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24 HOT WORK

24.1 Introduction

24.1.1 Based on the findings of the risk assessment, appropriate control measures should be put in place to protect those who may be affected. This chapter identifies some areas that may require attention in respect of hot work.

24.2 General

24.2.1 Hot work in places other than the workshop should be the subject of a permit to work (see Chapter 14, Permit to work systems).

24.2.2 Operators should be suitably trained in the process, familiar with the equipment to be used and instructed where special precautions need to be taken.

24.2.3 Before welding, flame cutting, angle grinding or other hot work is started, a check should be made that there are no combustible solids, liquids or gases at, below or adjacent to the area of work that might be ignited by heat or sparks from the work. Such work should never be undertaken on surfaces covered with grease, oil or other flammable or combustible materials. Where necessary, combustible materials and dunnage should be moved to a safe

distance before commencing operations. Such places should also be free of materials that could release a flammable substance if disturbed, for example.

24.2.4 When hot work is to be done in the vicinity of open hatches, suitable screens should be erected to prevent sparks dropping down hatchways or hold ventilators.

24.2.5 Port holes and other openings through which sparks may fall should be closed where practicable.

24.2.6 When work is being done close to or at bulkheads, decks or deckheads, the far side of the divisions should be checked for materials and substances that may ignite, and for cables, pipelines or other services that may be affected by the heat.

24.2.7 Cargo tanks, fuel tanks, cargo holds, pipelines, pumps and other spaces that have contained flammable substances should be certified as being free of flammable gases before any repair work is commenced. The testing should include, as appropriate, the testing of adjacent spaces, double bottoms and cofferdams. Further tests should be carried out at regular intervals and before hot work is recommenced following any suspension of the work. When carrying out hot work on tankers and similar ships, all tanks, cargo pumps and pipelines should be thoroughly cleaned and particular care taken with the draining and cleaning of pipelines that cannot be directly flushed using the ship's pumps.

24.2.8 Where portable lights are needed to provide adequate illumination, they should be clamped or otherwise secured in position, not handheld, with leads kept clear of the working area.

24.2.9 Hot work should be properly supervised and kept under regular observation. Suitable fire extinguishers should be kept at hand ready for use during the operation. A person with a suitable extinguisher should also be stationed to keep watch on areas that may be affected that are not visible to the seafarer doing the work.

24.2.10 In view of the risk of delayed fires resulting from the use of burning or welding apparatus, frequent checks should be made for at least two hours after the work has stopped.

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24.3 Welding and gas cutting

24.3.1 Harmful fumes can be produced from galvanising paint and other protective materials. Oxygen in the atmosphere can be depleted when using gas-cutting equipment and noxious gases may be produced when welding or cutting. Special care should therefore be taken to provide adequate ventilation when welding and flame cutting in enclosed spaces. The effectiveness of the ventilation should be checked at intervals while the work is in progress and, if appropriate, local exhaust ventilation should be considered. In dangerous spaces, breathing apparatus may be required.

24.3.2 Suggested procedures for lighting up and shutting down are in Annex 24.1.

24.4 Personal protective equipment

24.4.1 Personal protective equipment complying with the relevant standard specifications or their equivalent must be worn by the operator and as appropriate by those assisting with the operation to protect them from particles of hot metal and slag, and protect their eyes and skin from ultra-violet and heat radiation.

BS EN ISO11611:2007

The operator should normally wear:

BS EN 169:2002

- welding shields or welding goggles with appropriate shade of filter lens to EN 169 (goggles are only recommended for gas welding and flame cutting);
- leather gauntlets;
- leather apron (in appropriate circumstances); and
- long-sleeved natural-fibre boiler suit or other approved protective clothing.

24.4.2 Clothing should be free of grease and oil and other flammable substances.

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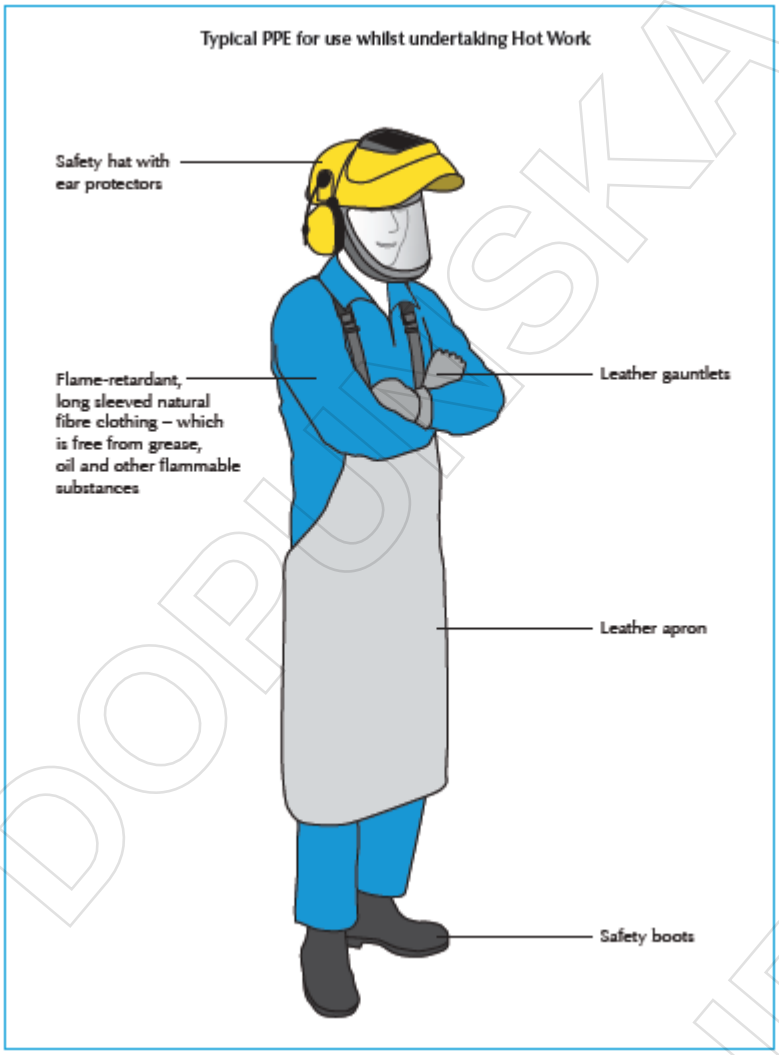

24.5 Pre-use equipment check

24.5.1 Hot work equipment should be inspected before use by a competent person to ensure that it is in a serviceable condition.

24.5.2 In cold weather, moisture trapped in the equipment may freeze and, for example, cause valves to malfunction. It is recommended that equipment is thawed out with hot water and cloths, never with naked flames.

24.6 Electric welding equipment

24.6.1 In order to minimise personal harm from electric shock, electric welding power sources for shipboard use should have a direct current (DC) output not exceeding 70V, with a minimum ripple. Further information on DC power sources is given in section 24.6.11.

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24.6.2 When DC equipment is not available, AC output power sources may be used providing they have an integral voltage-limiting device to ensure that the idling voltage (the voltage between electrode and workpiece before an arc is struck between them) does not exceed 25 V rms. The proper function of the device (which may be affected by dust or humidity) should be checked each time a welding set is used. Some voltage-limiting devices are affected by their angle of tilt from the vertical, so it is important that they are mounted and used in the position specified by the manufacturers. This requirement can be affected by adverse sea conditions.

24.6.3 A 'go-and-return' system using two cables from the welding set should be adopted; the welding return cable should be firmly clamped to the workpiece.

24.6.4 Earthing of the workpiece is used to provide protection against internal insulation failure of the welding transformer, by keeping the workpiece at or near earth potential until the protective device (e.g. a fuse) operates to cut off the mains supply. Where the welding circuit is not adequately insulated from the earthed referenced mains supply (i.e. not constructed to one of the standards listed in Annex 24.2), the workpiece should be earthed. The 'return' cable of the welding set and each workpiece should be separately earthed to the ship's structure. The use of a single cable with hull return is not recommended. The workpiece earthing conductor should be robust enough to withstand possible mechanical damage and should be connected to the workpiece and a suitable earth terminal by bolted lugs or secure screw clamps.

Note: Some manufacturers may recommend earthing as one of their measures to reduce electrical interference. This is not a safety-related measure, but the manufacturer's advice should be followed.

24.6.5 If an alternative method of protecting against welding transformer insulation failure is used, the hazards caused by stray welding currents can be avoided by not earthing the workpiece or the welding output circuit. Self-contained engine-driven welding sets, and welding power sources that comply with the standards listed in Annex 24.2, do not need the workpiece to be earthed. It should be noted, however, that other equipment connected to the workpiece may require earthing for safe operation (e.g. welding sets not constructed to one of the standards listed in Annex 24.2 or electrical pre-heating systems).

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24.6.6 To avoid voltage drop in transmission, the lead and return cables should be of the minimum length practicable for the job and of an appropriate cross-section.

24.6.7 Cables should be inspected before use; if the insulation is impaired or conductivity reduced, they should not be used.

24.6.8 Cable connectors should be fully insulated when connected, and so designed and installed that current-carrying parts are adequately recessed when disconnected.

EN 60529:1992 + A2:2013

24.6.9 Electrode holders should be fully insulated so that no live part of the holder is exposed to touch and, where practicable, they should be fitted with guards to prevent accidental contact with live electrodes, and as protection from sparks and splashes of weld metal.

24.6.10 A local switching arrangement or other suitable means should be provided for rapidly cutting off current from the electrode should the operator get into difficulties, and also for isolating the holder when electrodes are changed.

24.6.11 The direct current output from power sources should not exceed 70 volts open circuit. The ripple on the output from the power source should not exceed the values of the table below. The ripple magnitudes are expressed as percentages of the DC, and the ripple peak is that with the same polarity as the DC.

Ripple frequency, Hz	50/60	300	1200	2400
Max. rms O/C voltage ripple, (%)	5	6	8	10
Max. peak O/C voltage ripple, (%)	10	12	16	20

24.6.12 The conditions in the table in section 24.6.11 are normally met by DC generators incorporating commutators and by rectifier power sources having a three-phase bridge rectifier operating from a three-phase 50/60 Hz supply. Rectifier power sources should not be operated from a power supply of less than 50 Hz.

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24.6.13 Should it be necessary to use a power source with a DC output having a ripple magnitude in excess of those stated in the table (e.g. a single-phase rectifier power source), then a voltage-limiting device should be incorporated in the power source to ensure that the idling voltage does not exceed 42V.

24.7 Precautions to be taken during electric arc welding

24.7.1 In addition to the protective clothing specified in section 24.4.1, the welding operator should wear non-conducting safety footwear complying with BS 7193:1989. Clothing should be kept as dry as possible as some protection against electric shock; it is particularly important that gloves should be dry because wet leather is a good conductor.

24.7.2 An assistant should be in continuous attendance during welding operations and they should be alert to the risk of accidental shock to the welder and ready to cut off power instantly, raise the alarm and provide artificial respiration without delay. It may be desirable to have a second assistant if the work is to be carried out in difficult conditions.

24.7.3 Where persons other than the operator are likely to be exposed to harmful radiation or sparks from electric arc welding, they should be protected by screens or other effective means.

24.7.4 In restricted spaces, where the operator may be in close contact with the ship's structure or is likely to make contact in the course of ordinary movements, protection should be provided by dry insulating mats or boards.

24.7.5 There are increased risks of electric shock to the operator if welding is done in hot or humid conditions; body sweat and damp clothing greatly reduce body resistance. Under such conditions, the operation should be deferred until such time that an adequate level of safety can be achieved.

24.7.6 In no circumstances should a welder work while standing in water or with any part of their body immersed.

24.7.7 The electrode holder should be isolated from the current supply before a used electrode is removed and before a new electrode is inserted. This precaution is necessary because some electrode coatings have extremely low resistance. Even a flux coating, which is normally insulating, can become damp from sweating hands and thus potentially dangerous.

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24.7.8 When the welding operation is completed or temporarily suspended, the electrode should be removed from the holder.

24.7.9 Hot electrode ends should be ejected into a suitable container; they should not be handled with bare hands.

24.7.10 Spare electrodes should be kept dry in their container until required for use.

24.8 Compressed gas cylinders

24.8.1 Compressed gas cylinders should always be handled with care, whether full or empty. They should be properly secured and stored in a location appropriate to their intended use and risks, which an inadvertent release of gas may present. The cylinders should be so secured as to be capable of quick and easy release, e.g. in the case of fire. Where appropriate, cylinder trolleys should be used to transport cylinders from one place to another.

24.8.2 If the cylinder design permits protective caps over the valve, such caps should be screwed in place when the cylinders are not in use or are being moved. Where the cylinder design does not permit protective caps over the valve, the valve system should be protected from inadvertent damage, e.g. from impact. Valves should be closed when cylinders are empty.

24.8.3 Care should be taken in the storage of flammable gases used for hot work. The storage should:

- be separated according to type of gas, and empty cylinders kept separate from full ones;
- be well ventilated;
- not be subject to extremes of temperatures;
- not contain any sources of ignition, including electronic devices; and
- be prominently marked 'No smoking' and have safety signs in accordance with the standards in Chapter 9, Safety signs and their use, Annex 9.1.

24.8.4 The following precautions also need to be taken in the case of compressed gas cylinders:

- Cylinders' valves, controls and associated fittings should be kept free from oil, grease and paint; controls should not be operated with oily hands.
- Gas should not be taken from such cylinders unless the correct pressure-reducing regulator has been attached to the cylinder outlet valve.

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- Cylinders found to have leaks that cannot be stopped by closing the outlet valve should be taken to the open deck away from any sources of heat or ignition and slowly discharged to the atmosphere.

24.8.5 Identifying marks on cylinders are set out in section 9.7.

24.9 Gas welding and cutting

24.9.1 While this section deals almost exclusively with oxygen and acetylene, other fuel gases may be used and similar precautions should be taken.

24.9.2 The pressure of oxygen used for welding should always be high enough to prevent acetylene flowing back into the oxygen line.

24.9.3 Acetylene should not be used for welding at a pressure exceeding 1 atmosphere gauge because it is liable to explode when under excessive pressure, even in the absence of air.

24.9.4 Non-return valves should be fitted adjacent to the torch in the oxygen and acetylene supply lines.

24.9.5 Flame arrestors should be provided in the oxygen and acetylene supply lines and will usually be fitted at the low-pressure side of regulators, although they may be duplicated at the torch.

24.9.6 Should a backfire occur (i.e. the flame returns into the blowpipe and continues burning in the neck or mixing chamber), the recommended first action is to close the oxygen valve on the blowpipe – to prevent internal burning – followed immediately by shutting off the fuel gas at the blowpipe valve. Items 3–6 of the shutting-down procedure in Annex 24.1 may then be followed. When the cause of the backfire has been discovered, the fault rectified and the blowpipe cooled down, the blowpipe may be re-lit.

24.9.7 If there is a flashback into the hose and equipment, or a hose fire or explosion, or a fire at the regulator connections or gas supply outlet points, the first action should be to isolate the oxygen and fuel gas supplies at the cylinder valves or gas supply outlet points – but only if this can be done safely. Further action should follow in accordance with the vessel's fire-drill requirements.

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24.9.8 A watch should be kept on acetylene cylinders to ensure that they are not becoming hot. If they are, this could be a sign of acetylene decomposition and there is an increased risk of explosion. The cylinder stop valve should be closed immediately, which may limit or reduce the decomposition but is unlikely to stop it. Emergency action, such as evacuating the area and prolonged cooling by immersion or with copious amounts of water, will still be required. Consideration should be given to jettisoning the cylinder overboard, although movement of the cylinder can promote rapid decomposition, and cooling should continue while it is being moved. Any acetylene cylinder suspected of overheating should be approached with extreme caution because an impact could set off an internal ignition, which might cause an explosion.

24.9.9 Only acetylene cylinders of approximately equal pressures should be coupled.

24.9.10 In fixed installations, manifolds should be clearly marked with the gas they contain.

24.9.11 Manifold hose connections, including inlet and outlet connections, should be such that the hose cannot be interchanged between fuel gases and oxygen manifolds and headers.

24.9.12 Only those hoses specially designed for welding and cutting operations should be used to connect any oxy-acetylene blowpipe to gas outlets.

24.9.13 Any length of hose in which a flashback has occurred should be discarded.

24.9.14 The connections between hose and blowpipe and between hoses should be securely fixed with fittings that comply with Standard EN 1256. (More detailed guidance on hose connections and assemblies can be found in Annex 24.3.)

EN 1256:2006

24.9.15 Hoses should be arranged so that they are not likely to become kinked, tangled, tripped over, cut or otherwise damaged by moving objects or falling metal slag, sparks, etc. A sudden jerk or pull on a hose is liable to pull the blowpipe out of the operator's hands, or cause a cylinder to fall or a hose connection to fail. Hoses in passageways should be covered to avoid them becoming a tripping hazard.

24.9.16 Soapy water should only be used for testing leaks in hoses. If there are leaks that cannot easily be stopped, the gas supply should be isolated and the leaking components taken

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out of service, replaced or repaired. If the leak is at a cylinder valve or pressure regulator ('bull-nose') connection, the cylinder should be removed to a safe place in the open air. If it is a fuel-gas cylinder, it should be taken well clear of any source of ignition.

24.9.17 Excessive force should never be used on cylinder valve spindles or hexagon nuts of regulator connections in an attempt to stop a leak. Sealing tape and other jointing materials are not recommended for use in an attempt to prevent leaks between metal–metal surfaces that are designed to be gas tight. With an oxygen cylinder, this could result in initiation of a metal–oxygen fire.

24.9.18 Blowpipes should be lit with a special friction igniter, stationary pilot flame or other safe means.

24.9.19 Should a blowpipe-tip opening become clogged, it should be cleaned only with the tools especially designed for that purpose.

24.9.20 When a blowpipe is to be changed, the gases should be shut off at the pressure-reducing regulators.

24.9.21 To prevent a build-up of dangerous concentrations of gas or fumes during a temporary stoppage or after completion of the work, supply valves on gas cylinders and gas mains should be securely closed and blowpipes, hoses and moveable pipes should be removed to lockers that open onto the open deck.

24.9.22 Oxygen should never be used to ventilate, cool or blow dust off clothing.

24.10 Further information

24.10.1 Detailed advice on the selection and standards for equipment used in hot work is contained in the Health and Safety Executive (HSE) guidance note, 'HSG139 The safe use of compressed gases in welding, flame cutting and allied processes', which can be found on the HSE website.

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ANNEX 24.1 HOT WORK: LIGHTING UP AND SHUTTING DOWN PROCEDURES

These procedures are appropriate for oxy-fuel gas equipment and, with little modification, also for air-aspirated blowpipes.

Pre-lighting up

1. Complete risk assessment including survey of all adjacent spaces and obtain hot-work permit to work.
2. Fire sentries to be posted in all adjacent compartments.

Lighting up

1. Ensure that the pre-use equipment checks have been made.
2. Check that the outlets of adjustable pressure regulators are closed, i.e. that the pressure-adjusting screw of the regulator is in the fully unwound (anti-clockwise) position.
3. Check that the blowpipe valves are closed.
4. Slowly open the cylinder valves (or gas supply point isolation valves) to avoid sudden pressurisation of any equipment.
5. Adjust pressure regulators to the correct outlet pressures, or check that the pressures in distribution pipework are suitable for the equipment and process.
6. Open the oxygen valve at the blowpipe and allow the flow of oxygen to purge* air out of the oxygen hose and equipment. If necessary, reset the pressure regulator to ensure the correct working oxygen pressure.
7. Close the oxygen valve at the blowpipe.
8. Open the fuel gas valve at the blowpipe and allow the gas flow to purge* air or oxygen from the fuel gas hose and equipment. If necessary, reset the pressure regulator to ensure the correct working fuel gas pressure.
9. Light the fuel gas immediately, and preferably with a spark lighter.
10. Open the oxygen valve at the blowpipe and adjust it and the fuel gas valve to give the correct flame setting.

* Purging is important. It removes flammable gas mixtures from the hoses and equipment, which could result in explosions and fires when the blowpipe is first lit. It should be carried out in a well-ventilated area, and it may take from several seconds to a minute or more depending on the length of the hose and gas flow rates.

Shutting down

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1. Close the fuel gas valve at the blowpipe.
2. Immediately close the oxygen valve at the blowpipe.
3. Close the cylinder valves or gas supply point isolation valves for both oxygen and fuel gas.**
4. Open both blowpipe valves to vent the pressure in the equipment.
5. Close the outlets of adjustable pressure regulators by winding out the pressure-adjusting screws.
6. Close the blowpipe valves.

** Step 3 is not necessary when the equipment is to be used again in the immediate future.

On completion of hot work and following shutdown, all adjacent compartments should be visited to ensure that all is well.

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ANNEX 24.2 EARTHING OF ARC-WELDING SYSTEMS' TRANSFORMER CASING

Earthed	Class I appliance
Not earthed	Class II appliance

Transformer secondary

Earthed

This is an obsolete type of equipment and should be taken out of service. Failure of the weld-return connection might not be noticed, and damage to other earthed metallic paths could result.

Isolated

The absence of a weld-return conductor will prevent welding being carried out. However, a failure of isolation within the welding set could cause the work item to become live. For this reason, the workpiece should be earthed.

Isolated with double or reinforced insulation

BS EN 60974-1:2012

This is the most recent standard to which equipment is being built. Owing to the strengthened insulation, the workpiece need not be earthed. Furthermore, to prevent the possibility of stray weld-return currents in the supply system earth conductors, it is recommended that the workpiece is not earthed. Such welding power sources may be identified by the additional symbol if made to the relevant parts of BS EN 60974-1:2012 and complying with the requirements of British Standard Code of Practice 7418:1991, or they will be marked with the standards numbers EN 50.060, EN 60.974 or IEC974.

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ANNEX 24.3 HOT WORK: HOSES AND CONNECTIONS/ASSEMBLIES

Hoses

Rubber hoses complying with Standard BS EN ISO 3821:2010 are recommended for use in gas-welding and cutting processes, which are often carried out in aggressive working environments. Hoses satisfying these standards are reinforced with an outer protective cover designed to be resistant to hot surfaces, molten slag or sparks, and made with linings that resist the action of hydrocarbons (for liquefied petroleum gas (LPG) hose), acetone or dimethyl formamide (for acetylene hoses) and ignition in an atmosphere of oxygen (for all services). Burst pressure is 60 bar g and maximum working pressure 20 bar g.

BS EN ISO 3821:2010

Hose made of thermoplastics materials is not generally suitable for welding and cutting, because it does not have the same resistance to hot surfaces or hot particles as reinforced rubber hose.

BS 3212:1991

Connections

Hose connections (comprising hose nipples and 'bull-nose' hose connections) comply with EN 1256, ISO/TR 28821:2012 or equivalent. Thread sizes specified in these standards are based on Whitworth dimensions, which are generally used in this field in many countries. Right-hand threads are used for oxygen and non-combustible gases; left-hand threads are used for fuel gases, with the hexagon nuts on their union connections notched to aid identification.

EN 1256:2006

Hose connections may also be made with a quick-action coupling – a male probe fitted to the end of the hose and a female connector with a self-sealing valve usually fitted to a fixed piece of equipment or gas supply outlet point. The probe is pushed into the female fitting where it locks in position and automatically opens the internal valve. Connections of this type are simple and quick to operate, and there is no need to use a spanner to tighten any nuts.

Problems are that the male probe may become damaged (e.g. from being dragged along the ground or overuse) and cause the coupling to leak, and there is a possibility of connecting the hose to the wrong gas outlet. Both should be avoided if couplings comply with Standard EN 561 or ISO 7289:2010. These require hard material of construction to be used for the probes,

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and their design dimensions are intended to prevent interchangeability between oxygen and fuel gas connections.

BS EN 561:2002

Hose assemblies

Hose lengths are usually supplied in the UK as pre-assembled units complete with connection fittings crimped to the ends of the hose. Hose and hose-nipple dimensions are matched by the supplier to ensure a good fit. The recommended standard for hose assemblies is EN 1256, which specifies requirements for leak tightness and resistance to axial loading. Worm drive or similar clips are not recommended for fastening hoses.

BS EN 1256:2006

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