Methods for removal of welds and opening of cracks

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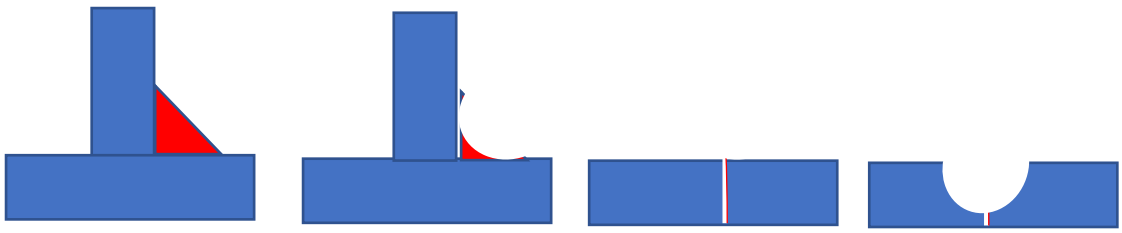
Maintenance Welding onboard very often require that old welds are removed or that cracks are gouged out before the actual welding is done. This article informs about the different gouging alternatives available.

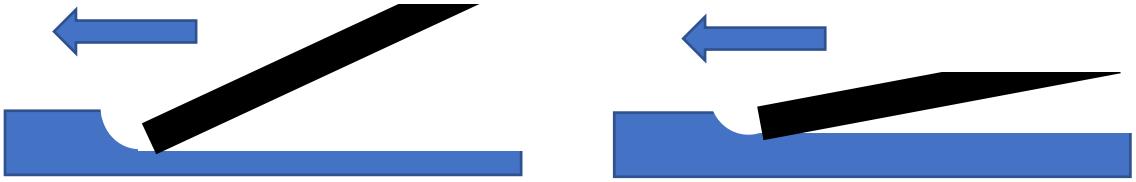
The Gouging Process

For all alternative gouging methods, it is of importance that there is no damage to deck plates or bulkhead/ brackets when old welds are being removed. It is likewise important to control the depth and width when gouging out a crack. Gouging therefore require considerable skill in operating the equipment in order to avoid damage.



Old weld …removed by gouging A crack …gouged out

The depth of the gouge is determined principally by the speed and angle of the torch or electrode. To cut a deep groove the angle of the torch or electrode is stepped up (this increases the impingement angle) and gouging speed is reduced. To produce a shallow groove, the torch or electrode is less steeply angled, and speed is increased. Wide grooves can be produced by weaving the torch or electrode. The contour of the groove is dependent upon the size of the nozzle or electrode and the operating parameters.

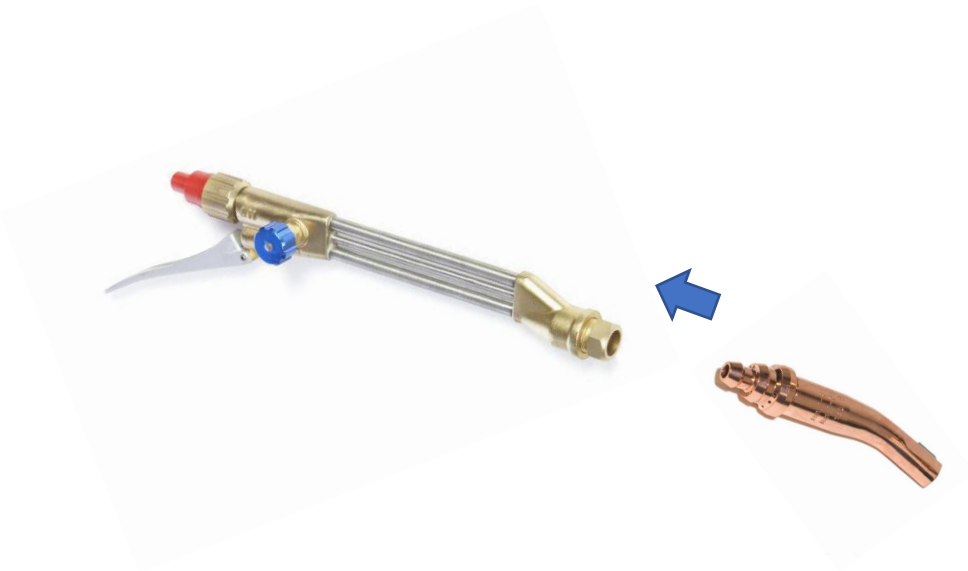


Stepped angle: Deep groove, reduced speed Low angle: Shallow groove, increased speed

Oxy-Acetylene Gouging

Most vessels will have access to Oxygen and Acetylene during voyage. It is therefore a likely process to be used for gouging. Standard oxygen and acetylene equipment used for cutting can be employed with only a few alterations in order to perform gouging. The process is particularly attractive because of its low noise, ease of handling, and ability to be used in all positions.

There are two important items that must be added. Firstly, change cutting attachment from 90 or 75 degrees to 0 degree. Fit the **0-degree cutting attachment** with a **Gouging nozzle**.



0 degree cutting attachment fitted with Gouging nozzle

Gouging nozzles operate with higher pressure settings than when doing cutting.
Acetylene: 0,5 bar (72,5 psi)
Oxygen: 5,7 bar (827 psi)
If hose length exceeds 10 m (32 ft.) increase pressure setting with 30%

The shape of the gouging nozzle makes it easier for the welder to operate the torch.

When cutting or gouging, the steel is locally heated to a temperature above the ignition temperature of steel that is approximately 900deg.C (1652deg F). At that moment the operator opens the oxygen cutting valve and a jet of oxygen is used to melt the metal in a chemical reaction between pure oxygen and the hot metal. This jet of oxygen is also used to blow away molten metal and slag.

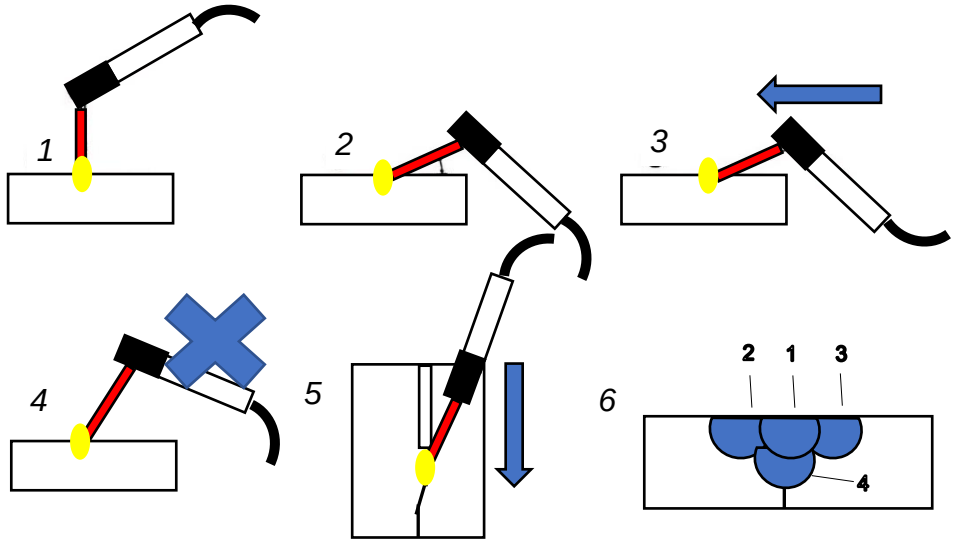
Keep in mind: It is more likely that one can experience flashbacks when doing gouging compared to cutting. Therefore make sure that the welding shank is fitted with non return valves and that regulators are protected by flashback arrestors.

NB. Oxy-Acetylene Gouging can only be performed on steel. It will not work on Aluminum, Copper or Stainless Steel. The three next mentioned methods can be used on all current carrying metals.

Exothermic Gouging

Using an exothermic electrode gives the possibility to utilize standard welding equipment. One can use an Alternating Current (AC) welding machine or a Direct Current (DC) welding machine. Using a DC welding machine, connect the electrode to either plus or minus polarity using a standard electrode holder. No oxygen or compressed air is needed. The term **exothermic process** describes a process or reaction that releases energy from the system to its surroundings. The energy is built into the electrode coating and is released when the electrode is ignited. For smaller gouging jobs where more productive methods are not available or take too long to rig up exothermic gouging might be an alternative. The process can be utilized on all current carrying materials.

Gouging Technique:



1) Hold the electrode vertically and press lightly against the workpiece. The arc will strike after a few seconds.
2) Hold the electrode at an angle of 15–20° to the workpiece.
3) Direction of travel.
4) Warning! Do not cut down into the workpiece. Should this happen inadvertently, move the electrode back and lower to correct angle.
5) Work downwards when cutting into a vertical surface.
6) If a deeper groove is required, proceed as in this sketch.

Exothermic electrodes are available in the following sizes and require amperage as indicated below:

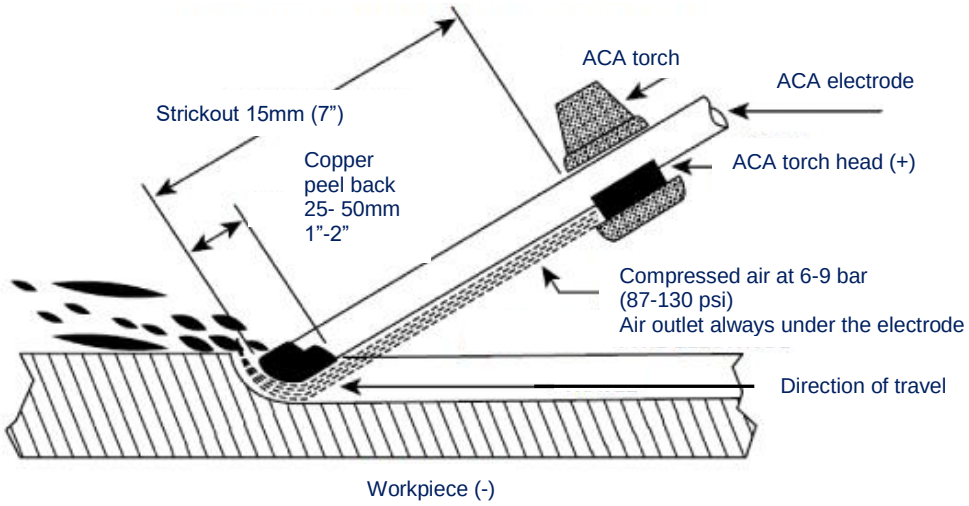
2,4mm	190Amp
3,2mm	310Amp
4,0mm	380Amp

The process develops a copious amount of fumes and smoke. Good ventilation is essential. For large jobs Oxy- acetylene, Air carbon arc or Plasma gouging is recommended.

Air Carbon Arc Gouging

Probably the fastest and most efficient way to remove metal is using ACA Gouging. The air-carbon-arc process utilizes the arc effect to melt the metal, which is subsequently blown away by a jet of compressed air. The method is therefore also useful for cutting stainless steel and other current carrying materials, which are difficult to cut by the oxy-acetylene method. The air carbon arc process leaves a fairly clean surface, free from slag, and further surface preparation is usually not necessary. Exception is on stainless steel where there will be necessary to remove the carbon deposit by grinding.

PRINCIPLES OF AIR CARBON ARC GOUGING



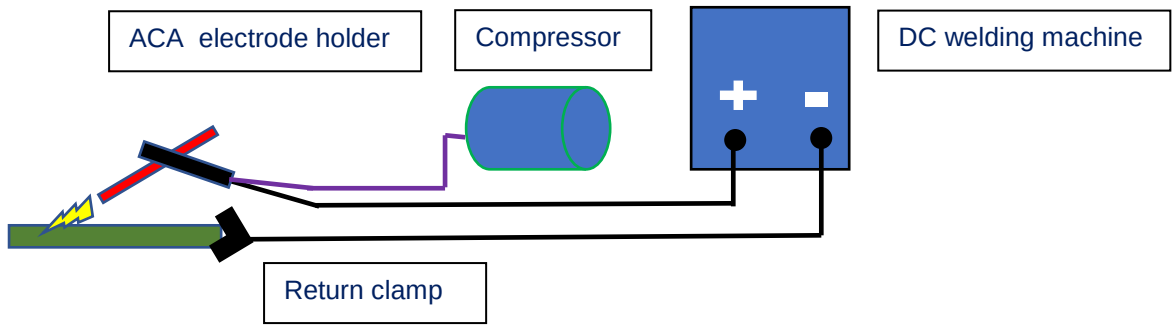
The equipment consists of a welding power source suitable for air carbon arc gouging, a special electrode holder with air ducts, copper coated carbon graphite electrodes, a compressed air source that deliver from 6 to 9 bars (87- 130 psi), cable and air hose.

ACA gauging electrodes are made from a blend of carbon and graphite. The electrode is copper cladded something that improves electric conductivity and helps maintain electrode diameter at the point of the arc. Normal electrode length is 305mm (12”). Electrode diameters and parameters are as follows:

6,3mm (1/4”)	200- 350 Amp
8,0mm (5/16”)	200-450 Amp
15 X 5mm (19/32” X 13/64”) *	400-600 Amp

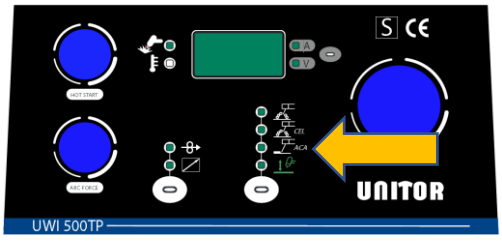
*A typical application for the 15 X 5mm flat electrode is for flushing the deck for weld leftovers after removal of sea fastening brackets onboard heavy lifters.

Electrode holder with electrode to be connected to welding machines plus (+) terminal. Return clamp to be connected to minus (-) terminal. Air pressure 6-9 bar (87- 130 psi)



The welding machine must have sufficient capacity in order to deliver the required amperage. The Unitor model UWI-500 TP is a suitable power source for ACA gauging delivering up to 500 Ampere at 50% duty cycle. At 400 Ampere the duty cycle is 100%. It also has a special characteristic required for the ACA process. This is an important feature for a welding machine to have if it is to be used for ACA gouging over time.

UWI-500 TP



Special characteristic for ACA Gouging

Two welding machines may also be connected together in parallel by connecting the negative terminal (-) from both machines to the return. The cables from the positive terminals (+) are then lead to the worksite and connected to the electrode holder. A remote control parallel connection must also be established in order to synchronise the electronics of the machines. Check with supplier/ manufacturer if the welding machines have this feature.

A special jaw-type electrode holder is used for air carbon arc gouging. The jaws are fitted with nozzles, which direct jets of compressed air parallel with the electrode to the molten pool. The holder is equipped with a cut-off valve for compressed air. Compressed air supply 400–900 l/min at a pressure of approx. 6–9 bar (87- 130 psi). The holder will accept round and flat electrodes. Most models are supplied complete with integrated compressed air hose/welding cable, cable connectors and a quick connector for compressed air.

General rules for ACA gouging:

- Check that all screw connections are properly tightened to minimize any loss of effect.
- Clean the electrode jaws occasionally with a steel brush to ensure good contact.
- Blow out the air line before connecting to the holder to remove any condensation.
- Set the air pressure at 6 to 9 bars (87- 130 psi).
- Check connections for correct polarity.
- Fit the electrode in the holder so that it protrudes approx. 150 mm (6”) from the holder. The full length of an electrode is 305mm (12”)

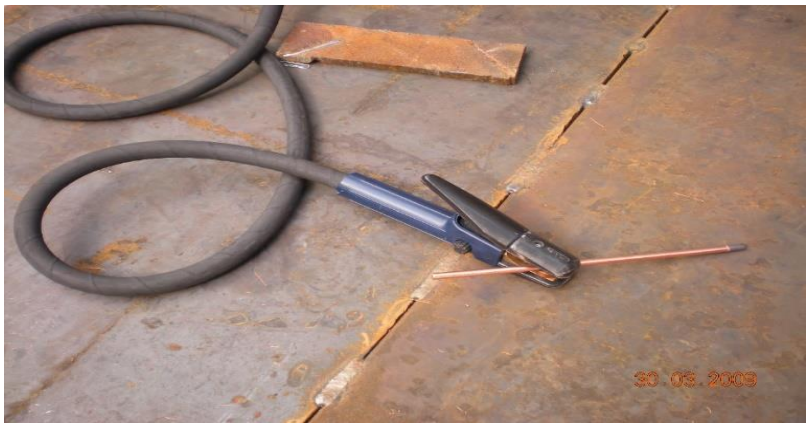
Stickout 150 mm (6”)

- When the electrode is moved from right to left, the air outlets in the electrode jaws must be positioned on the right side of the electrode so that the main stream of the compressed air jet is lead beneath the electrode.
- Check the current and remember that the high arc voltage will usually require a higher than normal setting on the amperage scale.
- If amperage is too low, gouging will be unsatisfactory.
- Check that the air supply is switched on and the air-valve on the holder is in the open position before striking the arc.
- Keep the arc short but avoid touching the workpiece with the electrode once gouging has commenced.
- When gouging in the overhead position, make sure that molten metal does not fall directly on to the electrode holder.
- Gouging in the vertical position is performed vertical down.
- When the equipment is in regular use, dismantle and clean the valve at least once a month and make sure that the air passage is not obstructed. Lubricate the 0-rings with special valve grease.

Most welders who have had some welding or cutting experience should be able to master the gouging technique by practising 2 or 3 times a day for about a week. A typical application of the ACA method is the removal of sections which have been welded to the deck for securing deck cargo. Hold the electrode holder so that the electrode slopes back from the direction of travel. The air blast is directed along the rear of the electrode towards the arc. The depth and contour of the groove is controlled by the electrode angle and speed of travel. It is possible to cut grooves with a depth of up to 25 mm (1”). A combination of wide electrode angle and slow speed of travel will produce a narrow, deep groove. The width of the groove will usually be about 3 mm (1/8”) wider than the electrode diameter. An electrode angle of approx. 35° will provide a normal groove depth and highest speed of travel. An electrode angle of 45 –70° is used to obtain the deepest groove. Adjust the speed of travel to obtain an even, hissing sound and clean, smooth groove surface. The amount of metal which can be removed increases with increasing current. However, every electrode has an ideal current level which is slightly below its maximum. If the ideal level is exceeded, the welder will notice a considerable increase in electrode consumption.

When ACA gouging with 8 mm (5/16”) electrodes and using 100 m (328ft) cable length or more, the cable size should be minimum 95 mm2 (3/0 AWG).

WARNING! Wet or damp ACA gouging electrodes will give off splinters and are dangerous in use. Damp electrodes must be dried out in a drying oven at 180 °C (356 °F) for 10 hours before use. The fumes from ACA gouging electrodes are dangerous and must not be inhaled. Arrange for suitable ventilation or use an air mask. The noise level during ACA gouging can be above 100 decibels. Therefor make sure to use approved ear protectors when working with the ACA gouging process and protect your body and head against molten metal spray.

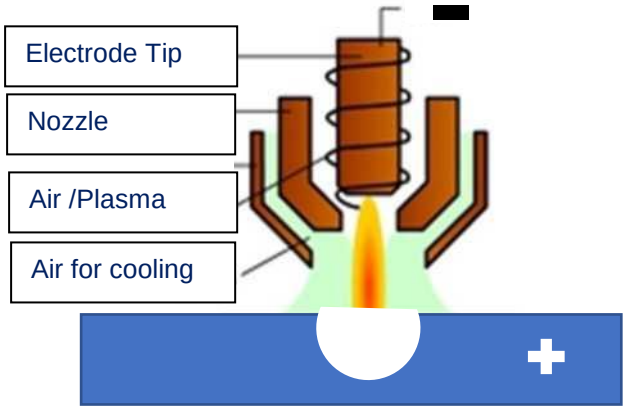


Plasma Gouging

For detailed information on Plasma and Plasma cutting/gouging go to TE Andersen Consulting> Marine Welding Library> Electric Arc Welding and Cutting> Technical update - PLASMA CUTTING & GOUGING.

Most people think plasma cutters are for cutting only but they can with good result be used for gouging. NB. You will need a 100 Amp plasma cutter to make it into an efficient unit for gouging. A 30, 40 or 50 Amp plasma cutter will not have sufficient capacity for this task.

The basic plasma cutting process involves creating an electrical channel of superheated, electrically ionized gas i.e. plasma from the plasma cutter itself, through the work piece to be gouged, thus forming a completed electric circuit back to the plasma cutter via a return clamp. This is accomplished by a compressed air which is blown through a focused nozzle at high speed toward the work piece. An electrical arc is then formed within the gas, between an electrode near or integrated into the gas nozzle and the work piece itself. The electrical arc ionizes some of the gas, thereby creating an electrically conductive channel of plasma. As electricity from the torch travels down this plasma delivers sufficient heat to gouge out the work piece. At the same time, much of the high velocity plasma and compressed air blow the hot molten metal away, thereby creating a groove.

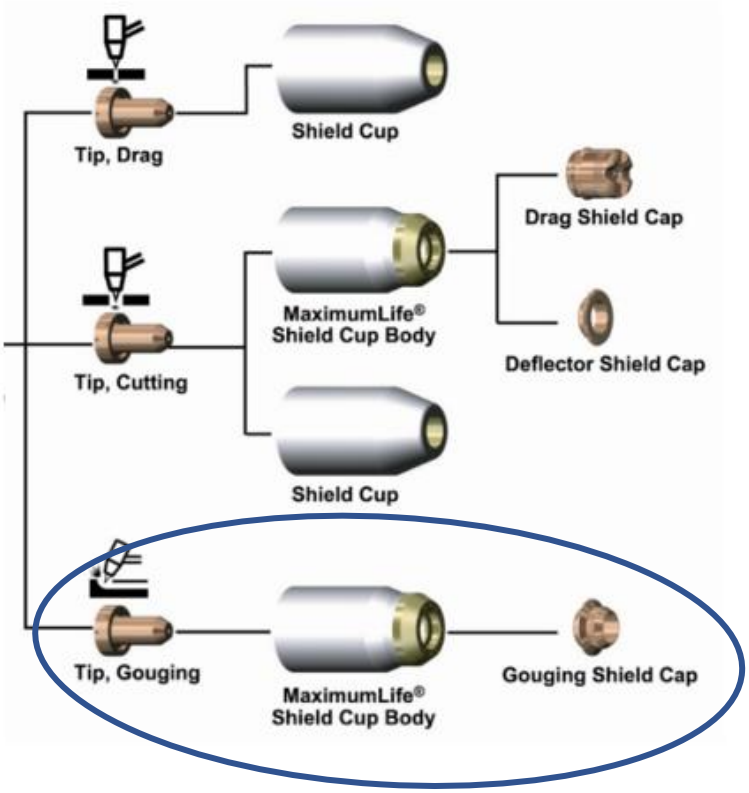


NB. Plasma cutters use a number of methods to start the arc. Avoid using plasma cutters that use a high voltage, high frequency circuit to start the arc. This method has a number of disadvantages, including risk of electrocution, difficulty of repair, spark gap maintenance, and the large amount of radio frequency emissions something that will disturb radio communication onboard. This method of starting can also interfere on sensitive electronics, such as CNC hardware or computers. A better method is starting the arc is where the nozzle and electrode in the first step are in contact. The nozzle is the cathode (+ polarity), and the electrode is the anode (- polarity). In the second step, when the plasma gas begins to flow, the nozzle is blown forward creating a gap and a pilot arc is established. This is refered to as Blow back system.

The Stel Thor 123 Plasma cutter delivers 100Amps and operates on 3 phase 400V +/- 15%, Fuse rating 25A. The feature “Check Consumables” warns the operator when the consumables (electrode and nozzle) are finished and need to be changed thereby avoid damage to the torch. The unit also have a RESET switch that offers added safety to the operator.

When gouging, angle the torch to a lead angle of 35°- 45°, using a gouging tip. While maintaining a constant standoff distance, this allows for only a partial penetration into the work, thus removing metal from the surface. The amount of current, travel speed, standoff distance, lead angle, and tip size will determine the amount of material removed and the profile of the gouge.

There will normally be a need to change some of the consumables in the torch when going from cutting to gouging. You can use the shield cup body with either the gouging shield cap or the shield deflector. Also, you can use the single piece shield cup.



Some good advice:

Keep longest possible distance between the plasma machine's front and location where gouging takes place. The machine need cooling and dust from the gouging can be drawn into machines interior if it is placed too close to gouging location.

The compressed air entering the plasma cutter must be absolutely dry and free from water and oil.

Change electrode tip and nozzle when "Check Consumables" warning is activated.

Make sure that location where return clamp is fastened to base material are grinded to secure good electric conductivity.

Every 1/2 year make sure to remove the plasma machine's cover plate and blow through with dry compressed air. This is in order to remove dust and dirt from electric components.

Despite great improvement in plasma machine technology the last couple of years making them more robust and sturdy, keep in mind that they like all electronic equipment must be handled with care. Do not leave the equipment out on the open deck or in other exposed locations when not in use.

Summing up the Gouging Processes Pro & Con:

All processes have a high degree of smoke and fumes developed. Good fume extraction and personal safety equipment must be made available. The area must be protected towards sparks and spatter.

Oxy-Acetylene Gouging:

The traditional oxy-acetylene equipment onboard may be used with only minor change of parts (0 degree cutting attachment and Gouging nozzle). High metal removal capacity. Equipment are robust and can be used in rough work locations. Can only be used on steel. High consumption of oxygen.

Exothermic Gouging:

Can make use of traditional electric arc welding machine onboard (Transformer, rectifier, inverter). Only exothermic electrodes need to be added. Can be used on all current carrying materials. Low metal removal capacity.

ACA Gouging:

Direct current Welding machine (Rectifier or Inverter) with high amperage capacity needed. Preferably 500 Amp with ACA characteristic. ACA Gouging torch and electrodes need to be added. The highest metal recovery capacity of the processes. Can be used on all current carrying materials. Low running cost (compressed air and electrodes) Equipment are robust and can be used in rough work locations. High noise level. Can be somewhat difficult to control and operate on thin materials.

Plasma Gouging:

Plasma machine with 100 Amp capacity needed. Can be used on all current carrying materials. High metal removal capacity. Low running cost (compressed air and torch parts). Gives good control to operate and use also on thin materials. More vulnerable towards rough environment onboard.