Welding Machines for Shipboard use

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It is crucial that electric arc welding machines and equipment are handled in a safe and secure way - safety in operation must always be a priority. This paper informs briefly about the electric system onboard ships and how welding machines work. It examines the safety checks and precautions that crew should adhere to before and during electric arc welding onboard.

BASIC PRINCIPLES OF WELDING

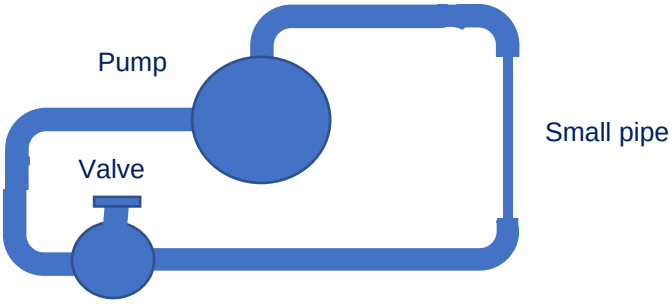
The generally accepted term of welding, particularly as it applies to the arc processes, implies a fusion weld wherein the base materials being joined are melted at the abutting faces and become all part of the weld. Depending on the welding process a filler material in the form of an electrode, wire or rod is added to the joint and is consumed in the process. The filler material added to the joint will form, along with the melted surfaces of the base material, the solidified mixture which is the weld metal.

A necessary part of an electric arc welding process is a source of intense heat sufficient to melt the material being joined and the filler metals added.

Maintenance welding onboard is an essential part of maintenance, but it must be done with equipment that is in compliance with maritime rules and regulations and according to safe working procedures.

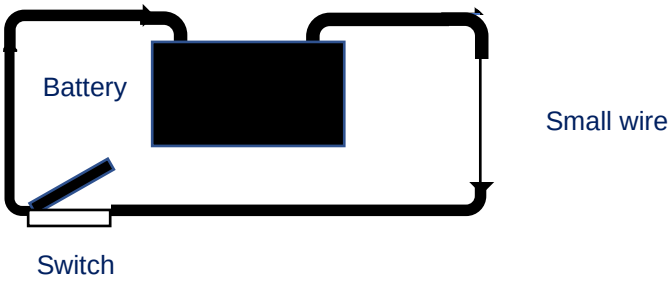
Elementary Aspects of Electricity

Water pipe circuit



Imagine a water pump with a closed pipe circuit including a valve. The pump can be working and a water pressure is established but no water will flow through the pipe until the valve is turned on to allow a path for the water to flow through. With the valve "on", the rate of water flow or current (litre per minute) will depend on the pressure provided by the pump and the size of the water conductor or pipe. A small pipe inserted into the system will restrict the rate of water flow. If we want a larger current to flow, we either have to increase the pressure applied by the pump or increase the size of the pipe.

Electric circuit



In the electrical circuit shown the "pump" or source of electrical pressure is a battery. The "pipe" becomes an electrical conductor (cable) and the "valve" that provides the path for turning on or off the flow is a switch. A smaller cable offering a higher resistance to current flow is included in the circuit.

Note the similarity between the two systems. However, while water can run to waste, there must always be a complete closed circuit for electrical current to flow.

Before the switch is closed (valve opened) to allow the current flow, the "head of electricity", or available electrical pressure is named **Open Circuit Volts (OCV).** The "230 volt" and "440 volt" power supplies indicate the open circuit voltage or available electrical pressure of the mains.

Once the circuit is closed then electric current will flow. This rate of flow is measured in **Amperes** or, as it is more commonly termed, amps. The size of the current is determined both by the **Voltage (pressure)** and the size of the conductor or its resistance to flow, which is measured in **Ohms.** Some materials are good conductors and offer little resistance to current flow (such as copper and aluminium). Others are less good conductors of electricity and offer greater resistance to current flow (steel, stainless steel). Still others are poor conductors and are **termed Resistors.** Very bad or "non-conductors" are called **Insulators** (Bakelite, fibreglass etc.).

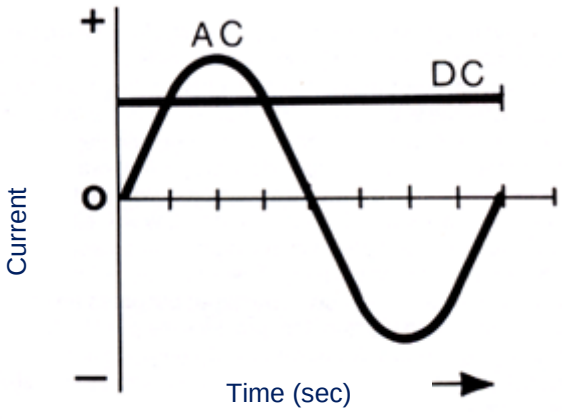
The resistance to flow of electric current shows its presence in the form of heat. If the current flow increases to a stage where wiring could overheat to a dangerous level, the fuse, a purposely smaller section of wire conductor designed to melt when it receives an overload current, will melt and break the circuit.

From one point of view the voltage is only really important in as much as sufficient "pressure" is required to make the current flow through a circuit. In any circuit of a given resistance, it is the current which primarily determines the amount of heat generated. It is therefore very important that, while one can use small cables on the high voltage low amperage (primary) side of an AC arc welder, one must have lower resistance heavy conductors (cables) for the high amperage low voltage (secondary) welding circuit. If not, the leads will overheat. Similarly, a secondary lead which is too long or too small will cause such a drop in voltage that it can no longer maintain a stable current across the arc between the electrode and the work.

AC and DC

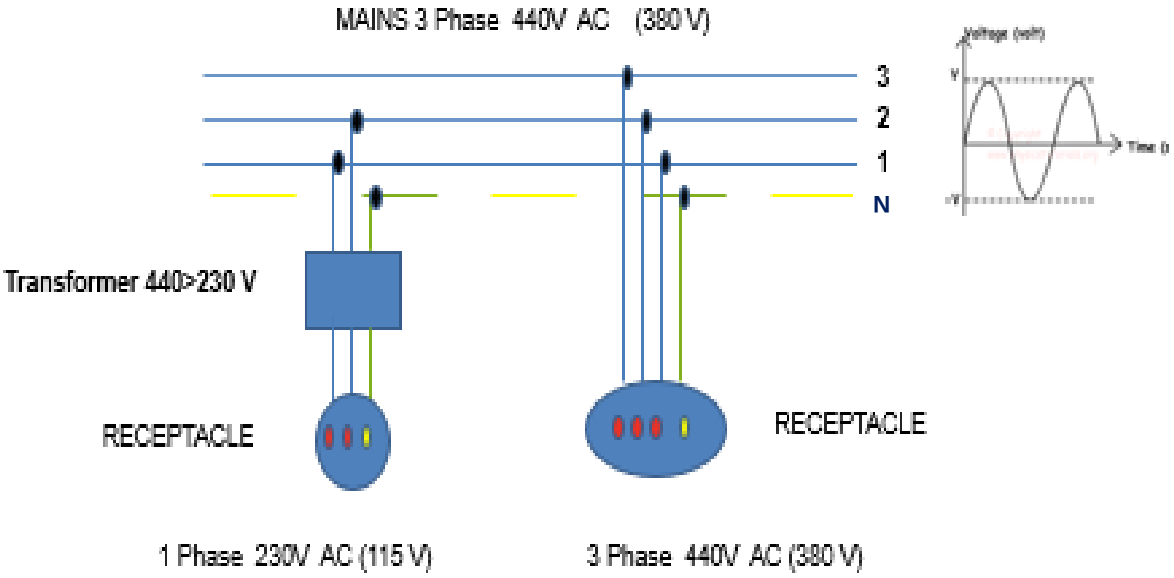
"DC" stands for direct current in which the current flows in the one direction constantly throughout the circuit. One side of the power source is nominated as the positive (+) pole and the other as the negative (-) pole. The electron flow is from negative (-) pole to positive (+) pole.

In "AC" or alternating current the current periodically reverses its direction along the conductor, i.e. one fraction of a second the right-hand terminal is "negative", the next fraction of a second it is "positive". In 60 Hertz AC current, this change from + to - to + occurs as a cyclic variation 60 times a second, the current thus changing direction of flow 120 times a second.



The electric system onboard ships

Almost all oceangoing ships have an A.C. distribution system in preference to a direct current D.C. system. AC, 3 phase power is preferred over DC as it gives more power for the same size. The 3 phases are preferred over single phase as it draws more power and in the event of failure of one phase, the other 2 can still work.

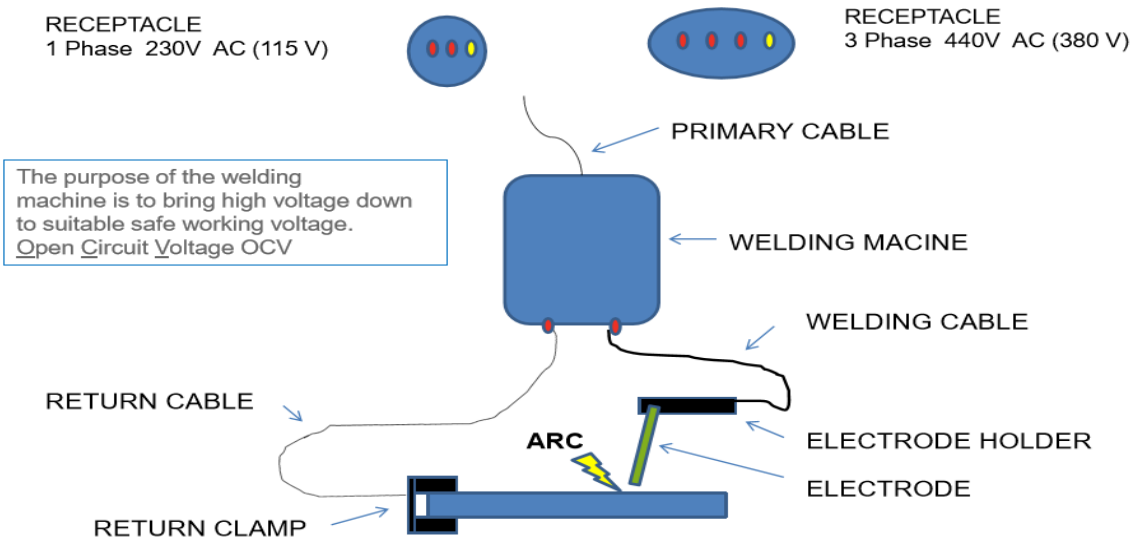


Usually a ship's electrical distribution scheme follows shore practice. This allows normal industrial equipment to be used after being adapted and certified where and if necessary, so it can withstand the conditions on board a ship (e.g. vibration, freezing and tropical temperatures, humidity, the salty atmosphere, etc. encountered in various parts of the ship).

Most ships have a 3-phase AC., 3-wire, 440V insulated-neutral system. This means that the neutral point of star connected-generators is not earthed to the ship's hull. Ship's with very large electrical loads have generators operating at high voltages (HV) of 3.3KV, 6.6KV, and even 11KV. By using these high voltages, they can reduce the size of cables and equipment. High voltage systems are becoming more common as ship size and complexity increase.

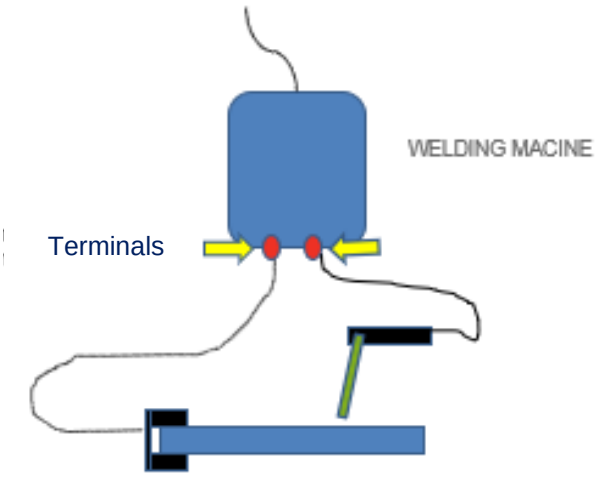
The frequency of an A.C. power system can be 50 Hz or 60Hz. The most common power frequency adopted for use on board ships is 60Hz. This higher frequency means that generators and motors run at higher speeds with a consequent reduction in size for a given power rating. Lighting and low power single-phase supplies usually operate at 230 V. This voltage is derived from a step-down transformer connected to the 440 V system. Please note: onboard some ships the 3-phase AC might be 380V and the 1-phase 115V.

When selecting a welding machine, it is important that one take into consideration the number of phases (1 phase or 3 phase), voltage (115, 230, 380, 440V) and frequency (50 or 60 Hz) on the receptacle the welding machine is to be connected to. Some modern welding machine are dual phase, voltage and frequency and will automatically adapt.



Arc Welding Machines

An arc welding machine is a machine capable of supplying current of sufficient magnitude to provide satisfactory welding heat at a safe voltage capable of sustaining the arc. The purpose of the welding machine is to bring high voltage down to suitable safe working voltage (Open Circuit Voltage OCV), and to make it able to adjust the amperage.

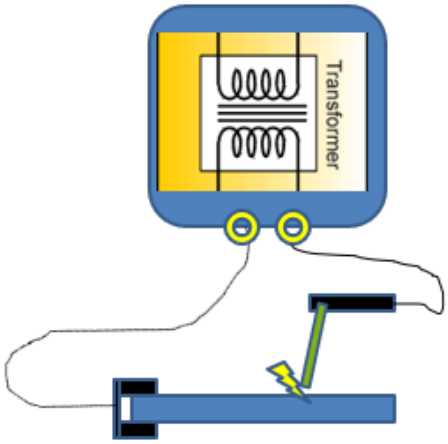


Receptacles for 1 phase 230V AC (sometimes 115V AC) are to be found at most locations onboard. If the receptacle delivers 230V and is fitted with 16 Amp slow fuse it will be able to power smaller welding machines that can deliver up to 150 Amp. If 115V the welding machine might deliver approximately 95 Amp. Receptacles for 3 phase 440V AC (sometimes 380V AC) can sometime be more limited onboard and are used for bigger size welding machines.

The definition of OCV: The voltage between the terminals of a welding machine that is switched on, but not in use.

Transformer machines

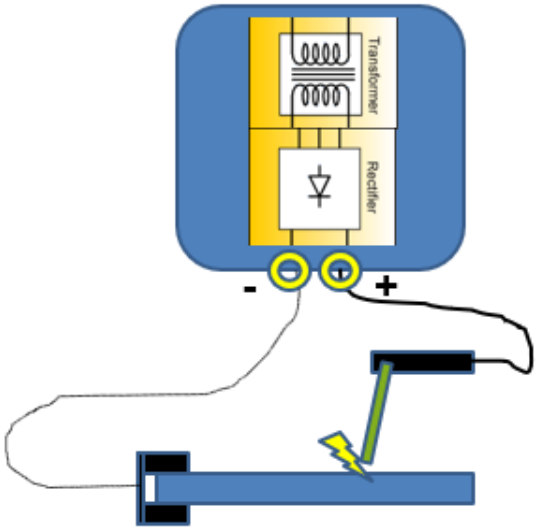
AC manual metal-arc welders are invariably based on a Transformer which is a static electrical machine which can convert AC power from high voltage low amperage to low voltage high amperage power. In addition, incorporated in the transformer design is a current control so that the correct amount of current can be employed on the job.



Transformers consist of an iron frame with primary and secondary copper windings. The current from the mains entering the primary windings create a magnetic field in the iron frame that are picked up by the secondary windings. An iron core regulated by a crank can be lowered or hoisted inside the frame to create alterations in Amperage. You recognize Transformers because of a hand crank on front or top and no +/- signs on the terminals (machine front).

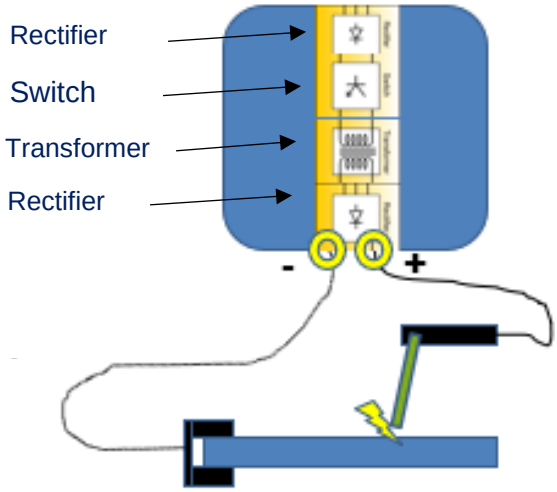
Rectifiers machines

DC arc welders use an AC transformer with a Rectifier attachment which is an electrical "one-way flow valve" permitting the AC welding current to only flow in one direction, thus achieving a DC effect.

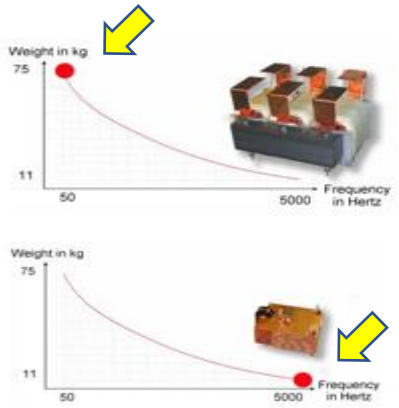


Rectifiers have a transformer part that brings high voltage to low voltage and in addition a rectifier part that convert Alternating Current to Direct Current. The direction of the electrons is from – to +.
The conversion is done by silicon diodes that works like one-way valves. By changing the electrode from + to – one can manipulate the heat input and welding characteristics.
Rectifiers are recognized by having a fan that cools down the silicon diodes and by having +/- signs on the terminals (machines front).

Inverter machines



Inverters first rectify the mains AC current to DC; then they switch (invert) the DC power into a step-down transformer to produce the desired welding voltage or current. The switching frequency is typically 10- 25 kHz (10.000 to 25000 Hz). Although the high switching frequency requires sophisticated components and circuits, it drastically reduces the bulk of the transformer and thereby the weight of the machine. The inverter circuitry can also provide features such as power control and overload protection. The high frequency inverter-based welding machines are typically more efficient and provide better control of variable functional parameters than Rectifier welding machines.

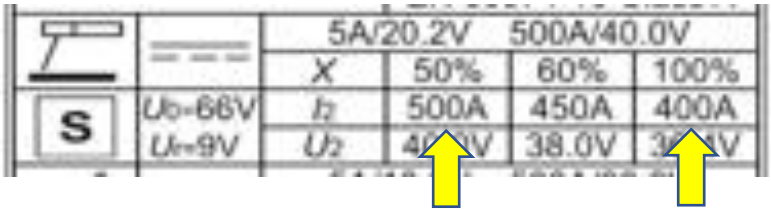


Note the dramatic weight reduction when we go from Rectifier to Inverter technology.
The Rectifier deliver 300 Amp and have a weight of 95Kg
The Inverter deliver also 300 Amp and have a weight of only 18Kg.

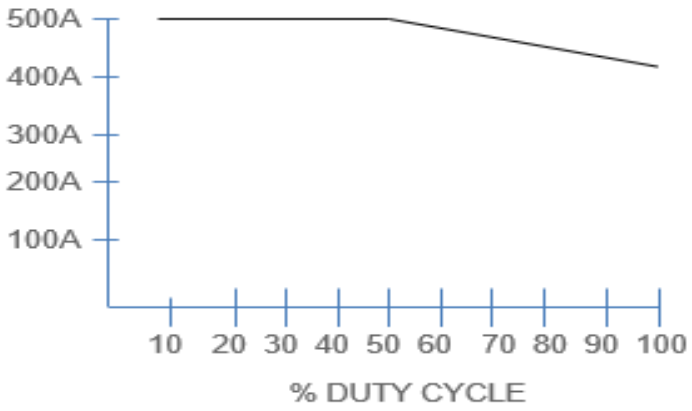
Avoid using Alternating Current (AC) welding machines when performing welding onboard.
The pulsating effect of AC current has proven to be especially dangerous to an operator in case of electric shock. Where burns are the main danger from an electric shock from DC, the AC pulses may in addition cause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

Machines duty cycle

Welding machines are rated with a Duty Cycle. The Duty Cycle is the percentage of 10 minutes that a welding machine can weld at rated load without overheating. It refers to a 40°C environmental temperature.



Example:
If a welding machine is rated 50% at its max rated load, that in our example is 500A, it can be welded at this value at 50% of a 10 minutes period. That will be 5-minute welding, 5 minutes rest. In a practical situation the 5 minutes rest will be removing electrode stub, placing new electrode into the electrode holder, remove slag of previous deposit and repositioning. If the welder reduces the amperage to for example 400A the duty cycle for the same welding machine will be 100%.



For Manual Metal Arc Welding (MMAW) and Tungsten Inert Gas (TIG) welding machines the minimum duty cycle should be 20% at max rated value.

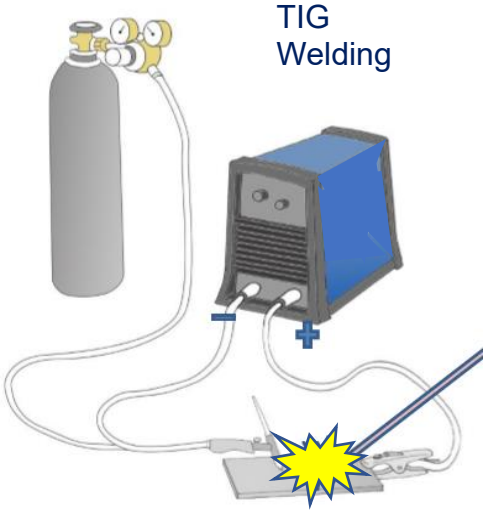
For Wire Welding machines the minimum duty cycle should be 35% at max rated value.

The electric arc welding machines used onboard will in most cases be:

Manual Metal Arc Welding machines (MMAW), American term are Shielded Metal Arc Welding (SMAW). Popular names are “stick welding” or “stick electrode welding machines”. The equipment is relatively simple, inexpensive and portable. The shielding gas provided by the burning the electrode coating is less sensitive to wind and drafts when compared to a process with an external shielding gas. The equipment takes little time to set up for different type of repair jobs. Simply change from one type of electrode to another. In maintenance welding onboard there will be a large number of different jobs involving different base materials. Bigger size MMAW welding machines can also be used for Air Carbon Arc (ACA) gouging.

Tungsten Inert Gas (TIG) welding also known as Gas tungsten arc welding (GTAW), is an arc welding process that uses a non-consumable Tungsten (Wolfram) electrode to produce a weld pool. TIG welding is most commonly used to weld thin sections of stainless steel and non-ferrous metals such as Cunifer and York Albro alloys. The process grants the operator greater control and accuracy over the weld than other processes, allowing for stronger, higher quality welds.
Many MMAW welding machines have the TIG function as an additional feature.

TIG Welding



Wire Welding

Wire Welding is a process where a wire from a reel is fed through a welding torch passing a contact tip supplying the welding current. The wire melts and is transferred to the pool through the arc. A shielding gas is in most cases necessary to prevent air oxidising the pool. The process can roughly be divided into two distinctive methods:
Gas Metal Arc Welding GMAW (solid wire)
Flux Cored Arc Welding FCAW (cored wire)
Flux Cored Arc Welding can further be divided into Self Shielded (flux also provide shielding gas) and Outer Shielded where a shielding gas is necessary.
Other names used:
MIG welding: Metal Inert Gas (Argon)
MAG welding: Metal Active Gas (CO_2)

Some welding machines are dual purpose and can do Wire Welding, TIG and MMAW.

MMAW and TIG welding machines are Constant Voltage (CV) machines. We regulate the amperage. The machines arc voltage will depend on the arc length.
Wire Welding machines are Constant Current (CC) machines. We regulate the Voltage and wire speed.

Rules and regulations

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. The definition of OCV is the voltage between the terminals of a welding machine that is switched on but not in use.

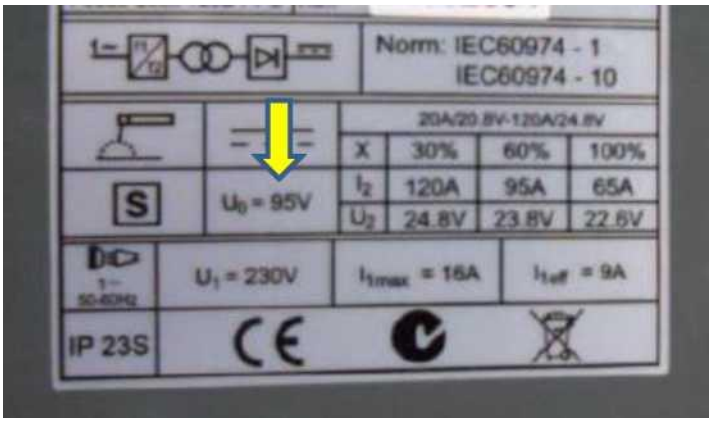
The UK Maritime and Coastguard Agency's Code of Safe Working Practices for Merchant Seamen states that the maximum voltages should be as follows:

For rectifiers and inverters delivering DC: Max 70 V DC.
For transformers delivering AC: Max 25 V AC.

Australian Standard AS 1674.22007 specify DC only and Touchable voltage (arc sensing voltage) max. 35 Volt by the use of Voltage Reduction Devise (VRD).

Therefore, the first thing that any crewman should check before they start working is whether the welding machine onboard is in compliant with these values. On most welding machines this is stated on the motor plate.

Keep in mind that land-based welding machine can have as high as 113 V OCV for DC welding machines and still be inside rules and regulations. For AC welding machines the OCV for land-based welding machines can be 48 V (60974-1 11.1.1).
Make sure this type of machines is not found onboard.



This is the motor plate on a land-based welding machine. It has CE, S, IP 23S so all looks good except for OCV that is far above legal limit for use on-board.

It is also recommended that crew should 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 TIG welding process.

Compliance

Within the European Union and on ships flagged to EU member states, crew should also check if the 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 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.

Other important features for welding machines

Ingress Protection (IP)
This informs the welding machines protection against foreign objects and liquids penetrating into the machine. A minimum requirement for a welding machine should be IP23. First digit, 2 informs protection against object not greater than 80mm in length and 12mm in diameter.
Second digit, 3 informs protection from sprayed water at an angle of 60° from vertical.

The Thermal insulation classes
Welding machines should preferably have insulation class H. This is the highest class and informs that the main transformers insulation material and insulation system can take up to 180°C.

RoHS2
Welding Machines should conform to RoHS2 directive that restricts the use of specific hazardous or restricted substances in new electrical and electronic equipment put on the market in the European Union after July 1,2006. On July 1,2011, the European Union Published the RoHS2 (Recast Directive).
The restricted substances are:

- Lead (0.1%)
- Mercury (0.1%)
- Cadmium (0.01%)
- Hexavalent chromium (0.1%)
- Polybrominated biphenyls (0.1%)
- Polybrominated diphenyl ethers (PBDE) (0.1%)

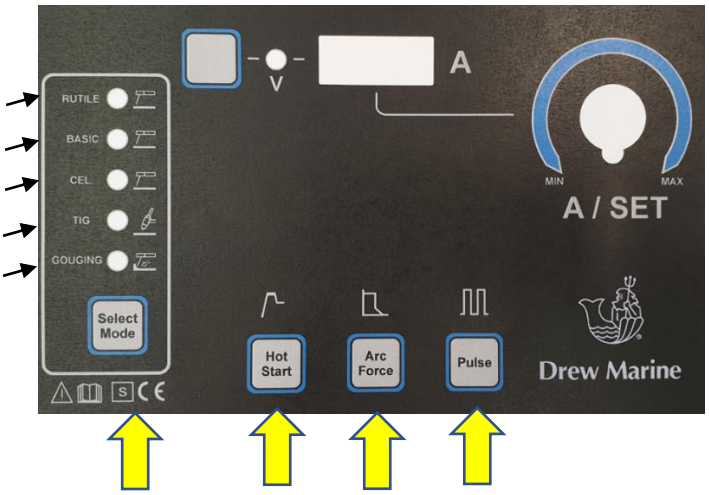
Polybrominated biphenyls and Polybrominated diphenyl ethers are both flame retardant products used as cable insulation.

Non-asbestos declaration
Welding machine manufacturers should also be asked to provide a Non-asbestos declaration.
This will confirm that no asbestos is used in the welding machine. Heavy metals and Asbestos will be a health hazard to the operator and environment.

If the welding machine comes with an undercarriage or protection cage that also incorporates the possibility for lifting, make sure that there is a TuV lifting certificate to prove this. This certifies that the item is certified according to the international labor office for testing and examination of lifting gear used in loading and unloading of ships.

Import information to check on the welding machines front panel and motor plate:

Select mode: With limitation to the open circuit voltage, modern welding machines are equipped with different characteristics settings for different types of electrodes. This makes them function at their optimal level. Cellulosic and Basic coated electrodes require high OCV in order to ignite and keep a stable arc. Rutile electrodes are not so sensitive but will never the less function better at its specific setting. It is important that the welding machine also has special characteristic setting for TIG welding and Air Carbon Arc gouging.



Hot start increases the start current for a short period. It makes arc striking easier and reduces the possibility for electrode sticking.
Arc force increases the short circuit amperage providing a crisper arc, allowing the welder to use very short arc without the electrode sticking in the melt pool. It is useful when welding with stick electrodes at low amperages but gives more spatter. Should not be used for TIG welding.
Pulse ability is an advantage when TIG welding. It will pulse between a maximum and minimum value giving better control and a cooling effect in the weld sone.

Power supply	380-440V ±10% 3~50/60 Hz
Mains fuse minimum (Slow blow)	16A
Maximum power	13.7kVA
Process power	300A 32V MMA MODE 300A 22V TIG MODE
Duty cycle @ 40°	35% @300A
	60% @ 250A
	100% @ 200A
Power factor	0,80
Open circuit voltage	18V
Protection class	IP 23
Environmental conditions	Welding: -10°C + 40°C storage: -20°C + 55°C
Cooling	Forced
Temperature class	H
Dimensions L x W x H	540x225x365 mm
Weight	22 kg

Check that the machine can be connected up to the mains onboard with regards to phases, voltage and Hz

Same apply for fuse size

Max amperage must be so that you can weld your biggest required electrode size.

Make sure the Duty cycle is sufficient.

That max OCV is below 70V DC

That IP 23 is minimum requirement

That temperature class is H

That the machine is sufficiently light if to be portable

Maintenance of the welding machines

Welding machines must be blown out regularly to maintain reliable performance. First disconnect the power to the machine. Approximately every six months use clean, dry air to blow out the inside of the machine. In heavy service conditions, cleaning monthly or weekly may be necessary. For inverter-type machines, leave the cover on and direct the airflow through the front of the machine. Failing to blow out the machine can lead to overheating, erratic arc performance, board or electrical failure, and premature wear.

Primary cable size (from receptacle to welding machine)

Most welding machines are delivered with a 2- or 3-meter primary cable. If a longer primary cable is needed this is our recommendation for length and dimension. Note that conductor size measured in square millimetre of the cable does not only depend on cable length but also the voltage on the mains.

1 phase 230V (115V) primary cables have 2 live cables + Neutral.

Conductor size	230V
2,5mm2	< 45m
4,0mm2	<60m

3 phase 440V (380V) primary cables have 3 live cables + Neutral.

Conductor size	380V	440V
1,5mm2	<30m	<200m
2,5mm2	<50m	<300m
4,0mm2	<80m	<500m

For all welding cables (welding and return cable): When welding, do not coil up the cables on the steel deck. It will work as an electromagnet and resistor and greatly reduce the current and develop into overheating. Cables must be stretched out and, in some cases, lifted up from the deck by for example arranging hooks along the railing.

Also: It's better to use long primary cables than long secondary cables in order to bring sufficient current to the welding location.

Secondary cable size (Welding and return cable)

In the metric system, welding cable size is typically expressed in square millimetres (mm2), representing the cross-sectional area of the cable. In the AWG (American Wire Gauge) system size, the smaller diameter cable has a larger number. The below table shows a comparison between welding cables in metric sizes and AWG sizes.

Metric/AWG Cable Size Comparison

Standard cable size mm2	Equivalent size AWG
10	6 (13,3mm)
16	5 (16,8mm)
25	3 (26,7mm)
35	2 (33,6mm)
50	1/0 (53,5mm)
70	2/0 (67,4mm)
95	3/0 (85,0mm)
120	4/0 (107,2mm)

The standard for welding cable is H01N2-D.

H01N2-D means that the cable is produced to an international harmonized standard.

When selecting the proper cable size for welding machines, it is best to choose cable that can handle the maximum output of the welding machine. To do this, first determine three factors. These are:

• Total length of the welding circuit (secondary cables).

• Rated output of welding machine.

• Duty cycle of the welding machine.

Total length of the welding circuit
The welding circuit is the total length in which the electricity travels. It includes the electrode cable and the return cable. Note that welding polarity does not affect the size of cable needed. It does not matter in which direction the current flows through the welding circuit, whether it be direct current positive (DC+), direct current negative (DC-) or alternating current (AC). Polarity and direction of current flow only affects welding characteristics and electrode selection.

Rated output of welding power source
Rated output of the power source is simply the maximum current or amperage level in which the machine is intended to be used (note that some welding machines can produce higher currents than their rated output for short periods of time). This rated output level is informed on the welding machines motor plate and/ or in the operating manual.

Duty cycle of the welding power source
Duty cycle is a capacity rating of a welding machine, expressed as a percent (%). It is the percentage of a 10minute period that the welding machine can operate at 40°C at a given output current level before exceeding its thermal limit and shutting down if it has thermal overload protection. Generally, as output levels decrease, duty cycle increases (until 100% or continuous output). The duty cycle rating(s) can be found on the welding machines motor plate and/or in the operating manual.

Recommended mm2 cable size rated at 40°C*

Combined length of welding cable and return cable.

Current Amps	Duty Cycle %	0-15m (0-50 ft.)	15-30m (50-100 ft.)	30-45m (100-150ft.)	45-60m (150-200ft.)	60-75m (200-250ft.)
125	30	10	16	25	35	50
150	40	10	16	25	35	50
180	30	25	25	25	35	50
200	60	35	35	35	50	50
225	30	25	25	35	50	50
250	30	25	25	35	50	50
250	60	50	50	50	50	50
300	60	50	50	50	50	70
350	60	50	50	70	70	95
400	60	70	70	70	95	120
400	100	95	95	95	95	120
500	60	70	70	95	95	120
600	60	95	95	95	120	2 x 70
600	100	2 x 50	2 x 50	2 x 50	2 x 70	2 x 95

*Values are for operation at ambient temperatures of 40°C and below. Applications above 40°C may require cables larger than recommended.

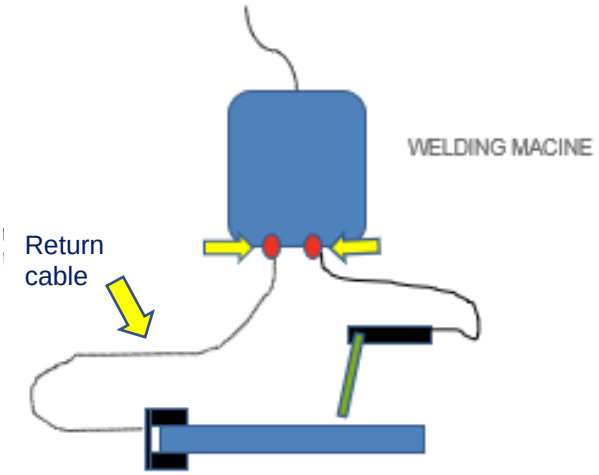
As an example, let's assume you have a 400-amp welding machine at 60% duty cycle and need a total combined length of electrode cable plus return cables of 30m. From the chart, the proper cable size to select would be 70mm2.

For higher current levels, two or more cables are sometime recommended and should be hooked up in parallel or together in order to share the current load.

The Return Cable

The welding machine return cable is often referred to as earth or ground 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 welder 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 electric shock. 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 welder 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”).

Only use fully insulated electrode holders**.**

The Arc

Dry air is a good insulator and it requires a very high voltage to jump an air gap. For both practical and safety reasons, one must use a relatively low voltage in a welding circuit. It we touch an electrode on to the work and then withdraw it slightly, the initial heat of the high current flow on touching will vaporise some of the core rod and coating materials so that a gaseous conductor is established between the electrode tip and the work. This short length of high current flow generates heat sufficient to melt both the base material beneath and the electrode above. The arc gap becomes ionised (electric conductive) and current can flow.

As been seen in the figure for AC/DC the current flow for AC actually momentarily drops to zero 120 times a second, requiring a highly conductive arc atmosphere for the re-establishment of the arc on AC.

Some electrodes, because of their type of coating, will not generate sufficient current carrying ions to maintain a stable arc at say 45 volts and require a higher voltage of say 80volts. Others fail to remain stable on AC at a safe voltage and require DC current. Thus, both AC and DC welding machines are used for the manual metal-arc welding process (MMAW).

Arc Welding Electrodes

The modern manual metal-arc welding electrode combines a central current carrying "core rod", which acts also as the filler rod, and a coating which carries out a number of important functions:

It provides a gaseous shield usually of hydrogen and/or carbon dioxide to exclude the air from the arc areas and so reduce the tendency of oxidation of the molten metal.

It produces a slag which assists in the protection of the molten metal and the moulding to a suitable contour.

It provides a vehicle for adding alloying elements into the weld metal, over and above those elements normally available within the core rod. Thus, quite complicated alloy weld metals can be reproduced from a simple mild steel core rod. It also adds deoxidants to the molten pool.

It can include arc stabilizing elements which permit smooth stable arcing characteristics, even on low voltage AC welding power, or other ingredients to increase arc penetration characteristics etc.

Most covered electrodes these days are designed for use on AC and DC and incorporate special stabilising ingredients in the coating to ensure a steady arc. Some are still designed specifically for DC only.

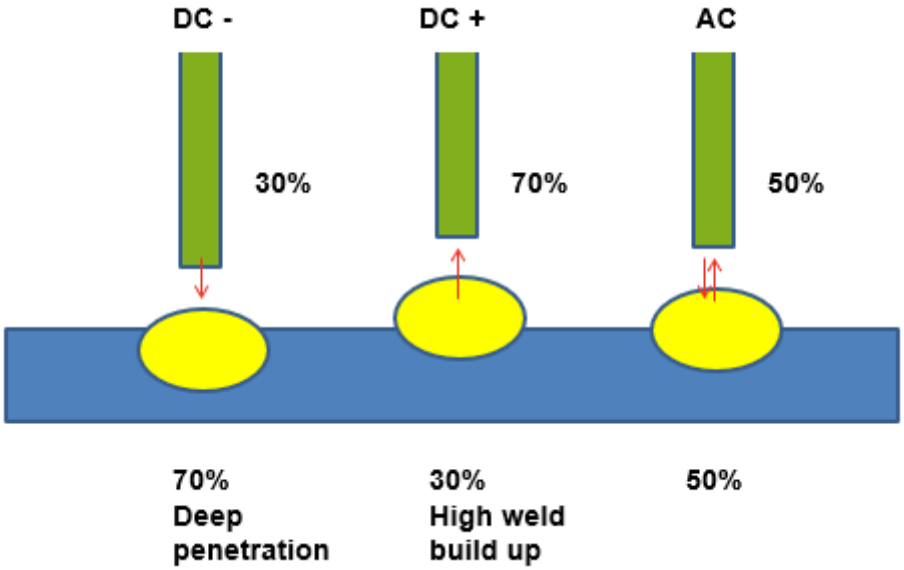
Modern electrodes can be classified into distinct groups based on the major constituents of the flux coating. Each group has its own particular characteristics which govern its usability in various positions and applications.

Parameters for MMAW

Always follow the recommended information from the electrode manufacturer. This will be informed on the electrode package label or in manufacturers technical literature.

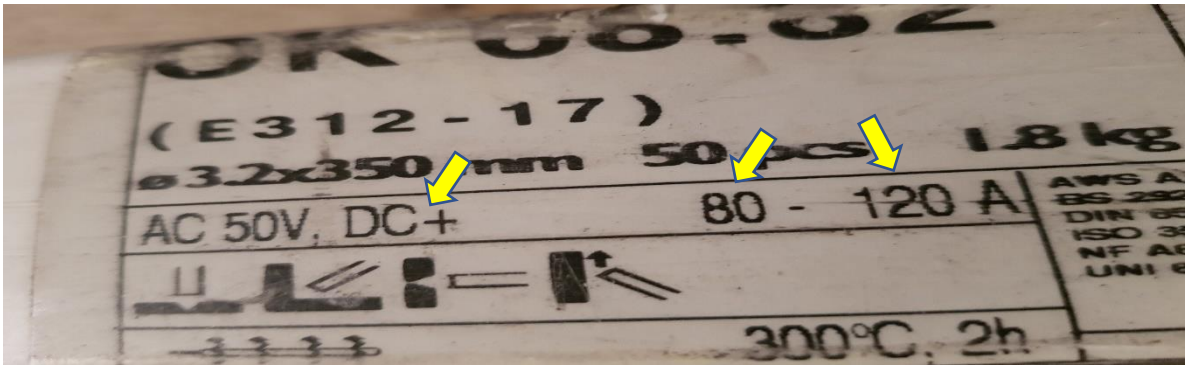
What polarity to choose:

Again, always follow manufacturers recommendation. If no information keep in mind that in the electric arc the temperature is approx. 7000°C. If doing DC welding and we connect the electrode holder with the electrode to – polarity the electrons will bombard the base material and 70% of the 7000°C will be transferred to the base material. Heat will result in expansion followed by contraction. The end result will be distortion. In most applications connect the electrode to + polarity. Always use + polarity when doing hard surfacing and welding of stainless steel. If you are to weld a root run in a V-butt joint it will give better penetration to use - polarity. For filler and capping runs use + polarity. Some electrode coatings require – polarity (rutile electrodes). If recommended by manufacturer, follow the recommendations. AC welding do not give the possibility to manipulate heat input.



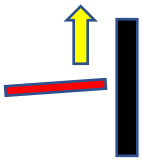
What amperage to choose:

Again, always follow manufacturers recommendation. In below case a 3,2mm electrode is according to manufacturer to be welded using an amperage between 80-120A. The 80A represent the minimum value, the 120A the maximum value. Also note that DC + polarity is recommended.

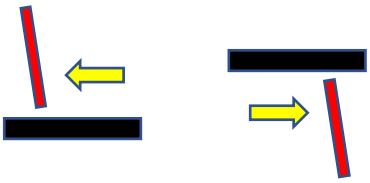


This information can be used the following way:

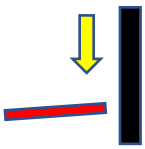
If welding vertical up use minimum value.



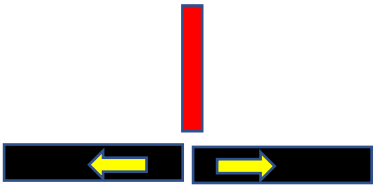
If welding horizontal and overhead use middle value.

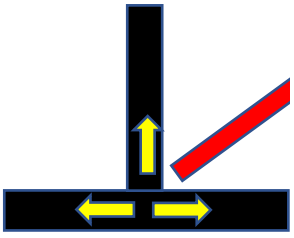


If the electrode can weld vertical down use maximum value.



Also take into consideration the type of joint. In a but joint the heat can escape in two directions. In a T-joint the heat can escape in 3 directions.





You have to compensate for this by increasing the amperage maybe to maximum value.

Also, long secondary cables (welding and return cables) will give less amp at the welding location and will have to be compensated for. Its therefore what you actually observe in the welding pool during welding that will give the final information if your amperage is correct or not.

If the molten pool is elongated and the slag forced to far behind, your amperage is too high and should be lowered.

If the slag is interfering in the molten pool your amperage is to low and must be increased.

The slag should come close to the pool and without interfering forming the weld. One definition of welding is: Welding is control of heat. Another: Welding is a small-scale casting operation.

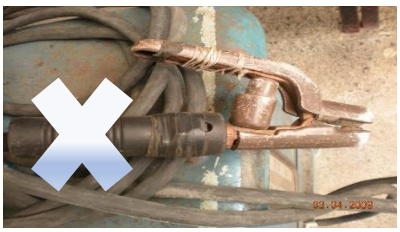
Placing of the welding machine

The welding machine must be placed in an adequately ventilated area, taking care not to block the air intake and outlet from the cooling slots. CAUTION: REDUCED AIR CIRCULATION causes overheating and could damage internal parts. Keep at least 500 mm of free space around the device. Never place any filtering device over the air intake points of the welding machine. Don't leave the welding machine on the open deck over night but bring it back to the workshop.

Make yourself safe for 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 with an OCV below 70 volts;
- 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;
- 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 electrical shock.