HEALTH and SAFETY in Welding.
Presentation of training materials

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1. Definition and types of hazards

- Hazard definition
- Types of hazards
- Hazards connected with welding and allied processes
Hazards categories connected with welding

- Chemical
- Physical
- Mechanical
- Electrical
- Fire

Health, Safety and Environmental Training for Welding Personnel  WeldTrain - HSE LLP - LdV / TOI / 2012 / RO / 036
2. Chemical hazards in welding – scope of theme

- Sources of hazardous substances
- General characteristics of fume
- Classification of hazardous substances according to their occurrence and effects
- Hazardous substances during welding and allied processes (soldering, brazing, thermal cutting, thermal spraying)
- Characteristics of fume components: iron, copper, zinc, manganese, aluminum
- Characteristics of carcinogenic fume components: chromium(VI), nickel, cadmium
- Chemical composition of fume during different welding methods
2. Chemical hazards in welding

Characteristics of gases: nitrogen oxides, carbon monoxide, ozone

Characteristics of organic substances during welding and allied processes

Illnesses caused by welding fume and gases

Ways of reduction hazardous substances during welding and allied processes (conception of protective measures)

Ways of process optimization in aspect of fume and gases reduction during welding and allied processes: Influence of current-voltage parameters, chemical composition of shielding gas and welding methods

Assessment of fume and gas emission rate during resistant welding, welding and braze welding of various constructional materials using innovative methods

Analysis of influence of material-technological conditions of alternating polarity MIG welding of aluminium alloys on welding fumes emission

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Sources of hazardous substances

Hazardous Substances in Welding and Allied Processes - V.E. Spiegel-Ciobanu BGI 593
Fumes

- Small solid particles are mainly generated by condensation of metals that have been volatilized to their gaseous state
  - VERY small particles (90% less than 1 micron in size)
  - Not always visible to the unaided eye
- Another source of these particles is very small spatters.
- Small particles are HIGHLY respirable meaning they can get into the deep lungs
- Vary considerably in their toxicity
- Sources
  - Consumable or filler metal
  - Base metal
  - Coatings or surface treatments
Size of particles

Inhalable = total dust

Respirable = fine dust

Welding fume

Soldering and brazing fume

0.01 µm  0.1 µm  1 µm  10 µm  100 µm (0.1 mm)

RESPIRABLE  NON-RESPIRABLE

V.E. Spiegel-Ciobanu BGI 593  Hazardous substances in welding and allied processes

Health, Safety and Environmental Training for Welding Personnel  WeldTrain - HSE
LLP - LdV / TOI / 2012 / RO / 036
## Possible effects of specific hazardous substances in welding

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<th>Effects</th>
</tr>
</thead>
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<tr>
<td><strong>2.1. Lung-stressing</strong></td>
<td></td>
</tr>
<tr>
<td>Aluminium oxide</td>
<td>Dust deposits in the lungs, aluminosis</td>
</tr>
<tr>
<td>Iron oxide</td>
<td>Dust deposits in the lungs, siderosis</td>
</tr>
<tr>
<td>Potassium oxide</td>
<td>Dust deposits in the lungs</td>
</tr>
<tr>
<td>Sodium oxide</td>
<td></td>
</tr>
<tr>
<td>Titanium dioxide</td>
<td></td>
</tr>
<tr>
<td><strong>2.2. Toxic</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Barium compounds, soluble | Toxic * nausea  
                        | * possible potassium deficiency |
| Iron oxide           | Toxic * nausea  
                        | * indigestion  
                        | * nervous and renal lesions |
| Fluorides            | Toxic * irritation of mucous membrane  
                        | * bone damage |
| Copper oxide         | Toxic * metal fume fever (copper fume fever) |
| Manganese oxide      | Toxic * irritation of mucous membrane  
                        | * nerve damage |
| Vanadium pentoxide   | Toxic * irritation of eyes and respiratory tract  
                        | * lung damage |
| Zinc oxide           | Toxic * metal fume fever (zinc fume fever) |
| **2.3. Carcinogenic**|     |
| Baryllium oxide      | Carcinogenic * metal fume fever  
                        | * chronic pneumonia |
| Cadmium oxide        | Carcinogenic * irritation of mucous membrane  
                        | * emphysema |
| Chromium (VI) compounds | Carcinogenic (respiratory system)  
                        | * irritation of mucous membrane |
| Cobalt oxide         | Carcinogenic * impairment of respiratory system |
| Nickel oxides        | Carcinogenic (respiratory system) |
Nitrogen oxides in welding

\[ \text{N}_2 + \text{O}_2 \xrightarrow{T > 1000 \degree \text{C}} 2 \text{NO} \]
\[ 2 \text{NO} + \text{O}_2 \xrightarrow{T_{\text{Room}}} 2 \text{NO}_2 \]

Ozone (\( \text{O}_3 \))

\[ \text{O}_2 \xrightarrow{\text{UV radiation}} 2 \text{O} \]
\[ \text{O} + \text{O}_2 \longrightarrow \text{O}_3 \]
\[ \text{O}_3 \xrightarrow{\text{gas and particles.}} \text{O}_2 + \text{O} \]
### Organic substances during welding and allied processes

<table>
<thead>
<tr>
<th>Organic Substance</th>
<th>Details</th>
</tr>
</thead>
</table>
| Benzene ($C_6H_6$) | - Benzene poisoning can cause bone marrow and nervous system injuries.  
- Benzene gets to human body through respiratory system (as vapour).  
- According to IARC (International Agency for Research on Cancer) guidelines benzene belongs to **Group 1: carcinogenic to humans**. |
| Phenol ($C_6H_5OH$) | - Phenol is used in production of paints, removers, rubber, synthetic resins and plastic materials.  
- Phenol gets to human body through respiratory system and skin.  
- It has toxic activity on nervous system, liver and kidneys. |
| Policyclic aromatic hydrocarbons (PAHs) | - Policyclic aromatic hydrocarbons belong to group of chemical compounds which are responsible for environment polution.  
- PAHs get to human body through respiratory system, digestive system and skin.  
- Epidemiological research proved the relationship between working in PAHs hazardous conditions and increasing amount of cases of tumour diseases.  
- **Group 1: carcinogenic to humans**  
  - Benzo(a)pyrene  
  - Benzo(a)anthracene  
  - Benzo(b)fluoranthen  
  - Benzo(k)fluoranthen  

**Metal fume fever**

Many welders report flu like symptoms after welding. The effects are often worse at the start of the working week. *Metal fume fever* is usually linked to welding or hot work on galvanised metals. High exposures to mild steel weld fume can also cause this illness. Metal fume fever does not usually have any lasting ill effects. Don’t believe the stories about drinking milk before welding. It does not prevent you getting metal fume fever.

**Irritation of throat and lungs**

Gases and fine particles in welding fume can cause dryness of the throat, tickling, coughing or a tight chest. The effects tend to be short lived. Ozone is a particular cause of this when TIG welding stainless steels and aluminium. High exposures to nitrous oxides (generated during most arc welding operations) can also cause this health effect. Extreme exposure to ozone can cause pulmonary oedema (fluid on the lungs).

**Temporary reduced lung function**

Overall lung capacity and the ease at which you can breathe out (peak flow) are affected by prolonged exposure to welding fume. The effects tend to get worse through the working week but gradually improve when not exposed (eg over the weekend).
How is welding fume controlled?

• Change the welding procedures;

• Use welding wires/rods designed for lower fume generation;

• Change power sources;

• Change shielding gases;

• Fume removal / extraction.
Can you use a welding technique that makes less fume?

• **Lowest fume**
  - Submerged arc
  - Resistance welding
    - Laser cutting
    - TIG
  - Plasma cutting
  - MIG
  - Flame cutting
    - MAG
  - MMA
    - Flux core
• **Highest fume**
  - Arc gouging

www.hse.gov.uk/welding/fume-welding.htm
Ways of process optimization in aspect of fume and gases reduction during welding and allied processes

1. Influence of current-voltage parameters on the emission of welding fume during welding processes

2. Influence of chemical composition of shielding gas on fume and gas emission rate during MIG/MAG

3. Influence of welding methods on fume and gas emission rate
1. Influence of current-voltage parameters on the emission of welding fume due to welding

Influence of current intensity and wire diameter on fume emission rate during MAG steel welding; shielding gas: 82%Ar+18%CO₂

Jolanta Matusiak: Biuletyn IS 5/2004

Health, Safety and Environmental Training for Welding Personnel  WeldTrain - HSE
LLP - LdV / TOI / 2012 / RO / 036
1. Influence of current-voltage parameters on the emission of welding fume due to welding

Fume emission rate during MIG/MAG welding using wire with and without copper covering

- Using wire Aristo Rod 12.50 (without covering) and shielding gas Ar+CO₂ type, fume emission rate is lower in whole current range in comparison with wire AutRod 12.95.

- Fume emission reduction is on the level of:
  - 35% in case of dip arc transfer,
  - 13% for globular arc transfer,
  - during spray arc transfer the fume emission reduction was at the level of 5%.
Optimization of current parameters

2. Influence of chemical composition of shielding gas on fume and gas emission rate during MIG/MAG

Influence of welding current intensity and chemical composition of shielding gas on total fume emission rate during welding of aluminum alloy AlMg3
2. Influence of chemical composition of shielding gas on fume and gas emission rate during MIG/MAG

MIG/MAG welding of austenitic steel X5CrNi18-10

Influence of welding current intensity and chemical composition of shielding gas on chromium(VI) content in welding fume

\[ \text{Cr VI} \text{ (% m/m)} \]

- Ar
- 98% Ar + 2% O2
- 97% Ar + 3% CO2
2. Influence of chemical composition of shielding gas on fume and gas emission rate during MIG/MAG

\[ I_0 = \frac{1}{2} \text{CO}_2 \% + \text{O}_2 \% \]

Influence of chemical composition of shielding gas on total fume emission rate during MAG steel welding

Filler wire: G3Si1, diameter: 1.2 mm, current intensity: 200A
2. Influence of chemical composition of shielding gas on fume and gas emission rate during MIG/MAG

Influence of welding current intensity and chemical composition of shielding gas on total fume emission rate during steel MAG welding
Filler wire: G3Si1, diameter: 1.2 mm

\(\text{Ep [g/min]}\)

- Ar+2%CO₂
- Ar+8%CO₂
- Ar+18%CO₂
- Ar+5%O₂
- Ar+8%O₂
- Ar+1%O₂+3%CO₂
- Ar+4%O₂+5%CO₂

\(\text{I [A]}\)

3. Influence of welding methods on fume and gas emission rate

Influence of chemical composition of shielding gas on chromium, chromium(VI) and nickel content in welding fume during steel X5CrNi18-10 (thickness 1,5 mm) welding using low-energetic methods: CMT and ColdArc. Filler wire 308L-Si/MVR diameter 1,2 mm.

\( I \) – welding current, 
\( U \) - arc voltage, 
\( V_{dr} \) - wire feed rate, 
\( V_{sp} \) - welding speed

Matusiak J., Wyciślik J., Ocena zagrożeń chemicznych, pyłowych i fizycznych w środowisku pracy przy innowacyjnych metodach spajania różnych materiałów konstrukcyjnych, Hutnik. Wiadomości hutnicze no 3/ 2014, p. 156-165
Comparative analysis of test results concerning the emission of pollutants generated during welding aluminium alloys using low-energy methods

The comparison of fume emission sizes for welding aluminium alloys with other gas-shielded arc welding methods, i.e. conventional MIG welding, MIG welding with a pulsating arc, MIG Double Pulse welding and welding with low-energy methods is presented below.

In order to reduce the emission of pollutions it is advisable that thin-walled elements made of various aluminium alloys should be welded using low-energy methods.

The lowest fume emission indicators were determined for the CMT method, the size of emission increased successively for the following methods: ColdArc, AC Pulse, MIG with a pulsating arc, MIG with a double-pulsed arc, Cold Process and conventional argon-shielded MIG welding.

Dust emission during welding of 5xxx, 6xxx and 2xxx series aluminium alloys with MIG welding and filler metal grade AlMg4.5MnZr
3. Physical hazards

- Characteristics of noise (audible, ultrasonic and infrasonic)
- Noise in welding and allied processes
- Ways of noise reduction
- Characteristics of electromagnetic fields
- Electromagnetic fields during welding and allied processes
- Characteristics of optical radiation
- Optical radiation during welding and allied processes
- Characteristics of optical radiation during CMT and ColdArc welding and braze welding
- Characteristics of laser radiation
- Characteristics of thermal hazards
- Characteristics of microclimate
- Characteristics of vibration
Physical Hazards

- Noise
- Optical Radiation
- Laser radiation
- Electromagnetic fields
- Thermal effects (heat and cold)
- Vibration
The traditional definition of noise is “unwanted or disturbing sound”.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>140</td>
<td>Intense pain</td>
</tr>
<tr>
<td>10</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>0,1</td>
<td>110</td>
<td>Plasma cutting</td>
</tr>
<tr>
<td>0,01</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>0,001</td>
<td>90</td>
<td>Welding</td>
</tr>
<tr>
<td>0,0001</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>0,00001</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40</td>
<td></td>
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<tr>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

[http://www.epa.gov/air/noise.html]
Effects of Noise on Hearing

How quickly hearing loss takes place depends on:

• the **intensity** of the noise,

• its **duration,**

• **how often** the exposure occurs.

[bfa.sdsu.edu/ehs/pdf/HearingConservation.ppt](bfa.sdsu.edu/ehs/pdf/HearingConservation.ppt)
Risk Management on Workplace Noise

Noise Control Safe Work Procedures (SWP)

- **Noise control measures**
- **Administrative control**
- **Audiometric test**
- **Hearing protectors**

https://www.wshc.sg/.../Noise%20&%20Hearing%20Conservation.ppt
Risk Management on Workplace Noise

HIERARCHY OF HAZARDS CONTROL

1. Elimination
2. Substitution
3. Engineering Controls
4. Administrative Controls
5. Personal Protective Equipment

https://www.wshc.sg/.../Noise%20&%20Hearing%20Conservation.ppt
Noise in welding and allied processes

Electric arc welding generates harmful levels of noise. The process itself produces noise, the other tasks that a welder will typically do are also noisy, and welding is generally carried out in a noisy environment. Noise levels experienced during arc welding and cutting vary with the process. A list of typical noise levels for different types of welding process and associated tasks is given below.

<table>
<thead>
<tr>
<th>Process</th>
<th>Typical noise levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIG</td>
<td>up to 75 dB(A)</td>
</tr>
<tr>
<td>MMA</td>
<td>85 - 95 dB(A)</td>
</tr>
<tr>
<td>MIG</td>
<td>95 – 102 dB(A)</td>
</tr>
<tr>
<td>Plasma cutting (hand-held up to 100A, cutting up to 25mm thickness only)</td>
<td>98 – 105 dB(A)</td>
</tr>
<tr>
<td>Flame gouging</td>
<td>95 dB(A)</td>
</tr>
<tr>
<td>Flame cutting (typically above 90 dB(A) when cutting thicknesses above 40 mm)</td>
<td>up to 100 dB(A)</td>
</tr>
<tr>
<td>Air arc gouging</td>
<td>100 – 115 dB(A)</td>
</tr>
<tr>
<td>Chipping</td>
<td>105 dB(A)</td>
</tr>
<tr>
<td>Grinding</td>
<td>95 – 105 dB(A)</td>
</tr>
</tbody>
</table>

The actual noise levels will depend on several factors. For instance, noise is likely to increase with increasing consumable diameter and with increasing current. Also, the type of metal being worked will have an effect, stainless steel tending to produce higher noise levels than mild steel.

Where cutting is concerned, the thickness of material being cut will affect the noise produced, thicker materials being noisier.

For the loudest processes (plasma cutting and air arc gouging) the dominant source of noise is the high-pressure compressed air. The design of air nozzle can have a big effect on noise emission and some companies may offer ‘reduced noise’ equipment.

www.hse.gov.uk/welding/noise-vibration.htm
Equivalent sound pressure level, normalized to an 8-h working day, $L_{eq,8h}$ during welding and weld brazing of different constructional materials using traditional methods - MIG/MAG and TIG and innovative low-energetic methods CMT and ColdArc.

Sheet thickness 1,5 mm. Microphone was located 0.5 m from welding arc.

Infrasonic and ultrasonic noise

- Acoustic waves of about 20 Hz may be heard as a low rumble and for frequencies below this the term infrasound is used.
- The term ultrasound is used for all frequencies higher than 20 kHz.

Electromagnetic fields

Electromagnetic fields (EMF) are a form of electromagnetic radiation and are defined as non-ionising radiation having both Magnetic and Electric field components varying with time at frequencies up to 300GHz.

The European Commission Directive aims at promoting the safety and health of individuals working in environments likely to be subjected to electromagnetic fields.

Measuring the EMF in welding

Arc Welding  Spot Welding  Stud Welding

Magnetic Particle inspection  Induction Heater

Optical radiation

Optical radiation is another term for light, covering ultraviolet (UV) radiation, visible light, and infrared radiation. The greatest risks to health are probably posed by:

• UV radiation from the sun. Exposure of the eyes to UV radiation can damage the cornea and produce pain and symptoms similar to that of sand in the eye. The effects on the skin range from redness, burning and accelerated ageing through to various types of skin cancer.

• Welding without proper PPE can cause serious damage to the eye and skin.

www.hse.gov.uk/radiation/nonionising/opticalintro.htm
Ultraviolet (UV) radiation comprising the wavelength range from 100 nm to 400 nm is the most energetic part of optical radiation. It adjoins directly to the range of ionising radiation. In the short wavelength range UV radiation can have similar effects as ionising radiation.

According to different biological effects UV radiation is subdivided into three wavelength ranges: UV-A radiation (400 – 315 nm), UV-B radiation (315 – 280 nm) and UV-C radiation (280 – 100 nm).

UV radiation is not visible for humans and cannot be perceived by other sense organs. Depending on wavelength and intensity UV radiation can produce numerous health effects mainly to eye and skin

http://www.bfs.de/en/uv
Optical radiation includes ultraviolet (UV), visible (VIS) and infrared (IR) radiation. The most hazardous optical radiation is generated during welding, as in such cases the spectrum of radiation contains UV, blue light and IR.

The temperature of gas torches does not exceed 2000 K and their spectrum does not contain UV, whereas the temperature of oxy-acetylene and oxy-hydrogen torches slightly exceeds a temperature of 3000 K, and as a result long-wave ultraviolet can be emitted in addition to infrared radiation and light.
The most common eye condition connected with exposure to infrared radiation is cataract or the lens opacity. Despite many tests on this subject, the mechanism of cataract generation caused by infrared radiation has not yet been explained nor have efficiency spectrum or threshold values been determined. Below is the list of eye and skin diseases caused by excessive exposure to optical radiation.

<table>
<thead>
<tr>
<th>Radiation range</th>
<th>Type of damage (eye)</th>
<th>Type of damage (skin)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV-B, UV-C</td>
<td>Keratitis, conjunctivitis</td>
<td>Erythema, burns, skin pigmentation, photoageing, precancerous and cancerous skin changes</td>
</tr>
<tr>
<td>UV-A</td>
<td>Photochemical cataract</td>
<td></td>
</tr>
<tr>
<td>VIS</td>
<td>Photochemical and thermal retinal damage</td>
<td>Thermal damage</td>
</tr>
<tr>
<td>IR-A</td>
<td>Thermal retinal damage</td>
<td>Thermal damage</td>
</tr>
<tr>
<td>IR-A, IR-B</td>
<td>Thermal cataract</td>
<td></td>
</tr>
<tr>
<td>IR-A, IR-B, IR-C</td>
<td>Cornea burns and damage</td>
<td></td>
</tr>
</tbody>
</table>

*Marzec St., Matusiak J., Nowicka J., Wyciślik J.:* Optical radiation in welding and braze welding by CMT and ColdArc methods English online version of "Biuletyn Instytutu Spawalnictwa" No. 5/2013
Optical radiation

- Protection measures:
  - Provide face shields, coveralls and gloves
  - Protect others using screens/curtains/restricted access
  - Provide information and training
  - Display appropriate warning signs
  - Monitor and enforce use of control measures
  - If any workers are over-exposed, provide medical examination and consider whether follow-up health surveillance is appropriate

- Only filter lenses with the appropriate shade number will provide protection against optical radiation.

Optical radiation during CMT and ColdArc welding and braze welding

Marzec St., Matusiak J., Nowicka J., Wyciślik J.: Optical radiation in welding and braze welding by CMT and ColdArc methods English online version of "Biuletyn Instytutu Spawalnictwa" No. 5/2013
The measurements revealed that the intensity of UV radiation during welding and braze welding increases exponentially along with an increase in welding/braze welding current. This increase depends on the type of shielding gas, the grade of a sheet being welded and on the selected welding or braze welding method.

During CMT welding of an X6Cr17 steel UV radiation intensity has the highest values for a gas mixture 82%Ar+18%CO2 and for the mixture 98%Ar+2%O2 mentioned above. The most convenient, as regards the reduction of UV radiation accompanying CMT welding of stainless steels, is the use of a gas mixture of 97.5%Ar+2.5%CO2 and of argon.
During ColdArc welding of stainless steels the effect of the type of shielding gas differs from that related to the use of the aforementioned CMT method.

During ColdArc welding of an X5CrNi18-10 austenitic steel the highest UV radiation intensity is connected with the use of a shielding gas of 97.5%Ar+2.5%CO₂, and the lowest when a mixture 98%Ar+2%O₂ is used.

A similar dependence can be observed during ColdArc welding of chromium ferritic steel X6Cr17.
Laser radiation

• Potential hazards:
  – Radiation (visible & invisible light, blue light, UV)
  – Fire
  – Fumes and mists
  – Electric shock
  – Eye and skin damage

• Safety needs:
  – provide certified laser protective eyewear, clothing, and shields where required
  – Be certain to follow recommendations from the laser system manufacturer
  – personnel protection, laser cell class conformance, and enforcement of all laser safety regulations
  – Designated laboratories with restricted access
Biological and health effects of laser radiation are similar to those of normal optical radiation. They depend strongly on wavelength. The range of wavelength of laser radiation extends from approximately 10,000 nanometres (nm) to approximately 200 nm, that is, from infrared via visible light to ultraviolet (UV) radiation. Since penetration depth into biological tissue is relatively low mainly skin and eyes are affected if laser radiation impacts accidentally on humans. Particular danger exists for the eyes due to their optical properties. The very high power density and the strong focussing of laser beams can result in special health risks.

http://www.bfs.de/en/uv/laser
# Laser Device Classes & Hazards

## LASER CLASSES TO EN 60825-1 (2007)

<table>
<thead>
<tr>
<th>Class</th>
<th>Concept</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The radiation emitted by this laser is not dangerous.</td>
<td>No need for protection equipment</td>
</tr>
<tr>
<td>1C</td>
<td>This class is only valid for medical applications. In general, the emitted radiation is not subject of any limitations. The protection is ensured by technical procedures in the following way: The laser can only irradiate a beam, while having contact to the skin or tissue and the accessible radiation is reduced or below the AEL of class 1.</td>
<td>No need for protection equipment. Is not yet valid!</td>
</tr>
<tr>
<td>1M</td>
<td>Eye safe when used without optical instruments, may not be safe when optical instruments are used.</td>
<td>No need for protection equipment, if used without optical instruments.</td>
</tr>
<tr>
<td>2</td>
<td>Eye safe by aversion responses including the blink reflex.</td>
<td>No need for protection equipment</td>
</tr>
<tr>
<td>2M</td>
<td>The light that can hit the eye has the values of a class 2 laser, depending on a divergent or widened beam, it may not be safe when optical instruments are used.</td>
<td>No need for protection equipment, if used without optical instruments.</td>
</tr>
<tr>
<td>3R</td>
<td>The radiation from this laser exceeds the MPE values (MPE: maximum permissible exposure). The radiation is max. 5 x AELs of class 1 (invisible) or 5 x of class 2 (visible). The risk is slightly lower than that of class 3B.</td>
<td>Dangerous to the eyes, safety glasses are recommended.</td>
</tr>
<tr>
<td>3B</td>
<td>Old class 3B without 3R. The view into the laser is dangerous. Diffuse reflections are not considered as dangerous.</td>
<td>Dangerous to the eyes, safety glasses are obligatory</td>
</tr>
<tr>
<td>4</td>
<td>Old class 4 Even scattered radiation can be dangerous, also danger of fire and danger to the skin</td>
<td>Personal safety equipment is necessary (glasses, screens)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Safety class</th>
<th>Long-term exposure</th>
<th>Short-term (accidental) eye exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>optical viewing instrument</td>
<td>naked eye</td>
</tr>
<tr>
<td>Class 1</td>
<td>Safe</td>
<td>Safe</td>
</tr>
<tr>
<td>Class 1M</td>
<td>!</td>
<td>Safe</td>
</tr>
<tr>
<td>Class 2</td>
<td>!</td>
<td>!</td>
</tr>
<tr>
<td>Class 2M</td>
<td>!</td>
<td>!</td>
</tr>
<tr>
<td>Class 3R</td>
<td>!</td>
<td>!</td>
</tr>
<tr>
<td>Class 3B</td>
<td>!</td>
<td>!</td>
</tr>
<tr>
<td>Class 4</td>
<td>!</td>
<td>!</td>
</tr>
</tbody>
</table>

**Class 4**

- high risk to eyes and skin
- diffuse reflection may be hazardous
- *(possible fire hazard)*
Thermal Hazards

1. Air temperature,
2. Air velocity,
3. Moisture contained in the air, and
4. Radiant heat.
Influence of microclimate parameters on human body/health

<table>
<thead>
<tr>
<th>Analysed factor</th>
<th>Action effects</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air temperature</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Too high</td>
<td>Increase of body temperature - Accelaration of heart action - Decrease of work productivity - Increase of number of mistakes - Sleepness</td>
<td>Increase of ventilation capacity Cool air supply</td>
</tr>
<tr>
<td>Too low</td>
<td>Feeling of muscle stiffness - Decrease of concentration</td>
<td>Warm air supply Increase of heating intensity</td>
</tr>
<tr>
<td><strong>Air humidity</strong></td>
<td>Too high</td>
<td>Improvement of ventilation Dry air supply</td>
</tr>
<tr>
<td>Too low</td>
<td>Mucous membranes parching</td>
<td>Air humidification</td>
</tr>
<tr>
<td><strong>Air movement rate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Too high</td>
<td>Pain in the muscles</td>
<td>Draught removal Decrease of speed of supply air by air stream disperse</td>
</tr>
<tr>
<td>Too low</td>
<td>Decrease of work ability in high temperatures</td>
<td>Improvement of ventilation</td>
</tr>
</tbody>
</table>
Vibration

- Whole body
- Segmental
- Tools

Welding and hot cutting processes do not usually generate harmful levels of vibration however there may be a risk from some associated tasks like grinding, needle scaling.

www.hse.gov.uk/welding/noise-vibration.htm
VIBRATION

Mechanical energy from oscillating sources

- **Types**
  - Segmental vibration
  - Whole body vibration

**Segmental Vibration:**
Health Effects: Hand Arm Vibration Syndrome (HAVS)

**Whole Body Vibration:**
Health effects: Fatigue, irritability, headache, and disorders of the spine
4. Mechanical hazards

- Characteristics of eyes injuries
- Causes of tripping and falling
- Prevention of mechanical hazards
- Personal safety
What causes eye injuries at work?

Flying particles
BLS found that almost 70% of the accidents studies resulted from flying or falling objects or sparks striking the eye. Injured workers estimated that nearly three-fifths of the objects were smaller than a pin head. Most of the particles were said to be traveling faster than a hand-thrown object when the accident occurred.

Contact with chemicals
Splashed liquids or flying chemical particles caused 20% of the injuries.

Other accidents
Caused by objects swinging from a fixed or attached position, like tree limbs, ropes, chains, or tools which were pulled into the eye while the worker was using them.
Personal safety

• Wear proper head, eye and hand protection.
• Use face shields, safety glasses, and goggles as appropriate.
• Wear dry, hole-free insulating gloves when welding or cutting.
• Avoid wearing loose items such as earrings, rings, necklaces, bracelets, loose clothing, neckties, and scarves.
• Watch out for sharp objects, pinch points, and moving objects.
• Protect long hair and beards.

5. Musculoskeletal disorders (MSDs)

Ergonomics and its objectives

Symptoms of musculoskeletal disorders

Solution of the problem
Ergonomics
Ergonomics is the science of arranging or designing things for efficient use.

Ergonomics is also called Human Factors Engineering. It involves making the workplace fit the needs of workers. It does not try to make workers adjust to the workplace. When a workplace is designed properly, the worker feels comfortable. Quality and production increase. Everyone benefits.

NATURE OF THE HAZARD

Welding introduces many ergonomic challenges. These challenges are starting to be recognized and addressed. Welding often requires awkward body positions. Body position and time are key factors in causing injuries.

PROBLEMS FROM POOR ERGONOMICS

- Musculoskeletal Disorders (MSDs).
- Repetitive Motion Injury.
- Lower productivity.
- Lower quality.
- Worker dissatisfaction.
- Increased absenteeism.
- Increased compensation costs.
- Increased turnover rate.
- Decreased compliance with regulations.
- Increased insurance costs.

CAUSES OF THE PROBLEMS

- Reaching.
- Bending.
- Heavy lifting.
- Using continuous force.
- Working with vibrating equipment.
- Repetitive motions.
- Awkward postures.
- Temperature.

6. Electric shock hazard

- Effect of electricity on human body
- Procedures for electric shock
- Electrical equipment selection
- Ways of avoiding electric shocks
Electrical hazards

The arc welding process requires a live electrical circuit. This means that all arc welders using hand held equipment will be at risk of electric shock and electrical burns. The risk for MIG/ MAG and TIG welding is much less as the welding current is normally switched on and off using the trigger or foot switch.

For all arc welding processes the essentials of safe practice are:

• Welding equipment conforms to the appropriate international or national standards.
• Installation of fixed welding equipment is carried out by a suitably qualified person and is connected as recommended by the manufacturer.
• The insulation on the welding and current return leads is undamaged and the conductor is thick enough to carry the current safely.
• All connectors are clean, undamaged and correctly rated for the current required.
• Don’t use welding equipment with damaged insulation on the welding cables, plugs, clamps or torch/electrode holder.
• Use the appropriate personal protective equipment for the task.

The welder is responsible for daily checks of equipment and reporting defects. Management should implement a programme of regular checks for fixed and mobile welding sets.

www.hse.gov.uk/welding/electrocution.htm
HOW TO AVOID ELECTRIC SHOCKS

Use proper precautionary measures and recommended safe practices at all times.
Train all personnel using welding and cutting equipment to reduce the risk of injuries, fatalities, and electrical accidents, by following these instructions:

• Read all instructions, labels, and installation manuals before installing, operating, or servicing the equipment.
• Do not touch live electrical parts.
• Have all installation, operation, maintenance, and repair work performed only by qualified people.
• Properly install and ground the equipment in accordance with the instruction manual and national, state, and local codes.
• Frequently inspect input power cord for damage or bare wiring – replace cord immediately if damaged – bare wiring can kill.
• Do not work alone where there are electrically hazardous conditions.
• Wear dry, hole-free, insulating gloves in good condition and protective clothing.
Do not touch the electrode with a bare hand.
• Insulate yourself from the workpiece and ground using dry insulating mats or covers big enough to prevent any physical contact with the work or ground, or wear properly designed and approved rubber-soled boots in good condition.
• Use fully insulated electrode holders. Never dip the holder into water to cool it or lay it on conductive surfaces or the work surface.
• Training
• Do not touch electrode holders connected to two welding machines at the same time since double open-circuit voltage can be present.
• Do not allow the electrode holder or electrode to come in contact with any other person or any grounded object.
• Do not use worn, damaged, undersized, or poorly spliced cables, welding gun cables, or torch cables. Make sure all connections are tight, clean, and dry.
• Do not wrap cables carrying electric current around any part of your body.
• Do not touch an energized electrode while you are in contact with the work circuit.

8. Hazards connected with welding-allied processes

- Laser Welding and Cutting Safety
- Thermal Spraying Safety
- Resistance Spot Welding Safety
POTENTIAL HAZARDS

SURFACES - Both visible and invisible light radiation are produced when welding or cutting. Due to the interaction with the workpiece, high levels of hazardous blue light and ultraviolet radiation (secondary radiation) are produced. This light radiation is often reflected from the workpiece into the work area. Radiation from these processes can seriously burn eyes and skin quickly and permanently.

FIRE - Since the laser system produces a very small spot size with high energy, the hazard of fire is present if the beam hits flammable material. Keep flammables away from the welding or cutting area. Be sure to cover and protect anything flammable in the area, since reflected radiation could start fires in unexpected places. Protect the work area.

FUMES AND MISTS - Lasers easily vaporize metals. In doing so, fumes and mists are created which can present a respiratory hazard. Often the fumes and mists cannot be seen, yet they can pose a serious health hazard. Always use adequate ventilation.

MECHANICAL - The optical device on the robotic arm or other beam manipulator can malfunction and send the laser beam in unintended directions. Therefore, it is essential that the work cell be shielded in conformance with standards for the laser type and class.

ELECTRIC SHOCK - Since most lasers require a large amount of electrical power to accomplish specific tasks, electrical hazards are present. Conventional hazards associated with any electrical industrial power source are present. Additionally, there are the unique electrical hazards common to lasers in general and the hazard of the individual application. Usually, the best source of safety information is provided in the instruction manual from the manufacturer of the laser system. Always read, understand, and follow the manufacturer’s recommended safety procedures.

EYE AND SKIN DAMAGE - In many use situations, special laser eye protective devices are required. This eyewear must be labeled with both the optical density (protective factor) and wavelength(s) for which the protection is afforded. The protective eyewear must be compatible with the manufacturer’s specifications for the laser system in use, to ensure that the eyewear is suitable. In addition to the primary hazard of the laser beam, there may be a considerable eye hazard from high levels of secondary radiation. A precaution must be added here-standard safety glasses alone do not provide protection. Any laser eyewear, plain or prescription, must be labeled with the wavelength(s) of protection and the optical density at that wavelength(s). In some laser systems, ultraviolet light may be leaked into the workplace. Thus the eyewear should provide primary beam protection, secondary radiation protection, and also ultraviolet protection.

THERMAL SPRAYING SAFETY

INTRODUCTION
Thermal spraying processes use electric arc, plasma, and combustion energy sources to produce a high temperature and high velocity gas stream. Powder or wire material is introduced to this gas stream. Particles of this material are heated and propelled onto a surface to produce a coating. The noise, heat, dust, fumes, and mechanical operations of the spraying processes create a unique set of safety hazards for the operator and those nearby.

DEFINITIONS/PROCESS DESCRIPTIONS
Thermal Spraying is a group of processes that deposit molten metallic or non-metallic surfacing materials onto a prepared substrate. All thermal spraying processes introduce a feedstock (usually a powder or wire) into a spraying device (combustion or electrical). The spraying device is generally referred to as a thermal spray gun. At the gun the material is heated, blended into a hot gas stream, and sprayed onto a prepared substrate. The heated particles strike the surface where they flatten and adhere to the surface. As this process continues a coating is formed from the spray material. The coating process is stopped when the desired thickness of coating is formed.

Thermal spray processes include:
- **Combustion processes**
  - LVOF: Low-Velocity Oxyfuel
  - HVOF: High Velocity Oxyfuel
- **Electrical processes:**
  - Arc (twin-wire)
  - Plasma Arc

RESISTANCE SPOT WELDING

Resistance Spot Welding is not an open-arc process. The weld is made inside the workpieces. Consequently there are unique hazards to consider. Here are the major ones:

- Flying sparks can cause fire and explosion.
- Flying sparks and spatter can burn or injure eyes and skin.
- Electric shock from live electrical parts is a possible hazard.
- Hot metal and parts can cause burns.
- Moving electrode parts, such as tongs, tips, and linkages, can injure fingers and hands.
- Fumes from spot welding parts coated with cleaners, paints, or platings can be hazardous.

HOW TO AVOID THE HAZARDS

- Wear safety goggles or a face shield. Wear long sleeved shirts. Do not weld near flammables – move them away. Keep a fire extinguisher nearby, and know how to use it.

- Wear dry insulating gloves. Install and ground unit according to electrical codes. Disconnect input power before servicing. Do not put hands between tips. Keep away from linkages and pinch points. Keep all guards and panels in place.

- Do not breathe the fumes. Use proper ventilation. Read Material Safety Data Sheets (MSDSs) for metals, coatings, and cleaners.

- Do not touch hot workpiece, tips, or tongs with bare hands. Allow tongs and tips to cool before touching. Wear proper insulating gloves when handling hot work or parts is necessary.

[Link to AWS website]

9. Personal protective equipment (PPE)

- Personal Protective Equipment (PPE) for Welding and Cutting
- Eye and Face Protection equipment
- Hearing protective equipment
- Respiratory Protective Equipment
- Clothes and gloves for Welding and Cutting
- PPE handling
Arc Welding PPE

- Welding hood with filtered lens
- Fire retardant welders cap
- Safety goggles
- Welders leathers with button up collar
- Gauntlet style welding gloves
- Welders chaps
- Steel toe work boots
HEAD AND EAR PROTECTION
• Wear a fire-resistant welder’s cap or other head covering under your helmet. It will protect your head and hair from flying sparks, spatter, burns, and radiation.
• When working out of position, such as overhead, wear approved earplugs or muffs. They prevent sparks, spatter, and hot metal from entering your ears and causing burns.
• If loud noise is present, wear approved earplugs or muffs to protect your hearing and prevent hearing loss.

FOOT PROTECTION
• Wear leather, steel-toed, high-topped boots in good condition. They will help protect your feet and ankles from injury.
• In heavy spark or slag areas, use fire-resistant boot protectors or leather spats strapped around your pant legs and boot tops to prevent injury and burns.
• Do not wear pants with cuffs. Wear the bottoms of your pants over the tops of your boots to keep out sparks and flying metal. Do not tuck pant legs into your boots.

HAND PROTECTION
• Always wear dry, hole-free, insulated welding gloves in good condition. They will help protect your hands from burns, sparks, heat, cuts, scratches, and electric shock.
• All welders are encouraged to wear protective flame-resistant gloves, such as leather welder's gloves. They should provide the heat resistance and general hand protection needed for welding.
Description and use of Eye/Face Protectors

Welding Shields

These shield assemblies consist of vulcanized fiber or glass fiber body, a ratchet/button type adjustable headgear or cap attachment and a filter and cover plate holder.

These shields will be provided to protect workers’ eyes and face from infrared or radiant light burns, flying sparks, metal spatter and slag chips encountered during welding, brazing, soldering, resistance welding, bare or shielded electric arc welding and oxyacetylene welding and cutting operations.
Hearing protective equipment

- Hearing protection should be selected based on four criteria:
  - Ability to reduce the noise exposure
  - Compatibility with other items of PPE (such as welding masks, safety helmets, etc.)
  - Comfort
  - Suitability for the working environment and activity

- Prevention measures for hearing loss:
  - Earplugs of muffs prevent sparks, spatter and hot metal from entering the ears and causing burns
  - If loud noise is present wear approved earplugs or muffs to protect hearing and prevent hearing loss

http://www.hse.gov.uk/welding/noise-vibration.htm
www.aws.org – Safety and Health Fact Sheet no. 33
Hearing protective equipment

- If, as may be the case with some welding activities, hearing protection is being relied on as the main solution to reducing noise exposure, it is vital that correct training in its use is given.
- The importance of wearing the protection for all the time spent in a noisy area, or engaged in a noisy activity, must be emphasised.
- Failure to wear hearing protection for even a small amount of the time exposed to noise can affect significantly the effectiveness of the hearing protection device in reducing daily noise exposure.

http://www.hse.gov.uk/welding/noise-vibration.htm

www.aws.org – Safety and Health Fact Sheet no. 33
PPE Shop — cont. Clothing

- The purpose of clothing is to protect the skin and extremities.
  - Coveralls
  - Aprons
  - Shop coats
  - Footwear
  - Gloves
  - Hardhats
  - Masks and respirators
  - Ear muffs & ear plugs
10. Risk analysis

- Risk assessment
- Ways of risk reduction
- Work practice controls
- Examples of risk analysis during welding and allied processes
What is risk assessment?

A risk assessment is simply a careful examination of what, in your work, could cause harm to people, so that you can weigh up whether you have taken enough precautions or should do more to prevent harm. Workers and others have a right to be protected from harm caused by a failure to take reasonable control measures.

Accidents and ill health can ruin lives and affect your business too if output is lost, machinery is damaged, insurance costs increase or you have to go to court. You are legally required to assess the risks in your workplace so that you put in place a plan to control the risks.

www.hse.gov.uk/pubns/indg163.pdf
How to assess the risks in your workplace
Follow the five steps:
Step 1 Identify the hazards
Step 2 Decide who might be harmed and how
Step 3 Evaluate the risks and decide on precautions
Step 4 Record your findings and implement them
Step 5 Review your assessment and update if necessary

Don’t overcomplicate the process. In many organisations, the risks are well known and the necessary control measures are easy to apply. You probably already know whether, for example, you have employees who move heavy loads and so could harm their backs, or where people are most likely to slip or trip. If so, check that you have taken reasonable precautions to avoid injury.

If you run a small organisation and you are confident you understand what’s involved, you can do the assessment yourself. You don’t have to be a health and safety expert.

If you work in a larger organisation, you could ask a health and safety advisor to help you. If you are not confident, get help from someone who is competent. In all cases, you should make sure that you involve your staff or their representatives in the process. They will have useful information about how the work is done that will make your assessment of the risk more thorough and effective. But remember, you are responsible for seeing that the assessment is carried out properly. When thinking about your risk assessment, remember:

■■ a hazard is anything that may cause harm, such as chemicals, electricity, working from ladders, an open drawer etc;
■■ the risk is the chance, high or low, that somebody could be harmed by these and other hazards, together with an indication of how serious the harm could be.
Safe Environment

A safe environment is an environment free of accidents.

+ Created by managing the risks associated with hazards.

Concerns:

+ How do you define acceptable level of risk?
+ Is the acceptable level of risk the same?
+ Is a person's perception of risk accurate?
Managing Risk –

Best Management Practice

- What is best management practices?
- Have a written, approved safety plan that follows recommended safety guidelines.
- Safety plan should include:
  - Hazard analysis
  - Appropriate training for all individuals
  - Maintenance of tools and equipment
  - Color code shop
  - Requiring appropriate personal protection equipment (PPE)
  - Documentation, Documentation, Documentation !!!
  - Safety plan should be approved by school administration (???).
11. Fire and explosion hazards

- Fire risk assessment
- Fire safety
- Types and general requirements of fire extinguishers
- Fire and Explosion Prevention
- Safety Signs and Colours
- Protection and prevention from burns
Managing Fire Hazards

- Store flammable materials correctly.
- Insure appropriate fire extinguishers are available.
- Keep fire extinguishers up-to-date.
- Post a fire watch when welding or cutting.
- Understand fire tetrahedron.
12. Compressed gases

- Handling and use of compressed gases
- Transport of compressed gases
- Safe Working with Gas Cylinders
Handling Gas Cylinders

- Wear PPE: gloves, protective footwear, eye protection
- Correct way to move cylinders is to: keep upright, secure and with valves uppermost
- Use mechanical aids such as a trolley where reasonably practicable (do a risk assessment)
- Use suitable cradles, slings, clamps or other effective means when lifting with a hoist or crane
- For short distances on even ground the practice of ‘milk-churning’ (manually moving cylinders) can be used only by trained personnel and never for longer distances, in uneven ground, wet or icy conditions, poor lighting, or at speed a trolley should be used
- All personnel involved should have completed manual handling training
- Never roll cylinders along the ground
- Never transport cylinder with valve and pressure regulator attached or with the valve open
- Never attempt to catch a falling cylinder just get out of the way
- Never lift a cylinder by its cap, valve or guard/shroud

*Remember that a cylinder is never empty*
13. Hazardous atmospheres

- Flammable Atmospheres
- Toxic Atmospheres
- Hoses
- Flashback Arresters
- Oxyfuel Safety
- Blow Pipes and Torches
Flammable Atmospheres

- Enriched oxygen atmospheres,
- Vaporization of flammable liquids,
- Byproducts of work,
- Chemical reactions,
- Concentrations of combustible dusts
14. Welding in confined spaces

Description and examples of confined spaces

Confined space safety

Welding, cutting, and heating in confined spaces.

Oxygen Deficient Atmospheres
Definition

• Any space which, by design, has:
  • limited openings for entry and exit;
  • unfavorable natural ventilation which could contain or produce dangerous air contaminants, and;
  • which is not intended for continuous employee occupancy.
Confined space safety

- All employees required to enter into confined or enclosed spaces **shall be instructed as to the nature of the hazards involved**, the necessary precautions to be taken, and in the use of protective and emergency equipment required.
- The employer shall comply with any specific regulations that apply to work in dangerous or potentially dangerous areas.
Typical Confined Spaces

• Boiler, Degreaser, Furnace
• Pipeline, Pit, Pumping Station
• Reaction or Process Vessel, Mills
• Septic Tank, Sewage Digestor
• Silo, Storage Tank, Barges
• Sewer, Utility Vault, Manhole
• Trenches, Shafts, Caissons
15. Ventilation

Types and examples of ventilation

Local exhaust ventilation

Ventilation for Welding and Cutting
Ventilation on the workstation

Different types of ventilation work together on the workstation:

- Supply ventilation,
- Exhaust ventilation,
- Air-conditioning,
- Local exhaust ventilation
- Ventilation devices, e.g. air curtains.

![Scheme of the ventilation system](image-url)
Local Exhaust Ventilation

• Local exhaust ventilation (LEV) is the preferred method of removing welding fumes and gases. It exhausts or removes the toxic gases, fumes, dusts and vapours before they can mix with the room air.

• A specifically designed welding helmet is recommended to reduce a welder's exposure to welding fumes by diverting the fume away from the welder's breathing zone.

• The most important types of local exhaust ventilation are presented next.


Local Exhaust Ventilation

Kemper, Klimaserw, ISPL
Kemper, Nederman, ISPL

Health, Safety and Environmental Training for Welding Personnel

WeldTrain - HSE

Kemper, Nederman, ISPL
Health, Safety and Environmental Training for Welding Personnel  WeldTrain - HSE LLP - LdV / TOI / 2012 / RO / 036
Ventilation in rooms for processes with filler metal

<table>
<thead>
<tr>
<th>Process</th>
<th>Filler metal</th>
<th>Welding of coated steel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>unalloyed and low-alloy steel, aluminium materials</td>
<td>high-alloy steel non-ferrous materials (except aluminium materials)</td>
</tr>
<tr>
<td>Gas welding</td>
<td>T</td>
<td>A</td>
</tr>
<tr>
<td>Manual metal arc welding</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>MIG/MAG welding</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>TIG welding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– with non-thoriated tungsten electrodes</td>
<td>T</td>
<td>A/T</td>
</tr>
<tr>
<td>– with thoriated tungsten electrodes</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Submerged arc welding</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>Laser cladding</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Thermal Spray</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

* A = extraction at the point of generation of hazardous substance
* T = forced (mechanical) room ventilation
## Ventilation in rooms for processes without filler metal

<table>
<thead>
<tr>
<th>Process</th>
<th>Parent metal</th>
<th>Welding of coated steel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>unalloyed and low-alloy steel, aluminium materials</td>
<td></td>
</tr>
<tr>
<td>Flame heating, Flame straightening</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>Flame hardening</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Flame priming</td>
<td>T</td>
<td>A</td>
</tr>
<tr>
<td>Flame cutting</td>
<td>T*</td>
<td>T*</td>
</tr>
<tr>
<td>Flame grooving</td>
<td>A</td>
<td>T</td>
</tr>
<tr>
<td>Scarfing</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>TIG welding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– with non-thoriated tungsten electrodes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– with thoriated tungsten electrodes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laser welding</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Laser cutting</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Plasma cutting (without water cover)</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Arc oxygen cutting. Arc air gouging</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Flash butt welding</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Other resistance welding processes</td>
<td>F</td>
<td>T</td>
</tr>
</tbody>
</table>

*) Digressively, for automated flame cutting equipment A is valid.
A = extraction at the point of generation of hazardous substances
F = free (natural) ventilation
T = forced (mechanical) room ventilation
16. Hazards management

- Electrical
- Mechanical
- Chemical
Managing Electrical Hazards

- Insure tools and equipment are grounded properly.
- Inspect power cords before using a tool.
- Do not use electrical tools on wet ground.
- Disconnect electrical power before working on tool.
- Look for overhead power lines.
- Maintain all electrical circuits and their hardware.
- Use appropriate PPE.

Is this all?

PPE that must be worn at all times?
PPE which may be required, depending on the hazards?
THANK YOU !!!!!