

Pipeline Hydrostatic Testing

STD.4507

Scope

This standard defines requirements for pressure testing of new and existing pipelines, pump stations, terminals, and other related pipeline facilities to substantiate the Maximum Allowable Operating Pressure (MAOP) or the Maximum Operating Pressure (MOP), and to assist in verifying the integrity of steel pipelines.

TABLE OF CONTENTS

1.0	REFERENCES	3
2.0	DEFINITIONS AND ABBREVIATIONS	4
3.0	APPLICABILITY AND FREQUENCY	5
4.0	SAFETY	5
5.0	WRITTEN PLAN	6
6.0	PRESSURE TEST EQUIPMENT	7
7.0	PERMITS	10
8.0	HYDROSTATIC TEST FIELD ACTIVITIES	10
9.0	STROKE-PRESSURE PLOT	14
10.0	PRESSURE-TEMPERATURE-VOLUME RELATIONSHIPS	16
11.0	STATIONS AND TERMINALS.....	16
12.0	PRETEST AND ABOVEGROUND TEST	17
13.0	ACCEPTABLE TEST REQUIREMENTS	18
14.0	PNEUMATIC TESTING.....	19
15.0	RECORD KEEPING.....	19
	APPENDIX A.....	21
	APPENDIX B.....	23

1.0 REFERENCES

1.1. Pipeline and Hazardous Materials Safety Administration (PHMSA)

49 CFR 192	Transportation of Natural and Other Gas by Pipeline
49 CFR 195	Transportation of Hazardous Liquids by Pipeline

1.2. American Society of Mechanical Engineers (ASME)

ASME B16.5-2009	Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard
ASME B31.4-2006	Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids
ASME B31.8-2007	Gas Transmission and Distribution Piping Systems

1.3. American Petroleum Institute (API)

API 6D	Specification for Pipeline Valves, 23 rd Edition (includes Errata 1 – June 2008, Errata 2 – November 2008, Errata 3 – February 2009, Errata 4 – April 2010, Errata 5 – November 2010, Errata 6 – August 2011, Addendum 1 – October 2009, Addendum 2 – August 2011, Addendum 3 – October 2012)
API RP 1110	Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids, Highly Volatile Liquids or Carbon Dioxide, Fifth Edition

1.4. Enterprise Standards, Specifications, and Procedures

STD.0002	Administration of Engineering Standards and Specifications, Section 9.0 Specification Waivers
STD.0250	Project Records Management
STD.9006	Pipeline Defect Evaluation and Repair Procedure
ENG-LAB-01	Metallurgical Laboratory Protocol for Analysis of Failures, Flaws, and Fractures
PRA-WW-5a	Hydrostatic Test Discharge Permitting – Pipelines
Enterprise Safety Policies Manual Section 6.3	Preparation of Pipeline Equipment and Systems for Repair and Maintenance

Gas Operations and Maintenance (O&M) Manual Section 1501	Purging
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1.5. Other References

AS/NZS 2885.5:2002	Australian/New Zealand Standard: Pipelines – Gas and Liquid Petroleum, Part 5: Field Pressure Testing
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2.0 DEFINITIONS AND ABBREVIATIONS

Company	Enterprise Products Company
Contractor	Any entity contracted by Enterprise Products Company to perform a pressure test or pressure test activities
Enterprise	Enterprise Products Company
ERW	Electric Resistance Weld (pipe)
°F	degree Fahrenheit (temperature)
MAOP	Maximum Allowable Operating Pressure
MOP	Maximum Operating Pressure
NDE	Non-destructive Examination
NIST	National Institute of Standards and Technology
PSIG	Pounds Per Square Inch Gauge
Shall	Indicates provisions that are mandatory.
Should	Indicates provisions that are recommended but not mandatory.
SMYS	Specified Minimum Yield Strength
Stabilization	A period of time after the pipeline is completely filled, but before the pressure is increased to test pressure to allow the pressure and temperature in the test section to achieve steady-state. This is generally the time after the fill pumps are shut down and while the pressure pumps are readied for service and/or immediately after reaching test pressure.
Double Deviation	Yield for unidentified or used pipe is determined by using the pressure at the highest elevation within a test section, at which the number of pump strokes (measured volume) per increment of pressure rise becomes twice the number of pump strokes (measured volume) per increment of pressure rise that was

	required during the straight-line part of the pressure-volume plot before any deviation occurs.
Company Representative	The Company Representative is assigned by the Company, usually the Project Manager or Project Manager's designee.
Test Director	The Test Director is assigned by the Company, usually the project engineer.

3.0 APPLICABILITY AND FREQUENCY

- (1) This standard is not intended to apply retroactively. Hydrostatic testing to be performed after the date on which this standard was adopted shall meet the requirements of this standard.
- (2) No Enterprise facility may be placed in pressure service without first having been tested in accordance with this procedure. However, pressure testing is not required for an individual component—other than pipe—that is added or replaced as long as the manufacturer certified either:
 - a. The component was hydrostatically tested to at least the minimum test pressure required below; or
 - b. The component was manufactured using a quality control system ensuring each item manufactured is at least equal in strength to a prototype that was tested to at least the minimum test pressure required below.
- (3) Pressure testing shall be performed:
 - a. Before placing in operation any new pipeline(s), pipeline facilities, replacement pipe, or fabrications used in pressurized service.
 - b. When qualifying a pipeline and associated facilities for a new or higher MAOP/MOP, and the pipeline's ability to withstand this pressure has not been verified or integrity verification is required.
 - c. As part of a conversion of service, prior to reinstating to service pipelines or facilities previously abandoned.
 - d. Prior to reinstating to service pipelines or facilities previously decommissioned, and the period of time decommissioned exceeds the recommended integrity reassessment date.
 - e. When the MAOP is to be requalified because of increases in class location in a gas pipeline and previous hydrotests were not sufficiently high for the new class location.

4.0 SAFETY

- (1) Personnel safety and environmental concerns shall be considered during the planning and during all phases of a pressure test.
- (2) No personnel shall be in the ditch during pressuring or within the testing area if the pressure is above 50 percent of SMYS.

- (3) There shall be no public/contractor personnel or equipment working over a test section after the test pressure has exceeded the operating pressure.
- (4) Test equipment and personnel shall be positioned to minimize potential hazards. Typical positioning should include a barrier between the test equipment and test manifold and/or placement of test equipment a minimum distance of 50 feet from the test manifold. Personnel performing the test should approach the pressured line only in the performance of their duties.
- (5) Local authorities, governmental agencies, potential emergency response personnel, and landowners along the right-of-way should be notified as applicable prior to the test.
- (6) Provide and maintain reliable communication equipment during pressure testing so that all personnel directly involved may communicate.
- (7) All pressure must be reduced to static pressure and verified prior to tightening of flanges or screwed fittings. Consideration must be made for the effects of check valves and trapped pressure.
- (8) When filling, if high pressure hose is not used, adequate support and bracing shall be provided for the rigid piping used in connecting to the facility to be tested to avoid whipping.
- (9) After the test is complete, adequate support and bracing shall be provided for the dewatering line, and extreme caution shall be taken when deflectors such as ells are used.
- (10) When required, an enclosed, lighted, heated, and/or air-conditioned shelter sized to house test recording equipment and test personnel at the data procurement site of each test section shall be provided. Adequate lighting shall be available for testing operations performed at night.

5.0 WRITTEN PLAN

Before any Enterprise facilities are pressure tested, a written hydrostatic testing plan shall be developed and approved by Enterprise. The plan will, at minimum, cover the following topics as applicable.

5.1. Materials and Strengths

- (1) List the materials and components to be tested and their rated strengths.
- (2) Provide a sketch of the facility to be tested (unless straight pipe).
- (3) Valves open/closed positions, within the scope of the test, are to be verified and marked on the P&ID.

5.2. Test Pressure and Duration

- (1) Determine the maximum and minimum test pressure and the duration.
- (2) Consider elevation changes – create a profile if elevations change more than 100 ft.
- (3) Refer to Appendix A for test pressure ranges and duration.

5.3. Test Medium, Source, and Disposal Methods

- (1) Describe the test medium to be used.

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- (2) Describe the source of the test medium.
 - (3) Describe line cleaning requirements.
 - (4) Describe how the test medium will be disposed after testing is completed.

5.4. Safety

Describe the safety procedures to be used during filling, testing, and dewatering. Consider company employees, contractors, and the general public as applicable.

5.5. Test Equipment

Describe the equipment required to acquire the data (fill volume, pressure, temperature, etc.).

5.6. Filling and Pressurizing

- (1) Describe how the facility to be tested will be filled and how the pressure will be increased from atmospheric to final test pressure.
- (2) Determine if a stroke-pressure plot is necessary.

5.7. Test Procedure

Describe how the test will be performed, including the necessity to perform stroke pressure graphs, the rate of pressure increases, stops for leak checks, etc.

5.8. Dewatering, Drying and Cleaning

Describe how the facility will be dewatered, dried, and cleaned after testing and what will be done to minimize contamination or corrosion if it will not be placed in service within one week of testing.

5.9. Permits

Describe any permits necessary to obtain fill water and dispose of the test water or medium.

6.0 PRESSURE TEST EQUIPMENT

The following is a comprehensive list of equipment and materials needed for a pressure test utilizing water as the test medium. Not all items will be required for each test.

6.1. Deadweight Pressure Gauges

The deadweight gauges shall be the prime source of monitoring pressure throughout the hydrostatic test. Accurate dead weight(s) shall be used to measure test pressures. Dead weights must have been certified for accuracy within the past 12 months by an independent testing laboratory. The accuracy of the deadweight gauges at the time of certification shall be at a minimum ± 0.1 percent of the indicated pressure, traceable to NIST Standards. The serial number shall be clearly indicated on the deadweight gauges. The Contractor shall present certification documents to the Company Representative prior to testing.

6.2. Fill Pumps

The Contractor shall provide fill pumps, when required, that shall be of sufficient size and capacity to fill the test section in an efficient and timely manner that prevents the inclusion of air into the test section.

6.3. Flow Meter

The Contractor should provide a flow meter of type and capacity capable of measuring the maximum water fill rate.

6.4. Water Filter

- (1) The fill pumps shall be equipped with a filter system, if required by the Company, rated at sufficient capacity to accommodate the output of the fill pump and capable of removing 99 percent of all particles 100 microns in diameter or larger in size.
- (2) The filter system shall be equipped with valves, gauges, and fittings sufficient to allow any necessary backwashing, and to monitor the differential pressure across the filter and positive pressure on the discharge side of the filter.
- (3) Water suction lines shall also be equipped with a filter screen to ensure no solids or debris are introduced into the test section.

6.5. Pressure Pump and Stroke Counter

- (1) Pressure pumps shall be capable of attaining the desired test pressure and shall be capable of maintaining a pressure rise equivalent to 10 psig/minute or less. The pump unit driver shall have an efficient clutch, transmission, and throttle system capable of maintaining a constant volumetric injection.
- (2) Once the volumetric injection rate has been established, the pump shall be capable of maintaining this rate with only minor adjustments of the throttle.
- (3) The pressure pump shall be equipped with a suitable stroke counter with a manual reset switch and a tachometer. The stroke counter shall be located at the deadweight gauge location during the testing operation.
- (4) The pressure pump's serial number and capacity, in terms of gallons/stroke, shall be provided to the Test Director prior to testing.

6.6. Pressure Recorder

- (1) At least one 24-hour pressure recorder with a ten inch (minimum) circular chart or digital strip chart shall be used to maintain a continuous record of the pressure versus time during testing and must have been certified for accuracy within the past twelve months by an independent testing laboratory. When a possibility exists that the pressure recorder may malfunction while unattended during the test, a second recorder should be used in order to enhance the likelihood that at least one recorded pressure chart is available for documentation.

- (2) Certification documents shall be provided to the Company Representative by the Contractor prior to testing.
- (3) The serial number shall be clearly indicated on the pressure recorder.
- (4) Compare the pressure recorder reading with the pressure obtained from the deadweight gauge before recording test pressures and make note of any differences between the two pressure readings.
- (5) The recorder shall not be used as the prime source of the pressure readings.
- (6) The range of the chart must be compatible to the spring range of the instrument on which it is used.

6.7. Temperature Recorder

- (1) At least one temperature recorder shall be used to maintain a continuous record of the pipe temperature versus time during testing and must have been certified for accuracy within the past twelve months by an independent testing laboratory.
- (2) Certification documents shall be provided to the Company Representative by the Contractor prior to testing.
- (3) The temperature recorder(s) shall be located so that they will not be affected by the injection of water used to pressure the segment to be tested.
- (4) The temperature probe shall be taped to the pipe and connected to the temperature recorder. For below ground tests, the temperature probes shall be buried. For aboveground tests, appropriate measures shall be taken to ensure the temperature probe is insulated and shielded from ambient conditions to better reflect the temperature of the water in the pipe and not ambient temperatures.
- (5) When test water temperature is significantly different from ground temperature, consideration should be given to locating one recorder at each end of the segment being tested, and the bulbs insulated from the surrounding soil with a suitable insulation.
- (6) Compare the temperature recorder readings against a certified thermometer immediately before beginning the test and make note of any differences between the two temperature readings.
- (7) The serial number shall be clearly indicated on the temperature recorder.
- (8) Ambient temperature can be monitored using a test thermometer as long as it is of laboratory grade with a range from 0°F to 120°F, and have 1°F divisions. Keep the thermometer shaded.

6.8. Test Headers

Test manifolds used to pressure test Company pipeline facilities shall be fabricated in accordance to the following requirements:

- (1) Except as specified immediately below, the minimum wall thickness and yield strength of pipe and components used to fabricate test headers shall be designed such that the maximum test pressure experienced during facility testing does not exceed 80 percent of SMYS.

- (2) In instances where the proposed test pressure will exceed 80 percent of SMYS of the test headers, an initial pre-test shall be conducted on the entire test header to 100 percent of the test header's specified minimum yield strength (SMYS) for 30 minutes. Subsequent testing shall be at the discretion of the Company Representative, dependent upon the condition of the test manifold and verification of qualification documentation (Test, NDE, Welding, and Material Records).
- (3) A qualified welder using a qualified welding procedure shall weld all pressure piping related to the pressure test.
- (4) All butt and fillet welds shall be nondestructively tested in accordance with all applicable Enterprise NDE standards and procedures.
- (5) Test headers may also serve as fill and launching assemblies and must be designed to accommodate the size and number of pigs or squeegees specified in the test plan.

6.9. Test Water

The Company Representative will approve the source and disposal means of the test water with required permits (see section 7.0 of this standard).

6.10. Tracer

Consider adding fluorescent dye or sulfur hexafluoride (SF₆)—a colorless, odorless, non-toxic and non-flammable greenhouse gas—to the fill water to aid with locating of leaks.

7.0 PERMITS

Permits shall be acquired for the use and/or discharge of hydrostatic test water, per Enterprise Environmental Practice PRA-WW-5a *Hydrostatic Test Discharge Permitting – Pipelines* and all applicable Company procedures referenced therein.

8.0 HYDROSTATIC TEST FIELD ACTIVITIES

8.1. General

- (1) Test information generally required includes: the number of test sections, test section numbering, appropriate test pressure, tolerances, test duration, required acceptance criteria, outside diameter, wall thickness, grade, footage, engineering station numbers and/or mileposts for the entire pipe being tested, and the written test plan.
- (2) Prior to pressure testing, ensure that the test section has been isolated from all other piping components, that all valves in the test section are open (half or full as applicable), that check valves are pinned open or the clapper is removed; all flanged and screwed connections have been tightened; pressure and temperature recorders, deadweight gauge, and pressure pump are in proper working condition and functioning properly; the deadweight gauge is level, free spinning, and properly oiled; the spring range in each recorder is compatible with its chart; the pressure recorder is calibrated to the deadweight gauge and the temperature recorders are calibrated to the test thermometer.

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- (3) For existing liquids facilities, purging shall be performed per applicable Company procedures in Enterprise O&M Manual and/or Enterprise Safety Policies Manual.

8.2. Filling

- (1) Prior to filling the test section, ensure that valves, flanges, closures or bull plugs at the high point are set to an appropriate position (open, closed, or partially open) to bleed all air out during filling, and that all instrument tubing has been disconnected.
- (2) Fill water shall be obtained only from approved sources.
- (3) As per environmental permit requirements, arrange with an approved contract laboratory to collect a sample of the fill water prior to filling the test section. Requested analysis will be dependent on the state the test is being conducted in and if the section is new or used, as well as the final discharge water quality limitations.
- (4) Fill the pipeline section with water at a continuous rate. Should the fill stop at any time due to uncontrollable circumstances, the fill line shall be purged of air. Care shall be taken to ensure that no excess air is entrapped in the pipeline.
- (5) The pipeline and components shall be completely filled with clean water from a source approved by the Company, free of silt, trash, or any substance that might be injurious to the system.
- (6) All fill pump filter apparatus back flushing operations and test media shall be properly disposed of without damage to land or contamination to the water source. Monitor the gauges on the filter for any differential pressure across the filter and positive pressure on the discharge side of the filter.
- (7) Measure the quantity of fill water pumped into the pipeline. Consider monitoring the pressure and temperature of the test medium during the filling operation.
- (8) During the filling process, construct dewatering piping (but do not connect) and water and sediment containment/filtration facilities as provided in the water discharge permit.

8.3. Pressuring

- (1) Prior to pressuring, ensure that the public, environment and Company personnel are secured. The test area should be secured with visible tape or fence materials and with visible signs indicating hazardous area.
- (2) The stabilization period shall begin after the fill operation is complete. Sufficient time shall be allowed for the temperature of the pipe, test medium and backfill (if any) to become relatively stable. Verify stabilization by comparing temperature readings taken from the temperature probes at the pipe and in the ground. Verify that all valves and components are in the proper orientation prior to pressurization.
- (3) After the stabilization period, the test section shall be pressurized to the test pressure with caution, recognizing the possibility of failure of the piping or equipment or the potential over-pressurization of the pipe. Meter and record the volume of water pumped into the test section during pressurization.

- (4) For pipeline test sections which are not 100 percent visible for tests pressures above 90% SMYS, the Company Representative will make a plot of the pressure versus volume of water being injected into the test section. Refer to section 9.0 of this standard, *Stroke – Pressure Plot*.
- (5) Pressurize the pipeline at a uniform rate, which can be maintained until test pressure is reached, and at a reasonable rate which allows accurate pressure readings and proper collection of data. Any abrupt changes or breaks on the charts should be labeled as to the cause, at that point on the face of the chart. Pressure charts should have the dead weight pressures noted at the beginning and end of the test.

8.4. Pressure Test

- (1) Pressure shall be increased or decreased as necessary during the hold period in order to maintain the test pressure within the desired range as specified within the hydrostatic test plan. The pressure range specified by the Test Director shall be in accordance to the specified range provided in Appendix A. Pressure, time, and volume of water shall be recorded for any "bleeding-off" or re-pressuring along with applicable comments.
- (2) The test period begins when stabilization to the required target test pressure has been reached.
- (3) Determine the quantity (gallons or strokes) of water used for each re-pressure. The volumes of water added or removed to control test pressures shall be metered and recorded.
- (4) Test pressures and ambient temperatures should be recorded at approximately 15 minute intervals for the entire test period. All information shall be recorded in ink in a neat and legible manner on the Form 4507 (See Appendix B of this standard). The form shall incorporate all pertinent information relating to the particular test. During all phases of pressuring, repressuring, and bleeding, an accurate log of time, pressures, strokes, and temperatures shall also be recorded in a similar manner.
- (5) The pressure and temperature recorders shall be operated throughout the test period, including the pressuring, the test duration, and the bleed down.

8.5. Hydrostatic Test Failures

- (1) The failure location shall be secured by the Company Representative. No one shall be allowed into the immediate leak/rupture location until the Company Representative determines that it is safe to do so. Contact the Test Director in all instances.
- (2) An initial evaluation shall be conducted. The initial evaluation may consist of the following:
 - a. Visual inspection of the failure location to note general ROW condition, geographic characteristics of the location, and any unusual or possibly contributing factors such as: water accumulation, other pipelines/utilities in the area, highway crossings, indications of land movement, third-party equipment/activity in the area, and obstacles to excavation safety.
 - b. Visual and NDE inspection of the pipe/component at the failure location to note steel condition (corrosion attack, gouges, dents, discoloration, etc.), external coating condition (disbonded, damaged, missing, etc.), appearance of the leak/rupture (small hole,

longitudinal crack, circumferential crack, etc.), orientation of the leak/rupture (o'clock position), location of the leak/rupture (pipe body, longitudinal weld, girth weld, component body, etc.), any solids/liquids located around the pipe/component, and any solids/liquids inside the pipe/component.

- c. Photographic evidence should be collected to document the failure site and other pertinent details regarding the failure. This should be made in place before the sample has been removed from the ditch. Mark each photograph with the Line Name, Line ID No. and the Asmt No., as well as the date and time the photograph was taken.
- (3) Subsequent to the initial location evaluation, activities can begin to repair or replace the failed pipe/component. All repair activities should follow STD.9006 Pipeline Defect Evaluation and Repair Procedure.
 - (4) For pre-in service hydrostatic tests, all pipe failures must undergo a root cause failure analysis to include a metallurgical examination of the failed pipe.
 - (5) For in-service systems, metallurgical examination is required for hydrostatic test failures unless a waiver has been obtained and approved per Enterprise STD.0002 section 9.0 Specification Waivers.
 - (6) Metallurgical examinations of hydrostatic test failures must be performed at Enterprise-approved laboratories in accordance with Enterprise Pipeline Integrity Procedure ENG-LAB-01 Metallurgical Laboratory Protocol for Analysis of Failures, Flaws, and Fractures.
 - (7) All repair activities shall be documented utilizing the Enterprise Form 140 Maintenance Report form. (See Enterprise O&M Manual).
 - (8) All hydrostatic test failures shall be documented on Form 4507 (see Appendix B of this standard).

8.6. Depressurizing and Dewatering

- (1) The test section shall be bled down, slowly and carefully, after successful completion of the test period and acceptance of the test.
- (2) After completion and acceptance of tests, completely dewater the pipeline by:
 - a. Connecting the discharge/dewatering pipe to the mainline and securing it to prevent whipping after the test pressure has been bled off;
 - b. Where feasible, running a sufficient number of appropriate pipeline pigs;
 - c. Filtering the test water as required by permits and/or Right of Way special requirements;
 - d. Sampling the discharged water as required;
 - e. Draining all valves, sections of non piggable pipe, and other places where water may be trapped.

8.7. Cleaning and Drying

- (1) Air dry the pipeline by repeated passages of squeegees, running a train of drying pigs with dehumidified air from an air compressor, or as otherwise indicated in the scope of work. This process shall continue until there is no evidence of free water exiting from the test section and the exhausted air inside the pipeline should achieve a specified dew point of -38°F or at a humidity level as otherwise indicated in the scope of work.
- (2) The pipeline will be considered “clean and dry” when the required dew point has been achieved and dust penetration of 1/4 in. or less is visible in a foam pig.
- (3) Consider removing the air from the test section with a nitrogen purge. The air should be displaced with squeegees or pigs followed by the nitrogen, with the nitrogen left in the system having a pressure of 50 psig or less. The nitrogen injected into the system should be at a temperature greater than 40°F but less than 90°F and a pressure less than the MOP or MAOP of the system.
- (4) After cleaning and drying, pipeline should be tied-in, purged, and loaded, per the Company’s commissioning plan, as soon as practical.

9.0 STROKE-PRESSURE PLOT

- (1) The starting test pressure for preparing the stroke-pressure plot (if required per ASME B31.8 Appendix N) is at the discretion of the Testing Director; however, the starting test pressure for the plot shall begin prior or equal to 200 psig below the anticipated ending test pressure or after reaching 80% of the anticipated final test pressure. The test section is to be pressured with the pump operated continuously at the determined stroke rate. It is most important that full attention be given to maintaining a constant pump rate. Observation of a tachometer or counting strokes versus time and small throttle adjustments may be needed to achieve a constant rate. The constant rate shall be maintained throughout preparation of the stroke-pressure plot.
- (2) A continuous plot shall be made of pump stroke versus pressure during at least the last 200 psig of pressuring to the anticipated ending test pressure, after reaching 80% of the anticipated final test pressure, or if the pipe properties are unknown. The yield level is defined as that point along the stroke pressure plot at which the number of strokes per pound of pressure rise is equal to twice the number of strokes per pound of pressure rise experienced prior to initial deviation and the yield is determined by using the pressure at the highest elevation within the test section. (See Figure 1) Pump strokes in excess of that determined for a constant pressure rise could be indicative of a leak. Pump strokes versus pressure shall be indicated as a plot point at 10 psig intervals in whole multiples of 10. Stroke readings shall be indicated at each plot point. Time in hours, minutes, and seconds shall be indicated at the beginning and ending points as well as intermediate points at 50 psig intervals.
- (3) Gear ratios and throttle settings for the pressure pump should be set so that speed changes will not be necessary during the plot. The recommended rate of pressure increase during pressuring is 10 psig/minute or less.
- (4) The pressure pump should be stopped when double stroking occurs, or if a specified maximum test pressure is reached. If double stroking (yielding) occurs before the specified minimum test pressure

is reached, the Company Representative and the Test Director shall determine whether to proceed with increasing the pressure, revising the specified minimum test pressure to the double stroke pressure, or other alternatives such as running a post-test deformation smart pig to detect piping that has been expanded.

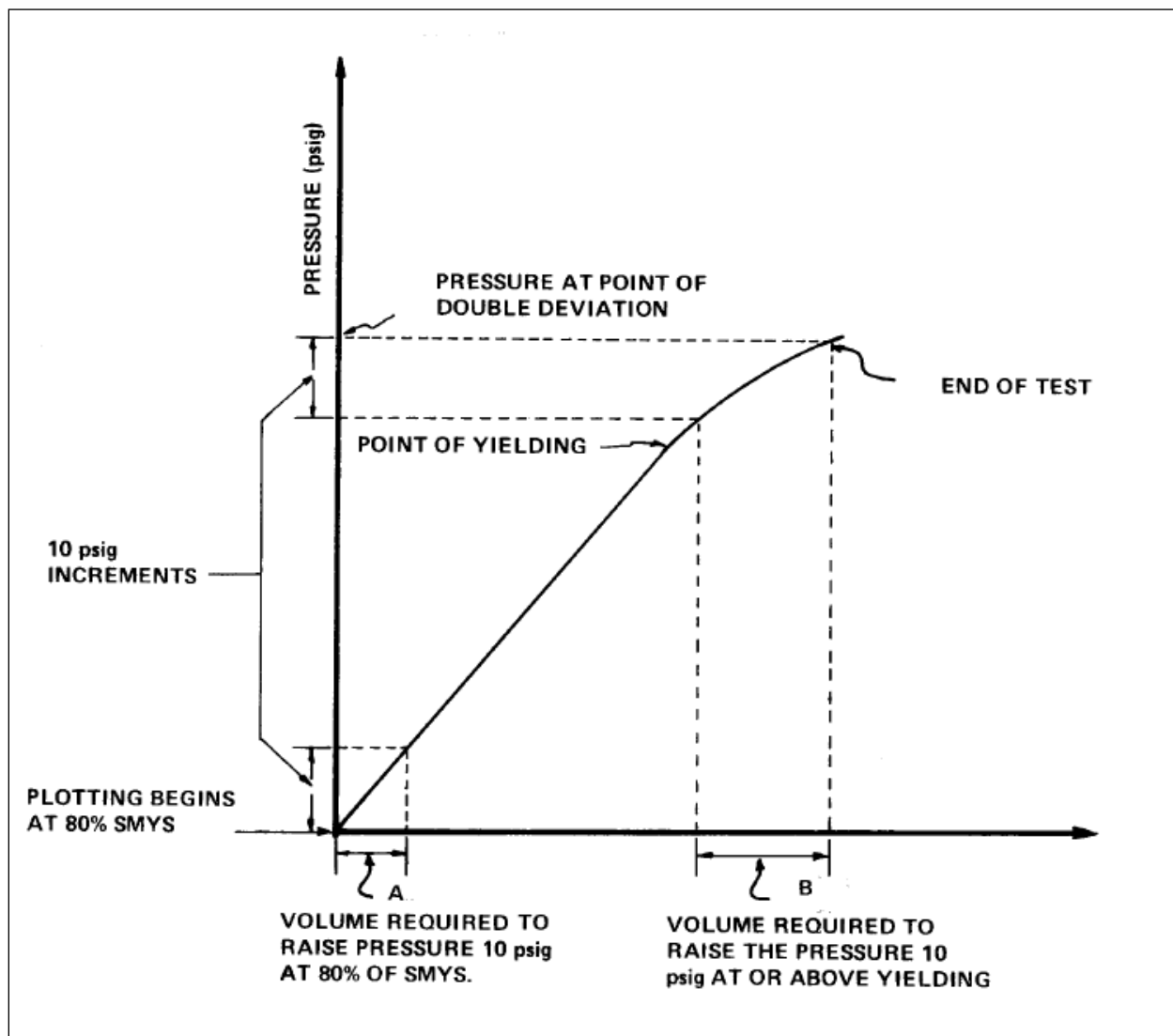


FIGURE 1: STRESS-STRAIN CURVE SHOWING YIELDING

10.0 PRESSURE-TEMPERATURE-VOLUME RELATIONSHIPS

Deviations in pressure, especially during the leak test phase of the pressure test, can sometimes be explained as a result of changes in the temperature of the environment. Refer to AS/NZS 2885.5:2002 *Australian/New Zealand Standard "Pipelines – Gas and Liquid Petroleum, Part 5: Field Pressure Testing"* for a method to determine the impact on pressure and volume due to variations in temperature.

11.0 STATIONS AND TERMINALS

- (1) The methods for filling station or terminal piping could be as numerous as the different configurations encountered. When filling station or terminal piping or pig traps piping, the best rule to follow is to use the lowest connection as the point of fill. A high point vent must also be identified to provide for complete venting of all entrapped air prior to starting the hydrostatic test.
- (2) The Test Director shall establish the maximum and minimum test pressure which shall be based on:
 - a. A test pressure calculated for an established pipe MOP or MAOP, or
 - b. As allowed by the ratings of components in the test sections such as valves, fittings, etc.
 - c. All test pressures are based on calculations using Barlow's Equation using the outside diameter, the nominal wall thickness, and the SMYS of the pipe. The maximum test pressure shall not exceed 90 percent of SMYS or component test ratings of valves, flanges, etc., whichever is less.

11.1. During the Test

- (1) Before pressurizing station or terminal piping, the Test Director or Company Representative shall ensure that the test section is securely isolated with blinds, skilllets, or plugs. Precautions shall be taken to ensure that the test will be conducted in a safe and workmanlike manner.
- (2) Pre-tested pipe must have the heat number, serial number, or manufacturer's unique identifier of each piece of pipe tested listed on the Pretested Pipe Tracking sheet of Form 4507. The total length for each joint shall support the sum of total length tested. All pretested pipe must be tracked to final disposition.
- (3) During initial pressurizing, determine and set a pump stroke rate which will pressure the test section at a constant stroke rate without lowering pump speed, change of pump speed, or changing gears during the pressuring operation. The rate of pressure rise should be less than 10 psig per minute. The final pump stroke rate and resulting rate of pressure rise shall have been finalized prior to and shall be used during the final pressuring in the region of 200 psig below the required test pressure.
- (4) When the pressurization of the test section has reached 60 to 80 percent of the test pressure, stop and hold the pressure for 15 minutes to allow for pressure equalization, to check for leaks, and to recheck instruments. During this leak test, the Test Director or Company Representative shall ensure that no leaks exist in the test section. The tight line leak test shall continue until all leaks have been stopped and no loss of pressure occurs for 15 consecutive minutes.
- (5) A Stroke-Pressure Plot will be created for all testing under this section whenever a yield test is required. Refer to section 9.0 of this standard for details.

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- (6) After the test pressure is reached, the time and pressure shall be recorded. These are the beginning time and pressure of the hold period. The minimum hold period shall be as indicated in Appendix A of this standard. The pressure during the hold period shall be the specified test pressure. During the hold period, the pressure shall be held between -0 and +15 psig of the specified test pressure, unless approval has otherwise been received from the Test Director. During the initial two hour period, the number of strokes to maintain the specified test pressure after 10 minutes, 30 minutes, 60 minutes, and 120 minutes shall be recorded. Ambient temperatures shall be recorded each half hour, beginning with initial pressuring and continuing for the duration of the hold period (i.e., till the end of the test).
- (7) All data shall be recorded on Form 4507. Pressures, temperatures, stroke counts, time, and all other data on the test section shall be clearly recorded, legibly and understandably. Each time the pressure is increased or decreased, the time and pressure shall be recorded before and after the change of pressure. The volume of water added or removed shall be either measured or calculated and recorded.

12.0 PRETEST AND ABOVEGROUND TEST

- (1) Some sections of the pipeline may require testing prior to installation. The pre-testing of such a section is necessary as it will be costly to gain access to this section to make repairs once it is permanently installed. Roadway, waterway, and railroad crossings are examples of pipeline sections that normally require pre-testing. The term pretest is used because the pipe segment, once installed, will be tested again with the connecting mainline or facility piping. An aboveground test has the same purpose of a pretest but differs in that it shall not be tested again with the interconnecting mainline or facility piping once installed. This type of test is used for pipe segments which will be installed in an existing pipeline or connection to an existing facility where the performance of a post installation hydrostatic test is not practical.
- (2) The Test Director shall determine the sections for pretest and aboveground test.
- (3) The pretest and aboveground test shall begin by filling the section of pipeline with water and, in doing so, making sure provision is made for the elimination of entrapped air by venting at the high elevation of the test section. Additionally, bleeding entrapped air out of hoses leading to instruments; i.e., deadweight gauge, recorders, prior to connecting hoses to said instruments shall be required.
- (4) The procedure for a pretest and the aboveground test, which follows, differs somewhat from that of a pipeline relocation or station and terminal test. However, the same care and precautions shall be exercised
- (5) The pretest or the aboveground test shall begin by pressurizing the pipeline section with water to a pressure equal to 60 to 80 percent of the final test pressure, allowing 15 minutes for pressure equalization, then checking for leaks. If the leaks cannot be stopped, bleed off pressure to atmospheric or a safe pressure and change out or repair the source of the leak. Once any leaks have been eliminated, continue pressurizing a pretest section to the required test pressure per Appendix A. Valves, fittings, etc., may be limiting components of the test. Form 4507 shall be used in monitoring the pretest and aboveground test. Test pressures and ambient temperatures should be recorded at

approximately 15 minute intervals for the entire test period. A record of bleeding off or pressuring up shall also be taken.

- (6) The minimum hold time shall be per applicable regulations (see Appendix A of this standard). The pressure variance shall be as specified in the hydrotest plan. If the Test Director is satisfied that no leaks exist, and can equate pressure rise or fall to temperature, the test may be accepted.
- (7) Dewatering shall be done by first bleeding the pressure off at either manifold. Environmental protection and safety is important in releasing the pressure and draining the water. Written permission or permits, as required, from state environmental agencies will be secured by the Company, per section 7.0 of this standard. In the event that the test medium must be discharged into vacuum trucks, provision must be maintained not to allow any of the test medium to flow into any watercourses, including ditches, or into environmentally sensitive areas. Provision must also be maintained to prevent erosion in the area of the discharge.
- (8) The test section shall be pigged, if required, during the dewatering stage to assure that all test water is removed. Especially in the case of the aboveground test, the test section shall be completely dewatered as this section will be tied into an existing facility or pipeline and will not be tested again as a pre-tested section would be.

13.0 ACCEPTABLE TEST REQUIREMENTS

- (1) An acceptable test will have been performed when the following conditions have been met:
 - a. The section has been maintained at the desired test pressure (in accordance with the hydrotest plan) for the required hold period.
 - b. No visible leakage occurs where the entire test section has been visually monitored during the required test period, and there is no unaccountable pressure loss when the test section is not under visual observation.
- (2) Once the test is complete, the Company Representative shall ensure that the test pressure and temperature log is reviewed by the Test Director for test approval. Depressurizing shall not begin prior to acceptance of the test by the Test Director.
- (3) For in-service pipelines, the Company Representative shall also ensure the hydrotest is reviewed and certified by a Professional Engineer (PE), unless a waiver has been obtained and approved, as per Enterprise STD.0002 section 9.0 *Specification Waivers*. This requirement does not apply to pre-testing of pipe or testing of newly fabricated segments.
 - a. The PE review will be performed as a project Quality Assurance/Quality Control and will most likely occur after the project field work has been completed. The PE review is not required prior to dewatering and placing the line back into service.
 - b. Upon completion of the PE review, the Company Representative and Test Director shall also perform a quality control review of the entire test package and any documents provided by the PE. Refer to section 15.1 of this standard for a list of items to be reviewed.
- (4) An approved specification waiver—per Enterprise STD.0002 Section 9.0—is required for exceptions to the above requirements for an acceptable pressure test.

14.0 PNEUMATIC TESTING

Pneumatic testing is not covered under this procedure and specification. See Enterprise STD.4403 *Pneumatic Testing of Piping* for pneumatic testing applicability and requirements.

15.0 RECORD KEEPING

A record of each pressure test performed, including records of unsuccessful attempts, shall be created and maintained for the useful life of the facility, as per Enterprise Standard STD.0250 *Project Records Management*. Only Enterprise approved forms shall be used. Forms shall be completely filled in and have the pressure and temperature recording charts attached. All forms must be properly signed and approved by the Test Director. The Project Name, Project Number, and Line Identification are to be included on ALL documentation. At a minimum, the following reports shall be provided:

15.1. Final Test Report

- (1) A final test report shall be prepared and filed, as per Enterprise Standard STD.0250 *Project Records Management*. The test report shall be retained for the useful life of the pipeline and shall include the originals of all test forms, recorder charts, etc. The Company's Test Director shall be responsible for documenting and filing the test reports and records.
- (2) The following information shall be included and clearly labeled with the test report:
 - a. Recorder serial number.
 - b. The original pressure chart shall be signed after successful completion of the test by the Company Representative present during the test.
 - c. AFE number and name of job.
 - d. Test reports on plants shall include a piping drawing showing what piping is included in each test.
 - e. Where elevation differences in the section under test exceed 100 ft, a profile of the pipeline that shows the elevation and test sites over the entire length of the test station.
 - f. Calibration data and independent party certification of test equipment.
 - g. Start time and date of "on" test with initial pressure.
 - h. End time and date of "off" test with final pressure.
 - i. Description of test section, to include pipe data and test section number.
 - j. Pressuring, leak test, start of plot (if applicable), and bleed down.
 - k. Test Site Location and Stations.
 - l. Pressure of any anomalies on chart with comment.
 - m. The name of the operator, the name of the person responsible for making the test and the name of the test company used (contractor – where applicable).
 - n. An explanation of any pressure discontinuities, including test failures.

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- o. In the case of a test failure, location, description, time and date of the failure, failure pressure, cause (if known), method of repair, any metallurgical analysis report, and disposition of failed pipe.
 - p. Description of the test medium, source of the test medium, and any additives used with it.
 - q. Other records as determined by the operator or required by regulation or law.
- (3) The following records should also be maintained with the test report following any pressure test:
- a. Sketch and/or profile drawing of the pipe or pipeline being tested, including equipment location and stationing.
 - b. ANSI rating for applicable pipeline components in the test segment.
 - c. Copies of pipe and fitting purchase orders, mill test records, or results of laboratory testing to confirm material composition
 - d. Straight-line plot of pump strokes per increment of pressure rise during pressurization.
 - e. Minimum and maximum test pressure and the locations of both in the test segment.
 - f. Physical description and location of the pressure-limiting component in the test segment.
 - g. Temperature log and continuous temperature chart, showing pipe or test medium temperature versus time.
 - h. Temperature log and continuous temperature chart, showing ambient temperature versus time.
 - i. Description of the weather during the test, including any changes.

15.2. Field Pressure Log

Company Form 4507 shall be signed after successful completion of the test by the Company Representative present during the test, thereby certifying that the hydrostatic test was conducted in accordance with this standard. The report must be filled out completely and shall include the disposition of any leaks or failures.

15.3. Fill Log

A record of water volume added to the pipeline during the filling process shall be maintained, if required by the permitting process.

15.4. Analytical Reports

All analytical laboratory reports and waste disposal records shall be maintained, as per Enterprise Standard STD.0250 *Project Records Management*, Enterprise Environmental Practice PRA-WW-5a *Hydrostatic Test Discharge Permitting – Pipelines*, and all applicable Company procedures referenced therein.

APPENDIX A

TEST PRESSURES AND DURATIONS

PRESSURE TEST SPECIFICATIONS FOR FACILITIES SUBJECT TO 49 CFR PART 192 REGULATIONS			
NEW CONSTRUCTION			
		PRESSURES	
FACILITY	DURATION*	MINIMUM	MAXIMUM[†]
Pipelines in Class 1 or 2 locations	8 hours	1.25 X MAOP	The lesser of 100% SMYS or double deviation
Pipelines in Class 3 or 4 locations	8 hours	1.5 X MAOP	The lesser of 100% SMYS or double deviation
Compressor station piping, metering facilities, offshore risers and storage field facilities	8 hours	1.5 X MAOP	The lesser of 100% SMYS or double deviation
Above Ground and Pretest	8 hours	1.5 X MAOP	The lesser of 100% SMYS or double deviation
Stations and Terminals	As Determined by the Test Director		
Pipelines Operating with an MAOP <30% of SMYS, at or above 100 psig	1 hour	1.5 X MAOP	The lesser of 100% SMYS or double deviation
Fabrications and short sections of pipe per 192.505(e)**	8 hours (4 hours with approval)	1.5 X MAOP	The lesser of 100% SMYS or double deviation
EXISTING FACILITIES			
		PRESSURES	
FACILITY	DURATION*	MINIMUM	MAXIMUM
Pipelines in Class 1 or 2 locations	8 hours	1.25 X MAOP	The lesser of 100% SMYS or double deviation
Pipelines in Class 3 or 4 locations, storage fields, facilities ^{††}	8 hours	1.5 X MAOP	The lesser of 100% SMYS or double deviation
Compressor station yard piping , metering facilities, and offshore risers	8 hours	1.5 X MAOP	The lesser of 100% SMYS or double deviation
Pipelines Operating with an MAOP <30% of SMYS, at or above 100 psig	1 hour	1.5 X MAOP	The lesser of 100% SMYS or double deviation
<p>* Test duration is a continuous hold period of the time interval indicated.</p> <p>** Test durations of less than 8 hours must be approved by the Enterprise Project Manager</p> <p>[†] Maximum pressures exceeding 100% SMYS require Engineering Senior Vice President approval</p> <p>^{††} For class upgrade testing to class 4 location, contact Enterprise Transportation Compliance department for test pressures</p>			

PRESSURE TEST SPECIFICATIONS FOR FACILITIES SUBJECT TO 49 CFR PART 195 REGULATIONS
NEW CONSTRUCTION and EXISTING FACILITIES

FACILITY	DURATION*	PRESSURES	
		MINIMUM	MAXIMUM
Pipelines, Meter Stations, and Fabrications ^{†††}	8 hours	1.25 X MOP	The lesser of 100% SMYS or double deviation
Above Ground and Pretest	4 hours	1.25 X MOP	The lesser of 100% SMYS or double deviation

^{†††} A component other than pipe does not need to be hydrotested if it is the only item being replaced or added to the pipeline system and complete records have been provided to confirm that the component was hydrostatically tested at the mill.

APPENDIX B

Form 4507



Microsoft Excel
97-2003 Worksheet

Attachment Revision Log/Record

Revision 0.0			Publish Date: 07 Sep 11
Location of Change	Type of Change	Reason for Change	
N/A	N/A		
Revision 1.0			Publish Date: 21 Sep 11
Location of Change	Type of Change	Reason for Change	
Section 8.6(2)	Revision	Clarification regarding density of foam pig	
Sections 9.0(1) and 9.0(2)	Deletion	Deleted language regarding Form 4507-B	
Section 10.0	Revision	Replaced reference to Appendix B with title of referenced publication	
Section 12.0(6)	Revision	Clarification of test duration for pretests and aboveground tests	
Appendix B	Addition	Inserted Form 4507 as an embedded MS Word file	
Sections 11.1(6), 11.2(2), 12.0(5), and 14.2	Revision	Revised "Form 4507-A" to "Form 4507"	
Revision 2.0			Publish Date: 16 Nov 11
Location of Change	Type of Change	Reason for Change	
Section 1.3	Addition	Added Enterprise standards and procedures to reference list	
Section 2.0	Revision	Edited definitions	
Section 3.0	Revision	Re-titled section "Applicability and Frequency;" Reworded several subsections to clarify requirements	
Section 3.0(1)	Addition	Added this section	
Section 4.0	Revision	Reworded several subsections to clarify requirements	
Section 5.3	Addition	Added "Describe line cleaning requirements"	
Section 6.0	Revision	Reworded several subsections to clarify requirements	

Section 7.0	Revision	Reworded section to reference Enterprise Environmental Practice PRA-WW-5a
Section 8.0	Revision	Reworded several subsections to clarify requirements
Section 8.0(3)	Addition	Added “For existing facilities, system should be purged prior to filling”
Section 9.0	Revision	Reworded several subsections to clarify requirements
Section 10.0	Revision	Added reference to AS/NZS 2885.5:2002
Section 11.0	Revision	Reworded several subsections to clarify requirements
Section 12.0	Revision	Reworded several subsections to clarify requirements
Section 13.0	Revision	Reworded several subsections to clarify requirements
Section 14.0	Revision	Added reference to Enterprise Standard STD.4403
Section 15.0	Revision	Reworded several subsections to clarify requirements
Throughout document	Revision	Converted bullet points to outline numbering/lettering
Appendix A	Revision	Edited facilities, duration, and pressure requirements
Appendix B	Revision	Inserted updated Form 4507 as an embedded MS Excel file
Revision 3.0		Publish Date: 05 Jun 12
Location of Change	Type of Change	Reason for Change
Appendix B	Revision	Inserted updated Form 4507 as an embedded MS Excel file. Refer to Form 4507 revision log for specific changes.
Revision 3.1		Publish Date: 06 Aug 12
Location of Change	Type of Change	Reason for Change
Section 6.7(3)	Addition	Added statement regarding steps to be taken when temperature probe cannot be buried.
Revision 4.0		Publish Date: 30 Nov 12
Location of Change	Type of Change	Reason for Change
Section 1.4	Addition	Added reference to Pipeline Integrity protocol for metallurgical testing

Section 3.0(1)	Correction	Grammatical correction
Section 4.0(4)	Revision	Revised distance between test equipment and manifold
Section 6.1	Revision	Revised to require deadweight pressure gauges
Section 6.3	Revision	Reworded to clarify requirements
Section 6.6(1)	Addition	Added option of using second pressure recorder
Section 6.6(4) and (5)	Revision	Reworded to clarify requirements
Section 6.7(1)	Addition	Added option of using second temperature recorder
Section 6.7(3)	Addition	Added requirement regarding position of temperature recorder
Section 6.7(4)	Revision	Revised to require temperature probes to be buried for below ground tests
Section 6.7(5)	Addition	Added requirement for situations where test water temperature is significantly different from ground temperature
Section 8.4(4)	Revision	Reworded for clarity
Section 8.5	Revision	Revised to incorporate metallurgical testing requirements
Section 8.6	Revision	Reworded to clarify requirements
Section 12.0(5)	Revision	Reworded for clarity
Section 13.0	Revision	Revised to incorporate approval process
Section 15.0	Revision	Revised to explicitly state that forms must be signed and approved by Test Director
Appendix B	Revision	Updated Form 4507
Revision 4.1		Publish Date: 18 Jun 13
Location of Change	Type of Change	Reason for Change
Appendix B	Revision	Updated Form 4507
Revision 4.2		Publish Date: 30 Apr 14
Location of Change	Type of Change	Reason for Change
Appendix A	Revision	Revised maximum test pressure requirements

Revision 4.3		Publish Date: 05 Feb 15
Location of Change	Type of Change	Reason for Change
Section 1.3	Update	Updated reference to API 6D to current edition incorporated by reference into 49 CFR 192 and 195
Section 3.0(7)	Addition	Reworded for clarity and a second sentence was added.
Section 4.1(1) and (3)	Addition	Added “and components” to existing sentence and added second sentence to account for the position of valves on the P&ID.
Section 5.6	Clarification	Clarified requirements for pressure recorder to be 1) certified for accuracy by an independent laboratory, and 2) calibrated against the deadweight gauge immediately before the pressure test.
Section 5.7	Clarification	Clarified requirements for temperature recorder to be 1) certified for accuracy by an independent laboratory, and 2) calibrated against a certified thermometer immediately before the pressure test.
Appendix A	Revision	Reworded for clarity
Appendix B	Revision	Revised to allow acceptance of 192.611 criteria. Added options for using design factor of 0.5 and 0.6 for liquid pipelines. For additional revision details see Appendix B Revision Log sheet.
Revision 4.4		Publish Date: 03 Mar 15
Location of Change	Type of Change	Reason for Change
TOC and All Sections	Update	Re-ordered the numbers in the TOC and the sections
Revision 4.5		Publish Date: 06 Mar 15
Location of Change	Type of Change	Reason for Change
Appendix B	Revision	Corrected logic to no longer apply 192.611 allowance to liquid pipelines using DF = 0.72.
Revision 4.6		Publish Date: 17 Sep 15
Location of Change	Type of Change	Reason for Change
Section 8.4(4)	Clarification	Added “See Appendix B of this standard” after “Form 4507”

Section 11.1(2)	Addition	Added section on tracking of pretested pipe, and renumbered following sections
Appendix B	Revision	Added notation to Pre-Approval sheet regarding requirement for Engineering SVP approval for pressure exceeding 100% SMYS; added "Maximum Actual Test Pressure" input box to Final Approval sheet and revised "Maximum Test Pressure" from this input box; added Pretested Pipe Tracking sheet.
Revision 4.7		Publish Date: 02 Oct 15
Location of Change	Type of Change	Reason for Change
Appendix B	Correction	Corrected formula error in cells K24:M25 on Final Approval worksheet
Revision 4.8		Publish Date: 05 Oct 15
Location of Change	Type of Change	Reason for Change
Appendix B	Correction	Corrected problem with document protection
Revision 4.9		Publish Date: 20 Oct 15
Location of Change	Type of Change	Reason for Change
Appendix B	Correction	Unlocked signature and date fields for "Witnessed by" on "Test Report" page
Revision 5.0		Publish Date: 04 Dec 18
Location of Change	Type of Change	Reason for Change
Appendix B	Revision	Added 0.84" OD & 1.05" OD to Component Properties Table – Drop Down List
Revision 5.1		Publish Date: 05 May 19
Location of Change	Type of Change	Reason for Change
Appendix B	Revision	Added 52"- 80" OD covered in API 5L and ASME B36.10M to Component Properties and Pre-Approval Table – Drop Down List
Revision 5.2		Publish Date: 03 Mar 20
Location of Change	Type of Change	Reason for Change



Appendix B	Revision	Added 5.563" OD to Component Properties and Pre-Approval Table – Drop Down List
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