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Ships and marine technology — Machinery-space flammable oil systems — Prevention of leakage of flammable oil

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 18770 was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 3, *Piping and machinery*.

Introduction

Fuel oil, lubricating oil and other flammable oil system failures are a major source of shipboard fires. This International Standard specifies the measures that shall be taken to reduce fires originating from machinery-space flammable oil systems, and is intended for designers, shipyard personnel, engine-room personnel, owners, operators and maintenance personnel. Requirements contained herein address the design, construction, testing, installation, maintenance and inspection of systems containing flammable oils.

It is the intent of this International Standard to supplement and provide guidance in support of the following International Maritime Organization circulars, with the eventual goal of replacing these circulars.

— MSC/Circular 647 (1994), "*Guidelines to Minimize Leakages from Flammable Liquid Systems*", a supplement for SOLAS Regulation II/2-15 ("*Arrangements for Flammable Oils*"). It addresses several aspects of the fuel oil, lubricating oil and other flammable oil systems, such as hoses, spray shields, insulation, connectors, joints and supports.

— MSC/Circular 851 (1998), "*Guidelines on Engine-Room Oil Fuel Systems*", a supplement to MSC/Circular 647. This circular addresses causes of oil fuel leakage, which sometimes result in machinery space fires. It discusses design, installation, maintenance and inspection issues, and explains some contributing factors such as frequent dismantling, short-duration pressure pulses, and vibration.

Ships and marine technology — Machinery-space flammable oil systems — Prevention of leakage of flammable oil

1 Scope

This International Standard specifies the measures to be taken to reduce fires originating from machinery-space flammable oil systems and to prevent leakage of flammable oil. It is intended for designers, shipyard personnel, engine-room personnel, owners, operators and maintenance personnel. Requirements contained herein address the design, construction, testing, installation, maintenance and inspection of systems containing flammable oil.

This International Standard is applicable to new and existing vessels, and is intended to be used as a supplement to the regulations for fuel oil, lubricating oil and other flammable oils contained in the *International Convention for the Safety of Life At Sea (SOLAS 74)*, as amended, issued by the International Maritime Organization (IMO).

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
flammable oil
oil easily ignitable and burned, generally found in machinery spaces

EXAMPLE fuel oil, lubricating oil, thermal oil or hydraulic oil

3.2
machinery space
space, generally containing main and auxiliary propulsion equipment and associated systems, as defined in the *International Convention for the Safety of Life At Sea (SOLAS 74)*, as amended, issued by the International Maritime Organization

3.3
hot surface
surface whose temperature exceeds 220 °C

3.4
electrical component
switchboard, instrument panel, electrical controller, instrumentation cabinet or other shipboard electrical equipment, whose wetting or spray by liquids could result in fire or loss of propulsion

3 General piping system considerations

3.1 General

Based on past experience, it is known that the combination of flammable materials and sources of ignition is the main cause of machinery-space fires. The flammable materials involved in the majority of cases are oils, i.e. fuel oil, lubricating oil or hydraulic oil. There are many potential ignition sources in a machinery space, the most common being hot surfaces, e.g. exhaust pipes and steam pipes. Overheating of machinery, ignition from electrical installations due to short-circuiting or arcing of switchgear and other fault conditions can result in fire. Other frequent ignition sources are those associated with human activities, e.g. smoking, welding and grinding.

3.2 Human element

The role of the human element shall always be considered. Personnel shall be properly trained and follow established procedures. Knowledge of the operation of engine fuel systems and other flammable oil systems, as well as the magnitude of pressures generated within them and hazards associated with leaks, should be included in training for engineer officers. These topics should receive detailed attention when candidates sit for their Certificate of Competency examinations.

3.3 Inspection, maintenance and repairs

Inspection, maintenance and repairs to flammable oil systems shall be carried out in a professional manner. Owners shall ensure that the necessary training, equipment and parts are available. Records of significant repairs and maintenance to these systems shall be noted in the engineer's daily log and/or maintenance log.

3.4 Operational considerations

3.4.1 Many fires have been caused by pipe connections and fittings working loose. The fuel, lubricating and hydraulic oil pipes, their fittings, connections and securing arrangements shall be routinely checked as part of a preventive maintenance plan. Care shall be taken not to overtighten fittings during checks.

3.4.2 When completing maintenance or repairs to main or auxiliary engines, checks shall be made to ensure that the insulation covering hot surfaces has been properly replaced. Regular checks of the engines shall be made to confirm that the insulation is in place.

3.4.3 Any fuel, lubricating- or hydraulic-oil leak shall be dealt with promptly. In the event of a major leak, every effort should be made to stop the pump or source of the oil pressure. When underway, the navigation bridge shall be immediately informed of major flammable-liquid leaks.

3.4.4 Serious fires have originated because of a failure to recognize potential hazards (such as burning oil running out of furnace fronts onto the tank top, a spray of oil from a defective gland, joint or a fractured pipe) in areas where these may not be readily noticeable, but can be easily ignited. It is essential to avoid the dangerous situation in which a small fire could spread to waste oil in the bilges or on tank tops, where it could rapidly spread out of control. Cleanliness is essential for safety, and a high standard of cleanliness shall always be maintained.

3.4.5 Woodwork or other readily combustible materials shall not be used in machinery spaces where flammable oil is used. No combustible material shall be stored near any part of oil installations. The use of bituminous or similar flammable compounds shall be kept to a minimum in machinery and boiler spaces.

3.4.6 When repairs, however temporary, are carried out to oil lines, special attention shall be paid to fire risks. All repairs shall be adequate to prevent any danger of leakage and shall be to a standard which would endure exposure to fire.

3.4.7 If there is a leakage of fuel, lubricating or hydraulic oil, the chances of preventing the outbreak of fire or quickly extinguishing one which has started, will be greatly improved if all affected or adjacent machinery which may have heated surfaces, including ancillaries, can be immediately shut down. The prevention of further leakage will reduce the probability of fire, or reduce the intensity of one that has already started and can help to avoid permanent disablement of the ship.

4 Flexible hose and flexible-hose assemblies

4.1 Application

The limited use of flexible hose in flammable oil systems is permitted. This clause provides guidance concerning the safe application of flexible-hose assemblies. Flexible-hose assemblies, which are flexible hoses with end fittings attached, shall be as short in length as practicable and only used where necessary to accommodate relative movement between fixed piping and machinery parts.

4.2 Design and construction

Hoses shall be constructed to a recognized standard and be approved as suitable for the intended service, taking into account pressure, temperature, fluid compatibility and mechanical loading including impulses where applicable. Each hose assembly shall be provided with a certificate of hydrostatic pressure testing and conformity of production. In addition, non-metallic hoses shall be provided with a certificate of fire-resistance testing; guidance for fire-resistance testing is provided in ISO 15540 [1].

4.3 Installation

Hoses shall be installed in accordance with the manufacturer's instruction, with regard to minimum bend radius, twist angle and orientation, as well as support where necessary. In locations where hoses are likely to suffer external damage, adequate protection shall be provided. After installation, the system shall be operated at maximum working pressure and checked for malfunctions and leaks. General installation guidelines are given in Figures A.1 and A.2.

4.4 Inspection and maintenance

Hose assemblies shall be periodically inspected according to the manufacturer's or ship's maintenance programme. Results of periodic inspections shall be documented. Hose assemblies shall be replaced when there is evidence of distress likely to lead to failure, or doubt as to their continued suitability for service.

Any of the following conditions can require replacement of a hose assembly:

— leaks at fitting or in flexible hose;

— damaged, cut or abraded cover;

— kinked, crushed, flattened or twisted flexible hose;

— hardened, stiff, heat-cracked or charred flexible hose;

— blistered, soft, degraded or loose cover;

— cracked, damaged or badly corroded fittings;

— fitting slippage on flexible hose.

It is expected that hose assemblies may need to be replaced several times during the life of the ship. Manufacturer's recommendations for maximum hose service life shall be followed.

5 Spray shields

5.1 Application

Spray shields prevent the impingement of leaked or sprayed flammable liquid onto a hot surface or other source of ignition. Fuel oil, lubricating oil and other flammable oil piping shall be screened or otherwise suitably protected to avoid, as far as practicable, oil spray onto hot surfaces, into machinery air intakes, or other sources of ignition. Spray shields are intended for use on flanged joints, flanged bonnets and other flanged connections in oil pressure systems which are located above the floor plates and which are not lagged (insulated). The number of joints in such systems shall be kept to a minimum. Spray shields shall be installed for pressurized flammable-liquid systems in the main and auxiliary machinery spaces if the joint is within 3 m (10 ft) of an electrical component or a hot surface.

Spray shields are not required for the following:

— suction piping, or piping not subject to pump discharge pressures;

— piping located in voids or cofferdams;

— tank-sounding tubes, air escapes, vents and overflows;

— piping located inside gas-turbine modules, reduction-gear enclosures, or otherwise protected by barriers such as lockers, decking or foundations;

— union-type fittings, consisting of a threaded three-piece (male, female, nut) assembly.

5.2 Design

Many types of spray shields are possible. An example of a spray shield that provides a total enclosure of a joint is given in Figure B.1. This spray shield is designed to wrap completely around the joint and is long enough to provide an overlap equal to one-quarter of the joint's circumference. The shield is wrapped around the sides of the flange far enough to cover the heads of the bolts. The shield is laced tightly with wire and the overlap is pointed away from potential ignition sources.

5.3 Inspection and maintenance

Spray shields shall be inspected regularly for their integrity, and any which have been removed for maintenance purposes shall be refitted on completion of the task. Oil-soaked spray shields normally indicate the presence of leaks. They shall be replaced as soon as possible, and the cause of the leak repaired.

6 Jacketed high-pressure fuel lines

6.1 Application

All external high-pressure fuel delivery lines between the high-pressure fuel pumps and fuel injectors shall be protected with a jacketed piping system capable of containing a high-pressure fuel line failure. A jacketed pipe incorporates an outer pipe into which the high-pressure fuel pipe is placed, forming a permanent assembly. The jacketed piping system shall include a means for collection of leakage, and arrangements shall be provided for a fuel line failure alarm.

6.2 Design

Two systems have been successfully used in meeting this requirement, namely, rigid-sheathed fuel pipe and flexible-sheathed fuel pipe. In either case, the sheathing shall fully enclose the pipe and resist penetration by the spray of oil from a pipe failure during service. Also, the annular space and drainage arrangements shall be sufficient to ensure that, in the event of a complete fracture of the internal pipe, an excessive build-up of pressure cannot occur and cause rupture of the sheath. The suitability of such pipes shall be demonstrated by prototype testing, appropriate design analysis, or class-society-type approval. The drainage arrangement shall prevent contamination of lubricating oil by fuel oil.

6.3 Inspection and maintenance

Regardless of the system selected, little additional maintenance or periodic inspection is required to keep the jacketed fuel lines in proper working order. However, jacketed pipes shall be inspected regularly and any drainage arrangement which may have been disconnected for maintenance shall be properly refitted. Inspection and maintenance to these systems shall be noted in the engineering log or maintenance log.

7 Bellows expansion joints

7.1 Application

This clause refers specifically to metallic expansion joints used in flammable-oil systems. To ensure adequate piping system flexibility, bends, loops, offsets or bellows expansion joints are required in most piping systems. The use of non-metallic expansion joints shall be limited, and the requirements of Clause 4 for flexible hose shall apply, particularly fire-resistance testing.

7.2 Design

Expansion joints are designed to accommodate axial and lateral movement and shall not be used to compensate for pipe misalignment. Design shall be based on an acceptable code or on testing of expansion joints of similar construction, type, size and use. Thermal expansion and contraction and the fatigue life due to vibration are also important points to consider. Where external mechanical damage is possible, the bellows shall be suitably protected. Each bellows expansion joint shall be provided with a certificate of hydrostatic pressure testing and conformity of production. The manufacturer's name, the month and the year of manufacture shall be permanently marked on expansion joints.

7.3 Installation, inspection and maintenance

Bellows expansion joints shall be installed in accordance with the manufacturer's instructions and examined under working conditions, and shall be inspected regularly and be replaced whenever there is doubt as to their suitability to continue in service.

8 Filters and strainers

8.1 Design

In general, filters and strainers used in fuel-oil, lubricating-oil or other flammable-oil systems shall have metallic housings and bodies with a melting point above 930 °C. Other metallic housing and body materials may be acceptable provided they have successfully completed a fire test according to ISO 15540 [1]. All pressure-retaining parts shall be suitable for the maximum operating temperature and pressures. The filter or strainer design and construction shall facilitate cleaning, and prevent or minimize spillage during maintenance. Where filters and strainers are required to be opened for cleaning during operation, they shall be fitted with a means of depressurization before being opened.

8.2 Installation, inspection and maintenance

Filters and strainers shall be located as far away as practicable from hot surfaces and other sources of ignition. They shall not be located in positions where spillage could fall onto a flywheel, or other rotating machinery parts, and be sprayed. Suitable drip trays shall be provided under filters and strainers. Filters and strainers shall be inspected every time they are opened for cleaning, and the cover gaskets or seals shall be renewed when necessary. Satisfactory seating and tightening of the cover shall be verified before the system is put back into service. Nuts, bolts, screws and studs associated with the filter covers and holding-down arrangements shall be inspected every time the filter is opened for cleaning. The nuts, bolts, screws and studs shall be replaced with the correct type as soon as they show signs of wear, crossed threads, stretching, or rounded hexagonal heads. Studs shall be inserted into the casing to the correct depth of thread.

Vent plugs shall be replaced whenever they show signs of wear or blockage. Vent plugs should not be replaced by valves or solid plugs.

Drain plugs shall be replaced when they show signs of wear or blockage. Open-ended drain lines shall be plugged or effectively sealed against inadvertent release of oil prior to the filter being put back into service.

9 Insulation

9.1 Design

All surfaces with temperatures above 220 °C, that can be impinged as a result of a flammable-oil system failure, shall be properly insulated. Insulation of hot surfaces reduces the risk of fire by keeping the temperatures of these surfaces below the auto-ignition temperature of the oil fluids. The insulating material shall be non-combustible and impervious to oil impingement. If the insulation is not impervious to oil, it shall be encased in a metallic sheath.

9.2 Installation, inspection and maintenance

Manufacturer's installation instructions shall be followed. Permanent insulation shall be used to the greatest extent possible. Insulation shall be provided with readily removable sections that allow access for normal maintenance. Regular checks of equipment shall confirm that insulation is properly in place, particularly following maintenance or repair.

10 Other mechanical components

10.1 Gauges

10.1.1 Design and installation

10.1.1.1 Pressure, temperature and oil-level gauges, and similar instrumentation have featured in many fires aboard ships. All pressure gauges and other similar instruments in oil systems shall, wherever possible, be fitted with an isolating valve or cock at the connection to the pressure take-off point. The number of pressure take-off points shall be kept to a minimum and gauge piping runs shall be as short as practicable. Copper pipes should not be used and, where already fitted, should be replaced by steel. As an interim measure, existing copper pipe should be properly secured against damage from vibration. Gauge pipes should incorporate an expansion loop to accommodate changes in temperature and to assist in resisting the effects of vibration and pressure pulses. Temperature gauges in oil systems should be fitted into a fixed pocket or thermo-well.

10.1.1.2 Oil-level gauges shall be of a design that is approved for the intended service. Installation of level gauges that require penetration below the top of the tank is generally prohibited for passenger ships, and discouraged for cargo ships. However, suitably protected gauges, having heat-resistant flat glass of substantial thickness and self-closing fittings at each tank connection, can be fitted to cargo ship oil tanks. Round gauge glasses are not permitted.

10.1.2 Inspection and maintenance

Copper gauge piping is particularly sensitive to work-hardening (see 11.2.5). All gauge pipes and fittings shall be regularly inspected and maintained in good working order.

10.2 Pipe connectors, joints, hangars and supports

10.2.1 There are many different types of pipe connectors and joints, some of which are not considered suitable for oil systems. In general, flanged joints conforming to recognized standards shall be used. Compression fittings and other types of connectors shall be approved for the intended service. The number of joints shall be kept to a minimum in oil systems.

10.2.2 Pipes in oil systems shall be adequately supported. Supports or hangars shall not be used to force alignment of piping. Hangars or supports that have been removed for maintenance purposes shall be properly refitted. Loose hangars or supports can lead to fretting and ultimate failure of oil pipes. Hangars and supports should be lined with material that resists fretting, and fastening should be checked regularly.

11 Operational and maintenance hazards

11.1 General

Investigations of fire casualties, analysis of casualty statistics and technical research have revealed that leakage from flammable oil systems is often due to the failure of worn, incorrectly fitted or unsuitable components.

Major factors of flammable oil system component failures have been found to be

— frequent partial dismantling and reassembly of system for maintenance purposes;

— effects of high frequency, short-duration pressure pulses generated by the action of fuel-injection pumps and transmitted back into the fuel supply and spill rails;

— vibration.

11.2 High-pressure pulses in fuel oil supply and spill systems

11.2.1 The most common fuel-injection pumps (monobloc or “jerk” pumps) comprise a plunger moving up and down in a barrel that contains ports for fuel to enter and leave. The pump is designed to provide the variable fuel flow required for the engine to operate under fluctuating load by adjustment of the plunger delivery stroke. At a point determined by the engine's fuel requirement, the plunger will uncover the ports and internal pressures of between 80 MPa (800 bar) and 150 MPa (1 500 bar) will be spilled back into the fuel supply and spill piping.

11.2.2 Each injection pump action generates high pressures followed by periods of reduced pressure. As a result, maximum pressure differences exist between successive injection pumps in the engine firing order. The pressure differences accelerate columns of fuel within the piping system and, when combined with the action of the circulating pump relief valve, can cause cavitation and reflected pressure waves. Cavitation implosions occur quickly, and can induce very short-duration pressure pulses in excess of 10 MPa (100 bar).

11.2.3 Tests have determined that the magnitude of pressure pulses in the fuel system of a typical medium speed engine installation is greatest at 40 % to 60 % engine load, and will reach 6 MPa (60 bar) to 8 MPa (80 bar). The pulses are approximately 8 times the nominal pressure of the system. High-speed engines such as those installed on high-speed craft generate higher injection pressures and it is likely that the fuel system will experience correspondingly higher pressure pulses.

11.2.4 High-pressure pulses lead to vibration and fatigue, and are responsible for many failures of equipment such as thermostats, pressostats and mechanical dampers. The failure of fuel lines and their components will invariably involve fatigue and the initiation of fractures due to tensile stress.

11.2.5 High-pressure fuel pumps are often fitted with erosion plugs to act as sacrificial elements to prevent erosion of the pump body in areas where cavitation can occur. These plugs shall be checked whenever fuel pumps are overhauled and replaced if necessary. Erosion plugs should be checked regularly in service for signs of external leakage or slackening.

11.3 Design considerations

11.3.1 It is essential that the fuel system be designed to accommodate high-pressure pulses generated by the injection pumps. The engine manufacturer, the fuel system manufacturer, and the piping installer, etc. shall be consulted for an explicit statement of the fuel system parameters, including the maximum pressures that will be generated. Many engine manufacturers, aware of the potential risks due to high-pressure pulses within the fuel system, aim to limit the magnitude of the pulses to 1,6 MPa (16 bar) at the engine fuel rail outlets.

11.3.2 Some alternative approaches that may be considered by the designer to reduce risk of leakage are

- design of the fuel system such that it can withstand the magnitude of pressure pulses generated. Piping systems shall be designed and installed to an appropriate classification society or ISO specification;
- installation of pressure-damping devices;
- specification of injection pumps which are designed to eliminate or reduce high-pressure pulses.

11.3.3 The fuel line between the fuel tank and the engine is made up of several parts from different suppliers. The fact that these suppliers are unaware of, and therefore do not take into account, the pressures that may be placed on their equipment by the other components of the system, is often the reason for the system's failure. It is recommended, therefore, that a single person be given responsibility for the coordination of the specification, design and installation of all components within the fuel system, so as to ensure that they are all suitable for the anticipated high-pressure pulses. It is important for the coordinator to ensure that the design intent is fully implemented in the on-board installation.

11.3.4 There are a number of pressure-damping devices that can be fitted within fuel systems. Mechanical pressure accumulators and gas-filled bellows have both been used. However, in some cases, problems of slow response and failure due to fatigue and vibration have been experienced.

11.3.5 Fuel pipes should be of steel, and supports shall be adequate to prevent fatigue due to vibration through the structure from the engines and propellers. Support arrangements shall also protect the system from vibration caused by high-pressure pulses. Copper and aluminium-brass pipes should not be used, as their inherent work-hardening characteristics make them prone to failure when subjected to vibration.

11.3.6 Experience indicates that compression couplings require careful attention to tightening procedures and proper torques to avoid leaks or damage to the pipe. They should not be used in the fuel supply lines of engines unless specifically type-approved for that service. Flanged connections should be considered for use in place of compression couplings for fuel systems.

11.3.7 In many cases, several engines are supplied by a single fuel-supply pump and, if there is a leakage, the watchkeeper shall stop all engines. However, there are occasions when promptly stopping the engine on which the leak has developed and isolating its fuel supply and spill lines would suffice. Therefore in multi-engine installations supplied from the same fuel source, means of isolating the fuel supply to individual engines shall be provided. The means of isolation should be operable from the control position or other location not rendered inaccessible by a fire on any of the engines.

11.4 Installation

One person should be designated as responsible for coordinating the initial on-board installation of the complete fuel system. The coordinator shall be able to understand the overall design criteria and ensure that the design intent is fully implemented during installation.

11.5 Maintenance and inspection procedures

11.5.1 The ship's preventative maintenance procedures shall contain procedures to identify vibration, fatigue, poor components and poor fitting of the fuel system and ensure that proper attention to insulating hot surfaces is maintained. Check lists shall be prepared to ensure that all procedures are followed at major overhauls and that all components, supports, restraints, etc., are refitted on completion of such work. The installed system shall be inspected for

- verifying the adequacy of its supports and the condition of its fittings,
- evidence of fatigue stresses to welded or brazed pipes and connections,
- assessing the level of vibration present, and
- checking the insulation or shielding of hot surfaces.

11.5.2 Components of the fuel system shall be comprehensively examined, particularly threaded connections, at each dismantling. Required torque settings shall not be exceeded.

Other requirements include the following.

- All gaskets shall be examined prior to reinstallation following repairs.
- In no case shall O-rings and lockwires be reutilized.
- In general, tab washers shall not be used more than twice.

11.5.3 Injection pump restraining bolts shall be proved tight by testing with a torque spanner at intervals not to exceed 3 months. Torque checks shall be documented.

11.5.4 The supports and retaining devices of the low-pressure fuel system shall be checked at regular intervals not to exceed 6 months, to be proved tight and to provide adequate restraint. The lining of such devices shall be examined for wear, and renewed if they provide insufficient support.

11.5.5 Flexible-hose assemblies shall be closely examined, and renewed if signs of material cracking or deterioration are evident. Extra care shall be exercised in the tightening of these connections to ensure that the hose is not twisted when re-installed.

11.5.6 Flexible-hose assemblies shall be pressure-tested to their original design pressure at least every 5 years. Alternatively, such pipes should be the subject of a study aimed at determining their finite life and then be automatically renewed before that limit has been reached. The views of engine and oil-system manufacturers shall be sought and considered.

11.5.7 All gasket, seal-ring materials and jointing compounds used shall comply with the requirements of the engine manufacturer.

11.5.8 Where already fitted, compression fittings shall be carefully examined and, if necessary, tightened with a torque spanner to the manufacturer's specification. Replacement with flanged connections should be considered.

11.5.9 Except where otherwise allowed for flexible-hose installations, materials for flammable-liquid piping systems in Category A and other machinery spaces shall have a melting point of not less than 925 °C. Existing copper and aluminium-brass piping should be heat-treated (annealed) and sufficient supports fitted to prevent damage from vibration. Replacement with steel piping should be considered.

11.5.10 All component locking devices (such as spring and tab washers, locking wires etc.) shall be in use. It is recognized that it is impracticable to lock fuel-pump-vent screws with wire, due to their frequent use. However, wire loops containing a weight attached to each screw would prevent them from unscrewing under the influence of vibration.

11.5.11 Fuel systems on existing ships shall be compatible with the high-pressure pulses generated by fuel-injection pumps.

Annex A
(informative)

Installation guidelines for hose assemblies

A.1 Metallic flexible hoses — General installation guidelines

Two points should be observed.

a) Avoid sharp bends — There are many ways a hose can be subjected to recurring sharp bends as a result of improper installation. A few are illustrated in Figure A.1. Should piping restrictions make the correct method of installation impractical, use of an interlocked hose as a guard over the corrugated hose is recommended. The interlocking guard will reduce the severity of bends and prolong the corrugated hose life.

b) Do not torque hose — A hose is subjected to torque by

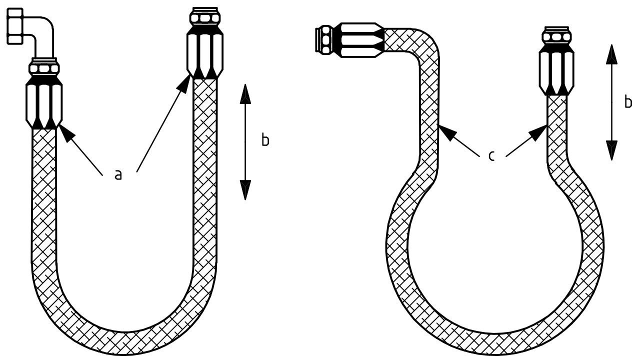
1) twisting on installation

To minimize the possibility of damage to a hose from this cause, it is recommended that a union or floating flange be provided at one end of each hose assembly.

2) twisting on flexure

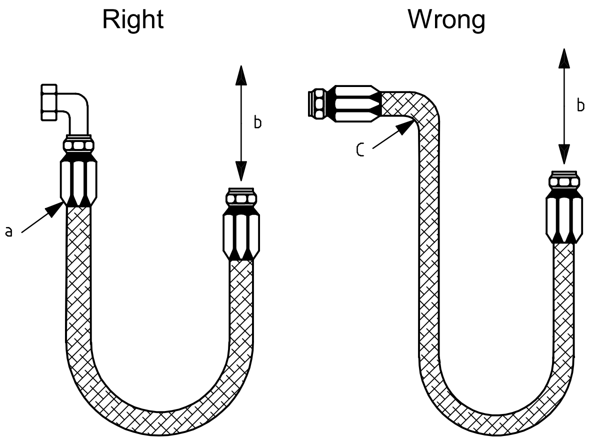
Always install hose so that flexing takes place in one plane.

Figure A.1 gives examples of these points.

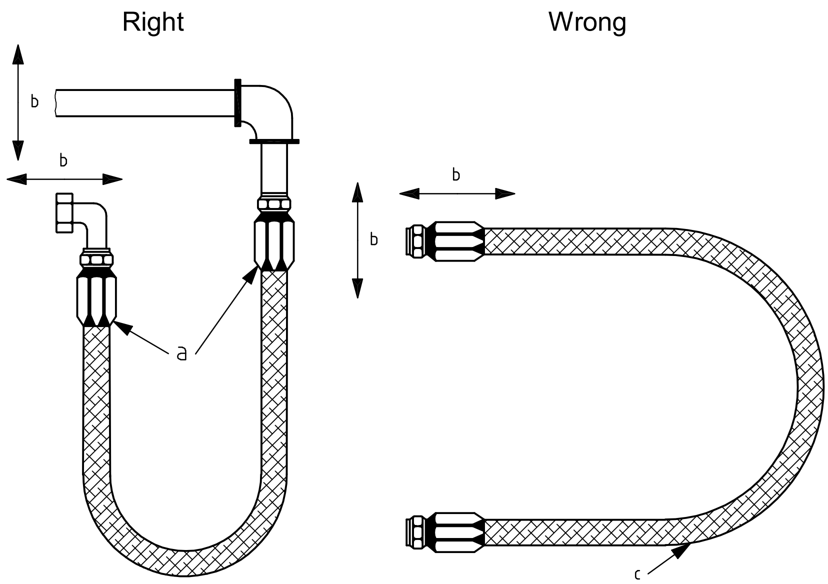


a Right
b Travel
c Wrong

Figure A.1 — Metallic flexible hose — General installation guidelines



a Right
b Travel
c Wrong



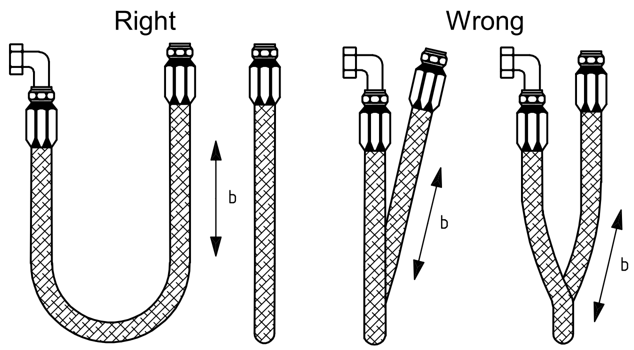
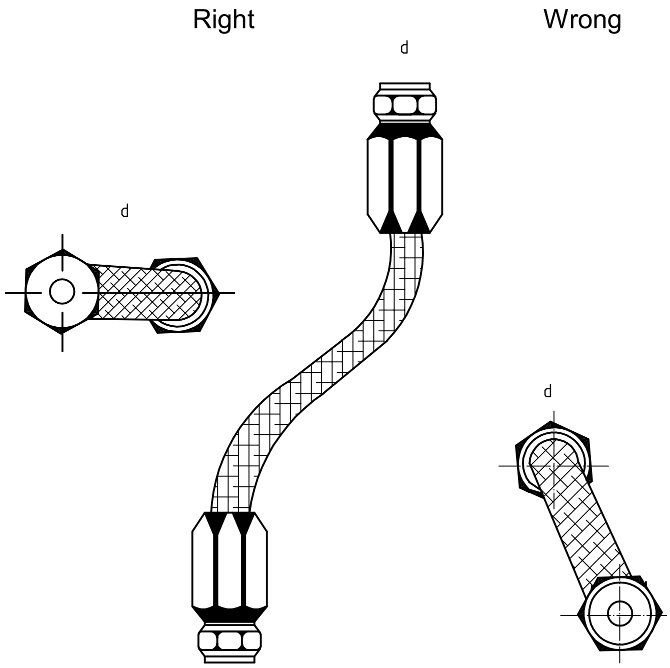


Figure A.1 (*continued*)



a Right
b Travel
c Wrong
d Motion

Figure A.1 (*continued*)

A.2 Non-metallic flexible hoses — General installation guidelines

Figure A.2 shows how to avoid problems in different situations.

The subfigures are further explained as follows.

a) Under pressure, a hose can change in length. Always provide some slack in the hose to allow for this shrinkage or expansion. (However, excessive slack in hose lines is one of the most common causes of poor appearance.)

b) If a hose is installed with a twist in it, high operating pressures tend to force it straight. This can loosen the fitting nut. Twisting can cause reinforcement separation and the hose could burst at the point of strain.

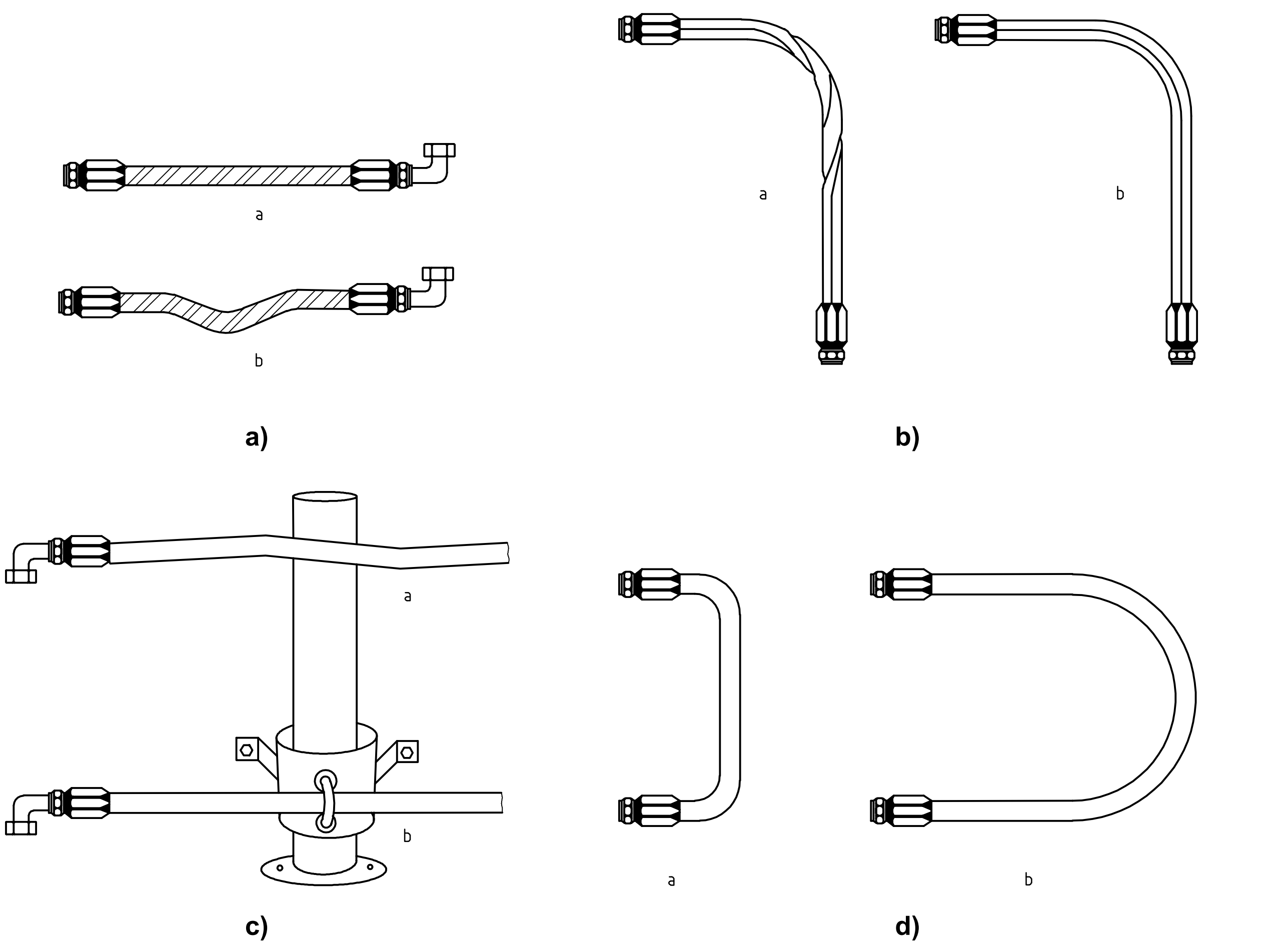
c) When hose lines pass near an exhaust manifold or other heat source, they should be insulated by a heat-resistant boot, firesleeve or a metal baffle. In any application, brackets and clamps keep hoses in place and reduce abrasion. For installations where abrasion to hose cover cannot be prevented with the use of clamps or brackets, a steel or plastic protective coil or abrasion-resistant sleeve should be placed over the hose.

d) At bends, provide enough hose for a wide radius curve. Too tight a bend pinches the hose and restricts the flow. The line could even kink and close entirely. In many cases, use of the right fittings or adapters can eliminate bends or kinks.

e) Use elbows and adapters in the installation to relieve strain on the assembly, and to provide easier installations that are accessible for inspection and maintenance. Remember that metal end fittings cannot be considered as part of the flexible portion of the assembly.

f) Install hose runs to avoid rubbing or abrasion. Clamps are often needed to support long runs of hose or to keep hose away from moving parts. It is important that the clamps be of the correct size. A clamp that is too large will allow the hose to move in the clamp, causing abrasion at this point.

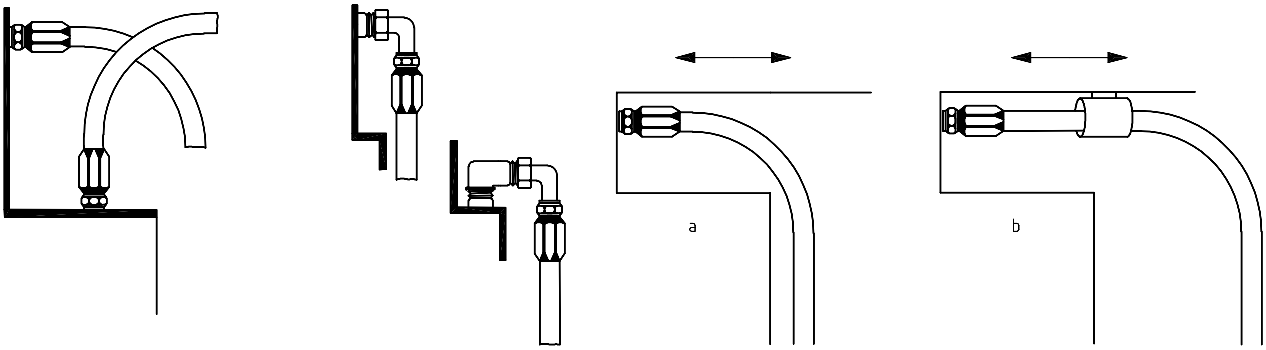
g) In applications where there is considerable vibration or flexing, allow additional hose length. The metal hose fittings, of course, are not flexible, and proper installation protects metal parts from undue stress, and avoids kinks in the hose.



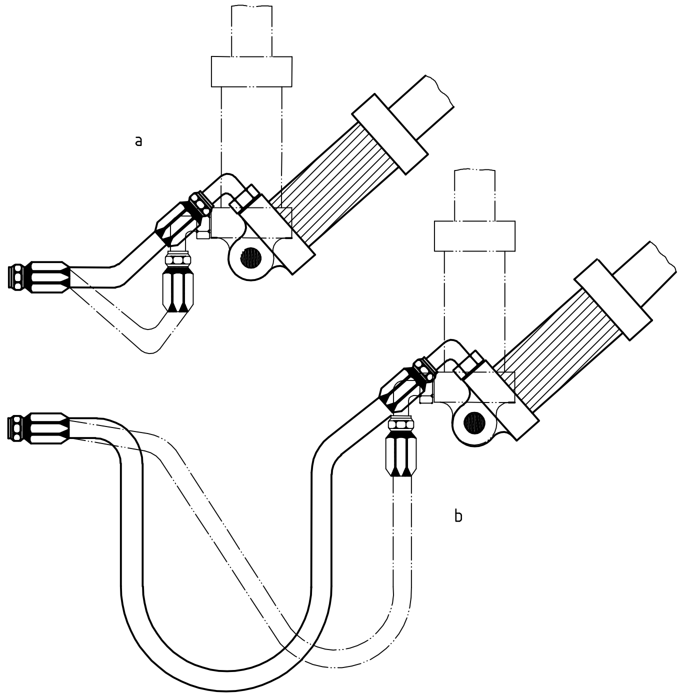
a Wrong

b Right

Figure A.2 — Non-metallic flexible hose — General installation guidelines



e) f)



g)

a Wrong

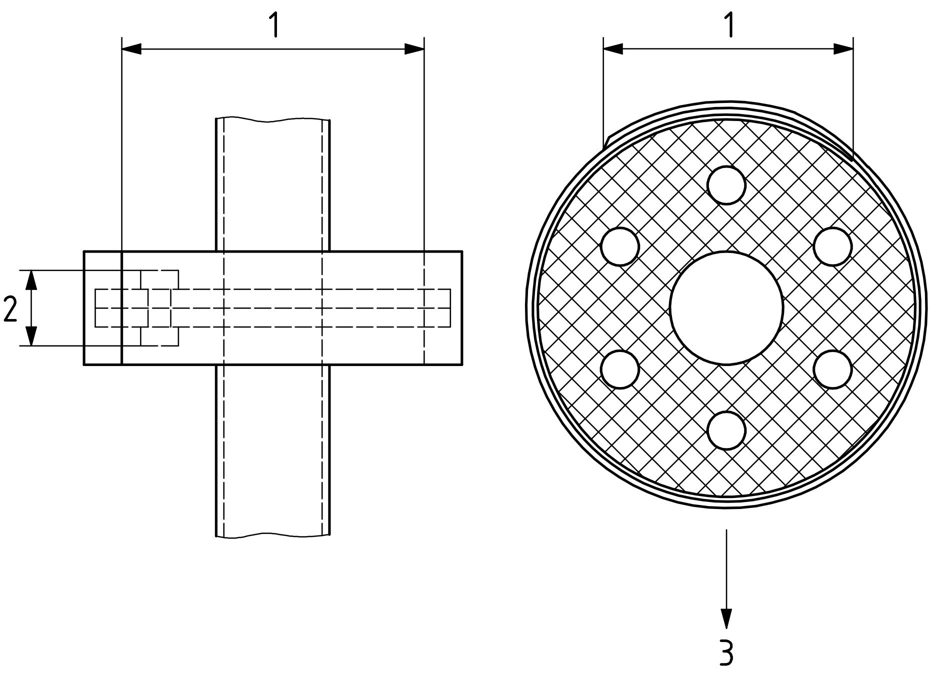
b Right

Figure A.2 (*continued*)

Annex B
(informative)

Installation guidelines for spray shields

An example of a spray shield that provides a total enclosure is given in Figure B.1. This spray shield is designed to wrap completely around the joint and is long enough to provide an overlap equal to one-quarter of the joint's circumference. The shield is wrapped around the sides of the flange far enough to cover the heads of the bolts. The shield is laced tightly with wire and the overlap is pointed away from potential ignition sources.



Key

1 overlap

2 bolt heads

3 ignition sources and hot surfaces opposite of overlap

Figure B.1 — Flange spray shield installation example

Bibliography

[1] ISO 15540:1999, *Ships and marine technology — Fire resistance of hose assemblies — Test methods*

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