Resolution A.753(18)

Adopted on 4 November 1993
(Agenda item 11)

GUIDELINES FOR THE APPLICATION OF PLASTIC PIPES ON SHIPS

THE ASSEMBLY,

RECALLING Article 15(j) of the Convention on the International Maritime Organization concerning the functions of the Assembly in relation tocregulations and guidelines concerning maritime safety and the prevention and control of marine pollution from ships,

NOTING that there is increasing interest within the marine industry in the use of materials other than steel for pipes and that there are no specific requirements for plastic and reinforced plastic pipes and piping systems in existing regulations,

RECOGNIZING that guidelines, covering acceptance criteria for plastic materials in piping systems, appropriate design and installation requirements and fire test performance criteria for assuring ship safety, are needed to assist maritime Administrations to determine, in a rational and uniform manner, the permitted applications for such materials,

RECOGNIZING ALSO that the framework of the guidelines should provide the freedom to permit the development of international and national standards and allow the natural development of emerging technology,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee at its sixty-first session,

1. ADOPTS the Guidelines for the Application of Plastic Pipes on Ships, set out in the annex to the present resolution;

2. INVITES Governments:

   (a) to apply the Guidelines when considering the use of plastic piping on board ships flying the flag of their State; and

   (b) to inform the Organization on the development of national standards and emerging technology on plastic piping;

3. REQUESTS the Maritime Safety Committee to keep the Guidelines under review and amend them as necessary.

Annex

GUIDELINES FOR THE APPLICATION OF PLASTIC PIPES ON SHIPS

Contents

1 INTRODUCTION

1.1 Purpose

1.1.1 The International Maritime Organization recognizes that there is increasing interest within the marine industry to use materials other than steel for pipes and that there are no specific requirements for plastic pipes in existing regulations.

1.1.2 These guidelines provide acceptance criteria for plastic materials in piping systems to assist maritime Administrations to determine, in a rational and uniform way, the permitted applications for such materials. These guidelines give appropriate design and installation requirements and, for each application, fire testing performance criteria necessary to ensure that vessel safety is adequately addressed.

1.1.3 Within the framework of these guidelines, there is freedom to permit development of international and national standards and allow the natural development of emerging technology.

1.2 Scope

1.2.1 The status of these guidelines is advisory. They are intended to cover the design and installation of plastic pipes, both with and without reinforcement, in either essential or non-essential systems, inboard of the shipside valves.

1.2.2 These guidelines are intended to comply with existing SOLAS regulations, MSC circulars, or other equivalent international criteria.

1.2.3 These guidelines are applicable to rigid pipes only. The use of flexible pipes and hoses and mechanical couplings which are accepted for use in metallic piping systems is not addressed.

1.3 Philosophy and contents

1.3.1 The International Convention for the Safety of Life at Sea (SOLAS 74), as amended, specifies steel should be used in some cases, but in other instances it is clear that materials other than steel are anticipated, subject to the Administration's acceptance. Guidelines to enable Administrations to make decisions on the use of plastic piping, and the possibility of extending its application, are therefore needed.

1.3.2 Certain material design properties and performance criteria are common to all piping systems, regardless of system or location, and these are addressed in section 2.1.

1.3.3 Section 2.2 addresses fire safety aspects and provides specific requirements applicable to piping systems depending on service and/or locations.

1.3.4 Section 3 addresses material approval and prescribes certain controls during manufacture of piping that should be considered in order to ensure the proper mechanical and physical characteristics.

1.3.5 Shipboard piping should be properly installed and tested to ensure the degree of safety necessary. Section 4 addresses these concerns, and incorporates MSC/Circ.449 "Guidance on installation of fibre glass reinforced pipe and fittings".

1.3.6 The fire test methods and the fire endurance requirements matrix, referenced in section 2.2, are given in appendices 1 to 4.

1.4 Definitions

1.4.1 *Plastic(s)* as used in these guidelines refers to both thermoplastic and thermosetting plastic materials, with or without reinforcement, such as uPVC and fibre-reinforced plastics - FRP.

1.4.2 *Piping/Piping systems* - The terms *piping* and *piping systems* include the pipe, fittings, system joints, method of joining and any internal or external liners, coverings and coatings required to comply with the performance criteria. For example, if the basic material needs a fire-protective coating to comply with the fire endurance requirements, then the piping should be manufactured and tested with both the basic material and coating attached and submitted to the Administration for approval as a material system.

1.4.3 *Joint* - the term *joint* refers to the permanent method of joining pipes by adhesive bonding, laminating, welding, etc.

1.4.4 *Fittings* - the term *fittings* refers to bends, elbows, fabricated branch pieces, etc., of plastic material.

2 MATERIAL DESIGN PROPERTIES AND PERFORMANCE CRITERIA

2.1 Requirements applicable to all piping systems

2.1.1 *General*

2.1.1.1 The requirements of this section apply to all piping and piping systems independent of service or location.

2.1.1.2 The specification of the piping should be to a recognized standard acceptable to the Administration and should meet the additional performance guidelines that follow.

2.1.1.3 The piping should have 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.

2.1.1.4 For the purpose of assuring adequate robustness for all piping, including open-ended piping (e.g. overflows, vents and open-ended drains), all pipes should have a minimum wall thickness to ensure adequate strength for use on board ships, 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.

2.1.1.5 The performance requirements for any component of a piping system such as fittings, joints, and method of joining are the same as those requirements for the piping system they are installed in.

2.1.2 *Internal pressure*

2.1.2.1 A piping system should be designed for an internal pressure not less than the maximum working pressure to be expected under operating conditions or the highest set pressure of any safety valve or pressure-relief device on the system, if fitted.

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

2.1.3 *External pressure*

2.1.3.1 External pressure should 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.

2.1.3.2 Piping should 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 should be determined by dividing the collapse test pressure by a safety factor of 3. The collapse test pressure should be verified experimentally or by a combination of testing and calculation methods to the satisfaction of the Administration.

2.1.4 *Axial strength*

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

2.1.4.2 In the case of fibre-reinforced plastic pipes, the sum of the longitudinal stresses should not exceed half of the nominal circumferential stress derived from the nominal internal pressure determined according to paragraph 2.1.2.2, unless the minimum allowable longitudinal stress is verified experimentally or by a combination of testing and calculation methods to the satisfaction of the Administration.

2.1.5 *Temperature*

2.1.5.1 Piping should meet the design requirements of these guidelines over the range of service temperatures it will experience.

2.1.5.2 High temperature limits and pressure reductions relative to nominal pressures should be according to the recognized standard, but in each case the maximum working temperature should 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. The minimum heat distortion temperature should not be less than 80°C.

2.1.5.3 Where low-temperature services are considered, special attention should be paid to material properties.

2.1.6 *Impact resistance*

2.1.6.1 Piping should have a minimum resistance to impact to the satisfaction of the Administration.

2.1.7 *Ageing*

2.1.7.1 Before selection of a piping material, the manufacturer should confirm that the environmental effects, including but not limited to ultraviolet rays, saltwater 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 these guidelines. The manufacturer should establish material ageing characteristics by subjecting samples of piping to an ageing test acceptable to the Administration and then confirming its physical and mechanical properties by the performance criteria in these guidelines.

2.1.8 *Fatigue*

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

2.1.8.2 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.

2.1.9 *Erosion resistance*

2.1.9.1 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 should be considered. If erosion cannot be avoided then adequate measures should be taken, such as increased wall thickness, special liners, change of materials, etc.

2.1.10 *Fluid absorption*

2.1.10.1 Absorption of fluid by the piping material should not cause a reduction of mechanical and physical properties of the material below those required by these guidelines.

2.1.10.2 The fluid being carried or in which the pipe is immersed should not permeate through the wall of the pipe. Testing for fluid absorption characteristics of the pipe material should be to a recognized standard.

2.1.11 *Material compatibility*

2.1.11.1 The piping material should be compatible with the fluid being carried or in which it is immersed such that its design strength does not degenerate below that recognized by these guidelines. Where the reaction between the pipe material and the fluid is unknown, the compatibility should be demonstrated to the satisfaction of the Administration.

2.2 Requirements applicable to piping systems depending on service and/or locations

2.2.1 *Fire endurance*

2.2.1.1 *General*

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

2.2.1.2 *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 severities 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) intends 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 functions should be capable of being restored after the fire has been extinguished.

2.2.1.2.1 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 should 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 appendix 1 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.

2.2.1.2.2 Level 2 - Piping systems essential to the safe operation of the ship should 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 appendix 1 for a duration of a minimum of 30 min in the dry condition is considered to meet level 2 fire endurance standard.

2.2.1.2.3 Level 3 - Piping systems essential to the safe operation of the ship should 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 appendix 2 for a duration of a minimum of 30 minutes in the wet condition is considered to meet level 3 fire endurance standard.

2.2.1.3 *System/location matrix*

2.2.1.3.1 The matrix in appendix 4 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.

2.2.1.3.2 Where, according to the matrix, remotely closed valves are required when permitting the use of plastic piping, the remote operation system should be designed such that its function will not be inhibited after being exposed to an equivalent level 1 fire endurance test. Remote operation is defined as an accessible, safe location outside the space in which the valves are installed. In the case of valves on the main deck of a tanker, remote operation should be from outside the cargo block.

2.2.1.3.3 Where the matrix stipulates endurance level L2, pipes of endurance level L1 may also be used. Similarly, where the matrix stipulates endurance level L3, pipes of endurance level L2 and L1 may be used.

2.2.2 *Flame spread*

2.2.2.1 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 resolution A.653(16) as modified for pipes.

2.2.2.2 In resolution A.653(16) the test sample configuration only considers flat surfaces. Procedure modifications to A.653(16) are necessary due to the curvilinear pipe surfaces. These procedure modifications are listed in appendix 3.

2.2.2.3 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 of 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 pipes is small, the Administration may allow equivalent acceptance criteria.

2.2.3 *Smoke generation*

2.2.3.1 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.

2.2.3.2 A fire test procedure is being developed and when finalized and appropriate smoke obscuration criteria have been recommended, this test will be incorporated into these guidelines. In the meantime, an absence of this test need not preclude the use of plastics. However, Administrations should consider this hazard when approving piping materials.

2.2.4 *Toxicity*

2.2.4.1 Toxicity testing is still being investigated and criteria are being developed. Before meaningful conclusions can be made, further experimentation and testing is needed. In the absence of a toxicity test, the use of plastics need not be precluded. However, Administrations should consider this hazard when approving piping materials.

2.2.5 *Electrical conductivity*

2.2.5.1 Electrostatic charges can be generated on the inside and outside of plastic pipes. The resulting sparks can create punctures through pipe walls, leading to leakage of pipe contents, or can ignite surrounding explosive atmospheres. Administrations should consider these hazards when approving plastic piping systems carrying fluids capable of generating electrostatic charges (static accumulators) inside the pipe, and when approving plastic piping systems in hazardous areas (i.e. areas that could, either in normal or fault conditions, contain an explosive atmosphere), for the possibility of electrostatic charges outside the pipe.

2.2.5.2 In practice, fluids with conductivity less than 1,000 picosiemens 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 should therefore be electrically conductive. Fluids with conductivity greater than 1,000 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.

2.2.5.3 Regardless of the fluid being conveyed, plastic piping should be electrically conductive if the piping passes through a hazardous area.

2.2.5.4 Where conductive piping is required, the resistance per unit length of the pipe, bends, elbows, fabricated branch pieces, etc., should not exceed 1×10^5 Ω/m and the resistance to earth from any point in the piping system should not exceed 1×10^6 Ω. It is preferred that pipes and fittings be homogeneously conductive. Pipes and fittings having conductive layers may be accepted subject to the arrangements for minimizing the possibility of spark damage to the pipe wall being satisfactory. Satisfactory earthing should be provided.

2.2.5.5 After completion of the installation, the resistance to earth should be verified. Earthing wires should be accessible for inspection.

2.2.6 *Fire-protective coatings*

2.2.6.1 Where a fire-protective coating of pipes and fittings is necessary for achieving the fire endurance standards required, the following requirements apply:

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

.2 The liquid-absorption properties of the coating and piping should be considered. The fire-protection properties of the coating should not be diminished when exposed to salt water, oil or bilge slops. The Administration should be satisfied that the coating is resistant to products likely to come in contact with the piping.

.3 Fire-protective coatings should not degrade due to environmental effects over time, such as ultraviolet rays, exposure to salt water, temperature and humidity. Other areas to consider are thermal expansion, resistance against vibrations, and elasticity. Ageing of the fire-protective coatings should be demonstrated to the satisfaction of the Administration in a manner consistent with the ageing test specified above.

.4 The adhesion qualities of the coating should be such that the coating does not flake, chip, or powder when subjected to an adhesion test acceptable to the Administration.

.5 The fire-protective coating should have a minimum resistance to impact to the satisfaction of the Administration.

.6 Pipes should be an appropriate distance from hot surfaces in order to be adequately insulated.

2.2.6.2 Special testing may be required as part of the approval procedure.

3 MATERIAL APPROVAL AND QUALITY CONTROL DURING MANUFACTURE

3.1 The Administration may require piping, as defined in section 1.4, to be prototype tested to ensure that the piping meets the performance requirements of these guidelines.

3.2 The manufacturer should 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 should consist of elements necessary to ensure that pipe and fittings are produced with consistent and uniform mechanical and physical properties in accordance with recognized standards. Control during manufacture should be certified by the manufacturer to the satisfaction of the Administration.

3.3 Dimensions and tolerances for pipes should conform to a recognized standard.

3.4 Piping and fittings should be permanently marked with identification in accordance with a recognized standard. Identification should include pressure ratings, the design standard that the pipe or fitting is manufactured in accordance with, and the material system with which the pipe or fitting is made.

3.5 Each length of pipe should 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 by the Administration.

3.6 Samples of pipe should be tested to determine the short-term and/or long-term hydrostatic design strength. These samples should be selected randomly from the production facilities at a frequency to the satisfaction of the Administration.

3.7 For piping required to be electrically conductive, representative samples of pipe should be tested to determine the electrical resistance per unit length. The test method and frequency of testing should be acceptable to the Administration.

3.8 Random samples of pipe should be tested to determine the adhesion qualities of the coating to the pipe. The test method and frequency of testing should be acceptable to the Administration.

4 INSTALLATION

4.1 Supports

4.1.1 Selection and spacing of pipe supports in shipboard systems should be determined as a function of allowable stresses and maximum deflection criteria. Support spacing should be not greater than the pipe manufacturer's recommended spacing. The selection and spacing of pipe supports should 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, vibration, maximum accelerations to which the system may be subjected, and the type of support. The support spans should also be checked for combinations of loads.

4.1.2 Each support should evenly distribute the load of the pipe and its contents over the full width of the support and be designed to minimize wear and abrasion.

4.1.3 Heavy components in the piping system such as valves and expansion joints should be independently supported.

4.1.4 Suitable provision should be made in each pipeline to allow for relative movement between pipes made of plastics and the steel structure, having due regard to:

.1 the difference in the coefficients of thermal expansion;

.2 deformations of the ship's hull and its structure.

4.1.5 When calculating the thermal expansions, account should be taken of the system working temperature and the temperature at which assembling is performed.

4.2 External loads

4.2.1 Where applicable, allowance should be made for temporary point loads. Such allowances should 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.

4.2.2 Pipes should be protected from mechanical damage where necessary.

4.3 Strength of connections

4.3.1 The requirements for connections are the same as those requirements for the piping system in which they are installed, as stated in paragraph 2.1.1.5.

4.3.2 Pipes may be assembled using adhesive-bonded, flanged or mechanically coupled joints.

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

4.3.4 Tightening of flanged or mechanically coupled joints should be performed in accordance with the manufacturer's instructions.

4.4 Control during installation

4.4.1 Joining techniques should be in accordance with MSC/Circ.449. This circular requires the fabrication to be in accordance with the manufacturer's installation guidelines, that personnel performing these tasks be qualified to the satisfaction of the Administration, and that each bonding procedure be qualified before shipboard piping installation commences.

4.4.2 To qualify joint bonding procedures, the tests and examinations specified herein should be successfully completed. The procedure for making bonds should include: all materials and supplies, tools and fixtures, environmental requirements, joint preparation, dimensional requirements and tolerances, cure time, cure temperature, protection of work, tests and examinations and acceptance criteria for the completed test assembly.

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

4.4.4 The employer should maintain a self-certification record available to the Administration of the following:

- the procedure used, and
- the bonders and bonding operators employed by him, showing the bonding performance qualifications, dates and results of the qualification testing.

4.4.5 Procedure qualification testing should conform to the following:

A test assembly shall be fabricated in accordance with the bonding procedure to be qualified and shall consist of at least one pipe-to-pipe joint and one pipe-to-fitting joint. When the test assembly has been cured, it shall be subjected to a hydrostatic test pressure at a factor of safety acceptable to the Administration times the design pressure of the test assembly, for not less than one hour with no leakage or separation of joints. The test shall be conducted so that the joint is loaded in both the circumferential and longitudinal directions similar to that to be experienced in service. The size of the pipe used for the test assembly shall be as follows:

.1 When the largest size to be joined is 200 mm nominal outside diameter, or smaller, the test assembly shall be the largest piping size to be joined.

.2 When the largest size to be joined is greater than 200 mm nominal outside diameter, the size of the test assembly shall be either 200 mm or 25% of the largest piping size to be joined, whichever is greater.

4.4.6 When conducting performance qualifications, each bonder and bonding operator should make up a test assembly consisting of one pipe-to-pipe joint and one pipe-to-fitting joint in accordance with the qualified bonding procedure. The size of the pipe used for the test assembly should be the same as required in paragraph 4.4.5. The joint should successfully pass the hydrostatic test described in paragraph 4.4.5.

4.5 Testing after installation on board

4.5.1 Piping systems for essential services should be subjected to a test pressure not less than 1.5 times the design pressure of the system.

4.5.2 Piping systems for non-essential services should be checked for leakage under operational conditions.

4.5.3 For piping required to be electrically conductive, the resistance to earth should be checked. Earthing wires should be accessible for inspection.

4.6 Penetrations of fire divisions

4.6.1 Where "A" or "B" class divisions are penetrated for the passage of plastic pipes, arrangements should be made to ensure that the fire resistance is not impaired. These arrangements should be tested in accordance with Recommendation on fire resistance tests for "A", "B" and "F" class divisions (resolution A.517(13), as amended*).

* Resolution A.517(13) has been revoked by A.754(18).

4.7 Penetrations of watertight bulkheads and decks

4.7.1 Where plastic pipes pass through watertight bulkheads or decks, the watertight integrity and strength integrity of the bulkhead or deck should be maintained.

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

4.8 Methods of repair

4.8.1 At sea, the pipe material should be capable of temporary repair by the crew, and the necessary materials and tools kept on board.

4.8.2 Permanent repairs to the piping material should be capable of exhibiting the same mechanical and physical properties as the original base material. Repairs carried out and tested to the satisfaction of the Administration may be considered permanent provided the strength is adequate for the intended service.

Appendix 1

Test method for fire endurance testing of plastic piping in the dry condition

Test method

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:

at the end of 5 min: 945°C

at the end of 10 min: 1,033°C

at the end of 15 min: 1,071°C

at the end of 30 min: 1,098°C

at the end of 60 min: 1,100°C

Notes: 1 The accuracy of the furnace control should be as follows:

1.1 During the first 10 min of the test the area under the curve of mean furnace temperature should not vary by more than ± 15% of the area under the standard curve.

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

1.3 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% of the area under the standard curve.

1.4 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.

2 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 paragraph 3.1.3 of the annex of Assembly resolution A.517(13).

Test specimen

2 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 pressurized 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.

Notes: 1 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 The number and size of test specimens required for the approval test should be specified by the Administration.

Test conditions

3 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% relative humidity at 20 $\pm$ 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.

4 A nitrogen pressure inside the test specimen should be maintained automatically at 0.7 $\pm$ 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.

Acceptance criteria

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

6 After termination of the furnace test, the test specimen together with fire-protective coating, if any, should be allowed to cool in still air to ambient temperature and then tested to the rated pressure of the pipes as defined in paragraphs 2.1.2.2 and 2.1.3.2 of these guidelines. The pressure should be held for a minimum of 15 min 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-protective insulation, removed, so that leakage will be readily apparent.

7 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.

Appendix 2

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

1 Test method

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

For piping up to 152 mm in diameter, the fire source should consist of two rows of five burners as shown in figure 1. A constant heat flux averaging 113.6 kW/m^2 ($\pm$ 10%) should be maintained 12.5 $\pm$ 1 cm above the centreline 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 should be measured with an accuracy of at least $\pm$ 3% in order to maintain a constant heat flux. Propane with a minimum purity of 95% should be used.

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/m^2 ($\pm$ 10%) should still be maintained at the 12.5 $\pm$ 1 cm height above the centreline of the burner array. The fuel flow should be increased as required to maintain the designated heat flux.

The burners should be type "Sievert No. 2942" or equivalent which produces an air-mixed flame. The inner diameter of the burner heads should be 29 mm (see figure 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.

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 $\pm$ 1 cm during the test. The free length of the pipe between its supports should be 0.8 $\pm$ 0.05 m.

2 Test specimen

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 pressurized water to be connected.

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% relative humidity at 20 $\pm$ 5°C. Accelerated conditioning is permissible provided the method does not alter the properties of the 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.

The pipe samples should rest freely in a horizontal position on two V-shaped supports. The friction between pipe and supports should be minimized. The supports may consist of two stands, as shown in figure 2.

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

3 Test conditions

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

Each pipe specimen should be completely filled with deaerated water to exclude air bubbles.

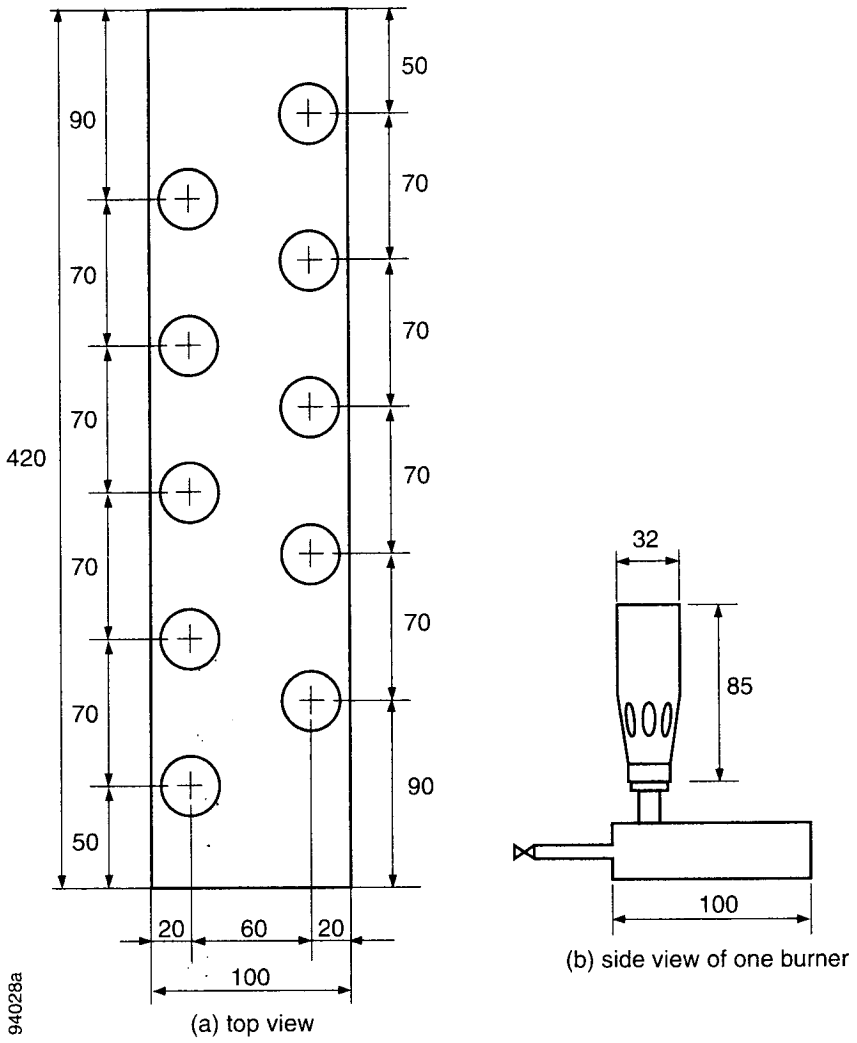

Figure 1 – *Fire endurance test: burner assembly (all dimensions in mm)*

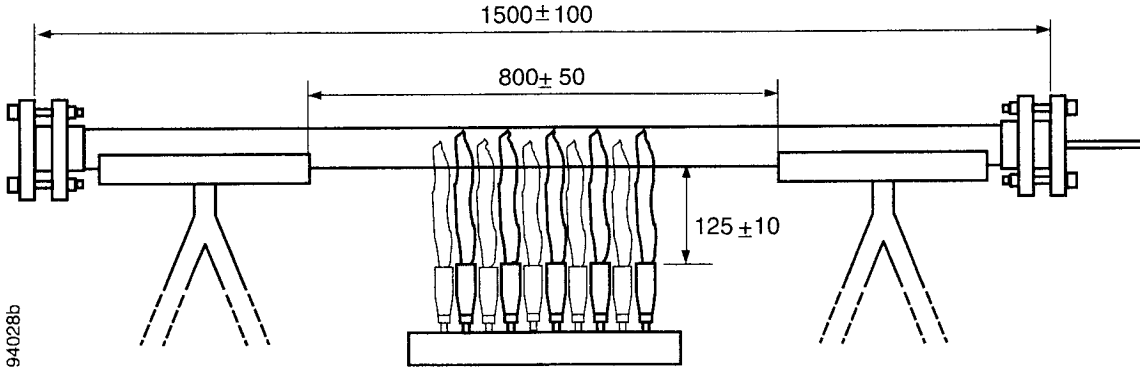

Figure 2 – *Fire endurance test: stand with mounted sample (all dimensions in mm)*

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

The water inside the sample should be stagnant and the pressure maintained at 3 ± 0.5 bar during the test.

4 Acceptance criteria

- During the test, no leakage from the sample(s) should occur except that slight weeping through the pipe wall may be accepted.
- After termination of the burner regulation test, the test sample, together with fire-protective coating, if any, should be allowed to cool to ambient temperature and then tested to the rated pressure of the pipes as defined in paragraphs 2.1.2.2 and 2.1.3.2 of these guidelines. 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 coverings, including fire protection insulation, removed, so that leakage will be readily apparent.

Appendix 3
Test method for flame spread of plastic piping

Flame spread of plastic piping should be determined by IMO resolution A.653(16) entitled "Recommendation on Improved Fire Test Procedures for Surface Flammability of Bulkhead, Ceiling and Deck Finish Materials" with the following modifications.

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

2 The test sample 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 ± 5 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 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 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.

Appendix 4

Fire endurance requirements matrix

	Piping systems	Location										
		A	B	C	D	E	F	G	H	I	J	K
		Machinery spaces of category A	Other machinery spaces and 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 tunnels and ducts	Accommodation, service and control spaces	Open decks
1	CARGO (FLAMMABLE CARGOES f.p. ≤ 60°C) Cargo lines	NA	NA	L1	NA	NA	0	NA	0[10]	0	NA	L1[2]
2	Crude oil washing lines	NA	NA	L1	NA	NA	0	NA	0[10]	0	NA	L1[2]
3	Vent lines	NA	NA	NA	NA	NA	0	NA	0[10]	0	NA	X
4	INERT GAS Water seal effluent line	NA	NA	0[1]	NA	NA	0[1]	0[1]	0[1]	0[1]	NA	0
5	Scrubber effluent line	0[1]	0[1]	NA	NA	NA	NA	NA	0[1]	0[1]	NA	0
6	Main line	0	0	L1	NA	NA	NA	NA	NA	0	NA	L1[6]
7	Distribution lines	NA	NA	L1	NA	NA	0	NA	NA	0	NA	L1[2]
8	FLAMMABLE LIQUIDS (f.p. > 60°C) Cargo lines	X	X	L1	X	X	NA[3]	0	0[10]	0	NA	L1
9	Fuel oil	X	X	L1	X	X	NA[3]	0	0	0	L1	L1
10	Lubricating oil	X	X	L1	X	X	NA	NA	NA	0	L1	L1
11	Hydraulic oil	X	X	L1	X	X	0	0	0	0	L1	L1
12	SEAWATER[1] Bilge main and branches	L1[7]	L1[7]	L1	X	X	NA	0	0	0	NA	L1
13	Fire main and water spray	L1	L1	L1	X	NA	NA	NA	0	0	X	L1
14	Foam system	L1	L1	L1	X	NA	NA	NA	NA	0	L1	L1
15	Sprinkler system	L1	L1	L3	X	NA	NA	NA	0	0	L3	L3
16	Ballast	L3	L3	L3	L3	X	0[10]	0	0	0	L2	L2
17	Cooling water, essential services	L3	L3	NA	NA	NA	NA	NA	0	0	NA	L2

	Piping systems	Location										
		A	B	C	D	E	F	G	H	I	J	K
		Machinery spaces of category A	Other machinery spaces and 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 tunnels and ducts	Accommodation, service and control spaces	Open decks
18	Tank cleaning services fixed machines	NA	NA	L3	NA	NA	0	NA	0	0	NA	L3[2]
19	Non-essential systems	0	0	0	0	0	NA	0	0	0	0	0
20	FRESH WATER Cooling water essential services	L3	L3	NA	NA	NA	NA	0	0	0	L3	L3
21	Condensate return	L3	L3	L3	0	0	NA	NA	NA	0	0	0
22	Non-essential systems	0	0	0	0	0	NA	0	0	0	0	0
23	SANITARY/DRAINS/ SCUPPERS Deck drains (internal)	L1[4]	L1[4]	NA	L1[4]	0	NA	0	0	0	0	0
24	Sanitary drains (internal)	0	0	NA	0	0	NA	0	0	0	0	0
25	Scuppers and discharges (overboard)	0[1,8]	0[1,8]	0[1,8]	0[1,8]	0[1,8]	0	0	0	0	0[1,8]	0
26	SOUNDING/AIR 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
28	MISCELLANEOUS Control air	L1[5]	L1[5]	L1[5]	L1[5]	L1[5]	NA	0	0	0	L1[5]	L1[5]
29	Service air (non-essential)	0	0	0	0	0	NA	0	0	0	0	0
30	Brine	0	0	NA	0	0	NA	NA	NA	0	0	0
31	Auxiliary low-pressure steam (≤ 7 bar)	L2	L2	0[9]	0[9]	0[9]	0	0	0	0	0[9]	0[9]

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
0 No fire endurance test required
NA Not applicable
X Metallic materials having a melting point greater than 925°C

FOOTNOTES:

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 contain flammable liquids with f.p. > 60°C, "0" may replace "NA" or "X".

4 For drains serving only the space concerned, "0" may replace "L1".

5 When controlling functions are not required by statutory requirements or guidelines, "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, 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 ship's whistle, "X" is to replace "0".

10 For tankers where compliance wth paragraph 3(f) of regulation 13F of Annex I of MARPOL 73/78 is required, "NA" is to replace "0".

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, stabilizing, 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 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.

* SOLAS 74 as amended.

H	Ballast water tanks	All spaces used for ballast water and trunks to such spaces.
I	Cofferdams, void spaces, pipe tunnels and ducts	Cofferdams and voids are those empty spaces between two bulkheads separating two adjacent compartments.
J	Accommodation, service and control spaces	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.