# Design, Construction, Operation, and Maintenance of Offshore Hydrocarbon Pipelines (Limit State Design)

**Downstream Segment**

API RECOMMENDED PRACTICE 1111
FOURTH EDITION, DECEMBER 2009

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## Foreword

This recommended practice (RP) sets out criteria for the design, construction, testing, operation, and maintenance of offshore steel pipelines utilized in the production, production support, or transportation of hydrocarbons; that is, the movement by pipeline of hydrocarbon liquids, gases, and mixtures of these hydrocarbons with water.

The criteria contained in this document are intended to permit the economical transportation of hydrocarbons while providing for the safety of life and property and the protection of the environment. The general adoption of these criteria should assure that offshore hydrocarbon pipelines possess the requisite structural integrity for their safe and efficient operation.

API created an industry committee to develop appropriate uniform guidelines. The resulting first edition of API Recommended Practice 1111 was published in 1976. In 1989, the decision was made to create a revision that would provide industry with a more functional document. The resulting second edition was issued in November 1993. In 1997, a task force was formed to consider proposed changes to the RP based on a growing concern among pipeline engineers that existing codes lead to overly conservative designs for high-pressure pipelines having a low diameter to wall thickness ($D/t$) ratio. In fact, the second edition of the RP and the codes specifically excluded the pipelines categorized as flowlines which typically require these low $D/t$ ratio (see ASME B31.4 and ASME B31.8). This RP includes a “limit state design” methodology. Safety margins similar to existing levels are obtained for the lower $D/t$ ratio by changing to a limit state design based on the actual burst strength of pipe. The burst pressure formula in the document is based on theoretical considerations and confirmed by more than 250 burst tests of full-size pipe specimens that cover a wide range of pipe grade, diameter, and wall thickness.

Portions of this publication have changed from the previous editions, which have been an RP, but the changes are too numerous to use bar notations in this edition. In some cases, the changes are significant, while in other cases the changes reflect minor editorial adjustments.

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Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the specification.

Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required in order to conform to the specification.

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, 1220 L Street, NW, Washington, DC 20005. 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 by API, 1220 L Street, NW, Washington, DC 20005.

Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

## Contents

# Design, Construction, Operation, and Maintenance of Offshore Hydrocarbon Pipelines (Limit State Design)

## 1 Scope

**1.1** This recommended practice (RP) sets criteria for the design, construction, testing, operation, and maintenance of offshore steel pipelines utilized in the production, production support, or transportation of hydrocarbons; that is, the movement by pipeline of hydrocarbon liquids, gases, and mixtures of these hydrocarbons with water. This RP may also be utilized for water injection pipelines offshore.

**1.2** The RP also applies to any transportation piping facilities located on a production platform downstream of separation and treatment facilities, including meter facilities, gas compression facilities, liquid pumps, associated piping, and appurtenances.

**1.3** Limit state design has been incorporated in this RP to provide a uniform factor of safety with respect to rupture or burst failure as the primary design condition independent of the pipe diameter, wall thickness, and grade. Background on theory and practice of limit states for pressure-containing cylinders may be found in Hill [2] and in Crossland and Jones [1], as listed in the Bibliography at the end of the RP. Burst design criteria within this practice are presently defined for carbon steel line pipe. Application of the proposed design criteria to other materials requires determination by the user of the minimum burst criteria using the procedure set forth in Annex A.

**1.4** The design, construction, inspection, and testing provisions of this RP may not apply to offshore hydrocarbon pipelines designed or installed before this latest revision of the RP was issued. The operation and maintenance provisions of this RP are suitable for application to existing facilities.

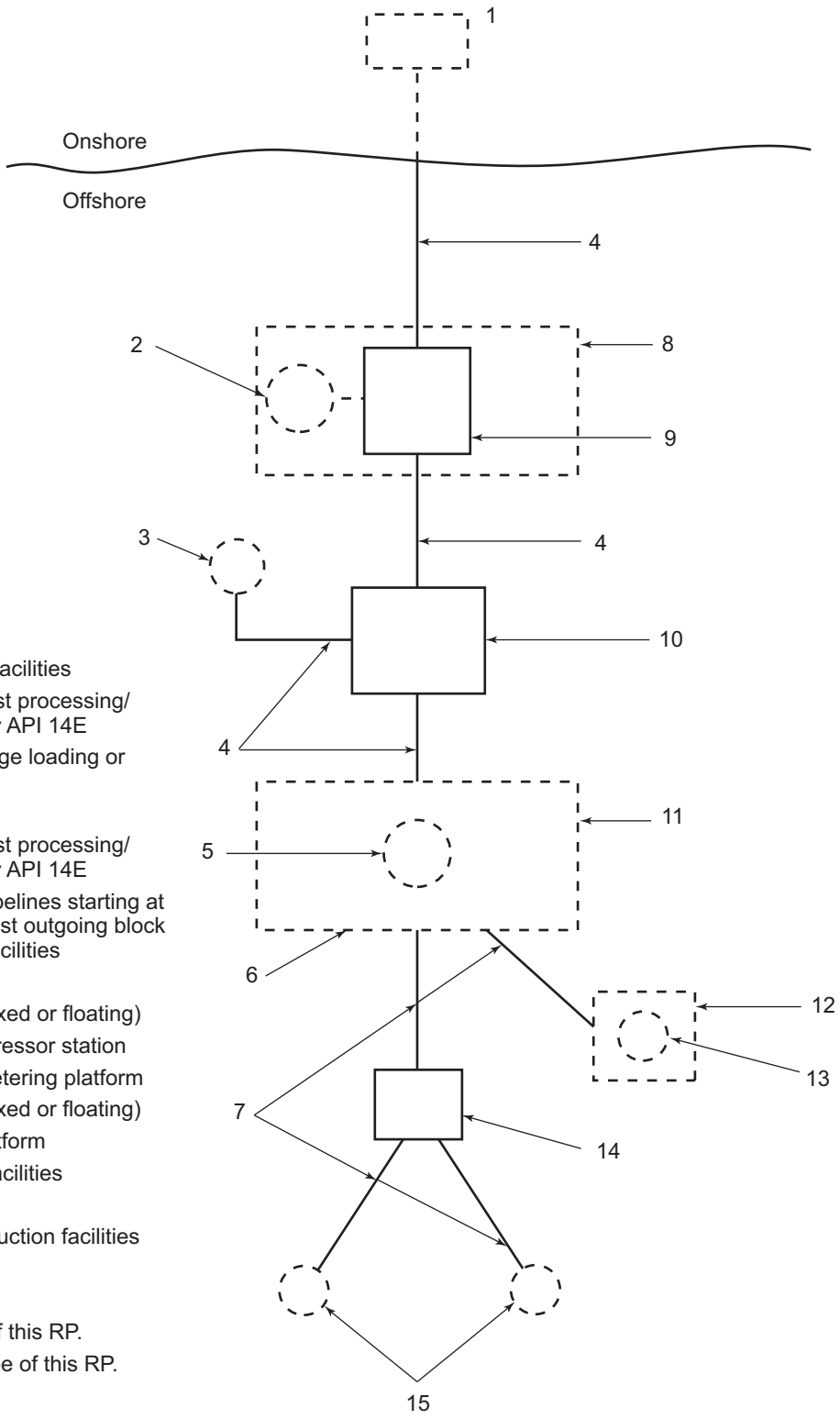
**1.5** Design and construction practices other than those set forth in Section 4 and Section 7 may be employed when supported by adequate technical justification, including model or proof testing of involved components or procedures as appropriate. Nothing in this RP should be considered as a fixed rule for application without regard to sound engineering judgment.

NOTE Certain governmental requirements or company specifications may differ from the criteria set forth in this RP, and this RP does not supersede or override those differing requirements or specifications.

**1.6** This publication has incorporated by reference all or parts of several existing codes, standards, and RPs that have been found acceptable for application to offshore hydrocarbon pipelines.

**Caution—Users shall use the most recent editions of all reference documents in this RP. For ASME B31.4 and ASME B31.8 specifically, the 2006 edition and the 2007 edition, respectively, of the documents were used as the basis for determining the requirements. However, the reference is meant to be to the corresponding part in the latest revision or edition of the publication.**

**1.7** For a graphic representation of the scope of this RP, see Figure 1.




**Key**

1 onshore pipeline and facilities
2 production facilities first processing/ separation covered by API 14E
3 tanker, barge, or storage loading or unloading facilities
4 pipeline
5 production facilities first processing/ separation covered by API 14E
6 API 1111 applies to pipelines starting at the first incoming or last outgoing block valve on production facilities
7 flowlines
8 production platform (fixed or floating)
9 pump station or compressor station
10 pipeline junction or metering platform
11 production platform (fixed or floating)
12 remote production platform
13 wellhead production facilities
14 subsea manifold
15 subsea wellhead production facilities

NOTE
Solid lines = within scope of this RP.
Broken lines = outside scope of this RP.

**Figure 1—Scope of API 1111**

## 2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Recommended Practice 2A-WSD, *Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms—Working Stress Design*

API Recommended Practice 2RD, *Design of Risers for Floating Production Systems (FPSs) and Tension-Leg Platforms*

API Specification 5L/ISO 3183, *Specification for Line Pipe*

API Recommended Practice 5L1, *Recommended Practice for Railroad Transportation of Line Pipe*

API Specification 6A/ISO 10423, *Specification for Wellhead and Christmas Tree Equipment*

API Specification 6D/ISO 14313, *Specification for Pipeline Valves*

API Recommended Practice 14C, *Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms*

API Recommended Practice 14E, *Recommended Practice for Design and Installation of Offshore Production Platform Piping Systems*

API Standard 1104, *Welding of Pipelines and Related Facilities*

API Recommended Practice 1110, *Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids, Highly Volatile Liquids or Carbon Dioxide*

API Publication 2200, *Repairing Crude Oil, Liquefied Petroleum Gas, and Product Pipelines*

API Recommended Practice 2201, *Safe Hot Tapping Practices in the Petroleum & Petrochemical Industries*

AGA [1], *Submarine Pipeline On-Bottom Stability Analysis and Design Guidelines*

ASME B16.5 [2], *Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard*

ASME B16.47, *Large Diameter Steel Flanges NPS 26 Through NPS 60*

ASME B31G, *Manual for Determining the Remaining Strength of Corroded Pipelines*

ASME B31.4, *Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids*

ASME B31.8, *Gas Transmission and Distribution Piping Systems*

ASME *Boiler and Pressure Vessel Code* (*BPVC*), *Section IX: Welding and Brazing Qualifications*

ASQC Z1.9:2003 [3], *Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming*

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1 American Gas Association, 1515 Wilson Boulevard, Arlington, Virginia 22209, www.aga.org.
2 American Society of Mechanical Engineers, 3 Park Avenue, New York, New York 10017, ASME International, 3 Park Avenue, New York, New York 10016-5990, www.asme.org..
3 American Society for Quality Control, 611 East Wisconsin Avenue, Milwaukee, Wisconsin 53202, www.asq.org.

AWS D3.6M [4], *Specification for Underwater Welding*

DNV-RP-F105:February 2006 [5], *Free Spanning Pipelines*

DOE [6], *Offshore Installations: Guidance on Design, Construction, and Certification*

MSS SP-44 [7], *Steel Pipeline Flanges*

NACE SP 0106:2006 [8], *Control of Internal Corrosion in Steel Pipelines and Piping Systems*

NACE SP 0607:2007/ISO 15589-2 (MOD)*, Petroleum and natural gas industries—Cathodic protection of pipeline transportation systems*

OMAE '85 [9], Murphey, C. E., and Langner C. G., "Ultimate Pipe Strength Under Bending, Collapse, and Fatigue," Proceedings, Vol. 1, pp. 467 to 477

Title 30 *Code of Federal Regulations* (*CFR*) Part 250, Subpart J [10], *Pipelines and Pipeline Rights-of-Way*

Title 49 *Code of Federal Regulations* (*CFR*) Part 192, *Transportation of Natural and Other Gas by Pipeline: Minimum Safety Standards*

Title 49 *Code of Federal Regulations* (*CFR*) Part 195, *Transportation of Hazardous Liquids by Pipeline*

# 3 Terms, Definitions, Acronyms, Abbreviations, and Symbols

## 3.1 Terms and Definitions

For the purposes of this document, the following definitions apply.

**3.1.1**
**design pressure**
The maximum difference, at each cross section, between internal pressure and external pressure during operating conditions.

NOTE Section 4.3.1 sets limits on design pressure.

**3.1.2**
**extreme loads**
Loads that are unlikely to be exceeded during the lifetime of the pipeline.

**3.1.3**
**gas**
A hydrocarbon in a vapor phase.

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4 American Welding Society, Inc., P.O. Box 351040, 550 NW Le Jeune Road, Miami, Florida 33135, www.aws.org.
5 Det norske Veritas, Veritasveien, 1, N-1322 Hovik, Norway, www.dnv.com.
6 Department of Energy, Petroleum Engineering Division, 1 Palace St., London, SW1E 5HE, United Kingdom, www.hss.doe.gov.
7 Manufacturers Standardization Society of the Valve & Fittings Industry, Inc., 127 Park Street, NE, Vienna, Virginia 22180, www.mss-hq.com.
8 National Association of Corrosion Engineers International, 1440 South Creek Drive, Houston, Texas 77084, www.nace.org.
9 Offshore Mechanics and Arctic Engineering Symposium, ASME International, 3 Park Avenue, New York, New York 10016-5990, www.asme.org.
10 The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, DC 20402.