TECHNICAL SPECIFICATION

HYDROSTATIC PRESSURE TESTING OF NEW PIPELINES

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DESIGN AND ENGINEERING PRACTICE

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

PREFACE

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The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use DEPs they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will expect them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal or its technical advisor.

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All administrative queries should be directed to the DEP Administrator in SIOP.

NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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APPENDICES

1. INTRODUCTION

1.1 SCOPE

This is a new DEP which gives minimum requirements for hydrostatic pressure testing of new onshore and offshore pipelines (buried, submerged and above-ground) after construction, to prove their strength and leak tightness. The test medium is water.

The various stages of planning and carrying out a hydrostatic pressure test are specified in this DEP. It describes the determination 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 defects detected during the hydrostatic pressure test, but not final dewatering.

This DEP is not intended to cover hydrostatic pressure testing of pipelines which have been in service.

It is assumed that the minimum test pressure is not less than 24.5 bar (ga) and the maximum test pressure is not above 550 bar (ga). It is also assumed that the hydrostatic pressure test is carried out at ambient temperature.

The scope of this DEP covers carbon steel, clad steel and stainless steel line pipe material. 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. The scope of this DEP does not cover hydrostatic pressure testing of flexible pipes, cement lined pipelines or GRP/GRE pipelines.

The special provisions for the various types of stainless steel and clad steel line pipe materials are covered in (Appendix A).

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIPM, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group Company, and to Contractors nominated by them (i.e. the distribution code is "C", as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use by Functions in the Group that are involved in the pressure testing of new pipelines.

If national and/or local regulations exist in which some of the requirements may 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 as regards 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 with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

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

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

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. 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 word **should** indicates a recommendation.

1.3.2 Specific definitions

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 to shut-in a section of a pipeline. A block valve is normally either fully opened or fully closed.
Golden weld	A weld which is not subject to a hydrostatic pressure test and as such must 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 leak tightness test.
Line-fill water	Fresh water or sea-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 part of the construction contract which includes the scope of work relating to the pressure testing of pipelines.
Test engineer	The specialist engineer appointed and specifically named by the Contractor to be in full charge of all tests to be performed.
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, rectifying and post-testing activities.
Test section	A section of the pipeline or the entire pipeline which is subject to a hydrostatic pressure test.

1.4 ABBREVIATIONS

MAOP	Maximum Allowable Operating Pressure
SMYS	Specified Minimum Yield Strength
TP	Test Pressure

1.5 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: A summary check-list of these items for the scope of work is given in (11). Where 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: It is intended that most, if not all, of these approvals would be part of the test procedure which is required to be approved by the Principal prior to the commencement of the hydrostatic testing operations. Requirements for the test procedure and the supervising personnel are given in (2.2). A summary listing of required additional approvals are given in (13). It is assumed that the Contractor's quality systems and procedural details will have been screened prior to contract award and that the referenced approvals merely need finalising and/or formalising.

1.6 CROSS - REFERENCES

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

2. GENERAL REQUIREMENTS

2.1 BASIC REQUIREMENTS

(S) The test pressure at any point of the test section shall at least be equal to the test pressure required in the ANSI/ASME B31.4 (ref. 437.4.1) or B31.8 (ref. table 841.322 (f) and A847.2), as applicable, or to the pressure creating a hoop stress of 90% SMYS of the line pipe material, based on the minimum wall thickness, whichever is higher, or unless otherwise specified by the Principal.

During the hydrostatic pressure test the combined stress shall not exceed 100% SMYS of line pipe material based on minimum wall thickness. The combined stress shall be calculated in accordance with ANSI/ASME B31.4 (ref. 419.6.4) or B31.8 (ref. A842.223).

(S) The margin between the hoop stress of 90% SMYS and the combined 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, or as specified in the scope of work.

The test medium shall be water.

All measurements and calculations shall be in SI units. The unit of pressure is the bar,

where 1 bar = 10^5 N/m^2
= 10^5 Pa

2.2 SEQUENCE, PERSONNEL AND PROCEDURES

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

Selection of test sections, see (2.3)
- Assemblies
- Pre-test sections

Preparation of the test section, see (6)
- cleaning
- gauging
- filling

Preparation of the hydrostatic test, see (7)
- temperature stabilisation
- pressurising
- air content check

Hydrostatic test, see (8)
- strength test
- leak tightness test
- testing of "special" test sections

Post-testing activities (9)
- depressurising
- documentation

Rectification activities, if required, see (10)
- leak locating during test
- dewatering for rectification
- rectification of defects

The hydrostatic pressure testing operations shall be carried out by an experienced test engineer who shall have no other duties during the hydrostatic testing operations. The test engineer shall be in full charge of all activities related to the hydrostatic testing operations. There shall be supervising assistants provided so that at least one shall be available on site at all times during each pressure testing operation. The test engineer should be mobilised allowing sufficient time for familiarisation with pressure testing related activities.

(S) The test engineer 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. Pressure testing shall not 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, and their qualifications tasks, responsibilities and authorities.

b) Detailed schedule giving proposed dates of the main activities, tests and mobilisation data of the test engineer.

c) Details of the selected test sections, including assemblies and pre-test sections in accordance with (2.3).

d) Identification of potential safety and enviromental hazards, including the necessary measures and emergency plans, in accordance with (3).

e) Details of the line-fill water, including the source, treatment method, discharge/disposal and permits in accordance with (4).

f) Details of the test equipment, including layouts and size and/or performance in accordance with (5).

g) Details of the test section preparation, including cleaning, gauging and filling in accordance with (6).

h) Details of the hydrostatic pressure test preparation, including temperature stabilisation period, in accordance with (7).

i) Details of the hydrostatic pressure tests, including pre-test, strength test and leak tightness test in accordance with (8).

j) Details of the post-testing activities, including depressurising and documentation in accordance with (9).

k) Details of rectification activities, including proposal of leak locating, dewatering and rectification in accordance with (10).

NOTE: A check-list of the details required in the test procedure is given in (12).

2.3 TEST SECTIONS

The Contractor shall determine the test sections in accordance with the following requirements.

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

Above-water or above-ground test sections shall be tested in accordance with (8.4).

The difference in elevation of each test section should not exceed the limits given in (2.1).

ONSHORE PIPELINES	OFFSHORE PIPELINES
Where the pipeline traverses hilly terrain, the elevation profile should be plotted to assist in checking that the test pressure at the low and high point falls within the specified limits. The Contractor shall determine the first test section to be tested and subsequent test sections sequence, taking account of the availability of water.	The elevation difference between the sea-level/water surface and the test head on the platforms should be measured to check that the test pressure at the water surface and high point falls within the specified limits. If the pipeline goes to shore the profile of the on-shore section should be plotted as specified for onshore pipelines. Pipelines should be pre-tested prior to burying or trenching.

When the pipeline consists of several sections with different wall thicknesses and/or steel grades, the hoop stress level should be considered in selecting test sections. It may be necessary that the various sections are tested separately; see (2.1).

(S) Separate assembly testing at a specific test pressure should be performed to demonstrate the strength and leak tightness of pipes and welded assemblies used for special installations such as rail crossings, river crossings, major road crossings, risers and block valves. The method of construction, components installed in a test section, the test pressure level and risk/consequences in the event of a test section failure should be considered in specifying separate assembly testing. Under certain circumstances it may be applicable to test assemblies prior to installation, i.e. strings for directional drilling, pipes for bored rail or major road crossing installed without casing or riser. The assembly testing and/or pre-testing should be specified in the scope of work and verified in the test procedure.

(S) To avoid damage caused by debris to the valve internals, it may be decided to install block valves after successful completion of the hydrostatic pressure test of the test section. The cleanliness of the test section, presence of internal coating, test sequence and the allowable test pressure level difference should be considered in specifying the timing of block valve installation. The timing of block valve installation should be specified in the scope of work.

The pressure test of each test section should commence as soon as practicable after construction of the test section or assembly has been completed. Testing should be undertaken progressively throughout the construction of the pipeline.

After the various test sections have been tied-in to each other, a hydrostatic leak tightness test should be carried out on the entire pipeline. The pressure tested test sections or assemblies shall be tied-in by "Golden Welds", see ANSI/ASME B31.4 (ref. 437.1.4 (5) (b)) and B31.8 (ref. 841.31 and A847.6).

3. SAFETY AND ENVIRONMENT

The Contractor shall take all necessary measures to ensure that his own personnel, those of the Principal and the general public are adequately protected from the consequences of a possible system failure during the testing operations. The Contractor shall ensure that no other work is permitted on the pressurised sections during the period of the test and during the subsequent depressurising operations.

The Contractor shall confirm to the Principal that he has instructed all employees engaged on testing work, or any work associated with testing, of the possible consequences of a pipeline or test fitting failure under pressure test conditions.

(A) The pressurising pump, pressure relief valve and test cabin shall be located away from public places/roads or living quarters. 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.

The test equipment shall be earthed to be adequately protected against lightning and accumulation of static electricity.

Flexible pressurising or monitoring hoses should not be allowed in the test cabin. They should be anchored at 5 metre intervals and protected against external damage. Hoses should not pass through doorways. Where hoses pass over walkways they should be protected against any passing personnel or equipment.

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 shall include, but not be limited to, the following:

- How to deal with washouts and other damage
- Telephone numbers of standby crews
- Telephone numbers of police, medical and other authorities which may be affected
- Telephone number of Principal's local operations base/control room which may be affected
- List of equipment and machines available or needed
- List of personnel
- Location of first aid facilities.

(A) The Contractor shall obtain the approval of the Principal before commencing pressurisation.

When during pressurising the pressure in the test section exceeds static head plus 1 bar, the test engineer shall ensure that no unauthorised person approaches within 20 m of the test head and the temporary piping. If site restrictions make it impossible to observe this 20 m limit, a protective wall should be constructed prior to the commencement of testing.

During the test, all construction within 20 m of the test section shall cease.

Any leaking flanges should be tightened only after the pressure in the test section is reduced to a safe level and not more than 70 bar (ga) or MAOP, whichever is the lesser. Before any other work 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. It may be possible to isolate the leaking part by use of a douple block and bleed installation.

ONSHORE PIPELINES

The sites for the test equipment should be away from public highways, other inhabited areas and depots.

The boundaries of the test equipment sites shall be defined by marker tapes or a fence.

When testing takes place, patrols shall be provided to watch special points of hazard, in particular road, railway, and water-crossings, block valve stations, above-ground installations and points of public access.

When deemed necessary, protective walls, constructed of sand bags or other methods approved by the Principal, shall be placed in agreed locations. Particular attention shall be paid to blanked or capped ends of pipe, unrestrained above-ground pipework and any adjacent operational pipework.

Testing shall not commence until the Principal has received from the Contractor confirmation that the following precautions have been taken:

a) that notification has been given, in writing, to persons resident in the vicinity of the pipeline that testing is to be carried out. Individual precautions shall be made by the Principal for persons resident within 20 m of the pipeline section during the period of test, see API RP 1110 .

b) that the local police, and other authorities who may be affected, have been notified in writing that testing is to take place.

Should there be an extension of the duration of testing, notification of this shall be given by the Contractor to the persons detailed in a) and b) above.

OFFSHORE PIPELINES

The main hazard lies in the topside facilities, onshore locations and site assembly testing.

Full attention must be given to erect barriers and warning notices forbidding entry to personnel other than the test team. The co-operation of platform or site safety officers should be sought in preventing unauthorised entry to these areas. If installed, regular tannoy announcements should be made.

If the pipeline goes to shore, the onshore locations should be supervised in accordance with the requirements of onshore pipelines.

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 required for diver safety.

All chemicals, including corrosion control products and leak detection dyes, should be handled as if toxic. Before purchase of these, the Contractor shall request from the Supplier a material safety data sheet and written recommendations for storing and disposal. The Contractor shall be responsible that the information contained within the documents is complete. The Contractor shall ensure that any suppliers' proposed protective 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 should not be stored in large quantities and should be stored well away from heat and flames.

Protective clothing, gloves and goggles shall be worn when handling chemicals. A safety shower and eyebath 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.

	ONSHORE PIPELINES	OFFSHORE PIPELINES
	The Contractor shall 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 Contractor shall have the written consent of the appropriate local Authorities before any substances other than uncontaminated fresh water or sea-water is discharged into the sea. If line-fill water contains millscale and/or rust, consent shall be obtained before discharging.
	Water, whether contaminated with chemicals or not, shall not be returned to any water course or lake without full permission of the appropriate local Authorities.	The Contractor shall ensure that the owner of any installation and/or any other person within 1 km of the point of line-fill discharge is not affected by the discharge. The Contractor shall obtain agreement from these persons prior to the discharge.
	If line-fill water contains millscale and/or rust, separation should be made before discharging.	
(A)	Line-fill water containing biocides shall not be discharged into water courses and sewer systems.	Any water desalination equipment within 1 km of the discharge point should not be used during the discharge period or for 24 hours thereafter unless approved by the safety officer.
	The Contractor shall at all times ensure that the noise level does not exceed the regulated limits within inhabited areas.	

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 local regulations.

4. LINE-FILL WATER

The Contractor shall ensure that the water to be used for the various pressure testing operations is of a quality that protects the test section from the ingress of foreign matter, sedimentation and internal metal corrosion. 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.

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 stabilisation period. The water shall be filtered through 50 micron filters, except for water injection lines for which the water shall be filtered through 2 micron filters, before entering the test section. The arrangement of filters at the test work sites should enable back flushing without disconnecting the pipe work.

ONSHORE PIPELINES	OFFSHORE PIPELINES
There is no requirement to inject dyes.	Where flanges are installed in a test section, a dye should be added to the line-fill water for leak detection during the hydrostatic pressure test. For longer sections, batches of dye located at flanges are preferred. Fluorescein and Rhodamine B, or equivalent, dosed into the line-fill water at a concentration of 40 ppmw (active constituent weight) are recommended.

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. Environmentally acceptable line-fill treatment packages should be used.

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 ppm
- ammonium concentration.

To minimise biological fouling and/or bacterial corrosion to an acceptable level in the filled pipeline, the above required analysis shall not exceed the following limits:
- sulphate concentration 42 ppm
- fatty acids concentration 14 ppm
- ammonium concentration 3 ppm

Sea-water analyses are not required. 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 required quality for the various pressure testing operations specified in this DEP.

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

(S) If the above limits for biological fouling cannot be met and/or oxygen corrosion must 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. The table below gives approved chemical treatment and concentrations for fresh water or sea-water to be used as line-fill water for carbon steel pipelines. All concentrations are related to the active constituents.

WATER	FRESH WATER Biological activity				SEA-WATER		
BIOLOGICAL ACTIVITY	Within specified limits		Outside specified limits		Always outside specified limits		
ARE CORROSION PRODUCTS ACCEPTABLE?	YES	NO	YES	NO	YES	YES	NO
DURATION OF CONTACT	< 24 months	< 24 months			< 1 month	> 1 month and <24 months	< 24 months
BIOCIDE	None	None			None	Polymeric Biguanide Hydrochloride 20 ppmw	Polymeric Biguanide Hydrochloride 20 ppmw
OXYGEN SCAVENGER	None	Sodium Hydroxide/ Sodium Bicarbonate Buffer pH of 9.8 to 10.2			None	None	Ammonium Bisulphite 100 ppmw or Sodium Bisulphite 100 ppmw

NOTES:
1. Overdosing of bisulphite can lead to possible sulphide corrosion problems. Precautions should be taken to prevent oxidation of bisulphite in its concentrated form, as this is important for pH control.
2. When a sodium hydroxide/sodium bicarbonate buffer is to be used it should be demonstrated to the Principal before use that no precipitation in the line-fill water will occur.
3. Sodium hydroxide/sodium bicarbonate buffer also achieves the required microbial control.
4. Monitoring of residual scavenger should be performed.
5. Samples should be taken from each tank at the end of the filling in order to check that no contamination has taken place.
6. Longer duration may be allowed if extra testing of the line-fill water is carried out.

Chemicals and dye shall be injected by separate injection pumps and an injection manifold. The injection points at the manifold shall be positioned at least 1 m apart. 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 water shall be checked and chemically retreated as necessary before transferring. No debris shall be transferred from one test section to another.

Line filling should not take place if the ambient temperature is below 2 °C unless a suitable antifreeze has been added to the line-fill water. It should be noted that the bulk modulus of water/antifreeze mixture is different from that of water alone. Also the volumetric expansion coefficient is different. The changes of both are a function of the antifreeze concentration. 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 leak tightness test, see (8.3). 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 and quality of water, the procedure for the withdrawal of water from the source and details of the water treatment proposal 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 standby units, and shall supply the test equipment necessary to fulfil the requirements of this DEP.

A schematic equipment layout of a typical test section is shown in 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, the material, length and if applicable the configuration of the shoes, brushes, oversize and hardness shall be defined by the Contractor.

TABLE 5.1 Test Equipment

	Filling and pressurising pumps	complete with stroke counter or flow meter suitable for the required duty.
(S)	Filters	2 micron or 50 micron, as specified in the scope of work, compatible with flow rate of filling pumps. Filters with 50 microns and above should be capable 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 no worse than 5% of the specified 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 engineer 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 the 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 in accordance with the specified accuracy in table 5.2.
	Soil temperature probes and recorder	measuring and recording equipment in accordance with the specified accuracy in table 5.2.
	Subsea temperature probes and recorder	measuring and recording equipment in accordance with the specified accuracy in table 5.2.
	Pressure relief valve	fitted to the pressuring pump with full capacity of the pump and set at 3% above the specified test pressure to assure that the test section is not overpressured.
	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 of longer than 5 km.
	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.

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 shall be designed, constructed and tested according to the same code as the pipeline. However, various options of design code break between ANSI/ASME B31.4/B31.8 and other codes may be used, specifically where prefabricated items have been used. The acceptability of the proposed code break shall be specified in the test procedure. Test heads and temporary pig traps shall be numbered and a certificate shall be kept by the Contractor showing the results of non-destructive tests on each weld and of the hydrostatic pressure test. The number of times each test head is used and the test pressure attained on each test shall be recorded. Entries in the record shall be signed by the test engineer. Test heads shall not be used if they do not have a complete certificate and record of use from the beginning.

Wall thickness transitions shall meet the welding configuration requirements as specified in the ANSI/ASME B31.4 (ref. 434.8.6) and B31.8 (ref. Appendix 1, Fig. 15) respectively.

NOTES: 1. t_D, the maximum thickness for design pressure, shall not be greater than 1.5 t, where 't' is the nominal wall thickness of the thinner pipe.

2. Pipes with a thickness less than 4.8 mm shall not be used.

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 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 from the bevelled end in accordance with L-2-2/3 or L-3-2/3.

(A) Flexible hose shall be of the armoured type and shall only be used if it is manufactured to standards applicable for 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. 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. The method of anchoring shall be approved by the Principal.

(S) Electrical installations shall comply with DEP 33.64.10.10-Gen. Particular attention is drawn to the use of electrical equipment in hazardous areas. The zone classifications are given in the scope of work.

If diesel engines are used in hazardous areas consideration of the protection of such engines are required. No such engines should be used in, or within 15 metres of, a zone 1 area. Their use in zone 2 area should be avoided wherever possible. If the use of diesel engines within 15 metres of a zone 1 or 2 area or within a zone 2 area is unavoidable the following is required:

- Surface temperature limitation to 250 °C or to the specified temperature class.
- Exhaust flame trap and spark arrestor.
- Non-electric starting system.
- An inlet air shut-down control system to operate on high temperature, overspeed and gas detection.
- Cooling fan blades should be non-metallic and all fan belts antistatic fire resistant type.
- Any ancillary electrical equipment shall comply with DEP 33.64.10.10-Gen.

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)	0.01 bar	0 to 1.5 x TP	± 0.05 % (NOTE 2)
Pressure data logger	0.01 bar	0 to 1.5 x TP	± 0.05 % (NOTE 2)
Pressure gauge	1, 2 or 5 bar	0 to 1.5 x TP	± 0.6 % (NOTE 3)
Pressure recorder (24 hours)	2 or 5 bar	0 to 1.5 x TP	± 1 % (NOTE 3)
Barometer	1 mbar	-	± 0.8 mbar
Ambient air temperature recorder (24 hours)	0.5 °C	0 to 80 °C	± 1% (NOTE 3)
Temperature probes and recorder (digital)	0.1 °C	0 to 50 °C -10 to 60 °C	± 0.1 °C ± 0.2 °C
Filling-flowmeter (turbine)	m^3/h	-	± 1% (NOTE 3)
Pressurising flowmeter	strokes/litres	-	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.

(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 tank for calibration.

(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

(A) Prior to pressure testing (or after, if approved by the Principal), the Contractor shall clean and gauge sections of lines 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, see (2.3).

(A) Temporary pig launchers and receivers shall be approved by the Principal prior to use and 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 (ga).

NOTE: In sections with a diameter less than 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, see (4).

In pipelines longer than 5 km single pigs or the last pig of a pig train should be fitted with a pig location device.

ONSHORE PIPELINES	OFFSHORE PIPELINES
An electromagnetic pig location device should be used.	A pinger-type pig location device should be used.

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 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.

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

The pig register should include the following:
- pig run number
- pig type
- launching and receiving time
- downstream pressure
- arrival condition of the pig
- amount and kind of material received with the pig.

(A) Should a pig become stuck in the pipeline, the Contractor shall not employ a differential pressure greater than 7 bar to dislodge the pig, if the driving medium is air. If a differential pressure up to 50% of MAOP generated with water 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

ONSHORE PIPELINES

The length of the cleaning sections to be cleaned and gauged should be between 10 and 20 km depending on suitable tie-in points.

OFFSHORE PIPELINES

Prior to using water for the cleaning operations, the Contractor shall ensure that all pipeline spans of the cleaning section have been inspected either by divers or by a remote controlled vehicle or side scan sonar survey to ensure the pipeline unsupported spans do not exceed the allowable span value for the hydrostatic pressure test conditions, see (8.2).

When lay-down heads are to be used a combined cleaning/gauging and filling operation may be required. As a minimum, 3 pigs should be used. The last pig should be the gauging pig as specified in (6.3).

The first pig driven through the cleaning section should be of a bi-directional type. The position of the pig should be monitored. A series of wire brush cleaning pigs in combination with a bi-directional pig should follow until the required cleanliness of the cleaning section has been established. The by-pass of the cleaning pigs should be kept open in order to transport the loose debris out of the cleaning section. To remove ferrous debris, including broken bristles from brush pigs from the cleaning section, a magnetic cleaning pig should be used after the brush cleaning has been completed.

In order to assist the speed control of the cleaning pig and the jet stream of the pig bypass, a constant back pressure should be maintained by suitable adjustment of a throttling valve (e.g. set at 3 bar (ga) depending on the driving medium) installed at the receiving test head. The speed of the cleaning pigs should not be less than 0.5 m/s and not more than 2.5 m/s.

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

The amount of material received at the end of each pig run should be assessed on a volume and weight basis. The material received should show a reducing trend, in both volume and particle size. Pigging should continue until the volume of the received material is less than 5 litres and further pigging will not result in a significant reduction in the material received.

The absence of rust in the discharge is a further indicator of the test section cleanliness. If all rust is removed, all other loosely adhered materials on the metal is considered removed. The time to inspect the outflow for rust colouring is just before and just after pig arrival.

All debris received with the pig shall be disposed off in an authorised manner.

6.3 GAUGING

After cleaning the test section and back-filling the trench, the test section shall be gauged.

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 thick for pipeline diameters up to DN 100
- 6 mm thick for pipeline diameters from DN 100 to DN 300
- 12 mm thick for pipeline diameters from above DN 300.

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

The radial incision 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:

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

where:	d	=	gauging plate diameter	mm
	D	=	nominal outside diameter	mm
	ID	=	minimum internal diameter	mm
	b	=	clearance of 5	mm

The gauging pig speed and back pressure control should be as specified in (6.2) for cleaning pigs.

(A) Gauging plate measurement, introduction of the gauging pig into in 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.

In cases where 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 size. If the defect cannot be located by the gauging operation, the Contractor shall run a geometric inspection pig to locate the defect.

Any damage noted by the gauging pig or by the geometric inspection pig shall be located and repaired by the Contractor in accordance with (10.3).

6.4 LINE FILLING

The test section shall be filled with line-fill water as specified in (4). All instruments and gauges to be used during filling and water-treating shall have been calibrated and their valid test certificates shall have been approved by the Principal.

If block valves are installed, the test engineer 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 engineer 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. The sections should, if possible, 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 pig speed should be approximately 0.6 m/s and should not exceed 1.8 m/s. The pressure in front of the pig shall be carefully monitored and controlled at not less than 2 bar (ga). 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 taken:

- inlet flowrate of line-fill water
- inlet pressure of line-fill water
- inlet temperature of line-fill water
- pressure at the receiver head
- chemical injection rates (if carried out)
- 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 and falling or in freezing conditions unless antifreeze precautions are taken in accordance with (4).

7. PRE-TEST REQUIREMENTS

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 check-list should include checks to confirm that:

- The test section has been isolated from all other pipeline sections.
- 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.
- The test section has been filled completely and air has been vented off.
- The block valves, if they are installed, have been returned to the half-open position so that there is no differential pressure across the seats/seals.
- All instruments and gauges to be used during pressurising and testing have been calibrated and valid test certificates have been approved by the Principal.
- All warning notices, marker tapes, protective barriers and other safety equipment have been positioned and the necessary authorities have been informed.
- All necessary personnel at the affected stations have been informed of the commencement and the duration of the hydrostatic pressure test.
- The communication channels have been tested and established and back-up equipment is available.
- The personnel engaged in the testing work have been briefed on the emergency plans.
- The person operating the pressurising equipment has been instructed by the test engineer regarding the limiting pressure which shall apply to the test section.

ONSHORE PIPELINES

The test section should be completely buried, up to the test heads, to specified depth before testing commences. The trench should also be reinstated to the maximum extent possible prior to commencement of the test. Test heads and above-ground sections should be sheltered and thermally insulated in order to minimise the effects of ambient temperature variations.

Pipe and soil temperature should be measured and recorded at each end of the test section and at approximately every 5 km throughout the length of the pipeline, depending on the ground water contact with the test section. A minimum of 3 temperature measurements should be carried out, one at each end plus one in the middle. The points of measurement at each end of the test section should be such that there is at least 100 m of pipeline buried to specified depth between that point and the test end.

OFFSHORE PIPELINES

Buried test sections should have the specified depth of cover before testing commences. The sea-water temperature should be measured next to the pipeline on the seabed and, if the volume of the riser exceeds 10% of the test section volume, additionally half-way down the riser. The test section temperature should be measured at each end of the test section using thermocouple type instruments. For the pipe temperature measurements, they should be firmly installed into the line-fill water at points where temporary fittings have been used. The location of temperature measurement on the seabed and the number of locations should be specified on site after the pipeline has been laid.

ONSHORE PIPELINES

For the temperature measurements, thermocouple type instruments with digital read-out should be used. For the pipe temperature measurements, they should be firmly attached to bare corrosion protection coating and covered with insulating materials or installed into the line-fill water (at points where temporary fittings have been used). For the soil temperature measurements, they should be buried at pipe centre line depth and 0.5 m laterally from the pipe.

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 metal and covered with insulating materials

7.2 TEMPERATURE STABILISATION

The temperature of the line-fill water should be stable before testing commences, see also (7.3). For longer test sections, typically in hot climates, the line-fill water temperature may take several days to stabilise.

Prior to commencing the hydrostatic test, the water temperature should be within 1.0 °C of ground or seabed temperature. This shall be 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 hours 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

The test engineer shall carry out a plot of pressure/added volume (P/V plot, see Figure 2) using measurement of volume added either by pump strokes or flow meter and instrument reading of pressure gauge plus deadweight tester. A tank should be available to enable checks to be made of the volume rating of the pressure pump or flow meter.

The rate of pressurisation should be constant and not exceeding 1 bar/minute until a pressure of 35 bar or 50% of the test pressure, whichever is lesser, has been attained. During this period, volume and pressure readings should be recorded at 1 bar intervals.

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

During pressurisation, all potential leakage points shall be checked.

When the pressure of 35 bar or 50% of the test pressure, whichever is lesser, has been reached, the air content shall be determined as specified in (7.4).

When the air content is within the maximum allowable limit of 0.2% of the test section volume, pressurisation should continue, at the rate given above, as follows:

- If flanges are installed, pressurisation should continue up to 70 bar or to the MAOP, whichever is the lesser and be held whilst checking flanges for leaks. This is the highest pressure permitted to tighten up any leaking flanges (except for subsea, see (3)).
- If flanges are not installed or the flanges have been checked, pressurisation should continue up to 80% of the test pressure and be held at this level for not less than 2 hours. During this water stabilisation period accessible flanges, if installed, should again be checked for small leaks. If any are found, the test section shall be depressurised at not more than 2 bar/min to 70 bar or to MAOP, whichever is lesser, prior to any bolt tightening.

The volume and pressure readings should be recorded at 10 minute intervals until the test pressure has been reached.

After stabilisation, the pressure should be raised to 95% of the test pressure and held for 30 minutes, then the pressurisation should be continued to the specified test pressure at a rate not exceeding 0.5 bar/min.

The pressures and added volumes should be continuously plotted until the specified test pressure has been achieved. The plot should be constantly checked and, in the event of any deviation of 10% or more from the theoretical line corresponding to 100% water content, the test should be terminated. The pressure should be released and an investigation shall be carried out to determine the cause of the deviation prior to re-pressurisation.

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 as specified in Figure 2. 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 = (Volume of air / Volume of line) 100

If the air content exceeds 0.2% of the line volume, testing shall be terminated and an investigation shall be carried out to determine the cause. The test section should be emptied and refilled at the discretion of the Principal.

8. HYDROSTATIC PRESSURE TEST

8.1 DURATION OF HYDROSTATIC TEST

The minimum duration for the hydrostatic pressure test shall be a 4-hour strength test followed by a 24 hour leak tightness test. The assembly testing shall comprise a 4-hour strength test followed by visual examination at the leak tightness test pressure.

8.2 STRENGTH TEST

The TP shall meet the requirements given in (2.1). When the TP is required to give a hoop stress of 90% of SMYS based on minimum wall thickness, then it should be calculated as follows:

$$TP = \frac{20 \quad (t - t_m) \quad S}{D} F \; E \; T$$

where	TP	=	hydrostatic strength test pressure	bar (ga)
	t	=	nominal wall thickness of pipe	mm
	t_m	=	maximum minus tolerance for wall thickness of pipe	mm
	D	=	outside diameter of pipe	mm
	S	=	Specified Minimum Yield Strength (SMYS)	N/mm^2
	F	=	design factor (for hydrostatic strength test, i.e. 90% stress level, F = 0.9)	-
	E	=	longitudinal joint factor (for linepipe in accordance with L-2-2/3 or L-3-2/3, E = 1.0)	-
	T	=	temperature derating factor (for hydrostatic strength test, T = 1.0)	-

(S) The required test section data are given in the scope of work. The test engineer shall confirm that the above calculated 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 design pressure of the fittings specified for the pipeline.

The combined stress for the hydrostatic pressure test condition shall be calculated in accordance with ANSI/ASME B31.4 (Ref. 419.6.4) and B31.8 (Ref. A842.223). 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 combined stress during the hydrostatic pressure test shall be limited to 100% of SMYS based on the minimum wall thickness. If the calculated combined 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 ± 1 bar by bleeding or adding water as required. The volumes of water added or removed shall be measured and recorded.

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

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

If a leak is suspected the actions shall be in accordance with clause (10.1).

8.3 LEAK TIGHTNESS TEST

8.3.1 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.

If it can be ensured that the pressure variations due to temperature fluctuations are in the specified limits (2.1 and 8.2), then a combined strength/leak tightness test at the strength test pressure, without water addition or removal, should be carried out. To allow for pressure variations caused by temperature fluctuations during the test duration, the test pressure should be set to a level of 80% of TP.

During the test, the pressure shall be recorded continuously, and the deadweight tester and air temperature readings shall be recorded every 30 minutes. The pipe and soil/sea-water temperature shall be recorded at maximum 3-hour intervals. The temperature recording interval should be reduced to a 1-hour duration for the first and last 3-hour periods of the 24 hours 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.

If the pipeline consists of several sections which have already been strength tested, the pressure for the final leak tightness test shall be based on 80% of the lowest TP of the tested sections. The difference in elevation over the test section shall be taken into account.

If a leak is suspected then actions shall be in accordance with (10.1).

8.3.2 Acceptance criteria

(A) To determine whether any pressure variation is a result of temperature changes or whether a leak is present, the pressure/temperature changes shall be calculated from the pressure/temperature equation formula 2 (2a for restrained test section or 2b for unrestrained test section) or unless otherwise approved by the Principal.

Formula 1. Volume/pressure equation

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

Formula 2. Pressure/temperature equation

2a) For restrained test sections	2b) For unrestrained test sections
$$\frac{\Delta p}{\Delta T} = \frac{\gamma - 2(1+\upsilon)\alpha}{\frac{D}{Et}\left(1-\upsilon^2\right)+\frac{1}{B}}$$	$$\frac{\Delta p}{\Delta T} = \frac{\gamma - 3(1+\upsilon)\alpha}{\frac{D}{Et}\left(1-\upsilon^2\right)+\frac{1}{B}}$$

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

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.
3. Above-ground or above-water test sections, if not anchored, and very short off-shore 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 leak tightness test.

The tightness test shall be deemed acceptable if any pressure change can be accounted for by a corresponding temperature change using formula 2. Allowance should be made for any recording inaccuracy.

In the event of any doubt by the Contractor or the Principal about the leak tightness of the line, for example when temperature and pressure trends are differentiated, the test shall be extended until such time as the acceptability is demonstrated.

8.4 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 and wind) or test sections of pipe bundles and insulated pipelines (slow heat transfer).

Therefore the test engineer should wherever possible carry out a visual examination to check the leak tightness of the test section after the satisfactory completion of the 4-hour strength test, see ANSI/ASME B31.4 (Ref. 437.4.1 (a)). The visual examination shall not commence before the pressure has been reduced to 80% of the test pressure. The results of the visual examination shall be documented by the test engineer, see (9.2).

If it is not possible to check the leak tightness of the test section by visual examination, then the leak tightness shall be demonstrated by a 24-hour leak tightness test in accordance with (8.3). 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-hour leak tightness test for pre-tests of assemblies is not necessary unless they are included in a final leak tightness test. 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 leak tightness tests, the test section shall be depressurised to hydrostatic head plus 1 bar 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.

Under normal circumstances the depressurisation rate shall not exceed 1 bar 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 per minute.

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

The above requirements also apply when the test section must 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, at the end and at least once during the test.

All recorder charts shall be signed by the test engineer 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 each completion of a successful section test a "hydrostatic test certificate" (see Figure 7) shall be completed and signed by 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:

- originals of all recorder charts
- all pressure readings, see (6 and 8)
- all temperature readings, see (6.4, 7.2, 8.2, 8.3 and 8.4)
- volumes of water added or bled off, see (8.2)
- instrument test certification, see (5)
- air content plot and calculation, see (7.4)
- pressure and temperature plots against time, see (7.2, 8.2, 8.3 and 8.4)
- pressure/temperature correlation calculation, see (8.3.2)
- details of line-fill treatment packages, see (4)
- pig register of cleaning, gauging and filling, see (6)
- photographic record of the used gauging plates, see (6.3)
- leak locating (if carried out), see (10.1)
- pig register of dewatering (if carried out), see (10.2)
- details of line-fill water disposal (if carried out), see (4 and 10.2)
- rectification records (if carried out), see (10.3)
- any special features of the test, see (3)
- test procedure (see 2.2).

(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 should 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. Some methods for locating leaks are listed in Figure 8.

When the leak has been found, the Contractor shall repair the test section in accordance with (10.2 and 10.3).

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 engineer shall confirm that all block valves if installed are in the fully open position. The Contractor shall confirm to the Principal that the disposal of line-fill water, including filtering, testing, etc., shall be in accordance with (4).

For partial dewatering of test sections containing treated water, the use of bi-directional pigs and/or hyperbaric spheres should be considered to isolate the repair or tie-in location from the water-filled test section rather than total dewatering.

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. No attempt should be made to dewater the test section by letting the water run out under the effects of gravity.

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 required to purge nitrogen or swab the test section with fresh water and/or inhibition slugs to avoid internal corrosion in the test section.

10.3 RECTIFICATION OF DAMAGE/DEFECTS

(A) Damage and/or defects detected during pre-cleaning, filling, gauging and pressure test operations shall 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 the failed activity has been successfully completed.

The Contractor shall keep complete records of all damages/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 as specified in (9.2).

(A) All defective materials such as pipes, fittings and valves which 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. SCOPE OF WORK CHECK-LIST

The scope of work should provide/specify the data/activities detailed below, for each hydrostatic pressure test.

Section/ Reference	Description	Value
2.1	HOOP STRESS LEVEL Is a deviation from the specified hoop stress level required? If yes, specify the hoop stress ALLOWABLE ELEVATION DIFFERENCE If applicable specify the allowable elevation either 5% of SMYS or to 50 m	 Yes [.....] No [....] .....% SMYS Yes [.....] No [....] Yes [.....] No [....]
2.2	TEST PROCEDURE Specify the submission of the test procedure in advance of the planned date of the first testing operation (if different from 28 days)	 ..... days
2.3	ASSEMBLY TESTING Is any assembly testing required: If yes, give the relevant details	 Yes [.....] No [....]
2.3	PRE-TEST Is any pre-test of assemblies required? If yes, specify these assemblies	 Yes [.....] No [....] ....
2.3	BLOCK VALVE INSTALLATION Is installation required before or after main line testing?	 Before [.....] After [.....]

Section/ Reference	Description	Value
4.	CORROSION PRODUCTS Are corrosion/oxidation products acceptable?	 Yes [.....] No [....]
5.	TEST EQUIPMENT Are filters with two micron required? Are hazardous area classifications required? If yes, specify	 Yes [.....] No [....] Yes [.....] No [....]
8.2	PIPELINE DATA/TEST SECTION DATA Give test section data: Outside diameter Nominal wall thickness Wall thickness plus tolerance Wall thickness minus tolerance Steel grade (SMYS) Test pressure at the mill Maximum allowable operating temperature	 .....mm .....mm .....mm .....mm .....N/mm^2 .....bar .....°C
9.2	DOCUMENTATION Specify the submission of the draft test report after completion of the test (if different from one week)	

12. TEST PROCEDURE CHECK-LIST

The test procedure should provide/specify the data/activities detailed below, for each pressure testing operation.

Section/ Clause	Activity/Procedure requiring information	Covered
2.2	**Sequence, personnel and procedure**	
	List of nominated personnel and their qualification	[....]
	Detailed schedule incl. mobilisation date of test engineer	[....]
2.3	**Test sections and assemblies**	
	Number of locations:	[....]
	Geometrical data and steel grades: (length, diameter, wall thickness, internal volume, elevation difference/profile)	[....]
	Number and locations of pre-tests, if appropriate:	[....]
3.	**Safety and environment**	
	Emergency plan	[....]
	Location of notice readings	[....]
	Locations of test equipment (chemicals, filters, break tank, pumps, safety relief valve, test heads and test cabin)	[....]
	Notification and consultation, if appropriate (persons, companies, authorities and local police)	[....]
	Patrols to watch special points of hazard (crossings, test sites, etc.)	[....]
	Seasonal environmental status (water source)	[....]
	Type of waste and location of disposal (dyes, chemicals, debris from cleaning operation)	[....]
4/A4	**Line-fill water**	
	Source of water	[....]
	Location and method of water withdrawal	[....]
	Independent testing laboratory, if applicable	[....]
	Water analysis report, if appropriate	[....]
	Chemical treatments and injection rates, if appropriate	[....]
	Dyes and injection rates, if appropriate	[....]
	Location and method of water discharge/disposal	[....]
	Details of winter testing, if appropriate	[....]
	Permits from the local authorities	[....]

Section/ Clause	Activity/Procedure requiring information	Covered
5/A5	**Test equipment**	
	Test equipment list, including performance of pumps and compressors	[....]
	Specification of temporary fitting and components (piping, pig traps, test heads, flexible hoses and connectors, etc.)	[....]
	Anchoring method of flexible hoses	[....]
	Type of pigs, dimensions, materials, hardness etc.	[....]
	Diameter of gauging plate	[....]
	Stainless steel gauging plate material, if applicable	[....]
	Sketch of the gauging pig showing the locations of the plate(s)	[....]
	Pig tracking system, if applicable	
	Instrument calibration certificates	[....]
6.	**Cleaning, gauging and line filling**	
6.1/A6.1	Typical pig register	[....]
	Pigging procedure	[....]
6.2/A6.2	**Cleaning**	
	Number and locations of cleaning sections	[....]
	Driving medium, driving pressure	[....]
	Proposed number of cleaning runs	[....]
6.3/A6.3	**Gauging**	
	Number and locations of gauging sections	[....]
	Driving medium, driving pressure	[....]
6.4	**Line filling**	
	Filling sequences of test section	[....]
	Requirements prior to testing	[....]
7.1	Number and location of temperature measurements	[....]
7.2	**Temperature stabilisation**	
	Estimated stabilisation period	[....]
8.2	**Strength test**	
	Test pressure for each test section	[....]
	Combined strength/leak tightness test, if applicable	[....]
	Leak tightness test	
8.3.1	Pressure of final leak tightness test, if appropriate	[....]

Section/ Clause	Activity/Procedure requiring information	Covered
9.1	**Depressurising**	
	Arrangement of pressure let-down valve for depressurising	[....]
9.2	**Hydrostatic pressure test documents**	
	Typical on-site tests document of test equipment, after equipment set-up	[....]
	Type of proposed leak detection technique and its use	[....]
10.2/ A10.2	**Dewatering for tie-in or rectification of damages**	
	Dewatering method and schedules	[....]
	Corrosion protection during the bulk dewatered period	[....]
10.3	**Rectification of damages/defects**	
	Rectification and replacement procedure	[....]

13. SUMMARY OF REQUIRED ADDITIONAL PRINCIPAL'S APPROVALS

Section/ Clause	Activity/Procedure requiring information
2.2	**General requirements** Test procedure
3.	**Safety and environment** Location and arrangement of the test equipment Prior to commencing pressurisation Operating desalination equipment
5.	**Test equipment** Anchoring method of flexible hoses Accuracy of pressure gauges and pressurising flowmeter Calibration certificates
6.1	**Cleaning, gauging and line-filling** Before or after pressure test Temporary pig launcher and receiver Removal of stuck pigs from the test section
6.3	**Gauging** Measurement, introduction and removal of the gauging plates
8.3.2	**Acceptance criteria** Pressure/temperature equation
9.2	**Hydrostatic pressure test documents** Review of hydrostatic pressure test records Hydrostatic test certificate Draft of the report of each test section Final hydrostatic test report
10.3	**Rectification of damage/defects** Verified repair and replacement procedure Disposal of defective materials

14. REFERENCES

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Welding of metals	DEP 30.10.60.18-Gen.
Electrical engineering guidelines	DEP 33.64.10.10-Gen.
Line pipe for use in oil and gas operations under non-sour conditions	L-2-2/3
Line pipe for use in oil and gas operation under sour conditions	L-3-2/3

AMERICAN STANDARDS

Liquid transportation systems for Hydrocarbons, liquid petroleum gas, anhydrous ammonia and alcohols, 1989 Edition, plus Addenda B31.4a-1991	ANSI/ASME B31.4
Gas transmission and distribution piping systems, 1989 Edition, plus Addenda B31.8a-1990, B31.8b-1990 and B31.8c-1992	ANSI/ASME B31.8

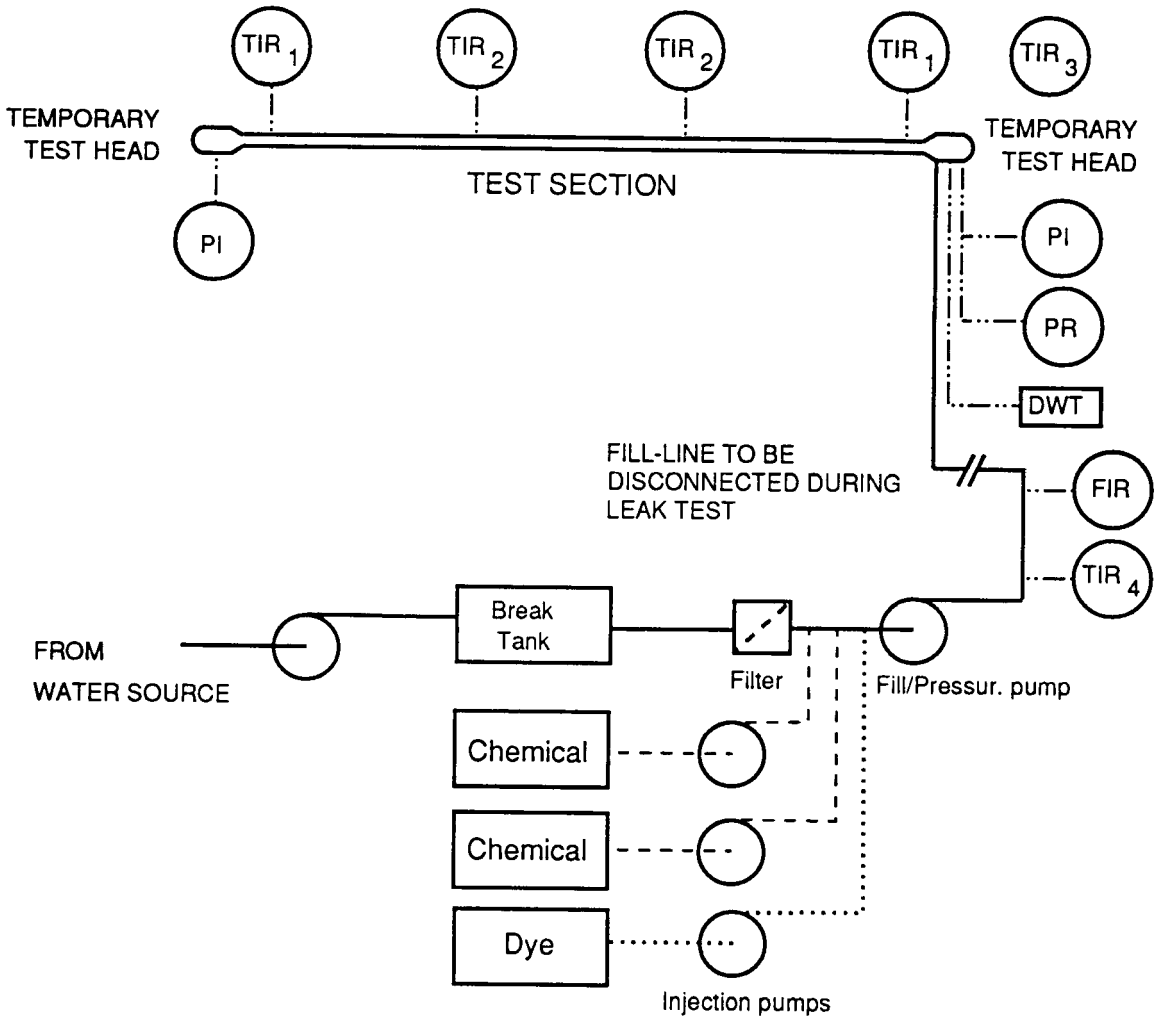
Issued by:
The American Society of Mechanical Engineers
345 East 47th Street
New York, NY 10017
USA.

Specification for linepipe	API Spec 5L
Recommended practice for the pressure testing of liquid petroleum pipelines	API RP 1110

Issued by:
American Petroleum Institute
Publications and Distribution Section
1220 L Street Northwest
Washington, DC 20005
USA.

FIGURES

FIGURE 1 SCHEMATIC OF TYPICAL TEST SECTION



Legend:

PI = pressure gauge

PR = pressure recorder

DWT = dead weight tester

TIR_1 = pipeskin recording temperature probes

TIR_2 = soil or seabed recording temperature probes

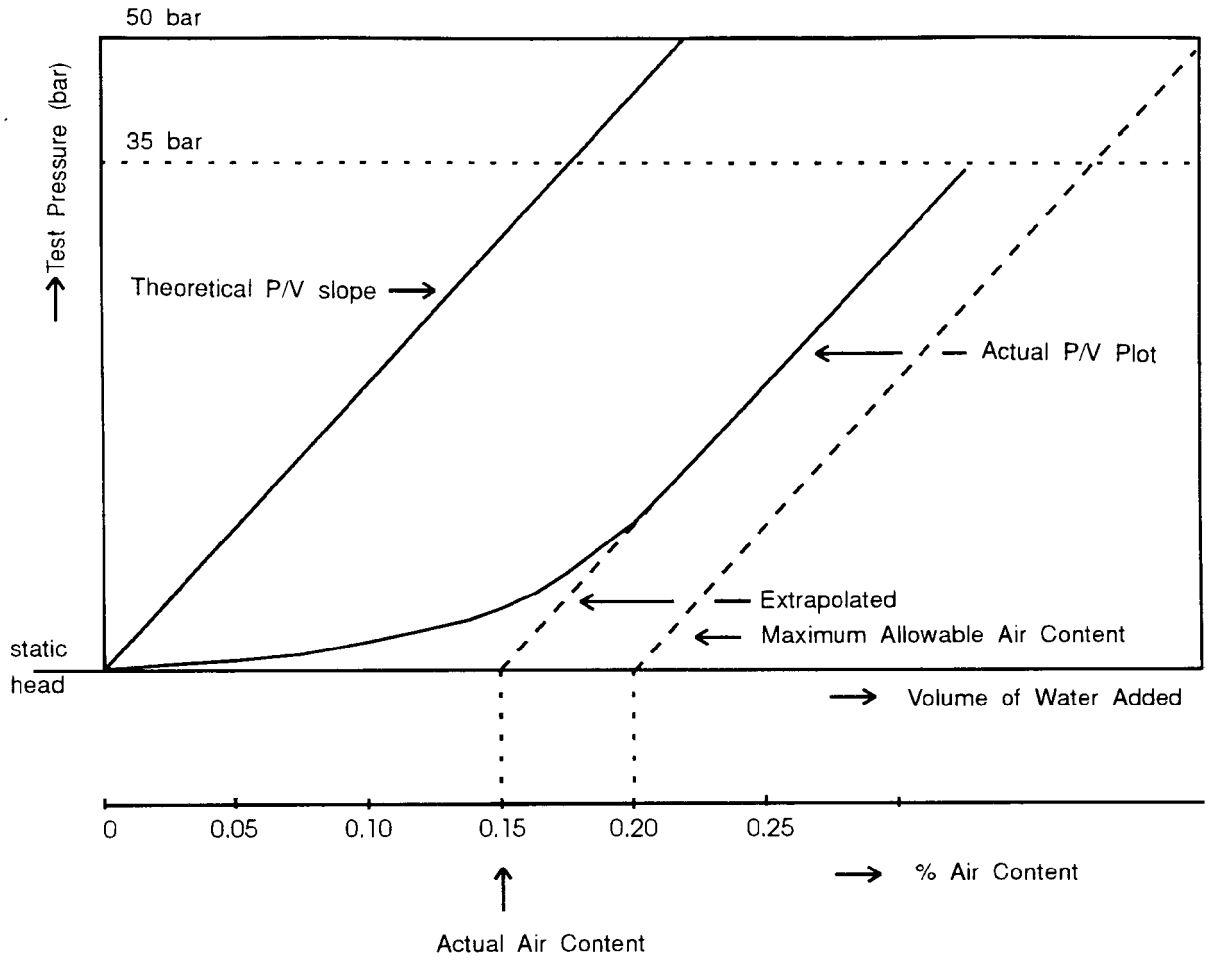
TIR_3 = ambient air recording temperature measurement

TIR_4 = Line-fill Water temperature recording probe during filling and pressurising

FIR = Volumetric measurement device during filling and pressurising
i.e. flowmeter or pump stroke counter

····· Off-Shore only

FIGURE 2 DETERMINATION OF RESIDUAL AIR VOLUME



The theoretical slope shall be calculated from the formula 1 of Section (8.3.2) and plotted in the actual P/V plot by the test engineer before pressurising commences. The bulk modulus for the line-fill water should be taken at the average test section temperature and at a pressure of 35 bar from Figure 3 or 4.

NOTES: 1. To ensure accuracy, the P/V plot shall be made only up to 50 bar.

2. If the P/V plot has not become linear at 50% of the MAOP it should be continued up to a maximum value of 35 bar or the test pressure, whichever is the lesser.

FIGURE 3 BULK MODULUS OF FRESH WATER

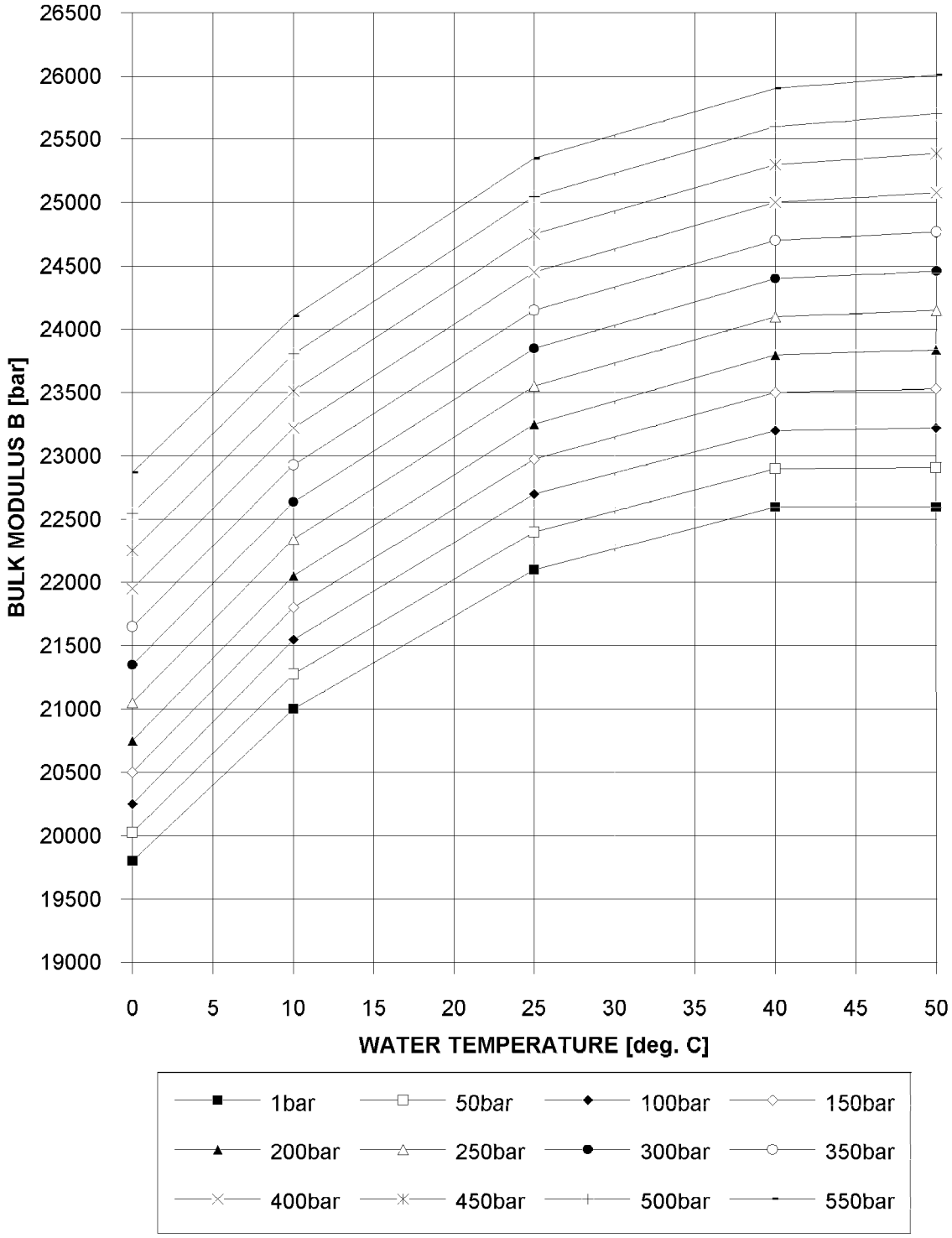


FIGURE 4 BULK MODULUS OF SEA-WATER

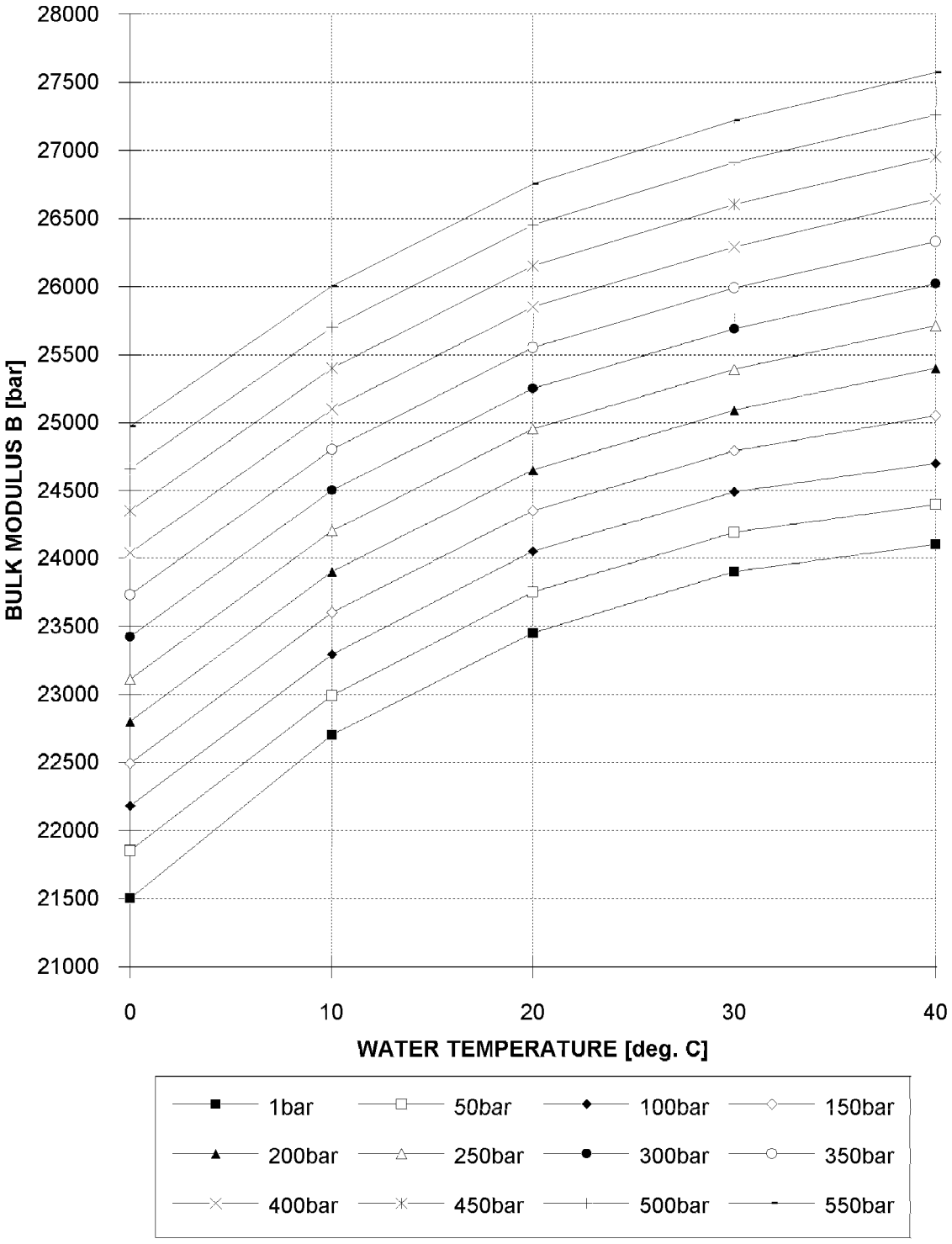


FIGURE 5 VOLUMETRIC EXPANSION COEFFICIENT OF FRESH WATER

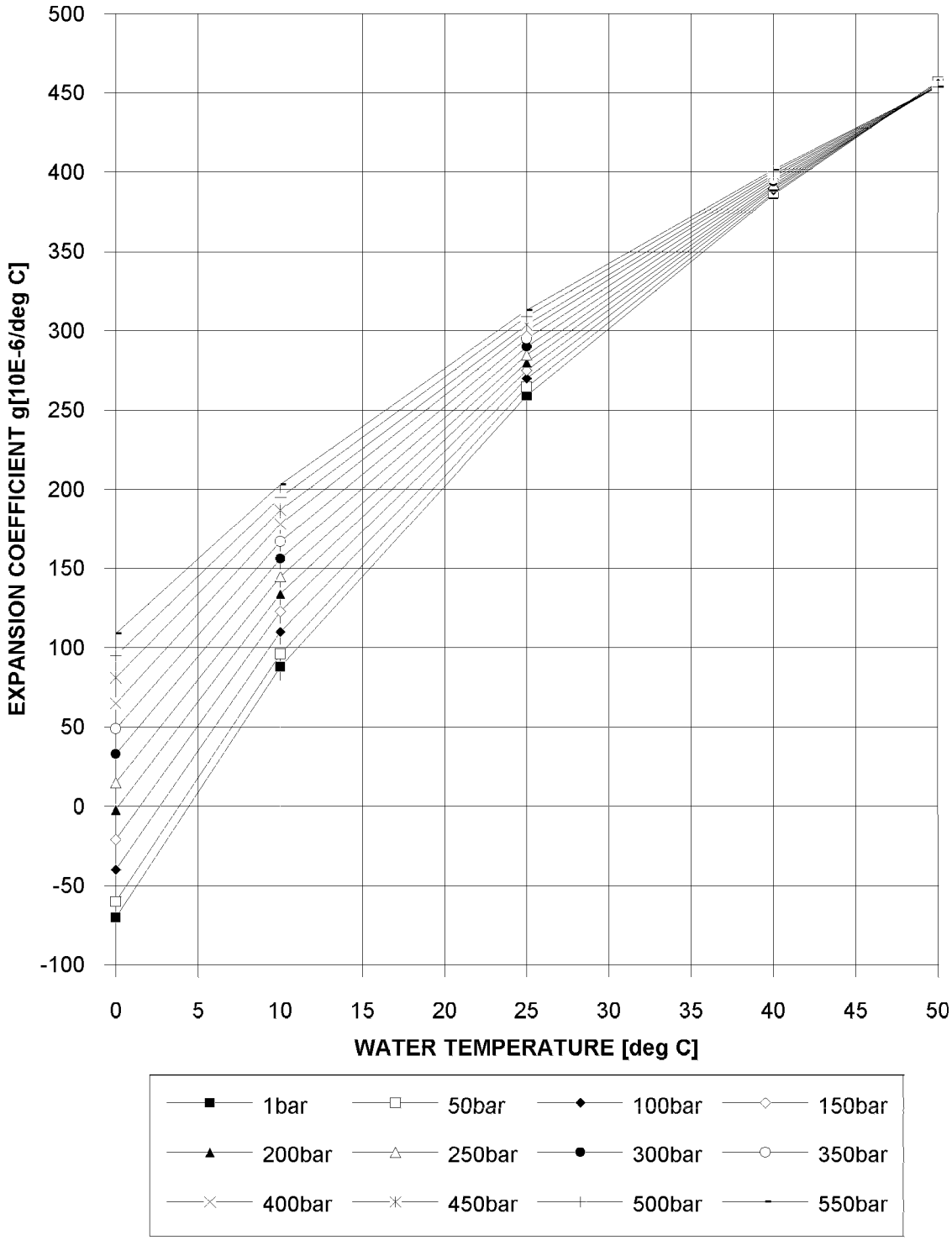


FIGURE 6 VOLUMETRIC EXPANSION COEFFICIENT OF SEA-WATER

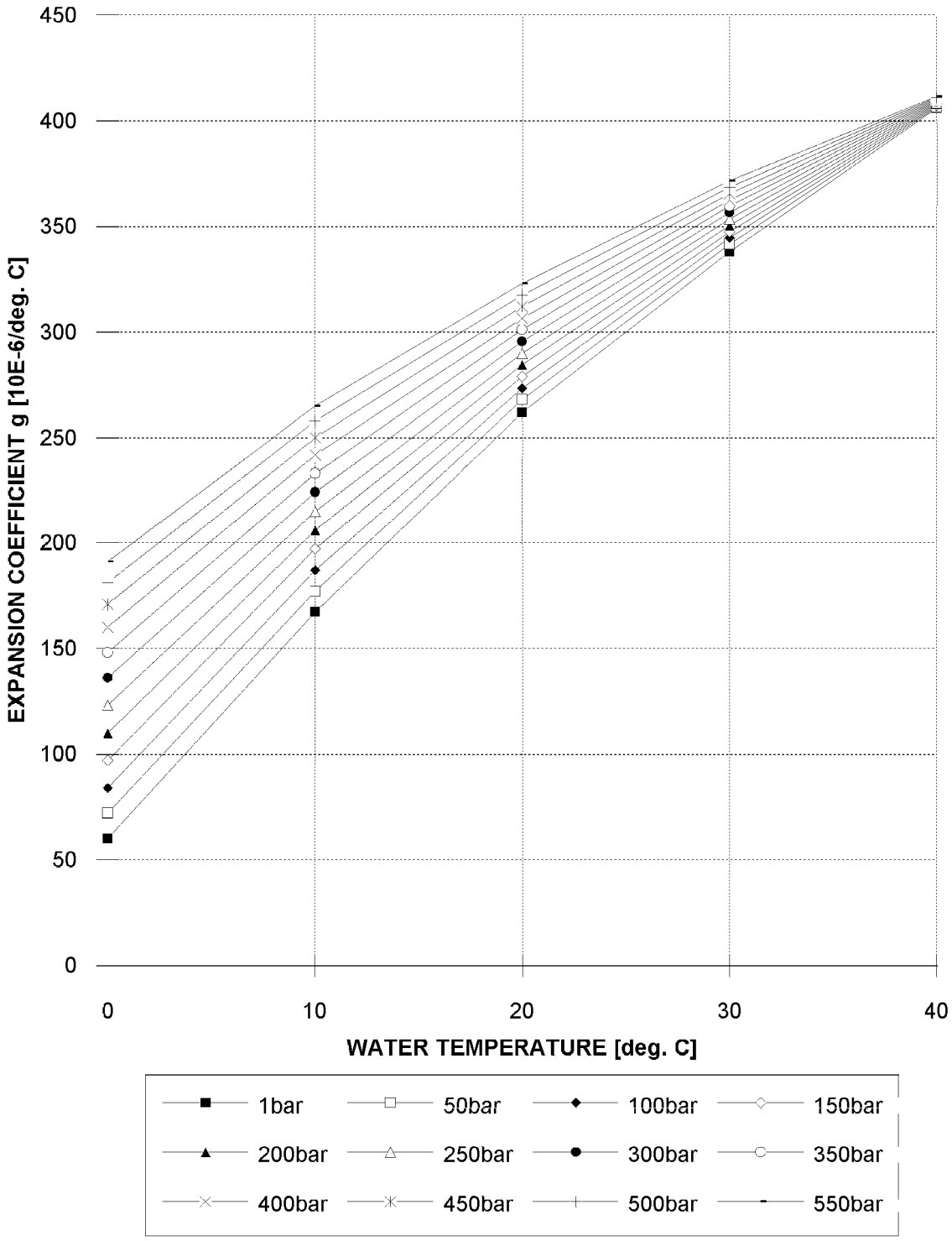


FIGURE 7 HYDROSTATIC TEST CERTIFICATE

HYDROSTATIC TEST CERTIFICATE
Hydrostatic Test No.....**Sheet 1 of 2**

PRINCIPAL:.....**Project**:.....

General Data
Pipeline:.....
Test Section: .....Date of Test:.....
Testing Company Name:.....
Test Engineer:.....

Test Section Design Data

Nom. Outside Pipe Diameter.....inch .....mm Total Section Length:.....m
Nominal Wall Thickness: .....mm Steel Grade:.....

When the test section consist of several sections:
1. Nominal Wall Thickness:.....mm Length:.....m
   Steel Grade :..... Theor.Volume:.....m^3
2. Nominal Wall Thickness:.....mm Length:.....m
   Steel Grade :..... Theor. Volume:.....m^3
3. Nominal Wall Thickness:.....mm Length:.....m
   Steel Grade :..... Theor. Volume:.....m^3
   Total Theor. Volume:.....m^3

Location of Test Point:..... **Theor. Test pressure:** .....bar
Elevation: Low Point:.....m High Point:.....m
Test Point:.....m
Test Pressure at the lowest Elevation Point in the Test Section:.....bar
No. of Temperature Measurement points:.....

Line-fill Water Data

Date of Line Filling: .....Type of Line-fill water: Fresh Water: [ ] Sea-water:[ ]
Type of Line-fill Water Treatment (if applicable):.....
Test Section Volume.....m^3 Temperature of Line-fill water:.....°C
Aver. Temperature of Soil/Sea water surroundings:.....°C

Pressurising

Stabilisation Time before Pressurising .....h Date of Pressurising:.....
Initial Pipe Temp. at Pressurising .....°C Time: .....h
Pipe Temp.at 80% of Test Pressure:.....°C Time: .....h
Air Content .....% of Line Volume Test Pressure: .....bar

HYDROSTATIC TEST CERTIFICATE
Hydrostatic Test No.....**Sheet 2 of 2**

Strength Test

	Initial	**Final**
Time:	.....h	.....h
Test Pressure:	.....bar	.....bar
Aver. Pipe Temp.:	.....°C	.....°C
Aver.Temp. of Soil/Sea water surroundings:	.....°C	.....°C
Temperature of Air:	.....°C	.....°C
Atmospheric Pressure:	.....mbar	.....mbar
Total Volume added:.....Litre	Total Volume withdrawn	.....Litre

Visual Inspection during Component Testing
(carried out at 80% of the strength test pressure)
Time: .....h Test Pressure:.....bar
Results:.....

Leak Tightness Test

	Initial	**Final**
Time:	.....h	.....h
Test Pressure:	.....bar	.....bar
Aver. Pipe Temp.:	.....°C	.....°C
Aver.Temp. of Soil/Sea water surroundings:	.....°C	.....°C
Temperature of Air:	.....°C	.....°C
Atmospheric Pressure:	.....mbar	.....mbar
Minimum Test Pressure: .....bar	Maximum Test Pressure:	.....bar

Unaccountable Pressure Changes: .....**bar**

No. of Documents/ Diagram/ Charts attached.....

Comments:.....
.....

Acceptance Signatures:

Name	**Date**	**Signature**
Test Engineer:.....	.....	.....
Contractor:.....	.....	.....
Principal:.....	.....	.....

FIGURE 8 LEAK LOCATING METHODS

Possible methods for locating leaks during hydrostatic pressure testing operations:

Method	Suitable for		Necessary to replace Line-fill Water	Special equipment and/or personnel	Comment
	Onshore	Offshore			
Visual inspection	Yes	No	No	No	Primarily for above-ground test section
Visual inspection using fluorescent or colour dye	No	Yes	No	Yes	Useful for detecting leaks of flanges
Sectioning by cut and cap	Yes	No	Partially (NOTE 1)	No	Additional method still required to locate leak in suspected section
Sectioning by ice plug	Yes	No	No	Yes	Additional method still required to locate leak in suspected section
Sectioning by special pig	Yes	Yes	Yes	Yes	Requires pumps at both ends (NOTE 2)
Leak location by differential pressure detection pig	Yes	Yes	Yes	Yes	Requires pumps and instruments at both ends
Leak location by flow detection pig	Yes	Yes	Yes	Yes	Requires pumps at both ends
Leak location ultrasonic pig	Yes	Yes	Yes	Yes	Pig velocity < 0.5 m/s at test pressure
Acoustic probes with cross-correlation	Yes	No	No	Yes	Probes at 100 m intervals
Hydrophones	No	Yes	No	Yes	Hydrophones mounted on remotely operated vehicle
Gas detection	Yes	Yes	Yes	Yes	Helium is more sensitive than other gases.

NOTES: 1. Lost water has to be replaced.
2. Normally a more attractive sectioning method than cut and cap.

APPENDIX A STAINLESS STEEL LINEPIPE MATERIALS

A1 INTRODUCTION

A1.1 SCOPE

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

A1.3 DEFINITIONS

A1.3.1 General definition

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

A2 GENERAL REQUIREMENT

A2.1 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 (A5). The test section should be kept clean, because any debris could create dangerous corrosion.

A4 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	<1000 mg/kg	
Duration of contact	< 14 days	< 24 months	< 24 months
Biocide	None	None	Polymeric Biguanide Hydrochloride 20 ppmw
Oxygen scavenger	None	Sodium Hydroxide/Sodium Bicarbonate Buffer pH of 9.8 to 10.2	Ammonium Bisulphite 100 ppmw or Sodium Bisulphite 100 ppmw

A5 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 linepipe 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 30.10.60.18-Gen. or the pipeline construction specification.

A6 CLEANING, GAUGING AND LINE FILLING

A6.1 GENERAL

If the cleaning operation is carried out with water, the water shall be in accordance with (A4).

A6.2 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.

A6.3 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 linepipe material. However the plate material shall be specified in the test procedure. The gauging plates should have the following thickness:

- 3 mm for pipeline diameters up and including DN 150
- 5 mm for pipeline diameters above DN 150

A8 HYDROSTATIC PRESSURE TEST

A8.3 LEAK TIGHTNESS TEST

A8.3.2 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

2.16×10^6 bar $\leq E \leq$ 2.20×10^6 bar

$10.0 \times 10^{-6}\ °C^{-1} \leq \alpha \leq 10.5 \times 10^{-6}\ °C^{-1}$

Austenitic stainless steel

$E = 2.00 \times 10^6$ bar

$15.5 \times 10^{-6}\ °C^{-1} \leq \alpha \leq 16.5 \times 10^{-6}\ °C^{-1}$

Austenitic/ ferritic stainless steel (duplex stainless steel)

$E = 2.00 \times 10^6$ bar

$\alpha = 13.5 \times 10^{-6}\ °C^{-1}$

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 by the actual linepipe data.

A10 RECTIFICATION OF DAMAGE/DEFECTS

A10.1 DEWATERING FOR TIE-IN OR RECTIFICATION OF DAMAGE/DEFECTS

If the chloride concentration of the line-fill water is greater than 200 mg/kg water, care shall be taken to ensure that no oxygen/air enters the wet test section during tie-in work or rectification work. Therefore the dewatering pigs shall be driven with nitrogen. If this is not possible the test section shall be carefully flushed immediately with condensate or demineralised water (up to 2 mg chlorides per kg water), followed by thorough drying.

Dewatering of subsea pipelines is not necessary. The exposure time to sea-water shall be limited to five days or unless otherwise the line-fill water has to be replaced.

If the chloride concentration of the line-fill water is less than 200 mg/kg water the test section shall be either dewatered and immediately dried or carefully flushed with condensate or demineralised water (up to 2 mg chlorides per kg water). However, the test section shall not be left in the partially or completely dewatered condition longer than one week without any further internal corrosion protection (e.g. filling with nitrogen or drying).