CARR Practical Welding and Fabrication

A fully illustrated training manual for adult beginners

Carr Consultancy and Engineering Services | Guyana | 2026

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Important safety limitation

Welding, cutting and grinding can cause fatal electric shock, fire, explosion, burns, eye injury, toxic exposure and long-term illness. This manual supports supervised beginner training; it does not replace a qualified instructor, an employer's risk assessment, equipment manuals, permits, local law or the governing welding standard. Settings and procedures must be confirmed for the exact machine, consumable, gas, material and job.

Do not use beginner projects for pressure service, lifting, fall protection, vehicles, structural support or other safety-critical applications. Confined spaces, fuel containers, unknown coatings, energized equipment and coded work require specialized controls and qualified personnel.

How to use this manual

This manual takes an adult beginner from safe workshop preparation through basic process knowledge, bead control, fabrication planning and supervised projects. Each lesson contains a purpose, key knowledge, a practical workflow, a stop-work rule, a supervised activity and review questions.

Recommended learning sequence

1. Complete Parts 1 and 2 before energizing welding or cutting equipment.
2. Observe a qualified instructor demonstrate each process.
3. Practise on clean mild-steel coupons before attempting an assembly.
4. Record machine settings from approved manufacturer information and label every coupon.
5. Inspect each result, identify one improvement and repeat safely.
6. Complete the projects only after the instructor approves the drawing, material and sequence.

Training record

Status	Meaning	Evidence
Not yet	Skill has not been demonstrated safely.	Instructor notes
Developing	Skill is improving but still needs prompts or correction.	Labelled practice samples
Consistent	Skill is repeated safely and within the training tolerance.	Signed assessment record

Contents

Part 6 Workshop Practice

Part 1 Safety

Safe skills | Clear practice | Measured results

1 Build a safe work system

Learn to stop, assess and control the job before an arc is struck.

Illustrated training scene

Key knowledge

- Treat every welding task as hot work.
- Identify people, fuels, coatings, confined spaces and nearby equipment before setup.
- Use the hierarchy of controls: remove the hazard, isolate it, ventilate it, then use appropriate PPE.
- Keep a trained person nearby when the risk requires supervision or a fire watch.
- Stop work whenever conditions change or a control fails.

Safe workflow

1. Read the drawing and job instructions.
2. Inspect the work area and write down hazards.
3. Choose controls and obtain authorization where required.
4. Inspect equipment, complete the work, monitor for fire and leave the area safe.

Stop work rule. Do not weld alone as an untrained beginner. Never work on a container, tank or pipe that may have held a flammable or unknown substance.

Supervised practice. Walk through a training bay with the power isolated. Point out at least ten hazards and explain the control for each.

Review questions

- What makes welding hot work?
- When must the job be stopped?

2 Personal protective equipment

Select clothing and equipment that protect the entire body without creating new hazards.

Illustrated training scene

Key knowledge

- Wear a welding helmet with a suitable filter lens and safety glasses with side protection underneath.
- Use dry leather welding gloves and flame-resistant clothing that covers the neck, arms and legs.
- Wear leather safety boots; keep trouser cuffs and open pockets away from sparks.
- Use hearing protection when noise or grinding exposure requires it.
- Inspect PPE before every session and replace cracked, wet, contaminated or damaged items.

Safe workflow

1. Match the PPE to the process, current, position and surrounding work.
2. Check helmet shell, lens, headgear and battery or shade mechanism.
3. Secure hair and remove jewellery or synthetic outerwear.
4. Clean and store PPE so it remains dry and ready.

Stop work rule. A welding helmet does not replace safety glasses. Ordinary sunglasses do not protect against welding radiation.

Supervised practice. Lay out a complete PPE set and conduct a head-to-toe inspection with an instructor.

Review questions

- Why are safety glasses worn under a helmet?
- Which clothing materials should be avoided around sparks?

3 Arc radiation and bystander protection

Control ultraviolet, visible and infrared radiation from the arc.

Illustrated training scene

Key knowledge

- Arc radiation can injure eyes and burn unprotected skin.
- Use the lens shade specified for the process and operating range by the helmet or equipment manufacturer.
- Close welding curtains before striking an arc.
- Warn nearby people and position screens so reflected radiation is also controlled.
- Seek medical attention for eye pain, light sensitivity or suspected arc injury.

Safe workflow

1. Set up screens with enough ventilation around them.
2. Check that no person can directly view the arc from doors, aisles or upper levels.
3. Lower the helmet before arc initiation.
4. Keep skin covered through the entire weld and slag-removal cycle.

Stop work rule. Never demonstrate an arc to an unprotected observer, even for a few seconds.

Supervised practice. Arrange curtains around a mock welding bay and check sight lines from all normal walkways.

Review questions

- What types of radiation come from an arc?
- Why must reflected radiation be considered?

4 Welding fumes and ventilation

Keep hazardous fumes and gases out of the breathing zone.

Illustrated training scene

Key knowledge

- The plume rising from the weld is not safe air.
- Position local exhaust close enough to capture fumes without disturbing shielding gas.
- Keep your head out of the plume and arrange the work so clean air reaches your breathing zone.
- Identify coatings, cleaners, base metals and consumables before heating them.
- Respirators must be selected, fitted and managed within an appropriate respiratory protection programme.

Safe workflow

1. Remove paint, oil and contaminants by an approved safe method.
2. Start ventilation before welding and verify airflow.
3. Watch the plume during the weld and reposition extraction when needed.
4. Stop if fumes accumulate, ventilation fails or you feel unwell.

Stop work rule. Never weld galvanized, painted, plated or unknown metal without a competent hazard assessment and effective controls. Confined spaces require specialized procedures.

Supervised practice. Use smoke from an approved training source, not welding fumes, to demonstrate how local extraction captures a plume.

Review questions

- Why is natural air movement not always enough?
- What should happen before welding coated metal?

5 Fire prevention and hot work

Prevent sparks, slag and hot metal from starting a fire.

Illustrated training scene

Key knowledge

- Move combustible materials away or protect them with approved fire-resistant barriers.
- Check both sides of walls, floors and partitions for hidden combustibles.
- Keep the correct extinguisher accessible and know how to raise the alarm.
- Use a trained fire watch when sparks can travel or when the site procedure requires one.
- Mark hot metal and monitor the area for the full period required by the site.

Safe workflow

1. Inspect the area above, below and beyond the work.
2. Obtain a hot-work permit where the workplace requires it.
3. Control sparks with screens and fire-resistant blankets.
4. After work, isolate equipment, inspect for heat and complete the fire-watch period.

Stop work rule. Do not weld near fuel, gas leaks, dust clouds, oxygen-enriched areas or closed containers.

Supervised practice. Create a hot-work checklist for a small workshop and practise the end-of-job fire inspection.

Review questions

- Where can hidden fires begin?
- What is the purpose of a fire watch?

6 Cylinders and fuel gases

Handle compressed-gas cylinders as high-energy equipment.

Illustrated training scene

Key knowledge

- Keep cylinders upright, secured and protected from impact, heat and electrical circuits.
- Move cylinders with an approved cart; keep valve caps fitted when not connected.
- Use the correct regulator, hose, non-return devices and flashback protection for the system.
- Keep oxygen equipment free from oil and grease.
- Close valves, release pressure safely and store equipment according to supplier and workplace rules.

Safe workflow

1. Identify the gas from its label, never by cylinder colour alone.
2. Inspect threads, valves, hoses and regulators.
3. Stand to the side while opening a valve slowly.
4. Leak-test connections only with an approved solution.

Stop work rule. Never use oil on oxygen fittings, lift a cylinder by its valve protection cap or attempt to repair a damaged valve.

Supervised practice. With cylinders isolated, demonstrate safe cart use, securing, cap fitting and pre-use inspection.

Review questions

- Why is cylinder colour not enough for identification?
- Why must oxygen fittings remain oil-free?

7 Electrical safety

Prevent shock, burns and equipment damage when using arc-welding power sources.

Illustrated training scene

Key knowledge

- Keep gloves, clothing and the work area dry.
- Inspect electrode holders, torches, leads, plugs and work clamps for exposed conductors or overheating.
- Connect the work lead to clean metal close to the weld path.
- Route leads to prevent trip, crush and cut hazards.
- Isolate power before opening covers, changing internal connections or servicing equipment.

Safe workflow

1. Check the equipment rating and supply protection.
2. Inspect cables from machine to accessory.
3. Make connections with the output safely isolated when the procedure requires it.
4. After work, switch off, isolate and coil leads without tight kinks.

Stop work rule. Do not weld while standing in water, in wet clothing or while touching the electrode and work with bare skin.

Supervised practice. Inspect a de-energized training machine and tag every defect that would remove it from service.

Review questions

- Why should the work clamp be near the weld?
- What must happen before a machine cover is opened?

8 Housekeeping lifting and ergonomics

Organize the workshop so people can move, lift and work without preventable strain.

Illustrated training scene

Key knowledge

- Store stock so it cannot roll, fall or block an exit.
- Keep floors dry and remove offcuts, electrode stubs and sharp scrap promptly.
- Use mechanical lifting aids or team lifts for awkward steel.
- Set the bench height and body position to reduce bending and twisting.
- Rotate repetitive tasks and take breaks before fatigue affects control.

Safe workflow

1. Plan the travel path before lifting.
2. Check weight, balance and sharp edges.
3. Use a trolley, hoist or a coordinated team when necessary.
4. Return tools and materials to assigned locations.

Stop work rule. Never stand beneath a suspended load or use welding cables as lifting slings.

Supervised practice. Rearrange a mock workstation to improve cable routing, stock storage, reach and body posture.

Review questions

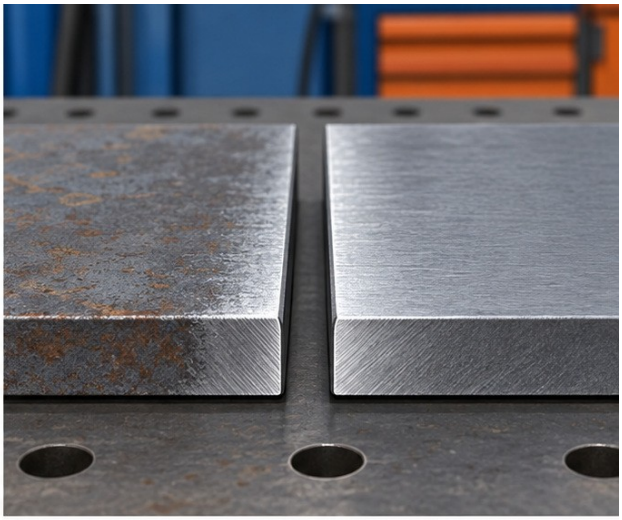
- What makes a load awkward even when it is not very heavy?
- How can poor housekeeping damage weld quality?

Part 2 Foundation Skills

Safe skills | Clear practice | Measured results

9 Metals and material identification

Recognize common fabrication metals and why their identity affects the process.



Illustrated training scene

Key knowledge

- Mild steel is the usual beginner material because it is widely available and comparatively forgiving.
- Stainless steel and aluminium require different consumables, cleaning tools and heat control.
- Coatings, plating and contamination can create fumes and weld defects.
- Material thickness influences joint design, heat input and process choice.
- Keep certificates, labels and stock markings with material when traceability matters.

Safe workflow

1. Check the drawing and purchase record.
2. Look for stamped grades, colour codes or supplier labels.
3. Measure thickness and inspect the surface.
4. When identity remains uncertain, stop and obtain confirmation.

Stop work rule. Do not rely on a spark test alone for critical identification, and do not heat unknown or coated material.

Supervised practice. Sort clean samples of mild steel, stainless steel and aluminium, then record visible and magnetic differences without grinding unknown coatings.

Review questions

- Why does material identity affect consumable choice?
- What should you do when the metal is unknown?

10 Measuring and marking

Transfer dimensions accurately from a drawing to the workpiece.

Illustrated training scene

Key knowledge

- Choose one reference edge and measure from it whenever possible.
- Use a steel rule or tape for length, a square for perpendicular lines and a scriber or marker suited to the surface.
- Allow for cut width, cleanup and final finishing.
- Mark waste sides clearly before cutting.
- Confirm important dimensions twice before removing material.

Safe workflow

1. Clean the reference edge.
2. Establish the datum and mark the first dimension.
3. Use the square to extend a clear cut line.
4. Check the measurement, waste side and orientation against the drawing.

Stop work rule. Keep hands away from sharp edges and never measure moving equipment.

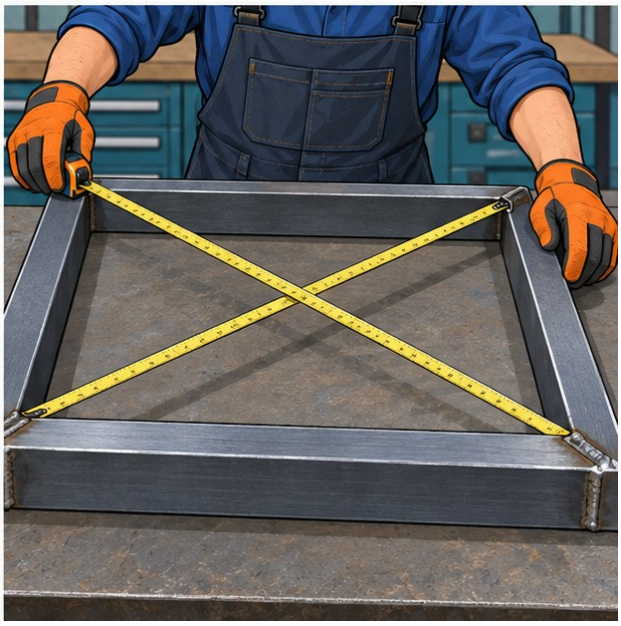
Supervised practice. Mark three lengths on flat bar within 1 mm of the assigned dimensions and verify them with a partner.

Review questions

- What is a datum?
- Why must kerf be considered before cutting?

11 Squareness and diagonal checks

Use diagonal measurements to build rectangular fabrications accurately.



Illustrated training scene

Key knowledge

- A square frame has four 90-degree corners and equal opposite sides.
- When a rectangular frame is flat, equal corner-to-corner diagonals indicate squareness.
- Small tack welds permit correction before the frame becomes rigid.
- Measure from consistent points on both diagonals.
- Check flatness as well as squareness; a twisted frame can have misleading measurements.

Safe workflow

1. Clamp the parts loosely on a flat table.
2. Confirm side lengths and corner fit-up.
3. Measure both diagonals and adjust until equal within the job tolerance.
4. Tack in a balanced sequence and recheck after every round.

Stop work rule. Never place fingers between a clamped frame and the table while adjusting it.

Supervised practice. Lay out a 600 mm by 400 mm rectangle without welding. Adjust it square using diagonal measurements.

Review questions

- What do unequal diagonals indicate?
- Why is squareness checked again after tacking?

12 Shop mathematics

Use simple calculations for lengths, angles, areas and material quantities.

Illustrated training scene

Key knowledge

- Convert units before calculating: 1 inch = 25.4 mm and 1 foot = 12 inches.
- Perimeter of a rectangle = 2 x length + 2 x width.
- Area of a rectangle = length x width.
- For a right triangle, the diagonal can be checked using the Pythagorean relationship.
- Add a realistic cutting and setup allowance, then record actual usage for future estimates.

Safe workflow

1. Write every known dimension with its unit.
2. Convert all values to one unit system.
3. Apply the formula and show the calculation.
4. Check whether the result is reasonable before cutting stock.

Stop work rule. Do not mix millimetres, inches and feet in one calculation without converting them.

Supervised practice. Calculate the steel needed for a 600 mm by 400 mm rectangular frame, then add a 10 percent planning allowance.

Review questions

- What is the perimeter of a 600 mm by 400 mm frame?
- Why is a planning allowance not the same as permission to waste material?

13 Reading fabrication drawings

Read the views, dimensions, notes and tolerances that define a fabrication.

Illustrated training scene

Key knowledge

- The title block identifies the job, drawing number, scale and revision.
- Orthographic views show the object from more than one direction.
- Dimensions state finished size; do not scale a printed drawing unless it explicitly permits it.
- General notes can control material, finish and workmanship.
- The newest approved revision must be used.

Safe workflow

1. Read the title block and revision first.
2. Identify material, quantity and units.
3. Trace each part through the available views.
4. Mark unclear information and resolve it before fabrication.

Stop work rule. Never guess a missing critical dimension or change a drawing without authorization.

Supervised practice. Create a cutting list from a simple instructor-issued frame drawing.

Review questions

- Why should a drawing not normally be measured with a ruler?
- Where are revisions identified?

14 Basic weld symbols

Understand the information carried by common welding symbols.

Illustrated training scene

Key knowledge

- The reference line and arrow connect the symbol to the joint.
- Symbol position distinguishes the arrow side from the other side.
- Fillet and groove symbols describe weld type; dimensions describe size, length or spacing when specified.
- A circle at the arrow junction indicates weld all around; a flag indicates field welding.
- Supplementary contour and finish marks require the stated finishing method.

Safe workflow

1. Locate the arrow and the joint it touches.
2. Identify arrow-side or other-side placement.
3. Read size, length, pitch and any process note.
4. Confirm the symbol against the drawing views before work.

Stop work rule. This chapter is an introduction. Structural or coded work must be interpreted and performed by qualified personnel to the governing standard.

Supervised practice. Match a set of basic symbols supplied by the instructor to sample butt, lap and T joints.

Review questions

- What does the arrow identify?
- What is the difference between weld type and weld size?

15 Hand tools clamps and workholding

Select and inspect tools that hold work securely without damaging it.

Illustrated training scene

Key knowledge

- Use clamps that fit the joint and leave access for tacks.
- Support long stock so it cannot tip the bench.
- Keep hammer faces, files and wire brushes in serviceable condition.
- Use separate stainless-steel brushes for stainless work to reduce contamination.
- Clamping pressure should align parts, not force a bad cut into position.

Safe workflow

1. Inspect the clamp screw, frame and pad.
2. Clean contact areas and position the work on a flat surface.
3. Tighten progressively while checking alignment.
4. Recheck after tack welding because heat can move the joint.

Stop work rule. Do not use damaged clamps or improvised handles, and keep hands out of pinch points.

Supervised practice. Clamp a butt joint, lap joint and T joint in turn, showing safe access for the torch or electrode.

Review questions

- Why can excessive clamping pressure create a problem?
- Why should stainless brushes be kept separate?

16 Grinding and mechanical cutting

Prepare edges and finish metal using guarded tools and controlled technique.

Illustrated training scene

Key knowledge

- Match the wheel or disc to the tool speed and intended operation.
- Inspect the disc, guard, handle, cable and switch before use.
- Secure the work and direct sparks away from people, cylinders and combustibles.
- Allow the tool to reach speed before contact and use moderate pressure.
- Let the wheel stop before putting the tool down.

Safe workflow

1. Isolate the tool before changing accessories.
2. Fit the correct guard and side handle.
3. Stand out of the wheel plane during startup.
4. After use, inspect the work for sharp edges and heat.

Stop work rule. Never fit an oversized disc, remove the guard or use a cutting disc for side grinding.

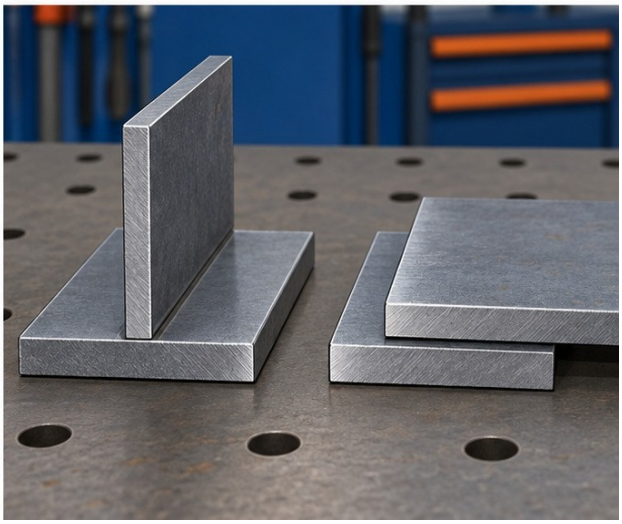
Supervised practice. On cold scrap with instructor supervision, deburr an edge while maintaining the original dimension.

Review questions

- Why must wheel speed ratings be checked?
- Where should grinding sparks be directed?

17 Joint types and edge preparation

Choose and prepare butt, lap, T, corner and edge joints for the required result.



Illustrated training scene

Key knowledge

- Joint type is selected by load path, access, thickness, drawing requirements and process.
- Fit-up controls penetration, weld volume and distortion.
- Groove angle, root face and root opening must follow the approved procedure when specified.
- Clean metal improves arc stability and weld soundness.
- Practice pieces should use consistent dimensions so results can be compared.

Safe workflow

1. Identify the joint and welding position.
2. Prepare edges without thinning them unintentionally.
3. Remove burrs and contaminants.
4. Set the gap and alignment with gauges or spacers, then clamp.

Stop work rule. Do not invent joint details for structural, pressure-containing or safety-critical work.

Supervised practice. Prepare labelled samples of butt, lap and T joints for inspection before welding.

Review questions

- Which factors influence joint selection?
- How can poor fit-up change the weld?

18 Fit-up and tack welding

Hold parts in position with sound tacks while preserving final alignment.

Illustrated training scene

Key knowledge

- Tacks are welds and must be clean, fused and appropriately placed.
- Use enough tacks to resist movement without making correction impossible.
- Balance tack placement around the fabrication.
- Remove cracked or defective tacks before final welding.
- Feather tack ends when the procedure requires the final weld to pass over them.

Safe workflow

1. Clamp and verify dimensions.
2. Place the first tacks where movement can still be corrected.
3. Recheck gap, alignment, square and flatness.
4. Complete a balanced tack sequence and inspect every tack.

Stop work rule. Never weld over a visibly cracked tack or use a tack to pull a dangerous gap closed.

Supervised practice. Tack a small practice rectangle, measure it, break the tacks under supervision and repeat with improved accuracy.

Review questions

- Why must tacks be inspected?
- How does tack sequence affect distortion?

Part 3 Welding Processes

Safe skills | Clear practice | Measured results

19 Power sources polarity and duty cycle

Understand the controls common to welding power sources.

Illustrated training scene

Key knowledge

- Constant-current machines are commonly used for SMAW and GTAW; constant-voltage machines are commonly used for wire processes.
- Polarity affects heat distribution, penetration and consumable behaviour.
- Open-circuit voltage exists before the arc is established.
- Duty cycle limits how long a machine may weld at a stated output within a defined period.
- The machine nameplate and manufacturer manual control safe setup.

Safe workflow

1. Identify the machine rating and input requirements.
2. Select the process and required polarity from the consumable data.
3. Connect torch or holder and work lead with power safely isolated.
4. Set a conservative starting point and test on matching scrap.

Stop work rule. Never bypass thermal protection or continue welding when the machine signals over-temperature.

Supervised practice. Using an isolated machine, locate the rating plate, output terminals, controls, fan openings and duty-cycle information.

Review questions

- What does duty cycle protect?
- Why must polarity match the consumable or process?

20 SMAW equipment and setup

Set up shielded metal arc welding equipment for safe practice.

Illustrated training scene

Key knowledge

- SMAW uses a flux-coated consumable electrode.
- The electrode classification, diameter and storage condition affect performance.
- A clean work connection completes the welding circuit.
- Current is adjusted to electrode size, position, joint and manufacturer guidance.
- Electrodes must be kept dry and handled according to their storage requirements.

Safe workflow

1. Inspect machine, leads, holder and work clamp.
2. Confirm electrode type and polarity.
3. Clamp to clean metal close to the work.
4. Set current from approved guidance and test on scrap.

Stop work rule. Remove damaged holders and cracked leads from service. Never cool an electrode holder in water.

Supervised practice. Prepare an SMAW station and explain every connection before the machine is energized by the instructor.

Review questions

- What provides shielding in SMAW?
- Why should the work connection touch clean metal?

21 SMAW arc control and beads

Coordinate arc length, travel angle, work angle and speed.

Illustrated training scene

Key knowledge

- A short, steady arc usually gives better control than a long wandering arc.
- Work angle aims heat into the joint; travel angle influences puddle support and bead profile.
- Travel speed controls bead width and heat input.
- The puddle, not the sparks, is the main visual guide.
- Slag must be removed completely before inspection or another pass.

Safe workflow

1. Strike the arc on the practice area without damaging the joint.
2. Establish a small puddle and hold a consistent arc length.
3. Travel steadily while watching both toes of the bead.
4. Break the arc safely, allow cooling, then chip and brush slag with eye protection.

Stop work rule. Hot slag can fly during chipping. Keep the helmet or safety glasses in place and direct chips away from others.

Supervised practice. Run parallel stringer beads on a mild-steel pad and compare width, straightness and tie-in.

Review questions

- What changes when arc length becomes excessive?
- Why must all slag be removed between passes?

22 GMAW MIG setup

Prepare a gas-shielded wire-welding system and verify smooth wire delivery.

Illustrated training scene

Key knowledge

- GMAW continuously feeds solid wire through a gun.
- Wire type, diameter, polarity and shielding gas must match the procedure.
- Drive-roll groove, tension, liner and contact-tip size must match the wire.
- Gas flow must be protected from wind and leaks.
- Voltage mainly influences arc length while wire-feed speed strongly influences welding current.

Safe workflow

1. Secure the cylinder and fit the correct regulator.
2. Load wire with power isolated and keep hands clear of drive rolls.
3. Trim the wire, set polarity and gas from approved data.
4. Test on scrap and adjust one variable at a time.

Stop work rule. Never point a welding gun toward yourself or another person while inching wire.

Supervised practice. Identify the wire path from spool to contact tip and demonstrate a safe pre-use inspection.

Review questions

- Why must drive-roll type match the wire?
- How can wind affect a gas-shielded weld?

23 GMAW technique

Control contact-tip distance, gun angles and travel speed during wire welding.

Illustrated training scene

Key knowledge

- Maintain a stable contact-tip-to-work distance.
- Keep the gun work angle centred on the joint.
- A push or drag travel angle may be chosen according to process, material and procedure.
- Listen for a steady arc and watch the leading edge of the puddle.
- Excessive weaving can trap defects and add unnecessary heat.

Safe workflow

1. Position the gun before lowering the helmet.
2. Start on a run-on area when provided.
3. Hold distance and angle while moving at a consistent pace.
4. Fill the crater as required, stop, allow cooling and inspect.

Stop work rule. Do not touch the nozzle, contact tip or work immediately after welding; they may remain hot.

Supervised practice. Run short straight beads, changing only travel speed between samples, then compare profiles.

Review questions

- What happens when contact-tip distance varies?
- Why should settings be changed one at a time?

24 FCAW flux core

Understand how flux-cored wire differs from solid-wire GMAW.

Illustrated training scene

Key knowledge

- Some flux-cored wires are self-shielded; others require external shielding gas.
- The exact wire classification determines polarity and operating range.
- Flux produces slag that must be removed between passes.
- FCAW can deposit metal quickly but produces fumes and spatter that require strong controls.
- Outdoor suitability depends on the specific wire and procedure, not on the process name alone.

Safe workflow

1. Read the wire label and data sheet.
2. Fit suitable drive rolls, liner and contact tip.
3. Set polarity and gas, if required, exactly as specified.
4. Test on matching scrap and inspect after slag removal.

Stop work rule. Never assume every flux-cored wire is gasless or uses the same polarity.

Supervised practice. Compare the equipment setup for one solid wire and one instructor-selected flux-cored wire without energizing the machine.

Review questions

- Why must the wire classification be checked?
- What must be done before a second FCAW pass?

25 GTAW TIG setup and control

Coordinate a non-consumable tungsten electrode, shielding gas and separate filler metal.

Illustrated training scene

Key knowledge

- GTAW offers precise heat control and clean welds when preparation and shielding are correct.
- Tungsten type, diameter, preparation and polarity must suit the material and power source.
- The torch angle, short arc and shielding-gas coverage protect the puddle.
- Filler rod must remain clean and should stay within the shielding envelope when practical.
- Contaminated tungsten must be reconditioned using an approved method.

Safe workflow

1. Clean the joint and filler rod with dedicated tools.
2. Fit the correct torch parts and inspect the gas path.
3. Set the machine from approved guidance.
4. Establish the puddle, add filler rhythmically and taper off to protect the crater.

Stop work rule. Do not grind tungsten on a wheel used for unknown metals, and do not touch hot tungsten with bare hands.

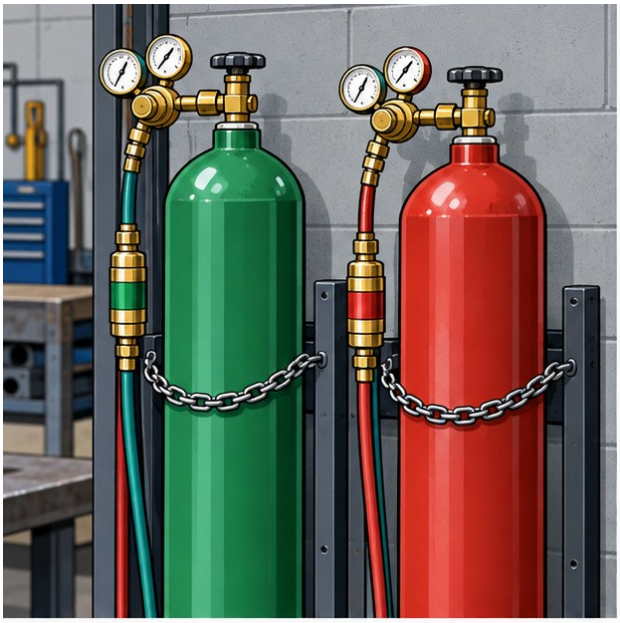
Supervised practice. With the machine isolated, practise torch-and-filler hand coordination along a marked line.

Review questions

- Why is GTAW cleanliness especially important?
- What should happen after tungsten touches the puddle?

26 Oxy fuel equipment and lighting

Recognize the oxy-fuel system and follow the manufacturer-approved operating sequence.



Illustrated training scene

Key knowledge

- Oxygen and fuel-gas equipment must be compatible with the gas used.
- Regulators reduce cylinder pressure to controlled working pressure.
- Correct hoses, check valves and flashback arrestors help manage reverse flow and flame travel.
- Connections are leak-tested with an approved solution.
- Torches are lit only with a friction striker and adjusted according to the task.

Safe workflow

1. Secure cylinders and identify gases from labels.
2. Inspect equipment and confirm valves are closed before connection.
3. Set pressures and purge only according to manufacturer and workplace procedures.
4. Use the approved lighting and shutdown sequence under qualified supervision.

Stop work rule. This manual does not provide gas-pressure values because they depend on gas, tip and equipment. Never use matches, cigarette lighters or oxygen to blow clothing clean.

Supervised practice. Identify each component of an isolated training outfit and explain its purpose.

Review questions

- Why are pressure values not universal?
- What device should be used to light a torch?

27 Oxy fuel cutting

Make controlled cuts by preheating steel and using the cutting-oxygen stream.

Illustrated training scene

Key knowledge

- Oxy-fuel cutting is mainly suited to suitable carbon steels.
- Tip condition and correct standoff affect cut quality.
- The line must be planned so sparks and hot slag have a safe path.
- A guide improves straight cuts.
- Cut parts and dropped slugs remain dangerously hot.

Safe workflow

1. Mark the cut and arrange fire-resistant support.
2. Check the underside and spark path.
3. Preheat the starting point, initiate cutting oxygen and move steadily.
4. Shut down correctly, mark hot metal and clean the cut after cooling.

Stop work rule. Never cut a closed container, vehicle fuel component or unknown coated material.

Supervised practice. Observe an instructor cut and record the signs of travel that is too fast or too slow.

Review questions

- Why must the underside be checked before cutting?
- Why is a guide useful to a beginner?

28 Plasma cutting

Use a plasma arc to cut electrically conductive material safely and accurately.

Illustrated training scene

Key knowledge

- Plasma cutters require a suitable power supply, work connection and clean dry air or specified gas.
- Consumables must match the torch and current range.
- A guide and correct standoff improve straightness.
- Plasma creates intense radiation, fumes, noise and a high-energy stream of hot material.
- Water, wet floors and damaged torch parts create severe hazards.

Safe workflow

1. Inspect torch parts, lead, air supply and work clamp.
2. Remove coatings using an approved safe method.
3. Set current and air from the manufacturer chart.
4. Pierce away from the body, travel steadily and allow parts to cool.

Stop work rule. Do not use a plasma torch near flammables or direct the arc toward people, cylinders or hidden services.

Supervised practice. Lay out a straight plasma cut and identify the safe torch path, body position and slag direction.

Review questions

- What condition should the compressed air meet?
- Why is the work connection important?

Part 4 Weld Control and Quality

Safe skills | Clear practice | Measured results

29 Welding positions

Recognize flat, horizontal, vertical and overhead work and how gravity changes puddle control.

Illustrated training scene

Key knowledge

- Position designations depend on joint type and the standard being used.
- Flat welding is normally the first training position.
- Out-of-position work often needs a smaller puddle, controlled travel and settings suited to the procedure.
- Body support and clear sight lines improve control.
- Practice progression should be approved by the instructor.

Safe workflow

1. Identify the joint plane and direction of travel.
2. Arrange leads so they do not pull the hand.
3. Choose a stable stance with the head outside the fume plume.
4. Make short practice welds and inspect before progressing.

Stop work rule. Overhead welding increases exposure to falling sparks and molten metal; use appropriate PPE and qualified supervision.

Supervised practice. Classify sample joints as flat, horizontal, vertical or overhead and explain the expected control challenge.

Review questions

- Why does gravity matter to the puddle?
- Which position should a beginner normally learn first?

30 Travel speed angles and heat input

Diagnose bead shape by connecting it to the welder's movements and settings.

Illustrated training scene

Key knowledge

- Travel speed that is too fast can reduce fusion and leave a narrow bead.
- Travel that is too slow can create excess buildup and heat.
- Work angle distributes heat between joint members.
- Travel angle influences puddle support and slag behaviour.
- Change one variable at a time so the result teaches you something.

Safe workflow

1. Mark equal-length practice runs.
2. Use the same clean material and setup.
3. Vary only one factor between samples.
4. Label the cooled samples and compare width, profile, toe blend and penetration evidence.

Stop work rule. Appearance alone cannot prove internal soundness; destructive or nondestructive testing may be required.

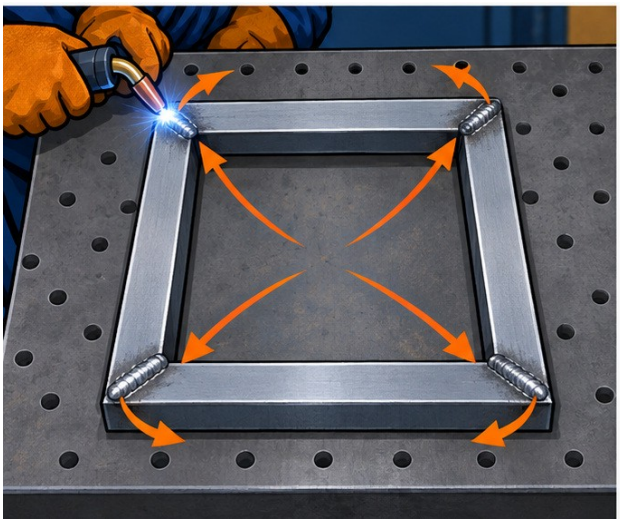
Supervised practice. Produce three practice beads at different travel speeds while keeping other variables steady.

Review questions

- Why should only one variable change during a practice comparison?
- Can surface appearance prove internal fusion?

31 Distortion and heat control

Limit movement caused by uneven heating and cooling.



Illustrated training scene

Key knowledge

- Weld metal and nearby base metal contract as they cool.
- Good fit-up, balanced tacks and a planned sequence reduce movement.
- Shorter weld segments or back-step methods may be useful when permitted.
- Clamps and strongbacks control movement but can also create high restraint stress.
- Check dimensions during fabrication, not only at the end.

Safe workflow

1. Predict which side will contract.
2. Tack symmetrically and verify the assembly.
3. Use the approved balanced sequence.
4. Allow suitable cooling, then check square, flatness and dimensions.

Stop work rule. Do not quench a weld unless the approved procedure specifically allows it; rapid cooling can damage the joint.

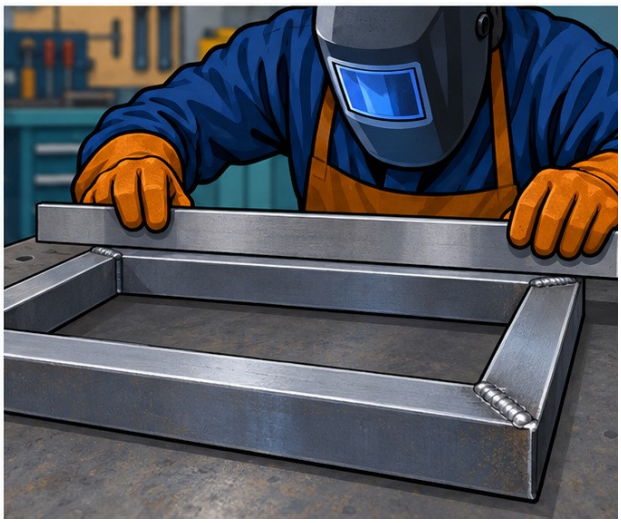
Supervised practice. Tack two identical small frames using different sequences and compare measured movement.

Review questions

- Why does a weld pull as it cools?
- How can balanced sequencing help?

32 Visual inspection

Inspect preparation, fit-up, welding and final condition systematically.



Illustrated training scene

Key knowledge

- Inspection starts before welding with material, joint preparation and fit-up.
- During welding, monitor cleaning, pass sequence, heat and technique.
- After welding, clean the surface and use adequate light.
- Check location, length, size where applicable, profile, continuity and visible discontinuities.
- Record findings against the drawing, procedure or acceptance criteria.

Safe workflow

1. Confirm the correct drawing and criteria.
2. Clean the weld without hiding defects.
3. Inspect from several angles with suitable gauges when trained.
4. Mark and report findings without making unauthorized repairs.

Stop work rule. A visually attractive bead may still contain hidden defects. Critical work requires inspection to the governing code by qualified personnel.

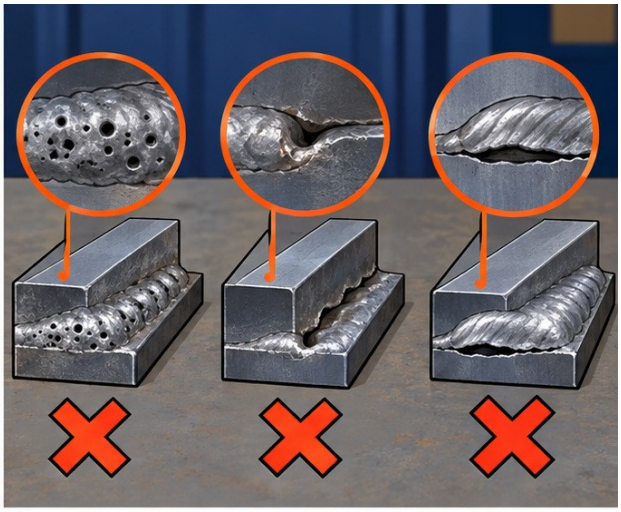
Supervised practice. Inspect labelled training coupons and write objective observations without using vague words such as bad or ugly.

Review questions

- When does weld inspection begin?
- Why must observations be compared with acceptance criteria?

33 Common weld discontinuities

Recognize visible signs that indicate a process or technique problem.



Illustrated training scene

Key knowledge

- Porosity can result from contamination, moisture or shielding loss.
- Undercut is a groove along a weld toe that is not properly filled.
- Lack of fusion can result from poor angle, insufficient heat or travel that is too fast.
- Slag inclusions can form when slag is trapped between passes.
- Cracks require immediate stop, evaluation and an approved repair decision.

Safe workflow

1. Identify and mark the indication.
2. Check setup, material preparation and technique records.
3. Determine the probable cause with an instructor.
4. Correct the cause on a new practice piece before attempting an authorized repair.

Stop work rule. Never simply cover a crack, slag pocket or suspected lack of fusion with another weld.

Supervised practice. Sort sample coupons by discontinuity and match each one to likely causes and prevention steps.

Review questions

- What can cause porosity?
- Why should a crack never be covered over?

34 Weld repair and finishing

Remove defects and finish work without weakening the base material.

Illustrated training scene

Key knowledge

- Repairs require authorization and a defined method.
- The full defect must be located and removed before rewelding.
- Grinding must preserve required thickness and avoid deep gouges.
- The repair area is cleaned and inspected before and after welding.
- Cosmetic blending must not hide cracks, undercut or lack of fusion.

Safe workflow

1. Confirm the repair instruction and boundaries.
2. Remove the indication using the approved process.
3. Inspect the excavation before welding.
4. Reweld, clean, finish and repeat the specified inspection.

Stop work rule. Do not repair pressure vessels, lifting equipment, vehicle safety structures or coded structural work without the required qualification and approved procedure.

Supervised practice. On a noncritical training coupon, practise removing a marked surface defect without gouging below the instructor's limit.

Review questions

- Why must the entire defect be removed?
- When can grinding create a new defect?

Part 5 Fabrication Practice

Safe skills | Clear practice | Measured results

35 Plan the fabrication workflow

Turn a drawing into a safe sequence that controls quality and waste.

Illustrated training scene

Key knowledge

- A cutting list converts the drawing into individual parts.
- The sequence should minimize repeated setup and preserve reference surfaces.
- Trial fit-up finds errors before welding makes them expensive.
- Inspection points belong inside the plan.
- The plan also identifies PPE, ventilation, lifting and fire controls.

Safe workflow

1. Review drawing, material and tolerances.
2. Prepare the cutting list and mark each part.
3. Cut, deburr and trial assemble.
4. Tack, verify, weld in sequence, inspect and finish.

Stop work rule. Do not let production speed remove safety checks or dimensional verification.

Supervised practice. Write a one-page job plan for a small square frame, including inspection hold points.

Review questions

- What is the purpose of a cutting list?
- Why should inspection points appear in the plan?

36 Material takeoff and cost control

Estimate stock, consumables and time without encouraging waste.

Illustrated training scene

Key knowledge

- Calculate finished lengths first, then plan how they nest on available stock.
- Account for kerf, end cleanup and legitimate test pieces.
- Separate purchased quantity from expected usable quantity.
- Consumables include electrodes or wire, gas, discs, tips and PPE wear items.
- Record actual usage and labour time after each project.

Safe workflow

1. List every part and quantity.
2. Choose stock lengths and create a cutting map.
3. Add documented allowances.
4. Price material, consumables and labour separately, then review actual results.

Stop work rule. An allowance is for predictable loss, not careless cutting. Recheck expensive or scarce material before cutting.

Supervised practice. Prepare a takeoff and cutting map for two identical 600 mm by 400 mm frames.

Review questions

- Why should stock nesting be planned?
- What is learned by recording actual usage?

37 Project 1 practice bead pad

Build consistent control through repeatable supervised bead practice.

Illustrated training scene

Key knowledge

- Use clean mild-steel plate of the instructor-selected thickness.
- Mark parallel guide lines and identify each run.
- Keep setup constant while practising one technique variable.
- Clean and cool the work in the approved manner between runs.
- Evaluate straightness, consistency, profile and visible discontinuities.

Safe workflow

1. Inspect the plate and prepare the station.
2. Run short beads along the guide lines.
3. Clean and label each bead with the setting and observation.
4. Select the best sample and explain why it improved.

Stop work rule. A bead pad is a controlled training exercise, not a structural qualification test.

Supervised practice. Complete the instructor's bead-pad sequence for the selected process and record settings from the approved machine chart.

Review questions

- Why should practice runs be labelled?
- Which visual features show improving control?

38 Project 2 square tube frame

Fabricate a small non-load-bearing frame while controlling square and distortion.

Illustrated training scene

Key knowledge

- Use a drawing that specifies finished outside dimensions and joint arrangement.
- Cut ends accurately and deburr every edge.
- Assemble on a flat table with stops or squares.
- Equalize diagonals before tacking.
- Use a balanced weld sequence and verify dimensions after cooling.

Safe workflow

1. Prepare the cutting list and inspect stock.
2. Cut, deburr and label four members.
3. Clamp, square and tack opposite corners.
4. Recheck, weld in balanced steps, inspect and finish sharp edges.

Stop work rule. This beginner frame is not for lifting, structural support, vehicle repair or fall protection.

Supervised practice. Build the frame only under supervision, recording side lengths, both diagonals and final flatness.

Review questions

- When should diagonals be checked?
- Why are opposite sides welded in a balanced order?

39 Project 3 open tool tray

Combine layout, cutting, corner fit-up and short welds in a useful light-duty project.

Illustrated training scene

Key knowledge

- The tray drawing must define length, width, side height and corner style.
- Sheet edges are sharp and must be deburred.
- Corners should be tacked in sequence while the tray is clamped square.
- Short intermittent welds may reduce distortion when the design permits.
- All edges and projections are finished safe to handle.

Safe workflow

1. Develop or use an approved flat pattern.
2. Cut and deburr the blank.
3. Form sides with suitable equipment and verify angles.
4. Tack, check, weld as specified, inspect and finish.

Stop work rule. Do not hand-bend sheet near sharp edges without correct tools and gloves, and never make sealed containers for fuel or pressure service as a beginner project.

Supervised practice. Fabricate an open tray from the instructor's drawing and complete a dimensional inspection sheet.

Review questions

- Why are short welds often useful on sheet metal?
- What makes sheet-metal edges hazardous?

40 Project 4 small table base

Apply planning, fit-up and quality checks to a larger but still supervised assembly.

Illustrated training scene

Key knowledge

- The training table must have a defined light-duty purpose and approved dimensions.
- Leg lengths must match and contact the same plane.
- Temporary bracing or fixtures can hold the base square during tacking.
- Weld sequence should alternate around the frame.
- The finished base is checked for wobble, sharp edges and weld condition before any top is fitted.

Safe workflow

1. Make the cutting list and confirm stock.
2. Build and square the top frame.
3. Fit legs using a square and equal reference dimensions.
4. Tack, brace, recheck, weld in sequence and inspect.

Stop work rule. Do not represent a beginner project as certified furniture, a work platform or a load-rated support.

Supervised practice. Prepare the complete job plan and fabricate only after instructor approval of material, dimensions and sequence.

Review questions

- How can equal leg length be verified?
- Why should the base be checked for wobble before use?

Part 6 Workshop Practice

Safe skills | Clear practice | Measured results

41 Equipment care and maintenance

Keep equipment reliable through inspection, cleaning and authorized maintenance.

Illustrated training scene

Key knowledge

- Disconnect equipment from its energy source before maintenance.
- Keep cooling openings clear without blowing hazardous dust into the air.
- Replace worn contact tips, nozzles, liners and torch parts with correct items.
- Inspect leads, earth connections, plugs and gas hoses on a schedule.
- Record faults and service rather than relying on memory.

Safe workflow

1. Follow the manufacturer's maintenance schedule.
2. Clean external surfaces using an approved method.
3. Check wear items and connections.
4. Tag defective equipment and return it to service only after authorized repair.

Stop work rule. Internal electrical repair and gas-regulator repair are not beginner tasks.

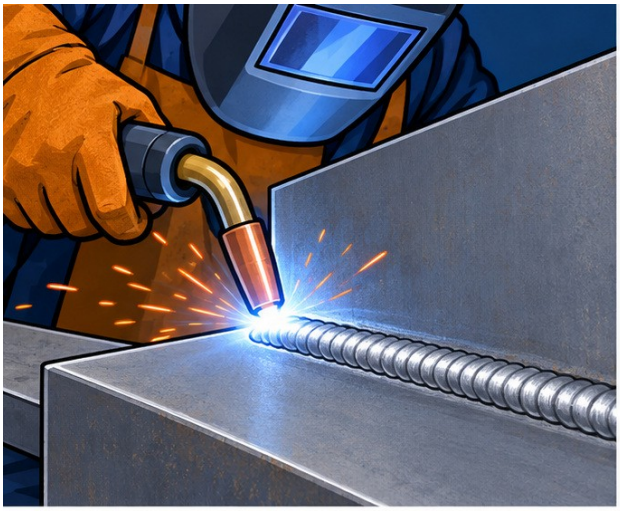
Supervised practice. Create a weekly inspection sheet for one welding machine and its accessories.

Review questions

- Why must equipment be isolated before maintenance?
- What should happen when a fault is found?

42 Troubleshooting by evidence

Solve welding problems systematically instead of changing many controls at once.



Illustrated training scene

Key knowledge

- Start with the symptom: unstable arc, poor feeding, porosity, excessive spatter or poor profile.
- Check simple external causes before suspecting internal failure.
- Compare the actual setup with consumable and machine data.
- Change one variable, test on scrap and record the result.
- Escalate electrical, gas-system or repeated faults to qualified service personnel.

Safe workflow

1. Stop safely and identify the exact symptom.
2. Inspect material, consumable, connections, gas and technique.
3. Correct one verified cause.
4. Test, inspect and document; tag the machine if the problem persists.

Stop work rule. Never defeat a safety device, increase settings beyond equipment limits or continue through overheating.

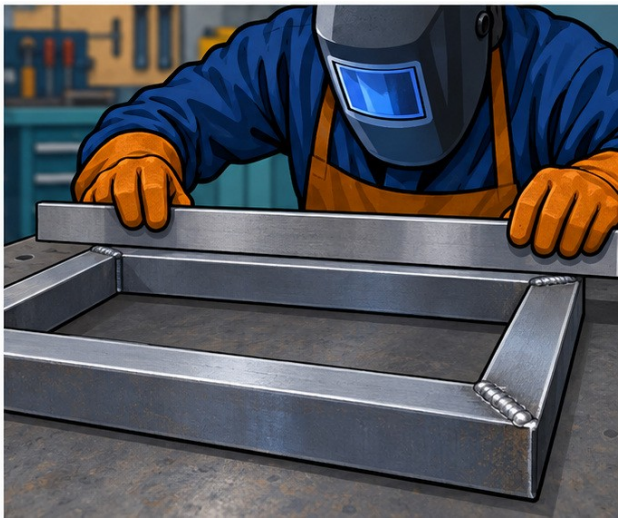
Supervised practice. Use a prepared fault board to diagnose three instructor-created setup problems without energizing the equipment.

Review questions

- Why should one variable be changed at a time?
- Which faults require escalation?

43 Quality records and traceability

Record enough information to repeat good work and investigate problems.



Illustrated training scene

Key knowledge

- A job record links the drawing revision, material, process, consumable and operator.
- Settings recorded from the machine help repeat successful practice.
- Inspection records should state criteria, actual observations and disposition.
- Corrections and repairs need authorization and traceable results.
- Clear records support estimating, training and continuous improvement.

Safe workflow

1. Identify the job and current drawing.
2. Record material and consumable details.
3. Enter setup, welder and inspection results.
4. File the record so it can be retrieved and protected from unauthorized changes.

Stop work rule. Never falsify an inspection result or sign for work you did not inspect.

Supervised practice. Complete a sample weld log for a training coupon from preparation through final inspection.

Review questions

- Which details make a record traceable?
- Why must corrections be authorized?

44 Skills assessment and next steps

Use evidence to decide whether the learner is ready for more difficult work.

Illustrated training scene

Key knowledge

- Safety behaviour is assessed before speed or appearance.
- The learner should set up, explain controls and stop safely without prompting.
- Practice pieces should be measured and inspected against stated criteria.
- A training certificate is not the same as a code qualification.
- Progress to structural or coded work requires the applicable formal training, testing and supervision.

Safe workflow

1. Complete the written safety review.
2. Demonstrate equipment inspection and setup.
3. Produce assigned practice joints.
4. Review results with the instructor and record the next training goals.

Stop work rule. Do not work beyond your competence, authorization or qualification.

Supervised practice. Use the final checklist to rate each skill as not yet demonstrated, developing or consistently demonstrated.

Review questions

- What is assessed before welding speed?
- Why is a course completion record not a code qualification?

Process selection summary

Choose a process from the drawing, approved procedure, material, joint, environment and available qualified personnel. The table is a learning summary, not a substitute for a welding procedure specification.

Process	Electrode	Shielding	Beginner strength	Main caution
SMAW	Flux-coated stick	Flux gas and slag	Portable and direct to learn	Slag, fumes and electrode control
GMAW	Solid wire	External gas	Fast clean practice on prepared steel	Wind, gas loss and wire feeding
FCAW	Flux-cored wire	Flux; some types also use gas	High deposition and useful outdoor options	Wire-specific polarity, slag and fumes
GTAW	Non-consumable tungsten plus filler	External inert gas	Precise heat and clean welds	Cleanliness and two-hand coordination
Oxy-fuel	Filler rod when welding	Flame atmosphere	Heating, brazing and carbon-steel cutting skills	Fuel-gas system and fire control
Plasma	Torch consumables	Air or specified gas	Fast cutting of conductive metals	Intense arc, fumes and hot ejected metal

Beginner troubleshooting guide

Use this guide only after the work is stopped and made safe. Check the approved procedure and equipment information before changing settings.

Symptom	Check first	Likely learning issue	Safe response
Arc will not start	Power, output control, work connection, lead condition	Poor contact or incorrect setup	Isolate, inspect and correct the verified cause
Unstable arc	Consumable, polarity, distance, clean metal	Changing arc length or poor feeding	Return to approved setup and test on scrap
Porosity	Surface cleanliness, gas flow, wind, leaks, moisture	Shielding loss or contamination	Stop, correct shielding and prepare a new coupon
Excess spatter	Polarity, settings, distance and gas	Long arc or unsuitable setup	Change one confirmed variable at a time
Undercut	Current or voltage, angle and travel speed	Excess heat at the toes or poor control	Reduce the cause and practise on a new coupon
Wire feeding fault	Spool, roll groove, tension, liner and tip	Incorrect feed path or worn part	Isolate before inspecting the feed system
Machine overheats	Duty cycle and blocked ventilation	Welding beyond rating	Stop and allow approved cooling; never bypass protection

Final learner assessment

The instructor should mark each item only after direct observation. Add the job-specific acceptance tolerance before the assessment begins.

Skill	Not yet	Developing	Consistent
Identifies hazards and applies controls before setup	☐	☐	☐
Selects and inspects complete PPE	☐	☐	☐
Inspects machine, leads, torch or holder and work connection	☐	☐	☐
Prepares and identifies material safely	☐	☐	☐
Measures, marks, cuts and deburrs within the stated tolerance	☐	☐	☐
Sets up the selected process from approved information	☐	☐	☐
Maintains controlled angles, distance and travel speed	☐	☐	☐
Cleans and visually inspects the completed practice weld	☐	☐	☐
Maintains workshop housekeeping and fire controls	☐	☐	☐
Stops work and reports a fault without taking an unsafe shortcut	☐	☐	☐
Completes a drawing-based cutting list and job plan	☐	☐	☐
Produces a square, flat beginner project within the stated tolerance	☐	☐	☐

Learner name: _____ Date: _____

Instructor: _____ Signature: _____

Next training goals: _____

Glossary

Arc. An electrical discharge across a gap that produces welding heat.

Base metal. The material being welded or cut.

Bead. Deposited weld metal formed during one pass.

Consumable. An item used up during the process, such as electrode, wire, gas, tip or disc.

Datum. A selected reference point, line or surface from which dimensions are taken.

Duty cycle. The rated operating time at a stated output within a defined period.

Fit-up. The alignment, gap and position of parts before welding.

Fume plume. The visible or invisible airborne material rising from hot welding work.

Heat-affected zone. Base metal changed by welding heat but not melted.

Kerf. The width of material removed by a cutting process.

Polarity. The electrical connection of electrode and work in a direct-current circuit.

Porosity. Gas cavities trapped in weld metal.

Root. The portion of a joint where members approach closest or where the weld begins through the thickness.

Slag. Nonmetallic material formed from flux that solidifies on or within weld metal.

Tack weld. A short weld used to hold alignment before final welding.

Toe. The junction between a weld face and the base metal.

Travel angle. The angle of the torch or electrode relative to the direction of travel.

Undercut. A groove melted into the base metal beside the weld and not fully filled.

Work angle. The angle that directs heat between the members of a joint.

Safety references and further study

The manual uses original wording and should be applied with the current requirements governing the reader's location and workplace. The following primary sources provide further safety information:

- Occupational Safety and Health Administration. Welding Cutting and Brazing standards, 29 CFR 1910 Subpart Q. https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910SubpartQ
- Occupational Safety and Health Administration. Eye and Face Protection, 29 CFR 1910.133. https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.133
- National Institute for Occupational Safety and Health. Welding Fumes and Manganese. https://www.cdc.gov/niosh/welding/about/index.html
- National Institute for Occupational Safety and Health. Respirator Types and Use. https://www.cdc.gov/niosh/ppe/respirators/index.html
- The current manufacturer manuals and safety data sheets for every machine, consumable, gas and chemical used in training.
- The current welding code or standard specified by the customer, engineer, employer or authority having jurisdiction.

Closing reminder

Sound fabrication starts before heat is applied: identify the job, control the hazards, prepare accurately, use the approved procedure, inspect the result and record what was learned.