....	.....	.....	.....	.....	.....	2 9/16	3 9/16
0.410	.....	.....	.....	.....	.....	.....	2 1/2	3 1/2
0.420	.....	.....	.....	.....	.....	.....	2 7/16	3 3/8
0.430	.....	.....	.....	.....	.....	.....	2 1/8	3 5/16
0.440	.....	.....	.....	.....	.....	.....	2 1/16	3 1/4
0.450	.....	.....	.....	.....	.....	.....	.....	3 1/8
0.460	.....	.....	.....	.....	.....	.....	.....	3 1/16
0.470	.....	.....	.....	.....	.....	.....	.....	3
0.480	.....	.....	.....	.....	.....	.....	.....	2 15/16
0.490	.....	.....	.....	.....	.....	.....	.....	2 7/8
0.500	.....	.....	.....	.....	.....	.....	.....	2 11/16
0.510	.....	.....	.....	.....	.....	.....	.....	2 1/4
0.520	.....	.....	.....	.....	.....	.....	.....	2 11/16
0.530	.....	.....	.....	.....	.....	.....	.....	2 1/8
0.540	.....	.....	.....	.....	.....	.....	.....	2 9/16
0.550	.....	.....	.....	.....	.....	.....	.....	2 1/2
0.560	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 3-9 VALUES OF *L* FOR PIPE SIZES ≥ NPS 42 AND < NPS 48

Depth, *d*, in.	Wall Thickness, *t*, in.								
	0.344	0.406	0.438	0.469	0.500	0.562	0.625	0.688	0.750
0.030	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.040	17	.....	.....	.....	.....	.....	.....	.....	.....
0.050	17	18 1/2	19 3/16	19 7/8	20 1/2	.....	.....	.....	.....
0.060	17	18 1/2	19 3/16	19 7/8	20 1/2	21 3/4	.....	.....	.....
0.070	10 15/16	18 1/2	19 3/16	19 7/8	20 1/2	21 3/4	22 15/16	24 1/16	.....
0.080	8 5/16	12 7/8	16 9/16	19 7/8	20 1/2	21 3/4	22 15/16	24 1/16	25 1/8
0.090	6 7/8	9 7/8	12 1/16	14 13/16	18 9/16	21 3/4	22 15/16	24 1/16	25 1/8
0.100	5 15/16	8 3/16	9 3/4	11 1/2	13 3/4	20 7/16	22 15/16	24 1/16	25 1/8
0.110	5 1/4	7 1/16	8 1/4	9 9/16	11 1/8	15 3/8	22 7/16	24 1/16	25 1/8
0.120	4 11/16	6 5/16	7 1/4	8 5/16	9 1/2	12 9/16	17 1/16	24 1/16	25 1/8
0.130	4 5/16	5 11/16	6 1/2	7 3/8	8 3/8	10 3/4	14	18 3/4	25 1/8
0.140	4	5 3/16	5 15/16	6 11/16	7 1/2	9 1/2	12 1/16	15 7/16	20 1/4
0.150	3 11/16	4 13/16	5 7/16	6 1/8	6 13/16	8 1/2	10 5/8	13 5/16	16 13/16
0.160	3 7/16	4 7/16	5 1/16	5 5/8	6 5/16	7 3/4	9 9/16	11 13/16	14 9/16
0.170	3 1/4	4 3/16	4 11/16	5 1/4	5 7/8	7 3/16	8 3/4	10 5/8	12 7/8
0.180	3 1/16	3 15/16	4 7/16	4 15/16	5 1/2	6 11/16	8 1/16	9 11/16	11 5/8
0.190	2 7/8	3 11/16	4 3/16	4 11/16	5 3/16	6 1/4	7 1/2	9	10 11/16
0.200	2 3/4	3 1/2	3 15/16	4 7/16	4 7/8	5 7/8	7 1/16	8 3/8	9 7/8
0.210	2 9/16	3 3/8	3 3/4	4 3/16	4 5/8	5 9/16	6 5/8	7 7/8	9 3/16
0.220	2 7/16	3 3/16	3 9/16	4	4 3/8	5 5/16	6 5/16	7 3/8	8 5/8
0.230	2 3/8	3 1/16	3 7/16	3 13/16	4 3/16	5 1/16	6	7	8 1/8
0.240	2 1/4	2 15/16	3 1/4	3 5/8	4	4 13/16	5 11/16	6 11/16	7 3/4
0.250	2 1/8	2 13/16	3 1/8	3 1/2	3 7/8	4 5/8	5 7/16	6 3/8	7 3/8
0.260	2 1/16	2 11/16	3	3 3/8	3 11/16	4 7/16	5 1/4	6 1/16	7
0.270	1 15/16	2 9/16	2 7/8	3 3/16	3 9/16	4 1/4	5	5 13/16	6 11/16
0.280	.....	2 7/16	2 13/16	3 1/8	3 7/16	4 1/8	4 13/16	5 5/8	6 7/16
0.290	.....	2 3/8	2 11/16	3	3 5/16	3 15/16	4 5/8	5 3/8	6 3/16
0.300	.....	2 1/4	2 9/16	2 7/8	3 3/16	3 13/16	4 1/2	5 1/16	6
0.310	.....	2 3/16	2 1/2	2 3/4	3 1/16	3 11/16	4 5/16	5 1/16	5 3/4
0.320	.....	2 1/8	2 3/8	2 11/16	2 15/16	3 9/16	4 3/16	4 7/8	5 9/16
0.330	.....	.....	2 5/16	2 9/16	2 7/8	3 7/16	4 1/16	4 11/16	5 3/8
0.340	.....	.....	2 1/4	2 1/2	2 3/4	3 5/16	3 15/16	4 9/16	5 1/4
0.350	.....	.....	2 3/16	2 7/16	2 11/16	3 1/4	3 13/16	4 7/16	5 1/16
0.360	.....	.....	.....	2 5/16	2 5/8	3 1/8	3 11/16	4 5/16	4 15/16
0.370	.....	.....	.....	2 1/4	2 1/2	3 1/16	3 5/8	4 3/16	4 3/4
0.380	.....	.....	.....	.....	2 7/16	2 15/16	3 1/2	4 1/16	4 5/8
0.390	.....	.....	.....	.....	2 3/8	2 7/8	3 7/16	3 15/16	4 1/2
0.400	.....	.....	.....	.....	2 5/16	2 13/16	3 5/16	3 7/8	4 7/16
0.410	.....	.....	.....	.....	.....	2 3/4	3 1/4	3 3/4	4 5/16
0.420	.....	.....	.....	.....	.....	2 5/8	3 1/8	3 11/16	4 3/16
0.430	.....	.....	.....	.....	.....	2 9/16	3 1/16	3 9/16	4 1/16
0.440	.....	.....	.....	.....	.....	2 1/2	3	3 1/2	4
0.450	.....	.....	.....	.....	.....	.....	2 15/16	3 3/8	3 7/8
0.460	.....	.....	.....	.....	.....	.....	2 13/16	3 5/16	3 13/16
0.470	.....	.....	.....	.....	.....	.....	2 3/4	3 1/4	3 3/4
0.480	.....	.....	.....	.....	.....	.....	2 11/16	3 3/16	3 5/8
0.490	.....	.....	.....	.....	.....	.....	2 5/8	3 1/8	3 9/16
0.500	.....	.....	.....	.....	.....	.....	2 9/16	3	3 1/2
0.510	.....	.....	.....	.....	.....	.....	.....	2 15/16	3 3/8
0.520	.....	.....	.....	.....	.....	.....	.....	2 7/8	3 5/16

TABLE 3-9 VALUES OF *L* FOR PIPE SIZES ≥ NPS 42 AND < NPS 48

Wall Thickness, *t*, in.								Depth, *d*, in.
0.812	0.875	0.938	1.000	1.062	1.125	1.188	1.250	
.....	.....	.....	.....	.....	.....	.....	.....	0.030
.....	.....	.....	.....	.....	.....	.....	.....	0.040
.....	.....	.....	.....	.....	.....	.....	.....	0.050
.....	.....	.....	.....	.....	.....	.....	.....	0.060
.....	.....	.....	.....	.....	.....	.....	.....	0.070
.....	.....	.....	.....	.....	.....	.....	.....	0.080
26 3/16	27 3/16	.....	.....	.....	.....	.....	.....	0.090
26 3/16	27 3/16	28 1/8	.....	.....	.....	.....	.....	0.100
26 3/16	27 3/16	28 1/8	29 1/16	29 15/16	.....	.....	.....	0.110
26 3/16	27 3/16	28 1/8	29 1/16	29 15/16	30 13/16	31 5/8	.....	0.120
26 3/16	27 3/16	28 1/8	29 1/16	29 15/16	30 13/16	31 5/8	32 7/16	0.130
26 3/16	27 3/16	28 1/8	29 1/16	29 15/16	30 13/16	31 5/8	32 7/16	0.140
21 3/4	27 3/16	28 1/8	29 1/16	29 15/16	30 13/16	31 5/8	32 7/16	0.150
18 3/16	23 5/16	28 1/8	29 1/16	29 15/16	30 13/16	31 5/8	32 7/16	0.160
15 3/4	19 9/16	24 13/16	29 1/16	29 15/16	30 13/16	31 5/8	32 7/16	0.170
14	17	20 15/16	26 1/4	29 15/16	30 13/16	31 5/8	32 7/16	0.180
12 11/16	15 1/8	18 1/4	22 1/4	27 5/8	30 13/16	31 5/8	32 7/16	0.190
11 5/8	13 11/16	16 1/4	19 7/16	23 1/2	29 1/16	31 5/8	32 7/16	0.200
10 3/4	12 9/16	14 3/4	17 3/8	20 9/16	24 13/16	30 7/16	32 7/16	0.210
10	11 5/8	13 9/16	15 3/4	18 7/16	21 13/16	26 1/8	31 3/4	0.220
9 7/16	10 7/8	12 9/16	14 1/2	16 3/4	19 9/16	23	27 5/16	0.230
8 7/8	10 1/4	11 3/4	13 7/16	15 7/16	17 13/16	20 11/16	24 1/8	0.240
8 7/16	9 11/16	11 1/16	12 9/16	14 5/16	16 3/8	18 13/16	21 3/4	0.250
8	9 3/16	10 7/16	11 13/16	13 3/8	15 1/4	17 3/8	19 13/16	0.260
7 11/16	8 3/4	9 7/8	11 3/16	12 5/8	14 1/4	16 1/8	18 5/16	0.270
7 3/8	8 5/16	9 7/16	10 5/8	11 15/16	13 7/16	15 1/8	17	0.280
7 1/16	8	9	10 1/8	11 5/16	12 11/16	14 1/4	15 15/16	0.290
6 13/16	7 11/16	8 5/8	9 11/16	10 13/16	12 1/16	13 1/2	15 1/16	0.300
6 9/16	7 3/8	8 5/16	9 1/4	10 5/16	11 1/2	12 13/16	14 1/4	0.310
6 5/16	7 1/8	8	8 15/16	9 15/16	11	12 1/4	13 9/16	0.320
6 1/8	6 7/8	7 11/16	8 9/16	9 9/16	10 9/16	11 11/16	12 15/16	0.330
5 15/16	6 11/16	7 7/16	8 5/16	9 3/16	10 3/16	11 1/4	12 3/8	0.340
5 3/4	6 7/16	7 3/16	8	8 7/8	9 13/16	10 13/16	11 7/8	0.350
5 9/16	6 1/4	7	7 3/4	8 9/16	9 7/16	10 7/16	11 7/16	0.360
5 3/8	6 1/16	6 3/4	7 1/2	8 5/16	9 1/8	10 1/16	11	0.370
5 1/4	5 7/8	6 9/16	7 5/16	8 1/16	8 7/8	9 3/4	10 5/8	0.380
5 1/8	5 3/4	6 3/8	7 1/16	7 13/16	8 9/16	9 7/16	10 5/16	0.390
5	5 9/16	6 1/4	6 7/8	7 5/8	8 3/8	9 1/8	10	0.400
4 7/8	5 7/16	6 1/16	6 11/16	7 3/8	8 1/8	8 7/8	9 11/16	0.410
4 3/4	5 5/16	5 15/16	6 9/16	7 3/16	7 7/8	8 5/8	9 3/8	0.420
4 5/8	5 3/16	5 3/4	6 3/8	7	7 11/16	8 3/8	9 1/8	0.430
4 1/2	5 1/16	5 5/8	6 1/4	6 13/16	7 1/2	8 3/16	8 7/8	0.440
4 7/16	4 15/16	5 1/2	6 1/16	6 11/16	7 5/16	8	8 11/16	0.450
4 5/16	4 13/16	5 3/8	5 15/16	6 1/2	7 1/8	7 13/16	8 7/16	0.460
4 3/16	4 3/4	5 1/4	5 13/16	6 3/8	7	7 5/8	8 1/4	0.470
4 1/8	4 5/8	5 1/8	5 11/16	6 1/4	6 13/16	7 7/16	8 1/16	0.480
4	4 1/2	5 1/16	5 9/16	6 1/8	6 11/16	7 1/4	7 7/8	0.490
3 15/16	4 7/16	4 15/16	5 7/16	6	6 9/16	7 1/8	7 11/16	0.500
3 7/8	4 5/16	4 13/16	5 5/16	5 7/8	6 3/8	6 15/16	7 9/16	0.510
3 3/4	4 1/4	4 3/4	5 1/4	5 3/4	6 1/4	6 13/16	7 3/8	0.520

(table continues)

TABLE 3-9 VALUES OF L FOR PIPE SIZES ≥ NPS 42 AND < NPS 48 (CONT'D)

Depth, d, in.	Wall Thickness, t, in.								
	0.344	0.406	0.438	0.469	0.500	0.562	0.625	0.688	0.750
0.530	.....	.....	.....	.....	.....	.....	.....	2 13/16	3 1/4
0.540	.....	.....	.....	.....	.....	.....	.....	2 3/4	3 3/16
0.550	.....	.....	.....	.....	.....	.....	.....	2 11/16	3 1/8
0.560	.....	.....	.....	.....	.....	.....	.....	.....	3 1/16
0.570	.....	.....	.....	.....	.....	.....	.....	.....	3
0.580	.....	.....	.....	.....	.....	.....	.....	.....	2 15/16
0.590	.....	.....	.....	.....	.....	.....	.....	.....	2 7/8
0.600	.....	.....	.....	.....	.....	.....	.....	.....	2 13/16
0.610	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.620	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.630	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.640	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.650	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.660	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.670	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.680	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.690	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.700	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.710	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.720	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.730	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.740	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.750	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.760	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.770	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.780	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.790	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.800	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.810	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.820	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.830	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.840	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.850	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.860	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.870	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.880	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.890	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.900	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.910	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.920	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.930	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.940	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.950	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.960	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.970	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.980	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.990	.....	.....	.....	.....	.....	.....	.....	.....	.....
1.000	.....	.....	.....	.....	.....	.....	.....	.....	.....
1.010	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 3-9 VALUES OF *L* FOR PIPE SIZES ≥ NPS 42 AND < NPS 48 (CONT'D)

Wall Thickness, *t*, in.								Depth,
0.812	0.875	0.938	1.000	1.062	1.125	1.188	1.250	*d*, in.
3 11/16	4 3/16	4 5/8	5 1/8	5 5/8	6 1/8	6 11/16	7 1/4	0.530
3 5/8	4 1/16	4 9/16	5	5 1/2	6	6 9/16	7 1/8	0.540
3 9/16	4	4 7/16	4 15/16	5 7/16	5 15/16	6 7/16	6 15/16	0.550
3 1/2	3 15/16	4 3/8	4 13/16	5 5/16	5 13/16	6 5/16	6 13/16	0.560
3 7/16	3 7/8	4 5/16	4 1/4	5 3/16	5 11/16	6 3/16	6 11/16	0.570
3 3/8	3 3/4	4 1/4	4 11/16	5 1/8	5 9/16	6 1/16	6 9/16	0.580
3 5/16	3 11/16	4 1/8	4 9/16	5	5 1/2	6	6 7/16	0.590
3 1/4	3 5/8	4 1/16	4 1/2	4 15/16	5 3/8	5 7/8	6 3/8	0.600
3 3/16	3 9/16	4	4 7/16	4 7/8	5 5/16	5 3/4	6 1/4	0.610
3 1/8	3 1/2	3 15/16	4 3/8	4 3/4	5 3/16	5 11/16	6 1/8	0.620
3 1/16	3 7/16	3 7/8	4 1/4	4 11/16	5 1/8	5 9/16	6 1/16	0.630
3	3 3/8	3 13/16	4 3/16	4 5/8	5 1/16	5 1/2	5 15/16	0.640
.....	3 5/16	3 3/4	4 1/8	4 9/16	4 15/16	5 3/8	5 13/16	0.650
.....	3 1/4	3 11/16	4 1/16	4 7/16	4 7/8	5 5/16	5 3/4	0.660
.....	3 3/16	3 5/8	4	4 3/8	4 13/16	5 1/4	5 11/16	0.670
.....	3 1/8	3 9/16	3 15/16	4 5/16	4 3/4	5 1/8	5 9/16	0.680
.....	3 1/8	3 1/2	3 7/8	4 1/4	4 11/16	5 1/16	5 1/2	0.690
.....	3 1/16	3 7/16	3 13/16	4 3/16	4 9/16	5	5 7/16	0.700
.....	.....	3 3/8	3 3/4	4 1/8	4 1/2	4 15/16	5 5/16	0.710
.....	.....	3 5/16	3 11/16	4 1/16	4 7/16	4 7/8	5 1/4	0.720
.....	.....	3 1/4	3 5/8	4	4 3/8	4 3/4	5 3/16	0.730
.....	.....	3 3/16	3 9/16	3 15/16	4 5/16	4 11/16	5 1/8	0.740
.....	.....	3 1/8	3 1/2	3 7/8	4 1/4	4 5/8	5	0.750
.....	.....	.....	3 7/16	3 13/16	4 3/16	4 9/16	4 15/16	0.760
.....	.....	.....	3 7/16	3 3/4	4 1/8	4 1/2	4 7/8	0.770
.....	.....	.....	3 3/8	3 11/16	4 1/16	4 7/16	4 13/16	0.780
.....	.....	.....	3 5/16	3 11/16	4	4 3/8	4 3/4	0.790
.....	.....	.....	3 1/4	3 5/8	3 15/16	4 5/16	4 11/16	0.800
.....	.....	.....	.....	3 9/16	3 15/16	4 1/4	4 5/8	0.810
.....	.....	.....	.....	3 1/2	3 7/8	4 3/16	4 9/16	0.820
.....	.....	.....	.....	3 7/16	3 13/16	4 1/8	4 1/2	0.830
.....	.....	.....	.....	3 3/8	3 3/4	4 1/8	4 7/16	0.840
.....	.....	.....	.....	.....	3 11/16	4 1/16	4 3/8	0.850
.....	.....	.....	.....	.....	3 5/8	4	4 5/16	0.860
.....	.....	.....	.....	.....	3 5/8	3 15/16	4 1/4	0.870
.....	.....	.....	.....	.....	3 9/16	3 7/8	4 1/4	0.880
.....	.....	.....	.....	.....	3 1/2	3 13/16	4 3/16	0.890
.....	.....	.....	.....	.....	3 7/16	3 13/16	4 1/8	0.900
.....	.....	.....	.....	.....	.....	3 3/4	4 1/16	0.910
.....	.....	.....	.....	.....	.....	3 11/16	4	0.920
.....	.....	.....	.....	.....	.....	3 5/8	3 15/16	0.930
.....	.....	.....	.....	.....	.....	3 5/8	3 15/16	0.940
.....	.....	.....	.....	.....	.....	3 9/16	3 7/8	0.950
.....	.....	.....	.....	.....	.....	.....	3 13/16	0.960
.....	.....	.....	.....	.....	.....	.....	3 3/4	0.970
.....	.....	.....	.....	.....	.....	.....	3 3/4	0.980
.....	.....	.....	.....	.....	.....	.....	3 11/16	0.990
.....	.....	.....	.....	.....	.....	.....	3 5/8	1.000
.....	.....	.....	.....	.....	.....	.....	.....	1.010

TABLE 3-10 VALUES OF *L* FOR PIPE SIZES ≥ NPS 48 AND < NPS 52

Depth, *d*, in.	Wall Thickness, *t*, in.								
	0.344	0.406	0.438	0.469	0.500	0.562	0.625	0.688	0.750
0.030	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.040	18 3/16	.....	.....	.....	.....	.....	.....	.....	.....
0.050	18 3/16	19 3/4	20 9/16	21 1/4	21 15/16	.....	.....	.....	.....
0.060	18 3/16	19 3/4	20 9/16	21 1/4	21 15/16	23 1/4	.....	.....	.....
0.070	11 11/16	19 3/4	20 9/16	21 1/4	21 15/16	23 1/4	24 9/16	25 3/4	.....
0.080	8 15/16	13 3/4	17 11/16	21 1/4	21 15/16	23 1/4	24 9/16	25 3/4	26 7/8
0.090	7 3/8	10 9/16	12 7/8	15 13/16	19 13/16	23 1/4	24 9/16	25 3/4	26 7/8
0.100	6 5/16	8 3/4	10 3/8	12 5/16	14 11/16	21 7/8	24 9/16	25 3/4	26 7/8
0.110	5 5/8	7 9/16	8 13/16	10 1/4	11 15/16	16 7/16	24	25 3/4	26 7/8
0.120	5 1/16	6 3/4	7 3/4	8 7/8	10 3/16	13 7/16	18 1/4	25 3/4	26 7/8
0.130	4 5/8	6 1/16	6 15/16	7 7/8	8 15/16	11 1/2	15	20	26 7/8
0.140	4 1/4	5 9/16	6 5/16	7 1/8	8	10 1/8	12 7/8	16 1/2	21 5/8
0.150	3 15/16	5 1/8	5 13/16	6 9/16	7 5/16	9 1/8	11 3/8	14 1/4	18
0.160	3 11/16	4 3/4	5 3/8	6 1/16	6 3/4	8 5/16	10 1/4	12 5/8	15 9/16
0.170	3 7/16	4 1/2	5 1/16	5 5/8	6 1/4	7 11/16	9 3/8	11 3/8	13 13/16
0.180	3 1/4	4 3/16	4 3/4	5 5/16	5 7/8	7 1/8	8 5/8	10 3/8	12 7/16
0.190	3 1/16	4	4 1/2	5	5 1/2	6 11/16	8 1/16	9 5/8	11 3/8
0.200	2 15/16	3 3/4	4 1/4	4 11/16	5 3/16	6 5/16	7 9/16	8 15/16	10 9/16
0.210	2 3/4	3 9/16	4	4 1/2	4 15/16	5 15/16	7 1/8	8 3/8	9 13/16
0.220	2 5/8	3 7/16	3 13/16	4 1/4	4 11/16	5 11/16	6 3/4	7 15/16	9 1/4
0.230	2 1/2	3 1/4	3 11/16	4 1/16	4 1/2	5 3/8	6 3/8	7 1/2	8 11/16
0.240	2 3/8	3 1/8	3 1/2	3 7/8	4 5/16	5 1/8	6 1/8	7 1/8	8 1/4
0.250	2 5/16	3	3 3/8	3 3/4	4 1/8	4 15/16	5 13/16	6 13/16	7 7/8
0.260	2 3/16	2 7/8	3 1/4	3 9/16	3 15/16	4 3/4	5 9/16	6 1/2	7 1/2
0.270	2 1/16	2 3/4	3 1/16	3 7/16	3 13/16	4 9/16	5 3/8	6 1/4	7 3/16
0.280	.....	2 5/8	3	3 5/16	3 11/16	4 3/8	5 3/16	6	6 7/8
0.290	.....	2 9/16	2 7/8	3 3/16	3 1/2	4 1/4	5	5 3/4	6 5/8
0.300	.....	2 7/16	2 3/4	3 1/16	3 3/8	4 1/16	4 13/16	5 9/16	6 3/8
0.310	.....	2 3/8	2 11/16	2 15/16	3 5/16	3 15/16	4 5/8	5 3/8	6 3/16
0.320	.....	2 1/4	2 9/16	2 7/8	3 3/16	3 13/16	4 1/2	5 3/16	5 15/16
0.330	.....	.....	2 1/2	2 3/4	3 1/16	3 11/16	4 3/8	5 1/16	5 3/4
0.340	.....	.....	2 3/8	2 11/16	3	3 9/16	4 3/16	4 7/8	5 9/16
0.350	.....	.....	2 5/16	2 9/16	2 7/8	3 7/16	4 1/16	4 3/4	5 7/16
0.360	.....	.....	.....	2 1/2	2 13/16	3 3/8	4	4 5/8	5 1/4
0.370	.....	.....	.....	2 7/16	2 11/16	3 1/4	3 7/8	4 1/2	5 1/8
0.380	.....	.....	.....	.....	2 5/8	3 3/16	3 3/4	4 3/8	5
0.390	.....	.....	.....	.....	2 9/16	3 1/16	3 5/8	4 1/4	4 13/16
0.400	.....	.....	.....	.....	2 7/16	3	3 9/16	4 1/8	4 11/16
0.410	.....	.....	.....	.....	.....	2 15/16	3 7/16	4	4 9/16
0.420	.....	.....	.....	.....	.....	2 13/16	3 3/8	3 15/16	4 1/2
0.430	.....	.....	.....	.....	.....	2 3/4	3 1/4	3 13/16	4 3/8
0.440	.....	.....	.....	.....	.....	2 11/16	3 3/16	3 3/4	4 1/4
0.450	.....	.....	.....	.....	.....	.....	3 1/8	3 5/8	4 3/16
0.460	.....	.....	.....	.....	.....	.....	3 1/16	3 9/16	4 1/16
0.470	.....	.....	.....	.....	.....	.....	2 15/16	3 7/16	4
0.480	.....	.....	.....	.....	.....	.....	2 7/8	3 3/8	3 7/8
0.490	.....	.....	.....	.....	.....	.....	2 13/16	3 5/16	3 13/16
0.500	.....	.....	.....	.....	.....	.....	2 3/4	3 1/4	3 11/16
0.510	.....	.....	.....	.....	.....	.....	.....	3 3/16	3 5/8
0.520	.....	.....	.....	.....	.....	.....	.....	3 1/16	3 9/16

TABLE 3-10 VALUES OF L FOR PIPE SIZES ≥ NPS 48 AND < NPS 52

Wall Thickness, t, in.								Depth, d, in.
0.812	0.875	0.938	1.000	1.062	1.125	1.188	1.250	
.....	.....	.....	.....	.....	.....	.....	.....	0.030
.....	.....	.....	.....	.....	.....	.....	.....	0.040
.....	.....	.....	.....	.....	.....	.....	.....	0.050
.....	.....	.....	.....	.....	.....	.....	.....	0.060
.....	.....	.....	.....	.....	.....	.....	.....	0.070
.....	.....	.....	.....	.....	.....	.....	.....	0.080
28	29 1/16	.....	.....	.....	.....	.....	.....	0.090
28	29 1/16	30 1/16	.....	.....	.....	.....	.....	0.100
28	29 1/16	30 1/16	31 1/16	32	.....	.....	.....	0.110
28	29 1/16	30 1/16	31 1/16	32	32 5/16	33 13/16	.....	0.120
28	29 1/16	30 1/16	31 1/16	32	32 5/16	33 13/16	34 11/16	0.130
28	29 1/16	30 1/16	31 1/16	32	32 5/16	33 13/16	34 11/16	0.140
23 1/4	29 1/16	30 1/16	31 1/16	32	32 5/16	33 13/16	34 11/16	0.150
19 7/16	24 5/16	30 1/16	31 1/16	32	32 5/16	33 13/16	34 11/16	0.160
16 13/16	20 5/16	26 9/16	31 1/16	32	32 5/16	33 13/16	34 11/16	0.170
14 5/16	18 3/16	22 3/8	28 1/16	32	32 5/16	33 13/16	34 11/16	0.180
13 9/16	16 3/16	19 1/2	23 3/4	29 1/2	32 5/16	33 13/16	34 11/16	0.190
12 3/8	14 11/16	17 3/8	20 3/4	25 1/8	31 1/16	33 13/16	34 11/16	0.200
11 1/2	13 7/16	15 3/4	18 9/16	22	26 1/2	32 9/16	34 11/16	0.210
10 3/4	12 7/16	14 1/2	16 7/8	19 11/16	23 5/16	27 15/16	33 5/16	0.220
10 1/16	11 5/8	13 7/16	15 1/2	17 15/16	20 5/16	24 9/16	29 3/16	0.230
9 1/2	10 5/16	12 9/16	14 3/8	16 1/2	19 1/16	22 1/8	25 13/16	0.240
9	10 5/16	11 13/16	13 7/16	15 5/16	17 1/2	20 1/8	23 1/4	0.250
8 9/16	9 13/16	11 1/8	12 5/8	14 5/16	16 5/16	18 9/16	21 3/16	0.260
8 3/16	9 5/16	10 9/16	11 15/16	13 1/2	15 1/4	17 1/4	19 9/16	0.270
7 7/8	8 15/16	10 1/16	11 3/8	12 3/4	14 3/8	16 3/16	18 3/16	0.280
7 9/16	8 9/16	9 5/8	10 13/16	12 1/8	13 9/16	15 1/4	17 1/16	0.290
7 1/4	8 3/16	9 1/4	10 3/8	11 9/16	12 15/16	14 7/16	16 1/16	0.300
7	7 7/8	8 7/8	9 15/16	11 1/16	12 5/16	13 11/16	15 1/4	0.310
6 3/4	7 5/8	8 9/16	9 9/16	10 5/8	11 13/16	13 1/16	14 1/2	0.320
6 1/2	7 3/8	8 1/4	9 3/16	10 3/16	11 5/16	12 1/2	13 13/16	0.330
6 5/16	7 1/8	7 15/16	8 7/8	9 13/16	10 7/8	12	13 1/4	0.340
6 1/8	6 7/8	7 11/16	8 9/16	9 1/2	10 1/2	11 9/16	12 11/16	0.350
5 15/16	6 11/16	7 1/2	8 5/16	9 3/16	10 1/8	11 1/8	12 3/16	0.360
5 3/4	6 1/2	7 1/4	8 1/16	8 7/8	9 3/4	10 3/4	11 3/4	0.370
5 5/8	6 5/16	7 1/16	7 13/16	8 5/8	9 1/2	10 3/8	11 3/8	0.380
5 1/2	6 1/8	6 7/8	7 9/16	8 3/8	9 3/16	10 1/16	11	0.390
5 5/16	6	6 11/16	7 3/8	8 1/8	8 15/16	9 3/4	10 11/16	0.400
5 3/16	5 13/16	6 1/2	7 3/16	7 7/8	8 11/16	9 1/2	10 5/16	0.410
5 1/16	5 11/16	6 5/16	7	7 11/16	8 7/16	9 1/4	10 1/16	0.420
4 15/16	5 9/16	6 3/16	6 13/16	7 1/2	8 1/4	9	9 3/4	0.430
4 13/16	5 7/16	6	6 5/8	7 5/16	8	8 3/4	9 1/2	0.440
4 11/16	5 5/16	5 7/8	6 1/2	7 1/8	7 13/16	8 9/16	9 1/4	0.450
4 5/8	5 3/16	5 3/4	6 3/8	7	7 5/8	8 5/16	9 1/16	0.460
4 1/2	5 1/16	5 5/8	6 3/16	6 13/16	7 7/16	8 1/8	8 13/16	0.470
4 3/8	4 15/16	5 1/2	6 1/16	6 11/16	7 5/16	7 15/16	8 5/8	0.480
4 5/16	4 13/16	5 3/8	5 15/16	6 1/2	7 1/8	7 3/4	8 7/16	0.490
4 3/16	4 3/4	5 1/4	5 13/16	6 3/8	7	7 5/8	8 1/4	0.500
4 1/8	4 5/8	5 3/16	5 11/16	6 1/4	6 13/16	7 7/16	8 1/16	0.510
4 1/16	4 9/16	5 1/16	5 9/16	6 1/8	6 11/16	7 5/16	7 7/8	0.520

(table continues)

TABLE 3-10 VALUES OF L FOR PIPE SIZES ≥ NPS 48 AND < NPS 52 (CONT'D)

Depth, d, in.	Wall Thickness, t, in.								
	0.344	0.406	0.438	0.469	0.500	0.562	0.625	0.688	0.750
0.530	.....	.....	.....	.....	.....	.....	.....	3	3½
0.540	.....	.....	.....	.....	.....	.....	.....	2 15/16	3 7/16
0.550	.....	.....	.....	.....	.....	.....	.....	2 7/8	3 5/16
0.560	.....	.....	.....	.....	.....	.....	.....	.....	3¼
0.570	.....	.....	.....	.....	.....	.....	.....	.....	3 3/16
0.580	.....	.....	.....	.....	.....	.....	.....	.....	3⅛
0.590	.....	.....	.....	.....	.....	.....	.....	.....	3 1/16
0.600	.....	.....	.....	.....	.....	.....	.....	.....	3
0.610	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.620	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.630	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.640	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.650	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.660	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.670	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.680	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.690	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.700	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.710	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.720	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.730	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.740	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.750	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.760	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.770	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.780	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.790	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.800	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.810	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.820	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.830	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.840	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.850	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 3-10 VALUES OF *L* FOR PIPE SIZES ≥ NPS 48 AND < NPS 52 (CONT'D)

Wall Thickness, *t*, in.								Depth,
0.812	0.875	0.938	1.000	1.062	1.125	1.188	1.250	*d*, in.
3 15/16	4 7/16	4 15/16	5 1/2	6	6 9/16	7 1/8	7 3/4	0.530
3 7/8	4 3/8	4 7/8	5 3/8	5 7/8	6 7/16	7	7 9/16	0.540
3 13/16	4 1/4	4 3/4	5 1/4	5 13/16	6 5/16	6 7/8	7 7/16	0.550
3 3/4	4 3/16	4 11/16	5 3/16	5 11/16	6 3/16	6 3/4	7 5/16	0.560
3 5/8	4 1/8	4 5/8	5 1/16	5 9/16	6 1/16	6 5/8	7 3/16	0.570
3 9/16	4 1/16	4 1/2	5	5 1/2	6	6 1/2	7 1/16	0.580
3 1/2	3 15/16	4 7/16	4 7/8	5 3/8	5 7/8	6 3/8	6 15/16	0.590
3 7/16	3 7/8	4 3/8	4 13/16	5 1/4	5 3/4	6 1/4	6 13/16	0.600
3 3/8	3 13/16	4 1/4	4 3/4	5 3/16	5 11/16	6 3/16	6 11/16	0.610
3 5/16	3 3/4	4 3/16	4 5/8	5 1/8	5 9/16	6 1/16	6 9/16	0.620
3 1/4	3 11/16	4 1/8	4 9/16	5	5 1/2	5 15/16	6 7/16	0.630
3 3/16	3 5/8	4 1/16	4 1/2	4 15/16	5 3/8	5 7/8	6 3/8	0.640
. . . . .	3 9/16	4	4 7/16	4 7/8	5 5/16	5 3/4	6 1/4	0.650
. . . . .	3 1/2	3 15/16	4 5/16	4 3/4	5 1/4	5 11/16	6 1/8	0.660
. . . . .	3 7/16	3 7/8	4 1/4	4 11/16	5 1/8	5 5/8	6 1/16	0.670
. . . . .	3 3/8	3 13/16	4 3/16	4 5/8	. . . . .	. . . . .	. . . . .	0.680
. . . . .	3 5/16	3 3/4	4 1/8	4 9/16	. . . . .	. . . . .	. . . . .	0.690
. . . . .	3 1/4	3 11/16	4 1/16	4 1/2	. . . . .	. . . . .	. . . . .	0.700
. . . . .	. . . . .	3 5/8	4	4 7/16	. . . . .	. . . . .	. . . . .	0.710
. . . . .	. . . . .	3 9/16	3 15/16	4 5/16	. . . . .	. . . . .	. . . . .	0.720
. . . . .	. . . . .	3 1/2	3 7/8	4 1/4	. . . . .	. . . . .	. . . . .	0.730
. . . . .	. . . . .	3 7/16	3 13/16	4 3/16	. . . . .	. . . . .	. . . . .	0.740
. . . . .	. . . . .	3 3/8	3 3/4	4 1/8	. . . . .	. . . . .	. . . . .	0.750
. . . . .	. . . . .	. . . . .	3 11/16	4 1/16	. . . . .	. . . . .	. . . . .	0.760
. . . . .	. . . . .	. . . . .	3 5/8	4	. . . . .	. . . . .	. . . . .	0.770
. . . . .	. . . . .	. . . . .	3 9/16	3 15/16	. . . . .	. . . . .	. . . . .	0.780
. . . . .	. . . . .	. . . . .	3 9/16	3 15/16	. . . . .	. . . . .	. . . . .	0.790
. . . . .	. . . . .	. . . . .	3 1/2	3 7/8	. . . . .	. . . . .	. . . . .	0.800
. . . . .	. . . . .	. . . . .	. . . . .	3 13/16	. . . . .	. . . . .	. . . . .	0.810
. . . . .	. . . . .	. . . . .	. . . . .	3 3/4	. . . . .	. . . . .	. . . . .	0.820
. . . . .	. . . . .	. . . . .	. . . . .	3 11/16	. . . . .	. . . . .	. . . . .	0.830
. . . . .	. . . . .	. . . . .	. . . . .	3 5/8	. . . . .	. . . . .	. . . . .	0.840
. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	0.850

TABLE 3-11 VALUES OF L FOR PIPE SIZES ≥ NPS 52 AND < NPS 56

Depth, d, in.	Wall Thickness, t, in. 0.406	0.438	0.469	0.500	0.562	0.625	0.688	0.750
0.040	.....	.....	.....	.....	.....	.....	.....	.....
0.050	20 9/16	21 3/8	22 1/8	22 13/16	.....	.....	.....	.....
0.060	20 9/16	21 3/8	22 1/8	22 13/16	24 3/16	.....	.....	.....
0.070	20 9/16	21 3/8	22 1/8	22 13/16	24 3/16	25 9/16	26 13/16	.....
0.080	14 5/16	18 7/16	22 1/8	22 13/16	24 3/16	25 9/16	26 13/16	28
0.090	11	13 7/16	16 1/2	20 5/8	24 3/16	25 9/16	26 13/16	28
0.100	9 1/8	10 13/16	12 13/16	15 5/16	22 3/4	25 9/16	26 13/16	28
0.110	7 7/8	9 3/16	10 11/16	12 3/8	17 1/8	25	26 13/16	28
0.120	7	8 1/16	9 1/4	10 9/16	14	19	26 13/16	28
0.130	6 5/16	7 1/4	8 3/16	9 5/16	11 15/16	15 5/8	20 13/16	28
0.140	5 3/4	6 9/16	7 7/16	8 3/8	10 9/16	13 3/8	17 3/16	22 9/16
0.150	5 5/16	6 1/16	6 13/16	7 5/8	9 1/2	11 13/16	14 13/16	18 3/4
0.160	5	5 5/8	6 5/16	7	8 11/16	10 5/8	13 1/8	16 3/16
0.170	4 5/8	5 1/4	5 7/8	6 1/2	8	9 3/4	11 13/16	14 3/8
0.180	4 3/8	4 15/16	5 1/2	6 1/8	7 7/16	9	10 13/16	12 15/16
0.190	4 1/8	4 5/8	5 3/16	5 3/4	6 15/16	8 3/8	10	11 7/8
0.200	3 15/16	4 7/16	4 7/8	5 7/16	6 9/16	7 7/8	9 5/16	11
0.210	3 3/4	4 3/16	4 11/16	5 1/8	6 3/16	7 3/8	8 3/4	10 1/4
0.220	3 9/16	4	4 7/16	4 7/8	5 7/8	7	8 1/4	9 5/8
0.230	3 3/8	3 13/16	4 1/4	4 11/16	5 5/8	6 5/8	7 13/16	9 1/16
0.240	3 1/4	3 5/8	4 1/16	4 1/2	5 3/8	6 3/8	7 7/16	8 9/16
0.250	3 1/8	3 1/2	3 7/8	4 5/16	5 1/8	6 1/16	7 1/16	8 3/16
0.260	3	3 3/8	3 3/4	4 1/8	4 15/16	5 13/16	6 3/4	7 13/16
0.270	2 7/8	3 3/16	3 9/16	3 15/16	4 3/4	5 9/16	6 1/2	7 1/2
0.280	2 3/4	3 1/8	3 7/16	3 13/16	4 9/16	5 3/8	6 1/4	7 3/16
0.290	2 5/8	3	3 5/16	3 11/16	4 3/8	5 3/16	6	6 7/8
0.300	2 9/16	2 7/8	3 3/16	3 9/16	4 1/4	5	5 13/16	6 5/8
0.310	2 7/16	2 3/4	3 1/16	3 7/16	4 1/8	4 13/16	5 5/8	6 7/16
0.320	2 3/8	2 11/16	3	3 5/16	3 15/16	4 11/16	5 7/16	6 3/16
0.330	.....	2 9/16	2 7/8	3 3/16	3 13/16	4 1/2	5 1/4	6
0.340	.....	2 1/2	2 13/16	3 1/16	3 3/4	4 3/8	5 1/16	5 13/16
0.350	.....	2 3/8	2 11/16	3	3 5/8	4 1/4	4 15/16	5 5/8
0.360	.....	.....	2 5/8	2 7/8	3 1/2	4 1/8	4 13/16	5 1/2
0.370	.....	.....	2 1/2	2 13/16	3 3/8	4	4 11/16	5 5/16
0.380	.....	.....	.....	2 3/4	3 5/16	3 7/8	4 1/2	5 3/16
0.390	.....	.....	.....	2 5/8	3 3/16	3 13/16	4 7/16	5 1/16
0.400	.....	.....	.....	2 9/16	3 1/8	3 11/16	4 5/16	4 7/8
0.410	.....	.....	.....	.....	3	3 5/8	4 3/16	4 3/4
0.420	.....	.....	.....	.....	2 15/16	3 1/2	4 1/16	4 11/16
0.430	.....	.....	.....	.....	2 7/8	3 7/16	4	4 9/16
0.440	.....	.....	.....	.....	2 13/16	3 5/16	3 7/8	4 7/16
0.450	.....	.....	.....	.....	.....	3 1/4	3 13/16	4 5/16
0.460	.....	.....	.....	.....	.....	3 3/16	3 11/16	4 1/4
0.470	.....	.....	.....	.....	.....	3 1/16	3 5/8	4 1/8
0.480	.....	.....	.....	.....	.....	3	3 1/2	4 1/16
0.490	.....	.....	.....	.....	.....	2 15/16	3 7/16	3 15/16
0.500	.....	.....	.....	.....	.....	2 7/8	3 3/8	3 7/8
0.510	.....	.....	.....	.....	.....	.....	3 5/16	3 13/16
0.520	.....	.....	.....	.....	.....	.....	3 3/16	3 11/16
0.530	.....	.....	.....	.....	.....	.....	3 1/8	3 5/8

TABLE 3-11 VALUES OF *L* FOR PIPE SIZES ≥ NPS 52 AND < NPS 56

Wall Thickness, *t*, in.								Depth,
0.812	0.875	0.938	1.000	1.062	1.125	1.188	1.250	*d*, in.
.....	.....	.....	.....	.....	.....	.....	.....	0.040
.....	.....	.....	.....	.....	.....	.....	.....	0.050
.....	.....	.....	.....	.....	.....	.....	.....	0.060
.....	.....	.....	.....	.....	.....	.....	.....	0.070
.....	.....	.....	.....	.....	.....	.....	.....	0.080
29⅛	30¼	.....	.....	.....	.....	.....	.....	0.090
29⅛	30¼	31⅝	.....	.....	.....	.....	.....	0.100
29⅛	30¼	31⅝	32⅝	33⅝	.....	.....	.....	0.110
29⅛	30¼	31⅝	32⅝	33⅝	34¼	35⅜	.....	0.120
29⅛	30¼	31⅝	32⅝	33⅝	34¼	35⅜	36⅛	0.130
29⅛	30¼	31⅝	32⅝	33⅝	34¼	35⅜	36⅛	0.140
24⅜	30¼	31⅝	32⅝	33⅝	34¼	35⅜	36⅛	0.150
20⅜	25⅝	31⅝	32⅝	33⅝	34¼	35⅜	36⅛	0.160
17½	21¾	27⅝	32⅝	33⅝	34¼	35⅜	36⅛	0.170
15⅝	18⅝	23⅜	29⅜	33⅝	34¼	35⅜	36⅛	0.180
14⅛	16⅞	20⅝	24¾	30⅛	34¼	35⅜	36⅛	0.190
12⅝	15¼	18⅛	21⅝	26⅛	32⅝	35⅜	36⅛	0.200
11⅝	14	16⅞	19⅝	22⅝	27⅝	33⅞	36⅛	0.210
11⅜	12⅝	15⅛	17⅝	20½	24¼	29⅛	35⅝	0.220
10½	12⅛	14	16⅛	18⅛	21¾	25⅝	30⅜	0.230
9⅞	11⅜	13⅛	14⅝	17⅜	19⅜	23	26⅞	0.240
9⅜	10¾	12⅝	14	15⅝	18¼	20⅝	24⅜	0.250
8⅝	10⅜	11⅝	13⅜	14⅝	16⅝	19⅝	22⅛	0.260
8⅝	9⅛	11	12⅞	14⅛	15⅞	17⅝	20⅜	0.270
8⅜	9⅝	10½	11⅜	13¼	14⅝	16⅜	18⅝	0.280
7⅞	8⅞	10⅛	11¼	12⅝	14⅛	15⅞	17¾	0.290
7⅝	8⅝	9⅝	10¾	12	13⅞	15	16¾	0.300
7¼	8¼	9¼	10⅝	11½	12⅜	14¼	15⅜	0.310
7	7⅝	8⅞	9⅝	11⅛	12¼	13⅝	15⅛	0.320
6⅜	7⅛	8⅝	9⅝	10⅝	11¾	13	14⅜	0.330
6⅝	7⅞	8⅝	9¼	10¼	11⅝	12½	13¾	0.340
6⅜	7⅜	8	8⅝	9⅞	10⅞	12	13⅜	0.350
6⅜	6⅝	7¾	8⅝	9⅝	10½	11⅝	12⅛	0.360
6	6¼	7⅝	8⅜	9¼	10⅜	11⅜	12¼	0.370
5⅞	6⅝	7⅝	8⅛	8⅝	9⅞	10⅜	11⅜	0.380
5⅛	6⅜	7⅛	7⅞	8⅛	9⅝	10½	11⅞	0.390
5⅝	6¼	6⅝	7⅛	8⅞	9⅝	10⅜	11⅛	0.400
5⅜	6⅛	6¾	7½	8¼	9	9⅞	10¼	0.410
5¼	5⅝	6⅝	7¼	8	8⅜	9⅝	10⅞	0.420
5⅛	5¾	6⅞	7⅛	7⅜	8⅝	9⅜	10⅜	0.430
5	5⅝	6¼	6⅝	7⅝	8⅝	9⅛	9⅞	0.440
4⅞	5½	6⅛	6¾	7⅞	8⅛	8⅞	9⅝	0.450
4⅜	5⅜	6	6⅝	7¼	7⅝	8⅛	9⅞	0.460
4⅛	5¼	5⅞	6⅞	7⅛	7¾	8⅞	9⅜	0.470
4⅝	5⅛	5¾	6⅝	6⅝	7⅝	8¼	9	0.480
4½	5⅛	5⅝	6⅜	6⅜	7⅞	8⅛	8¾	0.490
4⅜	4⅝	5½	6⅛	6⅝	7¼	7⅝	8⅝	0.500
4⅝	4⅜	5⅜	5⅝	6½	7⅛	7¾	8⅜	0.510
4⅜	4¾	5¼	5⅜	6⅜	7	7⅝	8¼	0.520
4⅛	4⅝	5⅛	5⅛	6¼	6⅜	7⅞	8⅛	0.530

(table continues)

TABLE 3-11 VALUES OF L FOR PIPE SIZES ≥ NPS 52 AND < NPS 56 (CONT'D)

Depth, d, in.	Wall Thickness, t, in.							
	0.406	0.438	0.469	0.500	0.562	0.625	0.688	0.750
0.540	.....	.....	.....	.....	.....	.....	3 1/16	3 1/16
0.550	.....	.....	.....	.....	.....	.....	3	3 1/2
0.560	.....	.....	.....	.....	.....	.....	.....	3 3/8
0.570	.....	.....	.....	.....	.....	.....	.....	3 5/16
0.580	.....	.....	.....	.....	.....	.....	.....	3 1/4
0.590	.....	.....	.....	.....	.....	.....	.....	3 1/16
0.600	.....	.....	.....	.....	.....	.....	.....	3 1/8
0.610	.....	.....	.....	.....	.....	.....	.....	.....
0.620	.....	.....	.....	.....	.....	.....	.....	.....
0.630	.....	.....	.....	.....	.....	.....	.....	.....
0.640	.....	.....	.....	.....	.....	.....	.....	.....
0.650	.....	.....	.....	.....	.....	.....	.....	.....
0.660	.....	.....	.....	.....	.....	.....	.....	.....
0.670	.....	.....	.....	.....	.....	.....	.....	.....
0.680	.....	.....	.....	.....	.....	.....	.....	.....
0.690	.....	.....	.....	.....	.....	.....	.....	.....
0.700	.....	.....	.....	.....	.....	.....	.....	.....
0.710	.....	.....	.....	.....	.....	.....	.....	.....
0.720	.....	.....	.....	.....	.....	.....	.....	.....
0.730	.....	.....	.....	.....	.....	.....	.....	.....
0.740	.....	.....	.....	.....	.....	.....	.....	.....
0.750	.....	.....	.....	.....	.....	.....	.....	.....
0.760	.....	.....	.....	.....	.....	.....	.....	.....
0.770	.....	.....	.....	.....	.....	.....	.....	.....
0.780	.....	.....	.....	.....	.....	.....	.....	.....
0.790	.....	.....	.....	.....	.....	.....	.....	.....
0.800	.....	.....	.....	.....	.....	.....	.....	.....
0.810	.....	.....	.....	.....	.....	.....	.....	.....
0.820	.....	.....	.....	.....	.....	.....	.....	.....
0.830	.....	.....	.....	.....	.....	.....	.....	.....
0.840	.....	.....	.....	.....	.....	.....	.....	.....
0.850	.....	.....	.....	.....	.....	.....	.....	.....
0.860	.....	.....	.....	.....	.....	.....	.....	.....
0.870	.....	.....	.....	.....	.....	.....	.....	.....
0.880	.....	.....	.....	.....	.....	.....	.....	.....
0.890	.....	.....	.....	.....	.....	.....	.....	.....
0.900	.....	.....	.....	.....	.....	.....	.....	.....
0.910	.....	.....	.....	.....	.....	.....	.....	.....
0.920	.....	.....	.....	.....	.....	.....	.....	.....
0.930	.....	.....	.....	.....	.....	.....	.....	.....
0.940	.....	.....	.....	.....	.....	.....	.....	.....
0.950	.....	.....	.....	.....	.....	.....	.....	.....
0.960	.....	.....	.....	.....	.....	.....	.....	.....
0.970	.....	.....	.....	.....	.....	.....	.....	.....
0.980	.....	.....	.....	.....	.....	.....	.....	.....
0.990	.....	.....	.....	.....	.....	.....	.....	.....
1.000	.....	.....	.....	.....	.....	.....	.....	.....
1.010	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 3-11 VALUES OF L FOR PIPE SIZES ≥ NPS 52 AND < NPS 56 (CONT'D)

Wall Thickness, t, in.								Depth,
0.812	0.875	0.938	1.000	1.062	1.125	1.188	1.250	d, in.
4 1/16	4 9/16	5 1/16	5 9/16	6 1/8	6 11/16	7 5/16	7 7/8	0.540
3 15/16	4 7/16	4 15/16	5 1/2	6	6 9/16	7 1/8	7 3/4	0.550
3 7/8	4 3/8	4 7/8	5 3/8	5 7/8	6 7/16	7	7 5/8	0.560
3 13/16	4 5/16	4 13/16	5 5/16	5 13/16	6 5/16	6 7/8	7 7/16	0.570
3 3/4	4 3/16	4 11/16	5 3/16	5 11/16	6 1/4	6 3/4	7 5/16	0.580
3 11/16	4 1/8	4 5/8	5 1/8	5 9/16	6 1/8	6 5/8	7 3/16	0.590
3 9/16	4 1/16	4 1/2	5	5 1/2	6	6 9/16	7 1/16	0.600
3 1/2	4	4 7/16	4 15/16	5 3/8	5 7/8	6 7/16	6 15/16	0.610
3 7/16	3 7/8	4 3/8	4 13/16	5 5/16	5 13/16	6 5/16	6 13/16	0.620
3 3/8	3 13/16	4 5/16	4 3/4	5 1/4	5 11/16	6 3/16	6 11/16	0.630
3 5/16	3 3/4	4 3/16	4 11/16	5 1/8	5 5/8	6 1/8	6 5/8	0.640
.....	3 11/16	4 1/8	4 5/8	5 1/16	5 1/2	6	6 1/2	0.650
.....	3 5/8	4 1/16	4 1/2	4 15/16	5 7/16	5 15/16	6 3/8	0.660
.....	3 9/16	4	4 7/16	4 7/8	5 3/8	5 13/16	6 5/16	0.670
.....	3 1/2	3 15/16	4 3/8	4 13/16	5 1/4	5 3/4	6 3/16	0.680
.....	3 7/16	3 7/8	4 5/16	4 3/4	5 3/16	5 5/8	6 1/8	0.690
.....	3 3/8	3 13/16	4 1/4	4 11/16	5 1/8	5 9/16	6	0.700
.....	.....	3 3/4	4 3/16	4 9/16	5	5 1/2	5 15/16	0.710
.....	.....	3 11/16	4 1/8	4 1/2	4 15/16	5 3/8	5 13/16	0.720
.....	.....	3 5/8	4 1/16	4 7/16	4 7/8	5 5/16	5 3/4	0.730
.....	.....	3 9/16	4	4 3/8	4 13/16	5 1/4	5 11/16	0.740
.....	.....	3 1/2	3 15/16	4 5/16	4 3/4	5 3/16	5 5/8	0.750
.....	.....	.....	3 7/8	4 1/4	4 11/16	5 1/8	5 1/2	0.760
.....	.....	.....	3 13/16	4 3/16	4 5/8	5	5 7/16	0.770
.....	.....	.....	3 3/4	4 1/8	4 9/16	4 15/16	5 3/8	0.780
.....	.....	.....	3 11/16	4 1/16	4 1/2	4 7/8	5 5/16	0.790
.....	.....	.....	3 5/8	4	4 7/16	4 13/16	5 1/4	0.800
.....	.....	.....	.....	3 15/16	4 3/8	4 3/4	5 1/8	0.810
.....	.....	.....	.....	3 7/8	4 5/16	4 11/16	5 1/16	0.820
.....	.....	.....	.....	3 13/16	4 1/4	4 5/8	5	0.830
.....	.....	.....	.....	3 13/16	4 3/16	4 9/16	4 15/16	0.840
.....	.....	.....	.....	.....	4 1/8	4 1/2	4 7/8	0.850
.....	.....	.....	.....	.....	4 1/16	4 7/16	4 13/16	0.860
.....	.....	.....	.....	.....	4	4 3/8	4 3/4	0.870
.....	.....	.....	.....	.....	3 15/16	4 5/16	4 11/16	0.880
.....	.....	.....	.....	.....	3 7/8	4 1/4	4 5/8	0.890
.....	.....	.....	.....	.....	3 13/16	4 3/16	4 9/16	0.900
.....	.....	.....	.....	.....	.....	4 3/16	4 1/2	0.910
.....	.....	.....	.....	.....	.....	4 1/8	4 1/2	0.920
.....	.....	.....	.....	.....	.....	4 1/16	4 7/16	0.930
.....	.....	.....	.....	.....	.....	4	4 3/8	0.940
.....	.....	.....	.....	.....	.....	3 15/16	4 5/16	0.950
.....	.....	.....	.....	.....	.....	.....	4 1/4	0.960
.....	.....	.....	.....	.....	.....	.....	4 3/16	0.970
.....	.....	.....	.....	.....	.....	.....	4 1/8	0.980
.....	.....	.....	.....	.....	.....	.....	4 1/8	0.990
.....	.....	.....	.....	.....	.....	.....	4 1/16	1.000
.....	.....	.....	.....	.....	.....	.....	.....	1.010

TABLE 3-12 VALUES OF L FOR PIPE SIZES ≥ NPS 56 AND < NPS 60

Depth, d, in.	Wall Thickness, t, in. 0.406	0.438	0.469	0.500	0.562	0.625	0.688	0.750
0.040	.....	.....	.....	.....	.....	.....	.....	.....
0.050	21 3/8	22 3/16	22 15/16	23 11/16	.....	.....	.....	.....
0.060	21 3/8	22 3/16	22 15/16	23 11/16	25 1/8	.....	.....	.....
0.070	21 3/8	22 3/16	22 15/16	23 11/16	25 1/8	26 1/2	27 13/16	.....
0.080	14 13/16	19 1/8	22 15/16	23 11/16	25 1/8	26 1/2	27 13/16	29 1/16
0.090	11 7/16	13 15/16	17 1/16	21 7/16	25 1/8	26 1/2	27 13/16	29 1/16
0.100	9 1/2	11 1/4	13 5/16	15 7/8	23 5/8	26 1/2	27 13/16	29 1/16
0.110	8 3/16	9 9/16	11 1/16	12 7/8	17 3/4	25 15/16	27 13/16	29 1/16
0.120	7 1/4	8 3/8	9 9/16	11	14 1/2	19 11/16	27 13/16	29 1/16
0.130	6 9/16	7 1/2	8 1/2	9 11/16	12 7/16	16 3/16	21 5/8	29 1/16
0.140	6	6 13/16	7 11/16	8 11/16	10 15/16	13 7/8	17 7/8	23 3/8
0.150	5 9/16	6 1/4	7 1/16	7 7/8	9 7/8	12 1/4	15 3/8	19 7/16
0.160	5 3/16	5 13/16	6 1/2	7 5/16	9	11 1/16	13 5/8	16 13/16
0.170	4 13/16	5 7/16	6 1/16	6 3/4	8 5/16	10 1/8	12 1/4	14 7/8
0.180	4 9/16	5 1/8	5 11/16	6 5/16	7 11/16	9 5/16	11 1/4	13 7/16
0.190	4 5/16	4 13/16	5 3/8	5 15/16	7 1/4	8 11/16	10 3/8	12 5/16
0.200	4 1/16	4 9/16	5 1/16	5 5/8	6 13/16	8 1/8	9 11/16	11 3/8
0.210	3 7/8	4 3/8	4 13/16	5 5/16	6 7/16	7 11/16	9 1/16	10 5/8
0.220	3 11/16	4 1/8	4 5/8	5 1/16	6 1/8	7 1/4	8 9/16	9 15/16
0.230	3 1/2	3 15/16	4 3/8	4 7/8	5 13/16	6 7/8	8 1/8	9 7/16
0.240	3 3/8	3 13/16	4 3/16	4 5/8	5 9/16	6 9/16	7 11/16	8 15/16
0.250	3 1/4	3 5/8	4	4 7/16	5 5/16	6 5/16	7 3/8	8 1/2
0.260	3 1/16	3 1/2	3 7/8	4 1/4	5 1/8	6 1/16	7 1/16	8 1/8
0.270	2 15/16	3 5/16	3 11/16	4 1/8	4 15/16	5 13/16	6 3/4	7 3/4
0.280	2 7/8	3 3/16	3 9/16	3 15/16	4 3/4	5 9/16	6 1/2	7 7/16
0.290	2 3/4	3 1/16	3 7/16	3 13/16	4 9/16	5 3/8	6 1/4	7 3/16
0.300	2 5/8	3	3 5/16	3 11/16	4 3/8	5 3/16	6	6 7/8
0.310	2 9/16	2 7/8	3 3/16	3 9/16	4 1/4	5	5 13/16	6 5/8
0.320	2 7/16	2 3/4	3 1/8	3 7/16	4 1/8	4 7/8	5 5/8	6 7/16
0.330	.....	2 11/16	3	3 5/16	4	4 11/16	5 7/16	6 1/4
0.340	.....	2 9/16	2 7/8	3 3/16	3 7/8	4 9/16	5 1/4	6 1/16
0.350	.....	2 1/2	2 13/16	3 1/8	3 3/4	4 7/16	5 1/8	5 7/8
0.360	.....	.....	2 11/16	3	3 5/8	4 5/16	5	5 11/16
0.370	.....	.....	2 5/8	2 15/16	3 1/2	4 3/16	4 13/16	5 1/2
0.380	.....	.....	.....	2 13/16	3 7/16	4 1/16	4 11/16	5 3/8
0.390	.....	.....	.....	2 3/4	3 5/16	3 15/16	4 9/16	5 1/4
0.400	.....	.....	.....	2 11/16	3 1/4	3 13/16	4 7/16	5 1/16
0.410	.....	.....	.....	.....	3 1/8	3 3/4	4 5/16	4 15/16
0.420	.....	.....	.....	.....	3 1/16	3 5/8	4 1/4	4 13/16
0.430	.....	.....	.....	.....	3	3 9/16	4 1/8	4 3/4
0.440	.....	.....	.....	.....	2 7/8	3 7/16	4	4 5/8
0.450	.....	.....	.....	.....	.....	3 3/8	3 15/16	4 1/2
0.460	.....	.....	.....	.....	.....	3 1/4	3 13/16	4 3/8
0.470	.....	.....	.....	.....	.....	3 3/16	3 3/4	4 5/16
0.480	.....	.....	.....	.....	.....	3 1/8	3 11/16	4 3/16
0.490	.....	.....	.....	.....	.....	3 1/16	3 9/16	4 1/8
0.500	.....	.....	.....	.....	.....	3	3 1/2	4
0.510	.....	.....	.....	.....	.....	.....	3 7/16	3 15/16
0.520	.....	.....	.....	.....	.....	.....	3 5/16	3 7/8
0.530	.....	.....	.....	.....	.....	.....	3 1/4	3 3/4

TABLE 3-12 VALUES OF *L* FOR PIPE SIZES ≥ NPS 56 AND < NPS 60

Wall Thickness, *t*, in.								Depth, *d*, in.
0.812	0.875	0.938	1.000	1.062	1.125	1.188	1.250	
.....	.....	.....	.....	.....	.....	.....	.....	0.040
.....	.....	.....	.....	.....	.....	.....	.....	0.050
.....	.....	.....	.....	.....	.....	.....	.....	0.060
.....	.....	.....	.....	.....	.....	.....	.....	0.070
.....	.....	.....	.....	.....	.....	.....	.....	0.080
30 3/16	31 3/8	.....	.....	.....	.....	.....	.....	0.090
30 3/16	31 3/8	32 1/2	.....	.....	.....	.....	.....	0.100
30 3/16	31 3/8	32 1/2	33 1/2	34 9/16	.....	.....	.....	0.110
30 3/16	31 3/8	32 1/2	33 1/2	34 9/16	35 9/16	36 9/16	.....	0.120
30 3/16	31 3/8	32 1/2	33 1/2	34 9/16	35 9/16	36 9/16	37 1/2	0.130
30 3/16	31 3/8	32 1/2	33 1/2	34 9/16	35 9/16	36 9/16	37 1/2	0.140
25 1/8	31 3/8	32 1/2	33 1/2	34 9/16	35 9/16	36 9/16	37 1/2	0.150
21	26 15/16	32 1/2	33 1/2	34 9/16	35 9/16	36 9/16	37 1/2	0.160
18 3/16	22 9/16	28 1/16	33 1/2	34 9/16	35 9/16	36 9/16	37 1/2	0.170
16 3/16	19 5/8	24 3/16	30 5/16	34 9/16	35 9/16	36 9/16	37 1/2	0.180
14 5/8	17 1/2	21 1/16	25 11/16	31 7/8	35 9/16	36 9/16	37 1/2	0.190
13 3/8	15 13/16	18 13/16	22 7/16	27 1/8	33 9/16	36 9/16	37 1/2	0.200
12 3/8	14 1/2	17 1/16	20 1/16	23 3/4	28 5/8	35 3/16	37 1/2	0.210
11 9/16	13 7/16	15 5/8	18 3/16	21 5/16	25 3/16	30 1/8	36 5/8	0.220
10 7/8	12 9/16	14 1/2	16 3/4	19 3/8	22 9/16	26 9/16	31 9/16	0.230
10 1/4	11 13/16	13 9/16	15 1/2	17 13/16	20 9/16	23 7/8	27 7/8	0.240
9 3/4	11 1/8	12 3/4	14 1/2	16 9/16	18 15/16	21 3/4	25 1/16	0.250
9 1/4	10 9/16	12 1/16	13 11/16	15 1/2	17 5/8	20 1/16	22 7/8	0.260
8 7/8	10 1/16	11 7/16	12 15/16	14 9/16	16 1/2	18 5/8	21 1/8	0.270
8 1/2	9 5/8	10 7/8	12 1/4	13 3/4	15 1/2	17 7/16	19 5/8	0.280
8 1/8	9 1/4	10 7/16	11 11/16	13 1/16	14 11/16	16 7/16	18 7/16	0.290
7 13/16	8 7/8	10	11 3/16	12 1/2	13 15/16	15 9/16	17 3/8	0.300
7 9/16	8 9/16	9 9/16	10 11/16	11 15/16	13 5/16	14 13/16	16 7/16	0.310
7 5/16	8 1/4	9 1/4	10 5/16	11 7/16	12 3/4	14 1/8	15 5/8	0.320
7 1/16	7 15/16	8 7/8	9 15/16	11	12 3/16	13 1/2	14 15/16	0.330
6 13/16	7 11/16	8 5/8	9 9/16	10 5/8	11 3/4	12 15/16	14 5/16	0.340
6 5/8	7 7/16	8 5/16	9 1/4	10 1/4	11 5/16	12 1/2	13 11/16	0.350
6 7/16	7 1/4	8 1/16	8 15/16	9 7/8	10 15/16	12	13 3/16	0.360
6 1/4	7	7 13/16	8 11/16	9 9/16	10 9/16	11 5/8	12 11/16	0.370
6 1/16	6 13/16	7 5/8	8 7/16	9 5/16	10 1/4	11 1/4	12 5/16	0.380
5 15/16	6 5/8	7 3/8	8 3/16	9	9 15/16	10 7/8	11 7/8	0.390
5 3/4	6 7/16	7 3/16	7 15/16	8 3/4	9 5/8	10 9/16	11 1/2	0.400
5 5/8	6 5/16	7	7 3/4	8 1/2	9 3/8	10 1/4	11 3/16	0.410
5 7/16	6 1/8	6 13/16	7 9/16	8 5/16	9 1/8	9 15/16	10 7/8	0.420
5 5/16	6	6 11/16	7 3/8	8 1/8	8 7/8	9 11/16	10 9/16	0.430
5 3/16	5 7/8	6 1/2	7 3/16	7 7/8	8 5/8	9 7/16	10 1/4	0.440
5 1/16	5 11/16	6 3/8	7	7 11/16	8 7/16	9 3/16	10	0.450
5	5 9/16	6 3/16	6 7/8	7 9/16	8 1/4	9	9 3/4	0.460
4 7/8	5 7/16	6 1/16	6 11/16	7 3/8	8 1/16	8 13/16	9 9/16	0.470
4 3/4	5 5/16	5 15/16	6 9/16	7 3/16	7 7/8	8 9/16	9 5/16	0.480
4 5/8	5 1/4	5 13/16	6 7/16	7 1/16	7 11/16	8 3/8	9 1/8	0.490
4 9/16	5 1/8	5 11/16	6 5/16	6 7/8	7 9/16	3 3/16	8 7/8	0.500
4 7/16	5	5 9/16	6 3/16	6 3/4	7 3/8	8 1/16	8 11/16	0.510
4 3/8	4 15/16	5 7/16	6 1/16	6 5/8	7 1/4	7 7/8	8 9/16	0.520
4 1/4	4 13/16	5 3/8	5 15/16	6 1/2	7 1/8	7 3/4	8 3/8	0.530

(table continues)

TABLE 3-12 VALUES OF *L* FOR PIPE SIZES ≥ NPS 56 AND < NPS 60 (CONT'D)

Depth, *d*, in.	Wall Thickness, *t*, in.							
	0.406	0.438	0.469	0.500	0.562	0.625	0.688	0.750
0.540	.....	.....	.....	.....	.....	.....	3 3/16	3 11/16
0.550	.....	.....	.....	.....	.....	.....	3 1/8	3 5/8
0.560	.....	.....	.....	.....	.....	.....	.....	3 9/16
0.570	.....	.....	.....	.....	.....	.....	.....	3 7/16
0.580	.....	.....	.....	.....	.....	.....	.....	3 3/8
0.590	.....	.....	.....	.....	.....	.....	.....	3 5/16
0.600	.....	.....	.....	.....	.....	.....	.....	3 1/4
0.610	.....	.....	.....	.....	.....	.....	.....	.....
0.620	.....	.....	.....	.....	.....	.....	.....	.....
0.630	.....	.....	.....	.....	.....	.....	.....	.....
0.640	.....	.....	.....	.....	.....	.....	.....	.....
0.650	.....	.....	.....	.....	.....	.....	.....	.....
0.660	.....	.....	.....	.....	.....	.....	.....	.....
0.670	.....	.....	.....	.....	.....	.....	.....	.....
0.680	.....	.....	.....	.....	.....	.....	.....	.....
0.690	.....	.....	.....	.....	.....	.....	.....	.....
0.700	.....	.....	.....	.....	.....	.....	.....	.....
0.710	.....	.....	.....	.....	.....	.....	.....	.....
0.720	.....	.....	.....	.....	.....	.....	.....	.....
0.730	.....	.....	.....	.....	.....	.....	.....	.....
0.740	.....	.....	.....	.....	.....	.....	.....	.....
0.750	.....	.....	.....	.....	.....	.....	.....	.....
0.760	.....	.....	.....	.....	.....	.....	.....	.....
0.770	.....	.....	.....	.....	.....	.....	.....	.....
0.780	.....	.....	.....	.....	.....	.....	.....	.....
0.790	.....	.....	.....	.....	.....	.....	.....	.....
0.800	.....	.....	.....	.....	.....	.....	.....	.....
0.810	.....	.....	.....	.....	.....	.....	.....	.....
0.820	.....	.....	.....	.....	.....	.....	.....	.....
0.830	.....	.....	.....	.....	.....	.....	.....	.....
0.840	.....	.....	.....	.....	.....	.....	.....	.....
0.850	.....	.....	.....	.....	.....	.....	.....	.....
0.860	.....	.....	.....	.....	.....	.....	.....	.....
0.870	.....	.....	.....	.....	.....	.....	.....	.....
0.880	.....	.....	.....	.....	.....	.....	.....	.....
0.890	.....	.....	.....	.....	.....	.....	.....	.....
0.900	.....	.....	.....	.....	.....	.....	.....	.....
0.910	.....	.....	.....	.....	.....	.....	.....	.....
0.920	.....	.....	.....	.....	.....	.....	.....	.....
0.930	.....	.....	.....	.....	.....	.....	.....	.....
0.940	.....	.....	.....	.....	.....	.....	.....	.....
0.950	.....	.....	.....	.....	.....	.....	.....	.....
0.960	.....	.....	.....	.....	.....	.....	.....	.....
0.970	.....	.....	.....	.....	.....	.....	.....	.....
0.980	.....	.....	.....	.....	.....	.....	.....	.....
0.990	.....	.....	.....	.....	.....	.....	.....	.....
1.000	.....	.....	.....	.....	.....	.....	.....	.....
1.010	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 3-12 VALUES OF *L* FOR PIPE SIZES ≥ NPS 56 AND < NPS 60 (CONT'D)

Wall Thickness, *t*, in.								Depth,
0.812	0.875	0.938	1.000	1.062	1.125	1.188	1.250	*d*, in.
4 3/16	4 11/16	5 1/4	5 13/16	6 3/8	6 15/16	7 9/16	8 3/16	0.540
4 1/8	4 5/8	5 1/8	5 11/16	6 1/4	6 13/16	7 7/16	8 1/16	0.550
4	4 9/16	5 1/16	5 9/16	6 1/8	6 11/16	7 5/16	7 7/8	0.560
3 15/16	4 7/16	4 15/16	5 1/2	6	6 9/16	7 1/8	7 3/4	0.570
3 7/8	4 3/8	4 7/8	5 3/8	5 15/16	6 7/16	7	7 5/8	0.580
3 13/16	4 5/16	4 13/16	5 5/16	5 13/16	6 3/8	6 7/8	7 7/16	0.590
3 3/4	4 3/16	4 11/16	5 3/16	5 11/16	6 1/4	6 3/4	7 5/16	0.600
3 5/8	4 1/8	4 5/8	5 1/8	5 5/8	6 1/8	6 11/16	7 3/16	0.610
3 9/16	4 1/16	4 9/16	5	5 1/2	6	6 9/16	7 1/16	0.620
3 1/2	4	4 7/16	4 15/16	5 7/16	5 15/16	6 7/16	7	0.630
3 7/16	3 15/16	4 3/8	4 7/8	5 5/16	5 13/16	6 5/16	6 7/8	0.640
.....	3 13/16	4 5/16	4 3/4	5 1/4	5 3/4	6 1/4	6 3/4	0.650
.....	3 3/4	4 1/4	4 11/16	5 1/8	5 5/8	6 1/8	6 5/8	0.660
.....	3 11/16	4 3/16	4 5/8	5 1/16	5 9/16	6 1/16	6 9/16	0.670
.....	3 5/8	4 1/16	4 9/16	5	5 7/16	5 15/16	6 7/16	0.680
.....	3 9/16	4	4 7/16	4 15/16	5 3/8	5 7/8	6 5/16	0.690
.....	3 1/2	3 15/16	4 3/8	4 13/16	5 5/16	5 3/4	6 1/4	0.700
.....	.....	3 7/8	4 5/16	4 3/4	5 1/4	5 11/16	6 1/8	0.710
.....	.....	3 13/16	4 1/4	4 11/16	5 1/8	5 5/8	6 1/16	0.720
.....	.....	3 3/4	4 3/16	4 5/8	5 1/16	5 1/2	6	0.730
.....	.....	3 11/16	4 1/8	4 9/16	5	5 7/16	5 7/8	0.740
.....	.....	3 5/8	4 1/16	4 1/2	4 15/16	5 3/8	5 13/16	0.750
.....	.....	.....	4	4 7/16	4 7/8	5 5/16	5 3/4	0.760
.....	.....	.....	3 15/16	4 3/8	4 3/4	5 3/16	5 5/8	0.770
.....	.....	.....	3 7/8	4 5/16	4 11/16	5 1/8	5 9/16	0.780
.....	.....	.....	3 13/16	4 1/4	4 5/8	5 1/16	5 1/2	0.790
.....	.....	.....	3 3/4	4 3/16	4 9/16	5	5 7/16	0.800
.....	.....	.....	.....	4 1/8	4 1/2	4 15/16	5 3/8	0.810
.....	.....	.....	.....	4 1/16	4 7/16	4 7/8	5 1/4	0.820
.....	.....	.....	.....	4	4 3/8	4 13/16	5 3/16	0.830
.....	.....	.....	.....	3 15/16	4 5/16	4 3/4	5 1/8	0.840
.....	.....	.....	.....	.....	4 1/4	4 11/16	5 1/16	0.850
.....	.....	.....	.....	.....	4 3/16	4 5/8	5	0.860
.....	.....	.....	.....	.....	4 1/8	4 9/16	4 15/16	0.870
.....	.....	.....	.....	.....	4 1/8	4 1/2	4 7/8	0.880
.....	.....	.....	.....	.....	4 1/16	4 7/16	4 13/16	0.890
.....	.....	.....	.....	.....	4	4 3/8	4 3/4	0.900
.....	.....	.....	.....	.....	.....	4 5/16	4 11/16	0.910
.....	.....	.....	.....	.....	.....	4 1/4	4 5/8	0.920
.....	.....	.....	.....	.....	.....	4 3/16	4 9/16	0.930
.....	.....	.....	.....	.....	.....	4 1/8	4 1/2	0.940
.....	.....	.....	.....	.....	.....	4 1/8	4 7/16	0.950
.....	.....	.....	.....	.....	.....	.....	4 7/16	0.960
.....	.....	.....	.....	.....	.....	.....	4 3/8	0.970
.....	.....	.....	.....	.....	.....	.....	4 5/16	0.980
.....	.....	.....	.....	.....	.....	.....	4 1/4	0.990
.....	.....	.....	.....	.....	.....	.....	4 3/16	1.000
.....	.....	.....	.....	.....	.....	.....	.....	1.010

This page intentionally left blank.

PART 4
EVALUATION OF MAOP IN CORRODED AREAS

4.1 COMPUTATION OF *A*

If the measured maximum depth of the corroded area is greater than 10% of the nominal wall thickness but less than 80% of the nominal wall thickness and the measured longitudinal extent of the corroded area is greater than the value determined by Eq. (2) of Part 2, calculate

$$A = 0.893\left(\frac{L_m}{\sqrt{Dt}}\right)$$

where

L_m = measured longitudinal extent of the corroded area, in.
D = nominal outside diameter of the pipe, in.
t = nominal wall thickness of the pipe, in. Additional wall thickness required for concurrent external loads shall not be included in the calculations.

4.2 COMPUTATION OF *P'*

(a) For Values of A Less Than or Equal to 4.0. A and d/t determine a unique point on Fig. 4-1 corresponding to an acceptable pressure level P'. P' is obtained by interpolation between the curves for P, $0.95P$, $0.90P$, $0.85P$, $0.80P$, $0.75P$, $0.70P$, $0.65P$, $0.60P$.

d = measured maximum depth of corroded area, in.
P' = the safe maximum pressure for the corroded area. Curves for various values of P' are given in Fig. 4-1 per

$$P' = 1.1P\left[\frac{1 - \frac{2}{3}\left(\frac{d}{t}\right)}{1 - \frac{2}{3}\left(\frac{d}{t\sqrt{A^2 + 1}}\right)}\right]$$

except that P' may not exceed P.

P = the greater of either the established MAOP or

$$P = 2StFT/D$$

where

S = specified minimum yield strength (SMYS), psi

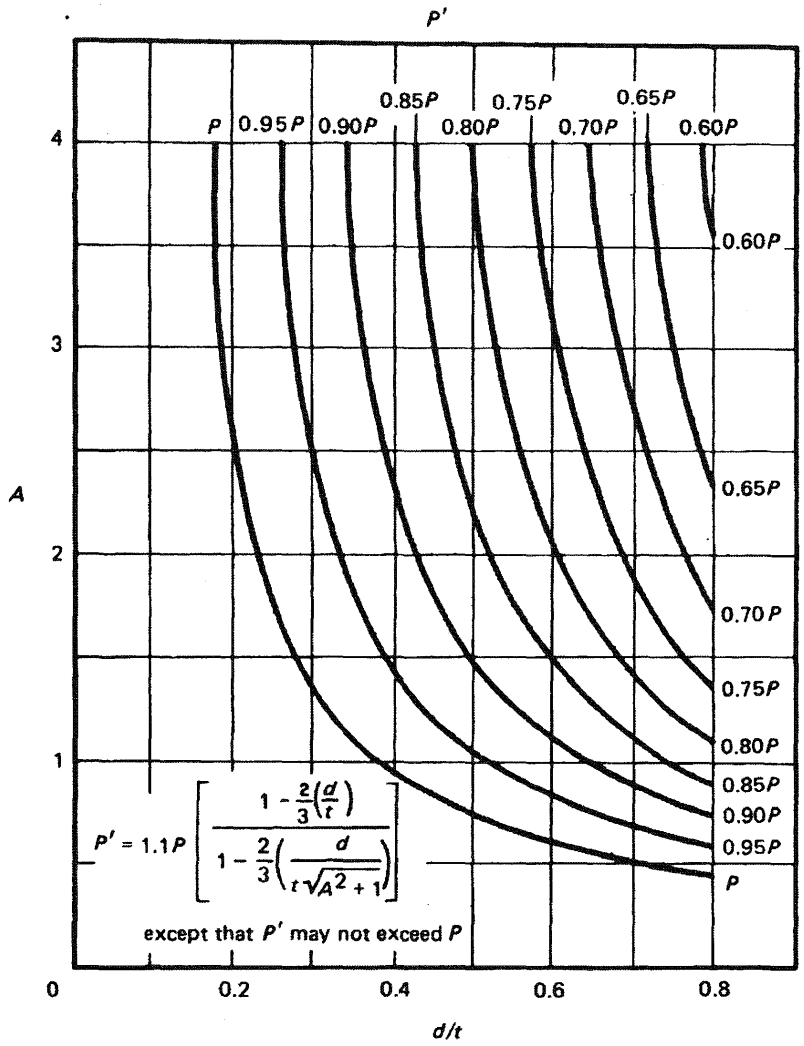

FIG. 4-1 CURVE FOR OBTAINING *P'* AS A FUNCTION OF *d/t* FOR VALUES OF *A* LESS THAN OR EQUAL TO 4.0

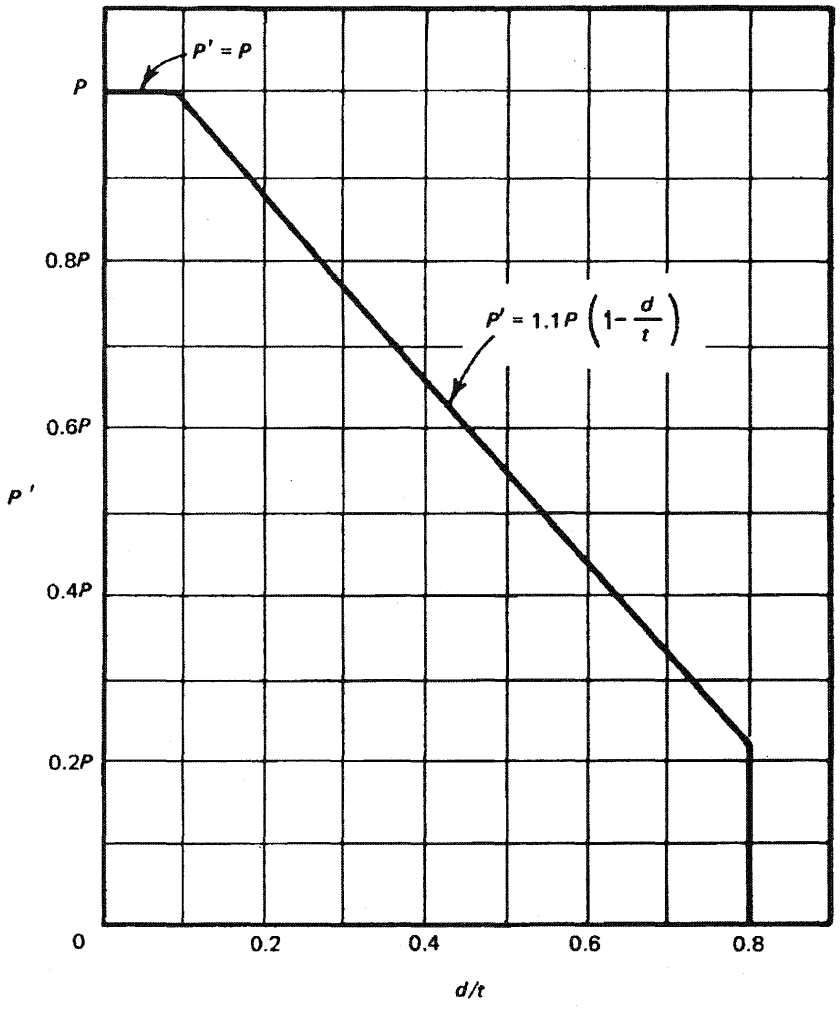

FIG. 4-2 P' AS A FUNCTION OF d/t FOR VALUES OF A GREATER THAN 4.0

F = appropriate design factor from ASME B31.4, ASME B31.8, or ASME B31.11

T = temperature derating factor from the appropriate B31 Code (if none listed, $T = 1$)

D = nominal outside diameter of the pipe, in.

t = nominal wall thickness of the pipe, in. Additional wall thickness required for concurrent external loads shall not be included in the calculations.

(b) For Values of A Greater Than 4.0

P' = the safe maximum pressure for the corroded area. Curves for various values of P' are given in Fig. 4-2 per

$$P' = 1.1P\left[1 - \frac{d}{t}\right]$$

except that P' may not exceed P.

4.3 MAOP AND P'

If the established MAOP is equal to or less than P', the corroded region may be used for service at that MAOP. If it is greater than P', then a lower MAOP should be established not to exceed P', or the corroded region should be repaired or replaced.

APPENDIX A
BASIC Computer Program, CRVL.BAS, for Determining Allowable Length *L* (Part 2) or Alternative Maximum Allowable Operating Pressure (Part 4)

Enter program and input as indicated. The examples should be used to verify correct entry of the program.

PROGRAM LISTING FOR CRVL.BAS BY R.L.SEIFERT

```
10 'PROGRAM WRITTEN BY R.L.SEIFERT, TENNESSEE GAS PIPELINE COMPANY,IN MICROSOFT
BASIC AND OPERABLE ON VARIOUS PERSONAL COMPUTERS, FEBRUARY 6, 1982, MODIFIED SEP
TEMBER 1984.
20 'EVALUATE EXTERNALLY CORRODED HIGH PRESSURE GAS PIPING TO DETERMINE THE MAXIM
UM PRESSURE THAT IT CAN SAFELY CONTAIN.
25 'THIS SYSTEM WAS DEVELOPED AT BATTELLE MEMORIAL INSTITUTE, COLUMBUS OHIO.
26 '***** PLEASE NOTE, THAT IF THE CORRODED SURFACE AREA EXTENDS ONTO OR ACROSS
A WELD, THEN THIS METHOD IS NOT VALID.  THE CORROSION MUST THEN BE EVALUATED BY
COMPANY-DESIGNATED SPECIALISTS.*****
30 'COMPUTER WILL DISPLAY AN "ILLEGAL FUNCTION ERROR" IF MAOP IS SET HIGHER THAN
 1.1 X P, BECAUSE AN ATTEMPT TO FIND THE SQUARE ROOT OF A NEGATIVE NUMBER WILL R
ESULT.  IN PRACTICE, THE MAOP WOULD NEVER BE SET THAT HIGH.
40 ' IF MAOP IS SET SLIGHTLY BELOW 1.1 X P, AND CORROSION DEPTH IS ALMOST 10% OF
 WALL THICKNESS, COMPUTER MAY CALL FOR A REDUCTION OF PRESSURE, BUT IT WILL ALSO
 STATE THAT THERE IS NO RESTRICTION OF OPERATION DUE TO d < .1t.
50 'MAOP IS NEVER SET THAT HIGH IN PRACTICE, SO THIS SHOULD BE NO PROBLEM.  THE
10% ALLOWABLE DEPTH WITH NO OPERATING RESTRICTIONS SHOULD APPLY.
60 'IF DEPTH OR LENGTH ARE SET TO ZERO, A RESPECTIVE SAFE LENGTH OR SAFE DEPTH W
ILL BE DETERMINED, EVEN THOUGH THAT IS AN IMPOSSIBILITY.  REGARD THE ZEROS AS IN
FINITESIMALS RATHER THAN ZEROS. (0 = .000001, FOR EXAMPLE)
70 'IF CORROSION DEPTH (d) IS ENTERED >1.5 X WALL THICKNESS (t), THEN THE EXPRES
SION (2/3 X (t/d) WILL BE =>1.  THIS WILL CAUSE A "DIVISION BY ZERO" ERROR IN TH
E CALCULATIONS.  DEPTH OF CORROSION CAN NEVER BE > WALL THICKNESS ANYWAY.
72 SCREEN 0,0,0:WIDTH 80:COLOR 14,1,0
75 DEFDBL A-Z
80 CLS:INPUT"MAXIMUM ALLOWABLE PRESSURE (MAOP) #/Sq.In.              ";M
90 INPUT"ENTER OUTSIDE DIAMETER OF PIPE (D) Inches               ";D
100 INPUT"ENTER PIPE WALL THICKNESS (t) Inch(es)                  ";T
110 INPUT"ENTER STRENGTH OF STEEL (SMYS) Lbs/sq.in.               ";S
120 INPUT"ENTER DESIGN FACTOR (F) (.72,.60,.50,.40)               ";F
130 INPUT"ENTER MAXIMUM CORROSION DEPTH (d)  Inch                 ";DE
140 INPUT"MAX.LONGITDNAL.LGTH OF CORRODED AREA (L) Inches         ";L
150 PRINT:IF DE>.8*T THEN INPUT"DEPTH OF CORROSION EXCEEDS 80% OF PIPEWALL. PIPE
 MUST BE REPLACED.                PRESS <ENTER> FOR FURTHER EVALUATION.";EN
160 IF DE=<.1*T THEN INPUT"CORROSION DEPTH IS LESS THAN 10% OF PIPE WALL. NO RES
TRICTIONS ON OPERATION.     PRESS <ENTER> FOR FURTHER EVALUATION.";EN
170 P=INT((2*S*T*F/D)+.5):A=(.893*L)/(D*T)^.5:A=(INT(1000*A))*.001
180 IF A<=4 THEN PS=INT(1.1*P*((1-((2*DE)/(3*T)))/(1-((2/3)*(DE/(T*(A^2+1)^.5)))
))+.5)
190 IF A>4 THEN PS=INT(1.1*P*(1-(DE/T))+.5)
195 IF PS>P THEN PS=P
200 CLS:PRINT"                          -- INPUTTED DATA --"
210 PRINT"PIPE DIAMETER (D)="D"In.";TAB(30)"DESIGN FACTOR(F)="F
220 PRINT"WALL THICKNESS(t) ="T"In.";TAB(30)"MAX.COR.DPTH(d) ="DE"In.
230 PRINT"SMYS     ="S"PSI";TAB(30)"MAX.COR.LGTH(L) ="L"In.
240 PRINT"                         MAOP  ="M"PSI
250 PRINT"                       -- CALCULATED DATA --"
260 PRINT"                  INTERMEDIATE FACTOR (A)= ";:PRINT USING "##.###";(INT(10
00*A))*.001
270 PRINT"DESIGN PRESS.(P)="P"PSI";TAB(30)"SAFE PRESS.(P') ="PS"PSI"
```

** LISTING CONTINUES **

PROGRAM LISTING FOR CRVL.BAS BY R.L.SEIFERT - CONTINUED

```
280 IF DE>.8*T THEN PRINT"REPAIR OR REPLACE PIPE BECAUSE CORROSION DEPTH EXC
EEDS .8t."
290 IF PS=>M THEN PRINT"PIPE MAY BE OPERATED SAFELY AT MAOP,"M"PSI"
300 IF M>P THEN PRINT"MAOP EXCEEDS DESIGN PRESSURE (P). VERIFY THAT THIS VAR
IANCE IS VALID."
310 IF M>PS THEN PRINT"REDUCE OPERATING PRESSURE SO IT WILL NOT EXCEED"PS"PS
I, SO THAT PIPE":PRINT"WILL OPERATE LEGALLY AND SAFELY."
330 IF A=<4 THEN DP=((M-(1.1*P))*((3*T)*((A^2+1)^.5)))/(2*(M-((1.1*P)*((A^2+
1)^.5)))):DP=(INT(1000*DP))*.001
340 IF DP>.8*T THEN DP=.8*T
350 IF A=<4 THEN PRINT"WITH CORR.LNGTH."L"In., MAX. DEPTH IS ";:PRINT USING
"#.####";(INT((1000*DP)+.5))*.001;:PRINT" Inch.  A = ";:PRINT USING "##.###"
;(INT((A*1000)+.5))*.001
360 IF A>4 THEN DP=((M/(1.1*P))-1)*(-T)
370 IF DP>.8*T THEN DP=.8*T
380 IF A>4 THEN PRINT"WITH CORR.LNGTH."L"In., MAX.DEPTH IS ";:PRINT USING "#
.####";(INT((1000*DP)+.5))*.001;:PRINT" Inch.  A = ";:PRINT USING"###.###";(
INT((A*1000)+.5))*.001
390 AP=5:PS=INT(1.1*P*(1-(DE/T))+.5):IF PS>P THEN PS=P
400 IF M>PS THEN 420
410 PRINT"WITH CORR.DEPTH"DE"In., MAX. LENGTH IS INFINITY.  A = ";:PRINT USI
NG "###.###";AP: GOSUB 530:GOTO 470
420 J=(2*DE)/(3*T):AP=(((J/(1-(((1.1*P)*(1-J))/M)))^2)-1)^.5:AP=INT((1000*AP
)+.5)*.001:PS=INT(1.1*P*((1-J)/(1-((2/3)*(DE/(T*AP^2+1)^.5))))+.5):LP=INT((1
000*((D*T)^.5)*1.12*AP))*.001:IF PS>P THEN PS=P
430 IF PS>M OR AP>4 THEN 450
440 PRINT"WITH CORR.DEPTH"DE"In., MAX. LENGTH IS ";:PRINT USING "###.###";IN
T(1000*((D*T)^.5)*1.12*AP)*.001;:PRINT" In. A = ";:PRINT USING"###.###";(INT
(AP*1000))*.001:GOSUB 530:GOTO 470
450 AP=4:PS=1.1*P*((1-((2*DE)/(3*T)))/(1-((2/3)*(DE/(T*(AP^2+1)^.5)))));PS=I
NT(PS+.5):IF PS>P THEN PS=P
460 GOTO 440
470 PRINT:INPUT"PRESS <1> FOR MORE CORROSION EVALUATIONS ON SAME PIPE,
                  OR <2> FOR CORROSION EVALUATIONS ON DIFFERENT PIPE.";
EN:IF EN<>1 THEN 20
480 CLS:PRINT"MAXIMUM ALLOWABLE OPERATING PRESSURE (MAOP) =  "M"#/sq.in.
490 PRINT"OUTSIDE DIAMETER OF PIPE (D) =                    ";D"Inches
500 PRINT"PIPE WALL THICKNESS (t) =                         ";T"Inch
510 PRINT"SPECIFIED MIN.YIELD STRENGTH OF PIPE (SMYS) =   "S"#/sq.in.
520 PRINT"DESIGN FACTOR (F) =                              ";F:GOTO 130
530 IF DE>.8*T THEN PRINT"!!! BUT"DE"Inch EXCEEDS ALLOWABLE CORROSION DEPTH
!!!"
540 RETURN
```

END OF PROGRAM LISTING

```
FOLLOWING ARE SOME EXAMPLES OF THE USE OF THE COMPUTER PROGRAM 'CRVL.BAS' BY
R.L.SEIFERT, TENNESSEE GAS PIPELINE COMPANY.

THE PROGRAM PROMPTS THE USER ONE LINE AT A TIME FOR INPUT AS FOLLOWS:

EXAMPLE #1


MAXIMUM ALLOWABLE PRESSURE (MAOP) #/Sq.In.            ? 910
ENTER OUTSIDE DIAMETER OF PIPE (D) Inches             ? 30
ENTER PIPE WALL THICKNESS (t) Inch(es)                ? .438
ENTER STRENGTH OF STEEL (SMYS) Lbs/sq.in.             ? 52000
ENTER DESIGN FACTOR (F) (.72,.60,.50,.40)             ? .72
ENTER MAXIMUM CORROSION DEPTH (d)  Inch               ? .1
MAX.LONGITDNAL.LGTH OF CORRODED AREA (L) Inches       ? 7.5

AFTER THE USER HAS INPUTTED THE 7.5 IN THE LAST LINE  (ABOVE), HE PRESSES THE
<ENTER> KEY AND THE FOLLOWING READOUT RESULTS:


                    -- INPUTTED DATA --
PIPE DIAMETER (D)= 30 In.     DESIGN FACTOR(F)= .72
WALL THICKNESS(t) = .438 In.  MAX.COR.DPTH(d) = .1 In.
SMYS     = 52000 PSI          MAX.COR.LGTH(L) = 7.5 In.
                     MAOP  = 910 PSI
                    -- CALCULATED DATA --
               INTERMEDIATE FACTOR (A)=  1.847
DESIGN PRESS.(P)= 1093 PSI    SAFE PRESS.(P') = 1093 PSI
PIPE MAY BE OPERATED SAFELY AT MAOP, 910 PSI
WITH CORR.LNGTH. 7.5 In., MAX. DEPTH IS 0.2490 Inch.  A =  1.847
WITH CORR.DEPTH .1 In., MAX. LENGTH IS INFINITY.  A =   5.000

PRESS <1> FOR MORE CORROSION EVALUATIONS ON SAME PIPE,
   OR <2> FOR CORROSION EVALUATIONS ON DIFFERENT PIPE.?

FOLLOWING ARE MORE EXAMPLES OF PRINTOUTS OF VARIOUS CORROSION EVALUATIONS, SEV-
ERAL OF WHICH REQUIRE REDUCTION OF PRESSURE, OR REPAIR, TO ALLOW RESUMPTION OF
PIPELINE OPERATION.

EXAMPLE #2

                    -- INPUTTED DATA --
PIPE DIAMETER (D)= 20 In.     DESIGN FACTOR(F)= .5
WALL THICKNESS(t) = .25 In.   MAX.COR.DPTH(d) = .18 In.
SMYS     = 35000 PSI          MAX.COR.LGTH(L) = 10 In.
                     MAOP  = 400 PSI
                    -- CALCULATED DATA --
               INTERMEDIATE FACTOR (A)=  3.993
DESIGN PRESS.(P)= 438 PSI     SAFE PRESS.(P') = 284 PSI
REDUCE OPERATING PRESSURE SO IT WILL NOT EXCEED 284 PSI, SO THAT PIPE
WILL OPERATE LEGALLY AND SAFELY.
WITH CORR.LNGTH. 10 In., MAX. DEPTH IS 0.0790 Inch.  A =  3.993
WITH CORR.DEPTH .18 In., MAX. LENGTH IS   2.018 In. A =   0.806

PRESS <1> FOR MORE CORROSION EVALUATIONS ON SAME PIPE,
   OR <2> FOR CORROSION EVALUATIONS ON DIFFERENT PIPE.?
```

```
EXAMPLE #3          -- INPUTTED DATA --
PIPE DIAMETER (D)= 24 In.     DESIGN FACTOR(F)= .72
WALL THICKNESS(t) = .432 In. MAX.COR.DPTH(d) = .13 In.
SMYS     = 52000 PSI          MAX.COR.LGTH(L) = 30 In.
                    MAOP  = 910 PSI
                    -- CALCULATED DATA --
               INTERMEDIATE FACTOR (A)=  8.320
DESIGN PRESS.(P)= 1348 PSI    SAFE PRESS.(P') = 1037 PSI
PIPE MAY BE OPERATED SAFELY AT MAOP, 910 PSI
WITH CORR.LNGTH. 30 In., MAX.DEPTH IS 0.167 Inch.  A =   8.320
WITH CORR.DEPTH .13 In., MAX. LENGTH IS INFINITY.  A =   5.000

PRESS <1> FOR MORE CORROSION EVALUATIONS ON SAME PIPE,
   OR <2> FOR CORROSION EVALUATIONS ON DIFFERENT PIPE.?

EXAMPLE #4          -- INPUTTED DATA --
PIPE DIAMETER (D)= 24 In.     DESIGN FACTOR(F)= .72
WALL THICKNESS(t) = .432 In. MAX.COR.DPTH(d) = .3 In.
SMYS     = 52000 PSI          MAX.COR.LGTH(L) = 30 In.
                    MAOP  = 910 PSI
                    -- CALCULATED DATA --
               INTERMEDIATE FACTOR (A)=  8.320
DESIGN PRESS.(P)= 1348 PSI    SAFE PRESS.(P') = 453 PSI
REDUCE OPERATING PRESSURE SO IT WILL NOT EXCEED 453
PSI,          SO THAT PIPE WILL OPERATE LEGALLY AND SAFELY.
WITH CORR.LNGTH. 30 In., MAX.DEPTH IS 0.167 Inch.  A =   8.320
WITH CORR.DEPTH .3 In., MAX. LENGTH IS  12.867 In. A =   3.568

PRESS <1> FOR MORE CORROSION EVALUATIONS ON SAME PIPE,
   OR <2> FOR CORROSION EVALUATIONS ON DIFFERENT PIPE.?


EXAMPLE #5

                    -- INPUTTED DATA --
PIPE DIAMETER (D)= 24 In.     DESIGN FACTOR(F)= .72
WALL THICKNESS(t) = .281 In. MAX.COR.DPTH(d) = .08 In.
SMYS     = 52000 PSI          MAX.COR.LGTH(L) = 15 In.
                    MAOP  = 731 PSI
                    -- CALCULATED DATA --
               INTERMEDIATE FACTOR (A)=  5.158
DESIGN PRESS.(P)= 877 PSI     SAFE PRESS.(P') = 690 PSI
REDUCE OPERATING PRESSURE SO IT WILL NOT EXCEED 690
PSI,          SO THAT PIPE WILL OPERATE LEGALLY AND SAFELY.
WITH CORR.LNGTH. 15 In., MAX.DEPTH IS 0.068 Inch.  A =   5.158
WITH CORR.DEPTH .08 In., MAX. LENGTH IS  11.634 In. A =   4.000

PRESS <1> FOR MORE CORROSION EVALUATIONS ON SAME PIPE,
   OR <2> FOR CORROSION EVALUATIONS ON DIFFERENT PIPE.?
```

```
EXAMPLE #6
MAXIMUM ALLOWABLE PRESSURE (MAOP) #/Sq.In.              ? 1000
ENTER OUTSIDE DIAMETER OF PIPE (D) Inches               ? 36
ENTER PIPE WALL THICKNESS (t) Inch(es)                  ? .5
ENTER STRENGTH OF STEEL (SMYS) Lbs/sq.in.               ? 52000
ENTER DESIGN FACTOR (F) (.72,.60,.50,.40)               ? .72
ENTER MAXIMUM CORROSION DEPTH (d)  Inch                 ? .41
MAX.LONGITDNAL.LGTH OF CORRODED AREA (L) Inches         ? 100

DEPTH OF CORROSION EXCEEDS 80% OF PIPEWALL. PIPE MUST BE REPLACED.
PRESS <ENTER> FOR FURTHER EVALUATION.?

                    -- INPUTTED DATA --
PIPE DIAMETER (D)= 36 In.     DESIGN FACTOR(F)= .72
WALL THICKNESS(t) = .5 In.    MAX.COR.DPTH(d) = .41 In.
SMYS     = 52000 PSI          MAX.COR.LGTH(L) = 100 In.
                     MAOP  = 1000 PSI
                    -- CALCULATED DATA --
               INTERMEDIATE FACTOR (A)= 21.048
DESIGN PRESS.(P)= 1040 PSI    SAFE PRESS.(P') = 206 PSI
REPAIR OR REPLACE PIPE BECAUSE CORROSION DEPTH EXCEEDS .8t.
REDUCE OPERATING PRESSURE SO IT WILL NOT EXCEED 206 PSI, SO THAT PIPE
WILL OPERATE LEGALLY AND SAFELY.
WITH CORR.LNGTH. 100 In., MAX.DEPTH IS 0.0630 Inch.  A =  21.048
WITH CORR.DEPTH .41 In., MAX. LENGTH IS   2.556 In. A =   0.538
!!! BUT .41 Inch EXCEEDS ALLOWABLE CORROSION DEPTH !!!

PRESS <1> FOR MORE CORROSION EVALUATIONS ON SAME PIPE,
   OR <2> FOR CORROSION EVALUATIONS ON DIFFERENT PIPE.?

EXAMPLE #7
MAXIMUM ALLOWABLE PRESSURE (MAOP) #/Sq.In.              ? 877
ENTER OUTSIDE DIAMETER OF PIPE (D) Inches               ? 12.625
ENTER PIPE WALL THICKNESS (t) Inch(es)                  ? .5
ENTER STRENGTH OF STEEL (SMYS) Lbs/sq.in.               ? 35000
ENTER DESIGN FACTOR (F) (.72,.60,.50,.40)               ? .4
ENTER MAXIMUM CORROSION DEPTH (d)  Inch                 ? .035
MAX.LONGITDNAL.LGTH OF CORRODED AREA (L) Inches         ? 3

CORROSION DEPTH IS LESS THAN 10% OF PIPE WALL. NO RESTRICTIONS ON OPERATION.
PRESS <ENTER> FOR FURTHER EVALUATION.?

                    -- INPUTTED DATA --
PIPE DIAMETER (D)= 12.625 In.DESIGN FACTOR(F)= .4
WALL THICKNESS(t) = .5 In.    MAX.COR.DPTH(d) = .035 In.
SMYS     = 35000 PSI          MAX.COR.LGTH(L) = 3 In.
                     MAOP  = 877 PSI
                    -- CALCULATED DATA --
               INTERMEDIATE FACTOR (A)=  1.066
DESIGN PRESS.(P)= 1109 PSI    SAFE PRESS.(P') = 1109 PSI
PIPE MAY BE OPERATED SAFELY AT MAOP, 877 PSI
WITH CORR.LNGTH. 3 In., MAX. DEPTH IS 0.4000 Inch.  A =  1.066
WITH CORR.DEPTH .035 In., MAX. LENGTH IS INFINITY.  A =  5.000

PRESS <1> FOR MORE CORROSION EVALUATIONS ON SAME PIPE,
   OR <2> FOR CORROSION EVALUATIONS ON DIFFERENT PIPE.?
```

```
EXAMPLE #8
                    -- INPUTTED DATA --
PIPE DIAMETER (D)= 24 In.     DESIGN FACTOR(F)= .5
WALL THICKNESS(t) = .5 In.    MAX.COR.DPTH(d) = .125 In.
SMYS     = 42000 PSI          MAX.COR.LGTH(L) = 12 In.
                      MAOP  = 790 PSI
                    -- CALCULATED DATA --
               INTERMEDIATE FACTOR (A)=  3.093
DESIGN PRESS.(P)= 875 PSI     SAFE PRESS.(P') = 845 PSI
PIPE MAY BE OPERATED SAFELY AT MAOP, 790 PSI
WITH CORR.LNGTH. 12 In., MAX. DEPTH IS 0.179 Inch.  A =  3.093
WITH CORR.DEPTH .125 In., MAX. LENGTH IS  15.519 In. A =   4.000

PRESS <1> FOR MORE CORROSION EVALUATIONS ON SAME PIPE,
   OR <2> FOR CORROSION EVALUATIONS ON DIFFERENT PIPE.?


THIS IS A TEST FOR THE ABOVE ALLOWABLE DEPTH AND LENGTH VALUES.
TEST #1. ENTER DEPTH OF .179 AND LENGTH OF 12.

                    -- INPUTTED DATA --
PIPE DIAMETER (D)= 24 In.     DESIGN FACTOR(F)= .5
WALL THICKNESS(t) = .5 In.    MAX.COR.DPTH(d) = .179 In.
SMYS     = 42000 PSI          MAX.COR.LGTH(L) = 12 In.
                      MAOP  = 790 PSI
                    -- CALCULATED DATA --
               INTERMEDIATE FACTOR (A)=  3.093
DESIGN PRESS.(P)= 875 PSI     SAFE PRESS.(P') = 791 PSI
PIPE MAY BE OPERATED SAFELY AT MAOP, 790 PSI
WITH CORR.LNGTH. 12 In., MAX. DEPTH IS 0.179 Inch.  A =  3.093
WITH CORR.DEPTH .179 In., MAX. LENGTH IS  12.182 In. A =   3.140

PRESS <1> FOR MORE CORROSION EVALUATIONS ON SAME PIPE,
   OR <2> FOR CORROSION EVALUATIONS ON DIFFERENT PIPE.?


TEST #1A.  ENTER DEPTH .179 AND LENGTH 12.182.

                    -- INPUTTED DATA --
PIPE DIAMETER (D)= 24 In.     DESIGN FACTOR(F)= .5
WALL THICKNESS(t) = .5 In.    MAX.COR.DPTH(d) = .179 In.
SMYS     = 42000 PSI          MAX.COR.LGTH(L) = 12.182 In.
                      MAOP  = 790 PSI
                    -- CALCULATED DATA --
               INTERMEDIATE FACTOR (A)=  3.140
DESIGN PRESS.(P)= 875 PSI     SAFE PRESS.(P') = 790 PSI
PIPE MAY BE OPERATED SAFELY AT MAOP, 790 PSI
WITH CORR.LNGTH. 12.182 In., MAX. DEPTH IS 0.178 Inch.  A =  3.140
WITH CORR.DEPTH .179 In., MAX. LENGTH IS  12.182 In. A =   3.140

PRESS <1> FOR MORE CORROSION EVALUATIONS ON SAME PIPE,
   OR <2> FOR CORROSION EVALUATIONS ON DIFFERENT PIPE.?
```

```
TEST #1B.  INCREASING DEPTH BY A THOUSANDTH SHOULD CAUSE UNSAFE OPERATION.
           ENTER DEPTH OF .180 AND LENGTH OF 12.182
                    -- INPUTTED DATA --
PIPE DIAMETER (D)= 24 In.     DESIGN FACTOR(F)= .5
WALL THICKNESS(t) = .5 In.    MAX.COR.DPTH(d) = .18 In.
SMYS     = 42000 PSI          MAX.COR.LGTH(L) = 12.182 In.
                   MAOP  = 790 PSI
                    -- CALCULATED DATA --
              INTERMEDIATE FACTOR (A)=  3.140
DESIGN PRESS.(P)= 875 PSI     SAFE PRESS.(P') = 789 PSI
REDUCE OPERATING PRESSURE SO IT WILL NOT EXCEED 789
PSI,          SO THAT PIPE WILL OPERATE LEGALLY AND SAFELY.
WITH CORR.LNGTH. 12.182 In., MAX. DEPTH IS 0.178 Inch.  A =  3.140
WITH CORR.DEPTH .18 In., MAX. LENGTH IS  11.961 In. A =   3.083

PRESS <1> FOR MORE CORROSION EVALUATIONS ON SAME PIPE,
   OR <2> FOR CORROSION EVALUATIONS ON DIFFERENT PIPE.?

TEST #2.  INCREASING LENGTH BY A FEW HUNDREDTHS SHOULD CAUSE UNSAFE OPERATION.
          FROM THE SAFE CONDITION OF TEST #1A, INCREASE THE LENGTH FROM 12.182
          IN. TO 12.297 IN.

                    -- INPUTTED DATA --
PIPE DIAMETER (D)= 24 In.     DESIGN FACTOR(F)= .5
WALL THICKNESS(t) = .5 In.    MAX.COR.DPTH(d) = .179 In.
SMYS     = 42000 PSI          MAX.COR.LGTH(L) = 12.297 In.
                   MAOP  = 790 PSI
                    -- CALCULATED DATA --
              INTERMEDIATE FACTOR (A)=  3.170
DESIGN PRESS.(P)= 875 PSI     SAFE PRESS.(P') = 789 PSI
REDUCE OPERATING PRESSURE SO IT WILL NOT EXCEED 789
PSI,          SO THAT PIPE WILL OPERATE LEGALLY AND SAFELY.
WITH CORR.LNGTH. 12.297 In., MAX. DEPTH IS 0.1780 Inch.  A =  3.170
WITH CORR.DEPTH .179 In., MAX. LENGTH IS  12.182 In. A =   3.140

PRESS <1> FOR MORE CORROSION EVALUATIONS ON SAME PIPE,
   OR <2> FOR CORROSION EVALUATIONS ON DIFFERENT PIPE.?

                    ***** END OF EXAMPLES *****

REFERENCES:

1.  THE PROGRAMMABLE ELECTRONIC CALCULATOR IN UNDERGROUND CORROSION RELATED AC-
    TIVITY.  Part 2,"Determination of Safe Operating Pressure for a Corroded
    High Pressure Gas Pipeline" by R.L.Seifert.
    Materials Performance, Vol.19, No. 7, (1980) July.

2.  Kiefner,J.F.,Duffy,A.R. Columbus Laboratories, Battelle Memorial Institute.
    SUMMARY OF RESEARCH TO DETERMINE THE STRENGTH OF CORRODED AREAS IN PIPE.
    (1971) 20 July

3.  Marvin, C.W.,DETERMINING THE STRENGTH OF CORRODED PIPE.  Materials Protect-
    ion and Performance, Vol.11,No.11,p.34 (1972) November.

4.  ASME GUIDE FOR GAS TRANSMISSION AND DISTRIBUTION PIPING SYSTEMS - 1976.
    Addendum No. 4, February, 1977 (Guide Material for Federal Standard
    192.485), and Appendices G-6, G-7, and G-8.

                          === END ===
```

APPENDIX B
BASIC Computer Program, CRLGTHU.BAS, Used in Generating Tables Like Those Which Are Printed in Part 3

Following is the BASIC computer program CRLGTHU.BAS, whose forerunner, CRLGTH.BAS, was used for generating some of the tables in Part 3 with the same computer equipment that is used in Appendix A. This upgraded version, CRLGTHU.BAS, does not require the BASIC program to be modified with each use as did the former version, CRLGTH.BAS, which was included in earlier printing(s) of this manual.

Enter the BASIC program which is listed on the following pages into the computer, and check its operation by running it and entering the following data as prompted: pipe diameter = 20; shallowest pit depth = .03; wall thicknesses as follows: .406, .438, .469, .5, .562, .625, .688, .750, .812, and .875. The printout should duplicate the example which is printed at the end of this Appendix. (Printer commands in the program are for the Epson FX series and compatible printers, and could result in strange formats on other printers.)

CRLGTHU.BAS

A computer program which provides the same type of information and printout as CRLGTH.BAS, except that the program does not need to be modified with each usage, and the user is asked for pipe diameter, the minimum pit depth to begin with, and up to 10 wall thicknesses. The program prompts the user for this information, in increasing order of thicknesses. (A thickness that is out of order will prompt a request to re-enter all of the thicknesses.)

```
10 'CRLGTHU.BAS
20 'THIS PROGRAM IS A UNIVERSAL PROGRAM, AND ALLOWS ENTRY OF ANY DIAMETER OF PIPE
 AND UP TO 10 WALL THICKNESSES TO EXAMINE FOR ALLOWABLE CORROSION LENGTHS.
30 CLS:'PROGRAM CRLGTHU.BAS BY R.L.SEIFERT TO LIST ALLOWED LENGTHS OF CORROSION
 FOR GIVEN DEPTHS OF CORROSION FOR SPECIFIED DIAMETER AND WALL THICKNESSES.FOR
 IBM-PC AND EPSON FX SERIES PRINTERS OR COMPATIBLE EQUIPMENT.
40 CLEAR 5000:DIM T(17):WIDTH "LPT1:",255
50 LPRINT CHR$(27);"@";:COLOR 7,1,0:CLS
60 PRINT TAB(30)"CRLGTHU.BAS"
70 PRINT TAB(26)"Revision of 2/17/89"
80 PRINT TAB(34)"by"
90 PRINT TAB(24)"Richard L. Seifert, P.E."
100 PRINT TAB(16)"Consultant for Pipeline Corrosion Control"
110 PRINT TAB(34)"and"
120 PRINT TAB(16)"Use and Application of Personal Computers"
130 PRINT TAB(25)"15602 Valley Bend Drive"
140 PRINT TAB(26)"Houston, Texas 77068"
150 PRINT
160 PRINT TAB(10)"This program prints a list of allowed lengths of corroded areas"
170 PRINT TAB(5)"on underground pressure piping for given pit depths. It is a
 general- "
180 PRINT TAB(5)"ized, conservative listing of allowed lengths, and if any
 corroded area "
190 PRINT TAB(5)"is 'condemned' by this listing, the corroded area should be
 examined
200 PRINT TAB(5)"further using Seifert's program CRVL.BAS. CRVL.BAS will examine
 the"
210 PRINT TAB(5)"corroded pipe using precise input parameters, and may allow the
 use of"
220 PRINT TAB(5)"the pipe, when this program, CRLGTHU.BAS, condemns it."
```

```
230 PRINT:PRINT TAB(22);:INPUT"Press <Enter> to proceed. ";EN
240 LPRINT CHR$(27);"@";:CLS:PRINT:INPUT"ADJUST PRINTER PAPER TO TOP OF FORM,
 TURN PRINTER ON, THEN PRESS <ENTER>";EN
250 INPUT"ENTER O.D. OF PIPE TO BE EXAMINED (EXAMPLE: 20)";D
260 INPUT"SHALLOWEST CORROSION DEPTH IN RANGE OF DEPTHS (E.G. .010)";DE:DE1=DE
270 J=0
280 PRINT"BEGIN ENTERING PIPE WALL THICKNESSES IN ASCENDING ORDER, FOR
 CALCULATIONS AND FOR COLUMN HEADINGS. MAXIMUM NUMBER OF ENTRIES = 10."
290 IF J=10 THEN J1=10:INPUT"MAXIMUM NUMBER OF THICKNESSES HAVE BEEN
 ENTERED. PRESS <ENTER> TO PROCEED.";EN:GOTO 330
300 J=J+1:PRINT"COLUMN "J". LAST ENTRY WAS "T(J-1):INPUT"ENTER WALL THICKNESS
 FOR THIS COLUMN. (-1 TO END ENTRIES) ";T(J)
310 IF T(J)=-1 THEN J=J-1:J1=J:GOTO 330
320 GOTO 290
330 FOR J=1 TO J1
340 IF T(J)<T(J-1) THEN BEEP:CLS:FOR Q=1 TO J1-1:PRINT T(Q)"  ";:NEXT Q:PRINT
 T(J1):ELSE 360
350 PRINT:PRINT"Wall thicknesses are all not in ascending order. You must re-enter
 wall thicknesses. Press <Enter> for re-entry of wall
 thicknesses. ":INPUT;EN:CLS:GOTO 270
360 NEXT J
370 LPRINT CHR$(27)"O";:FOR N=1 TO 4:LPRINT:NEXT N:LPRINT CHR$(27)"U";CHR$(1);
380 LPRINT CHR$(27)"G";:LPRINT CHR$(18);TAB(17)"VALUES OF L FOR PIPE WITH
 O.D. OF"D"INCHES"
390 LPRINT STRING$(75,"*")
400 LPRINT CHR$(15);
410 LPRINT"Pit Depth";TAB(60)"Wall Thickness (t), Inches";TAB(128)"|"
420 J2=19:LPRINT"d(Inch) ";:LPRINT USING"##.###";T(1);:FOR J=2 TO J1:LPRINT
 TAB(J2) USING"##.###";T(J);:J2=J2+12:NEXT J:LPRINT TAB(128)"|"
430 LPRINT STRING$(127,"=");"|"
440 FOR N=1 TO 150
450     TAB=0:IF     INT(N/5)=N/5     THEN     TAB=1:TAB2=1:LPRINT
 CHR$(27)CHR$(45)CHR$(1);: 'START UNDERLINE
460 LPRINT USING"#.###";(INT((DE*1000)+.5))*.001;:LPRINT"|";:TAB=TAB+19:IF
 DE=DE1 AND DE/T(1)<.1 THEN TAB=TAB-1
470 FOR J=1 TO J1
480 T=T(J)
490 IF DE/T<.1 OR DE/T>.8 THEN L$=" ":GOTO 620
500 IF 100*(DE/T)=>10 AND 100*(DE/T)=<17.5 THEN B=4:GOTO 520
510 B=SQR((((DE/T)/((1.1*(DE/T))-.15))^2)-1)
520 L=1.12*B*SQR(D*T)
530 L2=L-INT(L):L3=INT((L2/.0625)+.5):L4$=STR$(L3)+"/16":L=INT(L)
540 IF L3=0 THEN 560
550 IF 16/L3=2 THEN L4$=" 1/2":GOTO 600
```

```
560 IF L3=0 THEN L4$=" ":GOTO 600
570 IF L3=16 THEN L=L+1:L4$=" ":GOTO 600
580 IF INT(L3/2)=L3/2 THEN L3=L3/2:L4$=STR$(L3)+"/8"
590 IF INT(L3/2)=L3/2 THEN L3=L3/2:L4$=STR$(L3)+"/4"
600 IF L=0 THEN L$="  "+L4$:ELSE L$=STR$(L)+L4$
610 IF LEN(STR$(L))=2 THEN LPRINT"  ";
620 GOTO 630
630 LPRINT L$;:IF DE=DE1 THEN 640: ELSE LPRINT TAB(TAB);:TAB=TAB+12:GOTO 650
640 LPRINT TAB(TAB-1);:TAB=TAB+12
650 NEXT J
660 IF DE=DE1 THEN LPRINT TAB(128)".":ELSE LPRINT TAB(128+TAB2)".."
670 LPRINT CHR$(27)CHR$(45)CHR$(0);:TAB2=0 'STOP UNDERLINE
680 IF DE>((T(J1)*.8)+.01) AND L$="  "THEN LPRINT:LPRINT:LPRINT:LPRINT
 CHR$(27)"2":LPRINT  CHR$(27)"U"CHR$(0);:LPRINT  CHR$(27)"H";:WIDTH
 "LPT1:",80:LPRINT CHR$(18);:GOTO 710

690 DE=DE+.01
700 NEXT N
710 FL=1:CLS:Y$="":PRINT:INPUT"Do you want to print another table of acceptable
 corrosion lengths (Y/N*)";Y$:IF Y$="n" OR Y$="N" OR Y$="" THEN END
720 CLEAR 5000:DIM T(17):WIDTH "LPT1:",255
730 LPRINT CHR$(27);"@";:COLOR 7,1,0:CLS:GOTO 240
```

VALUES OF L FOR PIPE WITH O.D. OF 20 INCHES

Pit Depth d(Inch)	Wall Thickness (t), Inches 0.406	0.438	0.469	0.500	0.562	0.625	0.688	0.750	0.812	0.875
0.030										
0.040										
0.050	12 3/4	13 1/4	13 3/4							
0.060	12 3/4	13 1/4	13 3/4	14 3/16	15					
0.070	12 3/4	13 1/4	13 3/4	14 3/16	15	15 13/16	16 5/8			
0.080	8 7/8	11 7/16	13 3/4	14 3/16	15	15 13/16	16 5/8	17 3/8		
0.090	6 13/16	8 5/16	10 3/16	12 13/16	15	15 13/16	16 5/8	17 3/8	18 1/16	18 3/4
0.100	5 11/16	6 11/16	7 15/16	9 1/2	14 1/8	15 13/16	16 5/8	17 3/8	18 1/16	18 3/4
0.110	4 7/8	5 11/16	6 5/8	7 11/16	10 5/8	15 1/2	16 5/8	17 3/8	18 1/16	18 3/4
0.120	4 5/16	5	5 3/4	6 9/16	8 11/16	11 3/4	16 5/8	17 3/8	18 1/16	18 3/4
0.130	3 15/16	4 1/2	5 1/16	5 3/4	7 7/16	9 11/16	12 15/16	17 3/8	18 1/16	18 3/4
0.140	3 9/16	4 1/16	4 5/8	5 3/16	6 9/16	8 5/16	10 11/16	14	18 1/16	18 3/4
0.150	3 5/16	3 3/4	4 3/16	4 3/4	5 7/8	7 5/16	9 3/16	11 5/8	15	18 3/4
0.160	3 1/16	3 1/2	3 7/8	4 3/8	5 3/8	6 5/8	8 1/8	10 1/16	12 9/16	16 1/16
0.170	2 7/8	3 1/4	3 5/8	4 1/16	4 15/16	6 1/16	7 5/16	8 7/8	10 7/8	13 1/2
0.180	2 11/16	3 1/16	3 7/16	3 13/16	4 5/8	5 9/16	6 11/16	8 1/16	9 11/16	11 3/4
0.190	2 9/16	2 7/8	3 3/16	3 9/16	4 5/16	5 3/16	6 3/16	7 3/8	8 3/4	10 7/16
0.200	2 7/16	2 3/4	3 1/16	3 3/8	4 1/16	4 7/8	5 3/4	6 13/16	8	9 7/16
0.210	2 5/16	2 5/8	2 7/8	3 3/16	3 7/8	4 9/16	5 7/16	6 3/8	7 7/16	8 11/16
0.220	2 3/16	2 1/2	2 3/4	3 1/16	3 5/8	4 5/16	5 1/8	5 15/16	6 15/16	8 1/6
0.230	2 1/8	2 3/8	2 5/8	2 7/8	3 1/2	4 1/8	4 13/16	5 5/8	6 1/2	7 1/2
0.240	2	2 1/4	2 1/2	2 3/4	3 5/16	3 15/16	4 5/8	5 5/16	6 1/8	7 1/16
0.250	1 15/16	2 3/16	2 7/16	2 11/16	3 3/16	3 3/4	4 3/8	5 1/16	5 13/16	6 11/16
0.260	1 7/8	2 1/16	2 5/16	2 9/16	3 1/16	3 5/8	4 3/16	4 13/16	5 9/16	6 5/16
0.270	1 3/4	2	2 1/4	2 7/16	2 15/16	3 7/16	4	4 5/8	5 5/16	6
0.280	1 11/16	1 15/16	2 1/8	2 3/8	2 13/16	3 5/16	3 7/8	4 7/16	5 1/16	5 3/4
0.290	1 5/8	1 7/8	2 1/16	2 1/4	2 3/4	3 3/16	3 3/4	4 1/4	4 7/8	5 1/2
0.300	1 9/16	1 3/4	2	2 3/16	2 5/8	3 1/8	3 5/8	4 1/8	4 11/16	5 5/16
0.310	1 1/2	1 11/16	1 15/16	2 1/8	2 9/16	3	3 1/2	4	4 1/2	5 1/8
0.320	1 7/16	1 5/8	1 7/8	2 1/16	2 7/16	2 7/8	3 3/8	3 7/8	4 3/8	4 15/16
0.330		1 5/8	1 13/16	2	2 3/8	2 13/16	3 1/4	3 3/4	4 3/16	4 3/4
0.340		1 9/16	1 3/4	1 15/16	2 5/16	2 3/4	3 1/8	3 5/8	4 1/16	4 5/8
0.350		1 1/2	1 11/16	1 7/8	2 1/4	2 5/8	3 1/16	3 1/2	3 15/16	4 7/16
0.360			1 5/8	1 13/16	2 3/16	2 9/16	3	3 3/8	3 13/16	4 5/16
0.370			1 9/16	1 3/4	2 1/8	2 1/2	2 7/8	3 5/16	3 3/4	4 3/16
0.380				1 11/16	2 1/16	2 7/16	2 13/16	3 3/16	3 5/8	4 1/16
0.390				1 5/8	2	2 3/8	2 3/4	3 1/8	3 1/2	3 15/16
0.400				1 9/16	1 15/16	2 5/16	2 11/16	3 1/16	3 7/16	3 7/8
0.410					1 7/8	2 1/4	2 9/16	2 15/16	3 3/8	3 3/4
0.420					1 13/16	2 3/16	2 1/2	2 7/8	3 1/4	3 11/16
0.430					1 3/4	2 1/8	2 7/16	2 13/16	3 3/16	3 9/16
0.440					1 3/4	2 1/16	2 3/8	2 3/4	3 1/8	3 1/2
0.450						2	2 3/8	2 11/16	3 1/16	3 7/16
0.460						1 15/16	2 5/16	2 5/8	3	3 5/16
0.470						1 15/16	2 1/4	2 9/16	2 7/8	3 1/4
0.480						1 7/8	2 3/16	2 1/2	2 13/16	3 3/16
0.490						1 13/16	2 1/8	2 7/16	2 3/4	3 1/8
0.500						1 3/4	2 1/16	2 3/8	2 3/4	3 1/16
0.510							2 1/16	2 3/8	2 11/16	3
0.520							2	2 5/16	2 5/8	2 15/16
0.530							1 15/16	2 1/4	2 9/16	2 7/8
0.540							1 15/16	2 3/16	2 1/2	2 13/16
0.550							1 7/8	2 3/16	2 7/16	2 3/4
0.560								2 1/8	2 3/8	2 11/16
0.570								2 1/16	2 3/8	2 11/16
0.580								2	2 5/16	2 5/8
0.590								2	2 1/4	2 9/16
0.600								1 15/16	2 1/4	2 1/2
0.610									2 3/16	2 7/16
0.620									2 1/8	2 7/16
0.630									2 1/8	2 3/8
0.640									2 1/16	2 5/16
0.650										2 5/16
0.660										2 1/4
0.670										2 3/16
0.680										2 3/16
0.690										2 1/8
0.700										2 1/8
0.710										
0.720										

ASME CODE FOR PRESSURE PIPING, B31