

Australian Standard<sup>®</sup>

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**Pipelines—Gas and liquid  
petroleum—Field pressure testing**

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This Australian Standard was prepared by Committee ME/38, Gas and Liquid Petroleum Piping Systems. It was approved on behalf of the Council of the Standards Association of Australia on 30 July 1987 and published on 1 September 1987.

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The following interests are represented on Committee ME/38:

Australasian Corrosion Association  
Australasian Institute of Mining and Metallurgy  
Australian Gas Association  
Australian Institute for Non-Destructive Testing  
Australian Institute of Petroleum Ltd  
Australian Liquefied Petroleum Gas Association Ltd  
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Australian Standard<sup>®</sup>

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**PIPELINES—GAS AND LIQUID  
PETROLEUM—FIELD PRESSURE  
TESTING**

known as  
**SAA CODE FOR FIELD PRESSURE  
TESTING OF PIPELINES**

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## PREFACE

This Standard was prepared by the Association's Committee on Gas and Liquid Petroleum Piping Systems, to supersede AS 1978—1977, Rules for the Field Pressure Testing of Gas and Liquid Petroleum Land or Submarine Pipelines.

Among changes in this edition is the deletion of the maximum test pressure limit of 115 percent of SMYS where the maximum test pressure is unspecified in the application Standards.

Areas of conflict or omission between AS 1978 and the application Standards (AS 1958, AS 1697, and AS 2018) are resolved in either this Standard or the application Standard (AS 2885, Pipelines—Gas and Liquid Petroleum, a consolidation and revision of the three previously listed standards). Appendix A sets down the basis for this Standard, and provides commentary that the committee considered will be useful to users of this Standard.

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## STANDARDS ASSOCIATION OF AUSTRALIA

## Australian Standard

## PIPELINES—GAS AND LIQUID PETROLEUM—FIELD PRESSURE TESTING

## SECTION 1. SCOPE AND GENERAL

**1.1 SCOPE.** This Standard sets out two methods for the determination of the strength, and one method for the determination of the leak-tightness of a pipeline for the liquid phase or the gas phase of a petroleum product.

NOTE: Appendix B describes a test section of a hypothetical pipeline.

**1.2 APPLICATION.** This Standard is applicable to pipelines which comply with AS 2885. This Standard may be applied for pretesting of pipe and components and for testing sections of pipe separate from the field test (see Clause 4.3.2).

### 1.3 PURPOSE OF TESTS.

**1.3.1 Strength test.** The purpose of the strength test is to establish that a pipeline is capable of withstanding the pressure for which it is designed.

The test may also be used to—

- (a) measure certain mechanical properties of the test section or to relieve or reduce residual stress in the test section; and
- (b) determine the maximum allowable operating pressure (MAOP) of a pipeline.

**1.3.2 Leak test.** The purpose of the leak test is to establish that a pipeline complies with an agreed leak tightness.

### 1.4 DESIGNATION OF TEST METHODS.

**1.4.1 Strength tests.** The designation of a test method to determine strength shall be as follows:

- (a) Where the end point is determined from observations of the pressure of the test fluid added . . . . . pressure-controlled test.
- (b) Where the end point is determined from observations of the pressure and the volume of the test fluid . . . volume-strain controlled test.

**1.4.2 Leak-tightness.** The designation of the test method to determine leak-tightness under internal pressure shall be 'leak test'.

**1.5 REFERENCED DOCUMENTS.** The following Standards are referred to in this Standard:

|         |                                                                                      |
|---------|--------------------------------------------------------------------------------------|
| AS 1349 | Bourdon Tube Pressure and Vacuum Gauges.                                             |
| AS 1376 | Conversion Factors.                                                                  |
| AS 1514 | Glossary of Terms Used in Metrology, Part 1—General Terms and Definitions.           |
| AS 1855 | Methods for the Determination of Transverse Tensile Properties of Round Steel Pipes. |
| AS 2706 | Numerical Values—Rounding and Interpretation of Limiting Values.                     |
| AS 2885 | Pipelines—Gas and Liquid Petroleum.                                                  |
| API 5L  | Line Pipe.                                                                           |

**1.6 DEFINITIONS.** For the purpose of this Standard, the definitions given in AS 2885 and AS 1514, Part 1, and those below apply.

**1.6.1 Agreed test uncertainty**—the limiting value of test uncertainty in the test section that occurs during hold period which cannot be ascribed to known effects such as changes in temperature (see Appendix G).

**1.6.2 Approved and approval**—approved by the Operating Authority and including the approval obtained from the relevant Statutory Authority where this is a legal requirement. Approval is to be taken to require a conscious act and generally to be given in writing.

**1.6.3 Authority, Statutory**—the Commonwealth or State body empowered by an Act of Parliament to exercise jurisdiction over facilities within the scope of the standard.

**1.6.4 End-point**—that pressure at which the pumping is to cease.

**1.6.4.1 End-point, offset volume**—that pressure on the pressure/added volume plot at which the total added volume equals the sum of the volume required if the test section were wholly elastic, and a percentage of the calculated volume of the test section (see Appendix D), the zero pressure being measured at the highest elevation.

NOTE: Offset percentages of 0.2 and 0.4 are acceptable.

**1.6.4.2 End-point, half-slope**—that pressure on the pressure/added volume plot at which the slope (see Clause 1.6.15) is half that of the obviously elastic portion of the plot after the effects of residual air are overcome (see Appendix D).

NOTE: The added volume per unit pressure rise at this end point is double that of the obviously elastic portion of the plot after the effects of residual air are overcome.

**1.6.5 Hold period (hold time)**—that period during which the test pressure is maintained in a test.

**1.6.6 Industrial gauge**—a pressure gauge complying with the accuracy requirements specified in AS 1349 for an industrial gauge.

**1.6.7 Leak test**—a test carried out at a pre-determined pressure during which the leak-tightness is determined.

NOTE: The determination may be by visual means, or by calculation from any change in pressure.

**1.6.8 Pressure**—the pressure above atmospheric pressure, in megapascals, or where convenient, kilopascals, i.e. gauge pressure.

**1.6.9 Pressure change, agreed unaccountable**—that limiting value of pressure change in the test section occurring over a hold period and which cannot be ascribed to known effects, such as changes in temperatures.

**1.6.10 Pressure, mill test**—that pressure to which each length of pipe is subjected at the pipe manufacturer's works.

**1.6.11 Pressure strength (of a test section)**—the maximum successful test pressure recorded at the highest elevation in that test section.

**1.6.12 Pressure/added volume ( $p/V$ ) plot**—a graph of the pressure of the test liquid against the volume of liquid added to pressurize the test section, and drawn to scales which will enable the pressure to be read to 0.1% of that equivalent to specified minimum yield strength (SMYS) and the volume to be read to 0.1%.

**1.6.13 Residual air (air content)**—that volume of air trapped in the test section by the test liquid and referred to a pressure of 101.325 kPa absolute (1 atm).

**1.6.14 Shall and should**—'shall' is used to indicate that a provision is mandatory; 'should' is used to indicate that a provision is not mandatory but is advisory or recommended.

**1.6.15 Slope**—slope of a line on a pressure/added volume plot, typically expressed as litres per kilopascal.

**1.6.16 Strength test**—that part of the pressure test procedure that establishes the pressure strength of the test section.

**1.6.17 Test gauge**—a pressure gauge complying with the accuracy requirements specified in AS 1349 for a test gauge.

**1.6.18 Test program**—a written program, prepared before the test, which details the methods and procedures to be used.

**1.6.19 Test section**—that part of a pipeline subjected to testing as a unit.

**1.7 TESTING PERSONNEL.** The preparation of the test program and the assessment of the results of the tests shall be carried out by, or under the supervision of, an approved test engineer.

Tests shall be carried out by, or under the direction of, persons qualified by experience and training in the appropriate aspects of pipeline pressure testing.

**1.8 NOTATION.** Symbols are defined in the clause in which they are used.

**1.9 CONVERSION TO SI UNITS.** Where units other than SI units are used in other Standards, conversion to SI units shall be made in accordance with AS 1376.

Units shall be converted to SI units before any rounding.

**1.10 ROUNDING OF NUMBERS.** An observed or calculated value shall be rounded to the nearest unit in accordance with AS 2706, and for the purpose of assessing compliance with this Standard the specified limiting values herein shall be interpreted in accordance with the 'rounding method' described in AS 2706, i.e. the observed or calculated value shall be rounded to the same number of figures as in the specified limiting value and then compared with the specified limiting value. For example, for specified limiting values of 2.5, 2.50, and 2.500, the observed or calculated value would be rounded respectively to the nearest 0.1, 0.01, or 0.001. For examples of interpretation of specified values in accordance with the rounding method, see AS 2706.

## SECTION 2. EQUIPMENT AND TEST LIQUID

**2.1 SELECTION OF EQUIPMENT.** Equipments shall be appropriate to the test method and shall be selected from the following:

- (a) Deadweight testers for the appropriate pressure range.
- (b) Pressure gauges.
- (c) Pressure recorders.
- (d) Pressure transducers.
- (e) Volumetric measuring apparatus.
- (f) Temperature measuring apparatus.
- (g) Timing equipment.
- (h) Suitably sized graph paper.
- (j) Test record forms.

### 2.2 ACCURACY, SENSITIVITY, AND REPEATABILITY OF EQUIPMENT.

**2.2.1 General.** Instruments and equipment for measuring pressure, volume, and temperature shall be verified before the test as specified in this clause (2.2).

Indicated readings from verified instruments and equipment shall be used without correction.

**2.2.2 Pressure-measuring equipment.** Instruments and equipment for the measurement of pressure shall comply with the following:

- (a) *Pressure gauges.* Test grade and industrial grade pressure gauges shall comply with AS 1349. Test gauges shall be selected so that highest test pressure is between 50% and 90% of the scale range.
- (b) *Industrial grade gauges.*
  - (i) An industrial grade gauge may be used to measure pressures where the volume-strain controlled test is not required and where the strength test pressure exceeds the minimum test pressure by more than 5%, and it is safe to do so.
  - (ii) A gauge of accuracy not inferior to an industrial grade gauge, and with dial size 100 mm minimum shall be used for determination of the volume of residual air.
- (c) *Volume-strain controlled test.* Where a volume-strain controlled test is made, the pressure shall be measured by a deadweight tester, a pressure gauge, or a pressure recorder complying with the following:
  - (i) An accuracy of 0.25% of the scale range.
  - (ii) A sensitivity of 0.1% of the pressure equivalent to SMYS.
- (d) *Determination of MAOP.* Where the test pressure is to be used to determine the MAOP, and the provisions of Paragraph A5.3, Appendix A do not apply, accuracy of the deadweight tester or the test gauge shall be 0.25% of scale range.
- (e) *Leak tests.* The sensitivity of pressure-measuring instruments that are used to determine leak-tightness shall be better than 20% of the agreed unaccountable pressure change.

**2.2.3 Verification of pressure-measuring equipment.** The maximum period between verifications of equipment for measurement of pressure shall be as follows:

- (a) Industrial grade gauges—6 months.
  - (b) Test grade gauges—2 years.
  - (c) Deadweight testers—10 years.
- Industrial grade gauges shall be verified against a test grade gauge or deadweight tester.
- Records of verification tests shall be maintained.
- Test grade gauges which comply with AS 1349 and deadweight testers shall be deemed to have the required sensitivity and repeatability.

**2.2.4 Measurement of volume.** Instruments and equipment for the measurement of volume shall comply with the following:

- (a) *Volume-strain controlled test.*
    - (i) *Uniform pipeline.* For a uniform pipeline, the volume of liquid added or subtracted in a volume-strain controlled test shall be measured with equipment complying with the following:
      - A. Accuracy better than 1%.
      - B. Sensitivity better than 0.1% of the estimated volume of liquid required to produce a pressure equivalent to SMYS after filling has been completed. The sensitivity value shall be approved.
    - (ii) *Submarine and telescoped pipelines.* For a submarine pipeline or a telescoped pipeline, the measuring equipment shall comply with the following:
      - A. Accuracy better than 1%.
      - B. Sensitivity of an approved value.
- NOTE: Generally, the sensitivity required for submarine and telescoped pipelines will be greater than that for a uniform pipeline.
- (b) *Residual air.* Where residual air is to be determined from the observations of pressure and volume, and where the pressure does not exceed 2000 kPa, the equipment for measurement of volume shall be accurate to better than 2% of that volume which, when added, would produce a change in pressure of 1000 kPa.

- (c) *Pressurizing.* The counting of pumpstrokes shall not be used to determine the volume of test fluid added during pressurization.

**2.2.5 Verification of volume-measuring equipment.** The sensitivity and repeatability of equipment for the measurement of volume shall be verified, and subject to approval.

**2.2.6 Temperature-measuring equipment.** Instruments and equipment for the measurement of temperature shall comply with the following:

- (a) *Strength test.* For a strength test, the sensitivity and repeatability of the temperature-measuring equipment shall be approved.

The repeatability of liquid-in-glass and liquid-in-steel thermometers is deemed to be equal to their sensitivity. The repeatability of resistance, thermocouples and electronic temperature measuring devices shall be determined, and subject to approval.

- (b) **Leak test.** Where the agreed test uncertainty is 100 L per 24 hours, the equipment for measurement of temperature shall have a sensitivity and a repeatability of better than 0.1°C. Where the agreed test uncertainty is significantly less than 100 L per 24 hours, the equipment for measurement of temperature shall have a sensitivity equivalent to that of the equipment for measurement of pressure used to determine the agreed test uncertainty.

NOTE: The relationship between the change in temperature and change in pressure can be determined from the appropriate Equation (A1) or Equation (A2), and that between the change in volume and change in pressure from the appropriate Equation (C1) or Equation (C2) (see Appendices A and C).

### 2.3 COMMUNICATIONS AND TRANSPORT.

Adequate communication and transport systems shall be established and maintained for the duration of the test.

### 2.4 INSTALLATION AND LOCATION OF TEST EQUIPMENT.

**2.4.1 General.** Measuring equipment shall be installed and located to ensure that data obtained are representative.

Where necessary, precautions shall be taken to protect the equipment against adverse effects of weather.

**2.4.2 Pressure gauges.** Pressure gauges shall be installed in accordance with AS 1349.

**2.4.3 Temperature measurement.** Points for measurement of temperature shall be installed where temperature changes in the test section can be best measured, and where necessary shall be protected against the effects of ambient and extraneous temperature sources.

Devices for measurement of temperature shall be installed to enable determination of any relevant relationship between the pipe pressure and ground temperature or pipe temperature. Where required by the test procedure, the relationship between pressure and temperature during the leak test shall be determined.

Points for measurement of pipe temperature may be on the surface of the pipe or on the surface of the pipe coating.

## 2.5 TEST LIQUID.

**2.5.1 Type of test liquid.** The test liquid shall be one that is not detrimental to the future use of the pipeline. Where there is any doubt, experimental work should be carried out to determine its suitability.

Where the test fluid is a petroleum liquid, the flashpoint shall be greater than 61°C or shall be approved.

**2.5.2 Selection of test liquid.** The test liquid shall be water, petroleum liquid, or any other suitable liquid, the properties of which are known. Liquefied petroleum gas or any other high vapour pressure liquid is deemed not to be a suitable liquid. The test liquid may contain corrosion inhibitors or other appropriate additives.

The test liquid shall be selected after consideration of the consequences of a rupture of the test section or escape of the liquid during the test, with regard to the effects such an incident would have on the general public, operating and testing personnel, testing and operating equipment, and the environment.

NOTE: Clause 2.6 specifies particular procedures and precautions when a hydrocarbon liquid is the test fluid.

**2.6 PROCEDURES AND PRECAUTIONS WHERE TEST FLUID IS HYDROCARBON LIQUID.** Where the test fluid is a hydrocarbon liquid, the following procedures and precautions shall apply:

- (a) An approved emergency procedure shall be established which shall be implemented in the event of a failure.
- (b) Adequate warning signs shall be displayed along the test section.
- (c) During the period in which the hoop stress is first raised from 50% SMYS to the maximum test stress and until the pressure is reduced to the MAOP, consideration shall be given to—
  - (i) the evacuation of persons from all neighbouring buildings; and
  - (ii) constant surveillance of the test section.

## SECTION 3. PREPARATION FOR TESTS

**3.1 TEST PROGRAM.** A program for each pressure test, with explanatory notes and all necessary data, shall be prepared and approved before any testing takes place.

The test program shall take into account an assessment of stresses in the pipe wall of the test section resulting from mass of the test liquid, end restraints, any additional loading from other structures, and any other significant loadings.

Where a combination of hoop stress, longitudinal stress, and radial stress occurs, the cumulative effect of these shall be determined from the Von Mises equation, expressed as follows:

$$2\sigma_e^2 = (\sigma_h - \sigma_l)^2 + (\sigma_l - \sigma_r)^2 + (\sigma_r - \sigma_h)^2$$

where

- $\sigma_e$  = equivalent stress, in megapascals
- $\sigma_h$  = hoop stress, in megapascals
- $\sigma_l$  = longitudinal stress, in megapascals
- $\sigma_r$  = radial stress, in megapascals.

NOTE: It is necessary to adopt a sign convention for compressive and tensile stresses.

The test program shall include details of the following:

- (a) The location and identification of the test section.
- (b) The elevations of the measuring points and the highest point and lowest point of the test section.

NOTE: Test sections are to be chosen so that differences in elevation do not cause conflict between the lowest and highest test pressures.

- (c) The nominal diameter, nominal wall thickness, and length of the test section.
- (d) Where known, the specification of the pipes in the test section and the name(s) of the manufacturer(s).
- (e) Test pressure ratings of valves, components, connections, and appurtenances in the test section. Ratings may be taken from specifications.

NOTE: Consideration is to be given to the effect of pressure on all components in the test section, e.g. flanges, fittings, hot bends, and valves.

- (f) The highest pressure including any pretest pressure to which any valve, component, connection, or an appurtenance in the test section has been previously subjected.
- (g) An assessment of the possibility of expansion due to pressure causing damage to the pipe coating.
- (h) Where not water, the type of test liquid to be used and its—
  - (i) density;
  - (ii) cubic thermal expansion coefficient; and
  - (iii) compressibility.
- (j) The type of additive, if any, in the test liquid.
- (k) The minimum strength test pressure and leak test pressure at the highest and lowest points of the test section, and their relationship to the pressure at the measuring point.

- (l) Identification of the strength and leak test functions of the procedure.
- (m) The theoretical slope of the  $p/V$  plot (see Appendix C).
- (n) The agreed requirement for leak-tightness.
- (o) The choice and reasons for the selection of the end-point (see Appendix D).

NOTE: Where a volume-strain controlled test is to be carried out, consideration must be given to the stress/strain diagram typical of the pipe in the test section before the end-point is selected (see Appendix D).

- (p) The reason for specifying a pressure higher than that used in any previous pressure test on the pipe or component in the test section.
- (q) Procedures for cleaning and filling the test section.
- (r) Procedures for pressurizing the test section.
- (s) The location of pressurization injection points.
- (t) Procedures and precautions for the disposal of the test liquid.
- (u) Procedures and precautions for the safety of the general public, operating and testing personnel, and operating and testing equipment (see also Clause 2.6).
- (v) The value of combined stresses, as determined in accordance with AS 2885.
- (w) The value of relevant and significant external loads.

**3.2 TEST SECTION.** The test pressure ratings or pretest pressures of all valves, components, connections, hot bends, and appurtenances in the test section shall be suitable for the intended test pressure. All valves and equipment that are not suitable shall be isolated or removed. The closing mechanisms of block valves shall be suitable for the test pressure. Where necessary, precautions shall be taken to ensure that specified valve seat pressure differentials are not exceeded.

All temporary and permanent connections between the test section and all associated test equipment shall be adequately designed and supported.

Where the test liquid in the test section may experience thermal expansion, provision shall be made for the relief of the resulting increase in pressure.

Where the test liquid will be subject to low temperatures, precautions shall be taken to protect the equipment and the test section.

The test section volume and the test liquid temperature shall be such that the repeatability as required in Clause 4.7.1 is not affected.

**3.3 SITE WORK.** The preparation in the field should include the placement of pumps, laying of the test liquid supply lines, the installation of screens or filters, the line fill meter, temporary scraper traps, manifolds, testing, metering and recording equipment, and all other necessary equipment.

## SECTION 4. PRESSURE TESTING

**4.1 METHOD.** A test section is filled with the test liquid and then more liquid is pumped in until a predetermined pressure is attained. That pressure is then maintained for a hold period.

**4.2 FILLING.** The volume of air remaining in the test section after filling shall be in accordance with Clause 4.5(e).

The effects of any surge pressure on the safety of the filling operation shall be taken into account.

Where pigs are used, suitable dispatching and receiving equipment for the pigs shall be installed, and precautions shall be taken to ensure that pigs are under control on slopes.

Where it is necessary to use more than one pig, a slug of liquid of adequate volume shall separate the pigs, to ensure that air is not entrained in the test liquid behind the last pig.

### 4.3 PRESSURIZATION.

**4.3.1 General.** The following considerations shall apply to pressurization:

- (a) A strength test or a leak test shall be made by raising the pressure of the test liquid in the prefilled test section to the approved end-point.
- (b) The end-point shall be related to the maximum and minimum test pressures specified in the test program and to the maximum stress induced in the pipe in the test section.
- (c) The pressure in any part of the test section shall not exceed the maximum test pressure specified in the test program.
- (d) Where the maximum test pressure exceeds the mill test or any other previous test pressure, the probability of yielding shall be assessed. In making this assessment, consideration shall be given to—
  - (i) the relationship of the mill test pressure or any other previous test pressure to the maximum test pressure and to the pressure equivalent of 100% SMYS;
  - (ii) the restraint conditions and secondary loadings on the test section;
  - (iii) the method, and the orientation used in measuring the yield stress; and
  - (iv) the negative tolerance on the wall thickness specified in the pipe standard or that inferred from the quality assurance records at the pipe mill.

#### NOTES:

1. Where the test pressure is greater than either the mill test pressure or a previous test pressure, Paragraph A6.1 predicts that yielding may occur.
  2. Yielding will not occur at a pressure below a previous test pressure.
- (e) Where yielding is considered probable, the extent of yielding shall be monitored during the test by either—
- (i) reference to the results of the volume/strain controlled test; or
  - (ii) observation of the strain.

NOTE: Strain may be observed by direct measurement, use of strain-sensitive materials, or an approved method.

- (f) Where the strength and leak tests are to be carried out at different times, the strength test shall precede the leak test.

**4.3.2 Pretesting.** Where sections of pipe are tested prior to field testing (i.e. pretested), the end-point pressure of the pretest shall comply with the test program.

NOTE: Pretested pipe and components may be excluded from a field pressure test, in accordance with AS 2885.

Where pretesting is in accordance with this Standard the test should be a pressure-controlled test. The endpoint pressure should be not lower than the maximum pressure that pipe or component will be subjected to in any subsequent test.

Sections of a pipeline may be pretested prior to inclusion in a subsequent field test.

**4.3.3 Mechanical joints.** A test section containing mechanical joints which are dependent for effectiveness on residual stress should not be subjected to pressures which could cause yielding.

NOTE: Yielding relieves residual stress and measurements required in this standard would not detect the yielding of the localized sections of pipe containing these joints.

**4.4 PRESSURE-CONTROLLED TEST.** For a pressure-controlled test, the pressure of the test liquid shall be raised to the end-point, the pump shall then be stopped, and the isolating valve between the pump and the test section immediately closed.

NOTE: Where the maximum pressure is to be less than 2000 kPa, residual air may interfere with the assessment of leaks. The volume of residual air should be determined (see Appendix F) and should not be greater than 0.2% of the volume of the test section.

**4.5 VOLUME/STRAIN-CONTROLLED TEST.** The procedure for a volume/strain-controlled test shall be as follows:

- (a) Raise the pressure at a convenient rate, which may be interrupted or changed at any time except as specified in step (d). Continue pressurization until the end-point is reached. Then stop the pump and immediately close the isolating valve between the pump and test section.
- (b) During pressurization to a pressure equivalent to 50% SMYS, compare the obviously linear portion of the recorded  $p/V$  plot with the theoretical slope (see Figure 4.1 and Appendix C). If reasonable agreement between the theoretical value and the recorded slope is not obtained, halt pressurization until the lack of agreement is reconciled.

NOTE: The theoretical or the recorded slope of the  $p/V$  plot is also used to assist in the assessment of the test uncertainty because the elastic slope also represents the relationship between the pressure change and the volume change (see Figure 4.1). Use of the recorded slope is preferred.

- (c) Plot pressure and added volume on a scale that provides not less than 1000 readable units on each axis to coordinates equivalent to SMYS.

Take readings of the values of the pressure and added volume at pressure increments not greater than the following:

- (i) Up to the equivalent of 50% SMYS ..... 500 kPa.
- (ii) Greater than 50% SMYS but less than mill test pressure ..... 200 kPa.
- (iii) Greater than the mill test pressure ..... 100 kPa.

- (d) Maintain continuous pumping at pressures between 90% and 100% of the expected end-point. In the event of an interruption, restart the test from the 90% value. The pumping rate from 90% value to 100% pressure shall be constant.

NOTE: It is recommended that, before the mill test pressure (or the pressure of any separate test on a part of the pipeline) is reached, a pause and an inspection during pressurization be made to determine whether any significant leaks are present which could result in premature end-points being reported.

- (e) If the nominated end-point is 2000 kPa or greater, residual air may affect leak test assessment only if it prevents attainment of a linear relationship between pressure and volume. Where a  $p/V$  plot is made, the plot shall be free from curvature due to residual air at a pressure equivalent to 50% of the test pressure.
- (f) Measure the non-proportional or total volumetric strains from the intersection of the line of best fit with the zero pressure line. These may be calculated from the outside diameters, wall thicknesses, and length of pipe in the test section unless there is more accurate information available on the volume of the test section at zero pressure.

For the purpose of determining the half-slope or non-proportional strain, the elastic slope shall be taken as the average slope in the obviously elastic region.

#### 4.6 TEST PRESSURES.

**4.6.1 Strength test.** The minimum test pressure for a strength test shall be that specified in the test program (see also Clause 4.7.1).

**4.6.2 Leak test.** The pressures for leak testing shall comply with (a) or (b) as follows:

- (a) There is no reduction of pressure for the leak test where that test immediately follows the strength test, and the strength test is performed by pressure control (to 1.25 times design pressure).
- (b) Where the strength test is performed by volumetric control and the defined condition of curvature is

reached, it is not advisable for safety reasons to commence the leak test without first reducing the pressure; a 10% reduction is recommended.

At the commencement of the effective hold period any pressure surges shall be non-significant, and the minimum pressure at commencement shall be 1.1 times the design pressure (see Paragraph A4.2, Appendix A).

The maximum leak test pressure shall not exceed the lesser of—

- (i) the pressure equivalent to a reduction by 5% of the strength test pressure measured at the lowest point in the test section; and
- (ii) the pressure equivalent to 100% yield strength, interpreted from graphed end-points on the  $p/V$  plot.

NOTE: The pressures given in (b) above are intended to ensure that the leak test is carried out at or near MAOP, so that assessment of uncertainty relates closely to the pipeline service.

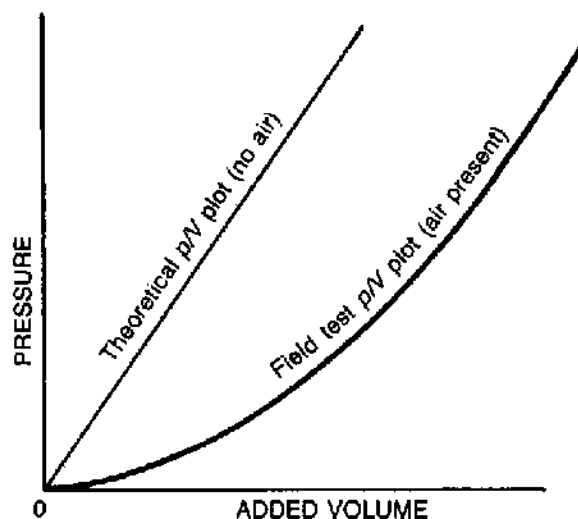
**4.6.3 Combined strength and leak test.** The minimum test pressure for a combined strength and leak test shall be the greater of that determined by Clause 4.6.1 and Clause 4.6.2.

#### 4.7 HOLD PERIOD.

**4.7.1 Strength test.** The hold period in a strength test shall be not less than 2 hours, and shall be considered completed when the calculated rate of pressure change is less than 1% per hour. The rate of change may be calculated over any convenient time interval for which reliable values of pressure changes are obtained. The hold period should not normally exceed 8 hours (see Appendix A).

During the hold period, the test pressure shall not exceed 102% and shall not be less than 98% of the end-point pressure. Where necessary, this shall be achieved by the addition or subtraction of test liquid.

When the hold period has been completed, the pressure should be reduced to a pressure not greater than the pressure specified for the leak test.



NOTE: Zero pressure is zero (gauge) at the highest elevation of the test section and is related to all the pressures read at the measuring point with the corresponding elevation difference expressed in pressure.

FIGURE 4.1. THEORETICAL AND TEST  $p/V$  PLOTS  
(SHOWING PRESENCE OF RESIDUAL AIR)

#### 4.7.2 Leak test.

The hold period for a leak test shall be one of the following:

- (a) Where leaks can be detected visually . . . sufficient for a full visual inspection, but not less than 3 hours.
- (b) Where leak detection equipment is used, or where the test sections are small and tested separately from the pipeline, e.g. station piping, road, rail, and river crossings . . . . . sufficient time to detect leakage, taking into account the sensitivity of the equipment and any provision of pressure compensation for expected temperature changes, but not less than 3 hours.

NOTE: Such compensation is not to exceed 50% of the change in pressure due to the agreed uncertainty.

- (c) All other cases . . . . . not less than 24 hours, and where sections are long and of large volume, of sufficient time to take into account diurnal variations and to establish thermal stability in accordance with Clause 4.7.3.

During the hold period, the test section shall be inspected for leaks.

When the hold period is completed, the pressure shall not be raised above the leak test pressure.

**4.7.3 Thermal stability for a leak test** Thermal stability for the purposes of this Standard is taken to be the condition where the liquid filled pipe has reached thermal equilibrium with the ground, so that temperature changes in the liquid filled pipe are in 'concert' with the ground. Thermal stability during a leak test shall be adequate for the purpose of leak test assessment.

NOTE: Thermal stability is only of concern for leak tests in accordance with Clause 4.7.2 (c) where the pipe is buried and the section is of sufficient length and volume that test liquid temperature changes affect leak assessment.

Sufficient time should be allowed between pipe filling and the conclusion of leak testing to ensure that thermal stability can be achieved during the leak test period.

NOTE: The time taken for stabilization to occur depends on the temperature of the test liquid at the time of filling, specific heat capacity of the test liquid, pipe diameter, burial depth, undisturbed ground temperature and the thermal conductivity of the backfill and ground which can be affected by ground water.

Assessment of thermal stability is recommended at leak test pressure, to avoid potential disturbances to thermal stability during addition or removal of any test liquid necessary to reach leak test pressure, and may be carried out during the leak test period. Assessment of thermal stability may be by a number of means, and these are discussed in Appendix A4.4.

NOTE: One method of assessment is to compare the pipe temperature change with the ground temperature change at the

same cross section of the pipeline. Where the difference between the changes during the leak test period is less than the agreed unaccountable pressure change converted to temperature, this location is considered to be thermally stable. Other methods discussed in Appendix A4.4 are equally acceptable.

Readings of test pressure and ambient temperature should be taken at hourly intervals where the hold period exceeds 3 hours. The temperature of the pipeline and/or ground temperature shall be taken at least 5 times during a 24 hour leak test period. Pressure, ambient temperature, pipeline and/or ground temperature should be plotted on the same graph. Account shall be made for any change in pressure due to change in temperature.

**4.7.4 Premature end-point.** If the end-point occurs prematurely, the test shall be stopped and an investigation shall be made. This investigation shall include a hold period to detect leaks and a thorough assessment of the accuracy of the measuring equipment. (See Appendix E.)

**4.7.5 Observed leaks during strength test.** Where leaks are observed during a strength test—

- (a) the quantity of leaked liquid shall be collected, measured and taken into account in the determination the end-point, and the details of the leak shall be reported; or
- (b) the test shall be stopped and the leak shall be repaired.

**4.7.6 Observed leaks during leak test.** Leaks in permanent installations, other than facilities related only to testing of the test section, shall be closed before a test section is declared leak-free, by—

- (a) stopping the test, repairing the leak, and repeating the test;
- (b) eliminating the leak during the hold period, and observing the point to be leak-free for not less than 3 hours; or
- (c) eliminating the leak after the leak test provided that the volume of test fluid that leaked shall be collected and used in assessment of the leak test. The leaking element shall be replaced with a pretested element (see AS 2885, Sections 9 and 12, on repair and retesting).

**4.7.7 Interrupted hold period.** Where a test is interrupted during the hold period and the test section is depressurized, the accrued hold time shall not be counted.

**4.7.8 Short test section.** Where observation of strain is used to check for yielding, strength testing of aboveground very short test sections may be performed without volumetric control.

## SECTION 5. ASSESSMENT OF STRENGTH TEST AND LEAK

**5.1 GENERAL.** The results of the strength test and leak test shall be assessed.

**5.2 STRENGTH TEST.** If, during the hold period, all pressure-containing components in the test section maintain their integrity, the strength test performance shall be deemed satisfactory.

If rupture occurs, the damaged pressure-containing component shall be replaced and the strength test shall be repeated.

**5.3 LEAK TEST.** If the pressure change during the test period, adjusted as appropriate for temperature effects, does not exceed the agreed test uncertainty, the leak performance shall be deemed satisfactory.

If the pressure change exceeds the agreed test uncertainty, the leak or leaks shall be repaired and the leak test repeated.

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## SECTION 6. REINSTATEMENT

**6.1 REINSTATEMENT OF THE TEST SECTION.** Disposal of the test liquid shall comply with the requirements of the relevant authorities and shall ensure that the general public, operating and testing personnel, operating equipment, and the environment are not exposed to any harmful effects. Where additives have been used, extra precautions may be necessary.

At the end of the test and before commissioning or recommissioning the pipeline, the test section and all associated equipment shall be put into a safe condition.

NOTE: AS 2885 provides for corrosion mitigation where a pipeline is placed in operation some time after it has been hydrostatically tested.

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## SECTION 7. REPORTS AND RECORDS

**7.1 GENERAL.** A report and a record shall be made for all pressure tests.

**7.2 REPORTS.** The report of the tests shall include the following:

- (a) Statement that the test section has been tested and does or does not comply with the requirements of the pipeline specification.
- (b) Strength test pressure.
- (c) Leak test pressure.
- (d) Elevation of the points in the test section where the reported pressures apply.
- (e) Corresponding pressures at the highest and lowest elevations in the test section.

- (f) Where not water, the type of the test liquid, and, relative to the temperature of the test liquid at the time of the test—

- (i) test liquid density ( $\rho$ );
- (ii) test liquid cubic expansion coefficient, ( $\gamma$ ); and
- (iii) the test liquid modulus of compressibility ( $\kappa$ ).

- (g) The method of temperature adjustment.

**7.3 RECORDS.** A completely documented record shall be made of all tests, the  $p/V$  plot where applicable, and notes on any incidents that took place during the tests. Records of the initial and all subsequent pressure tests shall be retained for the life of the pipeline.