



**GREEN
WELD**

**Training Materials:
Environmental for a Greener Welding Adaptation**

CU_GW_01

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Introduction

This document has been prepared to unify all contents that belong to the first competence unit **(CU_GW_01: Environmental Awareness for a Greener Welding)** in order to facilitate the study of the contents for the students. The teaching contents are separated into two parts, Part A and Part B, as follows:

Part A:

- Green Glossary
- Environmental deteriorating factors and their consequences
- Procedures and activities to protect the environment
- Usage and Handling of Welding Materials
- Recycling carbon steel, stainless steel and aluminium

Part B

- Maximizing Material Recovery
- Reducing Waste in Welding Processes
- Welding Techniques and Reduction of Repairs
- Optimization of Joint Preparation
- Maximizing Material Recovery



Part A

Awareness in green topics: Reducing, Recycling, Reuse

TOPICS

Green Glossary.

Environmental deteriorating factors and their consequences.

Procedures and activities to protect the environment.

Usage and Handling of Welding Materials.

Recycling carbon steel, stainless steel and aluminium.





1. Green Glossary

Below is a glossary of the most relevant terms in the context of the CUs developed in the GREENWELD project:

| | |
|-------------------------------|---|
| Big data | Extremely large data sets that may be analysed computationally to reveal patterns, trends, and associations. |
| Carbon neutral | A state achieved when an individual, organization, or activity offsets or balances the total amount of carbon dioxide emissions it produces by investing in the reduction or capture of an equivalent amount of greenhouse gases from the atmosphere. |
| Circular economy | An economic system designed to minimize waste and make the most of resources by emphasizing the continual use, recycling, and regeneration of products and materials. |
| Climatic changes | Alterations in long-term patterns of temperature, precipitation, wind, and other atmospheric conditions on Earth. |
| Cloud systems | Delivery of computing services, including storage, processing power, and software applications, over the internet, instead of relying on local servers or personal devices for data storage and computing. |
| Cyber-physical systems | Integrated systems that combine computational and physical processes, enabling interactions between the digital and physical worlds. Involves the tight integration of computer-based algorithms, communication networks, and physical processes to monitor, control, and automate various systems. |
| Digital manufacturing | An approach to manufacturing that leverages digital technologies, data, and communication tools throughout the entire product lifecycle, from design and production to maintenance and beyond. |
| Eco-design | An approach to design that involves principles such as life cycle thinking, material selection emphasizing renewable resources, energy efficiency, waste minimization, durability, and reparability. |

**Eco-friendly**

An adjective used to describe products, practices, or actions that are designed or performed to minimize harm to the environment.

Energy-related products

Items or systems designed, produced, and used with the primary purpose of generating, transmitting, storing, or conserving energy.

Environmental footprint

A measure of the human activities' impact on the environment, often expressed in terms of the amount of natural resources used, the emissions produced, and the waste generated. It encompasses carbon footprint, water, and ecological footprint.

Environmental impact

Effects of human activities, processes, products, or events on the environment. It includes a wide range of consequences, that may affect ecosystems, natural resources, biodiversity, and environmental quality.

Greenhouse gas emissions

Greenhouse gas emissions refer to the release of gas into the atmosphere, primarily from human activities such as burning fossil fuels, deforestation, industrial processes, and agriculture. Common greenhouse gases include carbon dioxide, methane, nitrous oxide, fluorinated gases, and others.

Green infrastructure

A strategic and sustainable approach to urban and regional planning that integrates natural and semi-natural features into the design and management of landscapes.

Greenwashing

A deceptive marketing practice in which a company or organization falsely portrays itself as environmentally friendly, sustainable, or socially responsible to attract environmentally conscious consumers.

Industrial internet of things

The integration of Internet of Things (IoT) technologies into industrial processes, facilities, and equipment, involves the connection of devices, machines, sensors, and systems to collect, exchange, and analyse data.

Industry 4.0

Refers to the ongoing transformation of traditional manufacturing and industrial processes through the integration of digital technologies, automation, and data exchange.

Recycling

Process of converting waste materials into new products or materials to prevent the disposal of items as waste and reduce the consumption of fresh raw materials.

**Reduce**

Decrease the consumption of resources, minimize waste generation, and lower overall environmental impact.

Renewable energy

Energy that is obtained from naturally replenishing sources that are not depleted when used. These sources include sunlight, wind, rain, tides, waves, geothermal heat, and biomass.

Resource

Any substance, asset, or capability that is utilized to fulfill a particular need or achieve a specific goal. Resources can be classified as natural resources, human resources, financial resources, and technological resources.

Reuse

Practice of utilizing products, materials, or items more than once, either for their original purpose or through repurposing

Smart factories

Manufacturing facilities that leverage advanced digital technologies and connectivity to enhance efficiency, productivity, and flexibility in industrial processes.

Sustainability

The ability to meet the needs of the present without compromising the ability of future generations to meet their own needs. A balanced approach to environmental, social, and economic fields to create a harmonious relationship between human activities and the natural world.

Upcycling

Creative and eco-friendly process of transforming discarded or unused items into products of higher value/quality, with a different function or aesthetic.

Waste

Any material or resource that is generated in the production process but does not contribute to the final product

Zero waste

Zero Waste is a philosophy and lifestyle approach that aims to minimize the generation of waste by promoting responsible resource use, reuse, recycling, and composting.



2. Environmental deteriorating factors and their consequences

Maximizing energy production and optimizing energy consumption have become paramount in both national and international policy agendas globally. Manufacturing industries are compelled to adhere to government mandates concerning energy conservation and the development of ecologically sustainable products. Additionally, these industries are grappling with the escalating costs associated with energy and material usage. Consequently, finding solutions that not only promote environmental preservation but also uphold competitiveness in the market has become a crucial imperative for these industries.

Welding, a prominent manufacturing process, wields a substantial influence on sustainability across environmental, economic, and social dimensions. In the metallurgical sector, the welding industry has faced considerable criticism due to its extensive consumption of raw materials, leading to environmental degradation, biodiversity loss, and water and soil pollution. The transformation of raw materials into new metals and alloys demands significant energy, resulting in greenhouse gas emissions, waste generation, and harmful emissions detrimental to human health, contributing to the global challenge of climate change.

This is just the tip of the iceberg; a thorough examination of welding processes reveals a diverse array of potential environmental contaminants and impacts throughout the industry.

Two facts are indisputable:

- Welding can exert significant harm on both local and global environments.
- Welding is indispensable to contemporary living.

Given its essential role in producing modern necessities, abandoning welding is not a feasible option. Hence, individuals engaged in welding activities should proactively take measures to reduce their environmental footprint. The question is, how? With numerous options available, let's explore them.

Despite environmental concerns, the welding industry holds economic importance, constituting a significant portion of industrial production in certain countries. In response to global sustainable development targets set by the United Nations, there is a growing call for the industry to transition toward sustainable production practices.



However, the welding industry encounters a deficiency in legislation addressing environmental, sustainability, and production issues. To address this gap, society must take the initiative to develop new knowledge and techniques aimed at achieving sustainable development objectives. This involves understanding the environmental impacts associated with various industry activities and implementing mitigation strategies. The focus should extend beyond the efficient use of natural resources and raw materials to encompass economic resources.

Traditional welding practices, reliant on heat and energy, inadvertently produce toxic emissions, contributing to challenges such as high energy consumption, the release of toxic greenhouse gases, and excessive waste generation. With escalating concerns about climate change, there is an urgent need for welding processes to evolve towards sustainability. Fortunately, through minor adjustments to processes and equipment, significant reductions in the environmental impact of welding techniques are achievable, fostering the development of more eco-friendly construction practices across diverse industries, from aerospace to construction.

Manufacturing, integral to the development of industrialized nations, relies heavily on welding and joining processes. These activities play a pivotal role in long-term growth by actively seeking innovative approaches. Whether through mimicking existing products or drawing inspiration from nature, the industry is focused on considerations for cost and energy savings, waste minimization, optimal parameters, and eco-friendliness. Additionally, advancements in computer technologies, such as smart factories, industrial internet of things (IIoT), cyber-physical systems, cloud systems, big data, digital manufacturing, and Industry 4.0, are increasingly influencing and shaping the manufacturing landscape.

Welding stands as a necessary process in various industries, yet its environmental impact necessitates a reevaluation. In our pursuit of environmentally friendly welding practices, we aim for five key pillars: minimum cost, highest process efficiency, optimum resource utilization, minimum environmental impacts, and minimal energy consumption. With these principles, we not only address the ecological footprint of welding but also enhance overall operational efficiency. Adopting cost-effective measures and maximizing process efficiency not only reduces expenses but also minimize waste generation and energy consumption. Optimal resource utilization ensures that materials are used carefully, reducing both environmental impact and production costs. Moreover, by prioritizing techniques and technologies that minimize environmental impacts, such as reducing emissions and waste generation, we contribute to a healthier planet and safer working



environments. In essence, by integrating these pillars into welding practices, we can mitigate the environmental impact of this necessary process while simultaneously increasing efficiency and sustainability.

Figure 1 shows the five pillars on which the sustainability of the welding process should be based.

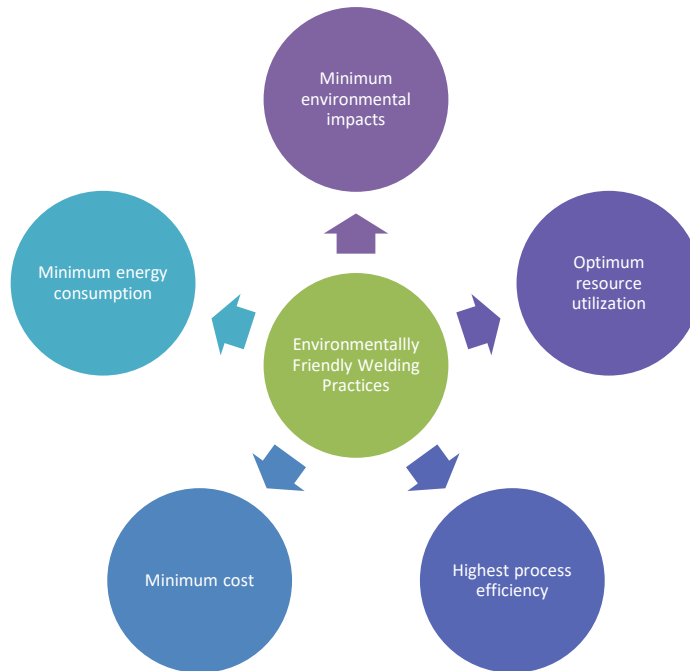


Figure 1 - Five pillars of environmentally friendly welding practices.

The Environmental Impact of Welding

Let's begin by examining the environmental impact of welding processes in construction. Traditional welding techniques employ heat and energy to fuse two metals, generating toxic emissions as a byproduct. These emissions consist of both minute and nano pollutants, as well as hazardous gases like carbon monoxide, ozone, and nitrogen oxides.

Improper welding practices contribute to a substantial waste of valuable materials and scarce gases. Inadequate disposal of this waste can pose significant environmental risks. Concurrently, the welding process needs considerable energy consumption, often sourced from the burning of fossil fuels.



Eco-Welding Design

While welding boasts a range of well-established and effective standards, there is a scarcity of pertinent information regarding environmental considerations associated with welding:

- EN 14717: 2005: Welding and allied processes - Environmental check list – provide a Vague guidance, merely emphasizing the correct operation of the equipment.
- IEC 60974-1 Ed. 4.0 b:2012 - Arc Welding Equipment - Part 1: Welding Power Sources - mention of welding power source efficiency.

However, efforts on the part of safety regulators and governments have had a positive impact on the introduction of intelligent welding machines in several companies in the sector. The European Commission (EC) has developed eco-design requirements for a wide range of product categories under the Eco-design of Energy-related Products framework.

Adopting Sustainable Welding Practices

Addressing the environmental impact of welding involves the adoption of eco-friendly techniques. Depending on the specific project, welders have various welding processes to choose from—some requiring less energy and generating less waste. Solid-state welding methods like friction stir welding or magnetic pulse welding, for example, prove more environmentally friendly by producing fewer harmful fumes, eliminating the need for filler gases, and reducing energy consumption. However, it's essential to acknowledge that these techniques may not be universally suitable for every construction project. Fortunately, alternatives like laser arc hybrid welding and gas metal arc welding are recognized for providing specific eco-friendly advantages as well.

Using Eco-friendly Equipment and Recyclable Materials

Reducing the environmental footprint of welding involves incorporating recycling in various ways. This encompasses recycling used metal scraps rather than disposing of them and opting for the reuse of salvaged and reclaimed materials. Simultaneously, the utilization of higher-quality welding equipment contributes to long-term waste reduction and minimizes energy consumption.



Integrating Industry 4.0

Moreover, the recent implementation of Industry 4.0, involving the digitization of production processes, data analysis, and the integration of technologies, along with manufacturing automation, has facilitated the acquisition of real-time information for informed decision-making. The industry's ongoing evolution towards automation is also spurred by heightened customer expectations regarding environmental awareness and carbon footprint reduction. However, the practical application of these new technologies in small- and medium-sized enterprises requires financial investment and resources that not all companies possess.

In the realm of sustainable welding, achieving maximum process efficiency, minimal environmental impact, optimal energy efficiency, efficient resource utilization, and minimal wastage of resources is paramount. A key strategy to realize these sustainability objectives is through the embrace of automation in welding procedures. Automation significantly reduces waste by leveraging robot efficiency in consistently producing welds without human errors, leading to a substantial decrease in unused by-products. This precision also implies a reduced demand for energy and materials at construction sites.

Furthermore, automation offers the advantage of reducing the need for human intervention. With a smaller workforce, there is a corresponding decrease in energy requirements, such as lighting, and a notable reduction in pollution associated with commuting to and from the site. Automation tools also play a crucial role in streamlining the recycling process.

Introduction to recycling

Recycling in welding processes is a critical aspect for both environmental sustainability and operational efficiency. By recycling materials and minimizing waste, not only are valuable resources conserved, but the environmental footprint of welding is also significantly reduced. This responsible approach towards the environment helps to mitigate the release of pollutants, a matter of great importance in the welding industry.

In the welding process, the generation of contaminants is a constant concern. These pollutants, which include fumes, gases, harmful radiations, and particle projections, pose risks to both the



health of workers and the environment. Identifying and understanding these contaminants is the first step towards implementing safer and more sustainable welding practices. In this context, we will explore the main pollutants generated during the welding process, highlighting the importance of efficient recycling strategies and waste management to minimize their impact.

The main contaminating agents to take into account in welding processes are the following:

Fumes and Gases

During welding, fumes and gases are generated through chemical reactions of the involved components. These vary in characteristics depending on their source, notably:

- Emitted by interaction with the surrounding air.
- Originating from the base material.
- Resulting from the coating or surface treatment of the base material.
- Produced by the filler material, coatings, or fluxes used.
- Emitted by liquids or gases present in the containers being welded.
- Generated by degreasers or cleaning products used on the materials.



Figure 2 - Fumes and gases during welding.



Radiation

Arc welding processes emit visible, ultraviolet, and infrared radiations, with ultraviolet being particularly harmful to the eyes and skin. On the other hand, flame welding produces similar radiations but at a lower intensity. As for resistance welding, it mainly emits infrared and visible radiations, which are less harmful.



Figure 3 - Radiation during TIG welding.

Noise and Particle Projection

The noise in welding comes from complementary tasks such as grinding, chipping, and hammering. Some methods, like plasma welding and certain types of resistance welding, can generate noises exceeding 90 dB.



Regarding particle projection, these can reach horizontal distances of up to 10 meters. The combination of these incandescent particles with gases and combustible materials, along with the generated heat, increases the risk of fires. Therefore, it is crucial to work in environments with fire-resistant floors, walls, and screens.



Figure 4 - Particle projection during GMAW welding



3. Procedures and activities to protect the environment

To protect the environment in the context of welding, there are several procedures and activities that can be implemented. Welding, being a process that can involve the emission of fumes, gases, and other by-products, requires careful practices to minimize its environmental impact. Here are some recommendations:

1. Use of Eco-friendly Equipment and Materials:

- Prefer welding equipment that is energy efficient.
- Use welding materials with low content of heavy metals and other toxic elements.

2. Emission Control and Ventilation:

- Implement smoke extraction and filtration systems to capture harmful particles and gases.
- Ensure that the work area is well ventilated.

3. Waste Management:

- Properly dispose of waste generated by welding, including used electrodes and metal scraps.
- Recycle materials whenever possible.

4. Responsible Energy Use:

- Turn off welding equipment when not in use.
- Maintain welding equipment in good condition to ensure energy efficiency.

5. Training and Awareness of Personnel:

- Train welders and related staff on safe and environmentally respectful work practices.
- Promote a culture of environmental responsibility in the workplace.

6. Noise Minimization:

- Use welding techniques and equipment that generate less noise.
- Implement acoustic barriers if necessary, to minimize the impact of noise on the environment.



7. Use of Alternative Welding Techniques:

- Consider using welding techniques that generate less smoke and waste, such as TIG or MIG welding, instead of more polluting methods. Use welding technologies that minimize waste generation, like Friction Stir Welding (FSW), which is particularly effective in joining aluminum and produces less waste compared to traditional methods.

8. Regular Inspections and Maintenance:

- Conduct regular inspections to ensure that welding equipment and processes are not causing environmental damage.
- Properly maintain equipment to prevent leaks and other problems that may be harmful to the environment.

Implementing these practices not only helps protect the environment but can also improve safety and efficiency in the workplace.



4. Usage and Handling of Welding Materials

Usage and Handling of Welding Materials

Welding processes, while essential in many industries, can have significant environmental and health impacts due to the nature of the materials used and the emissions generated. Here are key points on the usage and handling of welding materials:

1. **Safe Storage of Materials:** Welding materials like electrodes, wires, and gases should be stored safely to prevent accidental releases or exposures. Proper ventilation in storage areas is crucial to prevent the build-up of harmful gases.
2. **Proper Disposal of Waste:** Used electrodes, slag, and other welding waste should be disposed of in accordance with environmental regulations. Recycling should be considered wherever possible to minimize waste.
3. **Use of Protective Equipment:** Welders should use appropriate personal protective equipment (PPE), such as respirators and fume extractors, to minimize exposure to harmful fumes and gases.
4. **Training and Awareness:** Regular training on safe handling, storage, and disposal of welding materials is essential to ensure worker safety and environmental protection.

Pollution Level of Each Welding Process and Recommendations

Different welding processes emit varying levels of pollutants. Here's a brief overview with recommendations for using less polluting processes:

1. **SMAW (Stick Welding):** High emission of fumes and gases. Covered welding electrodes are evolving to emit less smoke and harmful gases. These cleaner electrodes reduce exposure to hazardous substances and minimize air pollution. Use alternatives where possible, especially in confined spaces.
2. **GMAW (MIG Welding):** Moderate emissions, but more controlled compared to SMAW. Consider using when precision and control are needed.



3. GTAW (TIG Welding): Low emission of fumes. Preferred for its cleaner operation, especially in stainless steel and aluminum welding.

4. FCAW (Flux-cored Arc Welding): Generates significant fumes, but can be more efficient than SMAW. Use with proper ventilation.

5. SAW (Submerged Arc Welding): Lower fume emission due to the flux covering, but waste from slag needs proper disposal.

6. Laser and Ultrasonic Welding: Very low pollution, ideal for high precision and clean welding requirements, though limited in application due to equipment cost and material limitations.

More information on this topic can be found in Competence Unit 2 (Parameters to measure the impact of work).

Below we will show an approximate graph in which you can assess the difference between different welding methods when it comes to generating waste and contamination.

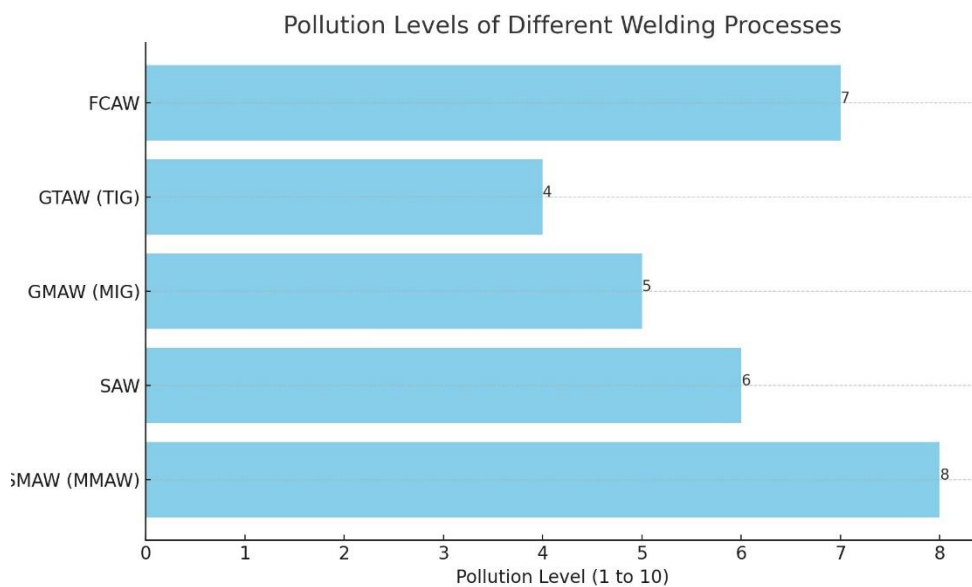


Figure 5 - Pollution levels of different welding processes



Conclusion and Recommendation

The choice of welding process should consider both the application requirements and the environmental impact. Wherever possible, preference should be given to processes with lower emissions, like GTAW (TIG), laser, or ultrasonic welding. Implementing effective ventilation systems, using eco-friendly materials, and ensuring proper waste disposal are key to reducing the environmental footprint of welding activities. As technology advances, seeking out and adopting newer, cleaner welding techniques can significantly contribute to sustainability in the welding industry.



5. Recycling carbon steel, stainless steel and aluminium

Carbon Steel:

In welding processes involving carbon steel, recycling plays a key role in efficient resource management. During welding, scraps and offcuts of carbon steel are generated, which can be collected for reuse. These remnants, often resulting from cuts and adjustments in the fabrication of structures or components, represent a valuable source of recyclable material.

Recycling these carbon steel scraps not only reduces the amount of waste destined for landfills but also decreases the need for mining new mineral resources. Carbon steel maintains its structural properties after recycling, allowing it to be melted and reshaped into a wide range of new products. This recycling process significantly contributes to environmental sustainability by reducing the carbon footprint associated with new steel production.

To maximize the efficiency of recycling in carbon steel welding, it is essential to implement collection and sorting systems in workshops and welding sites. This facilitates the separation of carbon steel remnants from other materials and ensures that the maximum possible amount is collected for recycling.

Stainless steel:

Recycling in stainless steel welding presents its own challenges and opportunities. As stainless steel is used in applications ranging from construction to the manufacture of kitchen utensils and medical equipment, the scraps and offcuts generated during welding are equally valuable for recycling.

An important consideration in recycling stainless steel is the need to properly classify the different types of alloys. Stainless steel comes in various compositions, each with specific properties and uses. This classification is crucial for maintaining the quality and desired characteristics of recycled stainless steel.

Once collected and classified, stainless steel undergoes a process of crushing and cleaning to prepare it for melting. During the melting process, the composition of stainless steel can be



adjusted by adding or removing elements to achieve the desired quality. Similar to carbon steel, recycling stainless steel helps conserve natural resources and reduces the carbon footprint associated with new material production.

The effective implementation of recycling practices in stainless steel welding is not only beneficial from an environmental standpoint but can also offer economic advantages by reducing the need for new and costly materials.

In summary, in both carbon and stainless steel welding, recycling is a key element in promoting sustainability and efficiency in the industry. By adopting recycling practices, welding operations can minimize their environmental impact and contribute to a more circular and sustainable economy.

Aluminum:

Recycling aluminum in welding is crucial for both environmental sustainability and operational efficiency. Aluminum is known for its high recyclability because it can be recycled repeatedly without losing its physical properties. This expanded section focuses on specific practices, technologies, and strategies to enhance aluminum recycling management in welding processes.

Specific Practices for Aluminum Recycling in Welding:

1. Effective Waste Separation: As aluminum can easily be contaminated with other metals during welding, efficient waste separation systems are essential. This includes using dedicated containers to collect aluminum scraps only.
2. Collection of Scraps and Shavings: During welding and machining of aluminum, shavings and scraps are generated that can be collected for recycling. Implementing collection systems at the workplace facilitates this task.
3. Melting and Refining Aluminum Waste: Collected aluminum waste can be melted and refined to produce aluminum ingots. These ingots can be used to create new aluminum products, maintaining the material's quality and properties.

Benefits of Aluminum Recycling in Welding:



1. Carbon Footprint Reduction: Recycling aluminum requires significantly less energy than producing primary aluminum, contributing to a notable reduction in CO2 emissions.
2. Conservation of Resources: Recycling aluminum conserves natural resources and reduces the need for mining and extraction.
3. Cost Reduction: Using recycled aluminum can lower material costs for manufacturers and welding workshops.

In summary, implementing sustainable practices in aluminum recycling in welding processes is essential for a more environmentally friendly, resource-efficient, and economically viable industry.

General Sustainability Practices in Welding:

- **Material Audits**: Perform regular audits to identify opportunities to reduce, reuse, and recycle materials.
- **Continuous Training**: Provide ongoing education to staff about sustainable practices and how to implement them efficiently.
- **Use of Advanced Technology**: Adopt welding technologies that minimize waste generation and improve material efficiency.

Conclusions

In conclusion, adopting sustainable welding practices is essential to minimizing the environmental impact of industrial processes:

1. **Eco-Friendly Equipment and Materials**: Adopting energy-efficient welding equipment and materials with low toxic content is crucial for environmental sustainability.
2. **Emission Control and Adequate Ventilation**: Implement smoke extraction and filtration systems to minimize exposure to harmful gases and fumes.
3. **Recycling of Welding Materials**: Essential for waste reduction, through the collection and recycling of metal scraps and consumables.



4. Safe and Responsible Work Practices: Include training and raising awareness among staff about environmentally friendly welding practices.
5. Energy Efficiency: Reduce energy consumption by turning off equipment when not in use and keeping it well-maintained.
6. Specific Metal Recycling: Carbon steel, stainless steel, and aluminum should be recycled properly, respecting their specific properties and compositions to maximize resource conservation and energy efficiency.



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Part B

Waste and Material Reduction

TOPICS

Maximizing materials recovery

Reducing welding processes

Different welding techniques and reduction in additional post-processes.

Optimization of joint preparation to the thickness to be welded





1. Maximizing Material Recovery

Efficiency in Material Usage:

The importance of using adequate cutting and welding techniques is very important to maximize material utilization.

This includes methods for optimizing edges preparation to minimize waste, following the drawings indications and selecting welding processes that maximize material use and energy consumption, according to the ranges of welding procedures specifications.

Recycling Metal Waste:

Follow an effective recycling system in the workshop is mandatory to optimize the materials. This may include separating different types of metals, optimize the materials, and collaborating with local recycling facilities.



Figure 1 - Management of metal waste



2. Reducing Waste in Welding Processes

Material Reuse:

Understand how to identify opportunities for reusing materials in the workshop. Include practical examples, such as using leftovers to create useful tools or artifacts, or for experimental welding practices.

Environmental Awareness:

Understand about the impact of welding waste on the environment and how sustainable practices can make a positive contribution. Following 'zero waste' policies and promoting an approach of environmental responsibility among peers.



Figure 2 – Zero waste policy on workshop



3. Welding Techniques and Reduction of Repairs

Selection of Welding Techniques:

Expand on how different welding techniques (like MIG, TIG, and submerged arc) adapt to different types of materials and projects. Discuss how the right choice of technique can influence the quality of the weld and reduce the need for touch-ups or repairs, which in turn reduces waste.

Quality over Quantity:

Learn techniques to improve the precision and quality of the weld. This includes training in temperature control, welding speed, and electrode manipulation and gases management techniques to minimize defects and the need for rework.



Figure 3 – Quality production based on technology



4. Optimization of Joint Preparation

Efficient Joint Preparation:

Explore joint preparation techniques that not only enhance welding quality but also minimize energy consumption.

Relation between Joint Preparation and Energy:

Understand the concept of the interconnectedness between joint preparation choices and energy conservation in welding operations. Learn about joint designs that optimize material usage and minimize the need for excessive welding passes. Emphasize the relationship between joint preparation and heat input during welding.



Figure 4- Welding preparation as first step



5. Maximizing Material Recovery

Importance of welding preparations

Respecting the geometry of the joint preparations for the welded joints is very important, since now times and material input in the execution of the welding.

An X preparation need less filler metal than V preparation.

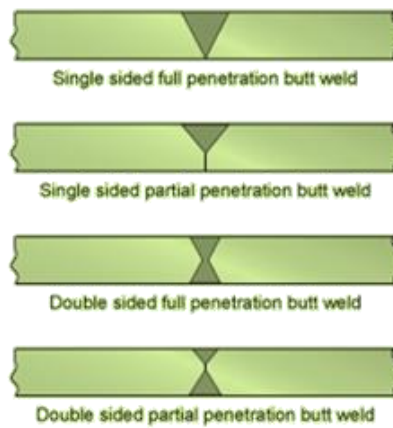


Figure 5 – Samples of BW welding joint options

A more open or closed angle may mean a lack of penetration or greater deformations, which would require extra repair work.

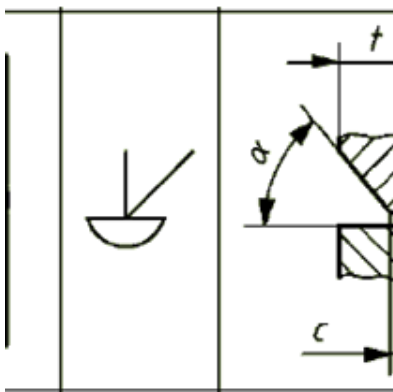


Figure 6 – Detail of welding preparation.

The **parameters** of cutting contribute to the overall efficiency of the welding process.

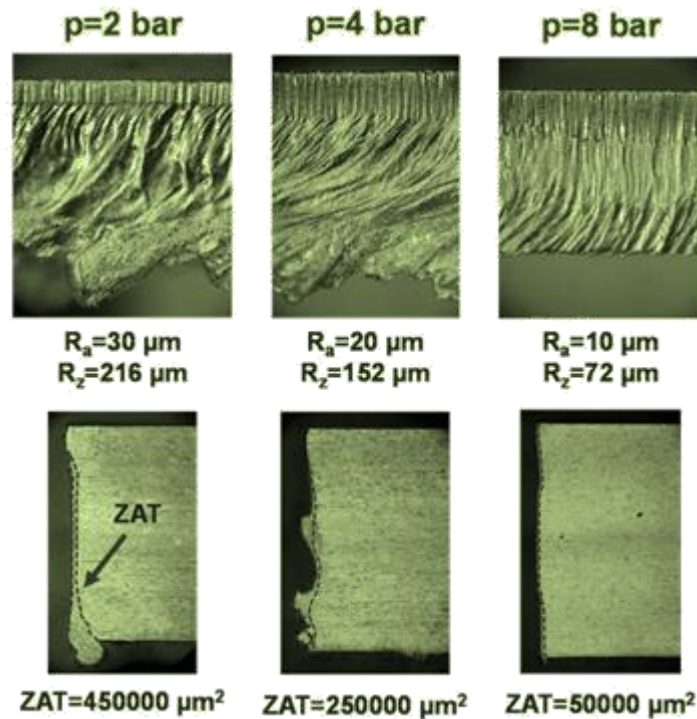


Figure 7 – Samples of cutting quality levels.

An incorrect parameters of cutting, may involve extra preparation work, due to the need for additional grinding, which requires greater energy and material consumption.

Understanding Welding Symbols and Drawings

Allows joints to be made "the first time", and to manage materials more efficiently, reducing the percentage of scrap.



Welding Symbols

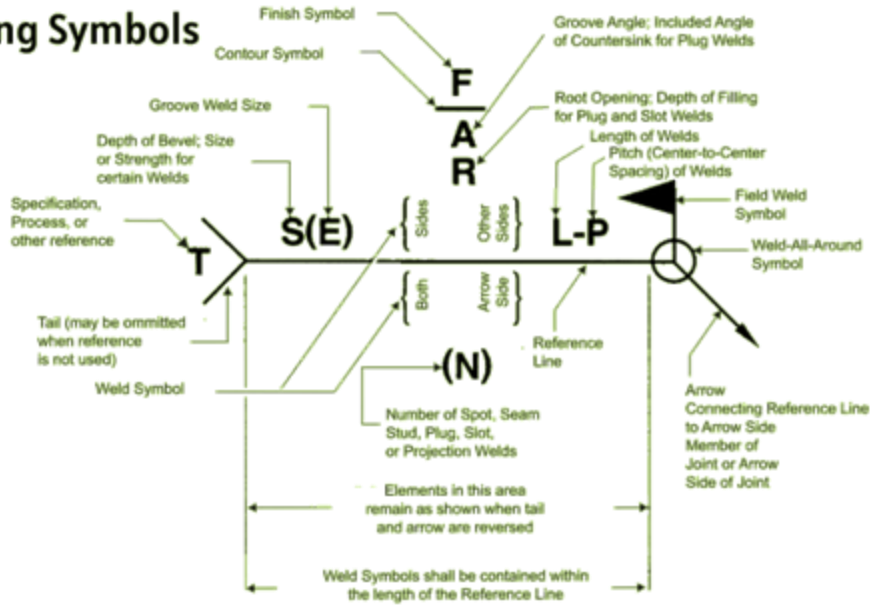


Figure 8 – Welding Symbology

Is important to understand project specifications, because very important details of the execution of the joints may appear, as well as admissible tolerances, and other construction details.

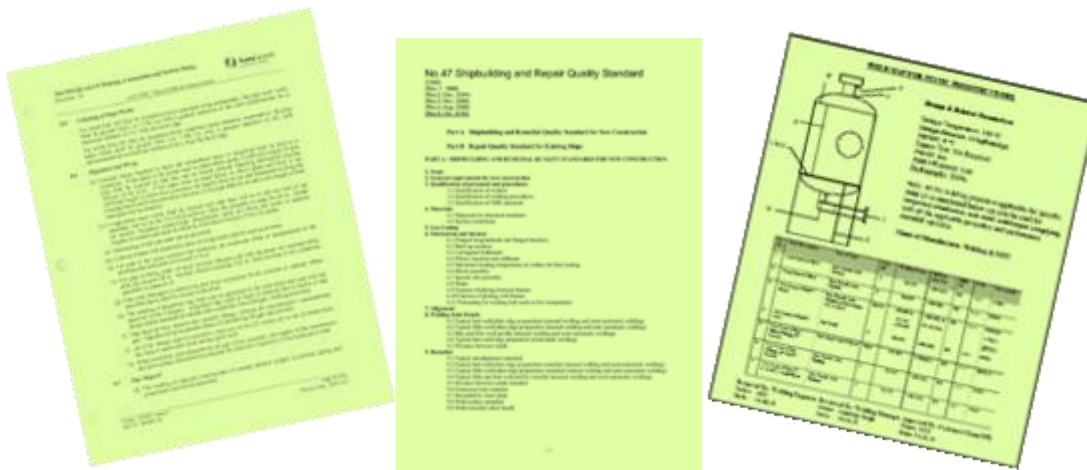


Figure 9 – Welding production documentation samples

Following a different assembly sequence or incorrect joints geometry, may cause poor use of the base material or repairs.



6. Reducing Waste in Welding process

Material Reuse

The welding coupons to qualify procedures can be extracted from scraps of material, and if they are not acceptable, reused again for previous tests.



Figure 10 – Welding of qualification procedure sample

Before starting the production is important to check the welding parameters from the procedure specification. A good practice is to have models or part sections on which to rehearse.



Figure 11 – Options to make welding samples



Environmental Awareness

The process of welding generates metal fumes, both from the metals being welded, from the fillers being used, and from the fluxes or shielding gasses being used. These fumes, released into the environment, can lead to poisoning the air, land, and water, as well as people or animals in the area. The electricity used in welding has to come from somewhere. As a very energy-intensive process, any steps taken to reduce energy consumption or make welding more energy-efficient can be beneficial to the environment, even if it is many steps removed from the generation of that energy. Welding has many consumables, many of which have debris or remains that are simply discarded as waste. This only scratches the surface; a comprehensive analysis of welding processes shows a wide range of potential environmental contaminants and impacts across the industry.



Figure 12 – Part finishing after welding



Environmental Awareness Good practices

- Skip the Feel-Good, No-Impact Gimmicks
- Examine Waste and Recycle Anything That Can Be Recycled
- Choose a Less Impactful Welding Process
- Use Automation to Increase Speeds and Decrease Waste
- Use a Fume Extraction System to Avoid Releasing Contaminants
- Switch to Eco-Friendly Consumables
- Choose in Energy-Efficient Welding Systems
- Use Virtual Reality for Operator Training



Figure 13 – Production cycle



7. Welding techniques and reduction of Repairs

Selection of Welding Techniques

Shielded Metal Arc Welding (SMAW) is commonly referred to as “STICK” welding and uses a stinger – the handle that holds the weld rod.

Advantages

1. Lower equipment cost than GTAW, FCAW and GMAW. (No bottle, gas hose, flowmeter, or TIG rig/Wire feeder needed).
2. Quick Change from one material to another.
3. The process lends itself to welding in confined spaces and various positions with few problems.
4. Deposition rates faster than GTAW Manual
5. Easy to move from one location to another. No Wire Feeder and Bottle.
6. Requires no outside shielding gas and can be used outdoors in light to medium wind.
7. The ability to bend the electrode and the small space the electrode takes allows the process to be used in comparatively tight spaces.

Disadvantages

1. Low deposition rate compared to GMAW/FCAW.
2. Filler metal cost per weld can be greater due to a low deposition efficiency that can vary greatly with stub length.
3. Production factor is typically lower due to rod changes and chipping slag (unless welding on various materials).
4. Needs more hand-eye coordination than GMAW/FCAW.
5. Slag must be removed as compared to GTAW/GMAW

Gas Metal Arc Welding (GMAW) is commonly referred to as “MIG” welding and uses a “MIG gun” with a wire feeder.

Advantages

1. High deposition efficiency when used in certain transfer modes.



2. No slag to chip as compared to SMAW and FCAW
3. The process can be used on thin materials with relative ease, if properly set.
4. Lower hydrogen weld deposit with all electrodes.
5. High production factor since no slag is required to be removed and uses a continuous electrode.
6. With the parameters properly set for the application, most people can weld after a very short amount of practice.
7. One given electrode size can be used on various thicknesses of materials productively, as compared to SMAW and GTAW

Disadvantages

1. Requires a wire feeder, which is difficult to move and can sometimes be a maintenance/repair burden.
2. Needs shielding gas, making welding in windy conditions difficult. Generally is not suitable for windy conditions.
3. Out of position welds are sometimes more difficult.
4. Increased chance of lack of fusion if parameters and welding technique are not controlled.
5. The gun is difficult to get into tight places.

Gas Tungsten Arc Welding (GTAW) is commonly referred to as TIG welding.

Advantages

1. GTAW welding offers more precision and higher quality when compared to other welding techniques.
2. It is a difficult skill to learn for many people because you must hold the welding torch in one hand and the filler material in the other for a successful result.
3. GTAW welding uses a cleaner process and you can operate a GTAW welder in almost any position.
4. GTAW welding allows you to choose the precise amperage for your work.
5. You can weld more types of metals and alloys with GTAW welding processes.



6. GTAW welding processes are useful for welding chrom alloy, aluminum, steel, nickel alloys, stainless steel, copper, brass, magnesium.
7. There are fewer fumes and less smoke when GTAW welding.
8. You don't need to purchase multiple shielding gases to work efficiently, as Argon gas is typically used for most GTAW welding applications.
9. The cost of a GTAW welder is comparable to the other methods.

Disadvantages

1. GTAW welding is more expensive than the other processes available.
2. Poor gas coverage can lead to contamination issues.
3. You need to understand the correct polarity for your welds.
4. Overheating can be a significant problem when GTAW welding.
5. GTAW welding requires higher skill sets and is a much slower process comparatively.
6. Quality over Quantity

7.1 Include tabs and slots and cleco holes

Tabs and slots reduce the need for complicated fixtures by interlocking metal parts with tabs on one piece of metal and slots, or holes, on the other. Designing your parts with tabs and slots enables welders to assemble your parts faster and more efficiently. You can also use tab and slot to ensure that parts are orientated correctly prior to being welded together. Essentially these can serve as error proofing the process, while also greatly improving the efficiency of welding them together. Similarly, cleco holes also help the welders locate the exact location to weld parts together, and these holes can be filled in if needed.

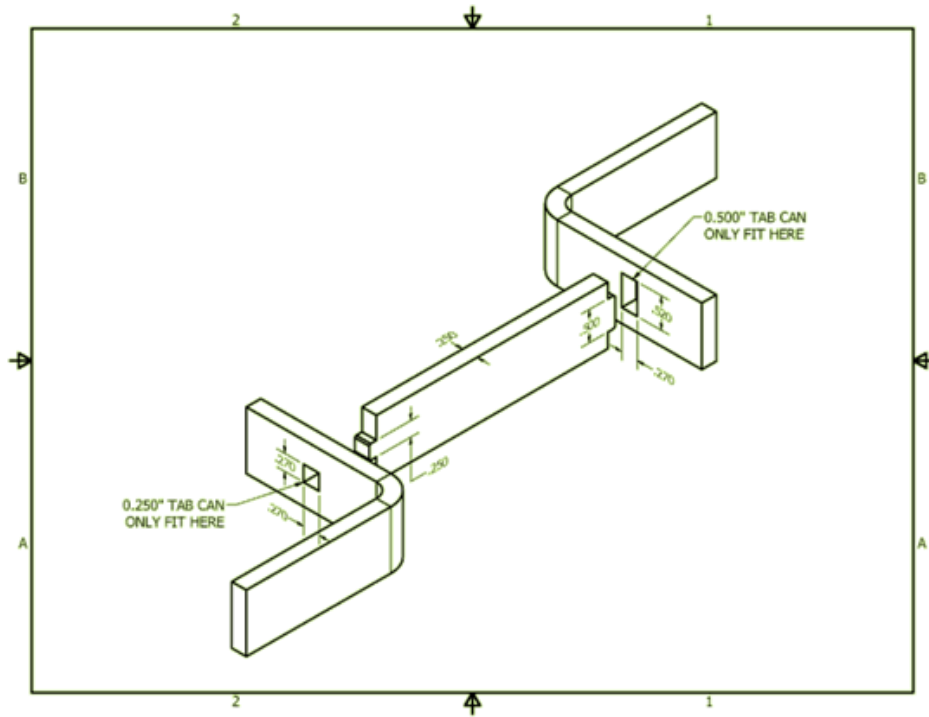


Figure 14 – Sample of welding joint definition

7.2 Select the right material for your project

It's very important to choose your project's material wisely.

If you change a material quality or thickness, it is very likely that you will have to scrap anything that has been manufactured under these conditions.



Figure 15 – Scrap



7.3 Reduce gap sizes or eliminate gaps completely

While there are techniques we can use to fill gaps, it's best to start with the smallest gaps possible to enable faster welding.



Figure 16 – Verification of part

7.4. Choose the right tolerances and quality of welds

Avoid reparations or scraps for not achieving tolerances or acceptance of quality criteria.

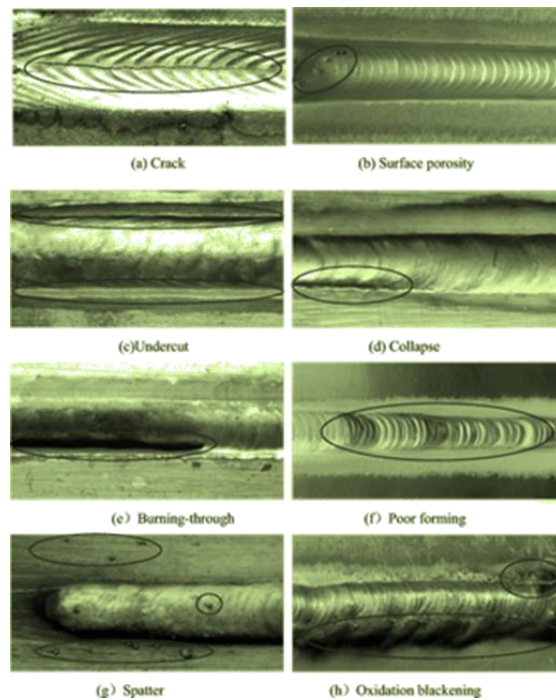


Figure 17 – Typical surface defects on welding

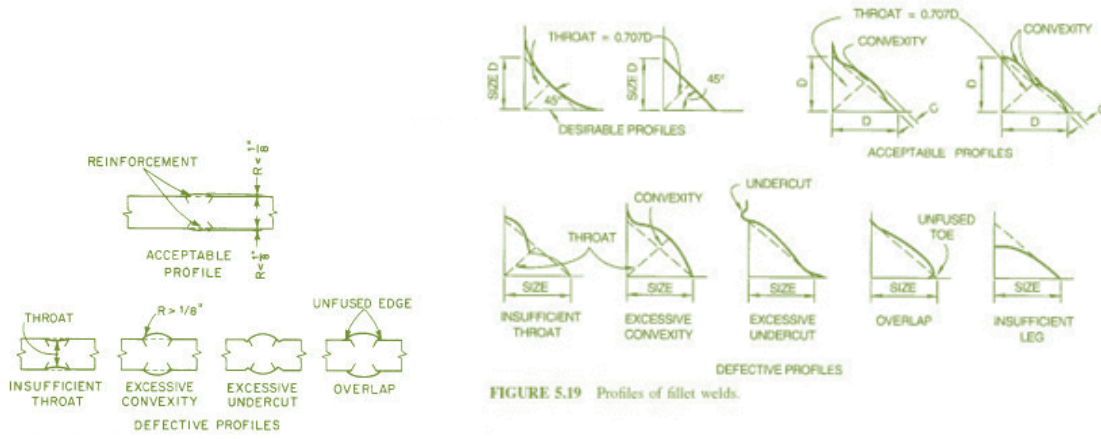


Figure 18 – Samples of sectional defects on welding



8. Optimization of Joint Preparation

Reducing the volume of weld metal

To minimize distortion, as well as for economic reasons, the volume of weld metal should be limited to the design requirements.

For a single-sided joint, the cross-section of the weld should be kept as small as possible to reduce the level of angular distortion.

Reducing the volume of metal, we will reduce the material, energy and gas consumption.

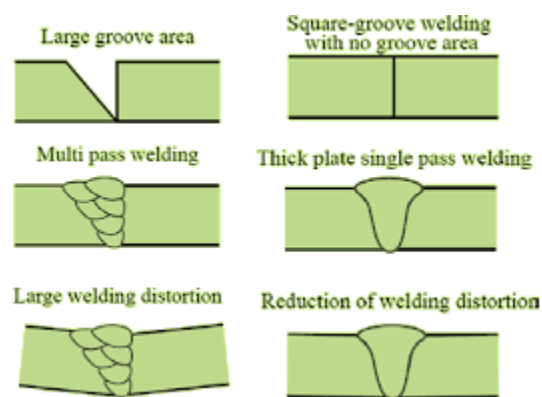


Figure 19 – Deformation vs joint preparation design

Reducing the number of runs

The degree of angular distortion is approximately proportional to the number of passes.

Reducing the distortion, we will reduce the energy to eliminate this effect, and avoid the possibility of scrap.

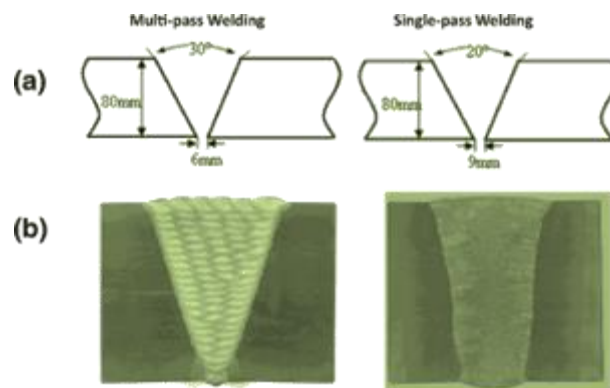


Figure 20 – Options to fill the joint. Single – multiple layer



Relation between Joint Preparation and Energy

Efficient joint designs play a crucial role in minimizing energy expenditure during welding. By selecting appropriate joint configurations, welders can reduce the amount of filler material and welding passes needed. This not only conserves energy but also contributes to cost savings and a more sustainable welding process.

The amount of heat required during welding is influenced by joint preparation. Welding thicker materials or using improper joint designs may demand higher heat input, leading to increased energy consumption. On the other hand, precise joint preparation that matches material thickness and welding requirements can optimize heat input, promoting energy efficiency.

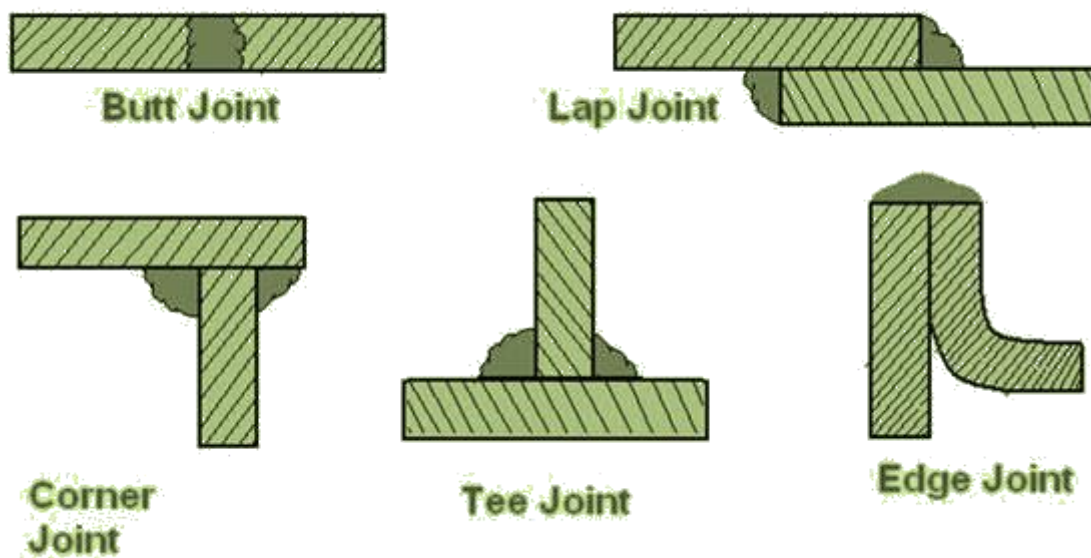


Figure 21 – Typical joints



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