

DEP SPECIFICATION

HYDROSTATIC PRESSURE TESTING OF NEW PIPELINES

DEP 31.40.40.38-Gen.

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DESIGN AND ENGINEERING PRACTICE

DEM1



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for hydrostatic pressure testing with water of new onshore and offshore pipelines after construction, to prove their strength and leak tightness.

The various stages of planning and carrying out hydrostatic pressure testing operations are specified in this DEP, including cleaning, gauging, filling, strength testing, leak testing and depressurising. It describes the selection and preparation of a test section, the safety and environmental precautions, the test medium and test equipment requirements, the specific parts of a pressure test and the documentation of the work. It also includes the necessary dewatering activities for the rectification of any defects detected during the hydrostatic pressure test, but excludes final dewatering. It also covers the post-testing period (up to 2 years) where the pipeline may be left full of treated test water. If corrosion protection methods other than leaving the pipeline full of treated test water during the post-testing period are necessary, they are classified as pre-commissioning and do not form part of this DEP.

It is assumed that the minimum test pressure is not less than 24.5 bar (g) (350 psig) and the maximum test pressure is not above 1500 bar (g) (21,750 psig). It is also assumed that the hydrostatic pressure test is carried out at ambient temperature.

This DEP is restricted to rigid metallic pipelines constructed from carbon steel, clad steel and stainless steel line pipe material. It does not address flexible pipelines or cement-lined pipelines, nor pipelines constructed from other materials such as GRP or RTP.

This DEP is not intended to cover hydrostatic pressure testing of pipelines which have been in service, although many of the same principles would apply.

The special provisions for pipelines constructed from the various types of stainless steel and clad steel line pipe materials are covered in APPENDIX B.

This DEP is intended for use in the pressure testing of new pipelines.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual DEM 1 – Application of Technical Standards.

This is a revision of the DEP of the same number dated January 2010; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil refineries, chemical plants, gas plants and exploration and production facilities and supply/distribution installations. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Term	Definition
Assembly	An arrangement of pipes/components such as a crossing, pig trap, block valve station or riser.
Block valve	A valve for interrupting the flow or shutting in a section of a pipeline. A block valve is normally either fully opened or fully closed.
Delegated Technical Authority	A Delegated Technical Authority is a person who has received delegated authority to approve Derogations from the Process Safety requirements from the Head of Shell P&T
Derogation	A Derogation is an authorised variance or exemption from a Process Safety requirement, with specified conditions.
Golden weld	A weld which is not subject to a hydrostatic pressure test and as such shall pass additional non-destructive inspection.
Hydrostatic pressure test	That part of the hydrostatic pressure testing operations during which the test section is pressurised. The hydrostatic pressure test includes a strength test and a leaktightness test.
Line-fill water	Water, chemically treated if required, used as medium to fill and pressurise the test section.
Pre-test	A hydrostatic pressure test carried out on part or all of an Assembly prior to final installation.
Scope of work	The contractual scope of work relating to the pressure testing of pipelines.
Test supervisor	The specialist supervisor appointed and specifically named by the Contractor to be in full charge of all pressure testing operations.
Test equipment	All temporary fittings, piping, test heads, pumps, pigs, materials, equipment and consumables used for the pressure testing operations.
Test point	The primary point of pressure measurement of a test section. This is normally at the point of pressurisation.
Test pressure	The pressure at which the pipeline is tested for strength.
Test procedure	The Contractor's procedure covering preparation, testing,

Term	Definition
	rectifying and post-testing activities.
Test section	A section of the pipeline or the entire pipeline which is subject to a hydrostatic pressure test.

1.3.3 Abbreviations

GRP	Glass Reinforced Plastic
MAOP	Maximum Allowable Operating Pressure
MIC	Microbial Induced Corrosion
RTP	Reinforced Thermo Plastic
SMYS	Specified Minimum Yield Strength
THPS	Tetrakis Hydroxymethyl Phosphonium Sulphate
TP	Test Pressure

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (14).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated January 2010. The following are the main, non-editorial changes.

Sections of this DEP that were informative in nature have been removed.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

1.7 ACTION ITEMS

An (S) in the margin is shown when the Principal is required to make a decision or to give the particular specification value of a parameter.

NOTE: If the Principal's decision is only required under certain circumstances, this is not shown by a margin marker.

An (A) in the margin is shown when the Contractor is required to obtain the Principal's approval for a particular action or procedure.

NOTE: Most, if not all, of these approvals are normally part of the test procedure which has to be approved by the Principal prior to the commencement of the hydrostatic testing operations.

1.8 DUAL UNITS

**Amended per
Circular 96/11**

Dual units have been incorporated throughout this DEP.

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

2. PROCEDURES

2.1 SEQUENCE, PERSONNEL AND PROCEDURES

The sequence of pressure testing operations of pipelines should be as follows:

- a) Selection of test sections
 - Assemblies
 - Pre-test sections
- b) Preparation of the test section
 - cleaning
 - gauging
 - filling
- c) Preparation of the hydrostatic test
 - temperature stabilisation
 - pressurising
 - air content check
- d) Hydrostatic pressure test
 - strength test
 - leaktightness test
 - testing of "special" test sections
- e) Post-testing activities
 - depressurising
 - documentation
- f) Rectification activities, if required,
 - leak locating during test
 - dewatering for rectification
 - rectification of defects

The hydrostatic pressure testing operations shall be carried out by experienced test personnel who shall have no other duties during the hydrostatic testing operations. The test supervisor shall be in full charge of all activities related to the hydrostatic testing operations. There shall be a sufficient number of qualified supervising assistants provided so that at least one shall be available on site at all times during each pressure testing operation. The test supervisor should be mobilised sufficiently early to familiarise himself with the specific job at hand.

- (S) The test supervisor shall prepare a procedure for all pressure testing operations, including
(A) a statement of the responsibilities of his subordinates. The test procedure shall be submitted to the Principal for approval not less than 28 days prior to commencement of testing or as specified in the scope of work. No part of the hydrostatic pressure testing operations shall commence until the approval is given in writing.

The test procedure shall include, but not be limited to:

- a) List of nominated personnel who are to supervise the pressure testing operations with their qualifications, tasks, responsibilities and authorities.
- b) Detailed schedule giving proposed dates of the main activities, tests and mobilisation dates of the nominated personnel.
- c) Details of the selected test sections, including assemblies and pre-test sections.

- d) Identification of potential safety and environmental hazards, including the necessary measures and emergency plans.
- e) Details of the line-fill water, including the source, treatment method, discharge/disposal and permits.
- f) Details of the test equipment, including layouts and size and/or performance.
- g) Details of the test section preparation, including cleaning, gauging and filling.
- h) Details of the hydrostatic pressure test preparation, including temperature stabilisation period.
- i) Details of the hydrostatic pressure tests, including pre-test, strength test and leaktightness test.
- j) Details of the post-testing activities, including depressurising and documentation.
- k) Details of rectification activities, including proposal for locating leaks, dewatering and leak rectification.

2.2 TEST SECTIONS

The Test Procedure should identify the test sections. Test sections should be as long as practicable and shall be piggable, either by temporary test heads or by pig launcher and receiver. If an above-ground or above-water section length exceeds 3 % of the total test section length, separate hydrostatic pressure tests for the above-ground/above-water and the buried/submerged sections shall be carried out to allow for the influence of temperature fluctuation.

The elevation profile shall be plotted to assist in checking that the test pressures at the low and high points fall within the specified limits.

After the various test sections have been tied-in to each other, a hydrostatic leaktightness test should be carried out on the entire pipeline. The pressure-tested test sections or assemblies SHALL [PS] be tied in by "tie-ins following testing" in accordance with ISO 13623:2000 Clause 11.5 and subjected to both radiographic and ultrasonic examination in accordance with DEP 61.40.20.30-Gen.

- NOTES
- 1. These are sometimes called "golden welds".
 - 2. This requirement does not apply to deepwater sections that are tied-in using mechanical connectors, such as jumpers that tie-in a pipeline to a manifold. In such cases, when allowed by regulation, and if approved by Principal, an external seal test to prove connector integrity may suffice.

3. SAFETY AND ENVIRONMENT

3.1 SAFETY MEASURES

The Contractor shall take all necessary measures to ensure that all persons and property are adequately protected from the consequences of a possible system failure during the testing operations. For the period from the start of pressurisation until the reduction in pressure at the end of the test, the Contractor SHALL [PS] ensure that all access to, or work on or near a pipeline section under test is properly authorised taking into account the hazards associated with pressure testing operations.

The Contractor shall confirm to the Principal in writing that he has instructed all employees engaged on testing work, or any work associated with testing, or any work in the immediate area (e.g. on platform) of the possible consequences of a pipeline or test fitting failure under pressure test conditions. The Contractor shall comply with any permit-to-work system applicable at any location influenced by the hydrotest activities.

- (A) Sites for test equipment shall be set up in a safe location away from public places, roads, inhabited areas/living quarters etc. The test work sites shall be closed off to unauthorised personnel. The arrangement of the test equipment and the location of the test work sites shall be approved by the Principal.

The sites shall be provided with a radio or other means of verbal communication to provide contact between all locations associated with the test work sites.

Warning notices reading 'KEEP AWAY - PIPELINE UNDER TEST' shall be placed at appropriate locations such as blanked ends of the test sections, areas where pre-tests or assembly testing are carried out and test equipment sites. Notices shall be in both English and the local/working language.

The Contractor shall prepare an emergency plan which shall describe actions to be taken in case the test section or test equipment leaks or bursts. The emergency plan should include, but not be limited to, the following:

- a) How to deal with washouts and other damage
 - b) Telephone numbers of standby crews
 - c) Telephone numbers of police, medical and other emergency services that may need to be summoned
 - d) Telephone number of the Principal's local operations base/control room which may have to be contacted
 - e) List of equipment and machines available or needed
 - f) List of personnel
 - g) Location of medical and first aid facilities.
- (A) The Contractor shall obtain the Principal's approval in writing of the emergency plan before commencing pressurisation.

Testing shall not commence until the Principal has received from the Contractor confirmation that notification has been given, in writing, to persons present in the vicinity of the pipeline (e.g. farmers, other construction contractors etc.) that testing is to be carried out; and that local authorities that may need to be informed have been notified in writing that testing is to take place.

Before any work, including tightening of leaking flanges, is permitted on the test section under pressure or associated connections, the pressure shall be reduced to a level not greater than static head plus 1 bar (15 psi). It may be possible to isolate the leaking part by use of a double-block-and-bleed installation. Flanges to be tightened by divers should have more stringent controls than above-water flanges, but work is permitted at a pressure level where the outflow from the leak has ceased. The diving superintendent shall be given full details from the risk evaluation, as required for diver safety.

3.2 ENVIRONMENTAL MEASURES

Before purchase of chemicals, including corrosion control products and leak detection dyes, the Contractor shall obtain from the chemicals' Supplier a material safety data sheet and written recommendations for handling, storing and disposal. The Contractor shall be responsible for ensuring that the information contained within the documents is complete. The Contractor shall be responsible for carrying out any Chemical Hazard Assessment and Risk Assessment required by local authorities before using the proposed chemicals.

- (A) The Contractor shall submit to the Principal for approval a comprehensive plan for all Chemicals to be used.

The Contractor shall ensure that any Suppliers' proposed measures are followed, and that the information is available, known and understood by the personnel carrying out the work.

The chemicals shall be stored in the original packing and properly marked. The chemicals shall be handled and stored in accordance with the HSE requirements stated in the Supplier's data sheet.

Protective clothing, gloves and goggles shall be worn when handling chemicals. A safety shower and eye-bath shall be available at appropriate locations.

The seasonal/environmental status of the source of line-fill water and the dilution and dispersion of the line-fill water after its use shall be taken into account when specifying the locations, methods, rates and timing. The Contractor shall ensure that the disposal recommendations of the Supplier are implemented and that all current environmental regulations applicable to the pipeline system are met. The Contractor must have the written consent of the owner/local authorities of any source or property before any water is taken from or discharged into that source or property.

The test sites shall be left in a clean condition and free of debris. The waste, chemicals, dyes, etc. shall be disposed of by the Contractor in accordance with the Principal's waste disposal requirements.

The Contractor shall ensure that the noise level does not exceed 85 dB in areas accessible to the general public.

4. LINE-FILL WATER

Water for testing and flushing shall be clean and free from any suspended or dissolved substances which could be harmful to the pipe material or internal coating (where applied) or which could form deposits within the pipeline, or which may be unacceptable at the disposal location. Only clean fresh water taken from a river, aquifer or a potable water system or clean sea-water taken from the open sea should be used. Brackish water from estuaries or harbours should be avoided as a source of line-fill water wherever possible.

The Contractor shall be responsible for obtaining all necessary permits from the owner/local authority concerning the supply and the disposal of line-fill water.

The water used for pressure testing should be selected from a location that will minimise the temperature stabilization period. The water shall be filtered through 50- μ m (2 mils) filters, except for water injection lines for which the water shall be filtered through 2- μ m (0.08 mils) filters before entering the test section. The arrangement of filters at the test work sites should enable back-flushing without disconnecting the pipe work.

Depending on the quality of water, the duration of contact of line-fill water with the interior of the test section, the pre-commissioning requirements and the future use of the pipeline, treatment packages containing an oxygen scavenger and biocide may be added to the line-fill water. The Contractor shall demonstrate the environmental acceptability of any proposed treatment package e.g. toxicological, Biochemical Oxygen Demand, Chemical Oxygen Demand etc. after filtering/separation and/or neutralisation. Environmentally acceptable line-fill treatment packages should be used.

- (A) The Contractor shall obtain samples from all water sources proposed as line-fill water for analysis by a testing laboratory approved by the Principal. The analysis shall show:

- sulphate concentration
- fatty acids concentrations, if the total dissolved organic carbon is above 15 mg/kg (15 ppm).
- ammonium concentration.

To minimise biological fouling and/or bacterial corrosion to an acceptable level in the filled pipeline, the above concentrations shall not exceed the following limits:

- sulphate concentration 42 mg/kg (42 ppm)
- fatty acids concentration 14 mg/kg (14 ppm)
- ammonium concentration 3 mg/kg (3 ppm)

If water from aquifers is used, the analysis shall show all components and their concentrations. The Contractor shall provide all details of water treatment necessary to bring the water to the quality as specified above.

Oxygen corrosion generated by the dissolved oxygen in the line-fill water is acceptable in carbon steel pipelines used for oil and gas service.

- (S) If the above limits for biological fouling cannot be met and/or oxygen corrosion shall be kept to a minimum as specified in the scope of work (e.g. for water injection lines), then the Contractor shall treat the line-fill water.

Individual chemicals and dye shall be injected by separate injection pumps and an injection manifold unless otherwise agreed by the Principal. The injection points at the manifold shall be positioned at least 1 m (3 ft - 3 in) apart. When both oxygen scavenger and biocide are required, the oxygen scavenger shall be injected upstream of the biocide and given sufficient time to react with the oxygen in the water before the biocide is injected. Concentrated chemicals shall not be mixed. The injection should be upstream of the filling pumps so as to allow thorough mixing before entry to the test section.

Where the line-fill water is to be transferred from one test section to another, the quality of the water shall be checked and the water shall be chemically retreated as necessary before

it is transferred. The water shall be refiltered through 50- μ m (2 mils) filters to reduce the entrainment of debris from one test section to another.

Line filling should not take place if the ambient temperature is below 2°C (36°F) unless a suitable antifreeze has been added to the line-fill water. If a hydrostatic pressure test is to be carried out in freezing conditions, the Contractor shall provide the required data for the pressure/temperature variation calculation as specified for the leaktightness test. The test equipment required and the disposal of the antifreeze/water mixture shall be part of the test procedure.

The Contractor shall detail in the test procedure the source(s) and quality of water, the procedure for the withdrawal of water from the source and the details of the water treatment proposed and dosing rates necessary to bring the water to the required quality for both filling and hydrostatic testing use. The disposal of the line-fill water after its use, including the timing, location, rates of discharge, treatment methods if required and filtration, shall also be detailed in the test procedure.

5. TEST EQUIPMENT

The Contractor shall define the number, size and/or performance of each component required for the work, including the spare parts and stand-by units, and shall supply all the test equipment necessary to fulfil the requirements of this DEP.

A schematic equipment layout of a typical test section is shown in Appendix A Figure 1. The test equipment should include, but not be limited to, that shown in Table 5.1.

The number and types of pigs to be used, and the material, length and if applicable the configuration of the shoes, brushes, oversize and hardness shall be defined by the Contractor.

Any test equipment pressurised during the test operations shall be designed for a working pressure not less than the test pressure. These components shall have material certificates and the equipment itself shall have data sheets from the Manufacturer. The test equipment connected to the test section shall have hydrostatic test certificates and shall have been tested to a pressure at least 1.25 times the test pressure of the test section. The test equipment shall be internally clean and fit for purpose.

The test heads and temporary pig traps which will be exposed to test pressure shall be designed, fabricated, installed and tested according to the same code as the pipeline. However, the allowable "code breaks" between ISO 13623 and other codes may be used, specifically where prefabricated items are used. The test procedure shall take account of any proposed code breaks. Test heads and temporary pig traps shall be numbered and a certificate shall be kept by the Contractor for each one. This certificate shall show the results of non-destructive tests on each fabrication weld, the pressure at which it was initially tested, the number of times it has been used and the test pressure attained on each test. Entries in the record shall be signed by the test supervisor. Test heads that do not have a complete certificate and record of use from the new condition shall not be used.

Wall thickness transitions between test heads and the pipeline resulting from unequal wall thickness or unequal yield strength, or both, shall meet acceptable welding configuration requirements in accordance with ASME B31.4 and ASME B31.8. The maximum wall thickness for design pressure of a test head shall not be greater than 1.5 times the nominal wall thickness of the matching pipe.

Prior to each re-use, the welded test head shall be cut back to remove all weld metal and the heat-affected zone. To achieve this at least 12 mm (1/2 in) of pipe should be removed. The full circumference of the new weld end shall be tested ultrasonically for laminations over a width of 25 mm (1 in) from the bevelled end in accordance with DEP 31.40.20.35-Gen. or DEP 31.40.20.37-Gen. as appropriate. All temporary connections fitted to enable the hydrostatic test to be performed shall be adequate to handle the test pressures involved and should be of rigid construction.

- (A) Flexible hose shall be of the armoured type and shall only be used if it is manufactured to standards applicable to permanent hydraulic installations. Such hose shall only be used in short lengths as required for the pressurising line to the test head and for instrumentation. Hoses shall be anchored at maximum of 5 m (16 ft) intervals to prevent "whip" in the event of failure and shall be protected against external damage. The method of anchoring shall be approved by the Principal. Hoses shall not pass through doorways. Where hoses pass over walkways they should be protected from any passing personnel or equipment. Only one system of hose connectors from one Supplier shall be used to ensure that the various types are not mixed up. Prior to each re-use, all hoses and connectors shall be visually inspected for damage. Flexible pressurising or monitoring hoses should not be allowed inside the test cabin.

The test equipment shall be adequately protected against lightning and accumulation of static electricity e.g. by earthing.

Equipment shall comply with DEP 33.64.10.10-Gen Electrical engineering design.

Table 5.1 Test equipment

(S)	Filling and pressurising pumps	complete with stroke counter or flow meter suitable for the required duty.
	Filters	2 μm (0.08 mils) or 50 μm (2 mils), as specified in the scope of work, compatible with flow rate of filling pumps. Filters with 50 μm (2 mils) and above should be suitable for back-flushing.
	Break tanks and piping	to keep the pumps constantly on load.
	Valves	to allow exchange or replacement of instruments and equipment during the hydrostatic pressure test.
	Chemical injection pumps	for continuous injection of water treatment packages and dye, including the injection manifold and block valves. The injection pumps shall have an accuracy within 5 % of the specified injection rate.
	Air-conditioned or heated test cabin unit	complete with the necessary gauges, recorders, deadweight tester, barometer, etc. for installation at the end of the test section so that the test supervisor can accurately assess the progress of the hydrostatic test and record the pressure and water volume conditions throughout the tests. As an alternative to the deadweight tester and pressure recorder, the use of a pressure transducer in combination with a computerised logging system is acceptable.
	Filling/Pressurising flowmeter and temperature probe	measuring and recording continuously the flow and temperature of the line-fill water with the specified accuracy in Table 5.2.
	Pipe wall temperature recorder	measuring and recording equipment in accordance with the specified accuracy in Table 5.2.
	Pressure recorder	measuring and recording continuously the pressure at the test head with the specified accuracy in Table 5.2.
	Ambient air temperature recorder	measuring and recording equipment with the specified accuracy in Table 5.2.
	Soil temperature probes and recorder	measuring and recording equipment with the specified accuracy in Table 5.2.
	Subsea temperature probes and recorder	measuring and recording equipment with the specified accuracy in Table 5.2.
	Pressure relief valve	fitted to the pressurising pump, capable of handling the full capacity of the pump, and set at 3 % above the specified test pressure to ensure that the test section is not overpressurised.
	Pressure let-down valve	to release the pressure in a controlled manner on completion of the hydrostatic tests.
	Tank	for calibrating the high-pressure pump and flow meter.
	Temporary pig launchers and receivers	for cleaning, gauging, filling and dewatering operations. The receiver should be fitted with a throttling valve.
	Pigs	various pigs for cleaning, gauging, filling and dewatering operations.
	Pig tracking equipment	for locating the pigs in the test section, usually only used when the test section length is greater than 5 km (3 miles).
	Test head	to separate the test section for pressure testing.
	Air compressors	if compressed air is to be used to drive pumps or pigs. The air to drive pigs shall be oil-free and air coolers shall be included if the discharge temperature is outside the limits specified for the test section.
	Communication equipment	for communication between the various locations of the test section.
	Spare parts and stand-by facilities	to replace any defective test equipment during the hydrostatic pressure test.

Test instruments shall be in accordance with the requirements of Table 5.2 below:

Table 5.2 Accuracy of test instruments

Instrument	Reading division	Range	Accuracy
Deadweight tester (NOTE 1)	0.05 bar (0.73 psi)	0 to 1.5 x TP	± 0.05 % (NOTE 2)
Pressure data logger	0.05 bar (0.73 psi)	0 to 1.5 x TP	± 0.05 % (NOTE 2)
Pressure gauge	1.2 or 5 bar (17 or 73 psi)	0 to 1.5 x TP	± 0.6 % (NOTE 3)
Pressure recorder (24 h)	2 or 5 bar (29 or 73 psi)	0 to 1.5 x TP	± 1 % (NOTE 3)
Barometer	1 mbar	-	± 0.8 mbar
Ambient air temperature recorder (24 h)	0.5 °C (1°F)	0 to 80 °C (32°F to 176°F)	± 1 % (NOTE 3)
Temperature probes and recorder (digital)	0.1 °C (0.2°F)	0 to 50 °C (32°F to 122°F)	± 0.1 °C (0.2°F) (NOTE 4)
Filling-flowmeter (turbine)	m ³ /h (ft ³ /h)	-	± 1 % (NOTE 3)
Pressurising flowmeter	strokes/litres (strokes/gal)	-	1 % volume per stroke

- NOTES:
1. For vessel-mounted operations, especially at high pressure, a data-logger should be used.
 2. Percentage of measured value.
 3. Percentage of the full range.
 4. When a short pipeline with small diameter is tested, an accuracy of ± 0.01 °C (± 0.02 °F) should be considered.

- (A) Pressure gauges shall be checked for accuracy on site, in the presence of the Principal, before the commencement of the hydrostatic pressure test of any test section. This shall be carried out by comparison with the deadweight tester.
- (A) The accuracy of the pressurising flow meter shall be checked by the Contractor, in the presence of the Principal, using a calibrated tank.
- (A) Other instruments shall have calibration certificates from a recognised certifying authority or a Principal-approved third party. Where instruments are connected with electrical cables to the test section or are in contact with the test medium, the instrument's calibration shall include the cabling. The certificates shall not be older than 6 months at the start of testing. The original certificates shall be shown to the Principal and copies included in the hydrostatic pressure test report. If, during the testing period, the certificates become older than 12 months, or if the Contractor or Principal has doubts about the calibration of any instrument to be used for the test, the Contractor shall have the instruments in question recalibrated in the presence of the Principal, or a Principal-approved third party.

6. CLEANING, GAUGING AND LINE FILLING

6.1 GENERAL

Prior to pressure testing, the Contractor shall clean and gauge sections of the pipeline between suitable tie-in points, such as block valve stations or crossings (river, railway, road), to ensure the removal of construction debris and loose scale and to check that the section is free of deformations and/or obstructions.

The Contractor shall calculate the required pressure and volume to drive the pigs as specified. The elevation difference and back-pressure of the outlet at the receiving end shall be taken into account.

Block valves should not be installed before the cleaning operations have been completed.

- (A) Temporary pig launchers and receivers shall be approved by the Principal prior to use and, except for subsea applications, shall be welded to the test section or flanged if a permanent flange is available. If compressed air is to be used as the driving medium, the air should be oil-free and the inlet line of the driving medium should be fitted with a pressure relief valve set at 7 bar (g) (100 psig).

In sections with a diameter less than DN 250 (NPS 10) a higher pigging pressure may be required. Therefore, water should be used as the driving medium for smaller pipelines.

When the driving medium is water, its source and the filtration method shall be as specified for line-fill water.

If water is to be used to drive pigs, a batch of water corresponding to a minimum of 4 % of the section volume or 150 linear metres (500 linear ft) of the line section, whichever is the greater, shall be introduced ahead of the first cleaning pig to wash foreign materials away. Pigs used in a pig train shall be separated by the same volume of water as specified ahead of the first pig.

During the running of all pigs, the Contractor shall record the pressure at the inlet and outlet of the test section.

The Contractor shall inform the Principal before any pigging operation is carried out. All pigging operations shall be documented in a pig register.

The pig register should include the following:

- a) pig run number
 - b) pig type
 - c) launching and receiving time
 - d) downstream pressure
 - e) arrival condition of the pig
 - f) amount and kind of material received with the pig.
- (A) If a pig becomes stuck in the pipeline and the driving medium is air, the Contractor shall not employ a differential pressure greater than 7 bar (100 psi) to dislodge the pig. If the driving medium is water and a differential pressure up to 50 % of MAOP is insufficient to dislodge the pig, the pig shall be located and removed from the pipeline by cutting the pipe or by other methods to be approved by the Principal.

6.2 CLEANING

If the pipeline has been internally coated, cleaning pigs without wire brushes shall be used.

All debris received with the pig shall be disposed off in accordance with the Principal's waste management requirements.

6.3 GAUGING

After cleaning and back-filling the trench, the complete test section shall be gauged by means of either a gauge plate pig or an instrumented caliper pig.

A bi-directional pig with 2 sets of separate guiding and sealing discs shall be fitted with one or two aluminium gauging plates to be located as follows:

If two gauging plates are fitted, one shall be fitted in front of the first set of discs and the second shall be in front of the last set of discs. If only one gauging plate is fitted it shall be at the rear location. The gauging plates should be made as follows:

- 3 mm (1/8 in) thick for pipeline diameters up to DN 100 (NPS 4)
- 6 mm (1/4 in) thick for pipeline diameters from DN 100 (NPS 4) to DN 300 (NPS 12)
- 12 mm (1/2 in) thick for pipeline diameters above DN 300 (NPS 12).

The gauging plates should have 8 radial incisions at 45 degree intervals.

The radial incisions should extend from the outside diameter of the gauging plate to the outside circumference of the locating plate of the pig.

The gauging plate diameter shall be determined from the formula:

$$d = ID - 0.01 D - 2b \quad \text{or} \quad d = 0.95 \times ID, \text{ whichever is smaller,}$$

where:

d	=	gauging plate diameter	mm (in)
D	=	nominal outside diameter	mm (in)
ID	=	minimum internal diameter	mm (in)
		taking due account of any	
		thick wall pipe section and	
		internal diameter of fittings	
		and valves	
b	=	clearance of 5 (3/16)	mm (in)

Gauging plate measurement, introduction of the gauging pig into the test section, and removal from the test section shall be carried out in the presence of the Principal. A photographic record shall be taken of the condition of each gauging plate after use.

If the test section to be filled with line-fill water is a combination of two or more cleaning and/or gauging sections, the second filling pig shall be a gauging pig which shall be inspected by the Principal upon removal of the test head.

The gauging plates shall be examined for any signs of damage or irregularities such as dents and buckles. In case of damage, the gauging pig shall be re-run with new gauging plates of the same diameter. If the defect cannot be located by the gauging operation, the Contractor shall run a geometric inspection pig to locate the defect.

- (A) Any damage noted by the second gauging pig or by the geometric inspection pig shall be located and repaired by the Contractor. The Contractor shall not proceed with the testing procedure before a re-run gauging plate has been accepted by the Principal.

6.4 LINE FILLING

If block valves are installed, the test supervisor shall ensure prior to filling that all block valves are correctly positioned in the fully open position. Provision shall be made to equalise the pressure between the valve body cavity and the line.

Before filling the test section the test supervisor shall ensure that piping and facilities for the disposal of treated water are installed and functional.

All necessary measures shall be taken by the Contractor to remove air from the line during filling. This includes back-pressure control, a steady controlled filling rate, use of a break tank, and use of at least two bi-directional pigs with water in front and in-between. Where practicable, the test sections shall be filled from the lower end. The Contractor shall ensure that the pump suction will not draw in air with the water and that the pigs are in good

working order and correctly fitted in the test section. Venting shall be carried out repeatedly at points in the test section where air might accumulate, e.g. at ancillary piping.

The filling shall be performed at a controlled rate. The filling pig speed should be approximately 0.6 m/s (2 ft/s) and should not exceed 1.8 m/s (6 ft/s). The pressure in front of the pig shall be carefully monitored and controlled at not less than 2 bar (g) (30 psig). Depending on the elevation profile of the test section and the pigging pressure, it may be necessary to increase the pressure at the receiver test head in order to control the pig speed.

In order to assist in controlling the line filling and water treating, the following measurements and records shall be recorded:

- a) inlet flowrate of line-fill water
- b) inlet pressure of line-fill water
- c) inlet temperature of line-fill water
- d) pressure at the receiver head
- e) chemical injection rates (if carried out)
- f) dye injection rate (if carried out).

In the event of chemical injection pump failure, the filling pump shall be stopped.

No filling shall take place if the air temperature is 2°C (36°F) and falling or in freezing conditions unless antifreeze precautions are taken.

7. REQUIREMENTS PRIOR TO HYDROTEST

7.1 REQUIREMENTS PRIOR TO PRESSURISING

A pre-test check shall be performed, detailing the status and location of each item to be inspected before pressurising is commenced.

The checklist should include checks to confirm that:

- a) The test section has been isolated from all other pipeline sections.
- b) All temporary piping, test heads, and other equipment connected to the test section have been tested to a pressure of at least 1.25 times the test pressure.
- c) The test section has been filled completely and air has been vented off.
- d) The block valves, if installed, have been returned to the half-open position so that there is no differential pressure across the seats/seals.
- e) All instruments and gauges to be used during pressurising and testing have been calibrated and valid test certificates have been approved by the Principal.
- f) All warning notices, marker tapes, protective barriers and other safety equipment have been positioned and the appropriate authorities have been informed.
- g) All relevant personnel at the affected stations have been informed of the commencement and duration of the hydrostatic pressure test.
- h) The communication channels have been tested and established and back-up equipment is available.
- i) The personnel engaged in the testing work have been briefed on the emergency plans.
- j) The person operating the pressurising equipment has been instructed by the test supervisor regarding the limiting pressure which shall apply to the test section.

For the above-water/above-ground test section temperature measurements, the thermocouples should be firmly installed into the line-fill water or firmly attached to bare pipe and covered with insulating materials. The bare pipe shall be recoated upon completion and acceptance of hydrostatic pressure testing.

7.2 TEMPERATURE STABILISATION

Before the hydrostatic test is commenced, the water temperature should be within 1.0°C (1.8°F) of ground or seabed temperature, determined as the difference between average pipe temperature and average ground temperature over the test section length.

The calculation of the temperature stabilisation period based on the expected line-fill water temperature and ambient temperature shall be detailed in the test procedure.

Pressure and temperatures, including ambient, shall be recorded every hour during the stabilisation period. If this is not practical for subsea pipelines, they should be filled for a minimum of 24 h before the hydrostatic pressure test begins.

The test section temperature and the ambient temperature (ground/air/water) shall be plotted against time during the temperature stabilisation period.

7.3 PRESSURISATION

Contractor shall draw a plot of pressure/added volume, taking the volume added as measured either by pump strokes or flow meter and the pressure as measured by deadweight tester or pressure data logger. A tank should be available to enable the volume rating of the pressurising pump or flow meter to be checked

The rate of pressurisation should be constant and should not exceed 1 bar/minute (15 psi/minute) until a pressure of 35 bar (500 psi) or 50 % of the test pressure, whichever

is lower, has been attained. During this period, volume and pressure readings should be recorded at 1 bar (15 psi) intervals.

The person operating the pressurising equipment shall immediately report to the test supervisor any variation in the rate of pressure increase resulting from the same volume of added water.

During pressurisation, all potential leakage points shall be checked.

7.4 AIR CONTENT DETERMINATION

The air content of the filled line shall be determined during initial pressurisation by using the pressure/ added volume plot. The linear section of the curve shall be extrapolated to the volume axis, which shall correspond to static head pressure. The volume of air can be read from the intersection of the line with the volume axis and shall be used to calculate the air content thus:

Percentage air content = $(\text{Volume of air} / \text{Volume of line}) \times 100$

If the air content exceeds 0.2 % of the line volume, testing shall be terminated and the cause investigated. If further venting does not bring the air content within acceptable limits, the test section should be emptied and refilled at the discretion of the Principal.

8. HYDROSTATIC PRESSURE TEST**8.1 TEST PRESSURES**

- (S) The minimum strength test pressure at any point of the test section shall be equal to the test pressure specified in ISO 13623:2000 Clause 6.7.3 or to the pressure creating a hoop stress of 96 % SMYS of the line pipe material, whichever is higher, unless otherwise specified by the Principal.

For pipelines conveying category C and D fluids and where a hoop stress design factor (F_h) of 0.83 has been applied, the strength test pressure may be reduced to a pressure of not less than 1.20 times the internal design pressure, provided the maximum incidental pressure cannot exceed 1.05 times the internal design pressure.

The minimum leak tightness test pressure at any point of the test section shall be at least the test pressure specified in ISO 13623:2000 Clause 6.7.3 or 1.1 times the internal design pressure, whichever is greater.

During the hydrostatic pressure test the equivalent stress shall not exceed 100 % SMYS of the line pipe material. The equivalent stress shall be calculated in accordance with ISO 13623:2000 Clause 6.4.1.2.

- (S) The margin between the hoop stress of 90 % SMYS and the equivalent stress of 100 % SMYS allows for elevation differences in the test section and/or longitudinal stresses, e.g. due to bending. However, the elevation differences in each test section shall be limited to a value corresponding to 5 % of SMYS of the line pipe material or to 50 m (165 ft) , whichever is the lower, or as specified in the scope of work.

NOTE 1: Especially in hilly terrain, this could lead to a large number of test sections. In such cases, it should be considered whether a possible reduction in MAOP would lead to a more cost effective solution.

The test pressures for deepwater pipelines shall be determined in accordance with Pipeline Engineering DEP 31.40.00.10-Gen.

8.2 DURATION OF HYDROSTATIC TEST

The minimum duration for the hydrostatic pressure test shall be a 4-h strength test followed by a 24-h leaktightness test. The strength test is a specific procedure to verify that the pipeline meets the requirements for mechanical strength and the leaktightness test is a specific procedure to verify that the pipeline meets the requirements for tightness.

8.3 STRENGTH TEST

If the test pressure is required to give a hoop stress of 96 % of SMYS based on minimum wall thickness, it should be calculated as follows:

$$TP = \frac{2(t_{\min})S}{D_o - t_{\min}} FET$$

where	TP	=	hydrostatic strength test pressure	MPa (ga) (psig)
	$t_{\min}$	=	specific minimum wall thickness of pipe (i.e. nominal wall thickness less maximum negative tolerance)	m (ft)
	D_o	=	nominal outside diameter of pipe	m (ft)
	S	=	Specified Minimum Yield Strength (SMYS)	MPa (ksi)
	F	=	design factor	-
			(for hydrostatic strength test, i.e. 96% stress level, F = 0.96)	

E	=	longitudinal joint factor	-
		(for linepipe in accordance with DEP 31.40.20.35-Gen. or DEP 31.40.20.37-Gen., E = 1.0)	
T	=	temperature derating factor	-
		(for hydrostatic strength test, T = 1.0)	

NOTE: For clad pipeline the pressure of the cladding is excluded for the purpose of calculation.

- (S) The required test section data shall be as specified by the Principal in the scope of work. The test supervisor shall confirm that the TP does not exceed the pressure to which the pipe has been subjected during the mill test and that it is not higher than the test pressure of the fittings specified for the pipeline.

The equivalent stress for the hydrostatic pressure test condition shall be calculated in accordance with ISO 13623:2000 Clause 6.4.1.2. The calculation shall include major residual stresses from construction, e.g. from towing or lay barge operations, and longitudinal stresses due to axial and bending loads, e.g. at unsupported pipeline spans. The equivalent stress during the hydrostatic pressure test shall not exceed 100 % of SMYS. If the calculated equivalent stress is higher than 100 % of SMYS, special measures shall be taken to reduce the longitudinal stresses in the test section.

The pressure shall be maintained during the strength test at $TP \pm 1$ bar (15 psi) by bleeding or adding water as required. The volumes of water added or removed shall be measured and recorded.

During the test, the TP shall be recorded continuously, and the deadweight tester readings and air temperatures shall be recorded at least every 30 min. The pipe and soil/sea-water temperature shall be recorded at the beginning and end of the 4-h test period.

The test section temperature and the ambient temperature against time plot created for the stabilisation period should be maintained.

8.4 LEAKTIGHTNESS TEST

8.4.1 General

The leak tightness test should commence immediately after the strength test has been completed satisfactorily. No water shall be added or removed during the tightness test. The test is intended to demonstrate that there is no leak in the pipeline. To allow for pressure variations caused by temperature fluctuations during the test duration, the leaktightness test pressure shall be set to the level specified in ISO 13623:2000 Clause 6.7.3 or 1.1 times the internal design pressure, whichever is greater.

If it can be ensured that the pressure variations due to temperature fluctuations are within the specified limits, then a combined strength/leaktightness test at the strength test pressure, without water addition or removal, should be carried out.

During the test, the pressure shall be recorded continuously, and the deadweight tester and air temperature readings shall be recorded every 30 min. The pipe and soil/sea-water temperature shall be recorded at maximum 3-h intervals. The temperature recording interval should be reduced to a 1-h duration for the first and last 3-h periods of the 24 h to assist with the pressure/temperature variation calculation. The test section temperature and the ambient temperature against time plot created for the stabilisation period should be maintained.

The requirement for a minimum duration of a leak test is not applicable to pipeline systems or assemblies completely accessible for visual inspection, provided the complete pipeline test section or assembly is visually inspected for leaks following a hold-period of a minimum of 4 h at the specified leak test pressure.

8.4.2 Acceptance criteria

- (A) To determine whether any pressure variation is due to temperature changes or whether a leak is present, the pressure/temperature changes shall be calculated from the pressure/temperature equation Formula 1 (1a for restrained test section or 1b for unrestrained test section), unless otherwise approved by the Principal.

Formula 1. Pressure/temperature equation

- 1a) For restrained test sections 1b) For unrestrained test sections

$$\frac{\Delta p}{\Delta T} = \frac{\gamma - 2(1+\nu)\alpha}{\frac{D}{Et}(1-\nu^2) + \frac{1}{B}}$$

$$\frac{\Delta p}{\Delta T} = \frac{\gamma - 3(1+\nu)\alpha}{\frac{D}{Et}(1-\nu^2) + \frac{1}{B}}$$

NOTE: Formula 1 is derived from the volume/pressure relationship

$$\frac{\Delta V}{\Delta p} = V \left[\frac{D}{Et}(1-\nu^2) + \frac{1}{B} \right]$$

where	ΔV	= incremental volume	m ³ (ft ³)
	Δp	= incremental pressure	bar (psi)
	ΔT	= incremental temperature	°C (°F)
	V	= pipeline fill volume	m ³ (ft ³)
	D	= pipeline outside diameter	m (ft)
	E	= Young's elastic modulus of steel (for carbon steel, $E = 2.07 \times 10^6$ bar [30×10^6 psi])	bar (psi)
	t	= nominal pipe wall thickness	m (ft)
	ν	= Poisson ratio (for steel, $\nu = 0.3$)	
	B	= bulk modulus of water (Figure 3 for fresh water or Figure 4 for sea-water)	bar (psi)
	γ	= volumetric expansion coefficient of water (Figure 5 for fresh water or Figure 6 for sea-water)	°C ⁻¹ (°F ⁻¹)
	α	= coefficient of linear expansion of steel (for carbon steel, $\alpha = 1.17 \times 10^{-5}$ °C ⁻¹ [2.11×10^{-5} °F ⁻¹])	°C ⁻¹ (°F ⁻¹)

- NOTES:
1. B is very sensitive to temperature and also sensitive to antifreeze.
 2. For fresh water γ changes significantly at low temperatures because the density of water is greatest at 4 °C (39°F).
 3. Above-ground or above-water test sections, if not anchored, and very short offshore on-bottom test sections, if not anchored or buried, are normally unrestrained.
 4. Figures 3 and 5 may be used for demineralised water.

The pressure, the test section temperature and the ambient temperature should be plotted against time during the period of the leaktightness test.

The tightness test shall be deemed acceptable if any pressure change can be accounted for by a corresponding temperature change using Formula 1. Allowance should be made for any recording inaccuracy.

In the event of any doubt by the Contractor or the Principal about the leaktightness of the line, for example if the temperature and pressure trends are different, the test shall be extended until such time as the acceptability can be demonstrated to the Principal's satisfaction.

8.5 TESTING OF "SPECIAL" TEST SECTIONS

In some test sections, it is difficult to correlate the pressure changes with the temperature fluctuation, because the temperature fluctuations of the test section are difficult to measure, e.g. in above-water or above-ground test sections (effects of the sun, rain and wind) or test sections of pipe bundles and insulated pipelines (slow heat transfer). In such cases, the leak test should be carried out, wherever possible, on the basis of a visual examination to check the leaktightness of the test section after the satisfactory completion of the 4-h strength test. The visual examination shall not commence before the pressure has been reduced to the leak test pressure and held for a minimum of 4 h. The results of the visual examination shall be documented by the test supervisor.

If it is not possible to check the leaktightness of the test section by visual examination, the leaktightness shall be demonstrated by a 24 h leaktightness test. The influence of the temperature fluctuation should be considered in specifying the location and number of temperature measurements. It may be necessary to protect above-ground or above-water test sections against sun radiation.

A 24-h leaktightness test for pre-tests of assemblies is not necessary. The influence of the temperature fluctuation should be considered in specifying the location and number of temperature measurements and the stabilisation period.

9. POST-TESTING REQUIREMENTS

9.1 DEPRESSURISING

After the satisfactory completion of the strength and leaktightness tests, the test section shall be depressurised to hydrostatic head plus 1 bar (15 psi) so that air does not enter into the test section. Pressure let-down valves shall be opened slowly and depressurising continued at a rate that does not generate vibrations in associated pipework. Under normal circumstances, no fitting of any type should be attached to the pressure let-down valve. If fittings or drain lines are attached they shall be adequately braced and tied down to prevent movement.

The depressurisation rate should not exceed 1 bar (15 psi) per minute until the pressure has been reduced to 40 % of the test pressure. Then depressurisation should continue at a rate of less than 2 bar (30 psi) per minute.

Test pressure shall not be used for transfer of water from one test section to another.

The above requirements also apply if the test section shall be depressurised for the rectification of damage/defects during the hydrostatic pressure test.

9.2 DOCUMENTATION

- (A) The Contractor shall keep records of all parameters specified in this DEP during each operation. The hydrostatic pressure test records should be reviewed by the Principal at the beginning and end of the test, and at least once during the test.

All recorder charts shall be signed by the test supervisor when placed on and taken off the recorder. All recorder charts taken during the hydrostatic pressure test shall also be signed by the Principal.

- (A) Upon completion of a successful section test a "hydrostatic test certificate" shall be completed and signed by the Contractor and Principal. This shall be supported by original hand-written test data of which photocopies shall be handed to the Principal. A separate certificate shall be completed for each test, including pre-test and assembly testing.

For each complete pipeline, the Contractor shall compile a "final hydrostatic test report", with a general introduction including all relevant pipeline data, detailing each hydrostatic pressure test. The contents, as a minimum, shall include the following:

- a) originals of all "hydrostatic test certificates"
- b) originals of all recorder charts (see Note)
- c) all pressure readings
- d) - all temperature readings- volumes of water added or bled off
- e) instrument test certification
- f) air content plot and calculation
- g) pressure and temperature plots against time
- h) pressure/temperature correlation calculation
- i) details of line-fill treatment packages
- j) pig register of cleaning, gauging and filling
- k) photographic record of the used gauging plates
- l) leak locating (if carried out)
- a. pig register of dewatering (if carried out)
- m) details of line-fill water disposal (if carried out)
- n) rectification records (if carried out)
- o) any special features of the test

p) test procedure

NOTE: An explanation and disposition shall be given for any pressure discontinuities, including test failure, that appear on the recording charts.

- (A) (S) The report should be submitted to the Principal in draft form for each test section within 1 week after completion of the test or as specified in the scope of work. The complete report shall be submitted within 4 weeks after testing of the last section, for the Principal's approval.

10. RECTIFICATION REQUIREMENTS

10.1 LEAK LOCATING DURING THE HYDROSTATIC TEST

If a leak is suspected, the Contractor shall reduce the pressure to less than 80 % of the test pressure before carrying out a visual examination.

If it is not possible to locate the suspected leak by visual examination, the Contractor shall use a method which enables the locating of leaks at test pressure without endangering the personnel carrying out the work.

When the leak has been found, the Contractor shall repair the test section.

10.2 DEWATERING FOR TIE-IN OR RECTIFICATION OF DAMAGE/DEFECTS

To tie-in or to rectify any defects, it may be necessary to partially or completely dewater the test section. Prior to dewatering, the test supervisor shall confirm that all block valves if installed are in the fully open position.

Bi-directional pigs propelled by compressed air should be used for displacement of the line-fill water. Pigging shall be carried out against a back-pressure of hydrostatic head plus 1 bar so that air does not enter into the water-filled section.

The test section shall not be left in the partially or completely dewatered condition longer than one week without any further internal corrosion protection. Depending on the post-dewatering period and the line-fill water quality, it may be necessary to purge the test section with nitrogen or swab it with fresh water and/or inhibition slugs to avoid internal corrosion.

10.3 RECTIFICATION OF DAMAGE/DEFECTS

- (A) Damage and/or defects detected during pre-cleaning, filling, gauging and pressure testing operations SHALL [PS] be located and repaired or replaced by the Contractor in accordance with the pipeline construction specification. The proposed repair and/or replacement procedure shall be verified by the Contractor and approved by the Principal when the actual site conditions are known.

Following the completion of repairs, the activity which has been interrupted for the repair works should be repeated in accordance with all requirements of this DEP until it has been successfully completed.

The Contractor shall keep complete records of all damage/defects identified and repairs that are carried out. The records shall include, but not be limited to, the following details:

- a) exact date/time, location, types and causes of the defects and/or failures
- b) method of repair used
- c) equipment, materials and personnel used.

These records shall be submitted to the Principal as part of the final hydrostatic test report.

- (A) All defective materials such as pipes, fittings and valves that have failed during the pressure testing and have been replaced, shall be marked/labelled. The mark/label shall clearly state the location, where it came from and the cause of failure. Such material shall be held by the Contractor until the means of disposal has been agreed by the Principal.

11. REFERENCES

In this DEP, reference is made to the following publications:

- NOTES:
1. Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.
 2. The DEPs and most referenced external standards are available to Shell staff on the SWW (Shell Wide Web) at <http://sww.shell.com/standards/>.

SHELL STANDARDS

Pipeline engineering (amendments/supplements to ISO 13623)	DEP 31.40.00.10-Gen.
Linepipe for non-critical service (amendments/supplements to ISO 3183-1)	DEP 31.40.20.35-Gen.
Linepipe for critical service (amendments/supplements to ISO 3183-3)	DEP 31.40.20.37-Gen.
Electrical engineering design	DEP 33.64.10.10-Gen.
Field welding of duplex and super duplex stainless steel pipelines (amendments/supplements to API 1104)	DEP 61.40.20.31-Gen.

AMERICAN STANDARDS

Pipeline transportation systems for liquid hydrocarbons and other liquids	ASME B31.4
Gas transmission and distribution piping systems	ASME B31.8

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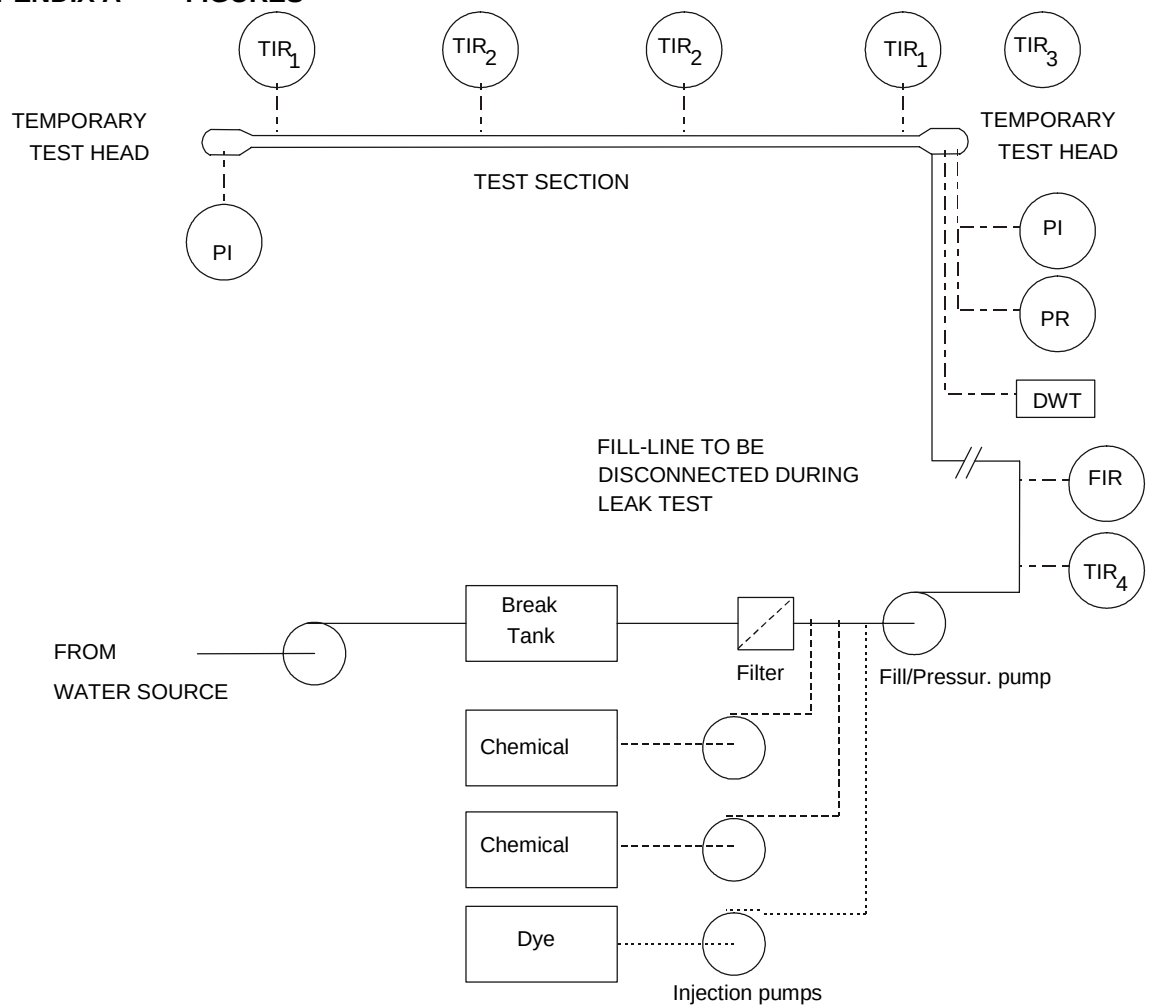
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CH-1211 Genève 20
Switzerland

Copies can also be obtained from national standards organizations.

APPENDIX A

FIGURES



Legend:

PI = pressure gauge

PR = pressure recorder

DWT = dead weight tester

TIR₁ = pipeskin recording temperatureTIR₂ = soil or seabed recording temperature probesTIR₃ = ambient air recording temperatureTIR₄ = Line-fill Water temperature recording probe during filling and pressurisingFIR = Volumetric measurement device during filling and pressurising
i.e. flowmeter or pump stroke counter

..... Offshore only

FIGURE 1 SCHEMATIC OF TYPICAL TEST SECTION

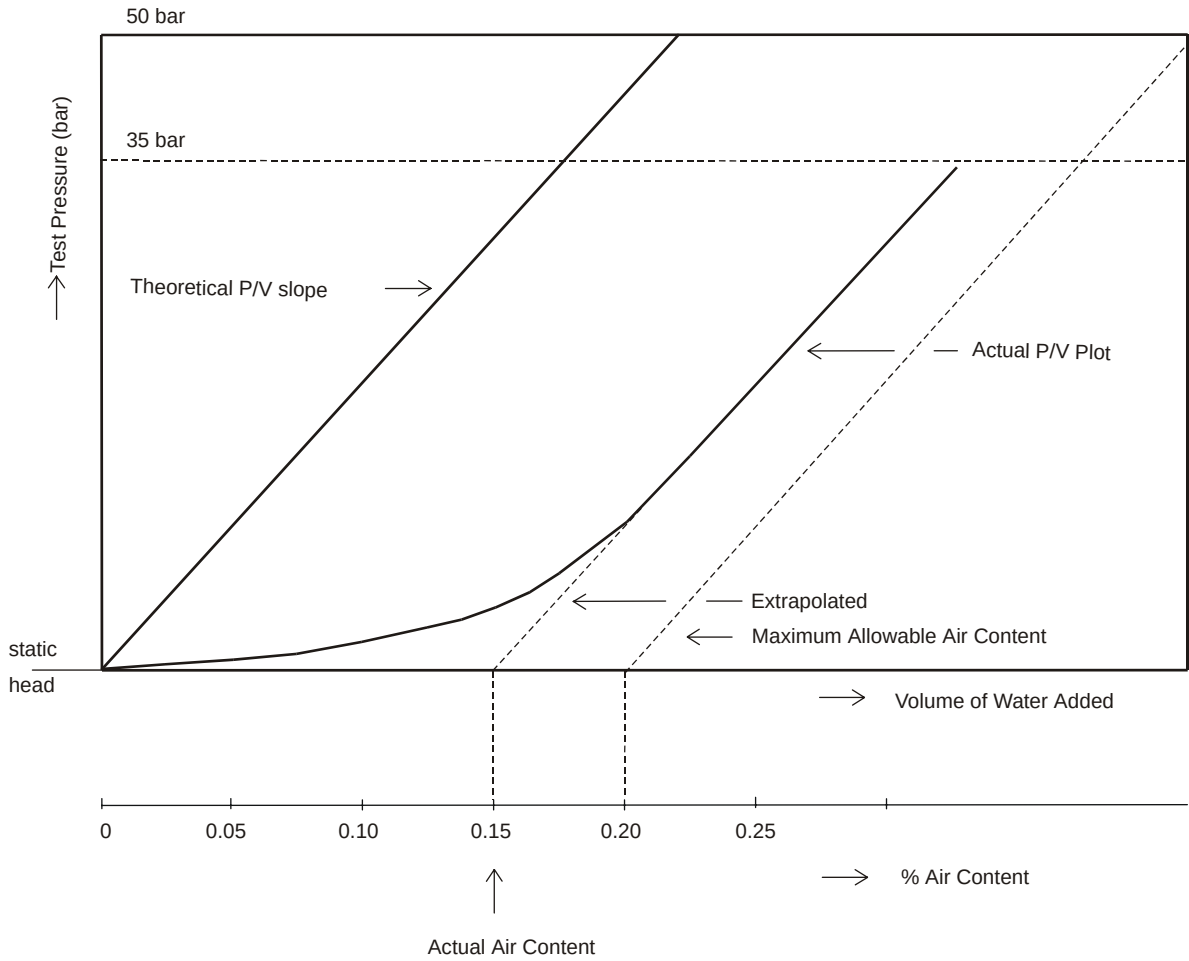


FIGURE 2 DETERMINATION OF RESIDUAL AIR VOLUME

APPENDIX B STAINLESS STEEL LINE PIPE MATERIALS**B1 INTRODUCTION****B1.1 SCOPE**

This Appendix gives amendments and additional minimum requirements for the hydrostatic pressure testing of new pipelines made of stainless steel, duplex stainless steel or clad steel line pipe materials.

B1.3 DEFINITIONS**B1.3.1 General definition**

The numbering system in this Appendix B is designed to allow for easy reference back to the remainder of the DEP by using the numbering system contained therein.

B2 GENERAL REQUIREMENT**B2.1 BASIC REQUIREMENT**

During the hydrostatic testing operations, the Contractor shall ensure that carbon steel or other non-compatible material does not come into contact with any stainless steel component at any part of the work, with the exception of temporary test heads and temporary pig launchers and receivers as specified in (B5). The test section should be kept clean, because any debris could create dangerous corrosion.

B4 LINE-FILL WATER

Clean filtered potable water should be used as line-fill water. If the use of potable water is not possible, the line-fill water shall be filtered and treated as follows:

Water	Fresh water Chlorides concentration		Sea-water
Biological activity	Within specified limits	Outside specified limits	Always outside specified limits
Chloride concentration	<200 mg/kg (200 ppm)	<1000 mg/kg (1000 ppm)	
Duration of contact	< 14 days	< 24 months	< 24 months
Biocide	None	None	Gluteraldehyde, THPS (or similar) 500 mg/kg (500 ppm)
Oxygen scavenger	None	Sodium hydroxide/sodium bicarbonate buffer pH 9.8 to 10.2	Ammonium bisulphite 100 mg/kg (100 ppm) or sodium bisulphite 100 mg/kg (100 ppm)

B5 TEST EQUIPMENT

During any pressure testing operations care shall be taken to ensure that only stainless-steel-compatible materials come in contact with the stainless steel line pipe materials. Only temporary pig traps and test heads made of stainless-steel-compatible material shall be directly connected to the test section. Any other material connected to the test section shall be only through line pipe pup pieces. After the test equipment has fulfilled its purpose, the pup pieces shall be cut back together with the test equipment. Welding shall be carried out in accordance with DEP 61.40.20.31-Gen. or the pipeline construction specification.

B6 CLEANING, GAUGING AND LINE FILLING**B6.1 GENERAL**

If the cleaning operation is carried out with water, the water shall be in accordance with (B4). This shall be fresh water with chloride concentration less than 200 mg/kg (200 ppm).

B6.2 CLEANING

Cleaning should be done using disc-type pigs. However, if circumstances necessitate the use of brush-type pigs only, stainless steel brushes shall be used.

B6.3 GAUGING

Only stainless steel gauging plates shall be used. The strength and hardness of the plate material shall be lower than the strength and hardness of the line pipe material. The plate material shall be specified in the test procedure. The gauging plates should have the following thickness:

- 3 mm (1/8 in) for pipeline diameters up and including DN 150 (NPS 6)
- 5 mm (3/16 in) for pipeline diameters above DN 150 (NPS 6).

B8 HYDROSTATIC PRESSURE TEST**B8.3 LEAKTIGHTNESS TEST****B8.3.2 Acceptance criteria**

For the pressure variation calculation based on temperature fluctuation the following Young's moduli, E and coefficients of linear expansion, α are given for information:

Martensitic or ferritic stainless steel:

$$\begin{array}{llll} 2.16 \times 10^6 \text{ bar (31.3} \times 10^6 \text{ psi)} & \leq & E & \leq & 2.20 \times 10^6 \text{ bar (31.9} \times 10^6 \text{ psi)} \\ 10.0 \times 10^{-6} \text{ }^\circ\text{C}^{-1} (18.0 \times 10^{-6} \text{ }^\circ\text{F}^{-1}) & \leq & \alpha & \leq & 10.5 \times 10^{-6} \text{ }^\circ\text{C}^{-1} (18.9 \times 10^{-6} \text{ }^\circ\text{F}^{-1}) \end{array}$$

Austenitic stainless steel:

$$\begin{array}{llll} E & = & 2.00 \times 10^6 \text{ bar (29.0} \times 10^6 \text{ psi)} \\ 15.5 \times 10^{-6} \text{ }^\circ\text{C}^{-1} (27.9 \times 10^{-6} \text{ }^\circ\text{F}^{-1}) & \leq & \alpha & \leq & 16.5 \times 10^{-6} \text{ }^\circ\text{C}^{-1} (29.7 \times 10^{-6} \text{ }^\circ\text{F}^{-1}) \end{array}$$

Austenitic/ ferritic stainless steel (duplex stainless steel)

$$\begin{array}{ll} E & = 2.00 \times 10^6 \text{ bar (29.0} \times 10^6 \text{ psi)} \\ \alpha & = 13.5 \times 10^{-6} \text{ }^\circ\text{C}^{-1} (24.3 \times 10^{-6} \text{ }^\circ\text{F}^{-1}) \end{array}$$

Clad steel:

E and α of the base material should be used.

NOTE: The given Young's moduli, E , and coefficients of linear expansion, α , should be verified against the actual line pipe data.

B10 RECTIFICATION OF DAMAGE/DEFECTS**B10.2 DEWATERING FOR TIE-IN OR RECTIFICATION OF DAMAGE/DEFECTS**

If the chloride concentration of the line-fill water is greater than 200 mg/kg (200 ppm) water, care shall be taken to ensure that no oxygen/air enters the wet test section during tie-in work or rectification work. In all cases, the test section shall be carefully flushed immediately with condensate or demineralised water (up to 2 mg chlorides per kg [2 ppm] water), followed by thorough drying.

The exposure time to sea-water shall be limited to five days, otherwise the line-fill water shall be replaced.