KNQF LEVEL 4 · TVET CDACC CYCLE 3

Welding Level 4

A Practical Study Guide for Kenyan Trainees

MIG/MAG welding · TIG welding · Stainless, aluminium & pipe



Realistic pictures **Step-by-step tasks** **Mock assessments**

For trainees, RPL candidates, trainers and fabrication fundis

Alphonce Kimutai Kirui

Aligned to the TVET CDACC Competency-Based Modular Curriculum, Welding KNQF Level 4

Welding Level 4

A Practical Study Guide for Kenyan Trainees

Metal Inert Gas Welding · Tungsten Inert Gas Welding · Industrial Attachment
Kenya National Qualifications Framework (KNQF) Level 4

Alphonce Kimutai Kirui

Welding Level 4: A Practical Study Guide for Kenyan Trainees
First edition, November 2026

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Published by the author. Website: alphoncekirui.com

About the curriculum

This book is an independent study guide. It follows the topics and units of the TVET CDACC Competency-Based Modular Curriculum and Occupational Standard for Welding, KNQF Level 4 (Cycle 3, programme code 0715 354A), and the assessment documents for Welder Level 4. It covers the two Level 4 units (Module II): Metal Inert Gas Welding (ENG/CU/WEF/CR/01/4/MA, 200 hours) and Tungsten Inert Gas Welding (ENG/CU/WEF/CR/02/4/MA, 200 hours), together with the 320 hours of industrial attachment (ENG/CU/WEF/CR/03/4/MA). The Level 3 units of the qualification (Module I: Fabrication Processes I, Arc Welding Processes I, and Gas Welding, Soldering and Brazing Processes) are covered in the companion book, *Welding Level 3: A Practical Study Guide for Kenyan Trainees*, by the same author. Unit titles and codes are used for reference only. This is an independent study guide, not published or endorsed by TVET CDACC, TVETA or the Ministry of Education. Always follow the current official curriculum and your trainer's guidance.

Safety and accuracy notice

Welding can injure and kill. Arc light burns eyes and skin, welding fume causes cancer and lung disease, argon and carbon dioxide can suffocate without warning in a tank, pit or small room, live wire and electrodes can give an electric shock, and hot work starts fires. Stainless-steel fume contains hexavalent chromium, galvanised steel gives off zinc fume, and pickling paste contains strong acids. The methods in this book are for training under the supervision of a qualified trainer, always with the correct personal protective equipment and fume extraction. Never enter a tank, pit or vessel that may hold argon or CO2; never weld or cut a drum, tank or container that has held fuel or chemicals unless a competent person has made it safe. Settings given as "typical" or "example" (currents, voltages, wire feed speeds, gas flows, shade numbers, tungsten sizes and prices) are general guidance only: always use the manufacturer's manual and your welding procedure specification (WPS). Follow the current Kenyan laws and rules, including the Occupational Safety and Health Act 2007 and its rules, the Environmental Management and Co-ordination Act and its waste regulations, and workplace rules. Prices are approximate (2026) and vary by town.

Names of people, businesses, email addresses, websites and phone numbers used in examples are made up for teaching. Machines and consumables are described by type, not by brand.

Illustrations and photographs

The illustrations in this book were drawn for it. They are realistic teaching illustrations and are not to scale unless dimensions are given. Charts marked "typical" or "illustrative" show typical shapes and values, not measured data. Photographs come from Wikimedia Commons under free licences (public domain, CC0, CC BY or CC BY-SA); some have been resized or cropped. Each photograph is credited under the picture, and the full list of credits is at the back of the book.

How this book was made

Automated tools, including AI writing and drawing assistants, were used under the author's direction to help draft the text, draw the illustrations and charts, and check calculations, cross-references and layout. The content was checked against the curriculum documents and against published sources such as makers' data, standards and Kenyan law, and the author is responsible for it. If you find a mistake, please report it through alphoncekirui.com so that it can be corrected in the next edition.

Contents

Part 1: Getting Started, Safety and Science

1. Moving Up to Level 4: The MIG and TIG Welder in Kenya 9
2. Safety, Health and Housekeeping for MIG and TIG Welding .....
3. Gas-Shielded Arc Welding Science: Power Sources, Shielding Gases and Metals .....

Part 2: Metal Inert Gas Welding

4. Working Drawings for Welded Fabrication .....
5. MIG/MAG Equipment, Wire and Setting Up 24
6. MIG Parameters and Modes of Metal Transfer .....
7. MIG Welding Plates and Pipes in Flat, Horizontal and Vertical Positions .....
8. MIG Weld Quality, Finishing and Equipment Maintenance .....

Part 3: Tungsten Inert Gas Welding

9. Welding Symbols, Assembly Drawings and Welding Procedures .....
10. TIG Equipment, Tungsten Electrodes and Filler Rods .....
11. TIG Parameters and Technique: DC, AC and Pulse .....
12. TIG Welding Steel, Stainless, Aluminium and Copper Alloys .....
13. TIG Weld Quality, Inspection and Equipment Maintenance .....

Part 4: Attachment, Work and Assessment

14. Industrial Attachment, Running a Welding Job and Getting Assessed .....

Reference

Glossary .....
Quick reference: welding symbols and typical values .....
Answers to practice questions .....
Industrial attachment logbook pages .....
Photograph credits .....
About the author .....

Preface

Walk past any busy fabrication workshop in Kenya today and you will hear the steady hiss of a MIG torch where a few years ago you heard only the crackle of the stick electrode. Gates and grills, lorry bodies and trailers, tank stands and steel structures are now welded faster and cleaner with wire. In the dairy co-operatives, hotels, hospitals and food factories, stainless-steel coolers, sinks, tables and milk lines are joined with the TIG torch, and aluminium ladders, tipper bodies and boats need a welder who understands argon, AC and clean preparation. That is the Level 4 welder.

This guide covers the new units of the Welding KNQF Level 4 course (Module II): Metal Inert Gas Welding and Tungsten Inert Gas Welding, together with the 320 hours of industrial attachment and the assessments that lead to your certificates. The Level 3 units of the qualification (Module I: Fabrication Processes I, Arc Welding Processes I, and Gas Welding, Soldering and Brazing Processes) are not repeated here. They are covered in the companion book, *Welding Level 3: A Practical Study Guide for Kenyan Trainees*, which this book calls "the Level 3 guide". Where a Level 4 job uses a Level 3 skill, such as marking out, fitting and tacking, using an angle grinder or handling a gas cylinder, this book gives a short reminder and points you to the right chapter of the Level 3 guide.

The book is written for trainees in vocational training centres and technical colleges, for candidates seeking recognition of prior learning, for trainers, and for working welders in jua kali sheds, fabrication firms, body builders and food-equipment workshops who want their skills recognised. Everything is explained in plain English, with realistic drawings, worked calculations using Kenyan prices and conditions, practical tasks with record sheets, and checklists matched to the way you will be assessed.

Above all, work safely. The arc of a MIG or TIG torch is brighter than a stick arc, stainless and galvanised fume is poisonous, and argon gives no warning before it suffocates. Learn the safety rules in Chapter 2 before you strike an arc, and keep to them on every job.

Alphonce Kimutai Kirui
Bomet, November 2026

How to use this book

This book follows the Level 4 part of the Welding course from start to finish. It covers the two Level 4 core units and the industrial attachment, in the same order as your training. You can read it cover to cover, or study one unit at a time if you are taking a part qualification. Topics that both units share, such as safety, power sources, shielding gases and metals, are taught once in Part 1. The MIG chapters teach the ideas both processes use (joints, positions, defects, distortion and finishing) and the TIG chapters refer back to them and add only what is different. Level 3 topics are summarised and referred to the Level 3 guide.

The course at a glance

Part	What it covers	Training time
1. Getting started, safety and science	The Level 4 welder and the course, assessment, safety, health and housekeeping for MIG and TIG, power sources, shielding gases and metals	Used throughout (about 28 hours of the two units)
2. Metal inert gas welding	Unit 1 (ENG/CU/WEF/CR/01/4/MA): working drawings and operation plans, MIG/MAG equipment and set-up, parameters and transfer modes, welding plates and pipes in the flat, horizontal and vertical positions, quality, finishing and maintenance	200 hours
3. Tungsten inert gas welding	Unit 2 (ENG/CU/WEF/CR/02/4/MA): welding symbols, assembly drawings and WPS, TIG equipment, tungstens and filler rods, DC, AC and pulse technique, welding steel, stainless, aluminium and copper alloys, quality, finishing and maintenance	200 hours
4. Attachment, work and assessment	The industrial attachment (ENG/CU/WEF/CR/03/4/MA), the mentoring tool and portfolio, running a welding job, and getting ready to be assessed	320 hours of industrial attachment

The new Level 4 work is 200 + 200 + 320 = 720 hours (72 credits). The full Level 4 qualification also includes the three Level 3 units (Module I, 350 hours), covered in the Level 3 guide: 1,070 hours (107 credits) in all.

What is in each chapter

- **What you will learn:** the chapter's goals, with the unit, learning outcome and training hours it belongs to.
- **Key words:** the trade words you need, explained simply. More are in the Glossary at the back.
- **Explanations and drawings:** each topic explained step by step, with realistic labelled illustrations, cut-away and section drawings, charts, drawn forms and photographs.
- **Worked examples:** cutting lists, wire and gas use, duty cycle, heat input, fillet sizes, cylinder life, tungsten and cup sizes, cost per metre and job prices worked through with real numbers.
- **Practical tasks:** real workshop jobs with the tools, materials, steps, safety points and a "Record your results" table to fill in. Do them with your trainer.
- **Check your competence:** a checklist of what an assessor will expect you to show. Tick each item when you can do it without help.
- **Practice questions:** answers, with full working for calculations, are at the back of the book.

Look out for these boxes

SAFETY FIRST

Hazards and how to stay safe. Never skip these.

GREEN TIP

Ways to save gas, wire, electricity and metal, cut fume, and handle scrap, tungsten dust and pickling waste correctly.

TRAINER'S TIP

Advice from experienced trainers and welders to help you work faster and better.

COMMON MISTAKES

Errors trainees often make, and how to avoid them.

IN THE KENYAN WORKSHOP

How the topic looks in real Kenyan workplaces: jua kali sheds, fabrication firms, body builders, dairy and food-equipment makers, aluminium fabricators and county works.

WORKED EXAMPLE

A calculation worked step by step with real numbers.

About the pictures and diagrams

This book uses realistic illustrations of real machines, torches, consumables and welds, cut-away and transverse section drawings, charts, drawn forms and photographs. Labels and thin leader lines point to the parts that matter. In sections, parent steel is grey with 45° hatching, stainless a lighter grey, aluminium pale grey with wide hatching and weld metal golden brown. Argon shielding gas is drawn pale violet and CO2 or active mixes pale green-grey. Blue arrows show flow, movement or the direction of travel. Red marks a danger, defect or mistake; green marks the correct way. Settings marked "Example — use the manual/WPS" are typical starting points, not rules. Some photographs show real workshops where people are not following every safety rule; the captions point this out. Always wear the PPE shown in Chapter 2.

PART 1

Getting Started, Safety and Science

What a Level 4 welder does, how the MIG and TIG units and the attachment are trained and assessed, and how this book links to the Level 3 guide. Then the safety, health and housekeeping rules for wire and tungsten welding (arc light, fume, shielding gases, electricity, hot work and waste), and the science both units share: power sources and their characteristics, shielding gases and cylinders, and the metals you will weld.

Chapter 1: Moving Up to Level 4: The MIG and TIG Welder in Kenya
Chapter 2: Safety, Health and Housekeeping for MIG and TIG Welding
Chapter 3: Gas-Shielded Arc Welding Science: Power Sources, Shielding Gases and Metals

CHAPTER 1

Moving Up to Level 4: The MIG and TIG Welder in Kenya

WHAT YOU WILL LEARN

- Describe the work of a Level 4 welder and how it goes beyond Level 3.
- Explain how the course is built: the units, codes, hours, credits and the industrial attachment.
- Name the MIG/MAG and TIG processes in local and international terms.
- Explain how you will be assessed, where the marks are and how ratings are worked out.
- Plan a career path and know where Level 4 skills are used in Kenya.
- Find your way around this book and your Level 4 workshop.

Course overview · Units ENG/CU/WEF/CR/01/4/MA, 02/4/MA, 03/4/MA

At Level 3 you learned to cut, fit and join steel with the stick electrode and the gas torch. At Level 4 you move to the wire and the tungsten: MIG/MAG welding for fast, clean production work and TIG welding for stainless steel, aluminium and fine work. These are the skills that get a welder into dairy-equipment shops, body builders and the better fabrication firms. This chapter shows you the road ahead.

Key words

MIG/MAG welding
Arc welding with a wire that feeds continuously through a torch, shielded by gas. MIG uses an inert gas, MAG an active gas such as CO2.

TIG welding
Arc welding with a tungsten electrode that does not melt, shielded by argon; filler rod is added by hand.

Unit of competency
A block of the course that ends in its own assessment and certificate.

Element
A main task inside a unit, such as "carry out MIG welding".

Performance criterion (PC)
A statement of what you must show to prove you can do an element.

PC weighting
The marks given to each performance criterion in formative assessment.

Range
The list of machines, materials and conditions the unit covers.

Critical aspects
The things you must show in the summative assessment to be found competent.

RPL
Recognition of prior learning: assessing skills you already have from work.

Portfolio of evidence
Your file of drawings, weld records, photos and reports that proves your competence.

WPS
Welding procedure specification: written settings and method for a weld.

1.1 What a Level 4 Welder Does

A Level 3 welder can make sound joints with MMAW (stick) and oxy-acetylene on mild steel in the flat and horizontal positions. A Level 4 welder does more:

- welds with **MIG/MAG** and **TIG**, the gas-shielded processes used in modern shops;
- welds **mild steel, stainless steel and aluminium**, and with TIG also **copper alloys** such as brass and bronze;
- welds **plates and pipes up to 10 mm** thick in the **flat, horizontal and vertical** positions;
- handles thin sheet and tube without burning through;
- **drafts** working drawings and writes an operation procedure, not just reads them;
- reads and follows a WPS and records the settings used;
- sets up and maintains MIG and TIG machines, torches, wire feeders and gas equipment;
- works with less supervision and guides Level 3 juniors.

Figure 1.1 shows a typical Level 4 training workshop. Notice that everything in it is about control: of the arc, the gas, the fume and the quality of the finished joint.

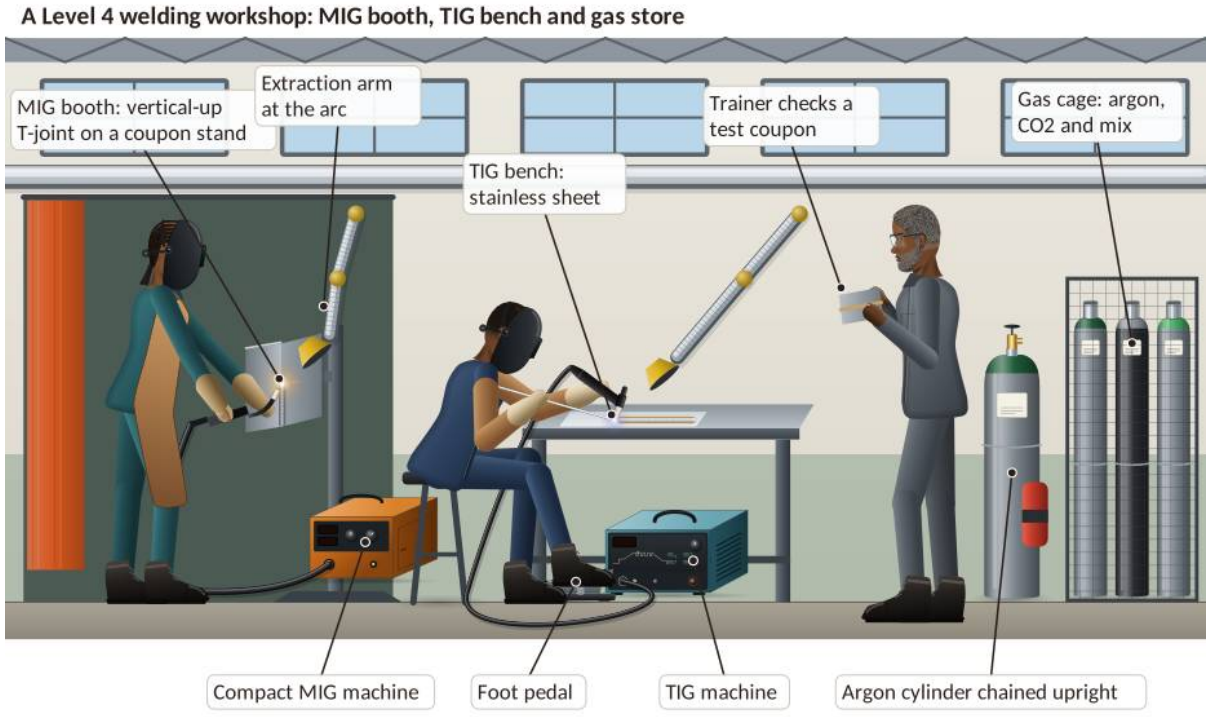


Figure 1.1 A Level 4 training workshop. The MIG trainee welds a vertical-up T-joint in a screened booth, the TIG trainee welds stainless sheet at a bench, both with extraction at the arc, and the gas cylinders stand chained in a ventilated cage.

1.2 Where This Book Fits in the Course

The CDACC curriculum for Welding Level 4 (Cycle 3, 2025; programme code 0715 354A) has two modules. **Module I** holds the three Level 3 units: Fabrication Processes I, Arc Welding Processes I, and Gas Welding, Soldering and Brazing Processes. **Module II** holds the new Level 4 work: MIG welding, TIG welding and a 320-

hour industrial training (attachment). This book covers **only Module II**. Module I is taught in the companion book, *Welding Level 3: A Practical Study Guide for Kenyan Trainees*, called "the Level 3 guide" from now on. If you are entering with KCSE and no Level 3, study the Level 3 guide alongside this one.

Table 1.1 The units of the Welding Level 4 course

Module	Unit	Code	Hours	Credits
I	Fabrication Processes I	ENG/CU/WEF/CR/01/3/MA	150	15
I	Arc Welding Processes I	ENG/CU/WEF/CR/02/3/MA	100	10
I	Gas Welding, Soldering and Brazing Processes	ENG/CU/WEF/CR/03/3/MA	100	10
II	**Metal Inert Gas Welding**	ENG/CU/WEF/CR/01/4/MA	200	20
II	**Tungsten Inert Gas Welding**	ENG/CU/WEF/CR/02/4/MA	200	20
II	**Industrial Training**	ENG/CU/WEF/CR/03/4/MA	320	32
	Total		**1,070**	**107**

The total of 1,070 hours includes the 350 hours of Module I but not the 240-hour Level 3 attachment. The new Level 4 work is 200 + 200 + 320 = 720 hours (72 credits). Each welding unit has three learning outcomes: draft a working drawing (40 h), carry out the welding (140 h) and maintain the equipment (20 h) (Figure 1.2). The occupational standard and the assessment tools print the same units with OS instead of CU; they refer to the same units.

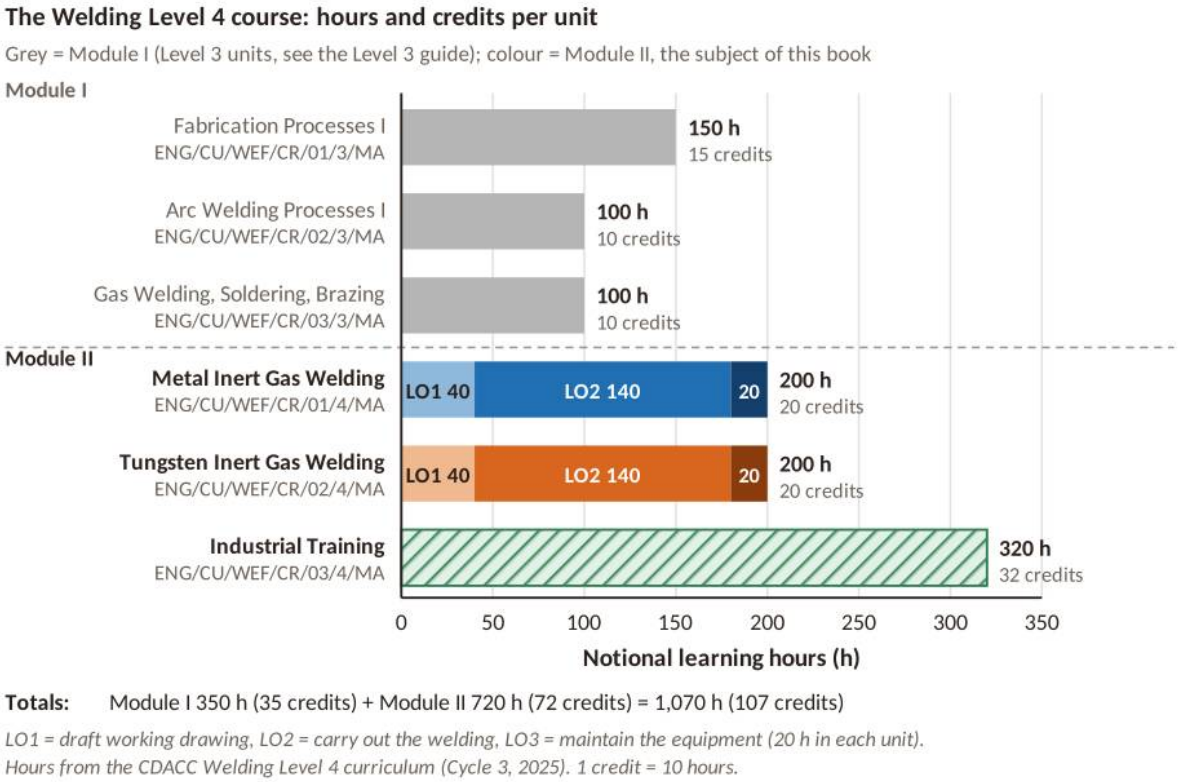


Figure 1.2 The course map. Module I (grey) is covered in the Level 3 guide; this book covers Module II: the MIG and TIG units, each split into three learning outcomes, and the 320-hour industrial training.

1.2.1 Entry and credit transfer

You can enter with KCSE or its equivalent, or with a KNQF Level 3 qualification in welding or a related field. If you already hold the Level 3 units, the TVET CDACC guidelines on credit accumulation and transfer apply, so you may not need to repeat Module I. Ask your institution how it applies them. Trainers for this course hold at least a Level 5 welding qualification, a TVETA licence and registration with EBK or KETRB.

WORKED EXAMPLE 1.1: HOURS TO WEEKS

Your VTC runs 40 hours of training a week. How long is the Level 4 part of the course, the attachment and the whole course?

Weeks = hours ÷ hours per week

Level 4 part: 720 h ÷ 40 h/week = **18 weeks**

Attachment: 320 h ÷ 40 h/week = **8 weeks** (40 working days of 8 hours)

Whole course: 1,070 h ÷ 40 h/week = 26.75, about **27 weeks**

Sense-check: 18 + 8.75 weeks for Module I = 26.75 weeks. Real timetables add holidays, revision and assessment weeks, so the calendar time is longer.

1.3 The Processes You Will Learn

Both new processes use an electric arc, as stick welding does, but protect the weld with a **shielding gas** from a cylinder instead of a flux coating. Figure 1.3 shows how they sit in the arc-welding family.

MIG/MAG welding. A thin wire, usually 0.8–1.2 mm, is fed from a spool through the torch by motor rollers. The wire is both the electrode and the filler metal. Strictly, MIG (metal inert gas) uses argon, an inert gas, for aluminium; MAG (metal active gas) uses CO2 or an argon–CO2 mix for steel. Kenyan workshops call both "MIG" or "CO2 welding". The international name is GMAW, and ISO 4063 gives the process numbers 131 (MIG), 135 (MAG) and 136 and 114 for flux-cored wire. The curriculum calls the unit "Metal Inert Gas Welding"; this book says MIG/MAG where the difference matters.

TIG welding. The arc burns from a tungsten electrode that does not melt. You add filler rod with the other hand, or fuse thin edges without filler. Argon shields everything. Kenyan welders call it "argon welding". The international name is GTAW and the process number is 141. TIG is slow but gives the cleanest, most controlled welds.

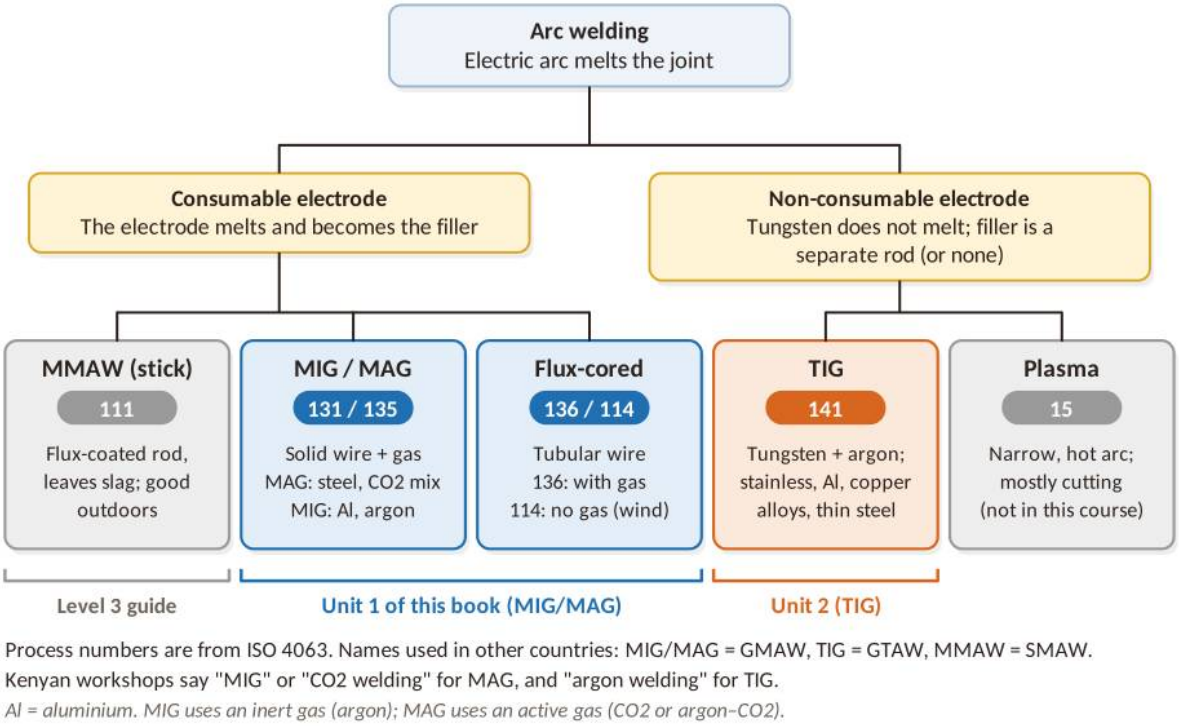


Figure 1.3 The arc-welding process family, with ISO 4063 process numbers. This book covers MIG/MAG (with flux-cored wire) and TIG.

Figure 1.4 compares the two new processes with stick welding. MIG/MAG wins on speed and on thin tube, which is why it has taken over gate and frame work in towns. TIG wins on cleanliness and on stainless, aluminium and copper. Stick welding still wins outdoors in the wind and on cost, so it does not disappear. Chapter 3 compares the processes in more detail.

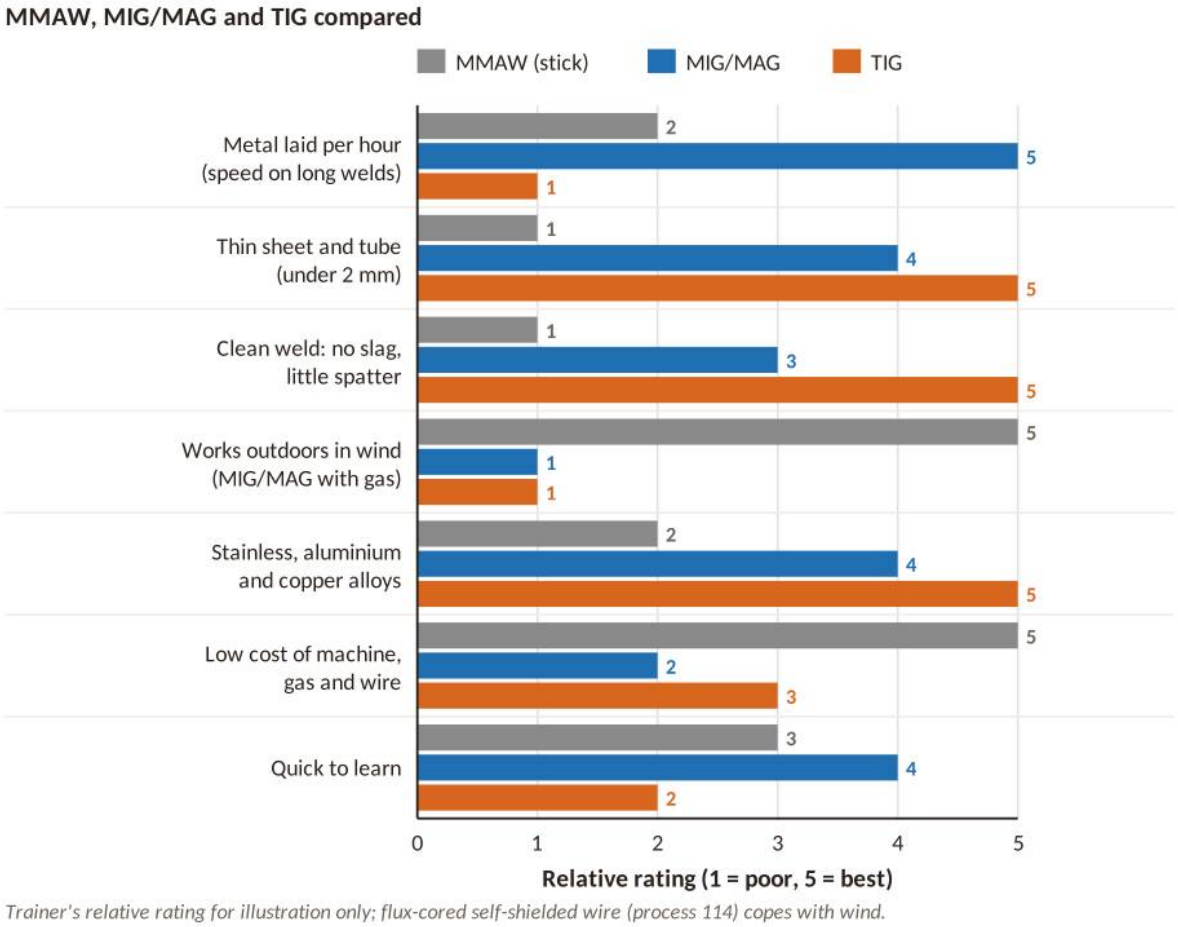


Figure 1.4 Stick, MIG/MAG and TIG compared on seven practical points (relative ratings for illustration). No process is best at everything.

1.4 Where Level 4 Skills Are Used in Kenya

Level 4 work is all around you once you know where to look (Figure 1.5):

- **Jua kali and town fabricators** at Kamukunji, Gikomba, Kariobangi Light Industries, Ziwani, Kisumu's Kibuye area and every county town are moving from stick to MIG for gates, window grills, burglar-proofing, steel furniture, school beds and lockers, carports, roof trusses, tank stands and greenhouse frames. On light 1.2–1.5 mm square tube, MIG with 0.8 mm wire is faster, leaves no slag and needs far less grinding.
- **Body builders and trailer makers** MIG-weld matatu and bus bodies, lorry bodies, tippers and trailers.
- **Dairy and food processing** runs on stainless steel: bulk milk coolers of 3,000–10,000 litres at collection centres, milk cans, pasteurisers, pipework, and kitchen equipment for hotels, schools and hospitals. These need smooth, crevice-free TIG welds that can be cleaned.
- **Aluminium** work includes truck and tipper bodies, ladders, boat repairs on Lake Victoria and at the coast, and sufuria repairs.
- **County works and water projects** (pipes, tanks) and **agricultural machinery** (posho mills, chaff cutters, ploughs) use MIG and TIG for repairs and new work.

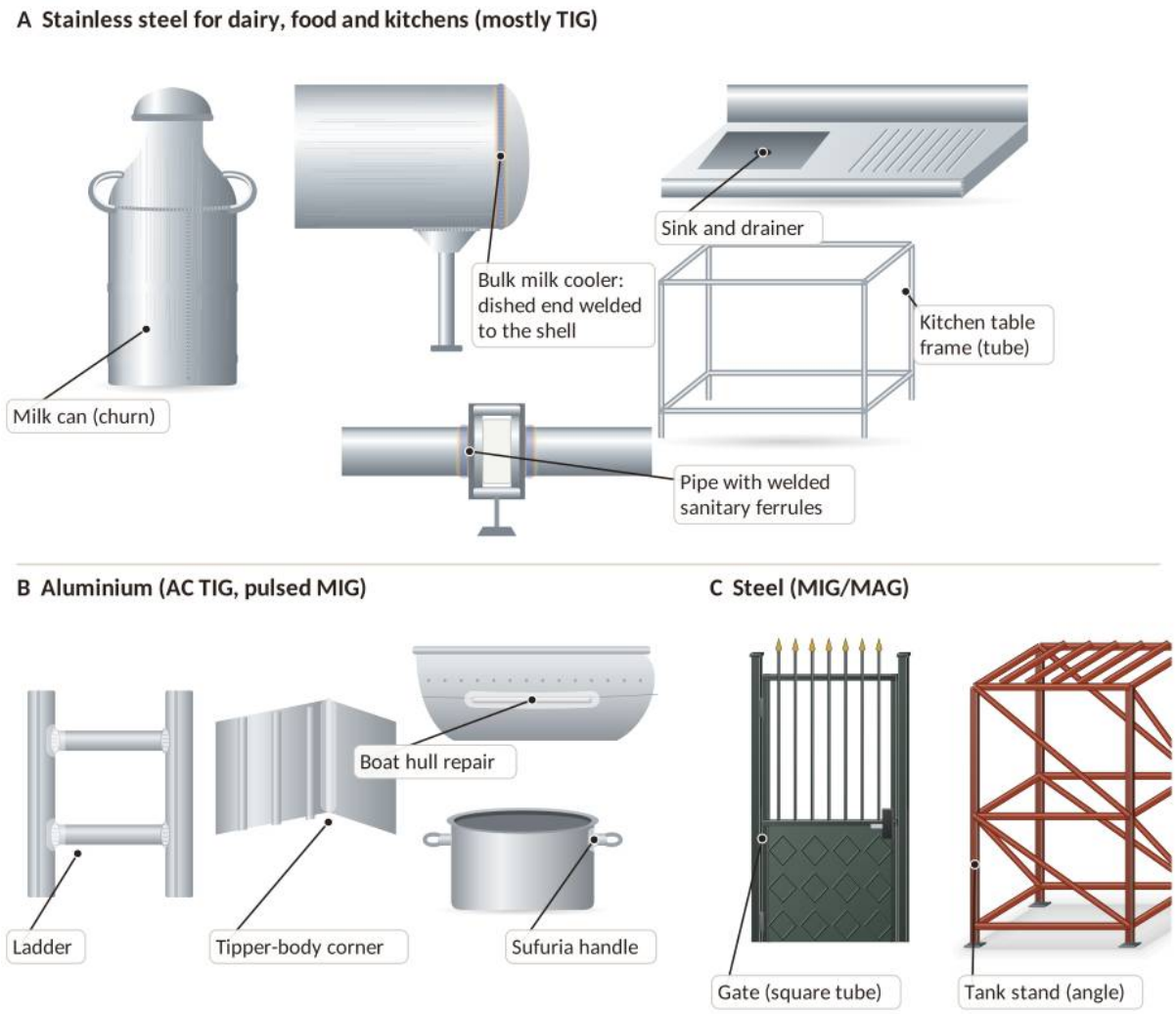


Figure 1.5 Products a Level 4 welder makes or repairs: stainless dairy and kitchen equipment (A), aluminium items (B) and MIG-welded steel (C).

IN THE KENYAN WORKSHOP

Many fundis switch from stick to MIG after one job: a long run of burglar-proof grills on thin tube. With stick they fight burn-through and chip slag from hundreds of short welds; with MIG and 0.8 mm wire the welds are fast and need only a light dressing before paint. The catch is the gas: a cylinder must be rented or bought and refilled in a big town. Rural workshops plan their cylinder exchanges like any other stock. Stainless work for dairies pays better still, and a 2026 Nairobi advert for a stainless TIG welder asked for ten years' experience. Good TIG welders are scarce. Figure 1.6 shows the busy, crowded kind of shop where many of you will work.



Figure 1.6 A busy African fabrication workshop making school furniture. Look at the PPE: the grinder operator has no eye protection or gloves. A Level 4 welder sets a better example (Chapter 2).

Photo: Kehvkevv, CC BY-SA 4.0, via Wikimedia Commons

1.5 How You Will Be Assessed

You met competency-based education and training (CBET) in the Level 3 guide, Chapter 1. Here is a short reminder of the terms you will see on every assessment tool:

- A **unit** is split into **elements**; each element has **performance criteria** (PCs). The **range** lists the machines and materials covered; the **evidence guide** lists the **critical aspects** the assessor must see.
- **Formative** assessment happens during training and covers every PC. **Summative** assessment at the end of the unit focuses on the critical aspects. Your unit score is **60% formative and 40% summative**.
- Theory and practical are weighted **10:90**. Most theory is checked by oral questions and short written tests linked to your practical work.
- You are assessed in a real or simulated workplace, working on your own, with real equipment, materials, instructions and time limits.

For both welding units the critical aspects are the same: develop an operation procedure, work safely, read the working drawing, prepare the material, weld up to 10 mm in the flat, horizontal and vertical positions, and finish the product. Overhead welding and fixed-pipe positions are not required at Level 4; they come at higher levels and in coded pipe-welder tests.

Table 1.2 Competence ratings for each unit

Score	Rating
80–100	Attained Mastery
65–79	Proficient
50–64	Competent
49 and below	Not Yet Competent
Y / X / CRNM	Assessment malpractice / absent / course requirement not met

1.5.1 Where the marks are

Figure 1.7 shows how the PC weighting spreads the marks in each unit. The weighting tool numbers the elements differently from the curriculum: there, "carry out the welding" is element 1, while in the curriculum "draft working drawing" is learning outcome 1. This book always uses the curriculum numbers. Two lessons stand out. First, the drawing element carries about a third of the marks in both units, so do not neglect Chapters 4 and 9. In TIG the single heaviest PC is "work drawing drafted" (72 of 310 marks, 23.2%). Second, in MIG the PC for setting parameters carries only 6 marks on paper, but it decides the quality of the 60-mark weld.

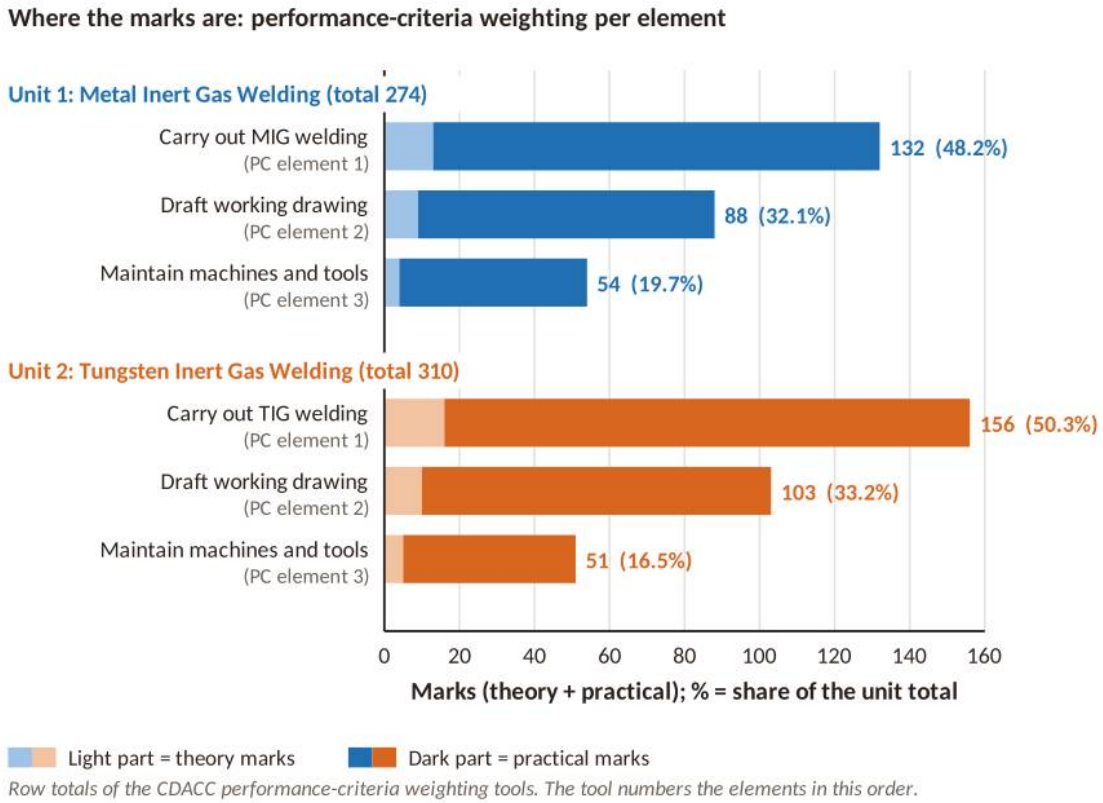


Figure 1.7 Where the marks are in formative assessment, element by element. The drawing element carries about a third of the marks in both units.

WORKED EXAMPLE 1.2: WEIGHTED UNIT SCORE

Wanjiru scores 72% in formative assessment and 64% in the summative assessment of the MIG unit. What is her unit score and rating?

Score = 0.6 × formative + 0.4 × summative

Score = 0.6 × 72 + 0.4 × 64 = 43.2 + 25.6 = **68.8**

68.8 lies in 65–79, so her rating is **Proficient**.

Sense-check: the answer lies between 64 and 72, and nearer 72 because formative carries more weight.

WORKED EXAMPLE 1.3: MARKS TO A PERCENTAGE

In formative assessment Otieno gains 200 of the 274 MIG marks and 245 of the 310 TIG marks. Convert to percentages.

Percentage = marks gained ÷ marks available × 100

MIG: 200 ÷ 274 × 100 = **73.0%** (Proficient)

TIG: 245 ÷ 310 × 100 = **79.0%** (Proficient, just below Attained Mastery at 80)

Sense-check: 200 is a little under three-quarters of 274 (205.5), so a little under 75% is right.

1.5.2 Certificates

TVET CDACC awards a **Certificate of Competency** for each core unit you pass, and the full **Kenya National TVET Certificate in Welding Level 4** when you are competent in all units (the occupational standard calls the qualification Welder Level 4). A **Statement of Attainment** may be given for a certifiable element. Experienced welders can be assessed through RPL for part or all of the qualification.

1.5.3 The industrial attachment

You must spend at least 320 hours in a welding and fabrication workplace: after all units for the full qualification, or spread across the units for part qualification. Your mentor uses a mentoring tool that covers all five units, MIG and TIG included, plus 17 points of worker behaviour, over at least three months with three assessments; only the last one counts. For MIG you must meet at least 5 of 10 items, including all five practical skills items. Chapter 14 explains the tool in full.

1.6 Careers and Professional Conduct

Level 4 opens doors (Figure 1.8). Employed MIG/TIG welders in fabrication and food-equipment firms typically earn about KSh 35,000–70,000 a month (an estimate; one salary survey shows KSh 39,000–86,000), and casual MIG/TIG day rates run at about KSh 1,500–3,000. The legal minimum for an Artisan Grade III in Nairobi is KSh 27,352 a month. Coded pipe welders and good stainless TIG welders earn more.

From Level 4 you can climb to Level 5 and Level 6 qualifications, or specialise. Pipe welders pass **coded welder tests** to standards such as ISO 9606-1; these are beyond this course, but the habits you learn here (clean preparation, recorded settings, inspection) are the same. KEBS launched a Welders Certification Scheme in November 2020, open to the informal sector, with certificates valid for three years. NITA trade tests (Grades III, II and I) also continue; ask NITA or your trainer which processes the current welding test uses.

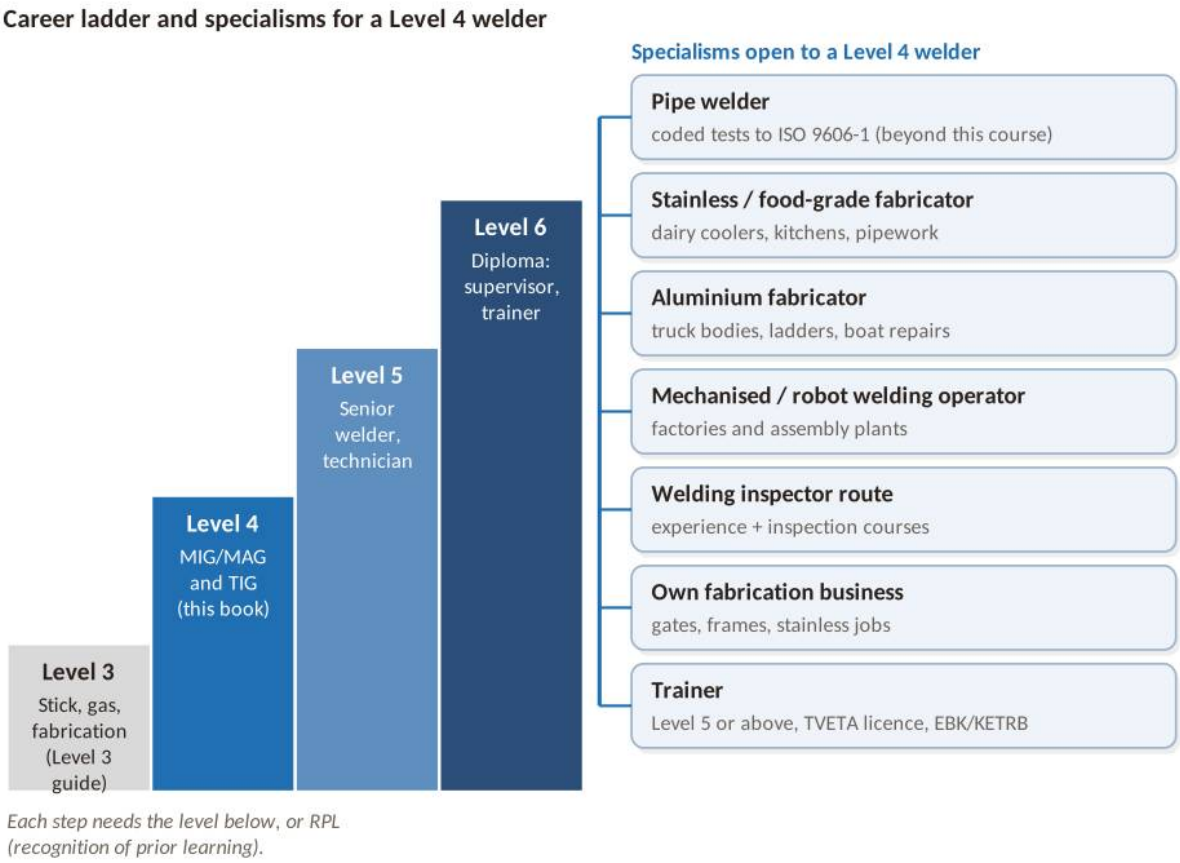


Figure 1.8 The career ladder from Level 3 to Level 6, and specialisms open to a Level 4 welder.

1.6.1 Professional conduct and digital tools

- **Record everything.** Photograph every weld, front and root, with your phone, and write the settings on a weld record. These photos and records build your portfolio of evidence.
- **Use the machine chart** or the synergic programme as a starting point, then fine-tune and record what worked.
- **Quote professionally.** A WhatsApp quotation is still a business document: itemise it, keep it polite and keep a copy.
- **Respect customers' property and time,** keep your bay tidy and never cover up a defect with grinding and paint.

SAFETY FIRST

MIG and TIG arcs give off more ultraviolet light than stick welding because there is no smoke cloud to absorb it, so exposed skin burns in minutes. Argon and CO2 have no smell and sink into pits and tanks, where they can kill without warning. Stainless steel fume contains hexavalent chromium, a cancer hazard. Do not weld in the Level 4 workshop until you have studied Chapter 2 and your trainer has signed you off.

GREEN TIP

Gas is money. A leak of just 1 litre a minute through a loose hose fitting wastes 840 litres overnight in 14 hours, almost a tenth of a cylinder. Close the cylinder valve at the end of every day and leak-test new connections with soapy water.

COMMON MISTAKES

- Thinking MIG is "point and pull the trigger". A MIG weld can look smooth and still have no fusion underneath.
- Buying a cheap "MIG 400 A" machine online. Many are small gasless flux-cored units with inflated ratings; read the rating plate, not the advert.
- Leaving the drawing work to the end. Drafting carries about a third of the marks in both units.
- Not recording settings. Without a record you cannot repeat a good weld or prove it to an assessor.

1.7 How to Use This Book

Chapters 2 and 3 cover safety and the science shared by both processes. Chapters 4 to 8 follow the MIG unit; Chapters 9 to 13 follow the TIG unit, referring back to the MIG chapters where the topic is shared. Chapter 14 covers the attachment and assessment. Each chapter has key words, worked examples, practical tasks with a "Record your results" table for your portfolio, a summary, a competence checklist and practice questions with answers at the back. Settings printed in this book are **typical examples**, marked "Example — use the manual/WPS": always check the machine maker's data, the wire and gas labels, and your WPS.

TRAINER'S TIP

Keep a small notebook in your overall pocket. Every time a weld goes well, write down the wire size, gas, flow, voltage, wire feed speed and travel speed. In three months you will have your own setting chart, and your assessor will see a welder who works by method, not by luck.

Practical task 1.1: Know your Level 4 workshop

Tools and equipment

- Notebook or the record sheet below
- Phone camera
- Torch (flashlight) for reading plates

Materials

- Workshop layout sketch (A4)
- Machine manuals, if available

Steps

1. With your trainer, walk round the workshop with all machines switched off and isolated.
2. Find each MIG and TIG machine. From the rating plate record the input supply (single- or three-phase), the output current range and the duty cycle at the rated current.
3. For each MIG machine note whether the wire feeder is built in or separate, the wire size fitted and the torch type.
4. Find the gas store. Record each cylinder's gas from the label (not the colour), whether it is chained upright and whether its cap or guard is in place.
5. Locate the fume extraction arms, curtains and screens, fire extinguishers, first-aid box, eye-wash point, tungsten grinder and the main isolator.
6. Mark everything on your layout sketch and note anything damaged or unsafe. Report it to your trainer.

Safety

- Do not switch on, adjust or open any machine during this task.
- Do not open cylinder valves or move cylinders.
- Stay out of booths where someone is welding unless you wear the full PPE.

Record your results

Item	Location	Plate or label details (phase, A, duty cycle, gas)	Condition / safety notes
MIG machine 1			
TIG machine 1			
Gas cylinders			
Extraction			
Extinguishers / first aid			
Tungsten grinder			

Chapter summary

- A Level 4 welder uses MIG/MAG and TIG on steel, stainless and aluminium (TIG also copper alloys), up to 10 mm, flat, horizontal and vertical.
- This book covers Module II only: MIG 200 h, TIG 200 h and a 320 h attachment, 720 h and 72 credits; the Level 3 units are in the Level 3 guide.
- MIG/MAG feeds a wire electrode (processes 131, 135); TIG uses a tungsten electrode and argon (141).
- Units are scored 60% formative and 40% summative; theory to practical is 10:90; 50 is Competent.
- Drafting carries about a third of the marks in both units; parameters decide the weld.
- Kenya needs Level 4 welders in fabrication, body building, dairy and food processing, and aluminium work.
- Record your settings and photograph your welds from day one.

Check your competence

- [ ] I can name the three Module II units with their codes and hours.
- [ ] I can explain why the course total is 1,070 hours.
- [ ] I can explain the difference between MIG and MAG and give the process numbers.
- [ ] I can calculate a weighted unit score and give the rating.
- [ ] I can say which elements carry most marks in each unit.
- [ ] I can name three Kenyan industries that need MIG or TIG welders.
- [ ] I can read a machine rating plate and a cylinder label.

Practice questions

1. Name the three units of Module II, with their codes and hours.
2. The Level 4 units add up to 720 hours, but the course total is 1,070 hours. Explain the difference.
3. Your evening class runs 35 hours a week. How many weeks will the 720 hours of Level 4 work take?

4. Explain in your own words the difference between MIG and MAG welding. Give the ISO 4063 numbers for MIG, MAG and TIG.
5. Kiprop scores 60% in formative assessment of the TIG unit. What summative score does he need to reach Proficient (65)?
6. In formative assessment a trainee gains 230 of the 310 TIG marks. Give the percentage and the rating.
7. Oral: what is the difference between a Certificate of Competency and a Statement of Attainment?
8. Which PC carries the most marks in each unit, and what does this tell you about how to study?
9. Fault-finding: a fundi buys a "MIG 400 A" machine online for KSh 12,000. He fits solid wire and a CO2 cylinder, but the arc spits, the wire melts back and the welds are full of holes. Give two likely causes and what he should check.
10. Practical: read the rating plate of your workshop MIG machine. If it is rated 200 A at 60% duty cycle, how many minutes can you weld at 200 A in every 10 minutes? Record the real plate values on your Task 1.1 sheet.

PART 2

Metal Inert Gas Welding

Unit 1: Metal Inert Gas Welding (ENG/CU/WEF/CR/01/4/MA, 200 hours). Drafting working drawings, cutting lists and operation plans; MIG/MAG equipment, wire and setting up; parameters and modes of metal transfer; welding plates and pipes up to 10 mm in the flat, horizontal and vertical positions; weld quality and inspection, finishing, and maintaining MIG equipment.

Chapter 4: Working Drawings for Welded Fabrication
Chapter 5: MIG/MAG Equipment, Wire and Setting Up
Chapter 6: MIG Parameters and Modes of Metal Transfer
Chapter 7: MIG Welding Plates and Pipes in Flat, Horizontal and Vertical Positions
Chapter 8: MIG Weld Quality, Finishing and Equipment Maintenance

CHAPTER 5

MIG/MAG Equipment, Wire and Setting Up

WHAT YOU WILL LEARN

- Read a job drawing for the information that decides your wire, gas and set-up.
- Name the parts of a MIG/MAG system and explain how current, wire and gas reach the arc.
- Choose drive rolls, liner, contact tip, wire and gas for steel, stainless and aluminium.
- Read a wire label and work out wire length, arc time and cost per spool and per metre of weld.
- Set up a MIG machine from cold, safely, using a checklist, and fix common set-up faults.
- Use and care for MIG tools, jigs and fixtures.

Unit: Metal Inert Gas Welding · ENG/CU/WEF/CR/01/4/MA · Learning outcome 2 · About 22 hours

A MIG machine only welds as well as it is set up. Wrong rolls, a worn tip or a gas leak will ruin a weld before you touch the trigger. This chapter takes the system apart, shows how each part works, and then puts it back together in the right order. The settings themselves (voltage, wire speed and transfer modes) follow in Chapter 6.

Key words

Constant-voltage (CV) power source
A welding machine that holds the arc voltage steady; the current follows the wire feed speed.

Wire feeder
The motor, rolls and guides that push the wire from the spool to the torch.

Drive rolls
Grooved wheels that grip and push the wire.

Liner
The tube inside the torch cable that guides the wire.

Contact tip (tip)
The copper tube that passes the welding current into the wire.

Gas diffuser
The part that holds the tip and spreads the gas evenly into the nozzle.

Euro connector
The standard plug that joins the torch to the feeder and carries power, gas, wire and trigger signal.

CTWD
Contact-tip-to-work distance: from the end of the tip to the job.

Stick-out
The length of wire beyond the tip.

DCEP
Direct current electrode positive: torch on the + terminal.

Bird-nesting
Wire tangling in the drive area because it cannot move forward.

Jig
A fixture that holds parts in the right position for tacking and welding.

5.1 Read the Job Drawing First

Before you touch the machine, read the drawing (Chapter 4). It tells you the metal, its thickness, the joints and the weld sizes, and these decide your wire, gas and settings. The welding symbol may carry the process number in its tail: **135** means MAG with solid wire, **131** MIG and **136** flux-cored wire with gas. The parts list (bill of materials) gives each part's material and size; use it to choose the wire and to order material. Table 5.1 lists abbreviations you will meet on fabrication drawings.

Table 5.1 Common drawing abbreviations

Abbreviation	Meaning	Abbreviation	Meaning
MS	Mild steel	THK	Thick (e.g. 6 THK = 6 mm thick)
SS	Stainless steel	TYP	Typical: applies to all similar features
AL	Aluminium	EQ SP	Equally spaced
PCD	Pitch circle diameter (circle through hole centres)	NTS	Not to scale: never measure the drawing
CRS	Centres (e.g. bars at 120 CRS)	135 (in symbol tail)	MAG welding, solid wire

For example, a gate drawing that says "Frame 40 × 40 × 1.5 SHS MS, infill 20 × 20 × 1.2 at 120 CRS, fillet welds 135 TYP" tells you: mild steel, thin tube, MAG process, so 0.8 mm ER70S-6 wire with an argon–CO2 mix.

5.2 The MIG/MAG System

Strictly, **MIG** (metal inert gas) uses an inert gas such as argon, which does not react with the pool; it is used for aluminium and other non-ferrous metals. **MAG** (metal active gas) uses CO2 or an argon–CO2 or argon–oxygen mix, which takes part in the arc; it is used for carbon steel and, with low-CO2 mixes, stainless steel. The equipment is the same; only the gas and wire change. Kenyan shops call both "MIG" or "CO2 welding".

Follow the three paths in Figure 5.1:

- **Current (red):** from the power source + terminal to the feeder, through the Euro connector and torch cable to the contact tip, into the wire, across the arc, into the job, and back through the work clamp and lead to the − terminal. With solid wire the torch is positive (DCEP).
- **Wire (copper):** from the spool, through the inlet guide, drive rolls and outlet guide, along the liner to the tip.
- **Gas (violet):** from the cylinder through the flowmeter regulator and hose to the gas valve (solenoid) in the feeder, which opens when you press the trigger, then along the torch cable to the nozzle.

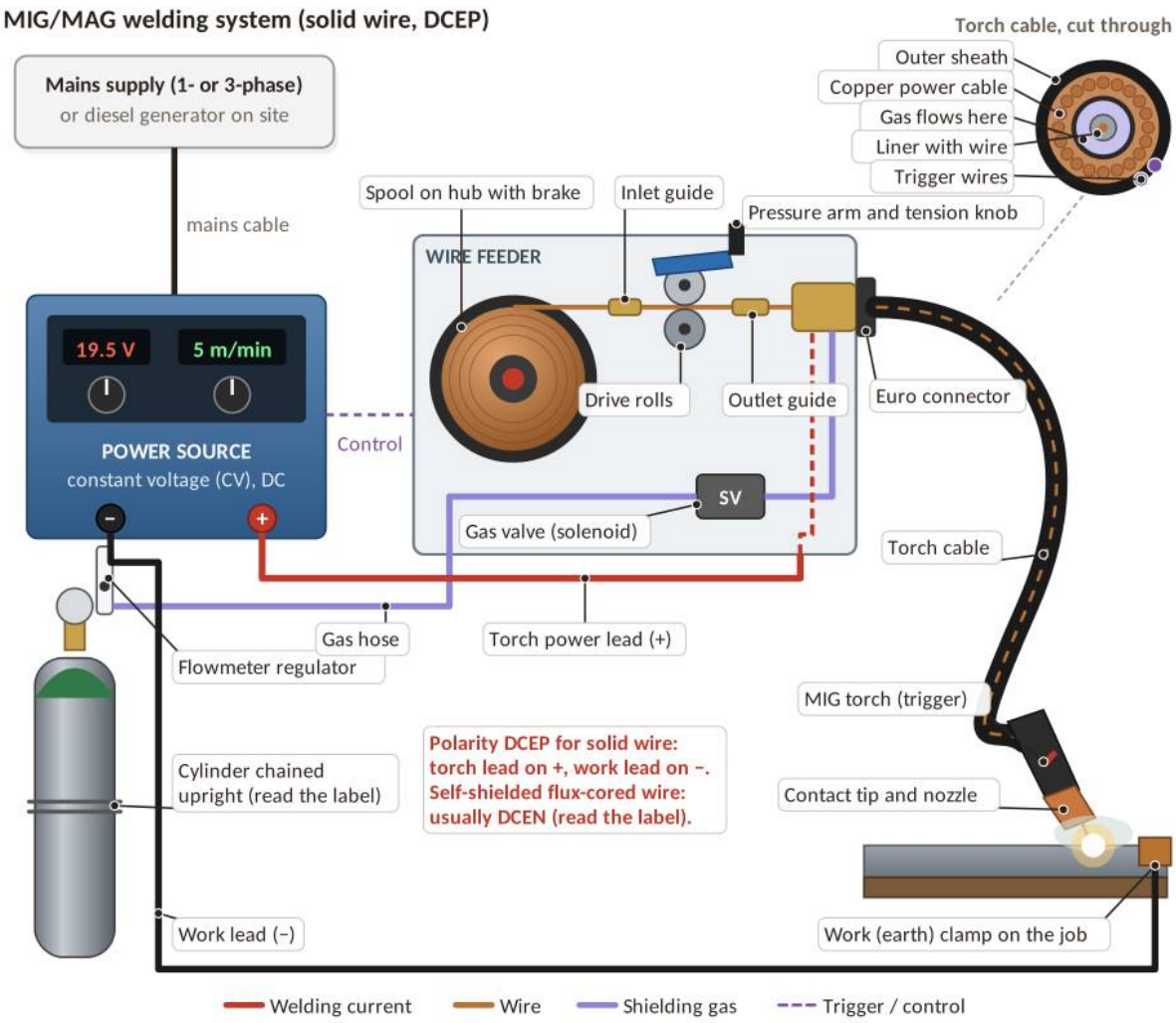


Figure 5.1 A MIG/MAG welding system for solid wire. The torch is on + (DCEP); follow the current (red), wire (copper) and gas (violet) paths. Inset: the parts of the torch cable.

5.3 The Power Source

A MIG power source is a **constant-voltage (CV)** DC machine. You set the voltage; the current follows the wire feed speed. If your hand moves and the arc lengthens, the current drops and the wire burns off more slowly, so the arc returns to its set length by itself. Chapter 3 explains this self-regulation.

Two layouts are common (Figure 5.2). A **compact machine** has the feeder built in and a 5 kg (200 mm) or 15 kg (300 mm) spool inside; most 200 A single-phase inverters are like this. A **separate-feeder machine** (for example a 350 A three-phase unit) has the feeder on top or on a long interconnecting cable so the welder can move around big jobs such as lorry bodies. Bigger machines need three-phase power; single-phase inverters run from a normal workshop supply on a correctly rated circuit.

Typical controls are:

- **Voltage** (arc length and bead width) and **wire feed speed** (current), set together from the machine chart.
- **Inductance**: controls how fast the current rises in short-circuit transfer, giving a softer or crisper arc. Some machines and documents call this "arc force"; Chapter 6 explains it.

- **2T/4T trigger mode**: in 2T you hold the trigger to weld; in 4T you press and release to start and again to stop, which saves your hand on long seams.
- **Spot and stitch timers** for repeated short welds on thin sheet and tube.
- **Burn-back** (lets the wire burn back a little after stopping so it does not stick in the pool) and **run-in (creep) speed** (slow wire until the arc strikes).
- **Synergic programmes**: you choose wire type, size and gas and the thickness; the machine proposes the voltage and wire speed, and you fine-tune.

Polarity. Solid wire with gas runs DCEP: torch lead on +, work lead on −. Most self-shielded flux-cored wires run DCEN (torch on −); the wire label tells you. On many compact machines the change is made with the polarity link inside the wire bay. A machine left on DCEN after flux-cored work will spatter badly and burn back with solid wire.

> **IN THE KENYAN WORKSHOP**
>
> Online adverts offer "MIG 400 A" machines for KSh 10,000–15,000. Most are small gasless flux-cored units with inflated ratings, set to DCEN. A proper 200 A gas-shielded MIG inverter costs about KSh 75,000 (approximate, 2026). Read the rating plate: the real output current, the duty cycle at that current and the supply needed. For gas, most fundis rent or buy a cylinder (deposit about KSh 30,000) and refill in Nairobi, Mombasa, Nakuru, Eldoret or Kisumu: argon–CO2 mix about KSh 9,000 and CO2 about KSh 6,000 a refill. Many jua kali shops weld gates with pure CO2 because it is cheaper; expect more spatter and more cleaning.

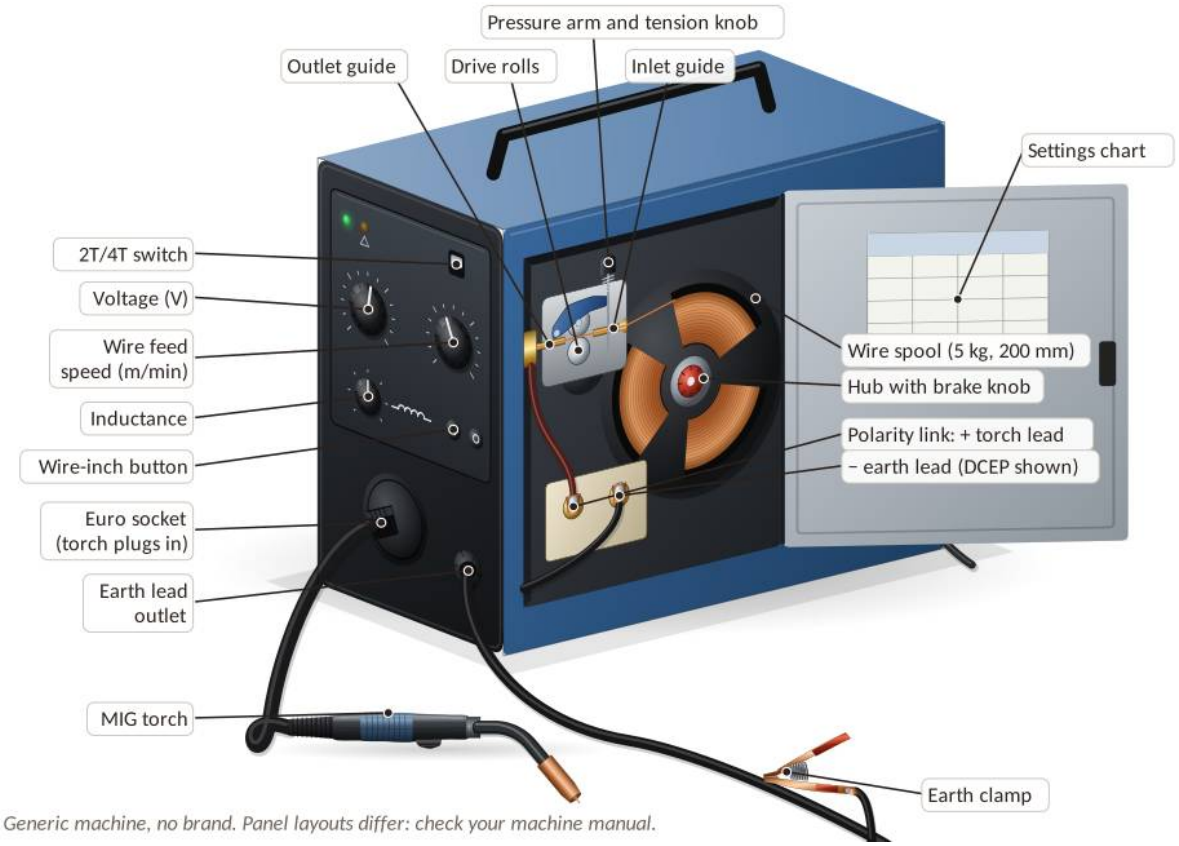


Figure 5.2 A compact single-phase MIG inverter with the wire bay open. The polarity link is shown set for solid wire (DCEP).

5.4 The Wire Feeder and Drive Rolls

The spool sits on a **hub** with an adjustable **brake**. Set the brake just tight enough that the spool stops when the motor stops; too loose and wire spills off the spool, too tight and the motor strains. The wire passes through an **inlet guide**, between the **drive rolls**, through an **outlet guide** and into the Euro block. Small machines have **2-roll** drives (one driven roll, one pressure roll); industrial feeders have **4-roll** drives, which grip better and push soft or flux-cored wire through long cables.

Choose the roll groove for the wire (Figure 5.3A):

- **V groove** for hard solid wire: steel and stainless.
- **U (round) groove** for soft aluminium wire, which a V groove would squash.
- **Knurled V groove** for tubular flux-cored wire, which needs grip without crushing.

The groove size must match the wire. Rolls usually have two grooves (for example 0.8 and 1.0); the size is stamped on the face. Then set the pressure (Figure 5.3B): just enough to feed without slipping in normal welding. Too tight flattens the wire and sheds shavings into the liner; too loose gives erratic feed and a surging arc.

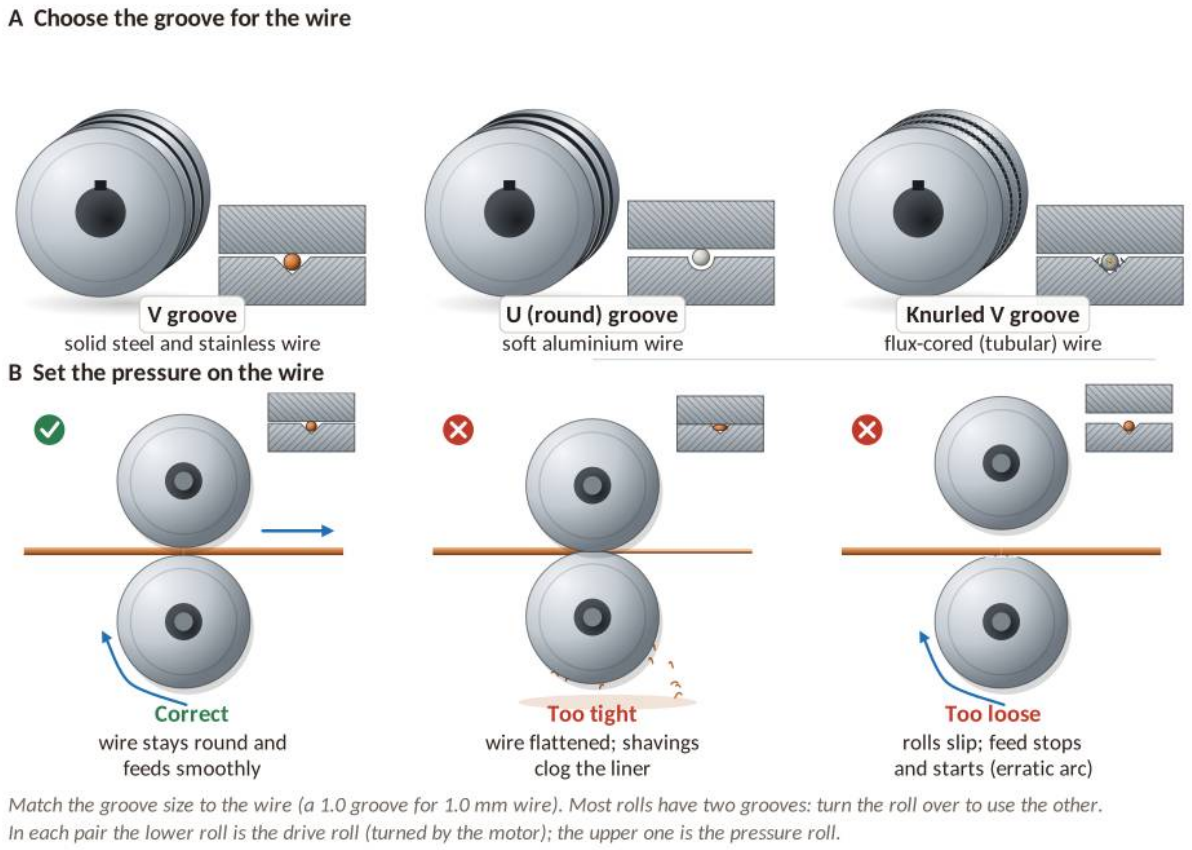


Figure 5.3 Drive rolls. A: choose the groove for the wire. B: set the pressure: the wire should stay round and feed without slipping.

Table 5.2 Matching rolls, liner and tip to the wire (typical)

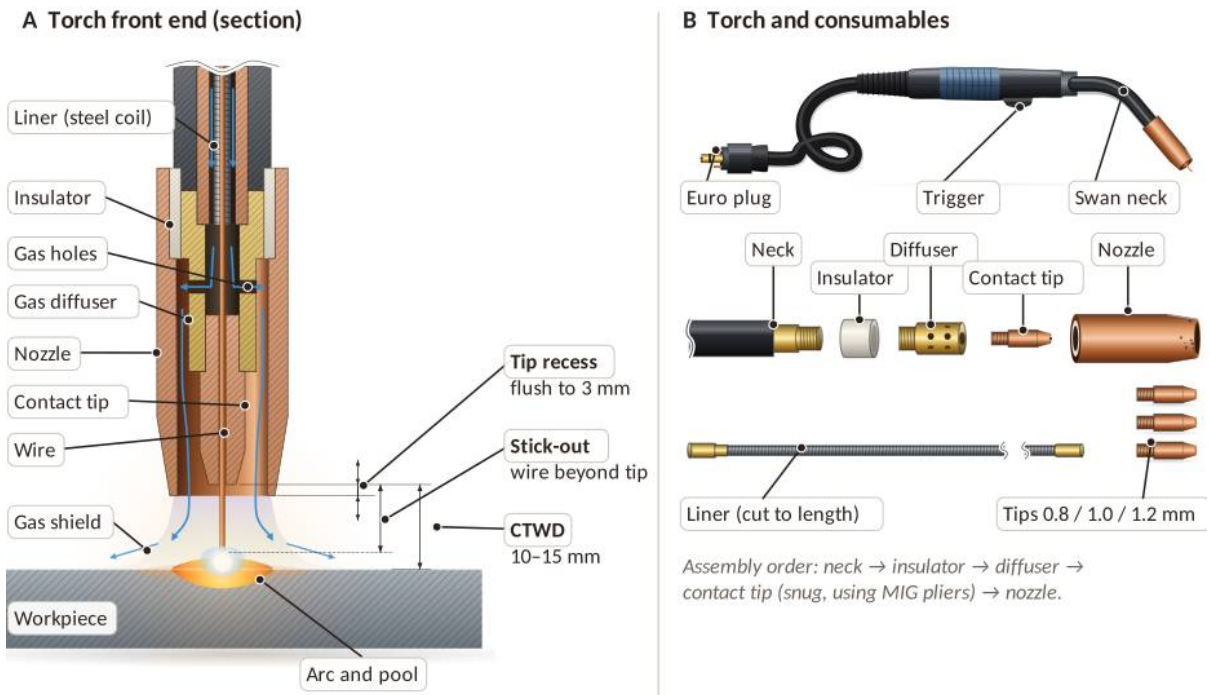
Wire	Drive roll	Liner	Contact tip
Steel ER70S-6, 0.8 mm	V groove 0.8	Steel coil for 0.6–0.9 mm	0.8 mm
Steel ER70S-6, 1.0 mm	V groove 1.0	Steel coil for 1.0–1.2 mm	1.0 mm
Stainless ER308LSi, 1.0 mm	V groove 1.0	PTFE or carbon-PTFE (keeps wire clean)	1.0 mm
Aluminium ER4043/5356, 1.0 mm	U groove 1.0	PTFE (plastic), as short as possible	1.0 mm aluminium tip (slightly larger bore)
Flux-cored, 1.2 mm	Knurled V 1.2	Steel coil for 1.0–1.2 mm	1.2 mm

5.5 The MIG Torch

The torch (gun) carries current, wire, gas and the trigger signal to the arc (Figure 5.4). Light and medium torches are **air-cooled**; for high current and long runs, **water-cooled** torches circulate coolant from a cooler. Every torch has a rating in amps at a stated duty cycle, usually lower with argon-rich gases; do not overload it.

- **Euro plug:** the central pin carries power, gas and wire; two small pins carry the trigger signal.
- **Liner:** a steel coil for steel wire; PTFE or carbon-PTFE for aluminium and stainless. Cut it to the length the torch maker gives, with the cable laid straight. Too short leaves a gap where the wire kinks; too long buckles the wire.
- **Gas diffuser:** holds the tip and spreads the gas.
- **Contact tip:** copper, stamped with the wire size, screwed into the diffuser (light torches often use an M6 thread; check yours). Its bore wears oval with use, so the current transfer becomes erratic: replace it.
- **Nozzle:** conical for access or cylindrical for better gas cover. The tip is flush or up to 3 mm recessed for short-circuit work, and 3–6 mm recessed for spray (typical).

Aluminium wire is soft and buckles in a long liner. Use a **spool gun** (a small spool on the gun itself) or a **push-pull** torch, or at least U rolls, a plastic liner and the shortest torch you have.



C Typical tip position and CTWD (steel, argon–CO2)

	Tip position	CTWD	*Example — use the manual/WPS*
Short circuit (thin sheet, all positions)	flush to 3 mm recessed	10–15 mm	
Spray (thick plate, flat and horizontal)	3–6 mm recessed	15–20 mm	
Self-shielded flux-cored wire	follow the wire data	20–40 mm	

Figure 5.4 The MIG torch. A: front end in section, showing the tip recess, stick-out and CTWD. B: the torch and its consumables in assembly order. C: typical tip positions and CTWD (example values).

5.6 Welding Wire

The wire is both electrode and filler. The common types are:

- **Solid steel wire**, copper-coated against rust, usually ER70S-6 (ISO G3Si1 type), in 0.6, 0.8, 0.9, 1.0 and 1.2 mm. Use 0.8 mm for thin tube and sheet (gates, grills, furniture) and 1.0–1.2 mm for plate. The 0.9 mm size is American; both systems are sold in Kenya.
- **Stainless wire**: ER308LSi for 304 and ER316LSi for 316, used with argon plus about 2% CO2 or oxygen, never 100% CO2.
- **Aluminium wire**: ER4043 (aluminium-silicon, flows easily, easier to use) or ER5356 (aluminium-magnesium, stronger, stiffer to feed), with 100% argon.
- **Flux-cored wire**: a tube filled with flux. Gas-shielded types (process 136) give deep, fast welds; self-shielded types (process 114) need no gas and cope with wind on site, but leave slag and more fume.

Reading the label. Figure 5.5B decodes a typical solid steel wire label. Every part of the name tells you something: the strength, the chemistry, and the gas it was tested with. Match the gas on the label to the gas you have.

Storage. Keep spools in their bag and box in a dry store, off the floor, and cover a spool left in a machine overnight. Rusty or damp wire gives porosity and poor feeding. Wear gloves to handle stainless and aluminium wire; sweat and oil spoil the weld.

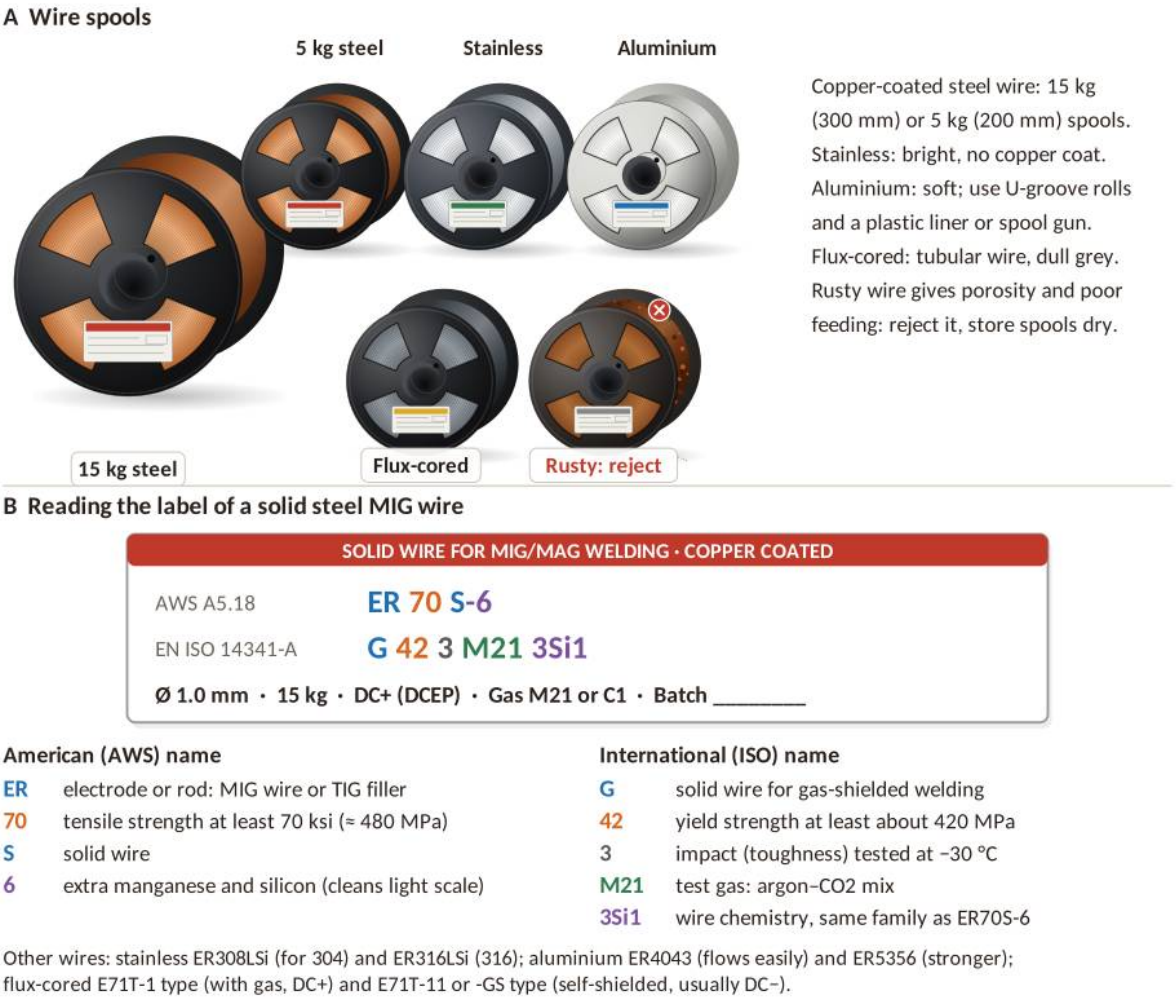


Figure 5.5 MIG wire. A: spools of different wires; reject rusty wire. B: what the name on a solid steel wire label means (generic label; read your own spool label and data sheet).

How long does a spool last? Thinner wire gives more metres per kilogram (Figure 5.6B), and aluminium, being light, gives almost three times as many metres as steel of the same size.

WORKED EXAMPLE 5.1: WIRE LENGTH AND ARC TIME PER SPOOL

How much wire is on a 15 kg spool of 1.0 mm steel wire, and how long will it last at a wire feed speed of 8 m/min?

Mass per metre = wire area × density = $(\pi \times d^2 \div 4) \times 7.85$ g/cm³

= $(3.1416 \times 1.0^2 \div 4)$ mm² × 7.85 g/cm³ = 0.785 mm² × 7.85 = **6.17 g/m**

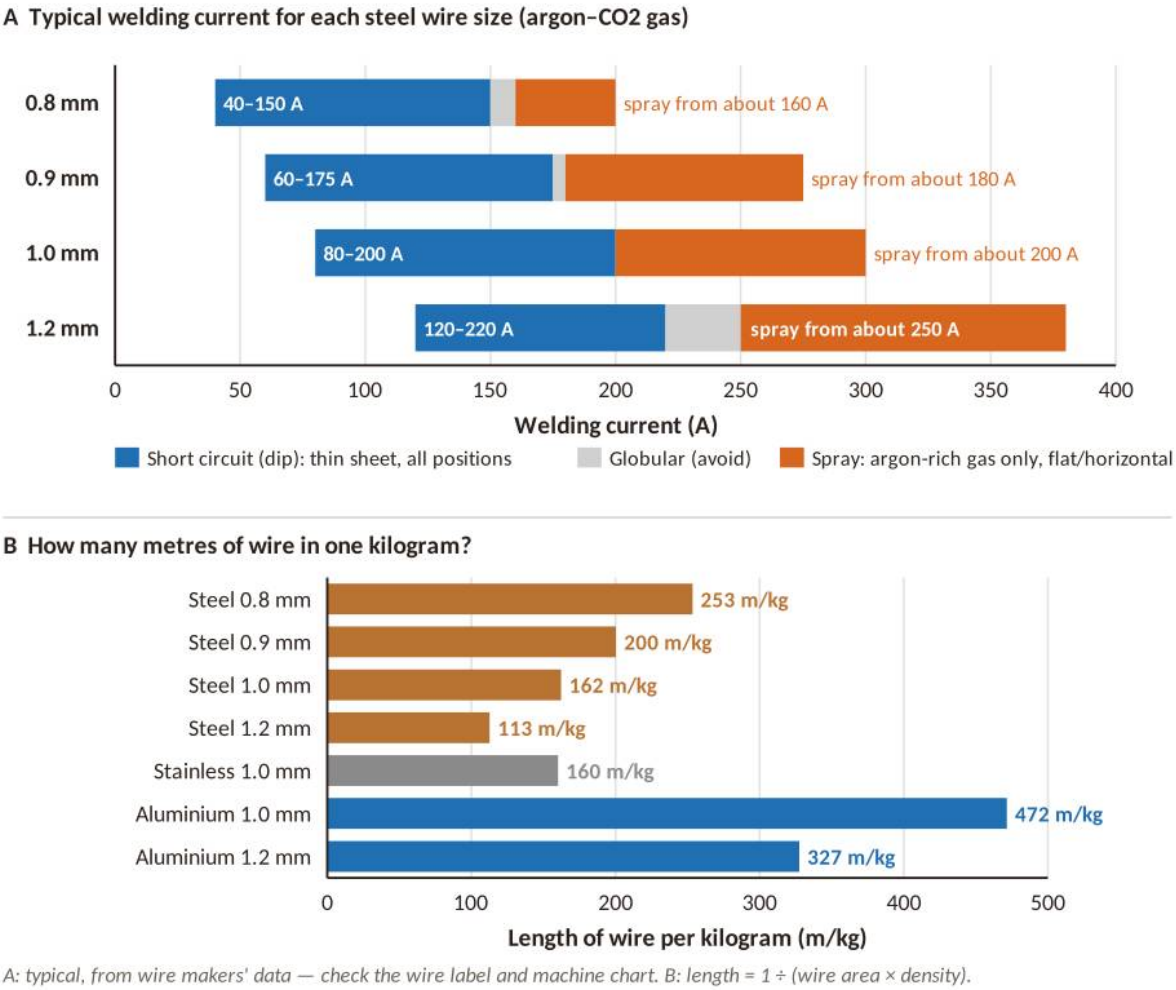
Length per kg = 1,000 g ÷ 6.17 g/m = **162 m/kg**

Length on the spool = 15 kg × 162.2 m/kg = **2,433 m** (about 2.4 km)

Arc time = 2,433 m ÷ 8 m/min = **304 min**, about 5 hours of arc-on time

For a 5 kg spool of 0.8 mm wire at 6 m/min: 3.95 g/m, 253 m/kg, so 1,267 m and 211 min (about 3.5 h).

Sense-check: the arc is on for only about a third of a working day, so a 15 kg spool of 1.0 mm wire lasts roughly two working days of steady welding.



A: typical, from wire makers' data — check the wire label and machine chart. B: length = 1 ÷ (wire area × density).

Figure 5.6 Choosing a wire size. A: typical current range for each steel wire diameter with argon–CO2 (example — use the machine chart). B: metres of wire per kilogram.

5.7 Shielding Gas, Cylinders and Regulators

Choose the gas by the metal (Figure 5.7):

- **Mild steel:** argon with about 15–25% CO2 (group M21, sold as "80/20" or "82/18") for good all-round welds; or 100% CO2 (C1), cheaper and deeper but with more spatter and no true spray transfer.
- **Stainless steel:** argon with about 2% CO2 or oxygen (M12/M13).
- **Aluminium:** 100% argon (I1).

A typical shoulder-height cylinder holds about 10,000 litres of gas at 200 bar (the label gives the true content). CO2 is stored as a liquid, so the cylinder must stand upright, and at high flow the regulator can freeze; a **heated CO2 regulator** prevents this. Cylinder colours vary between suppliers, and older colours may still be in use: **read the label and the valve outlet, not just the colour**.

Set the flow with a **flowmeter regulator**, in litres per minute, not by the "feel" of the pressure. Read a ball float at its centre unless the maker marks otherwise. Indoors, 12–18 L/min suits most steel work; spray and aluminium may need up to about 20 L/min. More gas is not better: too much flow becomes turbulent and pulls air into the shield. Draughts stronger than walking pace blow the gas away, so use screens or switch to self-shielded wire outside.

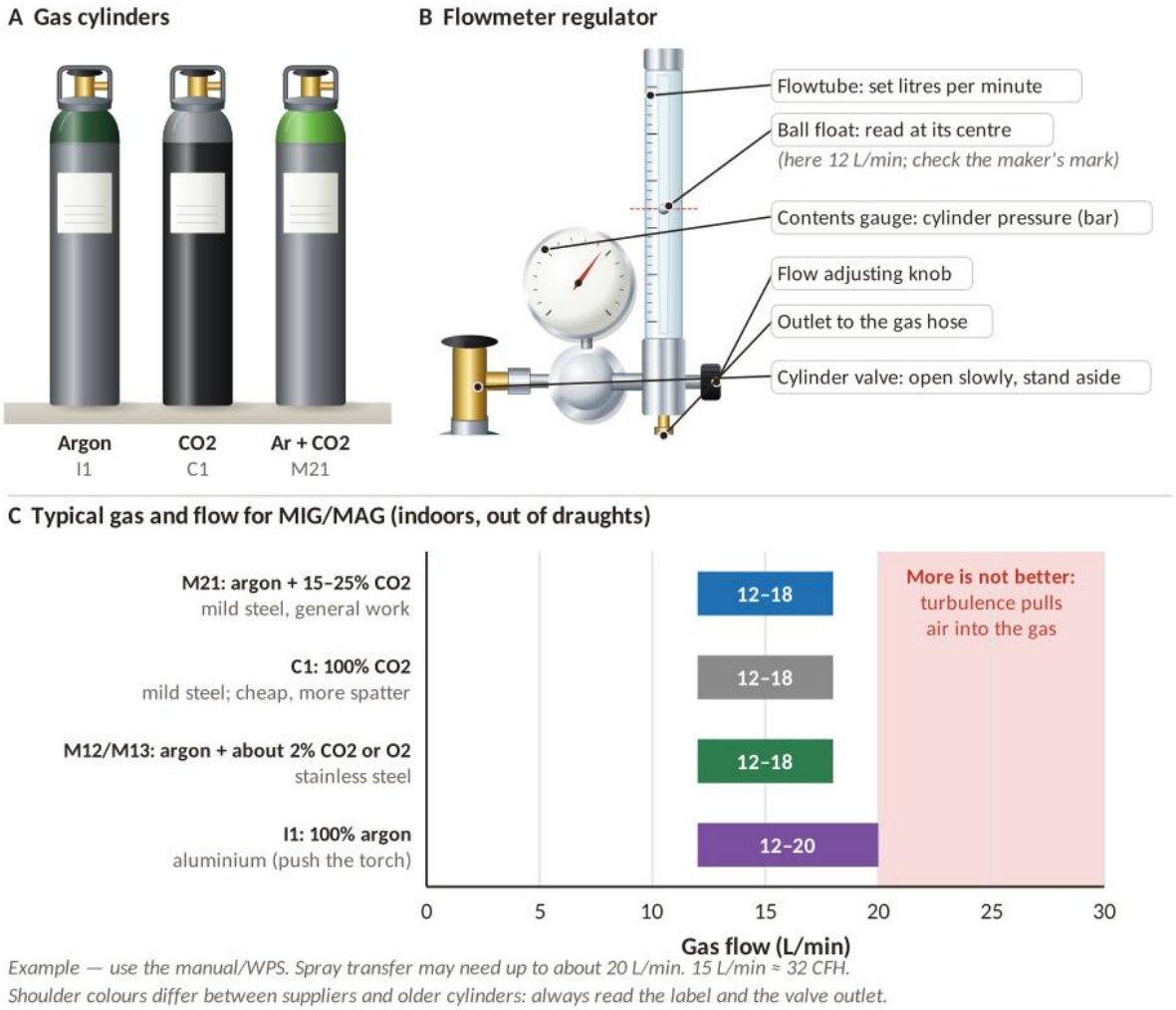


Figure 5.7 Shielding gas. A: cylinders (colours vary: read the label). B: flowmeter regulator. C: typical gas and flow for each metal (example — use the manual/WPS).

WORKED EXAMPLE 5.2: HOW LONG DOES A CYLINDER LAST?

A cylinder of argon–CO2 mix holds about 10,000 L. How many hours of arc-on time does it give at 15 L/min, and what does the gas cost per hour if the refill costs KSh 9,000?

Time = content ÷ flow = 10,000 L ÷ 15 L/min = **667 min ≈ 11.1 h** of arc-on time

Cost per litre = KSh 9,000 ÷ 10,000 L = KSh 0.90/L

Cost per hour of arc = 15 L/min × 60 min × KSh 0.90 = **KSh 810**

At 18 L/min the same cylinder lasts only 9.3 h. Sense-check: more flow, shorter life; set the flow you need, no more.

5.8 MIG Tools, Jigs and Fixtures

Keep a small kit at every MIG bay (Figure 5.8A): MIG pliers, side cutters, a nozzle reamer, a fillet gauge, soapstone, and two wire brushes, a steel one with a red tag and a stainless one with a blue tag, never swapped. Use anti-spatter spray or nozzle-dip gel sparingly: a light film on the nozzle and nearby surfaces, never soaking the tip, because excess spray contaminates the weld.

Jigs and fixtures hold parts square and in position while you tack and weld (Figure 5.8B). Magnetic squares and clamps are quick for one-off frames. For repeated jobs, such as twenty identical gates or school bed frames, fix stop blocks to the welding table around a soapstone outline. Every frame then comes out the same size and square, and the tack sequence controls distortion (Chapter 7).

A **fire extinguisher** belongs at every booth: CO2 or dry powder, suitable for electrical fires. Check its gauge and seal each week and keep the way to it clear.

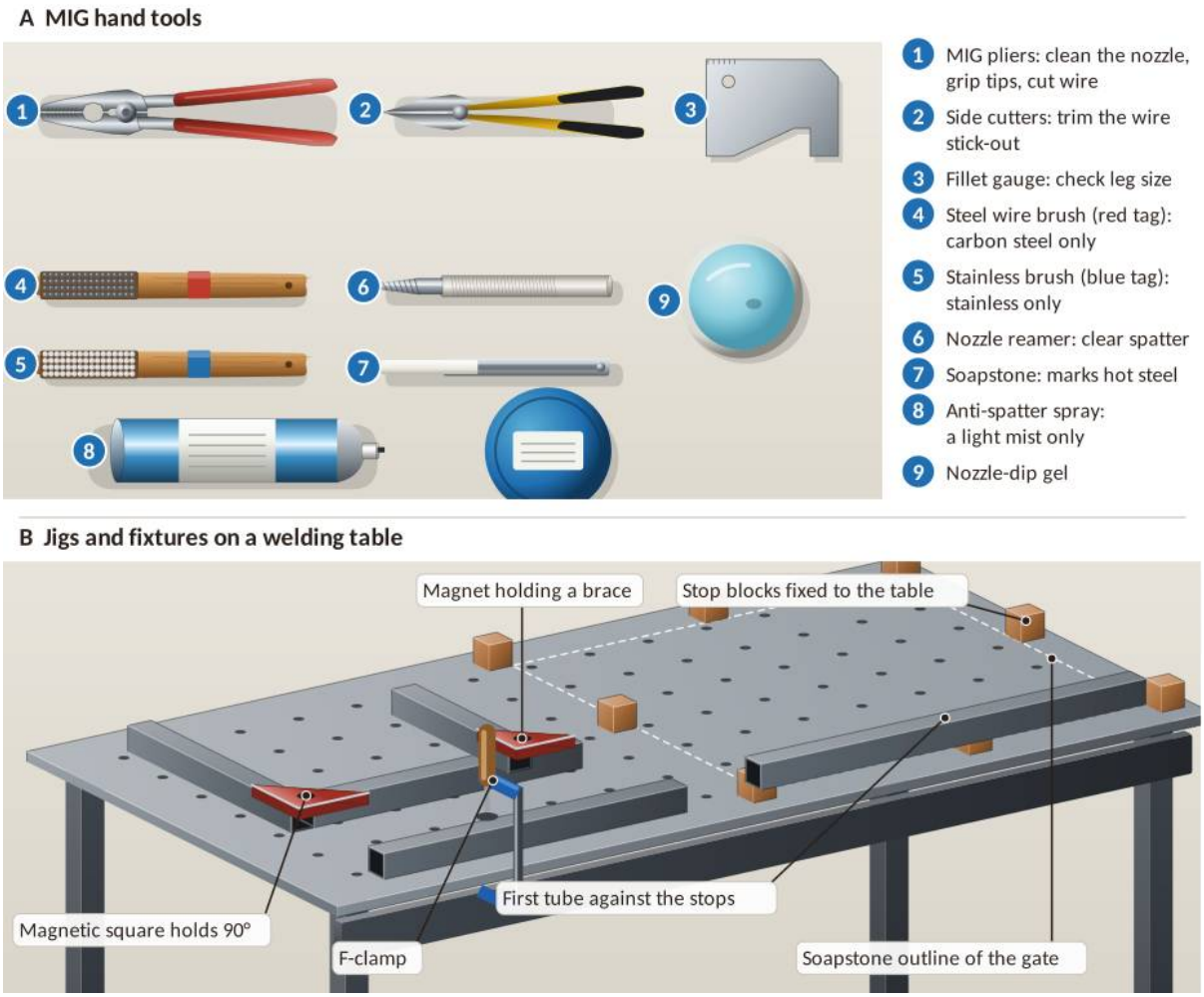


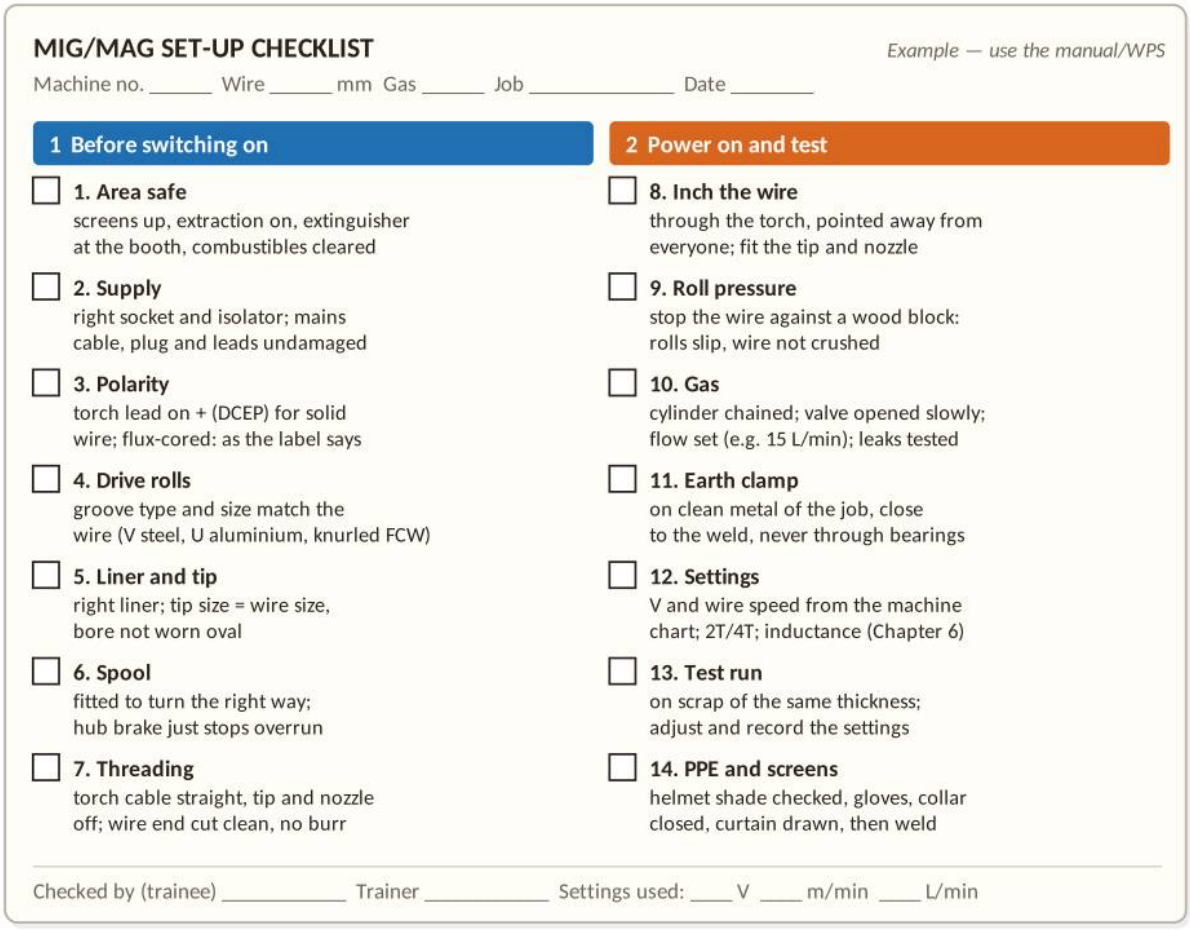
Figure 5.8 MIG tools (A) and a welding table with magnetic squares, a clamp and a simple gate jig (B).

5.9 Setting Up Step by Step

Work through the checklist in Figure 5.9 every time you set up a machine from cold or change the wire. The key points are:

1. **Isolate and inspect.** Machine off, cables, plug, torch and work lead undamaged. Check the polarity link.
2. **Fit the rolls** with the right groove facing the wire path. Check the liner and the tip size.
3. **Load the spool** so the wire leaves from the top towards the inlet guide without twisting. Set the hub brake.
4. **Thread the wire.** Hold the wire end so it cannot spring off the spool, cut off any bent end, and feed it through the inlet guide, over the drive roll and into the outlet guide. Close the pressure arm.
5. **Inch the wire through.** Remove the nozzle and tip, lay the torch cable straight and press the wire-inch button (or the trigger) until the wire appears. Point the torch away from everyone. Fit the tip and nozzle, then cut the wire to about 10–15 mm stick-out.
6. **Set the roll pressure.** Feed the wire against a block of wood held about 5 cm from the tip. The rolls should slip on the wire; the wire should not crush or bird-nest. Tighten a little at a time.
7. **Connect the gas.** Cylinder chained upright, valve opened slowly while standing to one side, flow set with the gas-test button, joints leak-tested with soapy water.

8. **Place the earth clamp** on clean metal of the job, close to the weld.
9. **Set starting values** from the machine chart (Chapter 6) and make a test run on scrap of the same thickness. Record the settings.



MIG/MAG SET-UP CHECKLIST

Example — use the manual/WPS

Machine no. _____ Wire _____ mm Gas _____ Job _____ Date _____

1 Before switching on

- ☐ **1. Area safe** — screens up, extraction on, extinguisher at the booth, combustibles cleared
- ☐ **2. Supply** — right socket and isolator; mains cable, plug and leads undamaged
- ☐ **3. Polarity** — torch lead on + (DCEP) for solid wire; flux-cored: as the label says
- ☐ **4. Drive rolls** — groove type and size match the wire (V steel, U aluminium, knurled FCW)
- ☐ **5. Liner and tip** — right liner; tip size = wire size, bore not worn oval
- ☐ **6. Spool** — fitted to turn the right way; hub brake just stops overrun
- ☐ **7. Threading** — torch cable straight, tip and nozzle off; wire end cut clean, no burr

2 Power on and test

- ☐ **8. Inch the wire** — through the torch, pointed away from everyone; fit the tip and nozzle
- ☐ **9. Roll pressure** — stop the wire against a wood block: rolls slip, wire not crushed
- ☐ **10. Gas** — cylinder chained; valve opened slowly; flow set (e.g. 15 L/min); leaks tested
- ☐ **11. Earth clamp** — on clean metal of the job, close to the weld, never through bearings
- ☐ **12. Settings** — V and wire speed from the machine chart; 2T/4T; inductance (Chapter 6)
- ☐ **13. Test run** — on scrap of the same thickness; adjust and record the settings
- ☐ **14. PPE and screens** — helmet shade checked, gloves, collar closed, curtain drawn, then weld

Checked by (trainee) _____ Trainer _____ Settings used: ____ V ____ m/min ____ L/min

Figure 5.9 A MIG set-up checklist. Copy it for your portfolio and tick each item every time you set up (example — use the manual/WPS).

A tidy MIG bay (Figure 5.10) has the cylinder secured beside the machine, cables off the walkway and curtains to screen the arc.

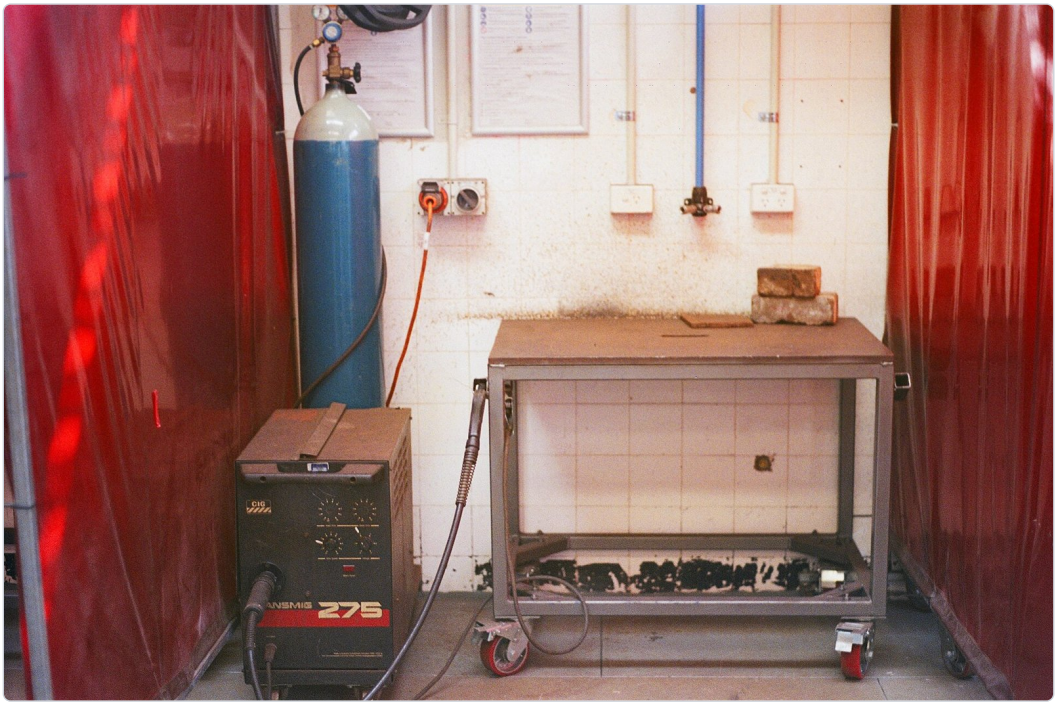


Figure 5.10 A MIG welding bay ready for set-up: machine beside the bench, gas cylinder secured upright against the wall with its regulator fitted, and curtains to screen the arc. Add fume extraction before welding.

Photo: Luke Haggart, CC BY-SA 4.0, via Wikimedia Commons

SAFETY FIRST

The wire is electrically live whenever the trigger is pressed, and on some machines while inching. Never point the torch at yourself or anyone else, never check the feed with a finger at the tip, and switch off before changing a tip or liner. Wire ends are sharp: cut them with side cutters and bend over the end of a removed spool. Keep cylinders chained upright with caps on when moving, and close the cylinder valve at the end of the day: argon and CO2 leaking into a closed booth or store can collect and suffocate without warning (Chapter 2).

5.10 Common Set-Up Faults

Table 5.3 Set-up faults, causes and cures

Fault	Likely causes	Cure
Bird-nesting at the rolls	Tip blocked or wrong size; liner kinked, dirty or too long; rolls too tight; wrong groove	Fit the right tip; blow out or replace the liner; reset the pressure
Erratic feed, surging arc	Rolls too loose or worn; hub brake too tight; worn tip; kinked cable	Reset pressure and brake; new tip; straighten the cable
Wire burns back into the tip	Stick-out too short; feed hesitates; worn tip; burn-back set too long	Hold 10–15 mm CTWD; fix the feed; new tip; adjust burn-back
No gas or porosity	Cylinder closed or empty; flow wrong; leak; nozzle full of spatter; draught; solenoid stuck	Check flow at the nozzle; leak test; clean the nozzle; screens
Heavy spatter, unstable arc	Wrong polarity; wrong gas; dirty plate; earth clamp loose	DCEP for solid wire; correct gas; clean metal; tight clamp
Wire stubs into the plate	Voltage too low for the wire speed; poor earth	Raise the voltage; check the clamp (Chapter 6)

COMMON MISTAKES

- Using a 1.0 mm tip with 0.8 mm wire. The arc wanders and the tip wears fast.
- Cranking the roll pressure to "cure" a feeding problem that is really a blocked liner.
- Setting the gas "by the hiss" instead of reading the flowmeter.
- Clamping the earth to the bench leg or through a hinge instead of on the job.
- Forgetting to change the polarity back after flux-cored wire.

5.11 Site Work: Generators and Long Cables

On site there may be no mains power, so the occupational standard lists diesel generators. Choose a generator well above the machine's input rating (given on its plate in kVA); inverter machines need a generator that gives a steady voltage. Earth the generator as its maker instructs, keep cables short and out of the way, and keep the extinguisher by the generator as well as the work. A thin or very long extension lead drops voltage and makes the arc unstable; use a lead of the cross-section the machine manual specifies.

WORKED EXAMPLE 5.3: SIZING A GENERATOR AND ITS FUEL

A MIG inverter's plate gives a maximum input of 9 kVA. Size a generator and estimate the fuel cost for a 6-hour site day. Example data: the generator uses 2.5 L/h at this load; diesel costs KSh 175/L (example price; check the generator data and the pump price).

Generator size = machine kVA × margin = 9 kVA × 1.5 = 13.5 kVA → choose about **15 kVA**

Fuel = 2.5 L/h × 6 h = **15 L**

Cost = 15 L × KSh 175/L = **KSh 2,625** per day

Sense-check: about KSh 440 an hour. The same 6-hour day on mains power with about 2 hours of arc at 4.5 kW is roughly 9 kWh × KSh 30 = KSh 270, so charge more for site work. The 1.5 margin is a typical rule; check the generator and machine makers' advice.

5.12 What Do the Wire and Gas Cost?

A spool and a cylinder are only worth what they produce. Turn their prices into a cost per metre of weld before you quote a job.

WORKED EXAMPLE 5.4: COST PER METRE OF A 6 MM MAG FILLET

Find the consumable, power and labour cost of 1 m of 6 mm fillet weld on mild steel, using 0.9 mm wire at 175 A and 22 V, which melts about 1.8 kg/h. Prices: wire KSh 600/kg (KSh 9,000 per 15 kg spool), gas about KSh 1/L at 15 L/min, power KSh 30/kWh, labour KSh 1,500 per 8-hour day.

Weld area = leg² ÷ 2 = 6 × 6 ÷ 2 = 18 mm², + 10% reinforcement = 19.8 mm²

Weld metal = 19.8 mm² × 1,000 mm × 7.85 g/cm³ = **0.155 kg/m**

Wire bought = 0.155 ÷ 0.95 (spatter and stub losses) = **0.164 kg** → × KSh 600 = **KSh 98**

Deposition = 1.8 kg/h × 0.95 = 1.71 kg/h; arc time = 0.155 ÷ 1.71 h = **5.45 min**

Gas = 15 L/min × 5.45 min = 82 L → **KSh 82**

Power = 175 A × 22 V ÷ 0.85 = 4.5 kW; × 0.091 h = 0.41 kWh → **KSh 12**

Labour: at 35% arc-on time, 0.091 h ÷ 0.35 = 0.26 h × KSh 187.50/h = **KSh 49**

Total ≈ 98 + 82 + 12 + 49 = **KSh 241, about KSh 240 per metre** before overheads and profit.

Per spool: 15 kg ÷ 0.164 kg/m ≈ **92 m** of this fillet from one spool. Sense-check: gas costs almost as much as wire, so a leak or too much flow eats your profit.

GREEN TIP

Small habits save money and waste: close the cylinder valve every night (a 1 L/min leak wastes 840 L in 14 hours); set the flow you need; keep spools covered so the wire is used to the last metres; set roll pressure correctly to avoid bird-nest scrap; and return cylinders with a little pressure left so moisture cannot get in. Sell empty plastic spools and copper-coated wire offcuts to licensed recyclers.

TRAINER'S TIP

When feeding goes wrong, work from the torch end backwards: tip, liner, rolls, spool. Nine times out of ten the fault is a worn or wrong tip, or a dirty liner, not the machine. Keep spare tips of each size in your pocket.

Practical task 5.1: Strip, identify and reassemble a MIG torch

Tools and equipment

- Air-cooled MIG torch on its machine
- MIG pliers, side cutters, nozzle reamer
- Vernier caliper or wire gauge; tape measure
- Dry compressed air (machine isolated)

Materials

- New contact tips (0.8 and 1.0 mm)
- New liner (if worn) and its fittings
- Clean rag, nozzle-dip gel

Steps

1. Switch off and isolate the machine. Remove the wire from the torch by cutting it at the tip and winding it back onto the spool.
2. Remove the nozzle, contact tip and diffuser in that order. Lay them out in order on a clean rag.
3. Read the size stamped on the tip and measure the wire diameter. Check the tip bore for wear (an oval hole) and the nozzle for spatter.
4. Undo the Euro nut, remove the liner, lay it straight and inspect it for kinks and dirt. Blow it through with dry air.
5. If you fit a new liner, cut it to the length in the torch maker's guide with the cable straight, and deburr the end.
6. Reassemble in the right order, tighten the tip snugly with MIG pliers, clean and dip the nozzle, and refit.
7. Re-thread the wire and test the feed (Task 5.2).

Safety

- Isolate before dismantling; the wire is live when the trigger is pressed.
- Wear safety glasses when blowing out the liner.
- Parts may be hot after welding.

Record your results

Part	Size or marking	Condition (good / worn / replaced)	Action taken
Contact tip			
Nozzle			
Diffuser			
Liner (type, length)			
Wire (diameter measured)			

Practical task 5.2: Set up a MIG machine from cold

Tools and equipment

- MIG machine, torch, work lead and clamp
- Argon–CO2 cylinder with flowmeter regulator, chained
- Drive rolls for 0.8 and 1.0 mm wire; MIG pliers, side cutters
- Block of wood; soapy water and brush; full PPE

Materials

- ER70S-6 wire, 0.8 or 1.0 mm
- Scrap mild steel, 3 mm and 6 mm, cleaned
- Set-up checklist (Figure 5.9)

Steps

1. Read the job card or drawing and decide the wire, gas, rolls, liner and tip.
2. Work through items 1–7 of the checklist with the machine off.
3. Switch on and work through items 8–14. Set the roll pressure with the wood-block test.
4. Set the gas flow (for example 15 L/min) and leak-test every joint with soapy water.
5. Set starting values from the machine chart and make a 100 mm test run on the scrap plate. Adjust until the arc sounds steady.
6. Record your settings, then have your trainer sign the checklist.

Safety

- Full PPE and the correct helmet shade before striking an arc (Chapter 2).
- Curtains closed; extraction on; extinguisher at the booth.
- Point the torch away from people while inching.

Record your results

Wire type and size	Rolls / tip	Gas and flow (L/min)	Voltage (V)	Wire speed (m/min)	Test run result

Chapter summary

- Read the drawing first: material, thickness, joints and process number decide the wire, gas and settings.
- A MIG/MAG system has three paths: current (DCEP for solid wire), wire and gas.
- Match the rolls (V, U or knurled), liner and tip to the wire type and size.
- ER70S-6 (G3Si1 type) is the standard steel wire; read the label for strength, chemistry and gas.
- Choose the gas by the metal and set the flow on the flowmeter, typically 12–18 L/min indoors.
- Set up with a checklist: rolls, spool, threading, roll pressure, gas, earth, settings, test run.
- A 15 kg spool of 1.0 mm wire is about 2.4 km; a 6 mm fillet costs about KSh 240 per metre in consumables, power and labour.

Check your competence

- [ ] I can interpret the abbreviations and process number on a fabrication drawing.
- [ ] I can name every part the wire, current and gas pass through.
- [ ] I can choose rolls, liner and tip for steel, stainless, aluminium and flux-cored wire.
- [ ] I can set the polarity for solid and flux-cored wire.
- [ ] I can decode a wire label and calculate wire length and arc time per spool.
- [ ] I can set gas flow on a flowmeter and leak-test the connections.
- [ ] I can set up a MIG machine from cold using the checklist and fix common feed faults.
- [ ] I can use and care for MIG pliers, brushes, jigs and the booth extinguisher.

Practice questions

1. List, in order, every part the wire passes through from the spool to the arc.
2. Why does aluminium wire need U-groove rolls, a plastic liner and a short torch or spool gun?
3. A 15 kg spool of 0.8 mm steel wire costs KSh 9,000. Calculate the length of wire, the arc time at 7 m/min and the cost of 1 m of wire.
4. A welder sets 18 L/min where 12 L/min is enough. How many hours of arc does a 10,000 L cylinder give at each flow, and how much gas is wasted per hour of arc?
5. Explain what each part of the name ER308LSi tells you, and which stainless grade and gas it is used with.
6. Fault-finding: a fundi MIG-welds a gate outside under a carport on a windy afternoon. The welds are full of pinholes. Give four possible causes and how to check each.
7. Oral: how do you set the drive-roll pressure, and why must you never test the feed with your finger?
8. What are CTWD and stick-out? Give a typical CTWD and tip position for short-circuit and for spray transfer.
9. A MIG machine plate gives a maximum input of 6 kVA. What size of generator would you choose, and why must inverter machines have a steady supply?
10. Practical: carry out Task 5.2 on your workshop machine and record the settings. Then explain how you would change the set-up to weld 3 mm aluminium.

Enjoyed this sample?

This free sample of **Welding Level 4** has the front matter, Chapter 1 and the full Chapter 5 on MIG/MAG equipment, wire and setting up: power sources, wire feeders and drive rolls, torches and consumables, wire types, gas and the step-by-step set-up. The complete guide has **14 chapters** and **282 pages**. It covers both Level 4 units (Metal Inert Gas Welding and Tungsten Inert Gas Welding) plus the 320-hour industrial attachment: working drawings, operation plans and welding symbols; MIG parameters and transfer modes; welding plates and pipes in the flat, horizontal and vertical positions; TIG on steel, stainless with back purge, aluminium and copper alloys; inspection, finishing and maintenance.

It also includes 118 realistic illustrations, diagrams, charts and photos, 50 worked examples, 30 practical tasks with record sheets, 140 practice questions with full answers, two mock assessments, a 189-term glossary, a welding symbols and typical-values quick reference and photocopiable logbook and weld record sheets.

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