Pressure Testing of Liquid Petroleum Pipelines

Transportation Department

API RECOMMENDED PRACTICE 1110
THIRD EDITION, DECEMBER 1991

American Petroleum Institute

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FOREWORD

This recommended practice has been prepared by API's Pipeline Transportation Committee on Design and Construction and updated by the Committee on Operations and Maintenance, which is composed of experienced pipeline engineers. This recommended practice suggests procedures for testing hydrostatically new and existing petroleum pipelines.

The purpose of this recommended practice is to increase safety and efficiency by encouraging the petroleum pipeline industry to adopt uniform pressure-testing practices for its liquid petroleum pipeline facilities. This recommended practice recommends procedures to be followed, suggests equipment to be used, and points out factors to be considered during the pressure testing. Liquid petroleum pipelines are pressure tested to verify that their test segments have the requisite structural integrity to withstand normal and maximum operating pressures and to verify that they are capable of liquid containment.

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

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SECTION 1—INTRODUCTION

1.1 Scope

This recommended practice covers the hydrostatic testing of new and existing liquid petroleum pipelines. It recommends minimum procedures to be followed, suggests equipment to be used, and points out factors to be considered during the hydrostatic testing of liquid petroleum pipelines.

This recommended practice suggests procedures that are based on sound engineering judgment, but certain governmental requirements may differ from the procedures set forth in this recommended practice. Such requirements should be fulfilled because this recommended practice is not intended to supersede or override them.

1.2 Conformance to API's Environmental Mission and Guiding Principles

This recommended practice has been reviewed to determine if it conforms to API's Environmental Mission and Guiding Principles.[1] It has been determined that because this recommended practice directly addresses safety and environmental issues, it does conform to API's Environmental Mission and Guiding Principles. The following guiding principles have been determined to be especially relevant to this recommended practice:

- To recognize and to respond to community concerns about our raw materials, products and operations.
- To operate our plants and facilities and to handle our raw materials and products in a manner that protects the environment, and the safety and health of our employees and the public.
- To make safety, health and environmental considerations a priority in our planning, and our development of new products and processes.
- To counsel customers, transporters and others in the safe use, transportation, and disposal of our raw materials, products and waste materials.
- To promote these principles and practices by sharing experiences and offering assistance to others who produce, handle, use, transport or dispose of similar raw materials, petroleum products and wastes.

1.3 Referenced Publications

The most recent editions of the following standards, codes, and specifications are cited in this recommended practice.

ASME[2]

B31.4 *Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohols*

B31.8 *Gas Transmission and Distribution Piping Systems*

DOT[3]

Research and Special Programs Administration (49 *Code of Federal Regulations* Part 195)

SECTION 2—HYDROSTATIC TESTING OF LIQUID PETROLEUM PIPELINES

2.1 Definition

In hydrostatic testing, internal pressure above the normal or maximum operating pressure is applied to a segment of pipeline, under no-flow conditions, for a fixed period of time. A liquid test medium is used to apply the internal pressure.

2.2 Code Requirements for Hydrostatic Testing

2.2.1 NEW CONSTRUCTION AND THE REPLACEMENT OF EXISTING PIPELINES

The hydrostatic testing of newly constructed pipelines and replaced segments of existing pipelines should be performed in accordance with ASME B31.4, 49 *Code of Federal Regulations* Part 195, and any other applicable governmental regulations.

2.2.2 QUALIFICATION OF EXISTING PIPELINES FOR A HIGHER OPERATING PRESSURE

The qualification of existing piping systems for an operating pressure higher than the previously established operating pressure should be performed in accordance with ASME B31.4 and any applicable governmental regulations.

[1] *Charter and Bylaws of the American Petroleum Institute*. American Petroleum Institute, Washington, D.C., April 3, 1991.

[2] American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017.

[3] U.S. Department of Transportation. The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402.

2.3 Test Medium

A hydrostatic test should be conducted with water; however, liquid petroleum that does not vaporize rapidly at atmospheric pressure may be used as the test medium if the pipelines are not offshore and if the following conditions are met:

a. The entire pipeline section to be tested is outside of cities and other populated areas.
b. Every building within 300 feet (92 meters) of the test section is unoccupied while the test pressure is greater than or equal to a pressure that produces a hoop stress of 50 percent of the specified minimum yield strength.
c. The test section is kept under surveillance by regular patrol during the test.
d. Continuous communication is maintained along the entire test section.

2.4 Equipment for a Hydrostatic Test

Equipment for a hydrostatic test should be properly selected, and it should be in working order. The measurement equipment should be designed to measure the pressures expected during the hydrostatic test. The following equipment may be required for a hydrostatic test:

a. A high-volume pump that *fills* the line, ensures adequate pressure to overcome head, maintains sufficient velocity to move debris, minimizes interfaces, ensures turbulent flow, and keeps any pigs moving.
b. A test medium supply line filter that ensures a clean test medium.
c. An injection pump that introduces corrosion inhibitors, leak detection dyes or gasses, or other chemicals into the test segment if their use is desired.
d. A meter for measuring line fill or a comparable means of measuring it.
e. A variable speed, positive displacement pump that pressurizes the line to a suitable or appropriate level that exceeds the specified test pressure. The pump should have a known volume per stroke and should be equipped with a stroke counter. (A constant-speed pump with a variable flow rate control may be used in lieu of the above if the liquid test medium injected into the pipeline is measured during pressurization.)
f. A relief valve. This may be included to prevent overpressure of the test segment during both the pressurizing activities and the test.
g. A portable tank. The liquid test medium may need to be provided in one.
h. A pressure sensing and display device that has the pressure range and increment divisions necessary to indicate anticipated test pressures.
i. A deadweight tester or an equivalent pressure sensing device that is certified for accuracy and capable of measuring in increments of less than or equal to 1.5 pounds per square inch (10 kilopascals).
j. A continuous-recording pressure measurement device that provides a permanent record of pressure versus time. This device should be calibrated immediately before and after use or calibrated in accordance with manufacturers' recommendations.
k. A test medium temperature sensing and display instrument that is properly calibrated with a 3-inch (75-millimeter) immersion capability and a range suitable for anticipated temperatures and is incremented in divisions less than or equal to 0.2°F (0.1°C).
l. A continuous-recording temperature measurement device that provides a permanent record of temperature versus time.
m. Facilities that protect all instrumentation from weather extremes.
n. Equipment that records ambient temperature.
o. Computerized pressure/temperature monitoring and recording systems that assist in the analysis of test data. Such systems can be used in lieu of the components listed above provided that the individual pressure sensors included in the systems have a level of sensitivity and can be field calibrated in a manner similar to those instruments listed in Items a through m above.
p. Pigs, scrapers, spheres, and similar devices that clean the test segment and facilitate the removal of air from the line.
q. Temporary manifolds and connections, as needed.
r. Equipment, materials, and fluids that are needed to displace the test medium from the test segments.
s. Communication equipment that is adequate for coordinating test activities.
t. Equipment that isolates line segments for leak determination and facilitates repair.

CAUTION: If freeze plugs are used to isolate line segments, special handling techniques should be used to ensure personnel safety.

2.5 Test Plan

When planning a hydrostatic test, the following factors should be considered:

a. The maximum operating pressure anticipated for the life of the facility. When lines are tested at pressures that develop a hoop stress, based on nominal wall thickness, near the specified minimum yield strength of the pipe, special care shall be taken to prevent the pipe from overstraining.
b. Locations of the pipe and piping components in the test segment. Pipe and piping components should be located by their size, wall thickness, grade type, internal design pressure, and elevation profile.
c. The shell pressure and flange rating and the location of all pipeline valves, equipment, air vents, and other connections to the segment that will be exposed to the test pressure.

d. The anticipated temperature of the test medium, atmosphere, and ground and the temperature stabilization period of the test medium.
e. The test medium's primary and makeup sources and any inhibited or other treating requirements. State and local codes should be reviewed to determine if regulatory requirements for obtaining source water and for disposing of test water exist.
f. Sampling provisions to ensure (and to document) water quality before the line is filled and again before ultimate disposal occurs.
g. Locations and requirements for test medium disposal.
h. Profile and alignment drawing maps.
i. Safety precautions and procedures for personnel who perform the test.
j. A delineation of the responsibilities of various personnel in the testing organization, especially those who prepare documentation.
k. Precautions and procedures to minimize risk to the public and the environment, especially when a test medium besides water is to be used.
l. Notification of proper authorities, agencies, and potential emergency response personnel.
m. A plan for dealing with failures.
n. Methods for preserving failed specimens of pipe.
o. Hydrostatic proof test and pressure leak test acceptance criteria.

2.6 Test Procedure

Before testing begins, a hydrostatic test procedure with explanatory notes and data should be prepared. This detailed procedure should provide the following:

a. A diagram indicating the lengths, elevations, and locations of the test segments.
b. The test medium to be used and the line fill volumes.
c. Methods for cleaning and filling the line.
d. Methods for pressurizing the test segments. These methods should indicate the locations of the injection points and should provide the specified minimum and maximum test pressures.
e. Methods for isolating the test segments. These methods should indicate which blinds to install and which valves to remove.
f. The minimum test duration for test segments.
g. Methods for removing and disposing of the test medium.
h. Safety precautions and procedures.
i. An identification and a specification of the weakest link or controlling component in the test section.

A specified test pressure is the minimum test pressure that should be applied to the most elevated point in the test segment. A detailed analysis of the profile to determine what the static and dynamic pressures will be during the test should be performed so that the pipeline will not be overpressured at points that are at low elevations.

2.7 Line Fill and Cleaning

The line fill operation should perform two functions: It should clean the line, and it should introduce the necessary test medium into the test segment. A sizing scraper may be run to identify dents that may cause failures during testing or that may cause the filling pigs to become stuck.

Screens or filters may be installed in the test medium supply line to prevent the test medium from becoming contaminated by debris or sediment. The number, sequence, and type of pigging devices to be used in the test should be specified in the test procedure.

If water is used as the test medium, its quality and source should be determined. Water that is not free of sediment and acid and may injure the pipe, valves, and equipment should not be used unless it is filtered and inhibited. The possible deleterious effect of additives or inhibitors on the processing of liquid petroleum to be transported should be investigated. If liquid petroleum is used as the test medium, the potential hazards to the public and the environment should be carefully considered, and appropriate precautions should be taken.

The filling operation should be planned and executed in a manner that prevents air from intruding into the test segment. If purging of trapped air becomes necessary, vents should be provided at appropriate locations on the test segment. Pumping of the test medium should continue until the pigging devices have been received at the receiving scraper trap or until they have passed the block valve terminating the test segment. Tracking pigs may be useful in locating interfaces or stuck pigs.

The below-ground test segment should be backfilled insofar as practicable before pressurization. The sensor of the recording temperature device should be installed so that it is in contact with the pipeline at a point where it has normal cover. The backfill around the recording temperature device sensor should be tamped. The hydrostatic test period should not begin until the temperature of the filled pipeline has stabilized. Large centrifugal pumps and storage tanks will affect the temperature of the test medium. The temperature of the buried line should be recorded until the hydrostatic test is completed.

2.8 Conducting the Hydrostatic Test

2.8.1 PRESSURIZATION

Note: Personnel conducting the test should maintain continuous surveillance over the operation and ensure that it is carefully controlled.

The test segment should be pressurized at a moderate and constant rate. When approximately 70 percent of the specified test pressure is reached, the pumping rate should be

regulated to minimize pressure variations. The rate should also be regulated to ensure that increments no greater than 10 pounds per square inch (70 kilopascals) may be accurately read and recorded. The pressure measurement recording device should be installed in parallel with the deadweight tester or its equivalent and should be checked with the tester at regular intervals during the testing period. The pressure and temperature recording devices should be set to local time and should be connected throughout the final pressurization and testing period. The pressure sensing and display device only provides approximations of the pressure and helps to maintain continuity of pressure, and its readings need not be recorded. Pipe connections should be periodically checked for leaks during pressurization.

2.8.2 THE TEST PERIOD

When the test pressure is reached, pumping should be stopped, and all valves and connections to the line should be inspected for leakage. After inspecting for leakage, personnel should take the time to verify that the specified test pressure is being maintained and temperatures have stabilized. When this verification procedure has been completed, the injection pump should be disconnected, or its connection to the pipeline should be checked for leakage. The test period should begin after the injection pump has been disconnected or its connection has been checked. The duration of the test period should be in accordance with ASME B31.4 and 49 *Code of Federal Regulations* Part 195.

Pressure should be continuously monitored during the test, and all of the pressure readings should be recorded. Deadweight tester checks should be made at the beginning of the test, periodically during the test, and at the end of the test. The results of the deadweight tester checks and hourly temperature readings should be recorded on an appropriate form. Weather changes, such as the development of rain or clouds, that could affect the pressure and temperature recording charts should be noted. Any added or subtracted test medium should be accounted for in the assessment of the results of the hydrostatic test.

2.8.3 HYDROSTATIC TEST RECORDS

Personnel conducting a hydrostatic test should keep a complete record of the test, and any failures that occur during the test should be described in this record. The record should indicate the exact location of each failure, describe the type of failure and its cause, and describe the method of repair. Pipe, fittings, or valves that fail and are replaced should be marked with their pipeline station location and the pressure at which they failed. When appropriate, such materials should be preserved by the operator for failure analysis.

Records of hydrostatic tests are to be maintained by the operator to comply with the requirements of ASME B31.4, 49 *Code of Federal Regulations* Part 195, and all other applicable governmental regulations. Test records may include but are not necessarily limited to the following:

a. Continuous pressure versus time record with appropriate information listed on it. (see Figure A-1 in the Appendix).
b. Continuous temperature versus time record with appropriate information listed on it (see Figure A-2).
c. Test instrument calibration data.
d. Test plan (see 2.5).
e. Hydrostatic test record and certification (see Figure A-3) that includes the following:
   1. Qualification calculations (see Figure A-4).
   2. Pressure and temperature log (see Figure A-5).
   3. Record of the failures that occurred during the test and the reason for the failures (see Figure A-6).
   4. Profile of the pipeline that shows the elevation and test sites over the entire length of the test section if elevation differences in the test section exceed 100 feet (30 meters).

These test records should be signed by the responsible parties and retained for the life of the facility or until new test records supersede them.

2.9 Displacement of Test Medium

A carrier may choose to displace test water with liquid petroleum. If the carrier so chooses, the carrier should specify that the test water be left in the line under sufficient pressure to pack the line.

Water may be displaced with spheres, squeegees, or other pigging devices. When the water is displaced, it should be disposed of in accordance with all applicable government environmental regulations. It should be noted, though, that all of the test water may have to be stored until permits are received for ultimate disposal.

APPENDIX—TEST RECORDS

SAMPLE PRESSURE RECORD

Company _____
System _____

Description of Instrument (make/model) _____
Serial Number of Instrument _____
Test Section No. _____ _____ miles
MP _____ to MP _____ Station No. _____ to Station No. _____
Location of Chart Recorder MP _____ Station No. _____
Start: Time _____ Date _____
End: Time _____ Date _____
Contractor Rep. _____ Title _____ Date _____
Pipeline Company Rep. _____ Title _____ Date _____
Project Engineer _____ Date _____

Notes:
1. MP = mile post.
2. This pressure information should be included on the permanent record of pressure versus time. Placing this information on a stick-on label and sticking the label to the permanent record might be considered.

Figure A-1—Sample Pressure Record

SAMPLE TEMPERATURE RECORD

Company _____
System _____

Description of Instrument (make/model) _____
Serial Number of Instrument _____
Test Section No. _____ _____ miles
MP _____ to MP _____ Station No. _____ to Station No. _____
Location of Chart Recorder MP _____ Station No. _____
Start: Time _____ Date _____
End: Time _____ Date _____
Contractor Rep. _____ Title _____ Date _____
Pipeline Company Rep. _____ Title _____ Date _____
Project Engineer _____ Date _____

Notes:
1. MP = mile post.
2. This temperature information should be included on the permanent record of temperature versus time. Placing this information on a stick-on label and sticking the label to the permanent record might be considered.

Figure A-2—Sample Temperature Record

SAMPLE HYDROSTATIC TEST RECORD AND CERTIFICATION

Test Section _____
Date _____

Company _____ System _____
Description from _____ to _____
New Construction O
Requalification O Replacement or Relocation O Pipeline O Station O
Test Medium: Water O Other _____ Inhibitor _____
Design Data Code: O B31.4 O B31.8 O Other _____

Pipe Design Data

Specification and Grade	Weld Joint Factor	Design Factor	OD	Wall Thickness	SMYS	Design Pressure	Comments

Pressure Test:
Test pressure should be as follows:
_____ Minimum at high point _____ %SMY _____ Maximum at low point _____ %SMY

Elevations: Low point _____ High point _____ DWT _____

Qualification:
Date of test _____ Duration of test _____
Testing and recording witnessed by _____ Date _____
Company _____ Title _____
Company representative _____ Title _____

Testing Pressure:
Maximum at low point _____ for %SMYS _____
Minimum at high point _____ for %SMYS _____
Qualified to operate at _____ for %SMYS _____
Report checked by _____ Date _____
Approved by _____ Title _____
Testing Company _____

Attached Documents:
Pressure Record O Pressure and Temperature Log O Temperature Record O
Test Instrument Calibration Data O Sketch or Diagram O Qualification Calculations O
Profile O Failure Records O

Comments:
_____
_____
_____
_____

Notes:
1. OD = outside diameter, SMYS = specified minimum yield strength, SMY = specified minimum yield, DWT = deadweight tester.
2. For test sections containing more than one type of pipe, the maximum test pressure at low point and minimum test pressure at high point and resulting specified minimum yield strength need to be calculated for each type of pipe.

Figure A-3—Sample Hydrostatic Test Record and Certification

SAMPLE QUALIFICATION CALCULATIONS

Company _____

System _____

Pipeline Data (at controlling location) _____ OD _____ _____ WT Specification

Internal Pressure at SMYS _____ psi

Test Medium: Fresh water? (Yes, at 0.433 psi/ft) (No) Other _____ at _____ psi/ft

Design Test Pressure: Maximum _____ psi Minimum _____ psi

Test Section Number _____

From Station _____ (MP _____) to Station _____ (MP _____)

Time and Dates: From _____ hours _____ to _____ hours _____

(Time) (Date) (Time) (Date)

Deadweight Tester Data

Location: Station _____ (MP _____) Elevation _____ ft

Tester Pressure: Beginning _____ psi Ending _____ psi Minimum _____ psi

Acceptable? (Yes) (No)

Use tester pressure of _____ psi at Station _____ Elevation _____

(P) (E)

Minimum Pressure in Test Section[a]	Maximum Pressure in Test Section[a]
Highest elevation in test section _____ ft (H)	Lowest elevation in test section _____ ft (L)
Location: Station _____ (MP _____)	Location: Station _____ (MP _____)
Difference in elevation from tester:	Difference in elevation from tester:
_____ (H) – _____ (E) = _____ (H) – (E) ft	_____ (E) – _____ (L) = _____ (E) – (L) ft
Pressure at highest elevation:	Pressure at lowest elevation:
= Tester pressure – (Difference in elevation x psi/ft)	= Tester pressure + (Difference in elevation x psi/ft)
= _____ (P) – (_____ (H) – (E) x _____)	= _____ (P) + (_____ (E) – (L) x _____)
= _____ = Minimum test pressure	= _____ = Maximum test pressure
= _____ %SMYS	= _____ %SMYS

Maximum allowable operating pressure in this test section = 72%SMYS = _____ psi or

80% minimum test pressure = _____ psi

or controlling component _____ (circle whichever is lowest).

Calculated by _____ Approved by _____

Remarks _____

_____ Date _____

Notes: OD = outside diameter, WT = wall thickness, SMYS = specified minimum yield strength, MP = mile post, P = pressure, E = elevation, H = highest, L = lowest.

[a]For test sections containing more than one type of pipe, the 72-percent specified minimum yield strength minimum test pressure and resulting percentage of specified minimum yield strength need to be calculated for each type of pipe and used in determining the maximum allowable operating pressure.

Figure A-4—Sample Qualification Calculations

SAMPLE PRESSURE AND TEMPERATURE LOG

Company _____
System _____

Test Section No. _____ From Station No. _____ MP _____
to Station No. _____ MP _____
Pressure/Temperature Sensor Station No. _____
Start of Test Period: Time _____ Date _____
End of Test Period: Time _____ Date _____

No.	Time	Pressure (psig)	Pipe Temp.	Ambient Temp.	No.	Time	Pressure (psig)	Pipe Temp.	Ambient Temp.
1.					25.				
2.					26.				
3.					27.				
4.					28.				
5.					29.				
6.					30.				
7.					31.				
8.					32.				
9.					33.				
10.					34.				
11.					35.				
12.					36.				
13.					37.				
14.					38.				
15.					39.				
16.					40.				
17.					41.				
18.					42.				
19.					43.				
20.					44.				
21.					45.				
22.					46.				
23.					47.				
24.					48.				

Figure A-5—Sample Pressure and Temperature Log

SAMPLE HYDROSTATIC TEST RECORD OF FAILURE

Company _____

System _____

Line Section _____

From Station No. _____ to Station No. _____

Date	Time	Leak Station No.	Leak Elevation	Leak (psi)	Deadweight Elevation	Deadweight (psi)	Deadweight Station	Failure Description

Figure A-6—Sample Hydrostatic Test Record of Failure

Order No. 831-11100

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