

# P4 Production and Application of Plastic Pipes on Ships\*

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## P4.1 Terms and Conditions

- .1 "Plastic(s)" means both thermoplastic and thermosetting plastic materials with or without reinforcement, such as PVC and fibre reinforced plastics - FRP.
- .2 "Pipes/piping systems" means those made of plastic(s) and include the pipes, fittings, system joints, method of joining and any internal or external liners, coverings and coatings required to comply with the performance criteria.
- .3 "Joint" means joining pipes by adhesive bonding, laminating, welding, etc.
- .4 "Fittings" means bends, elbows, fabricated branch pieces etc. of plastic materials.
- .5 "Nominal pressure" means the maximum permissible working pressure which should be determined in accordance with the requirements in P 4.3.1.
- .6 "Design pressure" means the maximum working pressure which is expected under operation conditions or the highest set pressure of any safety valve or pressure relief device on the system, if fitted.
- .7 "Fire endurance" means the capability of piping to maintain its strength and integrity (i.e. capable of performing its intended function) for some predetermined period of time while exposed to fire.

## P4.2 Scope

- .1 These requirements are applicable to plastic pipes/piping systems on ships.
- .2 The requirements are not applicable to flexible pipes and hoses and mechanical couplings used in metallic piping systems.
- .3 Piping systems made of thermoplastic materials, such as polyethylene(PE), polypropylene(PP), polybutylene(PB) and intended for non-essential services are to meet the requirements of recognized standards and P4.5 and P4.6 of this UR.

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\* This UR addresses the provisions of IMO Res. A.753(18).

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### Note:

1. Rev.3 introduced new section P4.7. The requirements of UR P4.7 are to be uniformly implemented by all IACS Societies to any new plastic pipe submitted for approval from 1 January 2007 and to any existing plastic pipe from the date of the first renewal of approval after 1 January 2007.
2. Changes introduced in Rev. 4 of this UR P4.5 are to be uniformly implemented by IACS Members and Associates from 1 January 2010.

**P4**  
(cont)**P4.3 General Requirements**

The specification of piping is to be in accordance with a recognised national or international standard acceptable to the Classification Society. In addition, the following requirements apply:

**4.3.1 Strength**

.1 The strength of the pipes is to be determined by a hydrostatic test failure pressure of a pipe specimen under the standard conditions: atmospheric pressure equal to 100 kPa, relative humidity 30%, environmental and carried fluid temperature 298 kPa (25°C).

.2 The strength of fittings and joints is to be not less than that of the pipes.

.3 The nominal pressure is to be determined from the following conditions:

**(i) Internal Pressure**

For an internal pressure the following is to be taken whichever is smaller:

$$P_n \text{ int} \leq P_{sth}/4 \text{ or } P_n \text{ int} \leq P_{lth}/2.5$$

where  $P_{sth}$  = short-term hydrostatic test failure pressure;

$P_{lth}$  = long-term hydrostatic test failure pressure ( > 100,000 h)

**(ii) External Pressure**

For an external pressure:

$$P_n \text{ ext} \leq P_{col}/3$$

where  $P_{col}$  - pipe collapse pressure.

.4 In no case is the collapse pressure to be less than 3 bar.

.5 The maximum working external pressure is a sum of the vacuum inside the pipe and a head of liquid acting on the outside of the pipe.

.6 The maximum permissible working pressure is to be specified with due regard for maximum possible working temperatures in accordance with Manufacturer's recommendations.

**4.3.2 Axial Strength**

.1 The sum of the longitudinal stresses due to pressure, weight and other loads is not to exceed the allowable stress in the longitudinal direction.

.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 condition (see P 4.3.1).

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## 4.3.3 Impact Resistance

.1 Plastic pipes and joints are to have a minimum resistance to impact in accordance with recognized national or international standards.

.2 After the test the specimen is to be subjected to hydrostatic pressure equal to 2.5 times the design pressure for at least 1 hour.

## 4.3.4 Temperature

.1 The permissible working temperature depending on the working pressure is to be in accordance with Manufacturer's recommendations, but in each case it is to be at least 20°C lower than the minimum heat distortion temperature of the pipe material, determined according to ISO 75 method A, or equivalent.

.2 The minimum heat distortion temperature is to be not less than 80°C.

**P4.4 Requirements for Pipes/Piping Systems Depending on Service and/or Locations**

## 4.4.1 Fire endurance

.1 Pipes and their associated fittings whose integrity is essential to the safety of ships are required to meet the minimum fire endurance requirements of Appendix 1 or 2, as applicable, of IMO Res A.753(18).

.2 Depending on the capability of a piping system to maintain its strength and integrity, there exist three different levels of fire endurance for piping systems.

- (i) Level 1. Piping having passed the fire endurance test specified in Appendix 1 of IMO Res. A.753(18) 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 (L1).
- (ii) Level 2. Piping having passed the fire endurance test specified in Appendix 1 of IMO Res. A.753(18) for a duration of a minimum of 30 minutes in the dry condition is considered to meet level 2 fire endurance standard (L2).
- (iii) Level 3. Piping having passed the fire endurance test specified in Appendix 2 of IMO Res. A.753 (18) for a duration of a minimum of 30 minutes in the wet condition is considered to meet level 3 fire endurance standard (L3).

.3 Permitted use of piping depending on fire endurance, location and piping system is given in Table 1 "Fire Endurance Requirement Matrix".

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Table 1 Fire Endurance Requirements Matrix

N	Piping Systems	Location										
		A	B	C	D	E	F	G	H	I	J	K
		Machinery spaces of category A	Other machinery spaces & pump rooms	Cargo pump rooms	Ro/Ro cargo holds	Other dry cargo holds	Cargo tanks	Fuel oil tanks	Ballast water tanks	Cofferdams void spaces pipe tunnel & ducts	Accommodation service & control spaces	Open decks
1	2	3	4	5	6	7	8	9	10	11	12	13

## CARGO (FLAMMABLE CARGOES f.p.≤60°C)

1.	Cargo lines	NA	NA	L1	NA	NA	O	NA	O <sup>10</sup>	O	NA	L1 <sup>2</sup>
2.	Crude Oil washing lines	NA	NA	L1	NA	NA	O	NA	O <sup>10</sup>	O	NA	L1 <sup>2</sup>
3.	Vent lines	NA	NA	NA	NA	NA	O	NA	O <sup>10</sup>	O	NA	X

## INERT GAS

4.	Water seal effluent line	NA	NA	O <sup>1</sup>	NA	NA	O <sup>1</sup>	O <sup>1</sup>	O <sup>1</sup>	O <sup>1</sup>	NA	O
5.	Scrubber effluent line	O <sup>1</sup>	O <sup>1</sup>	NA	NA	NA	NA	NA	O <sup>1</sup>	O <sup>1</sup>	NA	O
6.	Main Line	O	O	L1	NA	NA	NA	NA	NA	O	NA	L1 <sup>6</sup>
7.	Distribution lines	NA	NA	L1	NA	NA	O	NA	NA	O	NA	L1 <sup>2</sup>

FLAMMABLE LIQUIDS  
(f.p. > 60°C)

8.	Cargo lines	X	X	L1	X	X	NA <sup>3</sup>	O	O <sup>10</sup>	O	NA	L1
9.	Fuel oil	X	X	L1	X	X	NA <sup>3</sup>	O	O	O	L1	L1
10.	Lubricating	X	X	L1	X	X	NA	NA	NA	O	L1	L1
11.	Hydraulic oil	X	X	L1	X	X	O	O	O	O	L1	L1

SEAWATER<sup>1</sup>

12.	Bilge main & branches	L1 <sup>7</sup>	L1 <sup>7</sup>	L1	X	X	NA	O	O	O	NA	L1
13.	Fire main & water spray	L1	L1	L1	X	NA	NA	NA	O	O	X	L1
14.	Foam system	L1	L1	L1	NA	NA	NA	NA	NA	O	L1	L1
15.	Sprinkler system	L1	L1	L3	X	NA	NA	NA	O	O	L3	L3
16.	Ballast	L3	L3	L3	L3	X	O <sup>10</sup>	O	O	O	L2	L2
17.	Cooling water, essential services	L3	L3	NA	NA	NA	NA	NA	O	O	NA	L2
18.	Tank cleaning services fixed machines	NA	NA	L3	NA	NA	O	NA	O	O	NA	L3 <sup>2</sup>
19.	Non-essential systems	O	O	O	O	O	NA	O	O	O	O	O

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FRESHWATER												
20.	Cooling water essential services	L3	L3	NA	NA	NA	NA	O	O	O	L3	L3
21.	Condensate return	L3	L3	L3	O	O	NA	NA	NA	O	O	O
22.	Non-essential systems	O	O	O	O	O	NA	O	O	O	O	O
SANITARY/ DRAINS/ SCUPPERS												
23.	Deck drains (internal)	L1 <sup>4</sup>	L1 <sup>4</sup>	NA	L1 <sup>4</sup>	O	NA	O	O	O	O	O
24.	Sanitary drains (internal)	O	O	NA	O	O	NA	O	O	O	O	O
25.	Scuppers and discharges (overboard)	O <sup>1.8</sup>	O <sup>1.8</sup>	O <sup>1.8</sup>	O <sup>1.8</sup>	O <sup>1.8</sup>	O	O	O	O	O <sup>1.8</sup>	O
SOUNDING/AIR												
26.	Water tanks/ dry spaces	O	O	O	O	O	O <sup>10</sup>	O	O	O	O	O
27.	Oil Tanks (fp. > 60°C)	X	X	X	X	X	X <sup>3</sup>	O	O <sup>10</sup>	O	X	X
MISCELLANEOUS												
28.	Control air	L1 <sup>5</sup>	L1 <sup>5</sup>	L1 <sup>5</sup>	L1 <sup>5</sup>	L1 <sup>5</sup>	NA	O	O	O	L1 <sup>5</sup>	L1 <sup>5</sup>
29.	Service air (non essential)	O	O	O	O	O	NA	O	O	O	O	O
30.	Brine	O	O	NA	O	O	NA	NA	NA	O	O	O
31.	Auxillary low pressure steam (≤ 7 bar)	L2	L2	O <sup>9</sup>	O <sup>9</sup>	O <sup>9</sup>	O	O	O	O	O <sup>9</sup>	O <sup>9</sup>

**ABBREVIATIONS:**

- L1 Fire endurance test (appendix 1) in dry conditions, 60 min
- L2 Fire endurance test (appendix 1) in dry conditions, 30 min
- L3 Fire endurance test (appendix 2) in wet conditions, 30 min
- O No fire endurance test required
- NA Not applicable
- X Metallic materials having a melting point greater than 925°C

**FOOTNOTES:**

- Where non-metallic piping is used, remotely controlled valves to be provided at ship's side (valve is to be controlled from outside space).
- Remote closing valves to be provided at the cargo tanks.
- When cargo tanks contain flammable tanks with f.p. > 60°C, "O" may replace "NA" or "X".
- For drains serving only the space concerned, "O" may replace "L1".

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5. When controlling functions are not required by statutory requirements or guidelines, "O" may replace "L1".
6. For pipe between machinery space and deck water seal, "O" may replace "L1".
7. For passenger vessels, "X" is to replace "L1".
8. Scuppers serving open decks in positions 1 and 2, as defined in regulation 13 of the International Convention on Load Lines, 1966, should be "X" throughout unless fitted at the upper end with the means of closing capable of being operated from a position above the freeboard deck in order to prevent downflooding.
9. For essential services, such as fuel oil tank heating and ships whistle, "X" is to replace "O".
10. For tankers where compliance with paragraph 3 (f) of regulation 13F of Annex I of MARPOL 73/78 is required, "NA" is to replace "O".

### LOCATION DEFINITIONS:

Location	Definition
A - Machinery spaces of category A	Machinery spaces of category A as defined in SOLAS* regulation II-2/3.19.
B - Other machinery spaces and pump rooms	Spaces, other than category A machinery spaces and cargo pump rooms, containing propulsion machinery, boilers, steam and internal combustion engines, generators and major electrical machinery, pumps, oil filling stations, refrigerating, stabilising, ventilation and air-conditioning machinery, and similar spaces and trunks to such spaces.
C - Cargo pump rooms	Spaces containing cargo pumps and entrances and trunks to such spaces.
D - Ro-ro cargo holds	Ro-ro cargo holds are ro-ro cargo spaces and special category spaces and special category spaces as defined in SOLAS* regulation II-2/3.14 and 3.18.
E - Other dry cargo holds	All spaces other than ro-ro cargo holds used for non- liquid cargo and trunks to such spaces.
F - Cargo tanks	All spaces used for liquid cargo and trunks to such spaces.
G - Fuel oil tanks	All spaces used for fuel oil (excluding cargo tanks) and trunks to such spaces.
H - Ballast water tanks	All spaces used for ballast water and trunks to such spaces.
I - Cofferdams, voids, etc.	Cofferdams and voids are those empty spaces between two bulkheads separating two adjacent compartments.

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J - Accommodation, service	Accommodation spaces, service spaces and control stations as defined in SOLAS* regulation II-2/3.10, 3.12, 3.22.
K - Open decks	Open deck spaces as defined in SOLAS* regulation II-2/26.2.2. (5).

\* SOLAS 74 as amended by the 1978 SOLAS Protocol and the 1981 and 1983 amendments (consolidated text).

### 4.4.2 Flame Spread

.1 All pipes, except those fitted on open decks and within tanks, cofferdams, pipe tunnels, and ducts are to have low surface flame spread characteristics not exceeding average values listed in IMO Resolution A.653(16).

.2 Surface flame spread characteristics are to be determined using the procedure given in IMO Resolution A.653(16) with regard to the modifications due to the curvilinear pipe surfaces as listed in Appendix 3 of IMO Resolution A.753(18).

.3 Surface flame spread characteristics may also be determined using the text procedures given in ASTM D635, or in other national equivalent standards.

### 4.4.3 Fire Protection Coatings

.1 Where a fire protective coating of pipes and fittings is necessary for achieving the fire endurance level required, it is to meet the following requirements:

- (i) The pipes are generally to be delivered from the manufacturer with the protective coating on.
- (ii) The fire protection properties of the coating are not to be diminished when exposed to salt water, oil or bilge slops. It is to be demonstrated that the coating is resistant to products likely to come into contact with the piping.
- (iii) In considering fire protection coatings, such characteristics as thermal expansion, resistance against vibrations, and elasticity are to be taken into account.
- (iv) The fire protection coatings are to have sufficient resistance to impact to retain their integrity.

### 4.4.4 Electrical Conductivity

Where electrical conductivity is to be ensured, the resistance of the pipes and fittings is not to exceed  $1 \times 10^5$  Ohm/m.

## P4.5 Material approval and Quality Control During Manufacture

.1 Prototypes of pipes and fittings are to be tested to determine short-term and long-term design strength, fire endurance and low surface flame spread characteristics (if applicable), electrical resistance (for electrically conductive pipes), impact resistance in accordance with this UR.

.2 For prototype testing representative samples of pipes and fittings are to be selected to the satisfaction of the Classification Society.

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.3 The Manufacturer is to have quality system that meets ISO 9000 series standards or equivalent. The quality system is to consist of elements necessary to ensure that pipes and fittings are produced with consistent and uniform mechanical and physical properties.

.4 Each pipe and fitting is to be tested by the Manufacturer at a hydrostatic pressure not less than 1.5 times the nominal pressure. Alternatively, for pipes and fittings not employing hand lay up techniques, the hydrostatic pressure test may be carried out in accordance with the hydrostatic testing requirements stipulated in the recognised national or international standard to which the pipe or fittings are manufactured, provided that there is an effective quality system in place.

.5 Piping and fittings are to be permanently marked with identification. Identification is to include pressure ratings, the design standards that the pipe or fitting is manufactured in accordance with, and the material of which the pipe or fitting is made.

.6 In case the Manufacturer does not have an approved quality system complying with ISO 9000 series or equivalent, pipes and fittings are to be tested in accordance with this UR to the satisfaction of the Classification Society's surveyors for every batch of pipes.

.7 Depending upon the intended application a Society may require the pressure testing of each pipe and/or fitting.

**P4.6 Installation****4.6.1 Supports**

.1 Selection and spacing of pipe supports in shipboard systems are to be determined as a function of allowable stresses and maximum deflection criteria. Support spacing is not to be greater than the pipe Manufacturer's recommended spacing. The selection and spacing of pipe supports are to take into account pipe dimensions, mechanical and physical properties of the pipe material, mass of pipe and contained fluid, external pressure, operating temperature, thermal expansion effects, loads due to external forces, thrust forces, water hammer, vibrations, maximum accelerations to which the system may be subjected. Combination of loads is to be considered.

.2 Each support is to evenly distribute the load of the pipe and its contents over the full width of the support. Measures are to be taken to minimize wear of the pipes where they contact the supports.

.3 Heavy components in the piping system such as valves and expansion joints are to be independently supported.

**4.6.2 Expansion**

.1 Suitable provision is to be made in each pipeline to allow for relative movement between pipes made of plastic and the steel structure, having due regard to:

- (i) the difference in the coefficients of thermal expansion;
- (ii) deformations of the ship's hull and its structure.

2. When calculating the thermal expansions, account is to be taken of the system working temperature and the temperature at which assembly is performed.

**4.6.3 External Loads**



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.1 When installing the piping, allowance is to be made for temporary point loads, where applicable. Such allowances are to include at least the force exerted by a load (person) of 100 kg at mid-span on any pipe of more than 100 mm nominal outside diameter.

.2 Besides for providing adequate robustness for all piping including open-ended piping a minimum wall thickness, complying with 4.3.1, may be increased upon the demand of the Classification society taking into account the conditions encountered during service on board ships.

.3 Pipes are to be protected from mechanical damage where necessary.

#### 4.6.4 Strength of Connections

.1 The strength of connections is to be not less than that of the piping system in which they are installed.

.2 Pipes may be assembled using adhesive-bonded, welded, flanged or other joints.

.3 Adhesives, when used for joint assembly, are to be suitable for providing a permanent seal between the pipes and fittings throughout the temperature and pressure range of the intended application.

.4 Tightening of joints is to be performed in accordance with Manufacturer's instructions.

#### 4.6.5 Installation of Conductive Pipes

.1 In piping systems for fluids with conductivity less than 1000 pico siemens per metre (pS/m) such as refined products and distillates use is to be made of conductive pipes.

.2 Regardless of the fluid being conveyed, plastic piping is to be electrically conductive if the piping passes through a hazardous area. The resistance to earth from any point in the piping system is not to exceed  $1 \times 10^6$  Ohm. It is preferred that pipes and fittings be homogeneously conductive. Pipes and fittings having conductive layers are to be protected against a possibility of spark damage to the pipe wall. Satisfactory earthing is to be provided.

.3 After completion of the installation, the resistance to earth is to be verified. Earthing wires are to be accessible for inspection.

#### 4.6.6 Application of Fire Protection Coatings

.1 Fire protection coatings are to be applied on the joints, where necessary for meeting the required fire endurance as for 4.4.3, after performing hydrostatic pressure tests of the piping system.

.2 The fire protection coatings are to be applied in accordance with Manufacturer's recommendations, using a procedure approved in each particular case.

#### 4.6.7 Penetration of Divisions

.1 Where plastic pipes pass through "A" or "B" class divisions, arrangements are to be made to ensure that the fire endurance is not impaired. These arrangements are to be tested in accordance with Recommendations for fire test procedures for "A", "B" and "F" bulkheads (Resolution A.754(18) as amended).

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.2 When plastic pipes pass through watertight bulkheads or decks, the watertight integrity of the bulkhead or deck is to be maintained.

.3 If the bulkhead or deck is also a fire division and destruction by fire of plastic pipes may cause the inflow of liquid from tanks, a metallic shut-off valve operable from above the freeboard deck should be fitted at the bulkhead or deck.

#### 4.6.8 Control During Installation

.1 Installation is to be in accordance with the Manufacturer's guidelines.

2. Prior to commencing the work, joining techniques are to be approved by the Classification Society.

3. The tests and explanations specified in this UR are to be completed before shipboard piping installation commences.

4. The personnel performing this work are to be properly qualified and certified to the satisfaction of the Classification Society.

5. The procedure of making bonds is to include:

- (i) materials used,
- (ii) tools and fixtures,
- (iii) joint preparation requirements,
- (iv) cure temperature,
- (v) dimensional requirements and tolerances, and
- (vi) tests acceptance criteria upon completion of the assembly.

.6 Any change in the bonding procedure which will affect the physical and mechanical properties of the joint is to require the procedure to be requalified.

#### 4.6.9 Bonding Procedure Quality Testing

.1 A test assembly is to be fabricated in accordance with the procedure to be qualified and it is to consist of at least one pipe-to-pipe joint and one pipe-to-fitting joint.

.2 When the test assembly has been cured, it is to be subjected to a hydrostatic test pressure at a safety factor 2.5 times the design pressure of the test assembly, for not less than one hour. No leakage or separation of joints is allowed. The test is to be conducted so that the joint is loaded in both longitudinal and circumferential directions.

.3 Selection of the pipes used for test assembly, is to be in accordance with the following:

- (i) When the largest size to be joined is 200 mm nominal outside diameter, or smaller, the test assembly is to be the largest piping size to be joined.
- (ii) When the largest size to be joined is greater than 200 mm nominal outside diameter, the size of the test assembly is to be either 200 mm or 25% of the largest piping size to be joined, whichever is greater.

.4 When conducting performance qualifications, each bonder and each bonding operator are to make up test assemblies, the size and number of which are to be as required above.

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## 4.6.10 Testing After Installation on Board

- .1 Piping systems for essential services are to be subjected to a test pressure not less than 1.5 times the design pressure or 4 bar whichever is greater.
- .2 Piping systems for non-essential services are to be checked for leakage under operational conditions.
- .3 For piping required to be electrically conductive, earthing is to be checked, and random resistance testing is to be conducted.

**P4.7 Test Specification For Plastic Pipes**

## 4.7.1 Scope

Section P4.7 contains requirements for the Type Approval of plastic pipes. It is applicable to rigid pipes, pipe joints and fittings.

## 4.7.2 Documentation

The following information for the plastic pipes, fittings and joints is to be submitted for consideration and approval:

- I. General Information
  1. Pipe and fitting dimensions
  2. Maximum internal and external working pressure
  3. Working temperature range
  4. Intended services and installation locations
  5. The level of fire endurance
  6. Electrically conductive
  7. Intended fluids
  8. Limits on flow rates
  9. Serviceable life
  10. Installation instructions
  11. Details of marking
- II. Drawings and supporting documentation:
  1. Certificates and reports for relevant tests previously carried out.
  2. Details of relevant standards.
  3. All relevant design drawings, catalogues, data sheets, calculations and functional descriptions.
  4. Fully detailed sectional assembly drawings showing pipe, fittings and pipe connections.
- III. Materials
  1. The resin type.
  2. Catalyst and accelerator types, and concentration employed in the case of reinforced polyester resin pipes or hardeners where epoxide resins are employed.
  3. A statement of all reinforcements employed 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.

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4. Full information regarding the type of gel-coat or thermoplastic liner employed during construction, as appropriate.
5. Cure/post-cure conditions. The cure and post cure temperatures and times employ resin/reinforcement ratio.
6. Winding angle and orientation.

#### 4.7.3 Testing

Testing is to demonstrate compliance of the pipes, fittings and joints for which Type Approval is sought with Unified Requirement P4.

Pipes, joints and fittings are to be tested for compliance with the requirements of standards\* acceptable to classification society.

\* For the lists of standards refer to IACS Recommendation 86.

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