Lloyd’s Register
Type Approval System
Test Specification Number 2

Performance and Test Specifications
for Piping System Components
primarily to be used in Marine Applications

January 2017
Foreword

This specification details the requirements covering the phases of Lloyd’s Register (LR) Type Approval of Piping System Components. It includes particulars of the documentation and testing required for various related components.

For the purpose of this specification, a Piping System includes pipes and fittings such as expansion joints, valves, pipe joints, flexible hoses and integral items for system operation.

This specification is to be read in conjunction with the LR Type Approval Procedure.

Failure to comply with those requirements may render the test results unacceptable for the purposes of LR Type Approval.

The edition of the National/International Standard or LR Rules current at the time of application for Type Approval is to be applied. Where a standard including the LR Rules is subsequently amended, modified or superseded in any way, further testing in accordance with the new standard may be required before a Certificate can be renewed.

It is the responsibility of the purchaser and user of LR Type Approved piping system components to determine that the components covered by this specification are suitable for installation in specific piping systems.

The interpretation of this specification is the sole responsibility, and at the discretion, of LR. Any uncertainty in the meaning of the specification is to be referred to LR for clarification (tass@lr.org).
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1. Introduction

1.1 General

1.1.1 This specification is intended as an aid to assist a manufacturer seeking Lloyd's Register (hereinafter referred to as LR) Type Approval of Piping System Components.

1.1.2 Type Approval of Piping System Components will be based on design review, type testing and verification of the manufacturing facilities.

1.1.3 Separate Type Approval Certificates are not issued for individual components on the basis of tests carried out on a composite product.

2. Details of required documentation

2.1 Information to be submitted

2.1.1 Detailed product specification.

2.1.2 Relevant design drawings with materials specified, catalogues, data sheets, calculations and functional descriptions.

2.1.3 For various Piping System Components, reference is to be made to the guidance provided in the Appendices of this document. Where a component is not included in the Appendices, advice is to be sought from the relevant LR Design Support Office.

3. Design review

3.1 General

3.1.1 The submitted information is to be forwarded by the local LR office to the relevant LR Design Support Office for consideration.

3.1.2 A document review will be conducted to determine such facts as product acceptability, compliance with relevant standards and LR Rules, design appraisal, adequacy of proposed Type Test programme and relevance of previous certification and reports.

4. Testing

4.1 General

4.1.1 Type Tests are to be carried out in accordance with the agreed test programme on representative components, to confirm that the performance of the specified standard(s) is fulfilled. Type Tests are to be witnessed by the local LR Surveyor, unless otherwise agreed in writing.

4.1.2 All test and measuring equipment (and calibration thereof) is to be of proven accuracy and where appropriate, traceable to a National or International Standard of measurement. The equipment is to be suitable for the range of parameters to be measured and recognise the environmental conditions in which the equipment is to operate. Computer-generated data is to list all sensors and their units of measurement. Calculations performed by computer are to include the formulae with units and definitions of the relevant factors, coefficients and constants used.

4.1.3 Test area ambient conditions are to be monitored throughout testing.

4.1.4 Type tests may be carried out at the manufacturer’s works or at any establishment having suitable facilities acceptable to LR.

4.1.5 On completion of tests, a report is to be issued, identified by number and date, which accurately, clearly and unambiguously presents the test results and all other relevant information. Unless otherwise agreed the English language is to be used.
4.1.6 Test samples are to be representative of the entire range to be type approved. In general, unless specified otherwise in a particular standard, a test on a diameter of component will qualify related components anywhere between half the tested diameter and twice the tested diameter.

4.1.7 Test reports are to be signed by the test personnel and countersigned, as verification of the results, by the LR Surveyor or agreed independent representative witnessing the tests.

4.1.8 Reference is to be made to the Appendices of this document covering the Piping System Components, guidance is provided for various test procedures that may be required by the specified standard(s). Where there is no applicable test procedure included in the document, advice is to be sought from the relevant LR Design Support Office.
Appendix 1

Expansion pieces – Bellows and sliding types

1. Introduction

1.1 General

1.1.1 This Appendix includes detailed information for the Type Approval of expansion pieces – bellows and sliding types. It is applicable to expansion pieces for metallic piping systems only.

2. Definitions

2.1 General

2.1.1 Terminology used should be in accordance with a recognised Standard used in the field of design, manufacture, testing and marking of bellows and sliding type expansion pieces. Other terminology could be used provided the meaning is clearly defined.

3. Details of required information

3.1 General

3.1.1 Request for LR Type Approval including details for:
(a) The expansion piece manufacturer’s name and address;
(b) The trade name and reference numbers or designation specific to the expansion piece;
(c) Services and locations in which the expansion piece is intended to be used;
(d) Expansion piece dimensions;
(e) Maximum (and where applicable minimum) working pressure;
(f) Working temperature range.

3.1.2 Detailed product specification, including:
(a) Material manufacturer’s name and address and full trade name and reference number (where applicable);
(b) The dimensions and tolerances permitted for the finished products;
(c) Details of any alternative materials which may be used;
(d) Minimum distance between supports in way of expansion pieces;
(e) Method of attachment;
(f) Installation requirements, instructions and recommendations.

3.1.3 Manufacturing specification detailing:
(a) Manufacturing procedures including welding and welder qualifications;
(b) Quality control procedures including details and frequency of tests on the incoming materials, tests made during production and on the finished expansion pieces;
(c) Acceptance standards and tolerances, including all dimensions;
(d) Procedures for rectification of defects;
(e) System for traceability of the finished expansion piece to the batches of raw materials.

3.1.4 Drawings and supporting documentation, including:
(a) All relevant design drawings, catalogues, data sheets, calculations and functional descriptions;
(b) Fully detailed sectional assembly drawings, showing expansion pieces of each type.

3.1.5 Proposed field of application and operational limitations, so far as may be applicable, including:
(a) Intended fluids;
(b) Maximum internal and external pressures;
(c) Maximum and minimum fluid and environmental temperatures, or graph of pressure/temperature ratings showing reduction in pressure with temperature rise;
(d) Limits on flow rates;
(e) Where necessary, strength of connections of various expansion pieces;
(f) Installation instructions. Effect of external piping with regard to support requirements. Control during installation. System testing;
(g) Replacement instructions.

3.1.6 Quality control system arrangements to be sufficiently detailed in order to demonstrate that the quality of the finished product can be maintained in accordance with the required standards.

3.1.7 Proposed type test programme, sufficiently detailed in order to demonstrate that the performance provisions of the specified standards may be fulfilled for acceptance.

3.1.8 Certificates and reports for relevant tests previously obtained for the expansion pieces.

3.1.9 Relevant standards where necessary.

3.1.10 Details of marking so far as may be applicable. Where marking cannot be made on the expansion piece due to lack of space, identification documentation is to be provided. Identification is to include:
(a) Manufacturer’s name or trademark;
(b) Identification mark for the specification or grade of steel or other material, where applicable;
(c) Expansion piece type number;
(d) Date of manufacture;
(e) Nominal size (DN) and pressure (PN);
(f) Identification number and/or initials which will enable the full history of the item to be traced.

4. Testing procedures

4.1 General

4.1.1 Generally, the requirements of any suitable recognised Standard can be used for the basis of the test programme. The primary objective of the tests is to verify that the expansion pieces have sufficient strength to take account of the most severe coincident conditions of pressure, temperature, misalignment, weight effect of the piping itself and any static and dynamic loads imposed by the design or environment.

4.1.2 For the purpose of assuring adequate robustness of piping, all pipes and pipe fittings are to have a minimum wall thickness to ensure adequate strength for use in service, and also to withstand loads due to transportation, handling, personnel traffic, etc. This may require the expansion piece to have additional thickness than otherwise required by service considerations.

4.1.3 The performance requirements for any component of a piping system (such as an expansion piece) and method of connection are the same as those requirements for the piping system in which they are installed.

4.1.4 The tests are therefore to address the material design properties and performance criteria specified in the required standards.

4.1.5 Fire testing will be requested where the effects of fire could lead to leakage from a flammable fluid system, or in a system which, following failure of the expansion piece, could lead to danger due to possible flooding or loss of integrity of an emergency shut-down or control system.

4.1.6 Attention is also drawn to any special additional testing which may be required by National Authorities or local administrations.

4.2 Testing requirements

4.2.1 Proof testing is to be carried out on typical expansion pieces complete with end connections. Tests are to meet the requirements of the applicable specification, which may include, for example, hydrostatic proof, pneumatic proof, static bend tests, fatigue life tests, yield and burst/squirm/meridional yield-rupture tests, and where necessary, fire and intercrystalline corrosion tests.

Longitudinal and/or central restraint may require to be provided during some of the tests, dependent upon the design of the expansion piece and the applicable specification.

Examination during the testing may include:
(a) Radiographic examination (of welding for example).
(b) Liquid penetrant examination.
(c) Fluorescent penetrant examination.
(d) Magnetic particle examination.
(e) Ultrasonic examination.
4.2.2 Unless specified otherwise in the applicable standard, the following notes should be used for guidance when carrying out the tests:

(a) **Hydrostatic proof test.** All test assemblies are required to complete this test. Hydrostatic pressure of $1.5 \times$ maximum design pressures to be applied with assembly set at maximum specified misalignment, for at least one minute.

(b) **Pneumatic proof test.** Pneumatic pressure of $1.1 \times$ maximum design pressure to be applied with assembly set at maximum specified misalignment, for at least one minute.

(c) **Hydrostatic burst test.** (Yield and burst/squirm/meridional yield-rupture.) Representative test assemblies to be tested by hydraulic pressure to at least $4 \times$ maximum design pressure (or $2 \times$ estimated yield pressure) with assembly at maximum specified misalignment or until deformation/rupture takes place. Duration of the test should be not less than 5 minutes.

Samples from this test are not to be used for further testing.

(d) **Repeated assembly test.** This test is required for separable assembly expansion pieces only and is to be carried out on at least one representative sample. Sample assembly is to be dismantled and remade a total of 10 times and then tested as per the Hydrostatic Proof Test above.

(e) **Fatigue life tests.** Should be performed with a varying pressure unless a constant pressure is acceptable by the required standard. For the bellows design of an expansion piece, the minimum number of convolutions tested should be three of minimum diameter, and the cyclic movement should be of axial compression from free length. Maximum deflection should be applied at 30 cycles per minute maximum for a minimum of 10 000 cycles unless otherwise specified. Note, however, liquefied gas carriage on ships may require 2 000 000 cycles at not more than 5 cycles per second.

4.2.3 Additional testing, where required, may be requested, including:

(a) **Vacuum test.** Using a suitable pump, a vacuum of 635 mm of Hg shall be drawn and held for a minimum of 15 minutes with assembly at maximum specified misalignment. Loss of vacuum not to exceed 30 mbar in 15 minutes.

(b) **Extreme displacement test.** Assembly to be pressurised to $2 \times$ maximum design pressures at maximum displacement without permanent deformation. This test may require to be carried out at minimum design temperature.

(c) **Cyclic test.** For liquefied gas carriage, bellows type expansion pieces require a cyclic test to accommodate all conditions of pressure, temperature, axial movement, rotational movement, and transverse movement, as will be expected in actual service.

(d) **Fire test.** Where required, fire tests are to be carried out in accordance with an acceptable recognised Standard such as ISO 15540, ISO 15541 ASTM F 1387 Standard specification for performance of mechanically attached fitting, series S7. Attention is also drawn to the requirements of the Statutory Authorities, the United Kingdom’s Maritime and Coastguard Agency, e.g., Survey of Fire Appliances, Appendix D, ‘Fire Test Requirements for Fire Mains and Fittings’.

4.3 **Production testing**

4.3.1 Production testing is to be carried out to meet the requirements of the applicable specification. This may include the following:

(a) Material testing.

(b) Chemical analysis.

(c) Non-destructive testing, including any of the forms of examination referenced in 4.2.1.

(d) Hydrostatic testing.

(e) Air jet leak examination.

4.3.2 Large diameter expansion pieces may require to be tested so far as may be applicable, at the manufacturer’s production facility, to a hydrostatic pressure not less than $1.5 \times$ the rated pressure of the pipe. Other test criteria may be accepted.

4.3.3 Additional special testing may be required as part of the approval procedure, depending upon the use and location of the pipe joint.

5. **Material approval and quality control during manufacture**

5.1 **General**

5.1.1 Quality controls during manufacture are to include but not be limited to:
(a) Dimension and tolerances for expansion pieces are to conform to the specified standard.

(b) Expansion pieces, so far as may be applicable, should be permanently marked with identification in accordance with the required standard but see also 3.1.10.

(c) Samples of expansion piece are to be tested to determine the hydrostatic design strength. These samples are to be tested at a frequency to the satisfaction of LR.

(d) Where piping is required to be electrically conductive, representative samples of expansion pieces are to be tested to determine the electrical resistance. The test method and frequency of testing are to be acceptable to LR.

5.2 **List of standards**

5.2.1 A list of standards is held on file in LR to provide information for the design, manufacture, testing and marking of expansion pieces. The use of such standards is not mandatory and alternatives may be utilised where they are applicable to the application for Type Approval. LR Rules, IMO and statutory requirements may also require to be taken into consideration so far as may be applicable.
Appendix 2

Filter units

1. Introduction

1.1 General

1.1.1 This Appendix includes detailed information for the Type Approval of filter units, both suction and discharge types. Except for certain special applications, maximum pressures and temperatures applicable will be 10 bar and 100°C respectively.

2. Definitions

2.1 General

2.1.1 Terminology used should be in accordance with a recognised Standard used in the field of design, manufacture, testing and marking of filter units including LR Rules. Other terminology could be used providing the meaning is clearly defined.

3. Details of required documentation

3.1 General

3.1.1 Request for LR Type Approval including details for:
(a) The filter unit manufacturer’s name and address;
(b) The trade name and reference numbers or designation specific to the filter units;
(c) Services and locations in which the filter units are intended to be used;
(d) Filter unit dimensions including pipe connections and scantlings;
(e) Working pressure and temperature range.

3.1.2 Detailed product specification, including:
(a) Filter unit manufacturer’s name and address;
(b) Pressure ratings;
(c) Capacity;
(d) The dimensions and tolerances permitted of the finished products;
(e) Materials and details of any alternative materials/grades which may be used;
(f) Details of welding where applicable used in the production process. Approved welders and weld procedures may be required;
(g) Branch connection standards;
(h) Installation requirements, instructions and recommendations;
(j) Paint coatings, if any.

3.1.3 Manufacturing specification detailing:
(a) Manufacturing procedures;
(b) Quality control procedures including details and frequency of tests on the incoming materials, tests made during production and on the finished articles;
(c) Acceptance standards and tolerances, including all dimensions;
(d) Details of welding used in the production process. Approved welders and weld procedures may be required;
(e) Procedures for rectification of defects;
(f) System for traceability of the finished filter unit to the batches of material, etc.

3.1.4 Drawings and supporting documentation, including:
(a) All relevant design drawings, catalogues, data sheets, calculations and functional descriptions;
(b) Fully detailed sectional assembly drawings with details of branch connections, openings reinforcement, etc.

3.1.5 Proposed field of application and operational limitations, so far as may be applicable, including:
(a) Maximum pressures;
(b) Flow rate;
(c) Filtration properties;
(d) Maximum temperatures;  
(e) Installation instructions. Control required during installation;  
(f) Maintenance and repair instructions.

3.1.6 Quality control system arrangements to be sufficiently detailed in order to demonstrate that the quality of the finished product can be maintained in accordance with the required standards.

3.1.7 Proposed type test programme, sufficiently detailed in order to demonstrate that the performance provisions of the specified standards may be fulfilled for acceptance.

3.1.8 Certificates and reports applicable to relevant tests previously performed on the filter units.

3.1.9 Relevant standards where necessary.

3.1.10 Details of marking. This is to include as a minimum:  
(a) Manufacturer’s name or trademark;  
(b) Nominal diameter;  
(c) Gasket/sealing ring material;  
(d) Direction of flow;  
(e) Date of manufacture.

3.1.11 Marking which can also be included so far as may be appropriate includes:  
(a) Code applicable to manufacture;  
(b) Catalogue reference;  
(c) Size/capacity;  
(d) Design pressure and temperature;  
(e) Test pressure;  
(f) Manufacturer’s serial number and/or initials which will enable the full history of the filter unit manufacture to be traced;  
(g) Branch connection identification;  
(h) Intended service;  
(j) Welding code symbol where applicable;  
(k) Post-weld (or part post-weld) heat treatment code symbol where applicable;  
(l) Inspection authority.

4. Testing procedures

4.1 General

4.1.1 Generally, the requirements of any suitable recognised Standards can be used for the basis of the test programme. The primary objective of the tests is to verify that the filter unit has sufficient capability to take account of the most severe coincident working conditions.

4.1.2 For the purpose of assuring adequate robustness, all filter units are to have a minimum wall thickness to ensure adequate strength for use in service, also to withstand loads due to transportation, handling, personnel traffic, etc. This may require the filter unit to have additional thickness than otherwise required by service considerations.

4.1.3 The performance requirements for any component of a piping system and method of connection are the same as those requirements for the piping system in which they are installed. The tests are therefore to address the material design properties and performance criteria specified in the applicable standards.

4.1.4 Attention is also drawn to any special additional testing which may be required by National Authorities or local administrations.

4.2 Test requirements

4.2.1 Proof testing. The filter units require to be prototype tested to ensure that they meet the performance requirements of this Appendix and/or the requirements of the applicable specification, including hydrostatic or pneumatic testing.

4.2.2 Unless testing is to be restricted to specified standards only, consideration should be given to the following tests as appropriate:
(a) **Proof test** to be effected unless specifically not called for by the applicable specification. This hydrostatic test is to be limited to materials with a ratio of minimum specified yield to minimum specified ultimate tensile strength of 0.625 or less and is to be based on yielding of any part of the filter unit. The allowable design pressure will generally be based on 0.2 x the hydrostatic test pressure at which the proof test was stopped, dependent on the materials of manufacture. Tests are to be effected at a temperature of between 7°C and 25°C. Proposals to use other proof testing specifications can be considered.

(b) **Hydrostatic tests.** Each size of filter unit is to be individually subjected to a hydrostatic test of 1.5 x maximum allowable design pressure x the lowest ratio (for the materials from which the filter unit is to be constructed) of the stress value for the test temperature of the filter unit to the stress value for the design temperature or as otherwise called for by the specification. Tests are to be effected at a temperature of between 7°C and 25°C. Liquids other than water may be used subject to agreement.

(c) **Pneumatic tests** may be effected where water or other tests fluids cannot be tolerated or where the filter unit cannot be readily dried. The test pressure is to be limited to 1.25 x maximum allowable design pressure x the lowest ratio (for the materials of which the filter unit is to be constructed) of the stress value at test temperature to the stress value at design temperature, except where other specification requirements govern. Tests are to be effected at room temperature (at least 17°C) unless otherwise specified. Gases other than air can be considered and full details are to be submitted for consideration.

(d) Mountings – Hydrostatic tests are to be effected on applicable mountings at not less than 2 x design pressure.

(e) **Material tests** as may be required by the applicable specification or called for by the intended services. Tests are to be in accordance with recognised Standards.

(f) Performance testing with an agreed program of tests to demonstrate the filtration properties of the unit.

### 4.3 Production testing and inspection

4.3.1 Production testing is to be carried out to meet the requirements of the applicable specification. This may include the following:

(a) Material testing.

(b) Chemical analysis.

(c) Weld procedure tests.

(d) Welder qualification tests.

(e) Non-destructive testing, including visual, ultrasonic, magnetic particle, dye penetrant and radiographic examination, in way of any welding.

(f) Destructive weld inspection tests.

(g) Individual hydrostatic testing 1.5 x the design pressure. This test may be effected using air subject to prior agreement.

4.3.2 No welding shall be carried out on the pressurised parts of a filter unit once the pressure testing has been successfully completed.

4.3.3 Production inspection is to be carried out to meet the requirements of the applicable specification. This is likely to include:

(a) Material inspection.

(b) Welding inspection where applicable.

(c) Visual inspection.

(d) Dimensional inspection.

(e) Assembly inspection.

### 4.4 Additional testing

4.4.1 Additional special testing may be required as part of the approval procedure, depending upon the proposed use and location of the filter units.

4.4.2 Where filters are of a duplex design, the ability for one unit to be cleaned without interrupting the flow must be demonstrated.

4.4.3 A vibration test according to Test Specification Number 1 is to be undertaken if the filters are intended for installation directly on combustion engines or equivalents.
5. Material approval and quality control during manufacture

5.1 General

5.1.1 Quality controls during manufacture are to include but not be limited to:
(a) Dimension and tolerances for the filter units are to conform to the specified standard.
(b) The filter units are to be permanently marked with identification in accordance with a recognised Standard. See also 3.1.10 and 3.1.11.
(c) Each filter unit is to be tested at the manufacturer’s production facility to a hydrostatic pressure not less than 1.5 times the design pressure of the unit. Other test criteria may be accepted.
(d) Samples of filter unit are to be tested to determine the hydrostatic design strength. These samples are to be tested at a frequency to the satisfaction of LR.

5.2 List of standards

5.2.1 A list of standards is held on file in LR to provide information for the design, manufacture, testing and marking of filter units. The use of such standards is not mandatory and alternatives may be utilised where they are applicable to the application for Type Approval. LR Rules, IMO and statutory requirements may also require to be taken into consideration so far as may be applicable.
Appendix 3

Flexible hose assemblies

1. Introduction

1.1 General

This Appendix includes detailed information for the Type Approval of flexible hose assemblies.

This Appendix is only applicable to flexible hose assemblies for use within a piping system. It is not applicable to hoses used for supply and connecting systems such as cargo hoses of any type and gas cutting/burning equipment, nor is it applicable to the following offshore applications:

(a) Well stimulation connections.
(b) Christmas tree jumper hose to a production manifold.
(c) Blow out preventer control lines.
(d) Choke and kill lines.
(e) Diving support systems.

2. Definitions

2.1 General

2.1.1 Flexible hose assembly:
(a) A flexible hose assembly is a hose complete with end fittings permanently attached which can be installed on different fixing positions.
(b) A hose assembly is for use as a pipe fitting and is to be of a length not exceeding that necessary to accommodate relative movement between fixed piping and machinery on flexible mountings, or where there is vibration and/or relative movement using fixed metallic piping. Depending on the hose construction and installation arrangements, a flexible hose assembly is not normally to exceed 1 metre in length between end fittings.

2.2 End fittings

2.2.1 End fittings are the hose end attachments for connection to the piping system or machinery. The end fittings are to be in accordance with an acceptable standard for the intended applications.

Note
Cone unions are only acceptable in way of boiler burners and are required to be of robust construction.

2.3 Application

2.3.1 Application relates to the intended purpose and duty of the hose assembly. The application is to be stated by the manufacturer, and is to include:
(a) Design pressures – internal and external.
(b) Design temperature.
(c) Service fluids.
(d) Mechanical loading, including maximum impulse limitations.
(e) Service location/service location restrictions.

2.4 Design pressure

2.4.1 The internal design pressure is to be not less than the highest set pressure of the safety valve or relief valve.

2.4.2 Where the hose assembly is designed for installation in positions where the external pressure may exceed atmospheric, the maximum external working pressure is not to exceed the external design pressure.

2.5 Design temperature

2.5.1 The design temperature is to be taken as the maximum temperature of the internal fluid, but in no case to be less than 50°C.
2.5.2 The maximum continuous operating temperature is that temperature which will provide a continuous working life of not less than that specified by the manufacturer or 5 years, whichever is the least.

2.5.3 The minimum design temperature is to be not less than 25°C below the minimum temperature of the internal fluid or external environment, and the minimum continuous operating temperature.

2.5.4 The minimum continuous operating temperature is that temperature which will provide a continuous working life of not less than 5 years.

3. Details of required documentation

3.1 General

Request for LR Type Approval with detailed product specification including:
(a) Relevant design drawings with materials specified, catalogues, data sheets, calculations and functional descriptions.
(b) Fully detailed sectional assembly drawing, showing hose and end fitting(s).

3.2 Proposed field of application and operational limitations

3.1.2 Details to be submitted:
(a) Intended fluids.
(b) Maximum fluid pressure – static and pulsation if applicable.
(c) Maximum and minimum fluid and environmental temperatures.
(d) Limits on flow rate through the hose.
(e) Minimum bend radius and maximum relative movement between end fittings which can be accommodated for a hose length.
(f) Fire resistance of hose assembly.
(g) Effect of heat/ageing.
(h) Effect of liquids/deterioration.
(i) Types of end fittings.
(j) Method of securing the hose to the end fittings.
(k) Serviceable life in service and in storage.
(l) Installation instructions.
(m) Replacement instructions.
(n) Effect of ultraviolet light.
(o) Electrical resistance.
(p) Abrasive resistance.
(q) Effect of ozone.
(r) Effect of oil and oily atmosphere.

3.3 Proposed type test programme

3.3.1 Proposed type test programme, sufficiently detailed in order to demonstrate that the performance provisions of the specified standards are fulfilled.

3.4 Certificates and reports

3.4.1 Certificates and reports for relevant tests previously obtained for the flexible hose assembly.

3.5 Standards

3.5.1 Copies of the relevant standards where necessary and where no copyright exists.

3.6 Details of hose marking

3.6.1 This to include date of manufacture, shown as month/quarter and last two digits of year of manufacture, e.g., 12/12 or 4Q12.
4. Testing procedures

4.1 General

4.1.1 Generally, the requirements of any suitable recognised Standards can be used for the basis of the test programme. The primary objective of the tests is to determine the following with the hose assembly at the design bend radius:

(a) Pressure – static and impulse. Impulse testing is particularly important for main/auxiliary engine oil fuel supply and spill systems, and hydraulic oil systems, e.g., steering gears.

(b) Temperature conditions – maximum and minimum.

(c) Ageing of rubber in operating environment, e.g., at high temperatures.

(d) Degradation of flexible materials within operating pressure and temperature conditions, e.g., at low temperatures (bending tests).

(e) Endurance testing, including burst testing.

(f) Fire testing, e.g., for use in flammable fluid systems and systems which, following failure of a hose assembly, could lead to danger due to possible flooding or loss of integrity of an emergency shut-down or control system.

(g) Shore hardness test.

(h) Determination of adhesion between components.

(i) Assessment of ozone resistance under static/dynamic conditions.

4.1.2 Additional tests to those detailed in 4.1.1, which may have to be considered depending upon use and location of the hose assembly, are:

(a) Determination of permeability of gas.

(b) Determination of transmission of liquids through hose walls.

(c) Determination of abrasion resistance of outer cover.

(d) Determination of vacuum resistance – static and impulse.

(e) Determination of electrical resistance.

(f) Determination of ultraviolet resistance under static conditions.

(g) Determination of the effects of oil.

(h) Determination of crush resistance.

(i) Depending upon the field of application of the flexible hose assembly, additional testing may be required. This may include operating beyond the design ranges stipulated by the client.

5. Material approval and quality control during manufacture

5.1 General

5.1.1 Quality controls during manufacture are to include but not be limited to:

(a) Dimensional control of hose assemblies.

(b) Attachment of end fittings.

(c) Markings in accordance with the applicable standard.

(d) Samples of the flexible hose assembly are to be tested to determine the hydrostatic design strength. These samples are to be tested at a frequency to the satisfaction of LR.

6. List of standards

6.1 General

6.1.1 This list of standards is to provide information for the design, manufacture, testing and marking of flexible hose and hose assemblies. The use of these standards is not mandatory and alternatives may be utilised where they are applicable to the application for Type Approval.

Note

Where a standard is used, it should be the latest edition.


ISO 15541:1999 Ships and marine technology – Fire resistance of hose assemblies – Requirements for the test bench

ISO 10380:2012 Pipework – Corrugated metal hoses and hose assemblies

ISO 1307:2008 Rubber and plastics hoses for general-purpose industrial applications – Bore diameters and tolerances, and tolerances on length

ISO 1402:1994 Rubber and plastics hoses and hose assemblies – Hydrostatic testing
ISO 1817:2011 Rubber, vulcanised – Determination of the effects of liquids
ISO 4023:2009 Rubber hoses for steam – Test methods
ISO 4080:2009 Rubber and plastics hoses and hose assemblies – Determination of permeability to gas
ISO 4671:2007 Rubber and plastics hose and hose assemblies – Methods of measurement of dimension
ISO 10619-2:2011 Rubber and plastics hoses and tubing – measurement of flexibility and stiffness
ISO 6802:2008 Rubber and plastics hose and hose assemblies with wire reinforcements – Hydraulic impulse test with flexing
ISO 6803:2009 Rubber or plastics hoses and hose assemblies – Hydraulic-pressure impulse test without flexing
ISO 7326:2008 Rubber and plastics hoses – Assessment of ozone resistance under static conditions
ISO 7662:1998 Rubber and plastics hoses – Determination of abrasion of lining
ISO 8030:1998 Rubber and plastics hoses – Method of test for flammability
ISO 8031:2009 Rubber and plastics hoses and hose assemblies – Determination of electrical Resistance LR Type Approval System
ISO 8032:1998 Rubber and plastics hose assemblies – Flexing combined with hydraulic impulse test (Half omega test)
ISO 8033:2006 Rubber and plastics hose – Determination of adhesion between components
ISO 8308:2008 Rubber and plastics hoses and tubing – Determination of transmission of liquids through hose and tubing walls
ISO 10960:1997 Rubber and plastics hoses – Assessment of ozone resistance under dynamic conditions
Appendix 4

Mechanical pipe joints – Fixed connections

1. Introduction

1.1 General

1.1.1 This Appendix includes detailed information for the Type Approval of mechanical pipe joints (fixed connections). It is applicable to rigid ferrous and non-ferrous metallic pipe joints (fixed connections) only.

1.1.2 These requirements are based on IACS UR No. P2 Rules for piping design, construction and testing.

2. Definitions

2.1 General

2.1.1 Terminology used should be in accordance with a recognised Standard used in the field of design, manufacture, testing and marking of metallic pipe joints (fixed connections), including LR's Rules for the Manufacture, Testing and Certification of Materials (hereinafter referred to as the Rules for Materials) or other suitable recognised Standard. Other terminology could be used provided the meaning is clearly defined.

3. Details of required documentation

3.1 Details to be submitted

In addition to the Request for LR Type Approval, the following documents and information are to be submitted by the Manufacturer for assessment and/or approval:

3.1.1 A complete description of the product including:
(a) Typical sectional drawings with all dimensions, data sheets, calculations and functional descriptions;
(b) Complete specification of materials used for all components of the assembly;
   (i) Material manufacturer's name and address and full trade name and reference number where applicable.
   (ii) The dimensions and tolerances permitted for the finished products.
   (iii) Details of any alternative materials which may be used.
(c) Maximum design pressures (pressure and vacuum);
(d) Maximum and minimum fluid and environmental temperatures, or graph of pressure/temperature ratings showing reduction in pressure with temperature rise;
(e) Conveyed media including limits on flow rates;
(f) Intended service;
(g) Installation, repair and replacement instructions and details including:
   (i) Effect of external loading with regard to support requirements (maximum allowable axial, lateral and angular deviation).
   (ii) Minimum distance between supports in way of pipe joints.
   (iii) System testing.
   (iv) Methods of attachment.
   (v) Methods of repair

3.1.2 Quality control system arrangements to demonstrate that the quality of the finished product can be maintained in accordance with the required standards including:
(a) Manufacturing procedures.
(b) Quality control procedures, including details and frequency of tests on the incoming materials, tests made during production and on the finished pipe joints.
(c) Acceptance standards and tolerances, including all dimensions.
(d) Procedures for rectification of defects.
(e) System for traceability of the finished pipe joint to the batches of raw materials.

3.1.3 Proposed type test programme, sufficiently detailed in order to demonstrate that the performance provisions of the specified standard(s) may be fulfilled for acceptance. Guidance on some of the test procedures that may be required is included in Section 4.
3.1.4 Certificates and reports for relevant tests previously obtained for the pipe joints (fixed connections).

3.1.5 Relevant standards where necessary.

3.1.6 Details of marking so far as may be applicable. Where marking cannot be made on the joint due to lack of space, identification documentation is to be provided. Identification is to include:
   (a) Manufacturer’s name or trademark.
   (b) Identification mark for the specification or grade of steel or other material.
   (c) Pipe joint type number.
   (d) Date of manufacture.
   (e) Nominal size (DN).
   (f) Nominal pressure (PN).
   (g) Identification number and/or initials which will enable the full history of the item to be traced.

Where it is impracticable to affix the above marking due to the size of the product, the product shall be marked with at least:
   (a) Manufacturer’s name or logo
   (b) Type designation
   (c) Size
   (d) Maximum working pressure

4. Testing procedures

4.1 General

4.1.1 Generally, the requirements of any suitable recognised Standards can be used for the basis of the test programme. The primary objective of the tests is to verify that the piping has sufficient strength to take account of the most severe coincident conditions of pressure, temperature, the weight of the piping itself and any static and dynamic loads imposed by the design or environment. The scope and type of tests to be conducted e.g. applicable tests, sequence of testing, and the number of specimen, is subject to approval and will depend on joint design and its intended service in accordance with the requirements of this test specification.

4.1.2 For the purpose of assuring adequate robustness for all piping including open-ended piping (e.g., overflows, vents and open-ended drains), all pipes are to have a minimum wall thickness to ensure adequate strength for use in service, also to withstand loads due to transportation, handling, personnel traffic, etc. This may require the pipe joint to have additional thickness than otherwise required by service considerations.

4.1.3 The performance requirements for any component of a piping system (such as a pipe joint) and method of connection are the same as those requirements for the piping system in which they are installed.

4.1.4 The tests are therefore to address the material design properties and performance criteria specified in the specified standards.

4.1.5 Fire testing will be requested where the effects of fire could lead to leakage in a flammable fluid system or in a system which, following failure of the joint, could lead to danger due to possible flooding or loss of integrity of an emergency shut-down or control system.

4.1.6 Attention is also drawn to any special additional testing which may be required by National Authorities or local administrations.

4.1.7 Unless otherwise specified oil or water are to be used as the test fluid.

4.1.8 Test specimens are to be selected from production line or at random from stock. Where there is a variety of size of joints requiring approval, a minimum of three separate sizes, representative of the range, from each type of joint is to be subject to the testing required by the specified standard(s).

4.1.9 Unless otherwise specified in an alternative approval standard agreed with LR, mechanical couplings for use on board ships are to be subjected to the tests indicated in the following table:
Table A4.1 Test requirement for mechanical joints used on board ships (in accordance with IACS Unified Requirement P2)

<table>
<thead>
<tr>
<th>Tests</th>
<th>Compression couplings and pipe unions</th>
<th>Slip on Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grip type &amp; Machine grooved type</td>
</tr>
<tr>
<td>Tightness test</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Burst pressure test</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Vibration (fatigue) test</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Pressure pulsation test ¹</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Pull-out test</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Fire endurance test</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Vacuum test</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Repeated assembly test</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Abbreviations:
+ Test is required
- Test is not required

NOTES:
1. For use in those systems where pressure pulsation other than water hammer is expected.
2. Except joints with metal to metal tightening surfaces
3. Except press type

4.1.10 Assembly of mechanical joints for testing should consist of components selected in accordance with 4.1.8 and the piping used for the test assemblies is to be of a size or sized appropriate to the design of the joint. Where pipe material would affect the performance of the mechanical joints this is to be taken into consideration.

4.1.11 Where not stated in the specified standard, the length of pipes to be connected by means of the joint to be tested is to be at least five times the pipe diameter. Before assembling the joint, conformity of components to the design requirements, is to be verified. In all cases the assembly of the joint shall be carried out only according to the manufacturer’s instructions. No adjustment operations on the joint assembly, other than that specified by the manufacturer, are permitted during the test.

4.1.12 Where a mechanical joint assembly does not pass all or any part of the tests in Table A4.1, two assemblies of the same size and type that failed are to be tested and only those tests in which the mechanical joint assembly failed in the first instance, are to be repeated. In the event where one of the assemblies fails the second test, that size and type of assembly is to be considered unacceptable. The methods and results of each test are to be recorded and reproduced as and when required.

4.2 Test methods

4.2.1 The test procedures detailed in 4.2.2 to 4.2.9 are applicable for mechanical joints installed on board ships as specified in Table 4.1, the applicability of these tests for joints used in other applications will depend on the specified standard(s).

4.2.2 Tightness test - all mechanical joint types are to be subjected to a tightness test, as follows.

(a) The mechanical joint assembly test specimen is to be assembled in accordance with the requirements of 4.1.10, 4.1.11 and the manufacturer’s instructions, filled with test fluid and de-aerated. Mechanical joints assemblies intended for use in rigid connections of pipe lengths, are not to be longitudinally restrained.

(b) The pressure inside the joint assembly is to be slowly increased to 1.5 times the design pressure. This test pressure is to be retained for a minimum period of 5 minutes.

(c) In the event of a drop in pressure or visible leakage, the test (including fire test) is to be repeated for two further specimens. If during the repeat test one test piece fails, the coupling is regarded as having failed. An alternative tightness test procedure, such as a pneumatic test, may be accepted.

(d) For compression couplings a static gas pressure test is to be carried out to demonstrate the integrity of the mechanical joints assembly for tightness under the influence of gaseous media. The pressure is to be raised to the maximum design pressure or 70 bar whichever is the lesser using an inert gas. The pressure is to be held for not less than 10 minutes.

(e) Three test assemblies are to be subjected to a pressure Check for leaks by:

(i) Soap solution.
(ii) Submersion in water.
(iii) Gas detection equipment.

(f) Where the tightness test is carried out using gaseous media as permitted in (c) above, then the static pressure test mentioned in (d) and (e) above need not be carried out.
4.2.3 **Burst pressure test** – all mechanical joint types are to be burst tested. At least three representative mechanical joint test specimens are to be tested as follows:
(a) The sample joint is to be connected to the pipe or tubing in accordance with the requirements of 4.1.10 and the manufacturer’s instructions, filled with test fluid and de-aerated mechanical joint assembly intended for use in rigid connections of pipe lengths is not to be longitudinally restrained.
(b) Pressure inside the test assembly is to be increased to 4 x maximum specified design pressure with an increasing rate of 10% per minute of test pressure. The duration of this test is not to be less than 5 minutes at the maximum pressure. For design pressures above 200 bar the required burst pressure will be specially considered.
(c) The specimen may have small deformation whilst under test pressure, but no leakage or visible cracks are permitted.
(d) Where considered convenient, the mechanical joint test specimen used in tightness test may be used for the burst test provided it passed the tightness test. Samples from the burst test are not to be used for further testing.

4.2.4 **Vibration (fatigue) test** – The mechanical joint assembly is to be tested to establish the capability of the mechanical joint assembly to withstand fatigue, which is likely to occur due to vibrations under service conditions. The test method is dependent on the mechanical joint type as follows:
(a) Compression couplings and pipe unions intended for use in rigid pipe connections, where rigid connection means no free angular or axial movement, are to be tested as follows:
   (i) Two lengths of pipe are to be connected by means of the joint to be tested. One end of the pipe is to be rigidly fixed while the other end is to be fitted to the vibration rig. The test rig and the joint assembly specimen being tested are to be arranged as shown in Fig.1.
   (ii) The joint assembly is to be filled with test fluid, de-aerated and pressurised to the design pressure of the joint.
   (iii) Pressure during the test is to be monitored. In the event of a drop in the pressure and visible leakage the test is to be repeated as described in 4.1.12. Visual examination of the joint assembly is to be carried out. Re-tightening may be accepted once during the first 1000 cycles.
   (iv) Vibration amplitude is to be within 5% of the value calculated from the following formula:

\[
A = \frac{2 \times S \times L^2}{3 \times E \times D}
\]

where:
- \(A\) - single amplitude, mm
- \(L\) - length of the pipe, mm
- \(S\) - allowable bending stress in \(N/mm^2\) based on 0.25 of the yield stress
- \(E\) - modulus of elasticity of tube material (for mild steel, \(E = 210 \text{ kN/mm}^2\))
- \(D\) - outside diameter of tube, mm.

The test specimen is to withstand not less than \(10^7\) cycles with frequency 20 - 50 Hz without leakage or damage.
(b) Grip type joints and other similar joints containing elastic elements are to be tested in accordance with the following method:

(i) Two lengths of pipes are to be connected by means of joint assembly specimen to be tested. One end of the pipe is to be rigidly fixed while the other end is to be fitted to the vibrating element on the rig. The length of pipe connected to the fixed end should be kept as short as possible and in no case exceed 200 mm. Mechanical joint assemblies are not to be longitudinally restrained. The test rig and the joint assembly specimen being tested are to be arranged as shown in Fig. 2.

(ii) The joint assembly is to be filled with test fluid, de-aerated and pressurised to the design pressure of the joint.

(iii) Preliminary angle of deflection of pipe axis is to be equal to the maximum angle of deflection, recommended by the manufacturer. The amplitude is to be measured at 1m distance from the centre line of the joint assembly at free pipe end connected to the rotating element of the rig. (See Fig. 2)

(iv) Pressure during the test is to be monitored. In the event of drop in the pressure and visual signs of leakage the test is to be repeated as described in 4.1.11. Visual examination of the joint assembly is to be carried out for signs of damage which may eventually lead to joint leakage.

(v) Parameters of testing are to be as indicated below and to be carried out on the same assembly:

<table>
<thead>
<tr>
<th>Number of cycles</th>
<th>Amplitude, mm</th>
<th>Frequency, Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>3·10^3</td>
<td>± 0.06</td>
<td>100</td>
</tr>
<tr>
<td>3·10^3</td>
<td>± 0.5</td>
<td>45</td>
</tr>
<tr>
<td>3·10^3</td>
<td>± 1.5</td>
<td>10</td>
</tr>
</tbody>
</table>

(c) On completion of the tests, all sample joints tested require to be retested as per the tightness test above.

4.2.5 Pressure pulsation test - The mechanical joint assembly is to be tested to establish the capability of mechanical joint assembly to withstand pressure pulsation likely to occur during working conditions. Joint assemblies intended for use in rigid connections of pipe lengths, are to be tested in accordance with the following method.

(a) The mechanical joint test specimen for carrying out this test may be the same as that used in the test in 4.2.3(a) provided it passed that test. The vibration test in 4.2.3 and the pressure pulsation test are to be carried out simultaneously for compression couplings and pipe unions.

(b) The mechanical joint test specimen is to be connected to a pressure source capable of generating pressure pulses of magnitude as shown in Fig 3.
Impulse pressure is to be raised from 0 to 1.5 times the design pressure of the joint with a frequency equal to 30-100 cycles per minute. The number of cycles is not to be less than $5 \times 10^5$.

The mechanical joint is to be examined visually for signs of leakage or damage during the test. On completion of the tests, all sample joints tested require to be retested as per the tightness test above.

4.2.6 Pull-out test - In order to determine the ability of a mechanical joint assembly to withstand the axial loading likely to be encountered in service without the connecting pipe becoming detached, a following pull-out test is to be carried out:

(a) Pipes suitable length are to be fitted to each end of the mechanical joint assembly test specimen.
(b) The test specimen is to be pressurised to design pressure. When pressure is attained, an external axial load is to be imposed with a value calculated using the following formula:

$$L = \frac{\pi}{4} D^2 \cdot p$$

where

- $D$ = pipe outside diameter, mm
- $P$ = design pressure, N/mm²
- $L$ = applied axial load, N

(c) The pressure and axial load are to be maintained for a period of 5 minutes. During the test, pressure is to be monitored and relative movement between the joint assembly and the pipe measured.
(d) The mechanical joint assembly is to be visually examined for drop in pressure and signs of leakage or damage. There is to be no movement between the mechanical joint assembly and the connecting pipes.

4.2.7 Fire endurance test - In order to establish the capability of the mechanical joints to withstand effects of fire which may be encountered in service, mechanical joints are to be subjected to a fire endurance test. The fire endurance test is to be conducted on the selected test specimens in accordance with an acceptable recognised standard such as:

(i) ISO 19921: 2005(E): Ships and marine technology – Fire resistance of metallic pipe components with resilient and elastomeric seals – Test methods; or

Clarifications to the standard requirements:

(a) If the fire test is conducted with circulating water at a pressure different from the design pressure of the joint (however of at least 5 bar) the subsequent pressure test is to be carried out to twice the design pressure.
(b) A selection of representative nominal bores may be tested in order to evaluate the fire resistance of a series or range of mechanical joints of the same design. When a mechanical joint of a given nominal bore (Dn) is so tested then other mechanical joints falling in the range Dn to 2xDn (both inclusive) are considered accepted.
(c) Alternative test methods and/or test procedures considered to be at least equivalent will be considered by LR in cases where the test pieces are too large for the test bench and cannot be completely enclosed by the flames.
(d) Thermal insulation materials applied on couplings are to be non-combustible in dry condition and when subjected to oil spray. A non-combustibility test according to ISO 1182 is to be carried out.

4.2.8 Vacuum Test - In order to establish the capability of the mechanical joint assembly to withstand internal pressures below atmospheric, similar to the conditions likely to be encountered under service conditions, the following vacuum test is to be carried out.
(a) Each mechanical joint assembly is to be connected to a vacuum pump and subjected to a pressure of 170 mbar absolute.
(b) Once this pressure is stabilized the specimen under test is to be isolated from the vacuum pump and the pressure is to be retained for a period of 5 minutes.
(c) No internal pressure rise is permitted.

4.2.9 Repeated assembly test - This test is required for separable assembly joints only and is to be carried out on at least one representative sample of joint. Where impulse and/or flexure fatigue tests are required, the test may be conducted during those tests. The sample joint is to be dismantled and reassembled a total of 10 times and then tested as per the tightness test above.

4.3 Production testing

4.3.1 Production testing is to be carried out to meet the requirements of the applicable specification. This may include the following:
(a) Material testing.
(b) Chemical analysis.
(c) Non-destructive testing, including radiography in way of any welding.
(d) Hydrostatic testing.

4.4 Additional testing

4.4.1 Additional special testing may be required as part of the approval procedure, depending upon the use and location of the pipe joint.

5. Material approval and quality control during manufacture

5.1 General

5.1.1 Material of mechanical joints is to be compatible with the piping material and internal and external media. The manufacturer is to submit evidence to substantiate that all components are adequately resistant to working the media at design pressure and temperature specified.

5.1.2 Quality controls during manufacture to include but not limited to:-
(a) Dimension and tolerances for pipe joints are to conform to the specified standard.
(b) Pipe joints, so far as may be applicable, are to be permanently marked with identification in accordance with the specified standard. See also 3.2.6.
(c) Samples of pipe joints are to be tested to determine the hydrostatic design strength. These samples are to be tested at a frequency to the satisfaction of LR.
(d) Where piping is required to be electrically conductive, representative samples of pipe joints are to be tested to determine the electrical resistance. The test method and frequency of testing are to be acceptable to LR.

6. List of standards

6.1 General

6.1.1 A list of standards is held on file in LR to provide information for the design, manufacture, testing and marking of metallic pipe joints. The use of such standards is not mandatory and alternatives may be utilised where they are applicable to the application for Type Approval. LR Rules, IMO and statutory requirements may also require to be taken into consideration so far as may be applicable.
Appendix 5

Metallic formed pipe pieces

1. Introduction

1.1 General

1.1.1 This Appendix includes detailed information for the Type Approval of metallic formed pipe pieces. It is applicable to rigid ferrous and non-ferrous metallic formed pipe pieces only.

2. Definitions

2.1 Definitions

2.1.1 Terminology used should be in accordance with a recognised Standard used in the field of design, manufacture, testing and marking of metallic formed pipe pieces, LR’s Rules for Materials or other suitable recognised Standard, for example, although other terminology could be used provided the meaning is clearly defined.

3. Details of required documentation

3.1 General

3.1.1 Request for LR Type Approval including details for:
(a) The pipe manufacturer’s name and address.
(b) The trade name and reference numbers or designation specific to the piping.
(c) Services and locations in which the pipe is intended to be used.
(d) Pipe and fitting dimensions.
(e) Maximum (and where applicable minimum) working pressure.
(f) Working temperature range.

3.1.2 Detailed product specification, including:
(a) Material manufacturer’s name and address and full trade name and reference number where applicable.
(b) The dimensions and tolerances permitted of the finished products.
(c) Details of any alternative materials which may be used.
(d) Method of attachment, to other pipe and formed pipe pieces.
(e) Installation requirements, instructions and recommendations.

3.1.3 Manufacturing specification detailing:
(a) Manufacturing procedures.
(b) Quality control procedures including details and frequency of tests on the incoming materials, tests made during production and on the finished formed pipe pieces.
(c) Acceptance standards and tolerances, including all dimensions.
(d) Procedures for rectification of defects.
(e) System for traceability of the finished piping to the batches of raw materials.
(f) Method of connecting fittings.

3.1.4 Drawings and supporting documentation, including:
(a) All relevant design drawings, catalogues, data sheets, calculations and functional descriptions.
(b) Fully detailed sectional assembly drawings, showing formed pipe pieces.

3.1.5 Proposed field of application and operational limitations, so far as may be applicable, including:
(a) Intended fluids.
(b) Maximum internal and external pressures.
(c) Maximum and minimum fluid and environmental temperatures, or graph of pressure/temperature ratings showing reduction in pressure with temperature rise.
(d) Limits on flow rates.
(e) Where necessary, strength of connections of various formed pipe pieces.
(f) Installation instructions. Effect of external loading with regard to support requirements. Control during installation. System testing. Floor and wall penetrations. Methods of repair.
(g) Replacement instructions.
3.1.6 Quality control system arrangements are to be sufficiently detailed in order to demonstrate that the quality of the finished product can be maintained in accordance with the required standards.

3.1.7 Proposed type test programme is to be sufficiently detailed in order to demonstrate that the performance provisions of the specified standards may be fulfilled for acceptance.

3.1.8 Certificates and reports for relevant tests previously obtained for the formed pipe pieces.

3.1.9 Relevant standards where necessary.

3.1.10 Details of marking. This is to include:
(a) Manufacturer’s name or trademark.
(b) Identification mark for the specification or grade of steel.
(c) Formed pipe piece type number.
(d) Date of manufacture.
(e) Nominal size (DN).
(f) Nominal pressure (PN).
(g) Identification number and/or initials which will enable the full history of the item to be traced.

4. Testing procedures

4.1 General

4.1.1 Generally, the requirements of any suitable recognised Standards can be used for the basis of the test programme. The primary objective of the tests is to verify that the piping component has sufficient strength to take account of the most severe coincident conditions of pressure, temperature, the weight of the piping itself and any static and dynamic loads imposed by the design or environment.

4.1.2 The performance requirements for any component of a piping system (such as a formed pipe piece) and method of connection are the same as those requirements for the piping system in which they are installed.

4.1.3 The tests are therefore to address the material design properties and performance criteria specified in the applicable standards.

4.1.4 Attention is also drawn to any special additional testing which may be required by National Authorities or local administrations.

4.2 Test requirements

4.2.1 Proof testing. Proof testing is to be carried out to meet the requirements of the applicable specification, including hydrostatic testing and where necessary, vacuum and intercrystalline corrosion tests.

4.2.2 Production testing. Production testing is to be carried out to meet the requirements of the applicable specification. This may include the following:
(a) Material testing.
(b) Chemical analysis.
(c) Non-destructive testing, including radiography in way of welding.
(d) Hydrostatic testing.

4.2.3 Additional testing. Additional special testing may be required as part of the approval procedure, depending upon the use and location of the piping.

5. Material approval and quality control during manufacture

5.1 General

5.1.1 Quality controls during manufacture are to include but not be limited to:
(a) Dimension and tolerances for pipes are to conform to the specified standard.
(b) Piping and formed pipe pieces are to be permanently marked with identification in accordance with a recognised Standard. See also 3.1.10.
(c) Samples of formed pipe pieces are to be tested to determine the hydrostatic design strength. These samples are to be tested at a frequency to the satisfaction of LR.
6. List of standards

6.1 General

6.1.1 A list of standards is held on file in LR to provide information for the design, manufacture, testing and marking of metallic formed pipe pieces. The use of such standards is not mandatory and alternatives may be utilised where they are applicable to the application for Type Approval. LR, IMO and statutory requirements may also require to be taken into consideration so far as may be applicable.
Appendix 6

Plastics pipes and formed pipe pieces

1. Introduction

1.1 General

1.1.1 This Appendix includes detailed information for the Type Approval of plastic pipes and formed pipe pieces. It is applicable to rigid pipes/formed pipe pieces only.

2. Definitions

2.1 General

2.1.1 Terminology used should be in accordance with a recognised Standard used in the field of design, manufacture, testing and marking of plastic pipes and formed pipe pieces. ASTM D 883-96 “Standard Terminology Relating to Plastics” is a typical standard which provides a definitive and technical list of such terms which could be referred to, although other terminology could be used providing the meaning is clearly defined.

2.1.2 Accelerator. An additive that reduces the gel and curing times of thermosetting plastics such as polyester gel coat and resin. Also called promoter or activator.

2.1.3 Barcol hardness. A determination of hardness of a polyester using a Barcol Impresser.

2.1.4 Catalyst. In FRP terms, a substance added to the laminating or gel coat resin in controlled quantities to make it cure. Usually it is used with an accelerator, creating free radicals, which in turn cure the resin.

2.1.5 Chopped strand. Continuous strand yarn or roving cut up into uniform lengths, usually from 0.8 mm to 50 mm long. Lengths up to 3.22 mm are called milled fibres.

2.1.6 Composite. Dissimilar materials laminated together to form a single structure, for example, resin, gel coat, glass.

2.1.7 Continuous filament strand. An individual rod of glass of small diameter, flexibility and great or indefinite length.

2.1.8 Copolymer. A large chemical chain composed of two or more dissimilar groups.

2.1.9 Cross-laminated. Laminated so that some of the layers are oriented at right angles to the remaining layers with respect to the grain or strongest direction of tension.

2.1.10 Cross-linking. The process of bridging two polymer chains, which converts a thermoplastic to a thermoset.

2.1.11 Cure. The polymerisation or the transforming from the liquid to the solid state with maximum physical properties, including hardness.

2.1.12 Cure time. The time required for the liquid resin to reach a polymerised state after the catalyst has been added.

2.1.13 Curing agent. See 2.1.2.

2.1.14 Epoxide. Thermoplastic or thermosetting plastics containing ether or hydroxyalkyl repeating units or both.

2.1.15 Fibre. An individual rod of glass of sufficiently small diameter to be flexible, having a known or approximate limit of length.

2.1.16 Fibreglass. Fibres similar to wool or cotton fibres, but made from glass. Glassfibre forms include cloth, yarn, mat, milled fibres, chopped strands, roving, and woven roving.
2.1.17 Filament. A single, thread-like fibre or a number of these fibres put together. A variety of fibre characterised by extreme length, which permits its use in yarn with little or no twist and usually without the spinning operation required for fibres.

2.1.18 Filament winding. A process for production of high-strength, lightweight products in which tape, roving or single strands are fed from a creel through a bath of resin (or fed dry using pre-impregnated roving) and wound on a suitably designed mandrel. The wound mandrel can be at room temperature or in an oven.

2.1.19 Fillers. Relatively inert organic or inorganic materials which are added to plastics, resins or gel coats for special flow characteristics, to extend volume, or lower the cost of the article being produced.

2.1.20 Fire endurance. See Annex 1 and Annex 2.

2.1.21 Flame spread. See Annex 3.

2.1.22 FRP. Fibre Reinforced Plastics (may be glass, carbon, aramid (Kevlar – trade name of Dupont)).

2.1.23 Gel. A partial cure stage of plastics resins in a viscous, jelly-like state where the liquid material starts to transform into a solid.

2.1.24 Gel coat. A surface coat, either coloured or clear, providing a cosmetic enhancement and exposure improvements to a fibreglass laminate.

2.1.25 Gel time. The length of time that a catalysed polyester remains workable – starts to solidify.

2.1.26 Hardener. See Accelerator.

2.1.27 Isotropic. An arrangement of the reinforcing materials in a random manner, resulting in equal strength in all directions.

2.1.28 Lay-up. Placing reinforcing materials onto the mould and applying resin to it: can be done by hand or by using spray-up equipment. Lay-up is sometimes used as a term for the workpiece itself.

2.1.29 Mat. A randomly distributed felt of glass fibres held together with a binder, used in reinforced plastics lay-up moulding.

2.1.30 Monomer. A relatively simple compound capable of polymerisation with itself or with a compatible resin. It is also used to dilute polyester (e.g., styrene).

2.1.31 Ortho. Abbreviation of orthophthalic acid type resins and gel coats.

2.1.32 Plastics. Usually synthetic materials chemically created from organic substances classified as thermoplastics or thermosets.

2.1.33 Polyester. A resin formed by the reaction between dibasic acids and dihydroxy alcohols, one of which must be unsaturated (typically, maleic acid anhydride) to permit cross-linking.

2.1.34 Polymer. A large chemical chain composed of many identical groups, such as polystyrene.

2.1.35 Polymerisation. The chemical reaction of joining monomers to form a polymer. See also Cure.

2.1.36 Pressure. See 4.2 and 4.3.

2.1.37 Reinforcement. A strong inert material bound into plastics to improve its strength, stiffness and impact resistance. Usually long fibres of glass, sisal, cotton, etc., in a woven or non-woven form.

2.1.38 Resin. Any of a class of solid or semi-solid organic products of natural or synthetic origin, generally of high molecular weight, having no definite melting point. Used in reinforced products to surround and hold fibres. Most resins are polymers.

2.1.39 Roving. A collection of bundles of continuous filaments either as untwisted strands or as twisted yarns. For filament winding, they are generally wound as bands or tapes with as little twist as possible.
2.1.40 Shelf life. The length of time an uncatalysed polyester remains workable while stored in a tightly sealed container.

2.1.41 Sisal. A white fibre produced from the leaves of the agave plant. Used as a reinforcement filler, in short chopped lengths, to impart moderate impact resistance.

2.1.42 Smoke generation. Criteria for smoke production applied to pipes within the accommodation, service and control spaces.

2.1.43 Stabiliser. An additive for polyesters to maintain liquid characteristics such as gel time, viscosity and liquidity.

2.1.44 Styrene monomer. An unsaturated hydrocarbon, used in plastics. In polyester, it is a co-reactant dilutent.

2.1.45 Temperature. See 4.5.

2.1.46 Tex. Unit of measurement of roving based on linear weights (counts), e.g., 600, 1200, 2400 and 4800 tex.

2.1.47 Thermoplastics. Materials that will soften and reform repeatedly when heated and harden when cooled. Reinforced thermoplastics such as styrene polymers and copolymers, acrylics, polycarbonates, nylon and the various fluorocarbon materials are fast becoming important engineering materials.

2.1.48 Thermosets. Materials that will undergo or have undergone a chemical reaction by the action of heat, catalyst, ultraviolet light, etc., leading to a relatively infusible state. Typical materials are aminos (melamine and urea), most polyesters, alkyds, epoxies and phenolics. They are not reformable.

2.1.49 Toxicity. The ability of a substance to cause damage to living tissue, impairment of the central nervous system, severe illness or in extreme cases, death when ingested, inhaled or absorbed by the skin.

2.1.50 Vacuum. See 4.3.

2.1.51 Woven roving fabric. Heavy fabrics woven from continuous filament in roving form. They drape well, are quickly impregnated and intermediate in price between mats and yarn cloths.

Woven tape. Tape of various thicknesses woven from continuous filament yarns.

3. Details of required documentation

3.1 General

3.1.1 Request for LR Type Approval including details for:
(a) The pipe manufacturer’s name and address.
(b) The trade name and reference numbers or designation specific to the piping.
(c) Services and locations in which the pipe is intended to be used, or
(d) The level of fire endurance testing to be carried out.
(e) Pipe and fitting dimensions.
(f) Max. working pressure.
(g) Working temperature range.
(h) Electrically conductive.
(i) Electrically non-conductive.

3.1.2 Detailed product specification, including:
(a) Pipe and formed pipe pieces.
(b) The resin type, polyester or epoxide, together with the manufacturer’s name and address and full trade name and reference number.
(c) Catalyst and accelerator types, and concentration employed in the case of reinforced polyester resin pipes, or hardeners where epoxide resins are employed, also their manufacturer’s name and address, the full trade name and reference number for these additives.
(d) A statement of all reinforcements employed, together with manufacturer’s trade names and reference numbers. Where the reference number does not identify the mass per unit area or the tex number of a roving used in a filament winding process, these are to be detailed.
(e) Full information regarding the type of gel coat or thermoplastic liner employed during construction, as appropriate.
(f) Cure/post-cure conditions. The cure and post-cure temperatures and times employed.
(g) Resin/reinforcement ratio.
(h) Winding angle and orientation.
(j) The dimensions and tolerances permitted of the finished products.
(k) Details of any alternative materials which may be used.
(l) Maximum distance between supports.
(m) Method of attachment, to pipe and formed pipe pieces.
(n) Installation requirements and recommendations. Method of attachment to metallic piping.

3.1.3 Manufacturing specification detailing:
(a) All constituent materials, including bonding materials. (See 3.1.2.)
(b) Manufacturing procedures such as winding angle, the ratio of curing agent to resin and reinforcement to resin, the laminate thickness, the mandrel dwell time (initial cure) and the cure and post-cure conditions.
(c) Quality control procedures, including details and frequency of tests on the incoming materials, tests made during production and on the finished piping/formed pipe pieces.
(d) Acceptance standards and tolerances, including all dimensions.
(e) Procedures for cosmetic repair.
(f) System for traceability of the finished piping to the batches of raw materials.
(g) Method of bonding fittings.

3.1.4 Drawings and supporting documentation, including:
(a) All relevant design drawings, catalogues, data sheets, calculations and functional descriptions.
(b) Fully detailed sectional assembly drawings, showing pipe and formed pipe pieces.

3.1.5 Proposed field of application and operational limitations, so far as may be applicable, including:
(a) Intended fluids.
(b) Maximum internal and external pressures.
(c) Maximum and minimum fluid and environmental temperatures, or graph of pressure/temperature ratings showing reduction in pressure with temperature rise.
(d) Limits on flow rates.
(e) Fire endurance, flame spread, smoke generation and toxicity. Fire protection coatings.
(f) Effect of heat with regard to ageing and life expectancy. Thermal stress.
(g) Effect of liquids/fluid absorption/deterioration, including, where applicable, fresh and salt-water, chemicals, liquefied gases. Corrosion resistance. Effect of humidity. Effect of oil and oily atmospheres.
(h) Where used, types of formed pipe pieces, strength of connections.
(j) Serviceable life in service and in storage.
(k) Installation instructions:
   Effect of external loading with regard to support requirements, see NOTE.
   (i) Control during installation.
   (ii) System testing.
   (iii) Floor and wall penetrations.
   (iv) Methods of repair.
   NOTE
   This may require values of axial strength, elasticity, impact resistance and the effect of fatigue (static and dynamic) to be verified.
(l) Replacement instructions.
(n) Electrical resistance/conductivity.
(o) Abrasive resistance, where applicable.
(p) Erosion resistance, where applicable.
(q) Compatibility between materials.

3.1.6 Quality control system arrangements are to be sufficiently detailed in order to demonstrate that the quality of the finished product can be maintained in accordance with the required standards.

3.1.7 Certificates and reports for relevant tests previously obtained for the plastic pipes and formed pipe pieces.

3.1.8 Relevant standards where necessary.

3.1.9 Details of marking. This is to include date of manufacture, shown as month/quarter and last two digits of year of manufacture, e.g., 12/12 or 4Q12.
4. Testing procedures

4.1 General

4.1.1 Attention is drawn to Annex 4 which provides details of testing required for compliance with the minimum Classification requirements for marine services. Generally, the requirements of any suitable recognised Standards can be used for the basis of the test programme. The primary objective of the tests is to verify that the piping has sufficient strength to take account of the most severe coincident conditions of pressure, temperature, the weight of the piping itself and any static and dynamic loads imposed by the design or environment.

4.1.2 For the purpose of assuring adequate robustness for all piping, including open-ended piping (e.g., overflows, vents and open-ended drains), all pipes are to have a minimum wall thickness to ensure adequate strength for use in service, also to withstand loads due to transportation, handling, personnel traffic, etc. This may require the pipe to have additional thickness than otherwise required by service considerations.

4.1.3 The performance requirements for any component of a piping system such as formed pipe pieces, joints, and method of joining are the same as those requirements for the piping system in which they are installed.

4.1.4 The tests are therefore to address the material design properties and performance criteria specified in the required standards.

4.1.5 Attention is also drawn to any special additional testing which may be required by National Authorities or local administrations. These may include testing for fire endurance, flame spread, smoke generation and toxicity. Details of these tests are given in 4.12.

4.2 Internal pressure

4.2.1 The nominal internal pressure for a pipe is to be determined by dividing the short-term hydrostatic test failure pressure by a safety factor of 4 or the long-term hydrostatic (>100 000 h) test failure pressure by a safety factor of 2.5, whichever is the lesser. The hydrostatic test failure pressure is to be verified experimentally or by a suitable combination of testing and calculation methods.

4.3 External pressure

4.3.1 External pressure is to be taken into account in the design of piping for any installation which may be subject to vacuum conditions inside the pipe or a head of liquid acting on the outside of the pipe.

4.3.2 Piping is to be designed for an external pressure not less than the sum of the maximum potential head of liquid outside the pipe, plus full vacuum (1 bar). The nominal external pressure for a pipe is to be determined by dividing the collapse test pressure by a safety factor of 3. The collapse test pressure is to be verified experimentally or by a suitable combination of testing and calculation methods. For Classification marine applications, the collapse pressure is not to be less than 3 bar.

4.4 Axial strength

4.4.1 The sum of the longitudinal stresses due to pressure, weight and other dynamic and sustained loads is not to exceed the allowable stress in the longitudinal direction. Forces due to thermal expansion, contraction and external loads, where applicable, are to be considered when determining longitudinal stresses in the system.

4.4.2 In the case of fibre reinforced plastic pipes, the sum of the longitudinal stresses is not to exceed half of the nominal circumferential stress derived from the nominal internal pressure determined according to 4.2 unless the minimum allowable longitudinal stress is verified experimentally or by a suitable combination of testing and calculation methods.

4.5 Temperature

4.5.1 Piping is to meet the design requirements of this Appendix over the range of service temperatures it will experience.

4.5.2 High temperature limits and pressure reductions relative to nominal pressures are to be in accordance with the recognised Standard. For compliance with the Classification requirements for marine services, in each case the maximum working temperature is to be at least 20°C lower than the minimum heat distortion temperature.
(determined according to ISO 75 method A, or equivalent) of the resin or plastic material and the minimum heat distortion temperature is to be not less than 80°C.

4.5.3 Where low temperature services are considered, special attention is to be paid to material properties.

### 4.6 Impact resistance

4.6.1 Piping is to meet the minimum resistance to impact criteria of the applicable specification.

### 4.7 Ageing

4.7.1 Where applicable, before selection of a piping material, the manufacturer may be required to confirm that the environmental effects, including but not limited to, ultraviolet rays, salt-water exposure, oil and grease exposure, temperature, and humidity, will not degrade the mechanical and physical properties of the piping material below the values necessary to meet the criteria of the required specification. The manufacturer may have to establish material ageing characteristics by subjecting samples of piping to a suitable ageing test and then confirming its physical and mechanical properties by the performance criteria required.

### 4.8 Fatigue

4.8.1 In cases where design loadings incorporate a significant cyclic or fluctuating component, fatigue may require to be considered in the material selection process and taken into account in the installation design.

4.8.2 In addressing material fatigue, the designer may rely on experience with similar materials in similar service or on laboratory evaluation of mechanical test specimens. However, the designer is cautioned that small changes in the material composition may significantly affect fatigue behaviour.

### 4.9 Erosion resistance

4.9.1 In the cases where fluid in the system has high flow velocities, abrasive characteristics or where there are flow path discontinuities producing excessive turbulence, the possible effect of erosion may require to be considered. If erosion cannot be avoided then adequate measures are to be taken, such as increased wall thickness, special liners, change of materials, etc.

### 4.10 Fluid absorption

4.10.1 Absorption of contact fluids by the piping material is not to cause a reduction of mechanical and physical properties of the material below that required.

4.10.2 The fluid being carried or in which the pipe is immersed is not to permeate through the wall of the pipe. Testing for fluid absorption characteristics of the pipe material is to be to a recognised Standard.

### 4.11 Material compatibility

4.11.1 The piping material is to be compatible with the fluid being carried or in which it is immersed, such that its design strength does not degenerate below that required. Where the reaction between the pipe material and the fluid is unknown, the compatibility may require to be demonstrated.

### 4.12 Test requirements

4.12.1 It may also be necessary to consider the test requirements in 4.13 to 4.20 which may apply, dependent on the piping system service and/or location.

### 4.13 Fire endurance

4.13.1 General. Pipes and their associated formed pipe pieces whose functions or integrity are essential to the safety of ships are required to meet the minimum fire endurance requirements given below.

4.13.2 Fire endurance requirements. The fire endurance of a piping system is the capability to maintain its strength and integrity (i.e., capable of performing its intended function) for some predetermined period of time, while exposed to fire that reflects anticipated conditions. Three different levels of fire endurance for plastic are given. These levels consider the different severity of consequences resulting from the loss of system integrity for the various applications.
and locations. The highest fire endurance standard (level 1) will ensure the integrity of the system during a full-scale hydrocarbon fire and is particularly applicable to systems where loss of integrity may cause outflow of flammable liquids and worsen the fire situation. The intermediate fire endurance standard (level 2) is intended to ensure the availability of systems essential to the safe operation of the ship, after a fire of short duration, allowing the system to be restored after the fire has been extinguished. The lowest level (level 3) is considered to provide the fire endurance necessary for a water-filled piping system to survive a local fire of short duration. The system's function is to be capable of being restored after the fire has been extinguished.

4.13.3 **Level 1.** Piping systems essential to the safety of the ship and those systems outside machinery spaces where the loss of integrity may cause outflow of flammable fluid and worsen the fire situation are to be designed to endure a fully developed hydrocarbon fire for a long duration without loss of integrity under dry conditions. Piping having passed the fire endurance test method specified in Annex 1 of this Appendix for a duration of a minimum of one hour without loss of integrity in the dry condition is considered to meet level 1 fire endurance standard.

4.13.4 **Level 2.** Piping systems essential to the safe operation of the ship are to be designed to endure a fire without loss of the capability to restore the system function after the fire has been extinguished. Piping having passed the fire endurance test specified in Annex 1 of this Appendix for a duration of a minimum of 30 minutes in the dry condition is considered to meet level 2 fire endurance standard.

4.13.5 **Level 3.** Piping systems essential to the safe operation of the ship are to be designed to endure a fire without loss of the capability to restore the system function after the fire has been extinguished. Piping having passed the fire endurance test specified in Annex 2 of this Appendix for a duration of a minimum of 30 minutes in the wet condition to meet level 3 fire endurance standard.

4.14 **System/location matrix**

4.14.1 The matrix in Table 12.5.3 in Pt 5, Ch 12.5 of the Rules and Regulations for the Classification of Ships (hereinafter referred to as the Rules for Ships) establishes fire endurance requirements, which are system and location dependent, that pipe materials installed in a specific system and location should possess to meet accepted minimum levels of safety.

4.14.2 Where the matrix stipulates endurance level 2, pipes of endurance level 1 may also be used. Similarly, where the matrix stipulates endurance level 3, pipes of endurance levels 2 and 1 may be used.

4.15 **Flame spread**

4.15.1 For shipboard applications, IMO Resolution A. 753 (18) requires that all pipes, except those fitted on open decks and within tanks, cofferdams, void spaces, pipe tunnels and ducts should have low flame spread characteristics as determined by the test procedures given in IMO Resolution A.653(16) Recommendation on Improved Fire Test Procedures for Surface Flammability of Bulkhead, Ceiling and Deck Finish Materials. Some Classification Societies including Lloyd’s Register recommend other standards, e.g., BS 476 ‘Fire Tests on Building Materials and Structures’ Part 7 ‘Method of test to determine the classification of the surface spread of flame of products’ or ASTM D 635 ‘Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position’.

4.15.2 In Resolution A.653(16) the test sample configuration only considers flat surfaces. Procedure modifications to Resolution A.653(16) are necessary due to the curvilinear pipe surfaces. These procedure modifications are listed in Annex 3 of this Appendix.

4.15.3 Piping materials giving average values for all of the surface flammability criteria not exceeding the values listed in IMO Resolution A.653(16) Surface flammability criteria, bulkhead, wall and ceiling linings, are considered to meet the requirements for low flame spread in accommodation, service and control spaces. In other areas or where the quantity of pipe is small, equivalent acceptance criteria may be allowed.

4.16 **Smoke generation**

4.16.1 For shipboard applications, criteria for smoke production need only be applied to pipes within the accommodation, service, and control spaces. SOLAS Regulations II-2/34.7 and 49.2 are applicable to exposed interior surfaces which are interpreted as including the surface finish of piping systems.

4.16.2 Attention is drawn to the IMO Resolution MSC.61(67) (adopted on December 5, 1996) entitled Adoption of the International Code for Application of Fire Test Procedures, Annex 1 Fire Test Procedures, Part 2-Smoke and Toxicity Tests for fire test procedures and smoke obscuration criteria for shipboard applications together with any requirements
required by the National Authorities. For industrial purposes, consideration could be given to this hazard in accordance with ISO 5659-2: 1994 ‘Plastics – Smoke Generation, Part 2: Determination of Optical Density by a Single Chamber Test,’ or similar acceptable standard as may be applicable.

4.17 Toxicity

4.17.1 Attention is drawn to the IMO Resolution MSC.61(67) and the Annexes thereto (see 4.16.2) for toxicity testing together with any requirements required by the National Authorities.

4.18 Electrical conductivity

4.18.1 Electrostatic charges can be generated on the inside and outside of plastic pipes. The resulting sparks can ignite surrounding explosive atmospheres, or can create punctures through pipe walls leading to leakage of pipe contents. Consideration is to be given to these hazards when seeking approval of plastic piping carrying fluids capable of generating electrostatic charges (static accumulators) inside the pipe, and plastic piping in hazardous areas (i.e., areas that could, either in normal or fault conditions, contain an explosive atmosphere) where there is a possibility of electrostatic charges outside the pipe.

4.18.2 In practice, fluids with conductivity less than 1000 pico siemens per metre (pS/m) are considered to be non-conductive and therefore capable of generating electrostatic charges. Refined products and distillates fall into this category and piping used to convey these liquids are therefore to be electrically conductive. Fluids with conductivity greater than 1000 pS/m are considered to be static non-accumulators and can therefore be conveyed through pipes not having special conductive properties when located in non-hazardous areas.

4.18.3 Regardless of the fluid being conveyed, plastic piping is to be electrically conductive if the piping passes through a hazardous area.

4.18.4 Where conductive piping is required, the resistance per unit length of the pipe, bends, elbows, fabricated branch pieces, etc., is not to exceed 1 x 105 ohm/m and the resistance to earth from any point in the piping system is not to exceed 1 x 106 ohm. It is preferred that pipes and formed pipe pieces be homogeneously conductive. Pipes and such fittings having conductive layers may be accepted subject to the arrangements for minimising the possibility of spark damage to the pipe wall being satisfactory. Satisfactory earthing is to be provided.

4.19 Fire protection coatings

4.19.1 Where a fire protective coating of pipes and formed pipe pieces is necessary for achieving the fire endurance standards required, the following requirements apply:

(a) Pipes may be delivered from the manufacturer with the protective coating on, in which case on-site application of protection can be limited to what is necessary for installation purposes (e.g., joints). Alternatively, pipes may be coated on site in accordance with an approved procedure for each combination of materials, using approved materials of both pipe and insulation.

(b) The liquid absorption properties of the coating and piping are to be considered. The fire protection properties of the coating are not to be diminished when exposed to salt-water, rainwater, oil, bilge slops, etc., so far as may be applicable. That is, the coating is to be resistant to products likely to come in contact with the piping.

(c) Fire protection coatings are not to degrade due to the effects of environmental exposure over time, such as ultraviolet rays, salt-water, rainwater, temperature and humidity. Other areas requiring consideration include thermal expansion, resistance against vibration and elasticity. Resistance to ageing of the fire protection coatings is to be satisfactory, consistent with ageing tests specified for piping.

(d) The adhesion qualities of the coating are to be such that the coating does not flake, chip, or powder, when subjected to an acceptable adhesion test.

(e) The fire protection coating is to have an impact resistance of acceptable value.

4.19.2 Special testing may be required as part of the approval procedure, depending upon the use and location of the piping.

4.20 Prototype tests

4.20.1 Reference should be made to Tables A4.1 and A4.2 for a typical testing programme required for marine Classification applications.
Table A4.1  Typical requirements for all systems

<table>
<thead>
<tr>
<th>Test</th>
<th>Typical Standard</th>
<th>Sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Internal pressure</td>
<td>Pt 5, Ch 12,5.3.1 and 5.3.2 of the Rules for Ships</td>
<td>Top, middle, bottom (of range)</td>
</tr>
<tr>
<td>Short-term (w)</td>
<td></td>
<td>Each type of construction</td>
</tr>
<tr>
<td>Long-term (w)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. External pressure (w) (i)</td>
<td>Pt 5, Ch 12,5.3.1 and 5.3.3 of the Rules for Ships</td>
<td>As above</td>
</tr>
<tr>
<td>3. Load deformation</td>
<td>ASTM D 2412</td>
<td>Top, middle, bottom (of range)</td>
</tr>
<tr>
<td>4. Axial strength</td>
<td>Installation design</td>
<td></td>
</tr>
<tr>
<td>5. Temperature limitations</td>
<td>ISO 75 Method A</td>
<td>Each type of resin</td>
</tr>
<tr>
<td>7. Ageing (i)</td>
<td>Manufacturer’s standard</td>
<td>Each type of construction</td>
</tr>
<tr>
<td>8. Fatigue (i)</td>
<td>Manufacturer’s standard or service experience</td>
<td>Each type of construction</td>
</tr>
<tr>
<td>9. Erosion resistance (i)(ii)</td>
<td>Installation design</td>
<td></td>
</tr>
<tr>
<td>10. Fluid absorption (i)(ii)</td>
<td>Manufacturer’s standard</td>
<td>Each type of construction</td>
</tr>
<tr>
<td>11. Material compatibility (i)(ii)</td>
<td>Manufacturer’s standard</td>
<td></td>
</tr>
</tbody>
</table>

NOTES
(w)  Test to be witnessed by LR Surveyor.
(i)  If applicable.
(ii) To include any coatings.

Table A4.2  Typical additional requirements depending on service and/or locations

<table>
<thead>
<tr>
<th>Test</th>
<th>Typical Standard</th>
<th>Sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Fire endurance Level 1,2 or 3</td>
<td>See Annex 1 and Annex 2</td>
<td>Representative samples of each type of construction.</td>
</tr>
<tr>
<td>(w)(i)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Smoke generation (i)(ii)</td>
<td>IMO Fire Test Procedures Code</td>
<td></td>
</tr>
<tr>
<td>15. Toxicity (i)(iii)</td>
<td>IMO Fire Test Procedures Code</td>
<td></td>
</tr>
<tr>
<td>16. Electrical conductivity (w)(i)</td>
<td>ASTM F 927 or ASTM D 257</td>
<td>Representative samples of each type of construction</td>
</tr>
</tbody>
</table>

NOTES
(w)  Test to be witnessed by LR Surveyor.
(i)  If applicable.
(ii) To include any coatings.
Tests 12, 13 and 16 are optional but, if not carried out, the range of approved applications for the pipes will be limited accordingly. (See Table 12.5.3 in Pt 5, Ch 12 of the Rules for Ships.)

5. Material approval and quality control during manufacture

5.1  General

5.1.1  LR require the piping and formed pipe pieces to be prototype tested to ensure that they meet the performance requirements of this Appendix.

5.1.2  Dimension and tolerances for pipes are to conform to a recognised Standard.

5.1.3  Piping and formed pipe pieces are to be permanently marked with identification in accordance with a recognised Standard. Identification is to include pressure ratings, the design standard to which the pipe or formed pipe piece is manufactured and the material system with which the pipe or formed pipe piece is made.

5.1.4  Each length of pipe is to be tested at the manufacturer’s production facility to a hydrostatic pressure not less than 1.5 times the rated pressure of the pipe. Other test criteria may be accepted.

5.1.5  Samples of pipe and formed pipe pieces are to be tested to determine the short-term and/or long-term hydrostatic design strength. These samples are to be tested at a frequency to the satisfaction of LR.
5.1.6 For piping required to be electrically conductive, representative samples of pipe and formed pipe pieces have to be tested to determine the electrical resistance per unit length. The test method and frequency of testing are to be acceptable to LR.

5.1.7 Random samples of pipe and formed pipe pieces are to be tested to determine the adhesion qualities of the coating. The test method and frequency of testing is to be acceptable to LR.

5.1.8 Attention is drawn to Annex 4 to this Appendix which provides further detail of the requirements for material approval and quality control during manufacture.

6. List of standards

6.1 General

6.1.1 A list of standards is held on file in LR to provide information for the design, manufacture, testing and marking of plastic pipes and formed pipe pieces. The use of such standards is not mandatory and alternatives may be utilised where they are applicable to the application for Type Approval. LR Rules, IMO and statutory requirements also require to be taken into consideration so far as may be applicable.

  Part 1: General test method (Method A only).
  Part 2: Plastics and ebonite.
ISO 161-1:1996 Thermoplastic pipes for the transport of fluids – Nominal outside diameters and nominal pressures.
ISO 175:2010 Plastics – Determination of the effects of liquid chemicals, including water.
ISO 182-1:1990 Plastics – Determination of the tendency of compounds and products based on vinyl chloride homopolymer and copolymers to evolve hydrogen chloride and any other acidic products at elevated temperatures – Part 1: Congo red method.
  (NB. Not acceptable by LR for marine classification applications.)
  Part 2: Test conditions for moulding and extrusion plastics.
  Part 2: Flexural creep by three-point loading.

Reference:
Lloyd’s Register – Test Specification No.2 – 01/17
Reporting date: January 2017
Report by: Global Marine Technical Services
ISO 1167:2006 Plastics pipes for the transport of fluids – Determination of the resistance to internal pressure.
ISO 3129:1975 Polypropylene pipes – Burst test requirements.
ISO 3458:1976 Assembled joints between fittings and polyethylene (PE) pressure pipes – Test of leak proofness under internal pressure.
ISO 3501:1976 Assembled joints between fittings and polyethylene (PE) pressure pipes – Test of resistance to pull out.
ISO 3503:1976 Assembled joints between fittings and polyethylene (PE) pressure pipes – Test of leak proofness under internal pressure when subjected to bending.
ISO 3604:1976 Fittings for unplasticised polyvinyl chloride (PVC) pressure pipes with elastic sealing ring type joints – Pressure test for leakproofness under conditions of external hydraulic pressure.
ISO 22088-1:2006  Plastics – Determination of resistance environmental stress cracking (ESC)
ISO 6964:1986  Polyolefin pipes and fittings – Determination of carbon black content by calcination and pyrolysis – Test method and basic specification.
ISO 8572:1991  Pipes and fittings made of glass-reinforced thermosetting plastics (GRP) – Definitions of terms relating to pressure, including relationships between them, and terms for installation and jointing.
Test method for fire endurance testing of plastic piping in the dry condition

1. Test method

1.1 A furnace test with fast temperature increase likely to occur in a fully developed liquid hydrocarbon fire. The time/temperature of the furnace should be as follows:

<table>
<thead>
<tr>
<th>Time (Minutes)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>945°C</td>
</tr>
<tr>
<td>10</td>
<td>1033°C</td>
</tr>
<tr>
<td>15</td>
<td>1071°C</td>
</tr>
<tr>
<td>30</td>
<td>1098°C</td>
</tr>
<tr>
<td>60</td>
<td>1100°C</td>
</tr>
</tbody>
</table>

1.2 Note the accuracy of the furnace control should be as follows:

1.2.1 During the first 10 minutes of the test the area under the curve of mean furnace temperature should not vary by more than ±15 per cent of the area under the standard curve.

1.2.2 During the first half hour of the test the area under the curve of mean furnace temperature should not vary by more than ±10 per cent of the area under the standard curve.

1.2.3 For any period after the first half hour of the test the area under the curve of mean furnace temperature should not vary by more than ±5 per cent of the area under the standard curve.
1.2.4 At any time after the first 10 min of the test the mean furnace temperature should not differ from the standard curve by more than ±100°C.

1.3 The locations where the temperatures are measured, the number of temperature measurements and the measurement techniques are to be agreed by the Administration, taking into account the furnace control specification as set out in IMO Resolution 61(67).

2 Test specimen

2.1 The test specimen should be prepared with the joints and fittings intended for use in the proposed application. The number of specimens should be sufficient to test typical joints and fittings including joints between non-metal and metal pipes and fittings to be used. The ends of the specimen should be closed. One of the ends should allow pressurised nitrogen to be connected. The pipe ends and closures may be outside the furnace. The general orientation of the specimen should be horizontal and it should be supported by one fixed support with the remaining supports allowing free movement. The free length between supports should not be less than 8 times the pipe diameter.

2.2 Note that most materials other than steel used for pipes will require a thermal insulation to be able to pass this test. The test procedure should include the insulation and its covering.

2.3 The number and size of test specimens required for the approval test should be specified by LR.

3 Test conditions

3.1 If the insulation contains or is liable to absorb moisture, the specimen should not be tested until the insulation has reached an air-dry condition. This condition is defined as equilibrium with an ambient atmosphere of 50 per cent relative humidity at 20 ±5°C. Accelerated conditioning is permissible provided the method does not alter the properties of component material. Special samples should be used for moisture content determination and conditioned with the test specimen. These samples should be so constructed as to represent the loss of water vapour from the specimen by having similar thickness and exposed faces.

3.2 A nitrogen pressure inside the test specimen should be maintained automatically at 0,7 bar ±0,1 bar during the test. Means should be provided to record the pressure inside the pipe and the nitrogen flow into and out of the specimen in order to indicate leakage.

4 Acceptance criteria

4.1 During the test, no nitrogen leakage from the sample should occur.

4.2 After termination of the furnace test, the test specimen together with fire protection coating, if any, should be allowed to cool in still air to ambient temperature and then tested to the rated pressure of the pipes. The pressure should be held for a minimum of 15 minutes without leakage. Where practicable, the hydrostatic test should be conducted on bare pipe, that is, pipe which has had all of its coverings including fire protection insulation removed, so that leakage will be readily apparent.

4.3 Alternative test methods and/or test procedures considered to be at least equivalent, including open pit testing method, may be accepted in cases where the pipes are too large for the test furnace.

Annex 2

Test method for fire endurance testing of water-filled plastic piping

1 Test method

Test Level 3: Test sample required to complete this test for a duration of 30 minutes with minimal loss of integrity. (See Section 4, ‘Acceptance Criteria’.)

1.1 A propane multiple burner test with a fast temperature increase should be used.

1.2 For piping up to 152 mm in diameter, the fire source should consist of two rows of 5 burners. A constant heat flux averaging 113,6 kW/m² (±10 per cent) should be maintained 12,5 ±1 cm above the centreline of the burner array. This flux corresponds to a pre-mix flame of propane with a flow rate of 5 kg/h for a total heat release rate of 65
kW. The gas consumption should be measured with an accuracy of at least ±3 per cent in order to maintain a constant heat flux. Propane with a minimum purity of 95 per cent should be used.

1.3 For piping greater than 152 mm in diameter, one additional row of burners should be included for each 51 mm increase in pipe diameter. A constant heat flux averaging 113,6 kW/m² (±10 per cent) should still be maintained at the 12,5 ±1 cm height above the centreline of the burner array. The fuel flow should be increased as required to maintain the designated heat flux.

1.4 The burners should be type “Sievert No. 2942” or equivalent which produces an air-mixed flame. The inner diameter of the burner should be 29 mm (see Fig. 1). The burner heads should be mounted in the same plane and supplied with gas from a manifold. If necessary, each burner should be equipped with a valve in order to adjust the flame height.

1.5 The height of the burner stand should also be adjustable. It should be mounted centrally below the test pipe with the rows of burners parallel to the pipe’s axis. The distance between the burner heads and the pipe should be maintained at 12,5 ±1 cm during test. The free length of the pipe between its supports should be 800 ±50 mm.

2. **Test specimen**

2.1 Each pipe should have a length of approximately 1,5 m. The test pipe should be prepared with permanent joints and fittings intended to be used. Only valves and straight joints versus elbows and bends should be tested as the adhesive in the joint is the primary point of failure. The number of pipe specimens should be sufficient to test all typical joints and fittings. The ends of each pipe specimen should be closed. One of the ends should allow pressurised water to be connected.

2.2 If the insulation contains or is liable to absorb moisture, the specimen should not be tested until the insulation has reached an air-dry condition. This condition is defined as equilibrium with an ambient atmosphere of 50 per cent relative humidity at 20 ±5°C. Accelerated conditioning is permissible provided the method does not alter the properties of the material.

2.3 Special samples should be used for moisture content determination and conditioned with the test specimen. These samples should be so constructed as to represent the loss of water vapour from the specimen by having similar thickness and exposed faces.

2.4 The pipe samples should rest freely in a horizontal position on two v-shaped supports. The friction between pipe and supports should be minimised. The supports may consist of two stands.

2.5 A relief valve should be connected to one of the end closures of each specimen.

3. **Test conditions**

3.1 The test should be carried out in a sheltered test site in order to prevent any draught influencing the test.

3.2 Each pipe specimen should be completely filled with de-aerated water to exclude air bubbles.

3.3 The water temperature should not be less than 15°C at the start and should be measured continuously during the test.

3.4 The water inside the sample should be stagnant and the pressure maintained at 3 ±0,5 bar during the test.

4. **Acceptance criteria**

4.1 During the test, no leakage from the sample(s) should occur except that slight weeping through the pipe wall may be accepted.

4.2 After termination of the burner regulation test, the test sample, together with fire protection coating, if any, should be allowed to cool to ambient temperature and then tested to the rated pressure of the pipes. The pressure should be held for a minimum of 15 minutes without significant leakages, i.e., not exceeding 0,2 l/min. Where practicable, the hydrostatic test should be conducted on bare pipe, that is pipe which has had all of its covering including fire protection insulation removed, so that leakage will be readily apparent.
Annex 3

Test method for flame spread of plastic piping (See Note)

Flame spread of plastic piping for shipboard applications should be determined by IMO Resolution 61(67) with the following modifications:

1. Tests should be made for each pipe material and size.

2. The test samples should be fabricated by cutting pipes lengthwise into individual sections and then assembling the sections into a test sample as representative as possible of a flat surface. A test sample should consist of at least two sections. The test sample should be ±800 mm long. All cuts should be made normal to the pipe wall.

3. The number of sections that must be assembled together to form a test sample should be that which corresponds to the nearest integral number of sections which should make a test sample with an equivalent linearised surface width between 155 mm and 180 mm. The surface width is defined as the measured sum of the outer circumference of the assembled pipe sections that are exposed to the flux from the radiant panel.

4. The assembled test sample should have no gaps between individual sections.

5. The assembled test sample should be constructed in such a way that the edges of two adjacent sections should coincide with the centreline of the test holder.

6. The individual test sections should be attached to the backing calcium silicate board using wire (No. 18 recommended) inserted at 50 mm intervals through the board and tightened by twisting at the back.

7. The individual pipe sections should be mounted so that the highest point of the exposed surface is in the same plane as the exposed flat surface of a normal surface.

8. The space between the concave unexposed surface of the test sample and the surface of the calcium silicate backing board should be left void.

9. The void space between the top of the exposed test surface and the bottom edge of the sample holder frame should be filled with a high temperature insulating wool if the width of the pipe segments extend under the side edges of the sample-holding frame.

Note

Some Classification societies including Lloyd’s Register recommend other standards, such as BS 476 ‘Fire Tests on Building Materials and Structures’ Part 7 ‘Method of Test to Determine the classification of the Surface Spread of Flame of Products’ or ASTM D 653 ‘Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position’, for example.

Annex 4

Quality assurance

1 General

1.1 The manufacturer’s QA system is to be designed to provide compliance with the manufacturing specification.

1.2 Inspection of the works is to be carried out by an LR Surveyor.

1.3 Confirmation is required that the raw material manufacturer provides a certificate with each batch. This certificate is to detail the values obtained from the following measurements:

1.3.1 Thermoplastic pipes:
(a) Melting point.
(b) Melt flow index.
(c) Density.
(d) Filler/pigment content, where applicable.
(e) Tensile stress at yield and break.
(f) Tensile strain at yield and break.
1.3.2 Thermoset pipes:
(a) All resins:
   (i) Viscosity.
   (ii) Gel time.
   (iii) Filler content, where applicable.
(b) Polyester resins:
   (i) Type (orthophthalic, isophthalic, etc.).
   (ii) Volatile content.
   (iii) Acid value.
(c) Epoxide resins:
   (i) Free epoxide content.
(d) Phenolic resins:
   (i) Free phenolic content.
   (ii) Free formaldehyde content.

1.4 Details of all raw materials are to be in accordance with the manufacturing specification and the design submission.

1.5 All batches of raw materials are to be provided with unique identifications by their manufacturers so that each item of piping is traceable to the batch or batches of material used in the manufacture. The unique identifications are to be included on all documents.

1.6 Storage conditions for raw materials are to be adequate, i.e., with regard to temperature and humidity, for example.

1.7 No batch material is to be used later than its expiry date. All batches are to be used sequentially.

1.8 Records are to be maintained of the amounts of resin and reinforcement used to ensure the proportions are within the limits set in the manufacturing specification.

1.9 Records are to be kept of the wind angle and/or orientation of the reinforcement.

1.10 The temperature of the pipe or fitting during manufacture is to be controlled and recorded by the attachment of suitably placed thermocouples.

1.11 All pyrometric equipment is to be calibrated at least annually and records maintained.

1.12 The wall thickness of the pipes is to be measured at intervals around the circumference and along their length in accordance with an appropriate standard. The wall thicknesses are to be in accordance with the manufacturing specification.

1.13 The temperature of deflection under load is to be tested on at least one batch in twenty to ensure it exceeds the specified minimum under manufacturing conditions.

1.14 Where reinforcements are used, the following is to be recorded, where applicable, as a minimum:
(a) Tex of yarn(s) or roving(s).
(b) Ends per 100 mm in all reinforcement orientations.
(c) Weight per square metre.
(d) Binder/size content.
(e) Stitch type and count.
(f) Type of fibre used.
(g) Surface treatment and/or finish.
2 Testing

2.1 The following tests are to be carried out during manufacture:

<table>
<thead>
<tr>
<th>Component</th>
<th>Test</th>
<th>Test rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Resin/curing</td>
<td>Gel time</td>
<td>Two/Shift easiest to read number (a)</td>
</tr>
<tr>
<td>(b) Agent/catalyst</td>
<td>Rate of consumption</td>
<td>Continuous easiest to read number (b)</td>
</tr>
<tr>
<td>(c) Reinforcement</td>
<td>Quality</td>
<td>Continuous easiest to read number (c)</td>
</tr>
<tr>
<td></td>
<td>Wind angle</td>
<td>Continuous easiest to read number (c)</td>
</tr>
<tr>
<td></td>
<td>Rate of consumption</td>
<td>Continuous easiest to read number (c)</td>
</tr>
<tr>
<td>(d) Resin/Reinforcement</td>
<td>Ratio</td>
<td>Continuous easiest to read number (d)</td>
</tr>
<tr>
<td>(e) Pipe</td>
<td>Post-cure: temperature</td>
<td>Continuous easiest to read number (e)</td>
</tr>
<tr>
<td></td>
<td>of the pipe in oven</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cure level</td>
<td>At least 8 per length easiest to read number (e)</td>
</tr>
<tr>
<td></td>
<td>Dimensions</td>
<td>Each length easiest to read number (e)</td>
</tr>
<tr>
<td></td>
<td>Hydraulic pressure test.</td>
<td>Each length easiest to read number (e)</td>
</tr>
<tr>
<td></td>
<td>1.5 x rated pressure</td>
<td></td>
</tr>
</tbody>
</table>

2.2 Where a batch of resin or polymer, or the curing agent, or their ratio is changed during manufacture of a batch of pipes, at least two additional measurements of the gel time are to be carried out during each shift.

3 Visual examination

3.1 All pipes and fittings are to be visually examined to ensure freedom from surface defects and blemishes.

4 Identification

4.1 All piping is to be identified in such a manner that traceability to all the component materials in its manufacture is ensured.

4.2 Pipes and formed pipe pieces are to be permanently marked by the manufacturer by moulding, hot sampling or by any other suitable method, such as printing. The marking is to include:

(a) Identification number(s)
(b) ‘LR’ or ‘Lloyd’s Register’, and the abbreviated name of LR’s local office.
(c) Manufacturer’s name or trademark.
(d) Pressure rating.
(e) Design standard.
(f) Material system with which the piping is made.
(g) Maximum service temperature.
(h) Date of manufacture, shown as month/quarter and last two digits of year of manufacture, e.g., 12/12 or 4Q12.

5 Certification

5.1 Test certificates or shipping statements are to be provided for all material.

5.2 Each test certificate is to include:

(a) Purchaser’s name and order number.
(b) The contract number for which the piping is intended, if known.
(c) Address to which order is dispatched.
(d) Type and specification of material.
(e) Description and dimensions.
(f) Identification number.
(g) Test results.

6 Storage

6.1 Finished pipes are to be stored in a reasonable manner prior to shipment.
Appendix 7

Valves

1. Introduction

1.1 General

1.1.1 This Appendix includes detailed information for the Type Approval of valves and is part of LR’s Rules for Materials. It is applicable to ferrous and non-ferrous metallic valves only.

2. Definitions

2.1 General

2.1.1 Terminology used should be in accordance with a recognised Standard used in the field of design, manufacture, testing and marking of metallic valves, Rules for Materials, or other suitable recognised Standard, for example. Other terminology could be used provided the meaning is clearly defined.

3. Details of required documentation

3.1 General

3.1.1 Request for LR Type Approval including details for:
(a) The valve manufacturer’s name and address.
(b) The trade name and reference numbers or designation specific to the valves.
(c) Services and locations in which the valves are intended to be used.
(d) Valve and flange (or other connection where applicable) dimensions.
(e) Maximum working pressure.
(f) Working temperature range.

3.1.2 Detailed product specification, including:
(a) Material manufacturer’s name and address.
(b) Temperature pressure ratings for body, seat rating, and differential pressure rating as required.
(c) The dimensions and tolerances permitted of the finished products.
(d) Details of any alternative materials which may be used, including body, trim, stem seals, bolting, dowels and bonnet sealing.
(e) Details of any alternative designs which may be used.
(f) Details of any welding used in the production process (Approved welders and procedure may be required).
(g) Method of attachment (e.g., applicable flange standards).
(h) Details of any operating mechanisms requiring to be included in approval. Details of local manual operation are also to be provided.
(i) Installation requirements, instructions and recommendations.

3.1.3 Manufacturing specification detailing:
(a) Manufacturing procedures.
(b) Quality control procedures, including details and frequency of tests on the incoming materials, tests made during production and on the finished articles.
(c) Acceptance standards and tolerances, including all dimensions.
(d) Procedures for rectification of defects.
(e) System for traceability of the finished valves to the batches of castings, forgings or other material.

3.1.4 Drawings and supporting documentation, including:
(a) All relevant design drawings, catalogues, data sheets, calculations and functional descriptions.
(b) Fully detailed sectional assembly drawings.

3.1.5 Proposed field of application and operational limitations, so far as may be applicable, including:
(a) Intended fluids.
(b) Maximum pressure or pressure ratings.
(c) Maximum and minimum working temperatures or graph of pressure/temperature ratings showing reduction in pressure with temperature rise.
3.1.6 Quality control system arrangements to be sufficiently detailed in order to demonstrate that the quality of the finished product can be maintained in accordance with the required standards.

3.1.7 Proposed type test programme, sufficiently detailed in order to demonstrate that the performance provisions of the specified standards may be fulfilled for acceptance.

3.1.8 Certificates and reports applicable to relevant tests previously performed on the valves.

3.1.9 Relevant standards where necessary.

3.1.10 Details of marking. This is to include:
(a) Manufacturer’s name or trademark.
(b) Catalogue reference.
(c) Size (e.g., nominal pipe size).
(d) Pressure class for body or valve as required.
(e) Pressure at 38°C/20°C as applicable.
(f) Pressure and temperature at maximum allowable temperature as may be determined by other than the shell rating.
(g) Identification number and/or initials which will enable the full history of the valve to be traced, including those used in the body, the trim, and any internal liner or encapsulation.
(h) Valve standard identification applicable.
(i) The high pressure side of valves not having the same pressure rating from both directions is to be clearly marked in an appropriate location.
(j) Valves not suitable or intended for dead-end service are to be so identified.
(k) Valves suitable for dead-end service in one direction only are to be appropriately marked with the high pressure side clearly indicated.
(m) Date of manufacture.

4. Testing procedures

4.1 General

4.1.1 Generally, the requirements of any suitable recognised Standards can be used for the basis of the test programme. The primary objective of the tests is to verify that the valve has sufficient strength to take account of the most severe coincident conditions of pressure and temperature.

4.1.2 For the purpose of assuring adequate robustness, all valves are to have a minimum wall thickness to ensure adequate strength for use in service, also to withstand loads due to transportation, handling, personnel traffic, etc. This may require the valve to have additional thickness than otherwise required by service considerations.

4.1.3 The performance requirements for any component of a piping system and method of connection are the same as those requirements for the piping system in which they are installed. The tests are therefore to address the material design properties and performance criteria specified in the applicable standards.

4.1.4 Fire testing will be requested where the effects of fire could lead to leakage in a flammable fluid system or in a system which following failure of the valve could lead to danger due to possible flooding or loss of integrity of an emergency shut-down or control system.

4.1.5 Attention is also drawn to any special additional testing which may be required by National Authorities or local administrations.

4.2 Test requirements

4.2.1 Proof testing

4.2.2 The valves require to be prototype tested to ensure that they meet the performance requirements of this Appendix and/or the requirements of the applicable specification, including hydrostatic or pneumatic testing and, where necessary, intercrystalline corrosion tests.
4.2.3  Unless testing is to be restricted to specified standards only, consideration should be given to the following tests as necessary:

(a) **Shell test.** Each size of valve body is to be subjected to a hydraulic test of 7 bar g or 2 \( \times \) maximum specified design pressure at 20°C, whichever is the greater.

(b) **Backseat test.** Sample sizes should be tested by hydraulic pressure under the seat or with the pressure applied in the adverse direction, with the valve in the closed condition, to a pressure of 7 bar g or 1.1 \( \times \) maximum specified design pressure at 20°C, whichever is the greater. The test may require to be repeated in the reverse direction for certain designs of valve (certain resilient seated butterfly valves designed to API 609 Category B, for example).

(c) **High-pressure closure test.** The Backseat Test is to be repeated with the pressure in the normal direction of flow at a test pressure of 7 bar g or 1.5 \( \times \) maximum specified design pressure at 20°C, whichever is the greater.

(d) **Butterfly valve disc deflection test.** This test is sometimes requested for valves greater than DN 200 to ascertain the deflection of the disc under normal working pressure in the normal direction of flow or in both directions where applicable. With the valve stem mounted vertically the disc deflection is simultaneously recorded at the disc centre and at each horizontal extremity. One valve only, of largest diameter, need be tested unless otherwise specially required.

(e) **Fire test.** Unless otherwise required by the specified standards, the test should normally be carried out in accordance with ISO 10497, or equivalent.

(f) **Material tests,** as may be required by the applicable specification or called for by the intended services.

### 4.3  Production testing

4.3.1  Production testing is to be carried out to meet the requirements of the applicable specification. This may include the following:

(a)  Material testing.

(b)  Chemical analysis.

(c)  Non-destructive testing, including radiography in way of any welding.

(d)  Individual hydrostatic testing.

### 4.4  Additional Testing

4.4.1  Additional special testing may be required as part of the approval procedure, depending upon the proposed use and location of the valves.

### 5.  Material approval and quality control during manufacture

#### 5.1  General

5.1.1  Quality controls during manufacture to include but not be limited to:

5.1.2  Dimension and tolerances for the valves are to conform to the specified standard.

5.1.3  The valves are to be permanently marked with identification in accordance with a recognised Standard. See also 3.1.10.

5.1.4  Each valve is to be tested at the manufacturer’s production facility to a hydrostatic pressure not less than 1.5 times the rated pressure of the valve. Other test criteria may be accepted.

5.1.5  Samples of valve are to be tested to determine the hydrostatic design strength. These samples are to be tested at a frequency to the satisfaction of LR.

5.1.6  Where valves are required to be electrically conductive, representative samples of valve are to be tested to determine the electrical resistance. The test method and frequency of testing are to be acceptable to LR.

### 6.  List of standards

#### 6.1  General

6.1.1  A list of standards is held on file in LR to provide information for the design, manufacture, testing and marking of metallic valves. The use of such standards is not mandatory and alternatives may be utilised where they are applicable to the application for Type Approval. LR Rules, IMO and statutory requirements may also require to be taken into consideration so far as may be applicable.
Appendix 8

Air pipe closing devices

1. Introduction

1.1 General

1.1.1 This Appendix includes detailed information for the Type Approval of air pipe closing devices. Where air pipes are required by the Rules or Load Line Convention, 1966 to be fitted with automatic closing devices, they shall comply with the requirements of this appendix.

2. Definitions

2.1 General

2.1.1 Terminology used should be in accordance with a recognised Standard used in the field of design, manufacture, testing and marking of air pipe closing devices, with the Rules for Materials or other suitable recognised Standard. Other terminology could be used providing the meaning is clearly defined.

3. Details of required documentation

3.1 General

3.1.1 Request for LR Type Approval, including:
   a) The air pipe closing device manufacturer’s name and address.
   b) The trade name and reference numbers or designation specific to the air pipe closing device.
   c) Services and locations in which the air pipe closing device is intended to be used.
   d) Air pipe closing device drawing with dimensions.
   e) Diagram of differential pressure dependent on volume flow rate.
   f) Working temperature range.

3.1.2 Detailed product specification, including:
   a) Material manufacturer’s name and address and full trade name and reference number (where applicable).
   b) The dimensions and tolerances permitted of the finished products.
   c) Details of any alternative materials which may be used.
   d) Method of attachment, to pipe and formed pipe pieces.
   e) Installation requirements, instructions and recommendations.

3.1.3 Manufacturing specification, detailing:
   a) Manufacturing procedures.
   b) Quality control procedures, including details and frequency of tests on the incoming materials, tests made during production and on the finished formed air pipes closing device.
   c) Acceptance standards and tolerances, including all dimensions.
   d) Procedures for rectification of defects.
   e) System for traceability of the finished air pipes closing device to the batches of materials.
   f) Method of connecting the air pipes closing devices.

3.1.4 Drawings and supporting documentation:
   a) All relevant design drawings, catalogues, data sheets, calculations and functional descriptions.
   b) Fully detailed sectional assembly drawings, showing air pipe closing devices.

3.1.5 Proposed field of application and operational limitations, so far as may be applicable, including:
   a) Intended fluids.
   b) Maximum internal and external pressures.
   c) Limits on flow rates.
   d) Replacement instructions.

3.1.6 Quality control system arrangements to be sufficiently detailed in order to demonstrate that the quality of the finished product can be maintained in accordance with the required standards.
3.1.7 Proposed type test programme, sufficiently detailed in order to demonstrate that the performance provisions of the specified standards may be fulfilled for acceptance.

3.1.8 Certificates and reports for relevant tests previously obtained for the air pipe closing devices.

3.1.9 Relevant standards where necessary.

3.1.10 Details of marking. This is to include:
   a) Manufacturer’s name or trademark.
   b) Identification mark for the specification or grade of material.
   c) Air pipe closing device type number.
   d) Date of manufacture.
   e) Nominal size (DN).
   f) Nominal pressure (PN).
   g) Identification number and/or initials which will enable the full history of the item to be traced.

4. Design requirements

4.1 General

4.1.1 Air pipe automatic closing devices shall be so designed that they will withstand both ambient and working conditions, and be suitable for use at inclinations up to and including ± 40 degrees.

4.1.2 Air pipe automatic closing devices shall be constructed to allow inspection of the closure and the inside of the casing as well as changing the seals.

4.1.3 Efficient ball or float seating arrangements are to be provided for the closures. Bars, cage or other devices are to be provided to prevent the ball or float from contacting the inner chamber in its normal state and made in such a way that the ball or float is not damaged when subjected to water impact due to a tank being overfilled.

4.1.4 Air pipe automatic closing devices are to be self-draining.

4.1.5 The clear area through an air pipe closing device in the open position shall be at least equal to the area of the inlet.

4.1.6 An automatic closing device is to:
   a) Prevent the free entry of water into the tanks.
   b) Allow the passage of air or liquid to prevent excessive pressure or vacuum coming on the tank.

4.1.7 In the case of air pipe closing devices of the float type, suitable guides are to be provided to ensure unobstructed operation under all working conditions of heel and trim as specified in 4.1.1.

4.1.8 The maximum allowable tolerances for wall thickness of floats should not exceed ± 10 per cent of thickness.

4.1.9 The inner and the outer chambers of an automatic air pipe head are to be of a minimum thickness of 6 mm.

5. Test requirements

5.1 General

5.1.1 Each type and size of air pipe automatic closing device shall be surveyed and type tested at the manufacturer’s works or other acceptable location. The minimum test requirements for an air pipe automatic closing device shall include the following:
   (a) Determination of the flow characteristics. The flow characteristics of the air pipe closing device are to be determined. Measuring of the pressure drop versus rate of volume flow is to be carried out using water and with any intended flame or insect screens in place.
   (b) Tightness test during immersion/emerging in water. An automatic closing device is to be subjected to a series of tightness tests involving no fewer than two immersion cycles under each of the following conditions:
      (i) The automatic closing device is to be submerged slightly below the water surface at a velocity of approximately 4 m/minute and then returned to the original position immediately. The quantity of leakage shall be recorded.
(ii) The automatic closing device is to be submerged to a point slightly below the surface of the water. The submerging velocity is to be approximately 8 m/minute and the air pipe vent head is to remain submerged for no fewer than 5 minutes. The quantity of leakage shall be recorded.

(iii) Each of the above tightness tests shall be carried out in the normal position as well as at an inclination of 40 degrees under the strictest conditions for the device. In cases where such strictest conditions are not clear, tests shall be carried out at an inclination of 40 degrees with the device opening facing in three different directions: upward, downward, sideways (left or right). (See Figs A5.1 to A5.4).
(c) Discharge/reverse flow test

The air pipe head shall allow the passage of air to prevent excessive vacuum developing in the tank. A reverse flow test shall be performed. A vacuum pump or another suitable device shall be connected to the opening of the air pipe leading to the tank. The flow velocity shall be applied gradually at a constant rate until the float is sucked in and blocks the flow. The velocity at the point of blocking shall be recorded. 80 per cent of the value recorded will be stated in the certificate.

The maximum allowable leakage per cycle shall not exceed 2 ml/mm of nominal diameter of inlet pipe during any individual test.

5.1.2 Testing of non-metallic floats.

Impact and compression loading tests shall be carried out on the floats before and after pre-conditioning as follows:
### Table A5.1

<table>
<thead>
<tr>
<th>Test condition</th>
<th>Test temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>–25</td>
</tr>
<tr>
<td>Dry</td>
<td>+</td>
</tr>
<tr>
<td>After immersing in water</td>
<td>+</td>
</tr>
<tr>
<td>After immersing in fuel oil</td>
<td>–</td>
</tr>
<tr>
<td>Immersing in water and fuel oil</td>
<td></td>
</tr>
</tbody>
</table>

(a) Impact test. The test may be conducted on a pendulum type testing machine. The floats shall be subjected to 5 impacts of 2,5 Nm each and shall not suffer permanent deformation, cracking or surface deterioration at this impact loading. Subsequently, the floats shall be subjected to 5 impacts of 25 Nm each. At this impact energy level some localised surface damage at the impact point may occur. No permanent deformation or cracking of the floats shall appear.

(b) Compression loading test. Compression tests shall be conducted with the floats mounted on a supporting ring of a diameter and bearing area corresponding to those of the float seating with which it is intended that the float shall be used. For a ball type float, loads shall be applied through a concave cap of the same internal radius as the test float and bearing on an area of the same diameter as the seating. For a disc type float, loads are to be applied through a disc of equal diameter to the float.

A load of 350 kg shall be applied over one minute and maintained for 60 minutes. The deflection shall be measured at intervals of 10 minutes after attachment of the full load. The record of deflection against time is to show no continuing increase in deflection and, after release of the load, there shall be no permanent deflection.

5.1.3 Testing of metallic floats. Tests shall be conducted in accordance with 5.1.2(a). The tests shall be carried out at room temperature and in the dry condition.

### 6. Material approval and quality control during manufacture

#### 6.1 General

6.1.1 Air pipe closing devices are to be prototype tested to ensure that they meet the performance requirements of this Appendix.

6.1.2 Casings of air pipe closing devices are to be of approved metallic materials adequately protected against corrosion.

6.1.3 For galvanised steel air pipe heads, the zinc coating is to be applied by the hot method and the thickness is to be 70 to 100 microns.

6.1.4 For areas of the head susceptible to erosion (e.g., those parts directly subjected to ballast water impact when the tank is being pressed up, for example the inner chamber area above the air pipe, plus an overlap of 10º or more either side) an additional harder coating shall be applied. This is to be aluminium-bearing epoxy, or other equivalent, coating, applied over the zinc.

6.1.5 The manufacturer is to have a quality system that meets ISO 9001, ‘Quality systems – Model for quality assurance in design/development, production, installation and servicing’, or equivalent. The quality system is to consist of elements necessary to ensure that air pipe closing devices are produced with consistent and uniform mechanical and physical properties in accordance with the applicable standards. Control during manufacture is to be certified by the manufacturer to the satisfaction of the LR Type Approval Department.

6.1.6 Closures and seats made of non-metallic materials are to be compatible with the media intended to be carried in the tank and to sea-water and suitable for operating at ambient temperatures between –25°C and 85°C.

6.1.7 Dimension and tolerances for air pipe closing devices are to conform to the specified Standard.

6.1.8 Air pipes closing devices are to be permanently marked with identification in accordance with a recognised Standard.
7. List of standards

7.1 General

7.1.1 A list of standards is held on file in Lloyd’s Register to provide information for the design, manufacture, testing and marking of metallic formed pipe pieces. The use of such standards is not mandatory and alternatives may be utilised where they are applicable to the application for Type Approval. Lloyd’s Rules, IMO and statutory requirements may also require to be taken into consideration so far as may be applicable.