Polski Rejestr Statków

RULES

PUBLICATION NO. 53/P

PLASTIC PIPELINES ON SHIPS

2019
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Publications P (Additional Rule Requirements) issued by Polski Rejestr Statków
complete or extend the Rules and are mandatory where applicable.

GDAŃSK

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The present Publication replaces Publication No. 53/P – Plastic Pipelines on Ships – July 2016.

PRS/OP, 12/2018

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1 APPLICATION AND CONTENT

1.1 The requirements of the present *Publication* are applicable to plastic pipelines, intended to be installed on ships in systems subjected to PRS survey.

1.2 Application of requirements of the present *Publication* results from PRS Rules in which it is called.

1.3 The *Publication* contains material and construction, installation and tests and supervision requirements.

1.4 The requirements specified in this *Publication* are applicable to piping systems made predominantly of other material than metal. The use of mechanical and flexible couplings which are accepted for use in metallic piping systems is not addressed.

2 DEFINITIONS

Design pressure – the maximum working pressure which is expected under operation conditions or the highest set pressure of any safety valve or another pressure relief device on the system, if fitted.

Fire endurance – the capability of pipeline to maintain its strength and integrity in unharmed condition (i.e. capable of performing its intended function) for some predetermined period of time while exposed to fire.

Fittings – bends, elbows, fabricated branch pieces etc. of plastic materials.

Joint – joining pipes by adhesive bonding, laminating, welding, etc.

Nominal pressure – the maximum permissible working pressure, determined in accordance with the requirements given in 3.1.

Pipelines/piping systems – the pipes, fittings, piping system joints, method of joining and any internal or external liners, coverings and coatings required to comply with the performance criteria. For example, if a fire protective coating of pipes is necessary for achieving the required fire endurance of pipeline, then the pipeline is to be fire tested with a fire protective coating.

Plastic – both thermoplastic and thermosetting plastic materials with or without reinforcement, such as polyvinyl chloride (PVC) and fiber reinforced plastics (FRP). Plastic also includes synthetic rubber and materials of similar thermal and mechanical properties.

3 GENERAL

The specification of piping is to be in accordance with a recognized national or international standard acceptable to the PRS. Additional requirements are given below.

3.1 Strength

3.1.1 The strength of the pipes is to be determined by a hydraulic test failure pressure of a pipe test specimen under the standard conditions, i.e. atmospheric pressure equal to 0.1 MPa, relative humidity 30 ± 5%, environmental and carried fluid temperature 25 ± 3°C.

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

3.1.3 The nominal pressure is to be determined as follows:

.1 The nominal internal pressure $P_{n\,int}$ is to be determined basing on the conditions:

$$P_{n\,int} \le P_{sth}/4 \qquad (3.1.3.1\text{-}1)$$

and

$$P_{n\,int} \le P_{lth}/2.5 \qquad (3.1.3.1\text{-}2)$$

taking the smaller value,
where:

P_{sth} – short-term hydraulic test failure pressure;
P_{lth} – long-term hydraulic test failure pressure (test duration – above 100000 hours).

.2 The nominal external pressure $P_{n\,ext}$ is to be determined basing on the condition:

$$P_{n\,ext} \le P_{col}/3 \qquad (3.1.3.2)$$

where:
P_{col} – pipe collapse pressure (i.e. collapse pressure).

The collapse pressures are to be determined by experimental method, and in case of long-term hydraulic test, in order to while away the time of its duration, it is possible to use combination of experimental and calculation method (e.g. according to ASTM D2837 or ASTM D1598 standard).

3.1.4 In no case is the collapse pressure to be less than 0.3 MPa.

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

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

3.2 Axial Strength

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

3.2.2 In the case of fiber reinforced plastic pipelines, the sum of the longitudinal stresses is not to exceed half of the nominal circumferential stress derived from the nominal internal pressure condition (see 3.1.3.1).

3.3 Impact Resistance

3.3.1 Plastic pipes and joints are to have a minimum resistance to impact not less than specified in recognized national or international standards.

3.3.2 After the impact resistance test the specimen is to be subjected to hydraulic test with pressure equal to 2.5 times the design pressure for at least 1 hour.

3.4 Working and Distortion Temperature

3.4.1 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 distortion temperature of the pipe material, determined according to PN-EN ISO 75-2 standard – method A, or equivalent.

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

4 REQUIREMENTS FOLLOWING THE PURPOSE AND LOCATION OF PIPELINES

4.1 Fire Endurance

4.1.1 The minimum fire endurance of pipes and their associated fittings whose integrity is essential to the safety of ship, is to meet the relevant requirements given in 7.1 or 7.2.

4.1.2 Depending on the capability of a piping system to maintain its strength and integrity in unharmed condition, there exist three different levels of fire endurance:

– **L1** – The highest fire endurance level ensuring the integrity of the piping system during a full scale hydrocarbon fire, required for systems essential to safety of the ship, and particularly applicable to systems where loss of integrity may cause outflow of flammable liquids and worsen the fire situation. Pipelines having passed the fire endurance test method in the dry conditions, specified in subchapter

7.1, for a duration of a minimum of 60 minutes without loss of integrity are considered to meet level L1 fire endurance standards.

- **L1W** – Piping systems similar to **L1** systems which carry flammable fluid or any gas, except those systems where maximum 5% flow loss in the system is acceptable after exposure to fire.
- **L2** – The intermediate fire endurance level, required for piping systems essential to safety of the ship which are to survive a fire of short duration and allowing the system to be restored after the fire has been extinguished. Pipelines having passed the fire endurance test method in the dry conditions, specified in subchapter 7.1, for a duration of a minimum of 30 minutes are considered to meet level L2 fire endurance standards.
- **L2W** – Piping systems similar to **L2** systems except those where a maximum 5% flow loss in the system is acceptable after exposure to fire.
- **L3** – The lowest fire endurance level, required for piping systems essential to safety of the ship and normally filled with water, which are to survive a local fire of short duration and allowing the system to be restored after the fire has been extinguished. Pipelines having passed the fire endurance test method in the wet conditions, specified in subchapter 7.2, for a duration of a minimum of 30 minutes are considered to meet level L3 fire endurance standards.

4.1.3 Permitted use of plastic pipelines depending on its fire endurance, location and purpose is given in Table 4.1.3. Requirements given in Table concerning pipelines fire endurance are to be considered as a minimum, i.e. pipelines having higher fire endurance level can be always used instead of pipelines having lower fire endurance level.

EXPLANATIONS TO TABLE 4.1.3

Abbreviations

L1 – Fire endurance test in dry conditions for a duration of a minimum of 60 minutes is required (see subchapter 7.1)

L2 – Fire endurance test in dry conditions for a duration of a minimum of 30 minutes is required (see subchapter 7.1)

L3 – Fire endurance test in wet conditions for a duration of a minimum of 30 minutes is required (see subchapter 7.2)

0 – No fire endurance test required

X – Only metallic materials having a melting point greater than 940°C are to be used

NA – Not applicable

Explanations of location

Location	Explanation
A – Machinery spaces of category A	Machinery spaces of category A as defined in subchapter 1.2 of *Part VI – Machinery Installations and Refrigerating Plants* of the *Rules for the Classification and Construction of Sea-going Ships.*
B – Other machinery spaces and ~~pump~~ rooms	Spaces, other than category A machinery spaces and pump rooms other than cargo pump rooms.
C – Cargo pump rooms	Spaces containing cargo pumps and entrances and trunks to such spaces.
D – Ro-ro cargo holds	Ro-ro cargo spaces and special category spaces as defined in subchapter 1.2 of *Part V – Fire Protection* of the *Rules for the Classification and Construction of Sea-going Ships.*
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, void spaces, etc.	Void spaces between two bulkheads separating two adjacent compartments.
J – Accommodation and service spaces, control stations	Accommodation and service spaces and control stations as defined in subchapter 1.2 of *Part V – Fire Protection* of the *Rules for the Classification and Construction of Sea-going Ships.*
K – Open decks	Open deck spaces as defined in 6.1.4.2(5) of *Part V – Fire Protection* of the *Rules for the Classification and Construction of Sea-going Ships.*

Table 4.1.3
Pipelines fire endurance requirements depending on its purpose and location

PIPELINES PURPOSE	LOCATION										
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
1	2	3	4	5	6	7	8	9	10	11	12
FLAMMABLE CARGOES f.p. ≤ 60°C											
1. Cargo system	NA	NA	L1	NA	NA	0	NA	0[10)]	0	NA	L1[2)]
2. Crude oil washing system	NA	NA	L1	NA	NA	0	NA	0[10)]	0	NA	L1[2)]
3. Venting system	NA	NA	NA	NA	NA	0	NA	0[10)]	0	NA	X
INERT GAS SYSTEM											
4. Water seal effluent pipeline	NA	NA	0[1)]	NA	NA	0[1)]	0[1)]	0[1)]	0[1)]	NA	0
5. Scrubber effluent pipeline	0[1)]	0[1)]	NA	NA	NA	NA	NA	0[1)]	0[1)]	NA	0
6. Main pipeline	0	0	L1	NA	NA	NA	NA	NA	0	NA	L1[6)]
7. Distribution pipelines	NA	NA	L1	NA	NA	0	NA	NA	0	NA	L1[2)]
FLAMMABLE LIQUIDS f.p. > 60°C											
8. Cargo system	X	X	L1	X	X	NA[3)]	0	0[10)]	0	NA	L1
9. Fuel oil system	X	X	L1	X	X	NA[3)]	0	0	0	L1	L1
10. Lubricating oil system	X	X	L1	X	X	NA	NA	NA	0	L1	L1
11. Hydraulic oil system	X	X	L1	X	X	0	0	0	0	L1	L1

1	2	3	4	5	6	7	8	9	10	11	12
SEAWATER[1]											
12. Bilge system	L1[7]	L1[7]	L1	X	X	NA	0	0	0	NA	L1
13. Water fire main and water-spraying system	L1	L1	L1	X	NA	NA	NA	0	0	X	L1
14. Foam fire-extinguishing system	L1W	L1W	L1W	NA	NA	NA	NA	NA	0	L1W	L1W
15. Sprinkler system	L1W	L1W	L3	X	NA	NA	NA	0	0	L3	L3
16. Ballast system	L3	L3	L3	L3	X	0[10]	0	0	0	L2W	L2W
17. Cooling water system and other systems essential to safety of the ship	L3	L3	NA	NA	NA	NA	NA	0	0	NA	L2W
18. Fixed tank water cleaning system	NA	NA	L3	NA	NA	0	NA	0	0	NA	L3[2]
19. Systems non-essential to safety of the ship	0	0	0	0	0	NA	0	0	0	0	0
FRESHWATER											
20. Cooling water system and other systems essential to safety of the ship	L3	L3	NA	NA	NA	NA	0	0	0	L3	L3
21. Condensate system	L3	L3	L3	0	0	NA	NA	NA	0	0	0
22. Systems non-essential to safety of the ship	0	0	0	0	0	NA	0	0	0	0	0
SANITARY SYSTEM, SCUPPERS, DRAIN PIPES FROM DECKS AND SPACES											
23. Drain pipes from decks and spaces (internal)	L1W[4]	L1W[4]	NA	L1W[4]	0	NA	0	0	0	0	0
24. Sanitary pipelines (internal)	0	0	NA	0	0	NA	0	0	0	0	0
25. Scuppers and other overboard dischargers	0[1) 8)]	0[1) 8)]	0[1) 8)]	0[1); 8)]	0[1); 8)]	0	0	0	0	0[1); 8)]	0
AIR AND SOUNDING PIPES											
26. Water tanks, dry spaces	0	0	0	0	0	0[10]	0	0	0	0	0
27. Oil tanks f.p. > 60 °C	X	X	X	X	X	X[3]	0	0[10]	0	X	X
MISCELLANEOUS											
28. Control air system	L1[5]	L1[5]	L1[5]	L1[5]	L1[5]	NA	0	0	0	L1[5]	L1[5]
29. Air systems non-essential to safety of the ship	0	0	0	0	0	NA	0	0	0	0	0
30. Brine system	0	0	NA	0	0	NA	NA	NA	0	0	0
31. Auxiliary low pressure steam system (≤ 0.7 MPa)	L2W	L2W	0[9]	0[9]	0[9]	0	0	0	0	0[9]	0[9]
32. Central vacuum cleaners	NA	NA	NA	0	NA	NA	NA	NA	0	0	0

1) Where non-metallic piping is used, remotely controlled valves to be provided at ship's side. Valve is to be controlled from outside space.

2) Remote closing valves to be provided at the cargo tanks.

3) When cargo tanks are intended for carrying flammable liquids with f.p. above 60 °C, "0" may replace "NA" or "X".

4) For drain pipelines serving only the space concerned, "0" may replace "L1W".

5) When controlling functions are not required by rules, "0" may replace "L1".

6) For pipe between machinery space and deck water seal, "0" may replace "L1".

7) For passenger vessels, "X" is to replace "L1".

8) Scuppers serving open decks in positions 1 and 2 (see 7.1.4 of *Part III – Hull Equipment* of the *Rules for the Classification and Construction of Sea-going Ships*) 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 ship's whistle, "X" is to replace "0".

10) For tankers having protective compartments (see subchapter 21.2.2 of *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships*), "NA" is to replace "0".

4.2 Flame Spread

4.2.1 All pipes, except those fitted on open decks and within tanks, cofferdams, void spaces, pipeline tunnels and ducts, if separated from accommodation, permanent manned areas and escape ways by means of an A class bulkhead, are to have low surface flame spread characteristics not exceeding average values concerning bulkheads, ceilings and decks finish materials, listed in appendix 3 of the RESOLUTION A.753(18) with amendments.

4.2.2 Flame spread characteristics are to be determined according to procedure given in Chapter 8.

4.3 Fire Protection Coatings

4.3.1 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:

– the pipes and fittings are to be delivered from the manufacturer with the adequate protective coating on,
– the fire protection properties of the coating are not to be diminished when exposed to sea water, oil or bilge slops; it is to be demonstrated that the coating is resistant to products likely to come into contact in service,
– in considering fire protection coatings, such characteristics as thermal expansion, resistance against vibrations, and elasticity are to be taken into account,
– the fire protection coatings are to have sufficient resistance impact.

4.4 Electrical Conductivity

4.4.1 Where electrical conductivity is to be ensured, the resistance of the pipes and fittings is not to exceed 100 kΩ/m.

5 PRODUCTS APPROVAL AND QUALITY CONTROL DURING MANUFACTURE

5.1 Prototype of each pipe and fitting is to be tested to determine short-term and long-term design strength, fire endurance and low surface flame spread characteristics, electrical resistance (for electrically conductive pipes) and impact resistance in accordance with requirements of the present *Publication*.

5.2 Specimens for prototype testing shall be representative for pipes and fittings subjected to approval. Specimens are to be selected to the satisfaction of the PRS.

5.3 Manufacturing of pipes and fittings is to be based on certified quality management system complying with ISO 9000 series standards or equivalent. The quality system is to ensure that products are manufactured with consistent and uniform mechanical and physical properties. In case the Manufacturer does not have a certified quality management system then, to the satisfaction of PRS, from every produced batch of pipes and fittings the specimens are to be taken and tested in order to determine and check of the characteristics mentioned in 5.1.

Alternatively, for pipes and fittings not employing hand lay up techniques, the hydrostatic pressure test may be performed in accordance with the hydrostatic testing requirements specified 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.

5.4 Each length of pipe and each fitting produced is to be subjected to hydraulic test by the Manufacturer with pressure not less than 1.5 times the nominal pressure.

5.5 Pipes 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.

5.6 Type-approval Procedure for Plastic Pipes

5.6.1 Documentation

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

.1 General information:
- pipe and fitting dimensions,
- maximum internal and external working pressure,
- working temperature range,
- intended services and installation locations,
- fire endurance level,
- electrical conductivity,
- intended fluids,
- limits of flow rates,
- serviceable life,
- installation instructions,
- details of marking;

.2 Drawings and supporting documentation:
- certificates and reports for relevant tests previously carried out,
- details of relevant standards,
- all relevant design drawings, catalogues, data sheets, calculations and functional descriptions,
- fully detailed sectional assembly drawings showing pipe, fittings and pipe connections;

.3 Materials:
- resin type,
- catalyst and accelerator types, and concentration employed in the case of reinforced polyester resin pipes,
- hardener type and concentration employed where epoxide resins are applied,
- 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,
- full information regarding the type of gel-coat or thermoplastic liner employed during construction, as appropriate,
- cure/post-cure conditions. The cure and post-cure temperatures and times employed as well as resin/reinforcement ratio,
- winding and reinforcement orientation.

5.6.2 Testing

Testing is to demonstrate compliance of the pipes, fittings and joints for which the *Type Approval Certificate* is necessary with the requirements specified in this *Publication*.

Pipes, joints and fittings are to be tested for compliance with the requirements specified in this *Publication* as well as in the relevant standards acceptable to PRS. For the list of standards refer to Chapter 9 of this *Publication*.

5.7 Depending upon the intended application PRS may require the pressure testing of each pipe and/or fitting.

6 ASSEMBLING OF PIPELINES

6.1 Supports

6.1.1 Selection and spacing of pipe supports 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, length of the piping, 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 piping system may be subjected. Combination of above mentioned loads is to be considered.

6.1.2 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.

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

6.2 Compensation of Deformations

6.2.1 Suitable provision are to be made in each pipeline to allow for relative movement between pipes and the steel structure, having due regard to the different coefficients of thermal expansion and deformations of the ship's hull and its structure.

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

6.3 External Loads

6.3.1 When assembling the pipelines, 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.

6.3.2 Taking into account operation conditions of piping system on the ship, with reference to each pipeline together with open-ended pipes, PRS may demand to extend wall thickness above than specified in 3.1.

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

6.4 Strength of Connections

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

6.4.2 Pipes may be assembled using adhesive-bonding, welding, flanged or other joints.

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

6.4.4 Assembling of joints is to be performed in accordance with Manufacturer's instructions.

6.5 Assembling of Conductive Pipes

6.5.1 Piping systems for fluids with conductivity less than 1 nS/m such as refined products and crude oil distillates are to be made of conductive pipes. Regardless of the fluid being conveyed, pipelines are to be made of electrically conductive plastics if it passes through a hazardous area.

6.5.2 The resistance to earth from any point in the piping system is not to exceed 1 MΩ. It is preferred that pipelines and fittings (i.e. the material which they are made of) be homogeneously conductive. Where pipes and fittings having only conductive layers, their walls are to be protected against a possibility of spark damage. Satisfactory earthing of piping systems is to be provided.

6.5.3 After completion of the assembling, the resistance to earth is to be verified according to 6.10.2. Earthing wires are to be accessible for inspection.

6.6 Application of Fire Protection Coatings

6.6.1 Fire protection coatings are to be applied on the joints, where necessary for meeting the required fire endurance, after performing hydraulic test of the piping system according to 6.10.1.

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

6.7 Penetrations of watertight bulkheads and decks

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

6.7.2 If the watertight bulkhead or deck is also a fire-resistant division and destruction by fire of 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.

6.8 Assembling of Piping System on the Ship

6.8.1 Only pipes and fittings produced and tested in accordance with provisions of chapter 5 are to be used on the ship.

6.8.2 Assembling of piping system is to be in accordance with the Manufacturer's guidelines.

6.8.3 The personnel performing assembly of piping system are to have appropriate qualifications confirmed by adequate document. Such document is to be submitted to PRS.

6.8.4 Prior to commencing the assembly, joining technique is to be accepted by PRS.

6.8.5 The procedure of making piping joints as inseparable bonds (by adhesive-bonding, laminating, welding, etc.), submitted for PRS acceptance is to include following information:
- materials used,
- tools and fixtures used during making the joints,
- joint elements preparation requirements,
- temperature requirements during making and curing of the joint,
- dimensional requirements and tolerances of the joint,
- acceptance criteria for piping system upon completion of the assembly.

Any change in the above procedure which will affect the physical and mechanical properties of the joint requires the procedure to be requalified by PRS.

6.9 Acceptance of Making Inseparable Bonds Procedure

6.9.1 A test joints are to be fabricated in accordance with the procedure subjected for PRS acceptance. At least one pipe-to-pipe test joint and one pipe-to-fitting test joint is to be made.

6.9.2 When the joint has been cured, it is to be subjected to a hydraulic test with pressure equal at least 2.5 times the design pressure of that joint, for not less than one hour. No leakage or separation of joint is allowed. The test is to be conducted so that the joint is loaded in both longitudinal and circumferential directions.

6.9.3 Selection of the pipes used for test joints, is to be in accordance with the following guidelines:
– when the largest pipeline 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;
– when the largest pipeline 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.

6.9.4 When conducting qualification tests, each bonder and each bonding operator are to make up test joints. The type and number of joints are to be in accordance with 6.9.1, and their size – in 6.9.3.

6.10 Testing of Piping Systems after Assembly on the Ship

6.10.1 Piping systems essential to safety of the ship are to be subjected to a leak proof test with pressure not less than 1.5 times the design pressure or 0.4 MPa whichever is greater. Other piping systems are to be checked for leakage under operational conditions.

6.10.2 For pipelines required to be electrically conductive, earthing continuity is to be checked and random resistance testing is to be carried out.

7 FIRE TESTS OF PIPELINES

7.1 Fire Endurance Testing in Dry Condition

7.1.1 Description of Method

A furnace test with fast temperature increase likely to occur in a fully developed liquid hydrocarbon fire is to be conducted. The standard temperature-rise curve is to be as follows:

at the end of 5 min:	945°C
at the end of 10 min:	1033°C
at the end of 15 min:	1071°C
at the end of 30 min:	1098°C
at the end of 60 min:	1100°C

The accuracy of the furnace control is to be as follows:
– During the first 10 min of the test the area under the curve of mean furnace temperature is not to vary by more than ± 15% of the area under the standard temperature-rise curve.
– During the first half hour of the test the area under the curve of mean furnace temperature is not to vary by more than ± 10% of the area under the standard temperature-rise curve.
– For any period after the first half hour of the test the area under the curve of mean furnace temperature is not to vary by more than ± 5% of the area under the standard temperature-rise curve.
– At any time after the first 10 min of the test the mean furnace temperature is not to differ from the standard temperature-rise curve by more than ± 100°C.

The locations where the temperatures are measured, the number of temperature measurements and the measurement techniques are to be agreed by the PRS and paragraphs 7.1 to 7.4 of Part 3 of Annex 1 to the 2010 FTP Code could be used as a guidance.

7.1.2 Test Specimen

The test specimen is to be prepared with the joints and fittings intended for use in the proposed application. The number of specimens is to be sufficient to test typical joints and fittings including joints between plastic and metal pipes and fittings to be used. At least largest and smallest diameter or wall thickness should be tested for approval. The number and size of test specimens required for the approval test is to be agreed with PRS.

The specimen is to be placed in a horizontal position in furnace. The ends of the specimen are to be closed. The pipe ends and closures may be outside the furnace. One of the specimen supports is to be fixed type with the remaining supports allowing free movement. The free length between supports is not to be less than 8 times the pipe diameter. Because most plastics will require a thermal insulation to be able to pass fire endurance test, the test procedure is to include the insulation and its covering.

7.1.3 Test Conditions

If the insulation contains, or is liable to absorb moisture the tests is not to be started until the insulation has reached an air-dry condition. This condition is defined as equilibrium with an ambient atmosphere of 50% relative humidity at 20 ± 5 °C. Accelerated conditioning is permissible provided the method does not alter the properties of component material. Special insulation specimens are to be used for moisture content determination and conditioned with the isolated pipes specimens, intended for fire endurance test. These special insulation specimens are to be so constructed as to represent the loss of water vapour from the insulated pipes specimens by having similar thickness and exposed faces.

A nitrogen pressure inside the test specimen is to be maintained at 0.07 ± 0.01 MPa during the test. Means are to be provided to record the pressure inside the pipe and the nitrogen flow into and out of the specimen in order to indicate possible leakages.

7.1.4 Acceptance Criteria

During the test, no nitrogen leakage from the specimen is to occur.

After termination of the test, the test specimen (together with insulation, if applied) is to be allowed to cool in still air to ambient temperature and then subjected to hydraulic test with nominal pressure defined in accordance with 3.1.3. The pressure is to be held for a minimum of 15 min. Pipes without leakage qualify as **L1** or **L2** depending on the test duration. Pipes with negligible leakage, i.e. not exceeding 5% flow loss, qualify as level **L1W** or **L2W** depending on the test duration. Where practicable, the hydraulic test is to be conducted on bare specimen (i.e. pipe which has had all of its insulation and covering removed), so that possible leakage will be readily apparent.

7.2 Fire Endurance Testing of Water-filled Plastic Pipelines

7.2.1 Description of Method

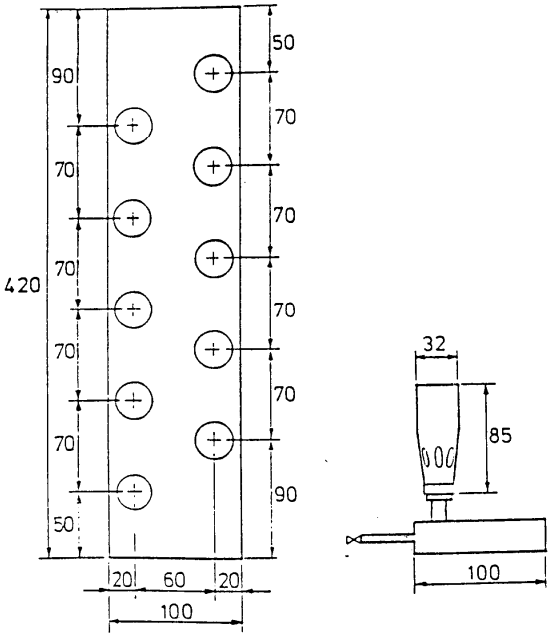
A propane multiple burner test with a fast temperature increase is to be used.

For pipelines up to 152 mm in diameter, the fire source is to consist of two rows of burners – with 5 burners in one row (see Figure 1). A constant heat flux averaging 113.6 kW/m^2 (± 10%) is to be maintained 125 ± 10 mm above the centerline of the burner array. This flux corresponds to a pre-mix flame of propane with a fuel flow rate of 5 kg/h for a total heat release rate of 65 kW. The gas consumption is to be measured with an accuracy of least ± 3% in order to maintain a constant heat flux. Propane with a minimum purity of 95% is to be used.

For pipelines greater than 152 mm in diameter, one additional row of burners is to be included for each 51 mm increase in pipe diameter. A constant heat flux averaging 113.6 kW/m^2 is to be still maintained at the 125 ±10 mm height above the centerline of the burner array. The fuel flow is to be properly increased in order to maintain the required heat flux.

The burners are to be type "Sievert No. 2942" or equivalent. The inner diameter of the burner heads is to be 29 mm (see Figure 1). The burner heads are to be mounted in the same plane. If necessary, each burner is to be equipped with a valve in order to adjust the flame height.

The height of the burners array is to be adjustable. It is to 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 face is to be maintained at 125 ± 10 mm during the test. The free length of the pipe between its supports is to be 800 ± 50 mm (see Figure 2).



a) View from the top b) View from the side

Figure 1 Burners array

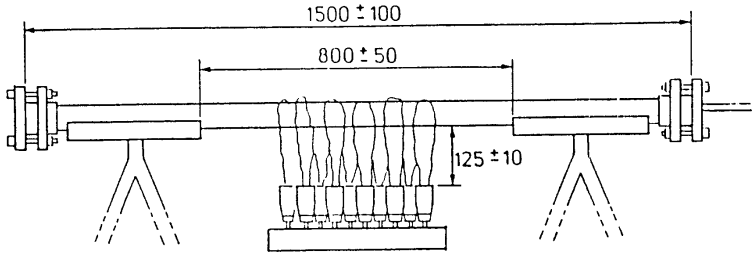


Figure 2 Stand with mounted specimen

7.2.2 Test Specimen

Each test pipe is to have a length of approximately 1.5 m. The pipe specimens are to be prepared with permanent (non dismantling) joints and fittings intended to be used. Only valves and straight joints versus elbows or bends are to be tested as the adhesive in the joint is the primary point of failure. The number of pipe specimens is to be sufficient to test all typical joints and fittings. The ends of each pipe specimen are to be closed and one of the ends is to allow pressurized water to be connected. A relief valve is to be connected to one of the end closures of each specimen.

The pipe samples are to rest freely in a horizontal position on two V-shaped supports. The supports may consist of two stands, as shown in Figure 2.

7.2.3 Test Conditions

If the insulation contains, or is liable to absorb moisture the tests is not to be started until the insulation has reached an air-dry condition. This condition is defined as equilibrium with an ambient atmosphere of 50% relative humidity at 20 ± 5 °C. Accelerated conditioning is permissible provided the method does not alter the properties of component material. Special insulation specimens are to be used for moisture content determination and conditioned with the isolated pipes specimens, intended for fire endurance test. These special insulation specimens are to be so constructed as to represent the loss of water vapour from the insulated pipes specimens by having similar thickness and exposed faces.

The test is to be carried out in a sheltered test stand in order to prevent any draught influencing the test.

Each pipe specimen is to be completely filled with deaerated water (i.e. without air bubbles).

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

The water inside the specimen is to be stagnant and the pressure maintained at 0.3 ± 0.05 MPa during the test.

7.2.4 Acceptance Criteria

During the test, no leakage from the sample is to occur except that slight weeping through the pipe wall may be accepted.

After termination of the test, the test specimen (together with insulation, if applied) is to be allowed to cool in still air to ambient temperature and then subjected to hydraulic test with nominal pressure defined in accordance with 3.1.3. The pressure is to be held for a minimum of 15 min without significant leakage, i.e. not exceeding 0.2 l/min. Where practicable, the hydraulic test is to be conducted on bare specimen (i.e. which has had all of its insulation and covering removed), so that possible leakage will be readily apparent.

8 TEST METHODS AND CRITERIA FOR FLAME SPREAD OF PLASTIC PIPELINES

Flame spread characteristics of plastic pipelines are to be determined by the 2010 FTP Code, Annex 1, Part 5 with the modifications listed below.

1. Tests is to be made for each pipe material and size. For homogenous thermoplastic pipes, the test specimens may be produced as flat plates in the required wall thickness(es).
2. The test specimen is to be fabricated by cutting pipe lengthwise into individual sections and then assembling the sections into a test specimen as representative as possible of a flat surface. A test specimen is to consist of at least two sections. The specimen is to be 800 ± 5 mm long. All cuts are to be made normal to the pipe wall surface.
3. The number of sections that must be assembled together to form a specimen is to be that which corresponds to the nearest integral number of sections which is to make a specimen with an equivalent linearized 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 specimen is to have no gaps between individual sections.
5. The assembled specimen is to be constructed in such a way that the edges of two adjacent sections are to coincide with the centerline of the test holder.
6. The individual test sections are to be attached to the backing calcium silicate board using wire inserted at 50 mm intervals through the board and tightened by twisting at the back.
7. The individual pipe sections are to 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 specimen and the surface of the calcium silicate backing board is to be left void.
9. The void space between the top of the specimen surface and the bottom edge of the specimen holder frame is to be filled with a high temperature insulating wool if the width of the specimen extend under the side edges of the specimen holding frame.

According to the 2010 FTP Code materials having average values for all of the surface flammability criteria that comply with the values as listed in table 8.1, are considered to meet the requirement for low flame-spread in compliance with the relevant regulations in chapter II-2 of the SOLAS Convention.

8.1 Criteria

Table 8.1
Flame Spread

Parameters	Criteria
CFE (kW/ m²)	≥20.0
Q_{sb} (MJ/m²)	≥1.5
Q_t (MJ)	≤0.7
Q_p (kW)	≤4.0
Burning Droplets	No burning droplets

Where:
CFE = Critical flux at extinguishment
Qsb = Heat for sustained burning
Qt = Total heat release
Qp = Peak heat release rate

9 APPLICABLE TESTING STANDARDS

Table 9.1
Typical requirements for all systems

	Test	Typical Standard	Notes
1	Internal pressure (1)	paragraph 3.1.3.1, ASTM D 1599, ASTM D 2992, ISO 15493 or equivalent	Top, Middle, Bottom (of range). Tests are to be carried out on pipe spools made of different pipe sizes, fittings and pipe connections.
2	External pressure (1)	paragraph 3.1.3.2, ISO 15493 or equivalent	As above, for straight pipes only.
3	Axial strength	paragraph 3.2	As above.
4	Load deformation	ASTM D 2412 or equivalent	Top, Middle, Bottom (of each pressure range).
5	Temperature limitations	*GRP piping system:* ISO 75 Method A	Determination of heat distortion temperature (HDT) acc. to ISO 75 Method A is to be carried out for each type of resin. Polyesters with HDT below 80°C are not permitted.
		Thermoplastic piping systems: ISO 75 Method A ISO 306 ISO 2507	Determination of heat distortion temperature (HDT) acc. to ISO 75 Method A is to be carried out for each type of resin. Polyesters with HDT below 80°C are not permitted. Determination of Vicat softening temperature (VST), VICAT test, is to be carried out for each type of resin.
6	Impact resistance	ISO 9854, ISO 9653, ISO 15493, AST D 2444 or equivalent	Representative sample of each type of construction
7	Ageing	Manufacturer's standard, ISO 9142	Each type of construction

	Test	Typical Standard	Notes
8	Fatigue	Manufacturer's standard or operational experience	Each type of construction
9	Fluid absorption	ISO 8361-1, 2, 3	
10	Material compatibility (2)	ASTM C581, Manufacturer's standard	

Table 9.2

Typical additional requirements depending on service and/or locations of piping

	Test	Typical Standard	Notes
1	Fire endurance[1) 2)]	IMO Res. A.753 (18), Appendix 1, 2	Representative sample of each type of construction and type pipe connection
2	Flame spread[1) 2)]	Sub-chapter 4.2	Representative sample of each type of construction
3	Smoke generation[2)]	IMO *Fire Test Procedures Code* (*FTP Code*)	Representative sample of each type of construction
4	Toxicity[2)]	IMO *Fire Test Procedures Code* (*FTP Code*)	Representative sample of each type of construction
5	Electrical conductivity[1) 2)]	AST F1173, ASTM D 257, NS 6126 para. 11.2 or equivalent	Representative sample of each type of construction

1) Test to be witnessed by PRS Surveyor.

2) If applicable.

Note: Tests specified in Table 9.2 are optional (if not carried out, the range of approved applications for the pipes will be limited respectively (see Chapter 4 of this *Publication*, Table 4.1.3).

List of amendments effective as of 1 January 2019

Item	*Title/Subject*	*Source*
Note to Table 9.2	Correction	IACS Rec 86 Rev.1
