

23.1 Introduction

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

23.2 General

23.2.1 Welding and flame-cutting elsewhere than in the workshop should generally be the subject of a 'permit-to-work' (see Chapter 16).

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

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

23.2.4 Harmful fumes can be produced during these operations 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 when welding and flame-cutting in enclosed spaces to provide adequate ventilation. 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 confined spaces, breathing apparatus may be required.

23.2.5 Suggested procedures for lighting up and shutting down are at Annex 23.1.

23.3 Personal Protective Equipment

23.3.1 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 their eyes and skin from ultra-violet and heat radiation.

23.3.2 The operator should normally wear:

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

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

23.4 Pre-use equipment check

23.4.1 Welding and flame-cutting equipment should be inspected before use by a competent person to ensure that it is in a serviceable condition.

23.4.2 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.

23.5 Precautions against fire and explosion

23.5.1 Before welding, flame-cutting or other hot work is begun, a check should be made that there are no combustible solids, liquids or gases, at, below or adjacent to the area of work, which 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 which could release flammable substance for example if disturbed.

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

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

23.5.4 Where 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 which may ignite, and for cables, pipelines or other services which may be affected by the heat.

23.5.5 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, cofferdams etc. Further tests should be carried out at regular intervals and before hot work is recommenced following any suspension of the work. When preparing 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 pumps.

23.5.6 Welding and flame-cutting operations 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 not visible to the welder which may be affected.

23.5.7 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.

23.6 Electric welding equipment

23.6.1 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 23.6.1.1.

23.6.2 When DC equipment is not available, then 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 work piece 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.

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

23.6.4 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 (eg 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 23.2) 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 the electrical interference. This is not a safety related measure, but the manufacturer's advice should be followed.

23.6.5 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 which comply with the standards listed in Annex 23.2 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 (eg welding sets not constructed to one of the standards listed in Annex 23.2 or electrical pre-heating systems).

23.6.6 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.

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

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

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

23.6.10 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.

23.6.11 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

23.6.12 The conditions in the table 23.6.11 are normally met by DC generators incorporating commutators and by rectifier power sources having a 3 phase bridge rectifier operating from a 3 phase 50/60 Hz supply. Rectifier power sources should not be operated from a power supply of less than 50 Hz.

23.6.13 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, for example 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.

23.7 Precautions to be taken during electric arc welding

23.7.1 In addition to the protective clothing specified in 23.3.2 the welding operator should wear non-conducting safety footwear complying with BS 7193. Clothing should be kept as dry as possible as some protection against electric shock; it is particularly important that gloves should be dry as wet leather is a good conductor.

23.7.2 An assistant should be in continuous attendance during welding operations, who 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.

23.7.3 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.

23.7.4 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.

23.7.5 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.

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

23.7.7 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.

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

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

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

23.8 Compressed gas cylinders

23.8.1 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 inadvertent release of gas may present. The cylinders should be so secured as to be capable of quick and easy release, for example, in the case of fire. Where appropriate, cylinder trolleys should be used to transport cylinders from one place to another.

23.8.2 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 from for instance impact. Valves should be closed when the cylinder is empty.

23.8.3 Where the International Maritime Dangerous Goods (IMDG) Code requires cylinders of differing gases to be segregated, such gases should be stored in separate, well-ventilated compartments that are not

subject to extremes of temperature. If gas is flammable, the compartment in which the cylinders are stowed should have no electrical fittings or other sources of ignition and prominent and permanent 'NO SMOKING' signs should be displayed in the entrance and within the space. Empty cylinders should be segregated from the full ones and so marked. All gas cylinder stores should be appropriately marked with safety signs, to the standards as in Annex 28.1.

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

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

23.8.5 Identifying marks on cylinders are set out in Section 28.5.

23.9 Gas Welding and Cutting

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

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

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

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

23.9.5 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.

23.9.6 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 23.1 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.

23.9.7 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.

23.9.8 A watch should be kept on acetylene cylinders to ensure they are not becoming hot. If they are, this could be 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.

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

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

23.9.11 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.

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

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

23.9.14 The connections between hose and blowpipe, and between hoses should be securely fixed with fittings which comply with Standard EN 1256. [More detailed guidance on hose connections and assemblies is in Annex 23.3].

23.9.15 Hoses should be arranged so that they are not likely to become kinked or tangled or be tripped over; cut or otherwise damaged by moving objects or falling metal slag, sparks etc; a sudden jerk or pull on the 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.

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

23.9.17 Excessive force should never be used on cylinder valve spindles or hexagon nuts of regulator connections in an attempt to stop a leak. Neither are sealing tape nor other jointing materials 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.

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

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

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

23.9.21 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 on to the open deck.

23.9.22 Oxygen should never be used to ventilate, cool or blow dust off clothing (see also Section 20.7)

23.10 Further information

23.10.1 Detailed advice on the selection and standards for equipment used in hot work is contained in the HSE guidance note "The Safe Use of Compressed Gases in Welding, Flame Cutting and Allied Processes" (HS(G)139).