Hot Work Permit and Safety Precautions in connection with welding and cutting work onboard

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Welding and cutting work are an unavoidable part of maintenance during voyage. However, when this type of hot work is performed onboard it must be done according to the International Safety Management Code and stringent safety procedures. In the below article we give information regarding the Hot Work Permit that applies for ships. This is followed by detailed safety information when performing Electric arc welding and Gas welding/cutting processes onboard.

International Safety Management (ISM) Code

The purpose of the International Safety Management (ISM) Code is to provide an international standard for the safe management and operation of ships and for pollution prevention.

The Code's origins go back to the late 1980s, when there was mounting concern about poor management standards in shipping. Revised Guidelines were adopted by resolution A.913(22) in 2001, and subsequently by resolution A.1022(26),adopted in December 2009, resolution A.1071(28) in December 2013, and revised Guidelines adopted by resolution A.1118(30) with effect from 6 December 2017.

Definition

Work involving sources of ignition or temperatures sufficiently high to cause the ignition of a flammable material and gas mixture is termed as Hot Work. This includes any work requiring the use of welding, cutting or brazing equipment, some power-driven tools, portable electrical equipment which is not intrinsically safe or contained within an approved explosion-proof housing, and internal combustion engines.

Hot Work Permit

A document issued by a Responsible Person permitting specific Hot Work to be done during a particular time interval in a defined area. The safety management system (SMS) should include adequate guidance on the control of Hot Work and should be robust for compliance to deliver the expectations of International Safety Management (ISM) code and confirm that it is effective and that stated procedures are being followed.

Responsibility

Master

1. The Master must satisfy himself that hot work is justifiable before granting permission for hot work to be carried out on the ship. It is the master's responsibility to ensure that the established procedures for all hot-work are implemented and complies fully with the company requirements.
2. If in port, Local port and/or terminal approval is obtained in writing prior carrying out any work.
3. All flag state regulations are considered.
4. Conduct a safety briefing to ensure that control measures are in place and understood & complied with to the fullest extent.
5. Prepare a risk assessment with the heads of department to ensure that the environment onboard is sufficiently safe for hot-work and identify any conflicting operation carried out simultaneously.
6. Issue the Work Permit just prior commencing work, monitor all safety controls are maintained throughout and cancel the permit if conditions are breached or advised by the responsible officer.

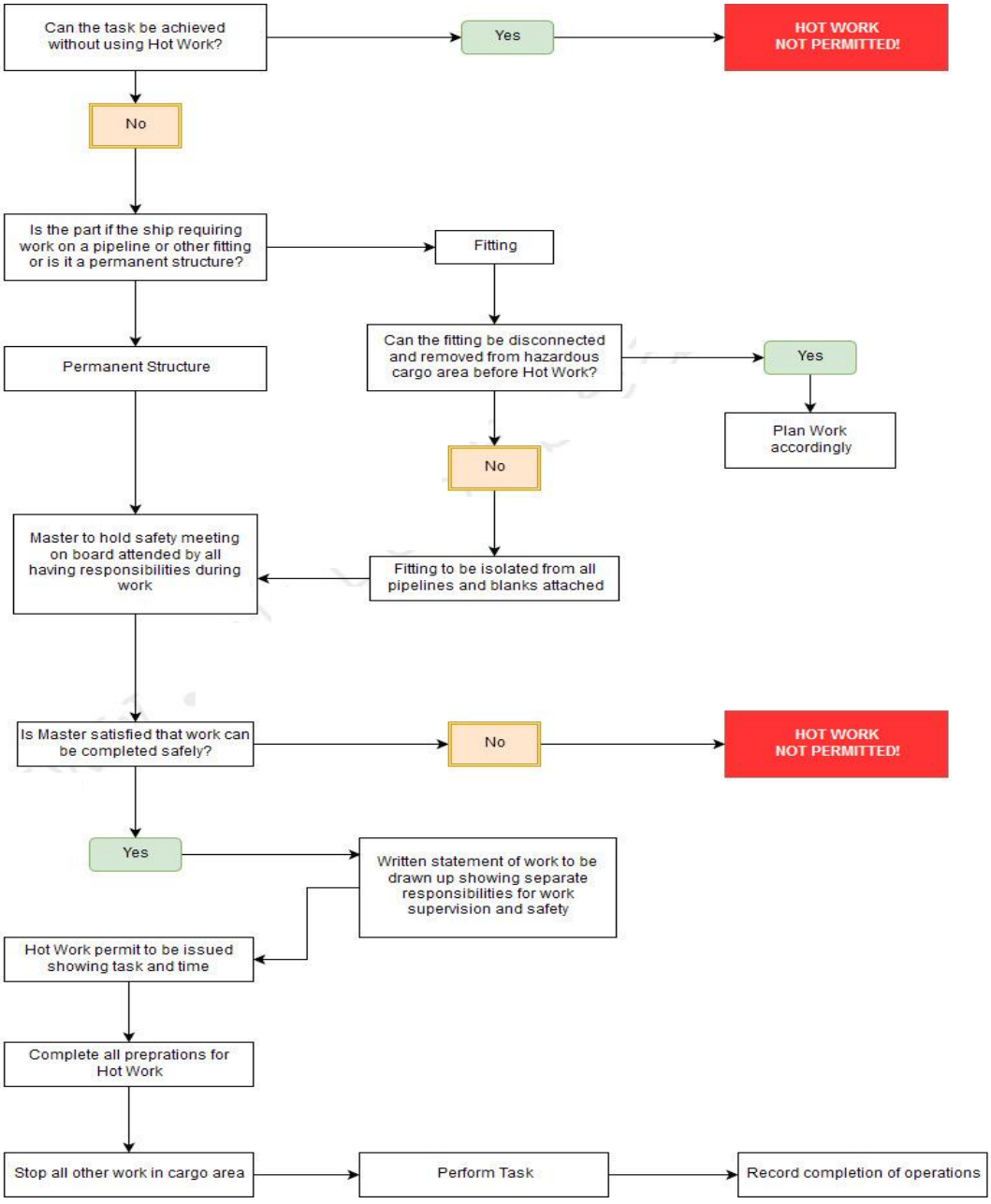
Head of Department (Chief Officer & Chief Engineer)

1. Inspecting the work area and the equipment to be used for hot-work together with the person/s carrying out the job.
2. Physically checking and filling-up the work permit jointly with the responsible officer and the person/s involved in the work.
3. Testing the atmosphere of the work area where applicable.
4. Ensuring continuous effective ventilation of the work area.
5. Determining that hot-work is safe to be carried out and signing the permit.
6. Monitor the work is going on as per safety briefing.
7. Inform the master to retract the permit if safe working conditions are breached.
8. To continue monitoring the worked area for at least 30 minutes after completion of hot work or until the risk of fire no longer exists.

The person carrying out the job is responsible for:

9. Following the safe procedures established and for using the specified personal protective equipment.

Hot work flow chart as in ISGOTT (International Safety Guide for Oil Tankers and Terminals)



Control

Hot Work inside a Designated Space

The Designated space for hot-work onboard is allocated where it is safe to carry out such operation with hot-work permit not required to be issued. However, the duty officer on the bridge shall always be informed before the start of hot work inside a designated space. Usually, Engine Room workshop is considered as a Designated Space.

Hot Work outside a Designated Space

To prevent unauthorized hot work outside the designated hot work area, welding extension cables & portable welding machines will be controlled items and kept under lock & key in the engine room workshop locker. The master is the only person allowed to approve any hot work outside the designated hot work area with prior approval from the company.

The Hot Work Process

1. The work area shall be carefully prepared and isolated before Hot Work commences.
2. Fire safety precautions and fire extinguishing measures shall be reviewed. Adequate fire-fighting equipment must be prepared, laid out and ready for immediate use.
3. Fire watch procedures must be established for the area of Hot Work and for adjacent spaces where the transfer of heat or accidental damage might create a hazard, e.g. damage to hydraulic lines, electrical cables, thermal oil lines, etc. The fire watch should monitor the work and take action in case of ignition of residues or paint coatings. Effective means of containing and extinguishing welding sparks and molten slag must be established.
4. The work area must be adequately and continuously ventilated and the frequency of atmosphere monitoring must be established.
5. When alongside a terminal, Hot Work should only be permitted in accordance with prevailing national or international regulations, port and terminal requirements.
6. Personnel carrying out the work shall be adequately trained and have the competency required to carry it out safely and effectively.
7. The Hot Work Permit shall be issued immediately before the work is to be performed. In the event of a delay to the start of the work, all safety measures shall be re-checked before work actually commences.
8. If the conditions under which the permit has been issued should change, Hot Work must stop immediately. The permit shall be withdrawn or cancelled until all conditions and safety precautions have been checked and reinstated to allow the permit to be reissued or re-approved.
9. Isolation of the work area and fire safety precautions should be continued until the risk of fire no longer exists.

10. Risks Involved in Carrying out Hot Work and Control Measures to be taken:

Hazard involved	**Control Measures to be made**
Inhalation hazard due to smoke generation.	– Proper PPE shall be done at all times. – Ventilation running throughout operation (if applicable). Source for driving the ventilation fan(s) must be kept on (air compressor/fire pump) throughout the hot work operation. – Follow safe practices as per Code of Safe Working Practices for Merchant Seamen (COSWP).
Electric Shock.	– Approved and good condition of electric welding equipment i.e. cables, electric holder shall be used. – All electric welding equipment to be checked for insulation, minimum 1 Mega ohm. – Earthing cable to be connected.
Eye injury	– Welding mask and safety goggles to be used. – All personnel involved in the operation shall wear safety glasses.
Falling from a height. Slipping/tripping depending on the location of hot work.	– Proper PPE shall be done at all times. – Adequate non-skid shoes to be worn. – Ensure area is clear of any slipping hazard. – Safety harness shall be used where applicable. – Working aloft checklist to be completed so as to avoid any crucial points.
Personnel injury by falling objects.	– Whilst lowering any objects, safety lines/ buckets to be used. – All equipment and ropes to be used for the job shall be thoroughly inspected. – Prior lowering any objects, ensure that all personnel in the space are clear underneath.
Burns, Scalds due to contact with Hot Surfaces.	– Proper PPE shall be donned at all times. – Personnel involved in the hot work to exercise utmost care to ensure no contact is made with hot surfaces.
Fire/ explosion hazard.	– A fire watch shall be posted. – Fire Fighting Equipment to be ready for immediate use in the vicinity. – All elements of the hot work permit shall be followed prior commencement of hot work. – Gas checks to be carried out to ensure space is free of any combustible material.

Hot work traditionally includes, but is not limited to, any work requiring the use of electric arc or gas welding equipment, cutting burner equipment or other forms of naked flame, as well as heating or spark generating tools which are not certified for use in hazardous areas.

Hot work within the cargo area is prohibited on ships that are carrying or have carried a flammable substance or those that emit flammable vapours, except when the process is strictly controlled in accordance with the ship's hot work procedures.

- Ensure the space is well ventilated
- If flammable gasses are suspected then test before and during the hot work task
- Check that the immediate area is free from combustibles
- Check neighbouring or connected areas (such as other side of bulkhead) or internal areas (such as inside a tank) that may be heat affected, to make sure they are free from flammables and combustibles
- Bulkhead insulation may need to be removed
- If appropriate, use portable barriers or shields and warning signs
- Maintain a dedicated fire watch for both the immediate area and any potentially affected neighbouring/ connected areas throughout the full operation
- Proper use of Personal Protective Equipment, such as welding mask/ goggles, gloves, apron
- Make sure that the welding and burning equipment is properly maintained and serviced
- Welding and burning equipment must be checked by a competent person before every use. Check that the hoses, cables and connections are in good condition
- Check that flame arrestors are in place on both the oxygen and acetylene lines at both the torch and bottle ends

  Persons carrying out the hot work should be properly trained and checks made to ensure they are competent.

  1.Hot work procedures

  Hot work procedures must be developed based on MSC/Circ.1084, Principles for Hot Work on Board All Types of Ships. The procedures must be incorporated into the SMS of the ship where such systems are required.

2. The procedures must ensure that:

- any hot work is justified and deemed necessary for the safety and/or the immediate operation of the ship and that all viable alternatives have been considered;
- the hot work policy supports a permit-to-work system that is easily understandable to the crew;
- a risk assessment has been conducted to consider all hazards, including but not limited to:

  -entering enclosed spaces if applicable to the job
  -the type of cargo being carried;
  -surrounding hazards near the work area (e.g. ventilator heads);
  -whether a fitting can be removed from a hazardous cargo area before hot work is performed;
  -availability of local fire-fighting equipment;
  -the anticipated duration of the work; and
  -the appointment of a suitably qualified responsible officer-in-charge.
- the Master maintains overriding authority and discretion to take actions deemed necessary in accordance with MI-108, §7.41.1.

3. Industry guidance

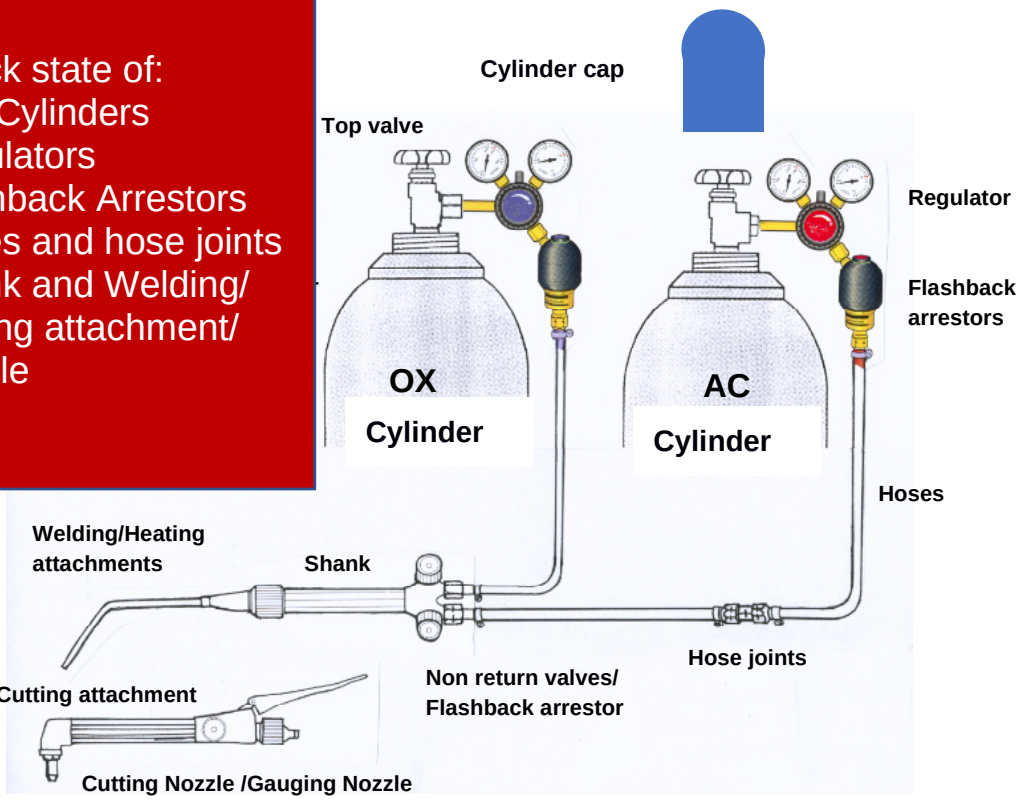
Industry guidance appropriate to the ship type is to be utilized when developing the hot work procedures. This guidance includes, but is not limited to, the most recent versions of:

- OCIMF, Guidelines on Safety Management Systems for Hot Work and Entry into Enclosed Spaces;
- ISGOTT, International Safety Guide for Oil Tankers and Terminals (ISGOTT), Chapter 9, Management of Safety and Emergencies, and Chapter 10, Enclosed Spaces;
- ICS, Tanker Safety Guide (Chemicals);
- ICS, Tanker Safety Guide (Liquefied Gas);
- BLU Code, The Draft Code of Practice for the Safe Loading and Unloading of Bulk Carriers; and
- ILO publication, Accident prevention on board ship at sea and in port.

Special safety precautions regarding:

Compressed gasses, Gas welding & Cutting equipment

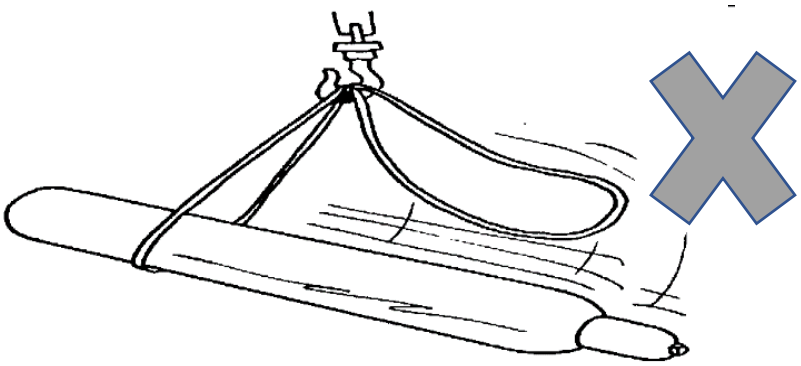
Check state of:
Gas Cylinders
Regulators
Flashback Arrestors
Hoses and hose joints
Shank and Welding/ Cutting attachment/ Nozzle



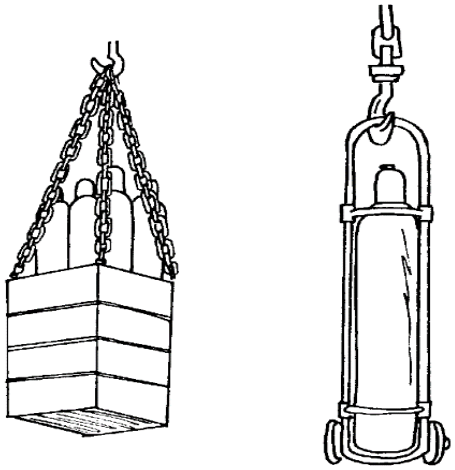
Gas Cylinders

- STORAGE OF CYLINDERS SHOULD BE ON OR ABOVE THE UPPER MOST OPEN DECK WITH DIRECT ACCESS TO OPEN DECK.
- NEVER STORE CYLINDERS INSIDE THE SHIPS HULL.
- Always make sure that the cylinder cap that protects the top valve is in place and screwed down before moving the cylinder. Cylinders, when not in active use, should have the cylinder cap in place and properly secured to prevent them from falling.

- Never use slings, chains or magnets to lift gas cylinders.



- Use racks, baskets or cylinder trolleys specially designed for hoisting gas cylinders, and equipped with proper lifting lugs. Cargo nets are not recommended for lifting gas cylinders. If a cargo net has to be used, it must be covered internally with a good tarpaulin to prevent the cylinders from sliding out through the mesh. If a crane or winch is used to lift gas cylinders, and the crane driver is not in a position from which he can see the entire hoisting operation, a signalman must be stationed where he can see both the load and the crane driver.



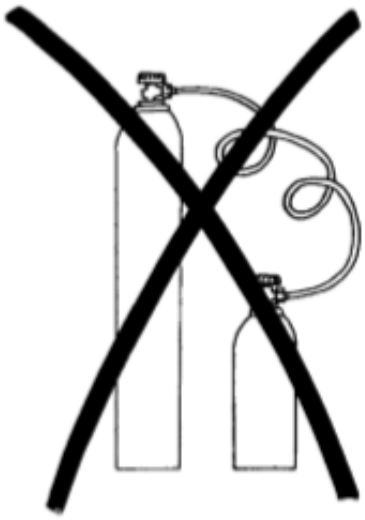
- Gas cylinders must never be hoisted or dragged by the cylinder cap or top valve. Do not subject the cylinders to unnecessary impacts or jolts during transport. Do not allow the cylinders to fall, or knock against one another.

- Never use gas cylinders as rollers or props for other cargo, or for any purpose whatever other than to contain a specific gas.

- Take care to avoid using or storing gas cylinders in places where they could become part of an electrical circuit. Never touch a cylinder with a live electrode.

- Never use flames to raise the pressure of a cylinder. Cylinders should not be subjected to temperatures above 45°C (113°F). As far as possible, avoid exposure of gas cylinders to moisture or salt water. Never expose cylinders to corrosive chemicals or gases.

- It is extremely dangerous, and therefore forbidden, to attempt to transfer oxygen or acetylene from one cylinder to another on one's own.



- During transport, gas cylinders must always be handled as if they were full. Never be indifferent or careless because they are "empties". Mistakes can be made, and full cylinders may be mixed with empty ones. Therefore, during transport treat all cylinders as if they were full.

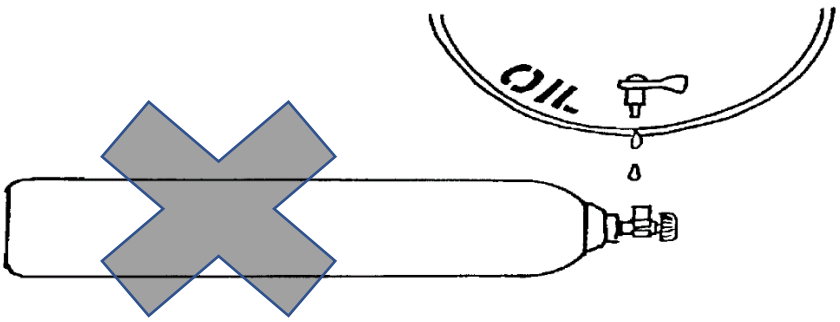
TRANSPORT CYLINDERS PREFERABLY USING A PURPOSE DESIGNED CYLINDER TROLLEY

- If the cylinder valve cannot be opened by hand alone, put the cylinder aside and inform the supplier. Never use wrenches or other tools to open cylinder valves. On valves intended for valve keys, use only valve keys supplied by or approved by the gas manufacturer. Valves with handwheels must be operated by hand only, without tools. Never hammer the hand-wheel in order to get the valve open or shut.

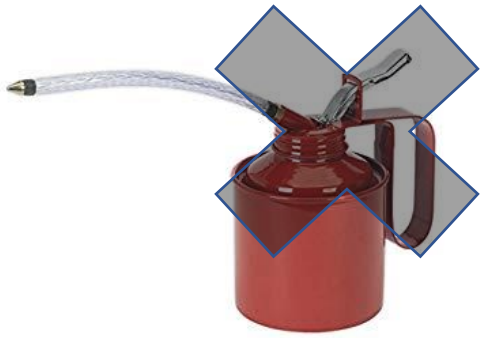
- The valve opening of the acetylene cylinder shall point away from other compressed gas cylinders, and a heat resistant mitten shall be available.

- **CYLINDERS MUST BE USED IN THE UPRIGHT POSISION AND SAFETY LASHED**

- Keep oil and grease away from valves and connections. High pressure oxygen will react violently with oil or grease which may explode.



- The operator's hands must not have Grease on them when handling Welding and cutting equipment.



Regulators

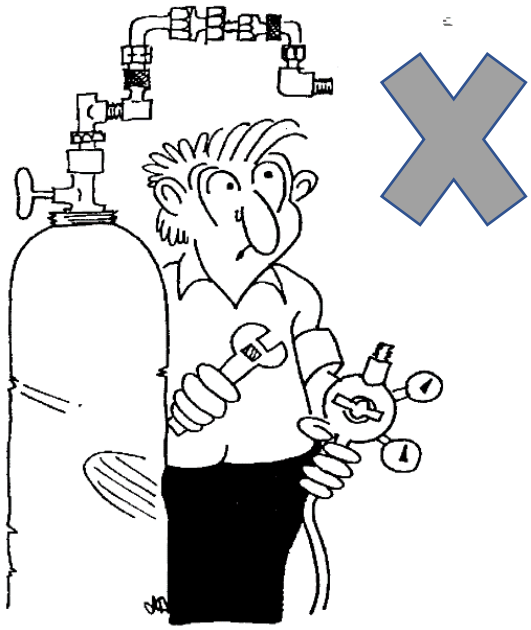
- The regulator for use is to be made according to standards:
  Oxygen regulator: EN ISO 2503 Class 3
  Acetylene regulator: EN ISO 2503 Class 2
  This will normally be stated by an imprint on the regulators back side.

- Open and close the top valve on the cylinder before mounting the regulator. This is in order to avoid particles entering into the regulator and cause accident.

- Make sure that the Regulators inlet connection is fitted with the correct type of washer/ gasket:
  ACETYLENE: Teflon washer/ gasket Polyamide PA6
  OXYGEN: Aluminium or Teflon washer/ gasket. Under no circumstances must one use a washer of organic material. Organic material at 150 bar (2176 psi) pressure and a purity of 99,5% oxygen might self-ignite.

- Inspect that the inlet pressure gauge and the working pressure gauge on the regulators are in working order.

- Make sure the regulator is mounted so that the safety valve outlet is pointed upwards.
- **NEVER MAKE EQUIPMENT FOR ACETYLENE OR OXYGEN YOURSELF**



- Life expectancy of regulators: Replace with 5 years interval.

Flashback Arrestors

- The flashback arrestors for use is to be made according to standards:
  EN 730-1/ISO 5175-1
  Preferably also BAM approval: BAM/ZBA/009/012
- The flashback arrestor should incorporate the following features:
  - ✓ Non- return valve
  - ✓ Flame arrestor
  - ✓ Temperature sensitive shut-off valve
  - ✓ Pressure sensitive shut-off valve
- Life expectancy: Replace with 5 years interval

Hoses

Regulators, flashback arrestors and the shank with its welding or cutting attachment are made of brass. The weak link in a gas welding/ cutting set up is the hoses. For flexibility, they are made of rubber and thereby vulnerable to damage, wear and tear by the elements.

Oxygen and Acetylene leaking can enrich the atmosphere to dangerous levels and cause fire and explosions. Normal oxygen content in air is 21%. Only a 3% increase will double the burning speed. An acetylene concentration in air reaching 12% will turn into a powerful explosion if ignited. Hoses must therefore be in accordance to European Norm ISO 3821 (before 2013 EN 559) This implies that the hose has been tested to 40 bar (580 psi) and max working pressure not to exceed 20 bar (290 psi). Hoses manufactured to this standard will have a minimum burst pressure of 60 bar (870 psi).

Hoses are measured on internal diameter and are normally available in 9mm (3/8”) or 6mm (1/4”) size. In the maritime industry the color code is Red for Acetylene and Blue for Oxygen. Hoses can be purchased as single hoses or as Twin hoses (Acetylene and Oxygen “welded together”). The hose should have an imprint with the applicable norm and year of manufacturing.

Hoses will over time deteriorate and it is important to keep them under close observation. The most vulnerable place is close to the shank (handle) where there is a lot of movement increasing the wear rate. Sometime it is sufficient to cut back half a meter and re fit the hose, sometime the entire hose length has to be replaced.

To give an exact lifetime expectancy for an oxy/ acetylene hose is close to impossible. Out on the open deck under strong sun light and seawater environment to freezing cold represent a number of variables that makes case-to-case evaluation necessary. Make sure to not purchase hoses that have an imprint that indicate more than 2 years old. Rubber hoses are fresh produce and will deteriorate.

A bending test is a simple way of checking the state of the hose

- Do not use welding gas hoses for other purposes, e.g. for compressed air or propane, and do not use air hoses for welding gases.

- Blow new hoses clean internally before connecting to blowpipes. Nitrogen or another inert gas is preferred to blow through Acetylene and Oxygen hoses. Never use compressed air, which may contain oil.

- Keep hoses away from strong heat and extreme cold, oil and grease, chemicals, and from slag and sparks from electric welding, gas welding or oxygen cutting.

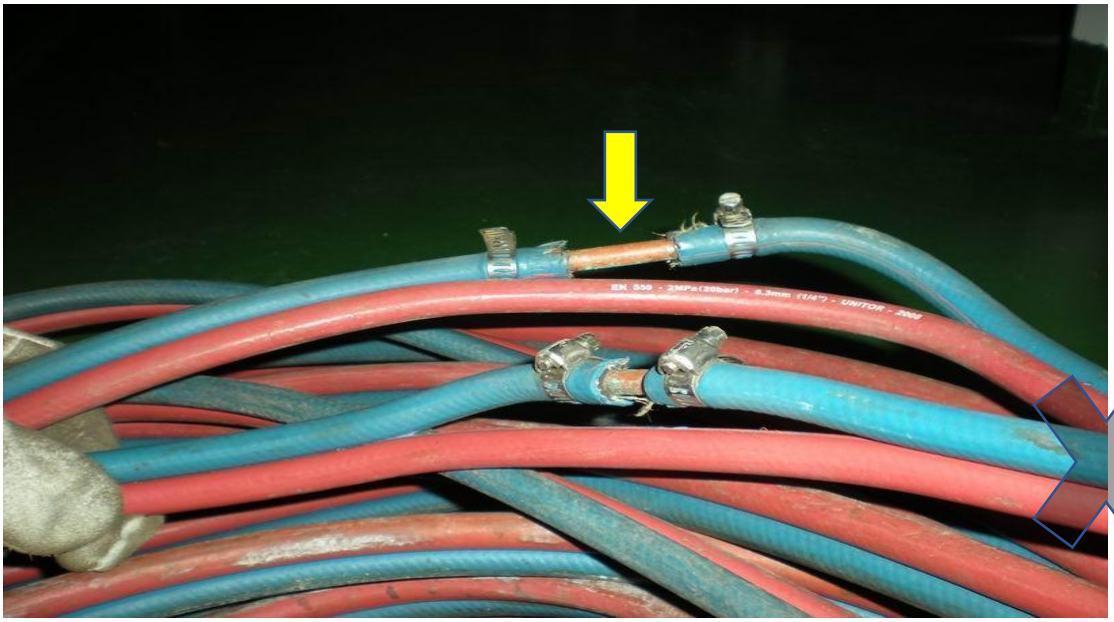
- Avoid undue stretching and kinking of hoses. Hanging hoses must be supported at suitable intervals. When gas hoses are not in use they must be coiled and hung up so as to avoid, as far as possible, the entry of damp or dirt.

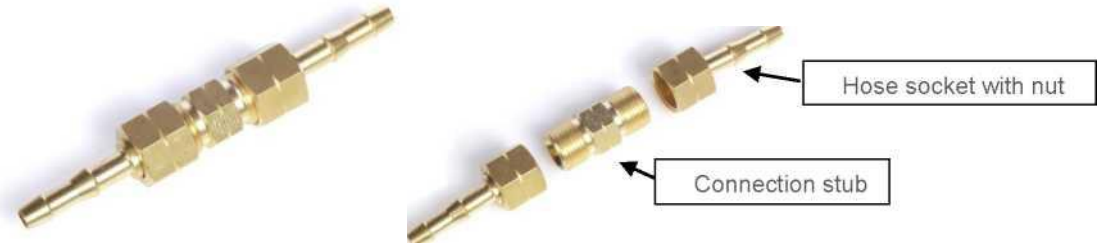
- Inspect hoses at regular intervals. Hoses of doubtful quality or condition should be scrapped. Do not use hoses that have been damaged by flashback or hose fires. Check that the rubber is supple and without cracks (do this by bending the hose). Check the hoses for leakage by dipping them in water while they are under normal pressure.

- Hoses must never be repaired by patching. Repair a leak immediately by cutting off the damaged part.

Hose connections

Hose connections are another source for leakages. It's of great importance that hose joints are not substituted by pipes of any kind. Use only type approved hose connectors. Pipes do not have the flange that prevents the hose slipping off under pressure. Also remember that acetylene reacts violently towards copper and that oxygen will react on oil or grease left in a steel pipe.



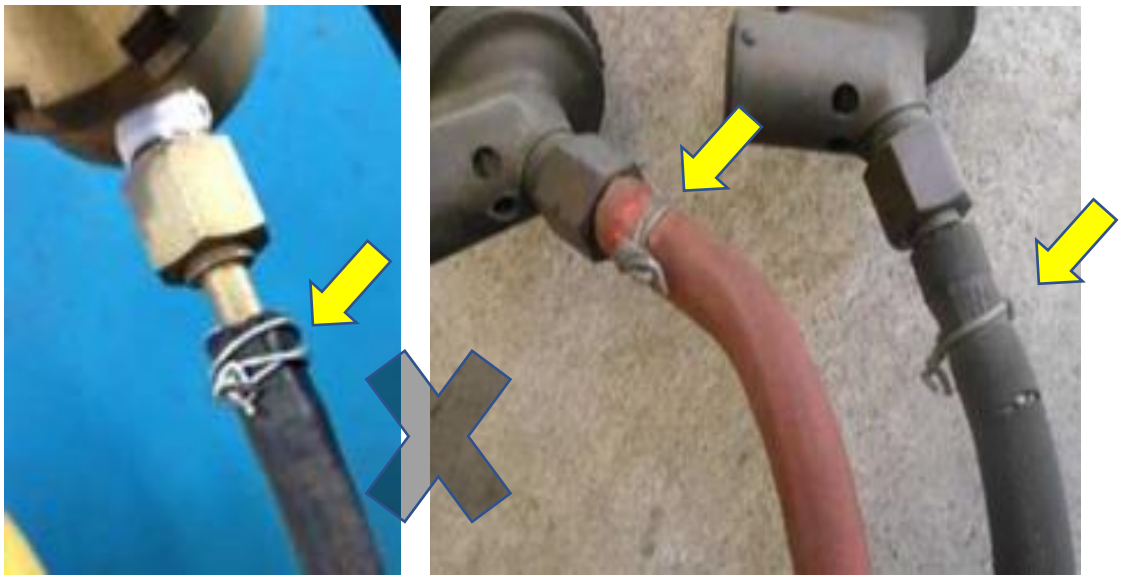


This is what proper hose joints should look like. Hose connectors have hose socket for 9mm (3/8") or 6mm (1/4") hose. Oxygen right hand treads an acetylene left hand treads.

- Hose connectors are used where long lengths of hose are needed. Screw the couplings together into a gastight joint (check with soapy water). It is not necessary to use force. Gentle tightening spares the sealing surfaces and should give a perfectly gastight connection.
- Always use the correct hose couplings to connect the welding hoses - never use metal tubing. Hose connectors have loose hose sockets with nuts for 9 mm (3/8”) and 6 mm (1/4”) welding hose. The connecting nuts on the oxygen couplings are right-hand threaded. The acetylene couplings are left-hand threaded and the connecting nut has an indentation in the corners of the hexagon for easy identification. This is international practice, and gives the operator extra protection by reducing the possibility of interchanging hoses.

Hose clamps

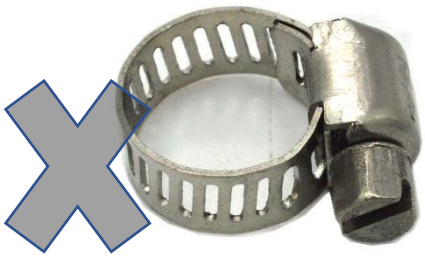
Do not substitute hose clamps with twisted metal wire or any other improvised solution.



The most common type of hose clamp is the Jubilee clip also referred to as worm drive type. They are popular because they give the opportunity for re use/ re mounting of the hoses. They have however a number of drawbacks. They can be tightened either too much and then damaging the hose, or too little making it slip off. They do not give a uniform result. They are also protruding out and can easily be hocked on corners or cause injuries by cutting the operator.

"The Code of Safe working Practice"
Chapter 23.3, states:

"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".



Worm drive/ Jubilee clip

Ear clamp

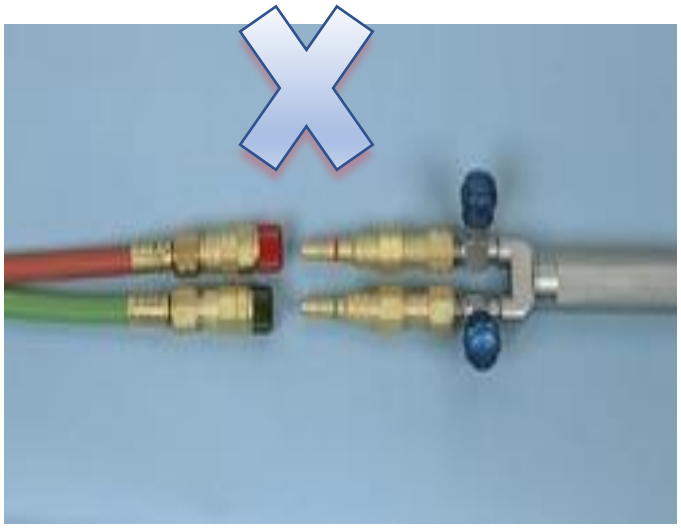
Preferably use ear clamps. They are gentler with the hose and give a uniform result. The reason for worm drives popularity is that they can be used repeatedly. This unfortunately on the expense of safety.

Ear clamp used to connect hose at shank and at flashback arrestor.

Quick connectors

- The quick connectors for use are to be made according to standards:
  EN 561, ISO 7289

- Quick connectors are convenient items that cuts back on rigging up time. They must however be connected up correctly and be of a type that do not accidently release.
- They must also be so designed that the interchange of acetylene and oxygen hose is impossible
- Make sure to never connect quick connectors directly to the shank. Always keep a distance of minimum 2m (6,5') to the first quick connector on the hoses.



Pre mounted hose connections

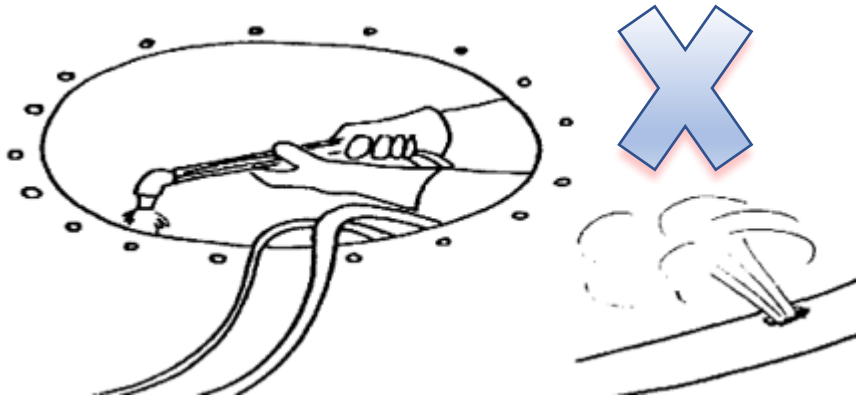
Today a number of suppliers also offer pre mounted hose connections. This is definitely the best and safest solution.

Shank (The blowpipe handle that can be fitted with cutting or welding attachment).

- The shank and its welding and cutting attachments is to be made according to standards: EN ISO 517211 K4
- The minimum requirement is that the shank must be fitted with a Non- return valve (back flow check valves). Non return valves prevents the passage of gas in the opposite direction. Effective to stop oxygen or acetylene back feeding and mixing within one of the hoses.
- Preferably the shank should also be fitted with a small-scale flashback arrestor that contain:
  - ✓ Non- return valve
  - ✓ Flame arrestor
- Inspect all seals and seating surfaces on welding and cutting attachments before being mounted to the shank.
- Carefully inspect tip and orifices on welding attachment and cutting nozzle.

Special notes regarding working in confined space using oxygen and acetylene equipment

- Do not leave oxygen and acetylene equipment in confined space when not in use.
- Do not use hoses that look worn.
- Check for faults and leaks. Pressurise the complete set up. Then close the cylinder top valve and check if there is any pressure drop on the regulator gauges. If pressure drop:
  Regulators, Flashback arrestors, Shanks: Leak detector spray.
  Hoses: Run hoses through a bucket of water to check for leaks.



- When in use in confined space, someone who understand the equipment should be stationed outside to control the gas supply and give the operator any necessary assistance.
- Never wrap hoses around your body.
- Welding, cutting and brazing with a gas torch can produce smoke, which may contain several toxic substances. Of the gases produced, it is primarily the nitrous gases (NO2 + NO) that are a health hazard. The amount of nitrous gases in the smoke depends on several conditions. The use of large size torches in confined spaces can quickly produce dangerous concentrations. No warning is given of the presence of these gases in the form of irritation of the mucous membrane in eyes, nose or throat. Proper ventilation must be arranged, and when working in confined spaces, the welder must not leave the torch alight when he is not actually using it.

- Carbon monoxide may be given off due to incomplete combustion of the gases or if the material being welded or cut is plastic coated, varnished, painted or oily. High concentrations, which constitute a health risk, can be formed in confined spaces, tanks, pipes etc. Inhalation of large quantities of carbon monoxide can lead to suffocation.

- Check adjacent compartments for flammable objects before commencing work.

Special safety issues regarding Oxygen and Acetylene:

Flashback

What is a Flashback?

A flashback will be initiated at the cutting nozzle or welding attachment tip (orifice).

Under correct conditions where there is a balance between the gas mix Exit velocity (speed of the gas out of the nozzle) and the Combustion velocity (speed of the gas burning) the gas burns correctly and stably.

If the gas mix Exit velocity is higher than the Combustion velocity, blow-off occurs. The flame burns at a distance away from the nozzle tip. This is corrected by the operator decreasing the pressure and thereby the velocity speed.

What will start a flashback is if the Combustion velocity exceeds the gas mix Exit velocity. If this happens, the flame burns into the equipment.

There are 3 distinct different types of the phenomena:

BACKFIRE

A backfire implies that the flame burns back into the welding torch with a sharp bang. Either the flame is extinguished or it reignite itself at the nozzle opening. A backfire is harmless in itself but it can be a sign of a fault in in equipment or gas supply.

SUSTAINED BACKFIRE

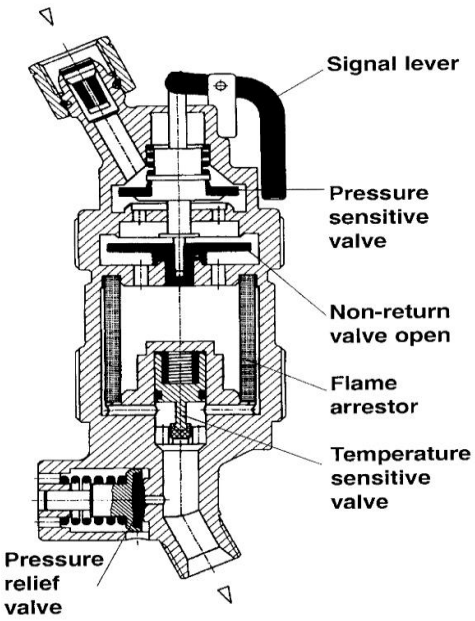
In a sustained backfire the flame burns, back into the torch handles mixing point (where oxygen and acetylene is mixed). It is characterised by an initial bang (backfire) followed by a whistling sound. If it is not quickly interrupted, the torch will melt and escaping combustion products can cause injuries. To stop a sustained backfire rapidly close the oxygen valve followed by the acetylene valve on the shank.

FLASHBACK

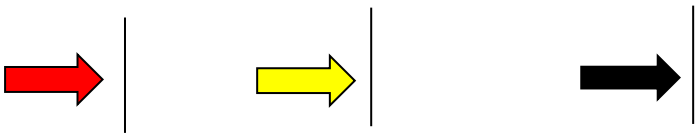
A flashback implies that the flame burns back at a very high speed through the torch, hoses and regulator. If the flashback reaches the acetylene cylinder, which lack the necessary safety equipment the flashback might enter the cylinder. A flashback consists of a Pressure front moving at twice the speed of sound, followed by a Flame front, followed by the Gas back feeding.

What can you do to prevent flashback?

- Do not use oxy/acetylene equipment unless you have been trained.
- Check the state of cutting nozzle and welding neck. Keep these items in good condition. Poorly maintained cutting nozzles and welding necks cause turbulent gas flow disturbing the gas mix Exit velocity, which increases the risk of flashback. Inspect nozzles and welding neck regularly. Make sure they are not blocked by dirt or spatter. Replace damaged nozzles.
- Check that the welding shank is fitted with non-return valves and that regulators are fitted with flashback arrestors.



Because the flashback consists of a Pressure front, a Flame front, and the Gas Back feeding, the flashback arrestor must be constructed accordingly.



GASES BACK FEEDING FLAME FRONT PRESSURE FRONT

The Pressure sensitive shut-off valve will be triggered if there is a sudden pressure change of approximately 1,2 bar (17,4 psi). This will also trigger the Non- return valve and cut off further gas supply from the cylinders. The flashback arrestor can be re-opened by depressing the signal lever. This should however not be done before the reason for the flashback have been found.

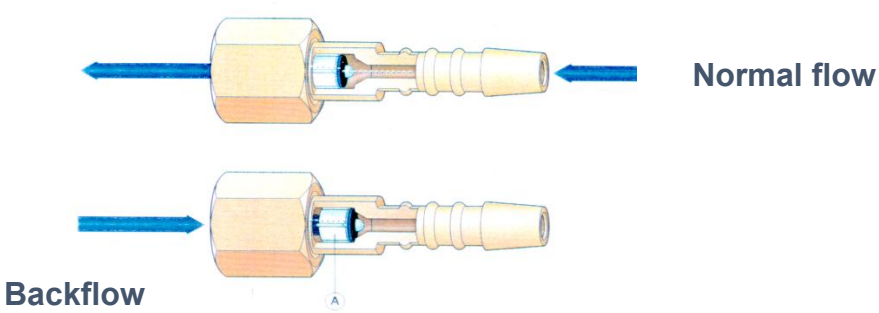
The Flame arrestor is made out of porous sintered stainless steel that allow the gas to pass through it. The flame front will not be able to penetrate this barrier and will be extinguished.

Should the unit be overheated the flashback arrestor is also fitted with a temperature sensitive valve that will melt at 95 °C (203°F). If this happens the Flashback arrestor will not be able to re set and the flashback arrestor will have to be replaced.

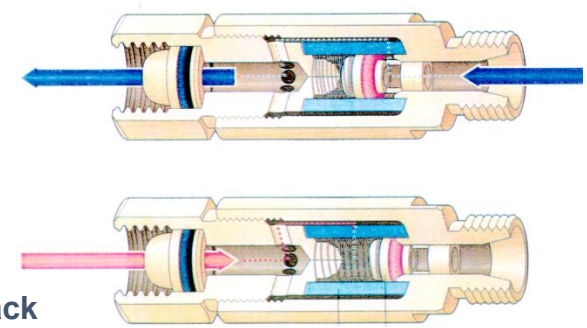
An additional feature on some Flashback arrestors is that they also are fitted with an Explosion Relief valve that opens at 7,5 bar (109 psi) for acetylene and 13-14 bar (189-203 psi) for oxygen. The pressure during a flashback can be more than 60 bar (870 psi) so the benefit of this valve is that it reduces the risk for a hose explosion.

Flashback arrestors should be according to EN 730-1/ISO 5175-1 and preferably have a BAM approval. Life expectancy: Replace with 5 years interval.

When it comes to Non-return valves (back flow check valves) that are mounted on the welding shank (handle) it prevents the passage of gas in the opposite direction. It is effective to stop oxygen or acetylene back feeding and mixing within one of the hoses. Keep in mind it does not respond quickly enough to stop a full flash- back.



In order to further, improve safety towards the operator one can move some of the flashback arrestor features down to the shank (handle) itself. The below shank flashback arrestor incorporates the non-return valve and flame arrestor in one single unit.



This type of flashback arrestor does not substitute the Flashback arrestor on the Regulator.

If a flashback does occur:

- Immediately close the cylinder valves, both acetylene and oxygen, if it is safe to do so. The flame should go out when the acetylene is shut off. If the flame cannot be put out at once, evacuate the area. It is important to have a mitten at a convenient location near to the gas cylinder. The mitten is made of a flame-retardant material and can be used on right or left hand. It is used for closing the top valve of an acetylene cylinder that is on fire.

- Check any acetylene cylinder which has been involved in a flashback or which may have been affected by fire or flames. If it becomes more than hand warm (60 to 70 °C/ 140 to 158°F) or starts to vibrate, evacuate the location immediately. Do not attempt to move an unstable cylinder. It could be several days before the cylinder can be moved. Moving the cylinder could restart or accelerate the decomposition. Use the fire hose from a distance of at least 20m (66') and hose down the cylinder body with a direct water spray. Cooling down is the only way of stopping a decomposition.

- Depending on situation, throw the cylinder overboard. If shore based, fill container with water and keep cylinder submerged for a minimum of 24 hours.

It is important that cylinders are kept on the uppermost open continues deck where they can easily be handled and removed in case of an emergency. Preferably as part of a Gas Distribution System (GDS). Avoid keeping cylinders inside the hull of the vessel.

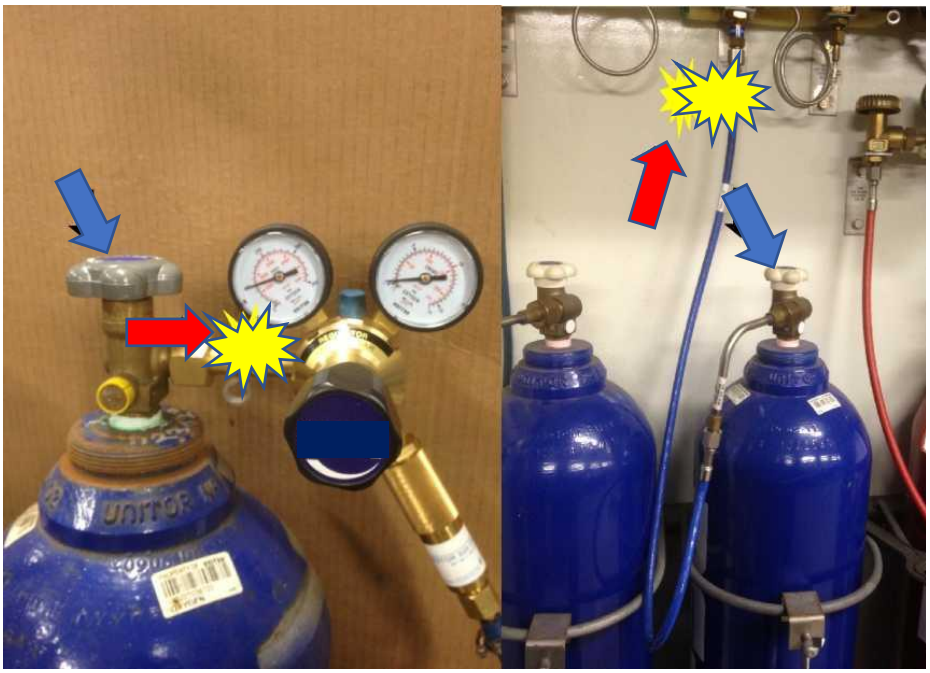
Acetylene is an extremely flammable gas. It is different from other flammable gases because it is also unstable (2 parts Carbone, 2 parts Hydrogen (C2H2)). Under certain conditions, it can decompose explosively into its constituent elements, carbon and hydrogen. Decomposition will be triggered at approximately 300°C (572°F). Despite this, the cylinder is by itself built to prevent detonation. Its design is different from most other gas cylinders. It consists of a steel shell containing a porous mass. The porous mass is a cellular structure, which completely fills the cylinder. The acetylene gas in the cylinder is dissolved in acetone, which is absorbed by the porous mass. Decomposition of the acetylene is usually triggered by heat. For example, involved in a flashback, involved in a fire, or scorched by flames from a welding torch. The porous mass is designed to slow down or stifle any decomposition of the gas. A detonation wave will have difficulties moving through a porous mass consisting of calciumoxyde lime and silicates. From the start of decomposition to the cylinder exploding should take several hours. This will usually (but not always) provide time for emergency action.

Adiabatic compression

The most likely accident handling and operating oxygen cylinders and its equipment is a phenomena called adiabatic compression.

Adiabatic compression (“GAS HAMMER” effect/ Metal fire).
Oxygen at 99.5% purity under high pressure of 150 bar (2176 psi) has strange properties. When a valve of an oxygen cylinder is opened quickly, the oxygen will rush into the high-pressure hose or the stem of the oxygen regulator and when reaching the end of the hose or regulator phenomena called, adiabatic compression might occur.

This means that locally the pressure will for a short period be much higher than the filling pressure of the cylinder 150 bar (2176 psi). This compression happens without any heat input from the outside (hence the name adiabatic). The effect of this is that local compression heat is generated. The net result is that for a very short time we can see a higher than normal pressure and an increased temperature. This higher oxygen pressure and temperature makes it more critical what products are in contact with the oxygen.



Products that are normally considered as non-flammable can when in contact with high pressure oxygen at higher temperatures become flammable. Any foreign object, organic or a metal particle might ignite and start a metal fire. The high pressure has under those circumstances no problem burning through the hose or regulator stem consuming it.

For this reason, oxygen components are specially designed and tested (oxygen surge testing) and cleaned fit for oxygen service. When replacing components like hoses and seals, attention must be paid to work “clean” so that possible flammable components (contaminants like dirt, fine particles, oil or grease) are not transferred. If small amounts of contaminants are present and the oxygen surge happens, ignition will occur instantly (explosive) and the hose or regulator stem will fail.

Because of the above-mentioned process, the instructions are: No foreign substances to be used, and always slowly open the cylinder top valves.

In test performed Teflon do not ignite at 21% oxygen even at 655 bar (9500 psi), but as oxygen concentration increases there is a dramatic change in the ignition threshold (Auto Ignition Temperature AIT) culminating in ignition of Teflon in 100% oxygen at 104 bar (1500 psi).

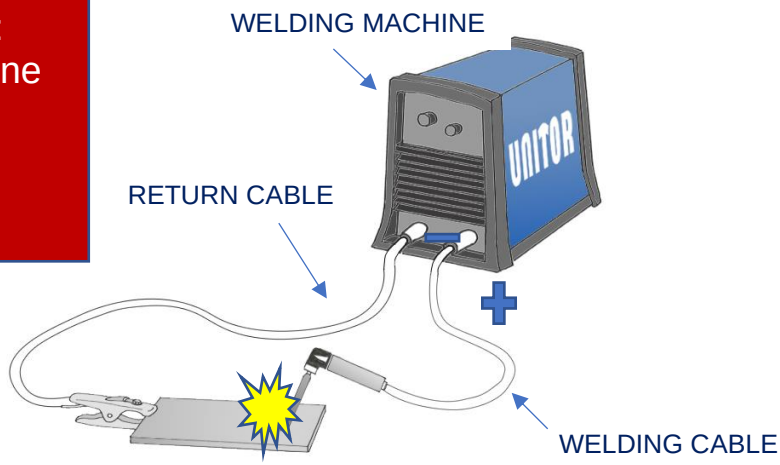
In order to avoid Adiabatic compression:

- Use only original equipment and spares when handling/ servicing oxygen equipment.
- Open and close oxygen cylinder top valves before connecting equipment. This in order to remove any foreign items and hence preventing them entering the system.
- Work clean. No oil or impurities must contaminate the parts (your hands, tools etc.)
- Open oxygen cylinder top valves slowly

Special safety precautions regarding:

Arc Welding and arc welding equipment

Check state of:
Welding Machine
Welding cable
Return cable



Type of welding machines to use

Avoid using Alternating Current (AC) welding machines when performing welding onboard. The pulsating effect of AC current has proven to be especially dangerous to an operator in case of electric shock. Where burns are the main danger from an electric shock from DC, the AC pulses may in addition cause cramps/seizures and heart failure as the pulses affect the nervous system which can result in cardiac arrest.

Typical AC welding machines are Transformers. DC welding machines are referred to as Rectifiers or Inverters.

The UK Maritime and Coastguard Agency's Code of Safe Working Practices for Merchant Seamen states that the maximum voltages should be as follows:
For rectifiers and inverters delivering DC: Max OCV 70 V.
For transformers delivering AC: Max OCV 25 V.

The most stringent standard towards OCV is the Australian Standard AS 1674.2-2007 Safety in welding and allied processes. The standard specifies OCV less than 35 Volts DC and 25 Volts AC by the use of a Voltage Reduction Devise (VRD). AC not recommended.

Voltage & Frequency

The main purpose of all welding machines is to bring high voltage down to suitable safe working voltage. The working voltage of a welding machine is referred to as Open Circuit Voltage (OCV) or sometime referred to as Non load Voltage or Idling Voltage. The definition of OCV is the voltage between the terminals of a welding machine that is switched on but not in use.

Why is this necessary?

A lot of new welding machines and some older units have an open circuit voltage in excess of 105 volts DC or 85 volts AC. This voltage is currently legal and in normal (dry) conditions on shore may be quite safe.

The only trouble is that 95% of sites onboard a vessel do not have these normal conditions e.g. (damp or wet, caustic, salty, working at height or in a confined space) an electric shock in these conditions can and has proven fatal. Heart failure (Ventricular fibrillation), falling from heights and inability to escape the power source when in confined spaces not to mention the serious physical injuries sustained as a secondary result of an electric shock.
Electric shock from a welder power source can also cause serious internal injuries to the human body. These injuries are not always immediately noticeable.

It is therefore recommended that:

- Welding machine insulation levels should be checked regularly.
- Check that the Voltage Reduction Device are functioning.

The first thing that should be checked before start working is whether the welding machine onboard is in compliant with these values. On most welding machines this is stated on the machinery plate.

Avoid using welding machines which use High Frequencies (HF) for starting the Tungsten Inert Gas (TIG) process. HF may cause interference with radio communications equipment and can also interfere with the start/stop controls of electronically operated equipment such as pumps. Low voltage TIG starting systems using the ‘lift arc’ process is available and make it unnecessary to use HF for starting the welding process.

Compliance

Within the European Union and on ships flagged to EU member states, crew should also check if the welding machine is in conformance to the Conformity European (CE) mark. This is a form of ‘passport’ that allows goods to pass freely into and throughout Europe and also guarantees that the machine conforms to EU electrical directives & standards.
The standards that welding equipment should conform to in EU member states are as follows:
EN 60974-10 European Norm for electromagnetic compatibility.
EN 60974-1/5 European Norm for arc welding appliance: current sources for welding.
This prevents inferior electric equipment being put to use endangering the crew.
Welding machines are ruled by the IEC 60974, which is the EN 60974 in Europe. This norm is internationally accepted, also in USA.
Operators should also look for the ‘S’ mark, indicating that the equipment is suitable for use in areas with increased electric shock hazard. This is of particular importance when working in potentially wet, humid and cramped locations such as the double bottom or in ballast tanks.

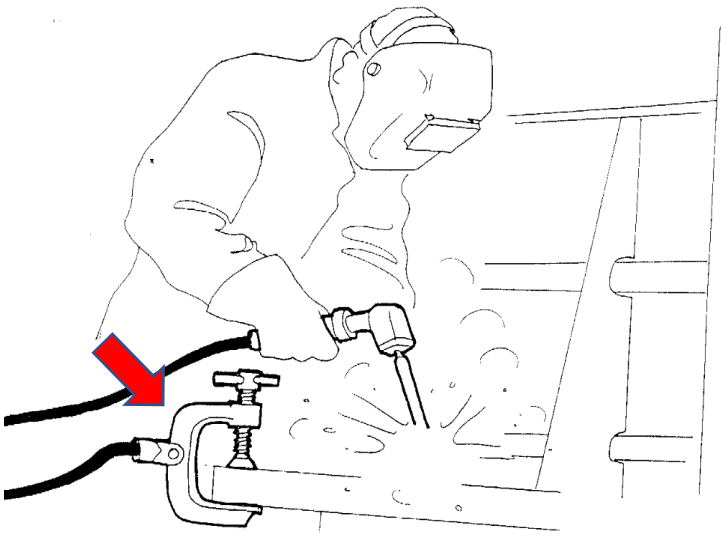
The Welding Cable and Electrode holder

Use only a fully insulated electrode holder. Electrode holders are produced in accordance with Standard 2006/95/EEG concerning low voltage, and conform to EN 60974-11.
Avoid using the crocodile type electrode holder where the current carrying metal is exposed.
Cables shall be of oil resistant type with undamaged insulation and properly mounted cable connectors. Standard for welding cable H01N2-D. This means that the cable is produced to an international harmonized standard. Use safety cable connectors where both halves are protected to prevent contact with deck when disconnected.

The Return Cable and Return clamp

The welding machine return cable is often referred to as earth or ground cable but it is neither. The terms ‘ground’ and ‘grounding’ are used in US electrical engineering to represent electrical equipment that is securely bonded to the ground for safety reasons. In the UK the equivalent terms are ‘earth’ and ‘earthing’.

The return cable on an arc welding machine carries just as much current as the welding cable itself. Both the welding and return cables are part of the electric circuit. As a result, for safe welding the crewman must use a return clamp and cable, which must be placed as near to where the welding is taking place as possible.



Placing the return clamp to the nearest bulb iron will make the ship's hull live in that area, creating the risk of electrocution. The welder will be actually standing on the return, possibly in poor quality footwear, using soiled gloves, in wet conditions, perhaps in salt water (an excellent conductor of electricity). If lying flat on his stomach or his back in a sweaty boiler suit, he is exposing large parts of the body to a live deck.

If the welding cable is not well insulated then using the hull as a return can also cause a short circuit, creating sparks and an explosion risk. This kind of operation, combined with the use of a transformer delivering AC with high OCV can be fatal to the welder.

It should also be remembered that connecting the return cable direct to the ship's hull can also cause the current to pass through ball bearings and pistons, causing damage. When welding on engine equipment the crewman should always run the return cable and clamp to where the welding is taking place and fasten it as close as possible to the welding area.
Maritime and Coastguard Agency Code of Safe Working Practices for Merchant Seamen specify, "Use of the hull as return conductor is against regulations."

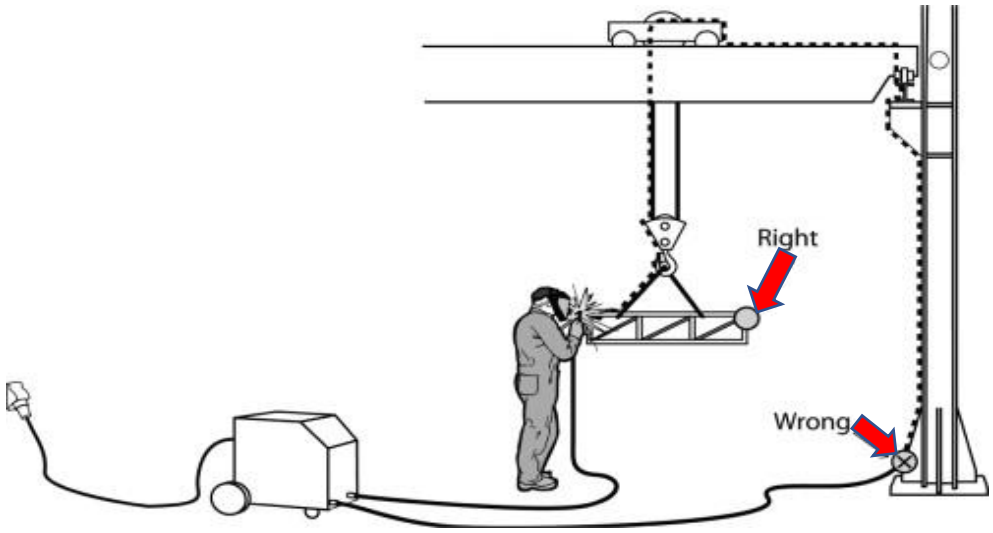
Make yourself safe for electric arc welding

To avoid electric shocks and the risk of electrocution and to ensure they are working safely, ships' personnel should take the following precautions:

- Only use DC power sources (rectifiers or inverters) with an OCV below 70 volts, preferably 35 volts in order to be in compliance to Australian Standard AS 1674.2-2007 Safety in welding and allied processes.

- Place the return clamp and cable as close to where welding takes place as possible. Remember that there is as much current running through the return cable as through the welding cable.

- Use of the hull as return conductor is against flag state regulations.



- Wear dry, insulated protective clothing and gloves in good condition, changing as necessary to keep dry. Insulate yourself from the work piece and return cable by wearing rubber-soled shoes or stand on a dry, insulated mat. Do not touch the return with any other part of your body.
  Gloves for Arc and TIG welding Comply to NEN-EN 12477 type A/B Protection: EN 388 3232 EN 407 332222. EN 12477:2001 is a standard specifically for gloves to be used when welding, and is based on the tests in EN 388, EN 407 and EN 420. Two types of glove are catered for – 'Type A' and 'Type B'. Type B has higher requirements for dexterity to cover use in some specialized welding operations, whereas Type A gloves are intended for other more general welding processes. Gloves which are intended to be used for arc welding must be tested to EN 1149 for electrical resistance.

- Use fully insulated electrode holders.
- Do not use worn, damaged, undersized or poorly spliced cables.
- Do not wrap cables carrying current around your body.
- Do not touch an energized electrode with bare hands.
- Turn off all equipment when not in use.
- Use only well-maintained equipment. Repair or replace damaged parts before further use. Wet working conditions should be avoided. Even a person's perspiration can lower the body's resistance to electric shock.

Special notes regarding working in confined space using Electric Arc Welding equipment and consumables

- Ensure that all relevant check lists, certificates and permits for hot work have been issued.
- Tidy up the work place and remove any flammable materials, liquids and gases from workplace and adjacent spaces including spaces above/below decks, behind bulkheads and inside pipes or containers. Cover any openings through which sparks may be led to other areas onboard which have not been prepared for hot work.

- When working, wear safety shoes and a proper boiler suit with long sleeves. Do not wear clothes of highly combustible materials or wet clothes, and do not carry combustible material, e.g. matches, lighters, oily rags. Welding gloves should always be used, and when necessary also use additional leather clothing for protection against sparks, heat and electric shock. Use head and face protection (helmet, shield). Ensure that filter glasses are unbroken and have the correct shade. The face shields should be CE approved and conform to DIN/EN 175: 1997.
  Many welders have experienced the discomfort of arc-eye or “sunburnt” skin on unprotected parts of the body, usually due to insufficient or incorrect protective equipment.

- Shield the work place to protect others from sparks and radiation from the arc, and post a warning sign that welding is in progress.

- Ensure that sufficient and correct fire fighting equipment is available at the workplace, and that personnel familiar with its use is present.

- Ensure that the work place is properly ventilated, if necessary with special fume extraction equipment. This is especially important when working on galvanized or coated surfaces which may produce harmful fumes when heated.

Special notes regarding Welding fumes

Welding fumes or smoke consists of a mixture of gases and dust particles. The composition of the fumes depends on:

- The filler material/ consumable and welding method.
- The base material.
- The base material coating.

Different welding methods and different metals, means that the fumes produced may contain numerous components, which can be dangerous if inhaled. The best protection is the use of a smoke extraction unit. When correctly positioned, this unit will protect the welder against fume inhalation and prevent the smoke spreading in the surrounding area and contaminating the area for others. If it is not possible to use a smoke extraction unit, the welder can minimize the risk of fume inhalation by positioning himself so that the smoke rises some distance from his nose and mouth or by using a welding face shield with fresh air supply. For on board use a self-contained unit with filter is a safe and flexible solution. Electric arc welding with coated electrodes may consist of several different components depending on the type of electrode. The composition of the smoke will therefore vary depending on the type of electrode.

Risks

The fumes produced when welding unalloyed or low-alloyed steel which has not been surface treated are not considered particularly dangerous as long as inhalation of these fumes is kept at a reasonable level. When the base metal has been surface- treated, the smoke may contain substances, which could constitute a health risk. Welding of galvanized materials or surfaces treated with substances containing zinc, produces fumes, which contain zinc oxide. Inhalation of these fumes can result in zinc poisoning with very unpleasant effects. It should be avoided by the use of a good extraction unit, or the use of a face shield with fresh air connection.

Cadmium plating is sometimes used instead of zinc plating. Welding or cutting cadmium-plated material can produce fumes, which contain cadmium oxide. Lung diseases may occur from the inhalation of this substance. When welding or cutting old steel plating, remember that the surface coating may contain lead or mercury. Fumes from these substances can result in serious health damage if inhaled. When welding or cutting any type of material that has been plated or surface coated, precautions must be taken against dangerous fumes before welding commences.

Welding of stainless or acid-resistant steel produces smoke containing nickel and chrome. Copper alloys (tin, bronze, leaded gun metal, leaded tin bronze and brass) contains items such as tin, zinc, lead, etc. Welding temperature tends to vaporize these items. Inhaling these substances can seriously affect the respiratory system. When welding these types of steel or materials plated or coated with substances containing chrome, cadmium, nickel, lead or mercury, it is essential that a smoke extractor unit is being used. If this is not possible, the welder must be equipped with, and must use a face shield with filter unit or fresh air connection.

Do not leave the workplace unattended. When hot work is completed the work place shall be inspected at regular intervals to ensure that no risk of fire remains. Only when this has been assured should firefighting equipment be returned to its normal storing place.

These points may seem obvious but, in our experience, there are often occasions when crew are not working safely. The results can be serious for all hands onboard and for the entire ship.