Welding and cutting – risks and measures

Contents

The welder’s working environment

Welders are members of an occupational group which is exposed to a number of different environmental problems. This booklet deals with the different factors in the welder’s working environment, as well as suitable measures that can be implemented to improve this environment and reduce the health risks. Effective protection can reduce the health risks. A good welding environment is far more important, however. Access to qualified welders is essential to obtain good quality and productivity. The working environment is one of the factors that have an effect on the choice of occupation.

Electricity

Human beings are extremely sensitive to current that passes through their bodies. Serious physical injury can be caused by currents of just 20 or 30 mA.

Physical injuries, such as falling from scaffolding or a ladder, can result indirectly from very low currents as a result of a sudden and uncontrollable reaction to an electric shock.

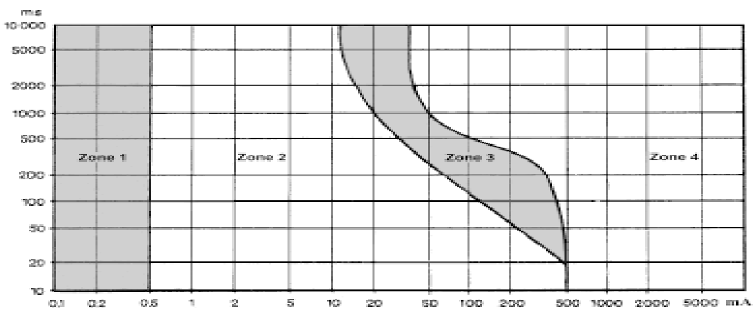

Figure 1. Time and current dependence of alternating current in the frequency range of 15-100 Hz.

Perceptible current (Zone 1). Alternating current is perceptible at just 0.5 mA, while the limit for direct current is around 2 mA. If the current increases, pain and physical discomfort are generated, but this normally produces no harmful physiological effects.

”Release limit” (Zone 2). Currents above the release limit produce muscular spasm and the inability to release the live component of one’s own free will. It is also difficult to breathe, especially if the current lasts for longer than two seconds. Normally, no damage is done to tissue and internal organs before the next threshold value is passed.

The next threshold value, auricular fibrillation (Zone 3), depends very largely on the build of the victim, but it also depends on how long the current lasts and the route it takes through the body, as well as the point in the cardiac cycle at which the disruption occurs.

Auricular fibrillation means that the ability of the heart to pump blood ceases. When this threshold is passed, serious, life-threatening injuries, such as cardiac arrest, occur, breathing stops and tissue and internal organs are burned.

The choice of the type of current (alternating or direct) during arc welding is important, as the risks associated with alternating current (AC) are as much as four times greater than those associated with direct current (DC).

Risk of electric shocks

The effects that result from current passing through the human body depend on:

- the level and duration of the current
- the current path through the body
- the frequency of the current

The level and duration of the current

If someone comes in contact with live components, the size of the current depends on the *voltage* and the *resistance* in the current circuit. The risk of ventricular fibrillation in the heart depends also very largely on the *duration* of the current.

The resistance in the current circuit is the sum of the resistance in the skin, the rest of the body and the protective clothing.

- The resistance of the skin depends, among other things, on the contact area and moisture.
- The resistance of a human body, excluding the resistance of the skin, is comparatively low (can be roughly set at 500 ohm in each arm and each leg).
- Sufficient protective clothing in form of dry leather gloves and shoes with soles made of rubber.

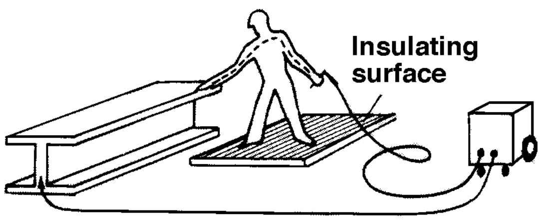

Figure 2b. Current passing from hand to hand

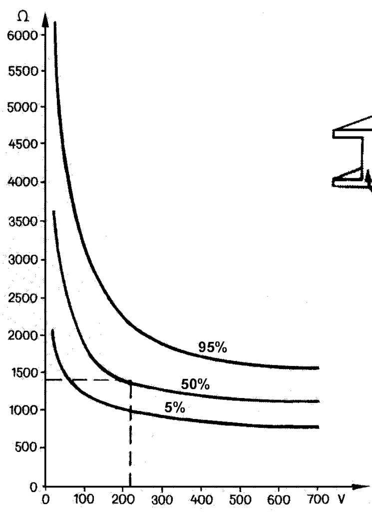

Figure 2. Statistical values for total body resistance when current passes from hand to foot at 50/60 Hz. For example, the resistance in 50% of all people is a maximum of 1,400 ohm when they are exposed to 230 V (AC).

The current path through the body
The danger of ventricular fibrillation in the heart depends on the path of the current through the body, i.e. the level and time of current passing through the heart.

The frequency of the current
As mentioned above the risks associated with alternating current are higher than for direct current. We are most sensitive in the frequency range of 15-100 Hz.

Welding equipment

Open circuit voltage
The highest permissible open-circuit voltage for a power source depends on whether it produces direct or alternating current. (Please note that the EN 60974-1 welding power source standard provides more detailed information than that which now follows.)

In the case of alternating current (AC), the open-circuit voltage must not exceed 80 V (rms), but there are some exceptions.

- If the equipment is being used in confined space where the risks are greater (such as moist, hot or confined spaces with conductive parts), the open-circuit voltage is limited to 48 V (AC). Equipment suitable for welding with increased hazard of electric shock may be marked with the S symbol on the rating plate **S**
- certain small MMA power sources which often are used at home can be marked according to the standard EN 50 060 with a limitation of 55 V (AC).
- In the case of mechanised welding in which the welder does not handle the welding gun manually, 100 V (AC) is permitted.
- In the case of direct current (DC), an open-circuit voltage of 113 V (peak value) is normally permitted, but here, too, there are exceptions for mechanised welding with a maximum of 141 V and for plasma cutting, where the live parts are not accessible, with 500 V.

Routine inspection of equipment
If the internal cooling surfaces of a power source are clogged up with dust and dirt, the temperature increases. It is important from a safety point of view to avoid overheating. A breakdown of the insulation between the primary and secondary windings in the transformer may admit the mains voltage to reach the welding circuit. The insulation resistance may also deteriorate from conducting dust coming from grinding.

As the secondary circuit not necessarily is connected to earth, this would be hazardous to the welder. It is therefore recommended to make routine inspections and cleaning of the internal of the welding power source.

Protection provided by the enclosure
Power sources should have protection for solid foreign objects and water penetration provided by the enclosure (IEC 60529). The degree of protection is indicated by the IP-code (International Protection) on the rating plate. Power sources for outdoor use shall have a minimum degree of protection of IP23.

Electromagnetic fields

The question of the health hazards associated with electromagnetic fields has still not been fully clarified. Even so, straightforward action may well be justified if it can reduce the level of exposure for people working in high electromagnetic fields and do so at a reasonable cost.

A low frequency electromagnetic field is a combination of electrical and magnetic fields but in a given situation, one of them can be dominating.

Electrical fields originate from the voltage. They occur between live cables or surfaces. Fortunately, it is easy to do something about these fields using an earthed sheath or screen.

Magnetic fields occur around conductors through which current flows. The magnetic flux density is measured in tesla (T). In air or other non-magnetic objects, the flux density is so low that the unit μT is normally used. A low value for the magnetic flux density for low-frequency fields is 0.2 μT and it is unusual for this value to exceed 1 μT in a normal office environment

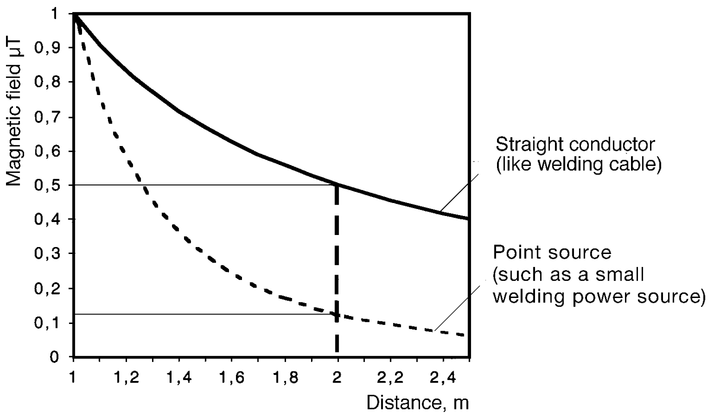

Figure 3. A magnetic field quickly decreases as the distance increases. It decreases most rapidly from a point source, where it declines to one-eighth the size when the distance doubles.

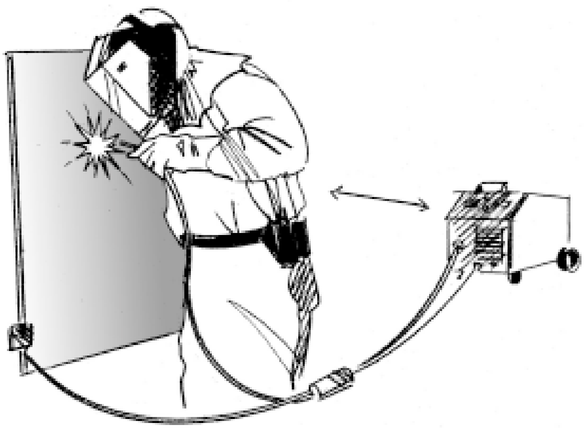

Fig. 4. It is important that the welding cable and return cable are kept together, and if possible it is also preferable to have the power source some metre away.

The frequency of the field is important when it comes to its ability to transfer energy to the surroundings. So, in this way, heat or electric currents can be generated in surrounding objects.

The welder's situation

Welders belong to one of the occupational groups which are exposed to the highest field strengths. Arc welding requires high welding currents. The welding equipment may be near the welder and the welding cables are often in direct contact with the body. In the area close to the welding cable, the magnetic field exceeds 200 µT.

A great deal of welding is performed with direct current. This applies, for example, to MIG/MAG welding, which is currently the most frequently-used welding method in industrial applications. Pure direct current probably has no effect on the health risks but a normal welding current often have some type of pulsations.

Perhaps the most powerful magnetic fields are found in conjunction with resistance welding. People with a pacemaker should be especially careful. It is unsuitable for them to be in the vicinity when resistance welding is in progress and, in some cases, even when some other type of welding with high currents is performed. Consult an expert physician.

Measures to improve the welder's working situation

A great deal can very definitely be achieved by passing on factual information about the health risks associated with welding. If there is a risk of injuries caused by the magnetic fields it is probably far lower than that associated with many other situations during welding.

Mechanisation of the welding process, perhaps using robots, improves the welder's working environment in a number of ways.

The following simple measures are recommended.

- Ensure that welding cables and return cables are together whenever this is practically feasible.
- Avoid to drape the cables over the shoulders or to wrap them around the body during welding.
- The best way to protect oneself from magnetic fields from a power source is to have the power source several metres away. The magnetic field decreases rapidly as the distance from the power source increases.
- Welding with direct current is preferable to welding with alternating current.

UV, IR and visible light radiation

Electric arcs – and molten pools to some degree – give off powerful radiation within the ultraviolet (UV), visible and infrared (IR) wavelengths. This radiation can also be reflected by certain surfaces. Moreover, the flames from a gas/oxygen mixture can emit visible and infrared radiation.

Radiation is reduced by the square of the distance. As far as the arc is concerned, the radiation is dependent on the current level, the length of

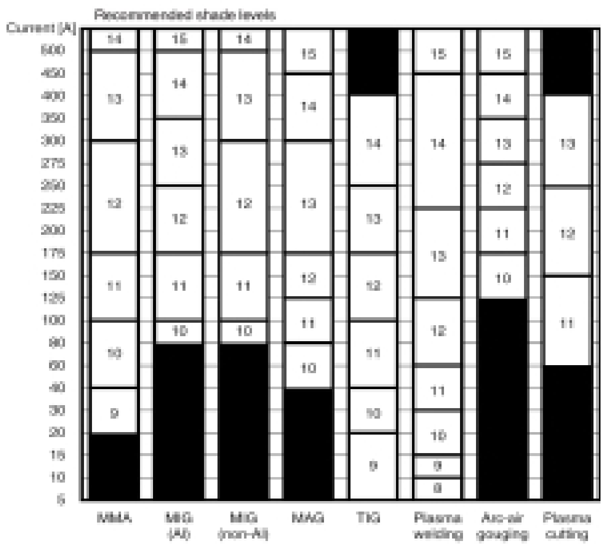

Figure 5. Recommended filter shade levels for protective glass filters. More detailed information is given in the standard EN 169.

the arc, the temperature level and the temperature distribution in the arc atmosphere. So sharp variations in radiation can occur using one and the same method. The same thing applies from one methodto another. For a given current, the radiation is more powerful during MIG/MAG welding than during normal metal-arc welding. In addition, higher currents are used during MIG/MAG welding and, as a result, gas-shielded arc welding almost always generates more powerful radiation.

Fig. 6. Protection from UV, IR and visible light radiation is clothing with a leather apron and gloves and a welding helmet.

Risks

Eye damage

UV radiation is most dangerous for the eyes. It causes what is known as arc eye (a temporary injury to the cornea).

Visible light can have a dazzling effect and temporarily affect the vision.

IR radiation can cause damage to the retina and the lens (cataracts).

Skin damage

UV radiation can damage unprotected skin. The damage resembles stinging sunburn.

Preventive action

- A welding screen or welding helmet with a glass visor which is regulated by liquid crystals or a fixed, standardised glass visor.
- A welding helmet with a window and side guards for use during slag removal.
- Welding overalls or some other protective clothing with a leather apron.
- Leather gauntlets, without rivets or other metal components, on both hands.

Thermal radiation

Thermal radiation is a major problem at welding workshops. This applies in particular when the welding is performed at increased working temperatures, i.e. when preheated objects are welded.

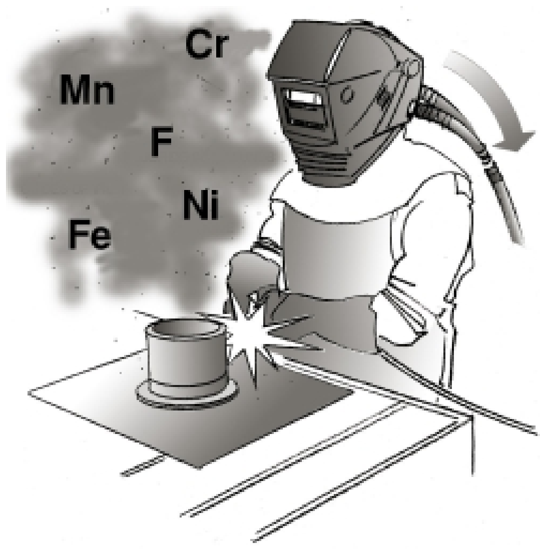

Fig. 7.When welding in confined spaces where there is a risk that the concentration of fumes and gases could be too high, the welder must use breathing protection with a supply of clean air, which makes him/her independent of the surroundings

Protective action

The following points should be taken into consideration when welding at increased working temperatures.

- The workplace should be well ventilated.
- The object should have effective thermal insulation.
- The welder should not be obliged to adopt uncomfortable working positions or to use heavy equipment.
- Suitable protective equipment, such as heat-insulated gloves, should always be used.

As working in high temperatures imposes a strain on the body, suitable breaks in the welding must be planned.

It is also important to make sure that the welder's back is not exposed to the cold and to draughts while the front of the body is exposed to very high temperatures. High temperatures also have a significant effect on people's judgement.

Air pollution in connection with welding

Different types of air pollution are caused by welding. Generally speaking, the welding method and consumable determines which impurities are generated (particles and gases) and in which amounts.

The base metal can also contribute if it has been treated with a volatile substance, for example.

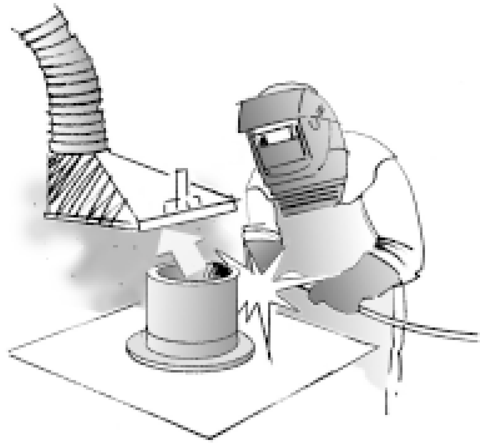

Fig. 8.Extraction and air treatment improve the air in the workplace and reduce the risk of injury to the people working there.

Fumes
Welding fumes are a result of the vaporisation and oxidation of different substances in the arc which is caused by the high temperature. The particles in these fumes are generally so small that they can reach the narrowest branches of the respiratory organs. These particles consist of oxides of iron, manganese, chrome and nickel, for example. There are also different types of fluoride compounds. The level of fumes (emissions) produced during MMA and MIG/MAG welding with solid wire or cored wire is virtually the same. In some cases, however, there are clear-cut differences. In favourable conditions, the fumes produced during MIG/MAG welding with solid wire can be far lower than those produced during MMA welding. In TIG welding, the emissions are far lower than those produced during MIG/MAG and MMA.

Risks
Hexavalent chrome, which is primarily produced during the MMA welding of stainless steel. It can cause cancer and asthma-like problems.
Manganese can affect the central nervous system.
Nickel can cause cancer and asthma.
Iron oxides can cause irritation in the airways.
Fluorides can affect the skeleton.
A number of different substances can be released from surface-coated material:
Material coated with lead paint can release lead and affect the central nervous system.
Zinc, which is found in galvanised materials, can cause shivering.

Polyurethane paint or insulation can release isocyanates which can cause asthma.

Gases
The most common gases produced during welding are ozone, nitrous gases and carbon monoxide. Other gases which are a health hazard and can be produced include phosphine and phosgene.

Risks
Ozone forms when the oxygen in the air reacts with the ultraviolet radiation from the arc. Ozone is a colourless gas, which is a powerful irritant which attacks the mucous membrane and the cell membrane. Nitrous gases (nitrogen oxides) form when the nitrogen and oxygen in the air react with the hot arc and the hot base metal. These nitrous gases affect the lungs. Carbon monoxide forms during MAG welding as a result of the atomisation of carbon dioxide in the shielding gas. Carbon monoxide affects the ability of the blood to absorb oxygen.

Preventive action
Different measures can reduce the risk of exposure to dangerous substances.

- Use spot extraction when working indoors. The spot extraction equipment must be moved along the weld joint when long joints are being welded.
- Even if you have an effective spot extractor, some welding fumes will spread into the workplace. Fumes from the underside of the workpiece and fumes which develop during finishing are difficult to trap with spot extraction equipment. The general ventilation requirements should therefore be rigorous.
- When welding in confined spaces where there is a risk that the concentration of fumes and gases could be too high, the welder must use breathing protection with a supply of clean air, which makes him/her independent of the surroundings.

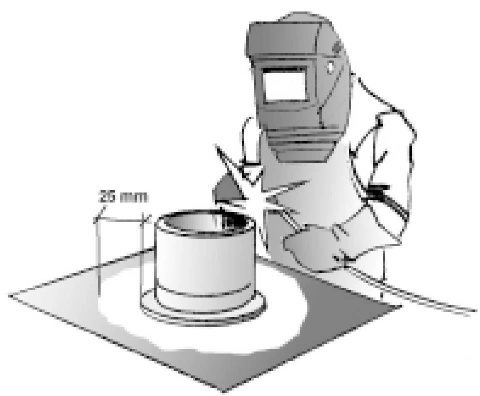

Fig. 9. The base metal must be exposed at least 10, sometimes even 25 cm from the point of welding to avoid fumes and gases from paint or other surface treatment

- To avoid fumes and gases from paint or some other surface treatment, the base metal must be exposed at least 10 cm from the point of welding.
- To avoid fumes and gases from foam insulation made of polyurethane, the base metal must be exposed at least 25 cm from the point of heating.

Handling of tungsten electrodes containing thorium oxide

Thorium oxide is a common additive to non-consumable tungsten electrodes used for TIG welding. It improves the arc striking ability, arc stability and the electrode longevity. As thorium is a slightly radioactive element, some precautionary measures have to be taken.

During normal storage and handling of the electrodes, the hazard from radiation is negligible. Inhalation of dust from grinding may cause hazards from so-called internal radiation.

Precautions

- Grinding of thoriated tungsten electrodes shall be performed with an effective extraction system or with special closed grinding tools. The operator should use a face mask if there is any doubts about the efficiency of the extraction system.
- Dust should be collected and disposed with care.
- If possible, use thorium-free electrodes. Alternatives exist with zirconium, lanthanum and cerium. 2 % thorium content (WT20) is better than 4 % (WT40) in this respect.
- Avoid thoriated electrodes or use an effective fume extraction when welding with alternating current. (The hazard of inhalation of welding fumes from thoriated tungsten electrodes is normally negligible but can reach or exceed the limit values when welding with AC-current).

Occupational exposure limits

Most harmful substances have occupational exposure limits (OEL) which are regularly revised. The most common of these limit values specifies the average concentration which does not normally represent a health risk during eight hours of work a day (level limit value). A maximum exposure limit or short-term limit value is also specified for certain substances.*)

As the gases and particles which form affect the body in different ways, it is important that the regulations issued by the authorities and the instructions issued by manufacturers are followed, in order to avoid ill-health.

Material Safety Data Sheets (MSDS) are also available. On these sheets, the manufacturer has 16 points in which to provide a detailed

description of ways of protecting oneself from injury, for example,

*) **Limit values for different substances in fume** (Swedish values)

Fume	5 mg/m^3
Fe	3.5
Mn	0.5
Cr	0.02
Ni	0.1
F	2
Cu	0.2
0_3	0.1 ppm
Th	
Nox	

Fire and spatter

Risks associated with spatter

In some cases, the spatter produced by welding can cause discomfort and even burns. One example is when large drops of spatter fall into wooden clogs. The risks increase in connection with overhead welding or if the welding is performed in confined spaces where the welder may even have to lie down to obtain better access to the object he/she is welding.

Preventive action

By using suitable welding parameters, a suitable shielding gas with a high argon content and the right working technique, it is possible to avoid overly large drops of spatter. Fine spatter is normally fairly harmless.

To avoid these problems, it is important to use fully-fitting clothing and clothing made of a suitable heat-resistant material and tested to EN 470-1.

Fire risks

Fires caused by welding and cutting are largely due to a lack of knowledge, carelessness and insufficient protection. Training and effective protection programmes are essential in this context. Experience reveals that the risks are greatest in connection with temporary work in premises or areas that are not designed for welding.

At temporary workplaces, welding or cutting is often used. This generates a great deal of heat that has to be conducted away and the risk of relatively large molten particles and sparks which can cause fires is greater.

Fig. 10. It is important to protect fire sensitive things where there is risk of fire when welding.

Workplaces where the risk of fire is high are particularly dangerous welding sites, e.g.:

- Places where flammable substances, such as petrol and oil, or flammable gases are handled.
- Premises containing packaging material or timber goods.
- Construction sites where sparks can more easily spread into areas that are not readily accessible, such as walls made of wood or containing flammable insulation.

When working in dangerous environments of this kind, welding inspections must always be conducted. In some cases, the approval of the municipal safety officer and insurance companies must be obtained.

Slow combustion

At other places where the material is perhaps less flammable, ignition can begin with slow combustion. It can then develop into a fire with open flames. A relatively long period can pass before the fire is discovered and, if the seat of the fire is also difficult to access, extinguishing the fire is more difficult, even if fire-fighting equipment is available.

Development of fire in different environments

Fires in PVC plastic, which is often found in electrical cables or other interior design materials, generate hydrogen chloride vapour which, together with the moisture in the air, creates hydrochloric acid. This is a powerful irritant and it is also highly corrosive when it comes to metals. In addition, it can damage sensitive electronic equipment.

There may be a risk of explosion when flammable substances like petrol, oil and paraffin are heated. If they do not ignite directly, there is a real risk of explosion as they first vaporise.

Remember that the heat produced by welding or cutting a pipe can be conducted into a nearby wall and cause a fire, even if the temperature is relatively low. A sufficiently large spark from welding, cutting or even grinding could cause a fire, even if it is not red-hot.

Fires in enclosed spaces such as walls and insulation can develop relatively slowly. Always call the fire brigade if a fire of this kind occurs. Call the fire brigade even if it appears that the fire has been put out, as it is important to check that no source of slow combustion is left.

Preventive action

If welding or cutting has to be performed in places where there is a risk of fire, a safety officer should assess the preventive action that needs to be taken.

- Cleaning and removal of flammable material in the risk zone.
- Any holes or cracks in flammable building components must be covered or sealed so that welding spatter or red-hot particles from cutting, for example, cannot penetrate them.
- Use water to dampen the area before and perhaps after work.
- Screen off the area.
- Make sure that sufficient fire-fighting equipment is available.
- Monitoring and after-inspection (one hour) by a fire guard.
- Make sure that the staff are sufficiently familiar with the regulations and the ways risks can be avoided.

Noise risks

MIG/MAG welding generates a relatively large amount of noise, up to 80 dB. Noisy grinding work, slag removal or straightening in connection with welding also take place frequently. There is thought to be a risk of permanent hearing impairment if people are exposed to 85 dB(A) for more than eight hours per working day. As a rule of thumb, it would be true to say that the noise level is unacceptable when it is difficult to conduct a conversation.

Measures to reduce noise

To begin with, an examination should be made to see whether the process or production set-up can be modified to avoid the sources of noise.

- Using a suitable welding process, welding data, shielding gases and welding technique can minimise grinding and slag removal or, at best, eliminate them completely.

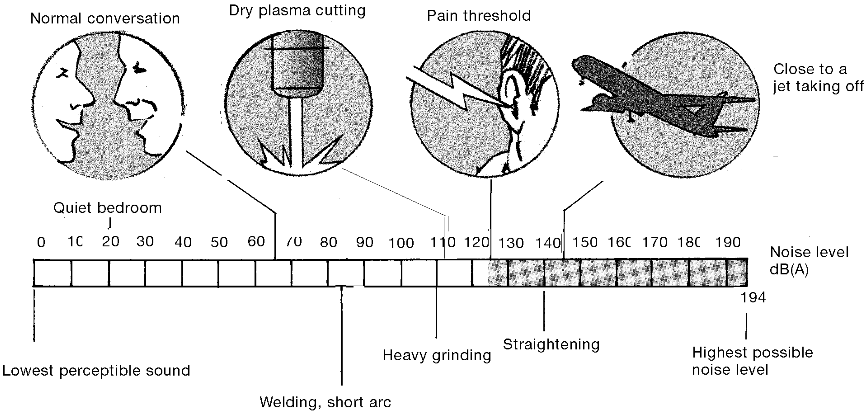

Figure 11. Some sources of noise as a reference to the dB scale

- Use quieter tools for grinding and removing slag.
- Plasma cutting can generate very high noise levels. Significant environmental improvements (reductions in noise levels of as much as 30-40 dB) can be obtained by using cutting tables which permit cutting under water.
- Screen off noisy work and take measures to reduce reverberation in working areas by putting up noise absorbers.
- Use ear protectors if the noise is disruptive or if there is a risk of hearing damage.

Hearing tests should also be conducted at regular intervals.

Ergonomics

Risks

When welding heavy material manually and during assembly welding, the loads are very static. The welding times are longer and the weight of the equipment is greater. In addition, the working position in this case is dependent on the position of the weld joint. Overhead welding is unsuitable from an ergonomic angle.

When MIG-welding small items in fixtures, there is a risk of industrial injury as a result of the monotonous, unchanging movements. The gun is often supported by holding one hand against the workpiece.

Measures - technical devices and equipment

When planning a workplace, the working height plays an important part

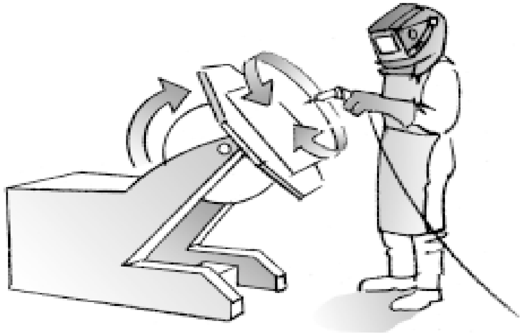

Figure 12. Positioner for positioning workpieces

in creating the correct working position. In this context, positioners and lifting tables can be very useful. The working position is partly determined by the welder's need to have his/her eyes close to the workpiece to be able to see the molten pool clearly while welding. If the working height is too low, the welder has to bend to see properly. A chair or stool might then be very useful. Working with the hands in a high position at or above shoulder level should be avoided whenever possible.

In conjunction with heavier welding, the gun and hoses are also heavier and the load on the body is more static. A balanced load-reduction arm is very useful in this situation. Lifting the hoses off the floor also protects them from wear and tear, as well as facilitating wire feed.

It is also a good thing if the workpiece is placed in a positioner and is positioned to ensure the best accessibility and height (Figure 12). A more comfortable working position can be created and, at the same time, welding can be facilitated as the joint is in the best welding position.

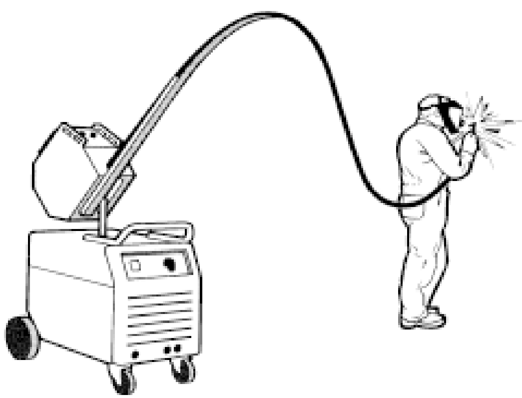

Figure 13. A load-reducing counter-balanced arm reduces the weight of the hoses through-out the working area.

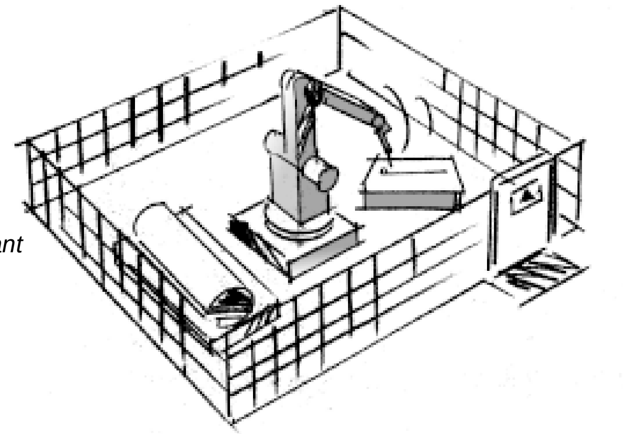

Fig.14. It is important to follow the safety requirements for machines

Roller beds can be used for welding tubes or other cylindrical items.

A hook or some other device on which the welding gun can be placed when it is not in use is another valuable piece of equipment.

Machine safety and mechanical protection

The moment we begin working with machines with moving parts, like welding robots or cutting machines, we must be aware of the possible risk of personal injuries. To begin with, the design should be such that risks are avoided wherever possible. If it is not possible for practical reasons to eliminate the risks, appropriate protective measures must be implemented to guarantee personal safety.

The appropriate action can be taken on several levels.

- *Mechanical protection* or hoods/casing which provide direct protection. These protective devices should be sufficiently robust without impeding or limiting visibility or operation.
- If straightforward mechanical protection is not possible for functional reasons, the operator must be positioned outside the risk zone and some form of enclosure must be created around the equipment to reduce the risk of injury. The opening to the risk zone, such as a hatch, gate or service entrance, must have an interlocking device which stops the machine in the event of unauthorised entry. The zone can be monitored with safety switches on hatches or gates, light bars for the service entrance or a pressure sensitive mat which senses when someone is present. The enclosure and safety devices should not be designed in such a way that they are easy to bypass or de-activate.

- Protection may also be required to protect the operator from risks when work has to be performed inside the risk zone for some reason.
- Personal safety equipment, training, information and warning signs provide a warning about the risks which may still exist after the above action is taken.

The EU's machinery directive

The machinery directive is a mandatory directive within the EU with which every new machine has been obliged to comply since January 1 1995. According to the definition, a machine has at least one moving part and can operate independently.

The machinery directive specifies the basic safety requirements for machines. More detailed information can be found in what are known as the harmonised European standards (EN). Applying them is basically voluntary, but, if a machine has been designed in accordance with these standards, it is also regarded as complying with the machinery directive. CE labelling indicates that a machine complies with the machinery directive.

The cutting operator’s environment

As with welding, the safety measures for thermal cutting and waterjet cutting are designed to provide protection from a combination of risk factors.

- Mechanical risks
- Electrical risks
- Light and thermal radiation
- Fumes and gas
- Noise

When it comes to the mechanical and electrical risks, please consult the general rules that are dealt with separately in this publication. Problems caused by light, fumes or noise are dependent on whether gas, plasma, laser or waterjet cutting is involved.

Risks and measures in gas cutting

Fumes and spatter from metal and molten slag are produced primarily from the underside of the plate. During manual cutting, there are special requirements which relate to personal safety equipment. During temporary work in areas where there is a risk of fire, suitable protective action should be taken.

Fumes and gases which are a health hazard develop. They include nitrogen oxide (NO_x) and ozone (O_3). It is a good idea to use a cutting table with integrated fume extraction.

The average noise level is around 85-90 dB(A).

Handling and installation of gases

A dangerous situation can occur if a bottle of gas or a centrally-installed system has not been connected or maintained correctly. Outlets for cutting gases and oxygen must be connected using reliable equipment which has been approved for the gas in question in order to provide

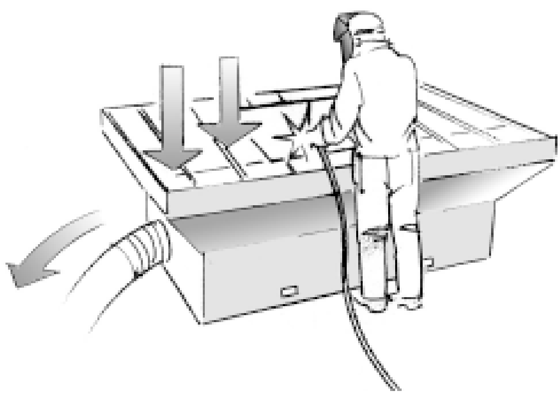

Fig.15. A cutting table is supplied with extraction for fume and gases.

protection from possible backfire.

When handling high-pressure gas bottles, the relevant rules must be complied with. These bottles should, for example,

- be easily accessible in the event of fire
- be secured so that they cannot fall over
- have a warning sign in a place that is clearly visible

Risks and measures in plasma cutting

The UV radiation from the arc can damage the skin and eyes and can also produce ozone. When it comes to the effects and to protective action, please consult the sections on radiation, page 9, and the risks associated with ozone, page 13.

Fumes are produced as a result of vapour from the material that is cut. When cutting surface-treated material, substances that are harmful to the health may be included in the fumes, depending on the type of surface treatment. When it comes to the health risks, please consult the corresponding section relating to welding, page 11.

The amount of fume that develops is dependent on a large number of factors, but it is generally higher if the settings are high. Examples of the factors that play a role here include plate thickness, current, the process (underwater cutting, cutting with a water curtain or cutting without special protective measures) and the number of torches. When it comes to radiation, the surrounding areas (such as reflective walls) also have an effect.

During “dry” plasma cutting, extraction from underneath (under the material which is being cut) is recommended, while extraction can be arranged above the plasma torch in connection with cutting under water.

The noise levels in workplaces where plasma cutting is performed are higher than those associated with normal gas cutting and can be as high as 115 dB(A).

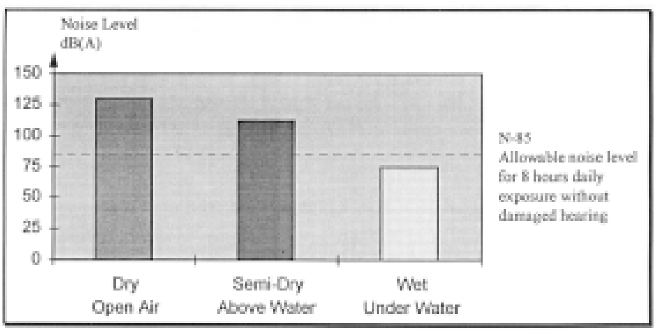

Fig. 17. Average noise levels when plasma cutting in open air, above water (60 mm) and under water (75 mm)

It is important that the operator uses suitable personal safety equipment, such as ear protectors, a welding visor and suitable clothing.

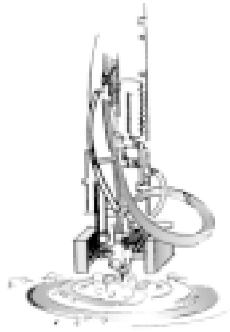

Fig. 18. Under water cutting is an effective way of improving the working environment.

Under water plasma cutting

One effective way of improving the working environment during plasma cutting is to use wet cutting with the plasma torch submerged in water. The emissions of metal fumes, nitrogen oxide and ozone are then reduced sharply, as are the noise levels.

The fumes can be reduced depending to some extent on the depth of the water. The nitrogen oxide can be reduced by three-quarters and the noise levels by as much as 30 dB(A).

Risks and measures in laser cutting

Spatter from metal and molten slag are produced primarily from the underside of the plate. Fumes and gases which are a health hazard develop. They include nitrogen oxide (NO_x) and ozone (O_3). It is a good idea to use a cutting table with integrated fume extraction.

Dust and gases (He, N_2, CO_2, O_2), noise, visible light and harmful laser radiation can also be produced. Use suitable ventilation and personal safety equipment.

The light from an Nd-YAG laser is invisible in the infrared range, but it has a shorter wavelength than a CO_2 laser. This light can therefore penetrate the retina and cause damage, even in fairly small doses.

Laser equipment in laser class 4

The direct laser beam and indirect, reflected radiation constitute a special risk.

Emission of fume when plasma cutting mild and stainless steel

Material and thickness	Dry cutting (g/min)	Under water cutting (g/min)
Mild steel, 8 mm	20-26	0.1-0.4
Stainless steel, 8 mm	30-40	0.2-0.5
Stainless steel, 35 mm	1.8-3.4	0.02

Table 1. Emissions of fume - comparison between dry cutting and under water cutting

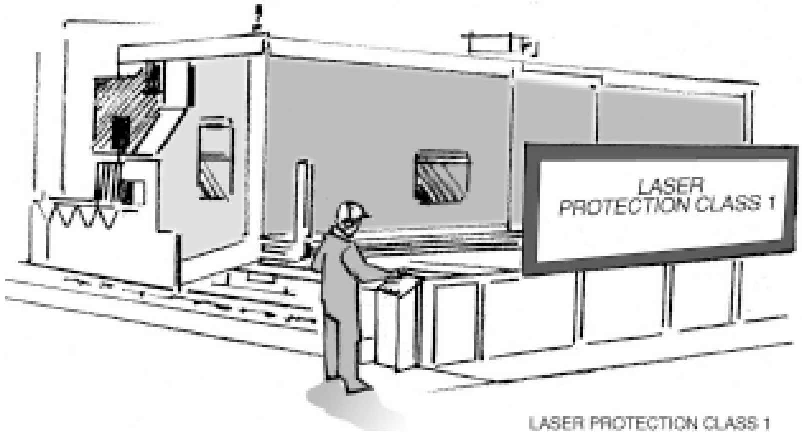

Fig. 19. ESAB PRO-LAS 1®. - a laser guard system which provides an intelligent combination of efficiency and safety to laser protection class 1.

Special requirements must be met and special action must be taken to protect the operators. Machines in class 4 can only be fitted if the laser beam is used in the vertical-down position. The operator and service technician must be protected from direct or indirect radiation using suitable equipment, such as protective screens, protective clothing and laser goggles. This is particularly necessary when working to adjust the laser and mirror system.

The people who are involved in maintenance and settings must be given special training.

Detailed user's instructions and warning signs should supplement the protective measures.

Laser equipment in laser class 1
The requirements relating to safety equipment and protective action are far more comprehensive than those relating to laser machines in laser class 4.

A double-walled protective screen which provides sufficient all-round protection must be used. Special protection from the reflective radiation must also be provided.

Risks and measures in waterjet cutting
The cutting beam, which contains sand and residue from the cut material, can constitute a risk in connection with waterjet cutting.

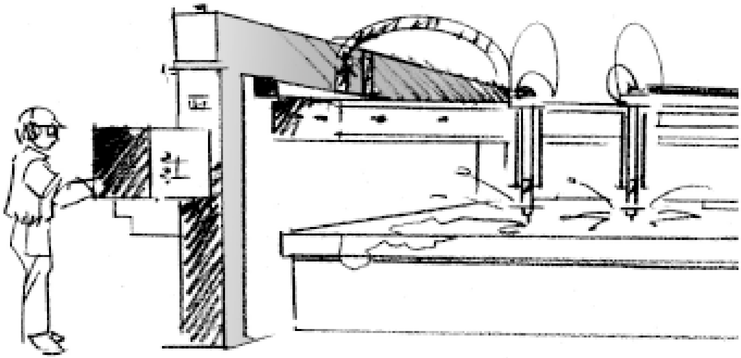

Fig. 20. Water jet cutting. The operator should keep a safe distance of at least one metre and wear protective clothing, goggles and ear protectors.

Waterjets

The abrasive (mixed with sand) waterjets have very high kinetic energy and, if this energy is utilised incorrectly, this can lead to serious injuries.

Even apparently small wounds can conceal a far more serious injury and should be treated as quickly as possible. There is a risk that foreign particles may have penetrated. A safe distance of at least a metre should be maintained during cutting.

Spatter guards can be put up around the nozzle. The operators should wear protective clothing, protective goggles and perhaps ear protectors as well.

High-pressure unit

The high-pressure unit should be serviced by trained staff.

Noise

The high-pressure unit should be equipped with a noise-reducing hood because of the high noise levels.

The noise level during waterjet cutting can be as high as 85 dB(A) or thereabouts.

Reference literature:

Hälsa och säkerhet vid svetsning och besläktade förfarande, utgåva 2, svetskommissionen

Arbetsmiljö vid svetsning, Arbetarskyddsnämnden

El- och brandsäkerhet vid svetsning. Svetskommissionen 1990.

Kjell Isacsson. Elmiljön i verkstadsindustrin. -artsgemensamt material, Industrilitteratur V060014

Hazardous substances in welding and allied processes, Metall-Gerufsgenossenschaften

Welding adds hazards to work in confined spaces, IIW 1998

Reduktion av ozon med MISON Skyddsgaser, AGA Gas AB

AG32 Arbetshygien, Faror och skydd vid svetsning 5. Elektromagnetiska fält vid svetsarbete, Svetskommissionen

Handling of non-consumable tungsten electrode containing thorium oxide, Schweissen und Schneiden, no. 11 1999.

Standards

Directives

IEC 62081:1999 Arc welding equipment- Installation and use

EN 60974-1:1998 Arc welding equipment - Part 1: Welding power sources.

EN 169:1992 Filters for personal eye protection equipment used in welding and other similar operations

EN 166 Personal eye protection-specifications

EN 470-1 Welders clothing.

IEC 479-1 Effects of current on human beings and livestock. Part 1: General aspects

IEC 479-2 Effects of current passing through the human body. Part 2: Special aspects

Machinery Directive 89/392/EEC (plus amendments)

Personal Protective equipment 89/686/EEC (plus amendments)

ESAB AB
Box 8004
S-402 77 Göteborg, Sweden
Phone: +46 31 50 90 00
E-mail: info@esab.se, Internet: www.esab.com

Reg.No. XA00096120