

# Steel Pipelines Crossing Railroads and Highways

API RECOMMENDED PRACTICE 1102  
SEVENTH EDITION, DECEMBER 2007

ERRATA, NOVEMBER 2008  
ERRATA 2, MAY 2010  
ERRATA 3, SEPTEMBER 2012  
ERRATA 4, FEBRUARY 2014  
ERRATA 5, MARCH 2014

REAFFIRMED, JUNE 2024



American  
Petroleum  
Institute

## Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representative warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

All rights reserved. No part of this work may be reproduced, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher, API Publishing Services, 200 Massachusetts Avenue, NW, Washington, DC 20001.

## Foreword

The need for an industry-recommended practice to address installation of pipeline crossings under railroads was first recognized by the publication of American Petroleum Institute (API) Code 26 in 1934. This code represented an understanding between the pipeline and railroad industries regarding the installation of the relatively small-diameter lines then prevalent.

The rapid growth of pipeline systems after 1946 using large-diameter pipe led to the reevaluation and revision of API Code 26 to include pipeline design criteria. A series of changes were made between 1949 and 1952, culminating in the establishment in 1952 of Recommended Practice 1102. The scope of Recommended Practice 1102 (1952) included crossings of highways in anticipation of the cost savings that would accrue to the use of thin-wall casings in conjunction with the pending construction of the Defense Interstate Highway System.

Recommended Practice 1102 (1968) incorporated the knowledge gained from known data on uncased carrier pipes and casing design and from the performance of uncased carrier pipes under dead and live loads, as well as under internal pressures. Extensive computer analysis was performed using Spangler's Iowa Formula [1] to determine the stress in uncased carrier pipes and the wall thickness of casing pipes in instances where cased pipes are required in an installation.

The performance of carrier pipes in uncased crossings and casings installed since 1934, and operated in accordance with API Code 26 and Recommended Practice 1102, has been excellent. There is no known occurrence in the petroleum industry of a structural failure due to imposed earth and live loads on a carrier pipe or casing under a railroad or highway. Pipeline company reports to the U.S. Department of Transportation in compliance with 49 *Code of Federal Regulations* Part 195 corroborate this record.

The excellent performance record of uncased carrier pipes and casings may in part be due to the design process used to determine the required wall thickness. Measurements of actual installed casings and carrier pipes using previous Recommended Practice 1102 design criteria demonstrate that the past design methods are conservative. In 1985, the Gas Research Institute (GRI) began funding a research project at Cornell University to develop an improved methodology for the design of uncased carrier pipelines crossing beneath railroads and highways. The research scope included state-of-the-art reviews of railroad and highway crossing practices and performance records [2, 3], three-dimensional finite element modeling of uncased carrier pipes beneath railroads and highways, and extensive field testing on full-scale instrumented pipelines. The results of this research are the basis for the new methodology for uncased carrier pipe design given in this edition of Recommended Practice 1102. The GRI summary report, *Technical Summary and Database for Guidelines for Pipelines Crossing Railroads and Highway* by Ingraffea et al. [4], includes the results of the numerical modeling, the full derivations of the design curves used in this recommended practice, and the data base of the field measurements made on the experimental test pipelines.

This recommended practice contains tabular values for the wall thickness of casings where they are required in an installation. The loading values that were employed are Cooper E-80 with 175% impact for railroads and 10,000 lbs (44.5 kN) per tandem wheel with 150% impact for highways. Due notice should be taken of the fact that external loads on flexible pipes can cause failure by buckling. Buckling occurs when the vertical diameter has undergone 18% to 22% deflection. Failure by buckling does not result in rupture of the pipe wall, although the metal may be stressed far beyond its elastic limit. Recommended Practice 1102 (1993) recognizes this performance of a properly installed flexible casing pipe, as opposed to heavy wall rigid structures, and has based its design criteria on a maximum vertical deflection of 3% of the vertical diameter. Measurement of actual installed casing pipe using Recommended Practice 1102 (1981) design criteria demonstrates that the Iowa Formula is very conservative, and in most instances, the measured long-term vertical deflection has been 0.65% or less of the vertical diameter.

Recommended Practice 1102 has been revised and improved repeatedly using the latest research and experience in measuring actual performance of externally loaded uncased pipelines under various environmental conditions and using new materials and construction techniques developed since the recommended practice was last revised. The

current Recommended Practice 1102 (2007) is the seventh edition and reflects the most recent design criteria and technology.

The seventh edition of Recommended Practice 1102 (2007) has been reviewed by the API Pipeline Operations Technical Committee utilizing the extensive knowledge and experiences of qualified engineers responsible for design construction, operation and maintenance of the nation's petroleum pipelines. API appreciatively acknowledges their contributions.

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 200 Massachusetts Avenue, NW, Washington, DC 20001. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually and updated quarterly by API, 200 Massachusetts Avenue, NW, Washington, DC 20001.

Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, NW, Washington, DC 20001, [standards@api.org](mailto:standards@api.org).

# Contents

	Page
<b>1 Scope</b> .....	<b>1</b>
1.1 General .....	1
1.2 Application .....	1
1.3 Type of Pipeline .....	1
1.4 Provisions for Public Safety .....	1
1.5 Approval for Crossings .....	1
<b>2 Symbols, Equations, and Definitions</b> .....	<b>1</b>
2.1 Symbols .....	1
2.2 Equations .....	4
2.3 Definitions .....	5
<b>3 Provisions for Safety</b> .....	<b>6</b>
<b>4 Uncased Crossings</b> .....	<b>7</b>
4.1 Type of Crossing .....	7
4.2 General .....	7
4.3 Location and Alignment .....	7
4.4 Cover .....	7
4.5 Design .....	9
4.6 Loads .....	9
4.7 Stresses .....	11
4.8 Limits of Calculated Stresses .....	22
4.9 Orientation of Longitudinal Welds at Railroad and Highway Crossings .....	30
4.10 Location of Girth Welds at Railroad Crossings .....	30
<b>5 Cased Crossings</b> .....	<b>30</b>
5.1 Carrier Pipe Installed within a Casing .....	30
5.2 Casings for Crossings .....	30
5.3 Minimum Internal Diameter of Casing .....	30
5.4 Wall Thickness .....	30
5.5 General .....	31
5.6 Location and Alignment .....	31
5.7 Cover .....	32
5.8 Installation .....	32
5.9 Casing Seals .....	32
5.10 Casing Vents .....	33
5.11 Insulators .....	33
5.12 Inspection and Testing .....	33
<b>6 Installation</b> .....	<b>33</b>
6.1 Trenchless Installation .....	33
6.2 Open Cut or Trenched Installation .....	34
6.3 General .....	35
<b>7 Railroads and Highways Crossing Existing Pipelines</b> .....	<b>36</b>
7.1 Adjustment of Pipelines at Crossings .....	36
7.2 Adjustment of In-service Pipelines .....	36
7.3 Adjustments of Pipelines Requiring Interruption of Service .....	36
7.4 Protection of Pipelines During Highway or Railroad Construction .....	37
<b>Annex A Supplemental Material Properties and Uncased Crossing Design Values</b> .....	<b>38</b>

## Contents

	Page
<b>Annex B Uncased Design Example Problems</b> .....	40
<b>Annex C Casing Wall Thicknesses</b> .....	49
<b>Annex D Unit Conversions</b> .....	50
<b>References</b> .....	51
<b>Figure</b>	
<b>1 Examples of Uncased Crossing Installations.</b> .....	8
<b>2 Flow Diagram of Design Procedure for Uncased Crossings of Railroads and Highway.</b> .....	10
<b>3 Stiffness Factor for Earth Load Circumferential Stress, <math>K_{He}</math></b> .....	13
<b>4 Burial Factor for Earth Load Circumferential Stress, <math>B_e</math></b> .....	13
<b>5 Excavation Factor for Earth Load Circumferential Stress, <math>E_e</math></b> .....	14
<b>6 Single and Tandem Wheel Loads, <math>P_s</math> and <math>P_t</math></b> .....	15
<b>7 Recommended Impact Factor Versus Depth</b> .....	16
<b>8 Railroad Stiffness Factor for Cyclic Circumferential Stress, <math>K_{Hr}</math></b> .....	17
<b>9 Railroad Geometry Factor for Cyclic Circumferential Stress, <math>G_{Hr}</math></b> .....	18
<b>10 Railroad Double Track Factor for Cyclic Circumferential Stress, <math>N_H</math></b> .....	19
<b>11 Railroad Stiffness Factor for Cyclic Longitudinal Stress, <math>K_{Lr}</math></b> .....	19
<b>12 Railroad Geometry Factor for Cyclic Longitudinal Stress, <math>G_{Lr}</math></b> .....	20
<b>13 Railroad Double Track Factor for Cyclic Longitudinal Stress, <math>N_L</math></b> .....	20
<b>14 Highway Stiffness Factor for Cyclic Circumferential Stress, <math>K_{Hh}</math></b> .....	21
<b>15 Highway Geometry Factor for Cyclic Circumferential Stress, <math>G_{Hh}</math></b> .....	22
<b>16 Highway Stiffness Factor for Cyclic Longitudinal Stress, <math>K_{Lh}</math></b> .....	23
<b>17 Highway Geometry Factor for Cyclic Longitudinal Stress, <math>G_{Lh}</math></b> .....	23
<b>18-A Longitudinal Stress Reduction Factors, <math>R_L</math> for <math>L_G</math> Greater Than or Equal to 5 ft (1.5 m) but Less Than 10 ft (3 m)</b> .....	28
<b>18-B Longitudinal Stress Reduction Factors, <math>R_L</math> for <math>L_G</math> Greater Than or Equal to 10 ft (3 m)</b> .....	28
<b>19 Examples of Cased Crossing Installations</b> .....	31
<b>A-1 Critical Case Decision Basis for Whether Single or Tandem Axle Configuration Will Govern Design</b> .....	39
<b>Tables</b>	
<b>1 Critical Axle Configurations for Design Wheel Loads of <math>P_s = 12</math> Kips (53.4 kN) and <math>P_t = 10</math> Kips (44.5 kN)</b> .....	15
<b>2 Highway Pavement Stiffness Factors, <math>R</math>, and Axle Configuration Factors, <math>L</math></b> .....	24
<b>3 Fatigue Endurance Limits, <math>S_{FG}</math>, and <math>S_{FL}</math>, for Various Steel Grades</b> .....	26
<b>A-1 Typical Values for Modulus of Soil Reaction, <math>E'</math></b> .....	38
<b>A-2 Typical Values for Resilient Modulus, <math>E'_r</math></b> .....	38
<b>A-3 Typical Steel Properties</b> .....	38
<b>C-1 Minimum Nominal Wall Thickness for Flexible Casing in Bored Crossings</b> .....	49
<b>D-1 Unit Conversions</b> .....	50

# Steel Pipelines Crossing Railroads and Highways

## 1 Scope

### 1.1 General

This recommended practice, *Steel Pipelines Crossing Railroads and Highways*, gives primary emphasis to provisions for public safety. It covers the design, installation, inspection, and testing required to ensure safe crossings of steel pipelines under railroads and highways. The provisions apply to the design and construction of welded steel pipelines under railroads and highways. The provisions of this practice are formulated to protect the facility crossed by the pipeline, as well as to provide adequate design for safe installation and operation of the pipeline.

### 1.2 Application

The provisions herein should be applicable to the construction of pipelines crossing under railroads and highways and to the adjustment of existing pipelines crossed by railroad or highway construction. This practice should not be applied retroactively. Neither should it apply to pipelines under contract for construction on or prior to the effective date of this edition. Neither should it be applied to directionally drilled crossings or to pipelines installed in utility tunnels.

### 1.3 Type of Pipeline

This practice applies to welded steel pipelines.

### 1.4 Provisions for Public Safety

The provisions give primary emphasis to public safety. The provisions set forth in this practice adequately provide for safety under conditions normally encountered in the pipeline industry. Requirements for abnormal or unusual conditions are not specifically discussed, nor are all details of engineering and construction provided. The applicable regulations of federal [5, 6], state, municipal, and regulatory institutions having jurisdiction over the facility to be crossed shall be observed during the design and construction of the pipeline.

### 1.5 Approval for Crossings

Prior to the construction of a pipeline crossing, arrangements should be made with the authorized agent of the facility to be crossed.

## 2 Symbols, Equations, and Definitions

### 2.1 Symbols

$A_p$  Contact area for application of wheel load, in in.<sup>2</sup> or m<sup>2</sup>.

$B_d$  Bore diameter of crossing, in in. or mm.

$B_e$  Burial factor for circumferential stress from earth load.

$D$  External diameter of pipe, in in. or mm.

$E$  Longitudinal joint factor.

$E'$  Modulus of soil reaction, in kips/in.<sup>2</sup> or MPa.