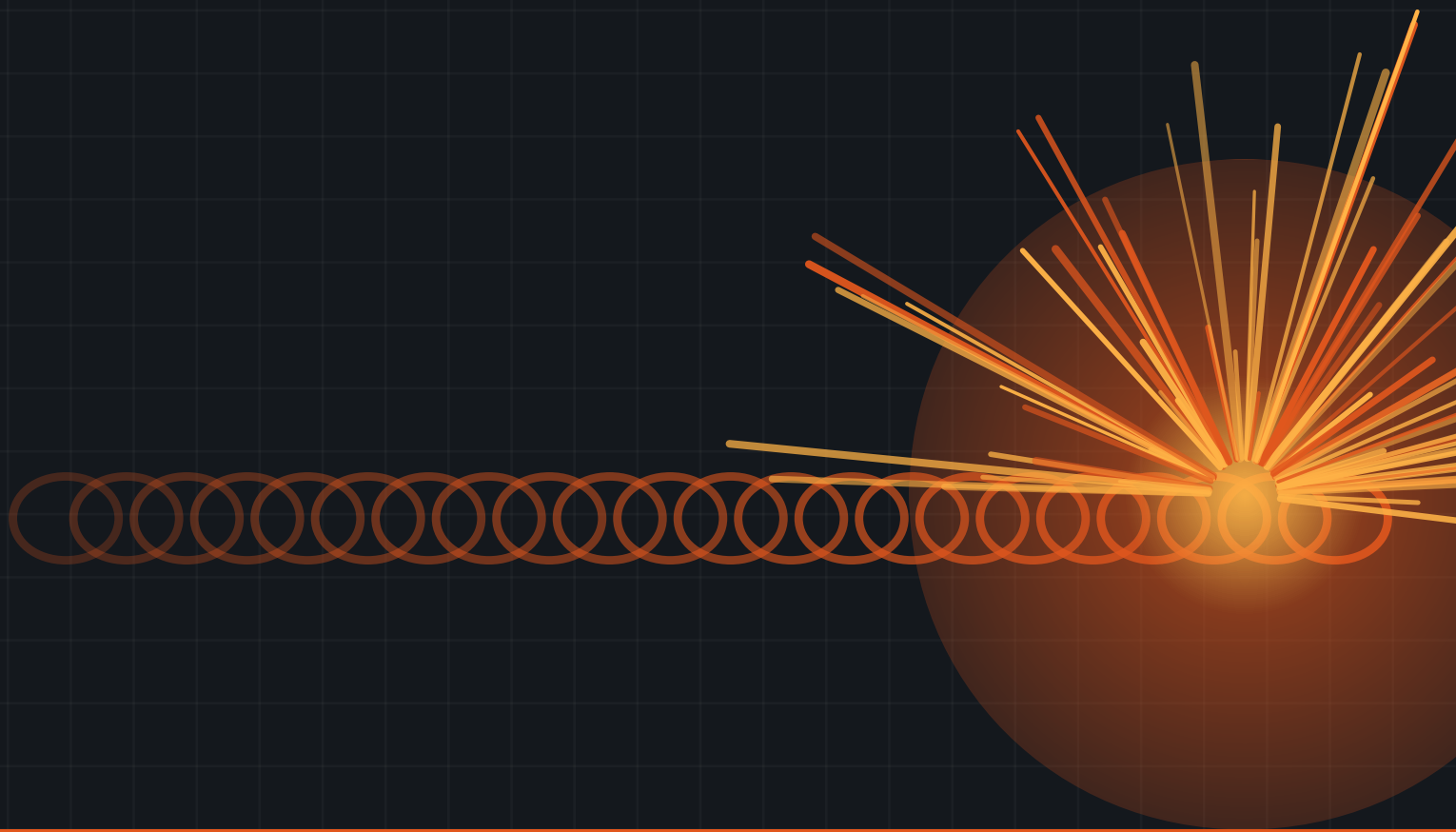




COMPLETE GUIDE

The Welder's Forge

Practical welding handbook: stick, MIG/MAG and TIG

ENGLISH EDITION · E-BOOK · PDF

Personal Protective Equipment (PPE)

Safety is the first skill a welder must build. Before you strike any arc or light any torch, you need to know how to choose, inspect and correctly use the personal protective equipment (PPE) that fits the process. Almost all PPE accidents are preventable.

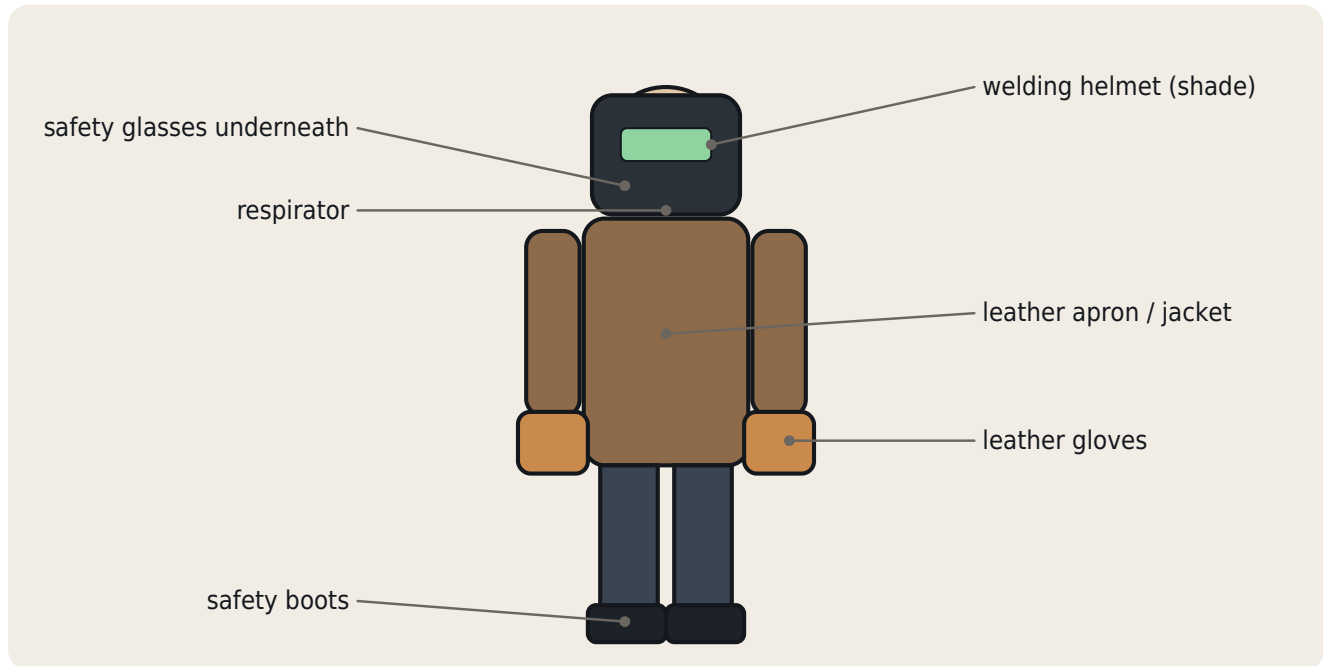


Figure 2.1 — Complete welding PPE: welding helmet, safety glasses, respirator, gloves, jacket or apron and boots. Inspect every item before each use.

PPE IN THE US

Eyes and face: look for the ANSI Z87.1 marking on safety glasses and on the helmet, and use the lens shade in Table 2.1. **Lungs:** a plain dust mask is not enough for welding fumes, and an N95 alone is not designed for them. Choose a NIOSH-approved respirator with P100 filters, or a powered air-purifying respirator (PAPR). At work, OSHA 29 CFR 1910.134 requires a respiratory protection program with medical evaluation and fit testing; in a home shop, pick the same class of equipment and make sure it seals on your face. **Body:** flame-resistant or natural-fiber clothing, never synthetics. **Hot work:** fire rules follow NFPA 51B and the OSHA welding rules in 29 CFR 1910 Subpart Q (general industry) and 1926 Subpart J (construction). ANSI Z49.1 is the safety standard for welding, cutting and allied processes.

2.1 The Hazards of Welding

Arc radiation. The arc gives off intense ultraviolet (UV) and infrared (IR) radiation. UV burns the cornea and the skin: it is sunburn in minutes. IR can progressively damage the retina with chronic unprotected exposure. Visible light at those intensities causes severe eye fatigue.

ARC EYE

"Welder's flash" (photokeratitis, "arc eye") does not show up right away. Symptoms (a sandy feeling, heavy tearing, pain and light sensitivity) appear 6 to 12 hours after exposure, so many people never connect the pain with the moment they looked at the arc. Proper eye protection is non-negotiable, including for anyone who is only helping or watching.

Fumes and gases. Welding makes metal fume, microscopic oxide particles in suspension, and toxic gases such as ozone, nitrogen dioxide, carbon monoxide and, depending on the material, compounds of manganese, hexavalent chromium and lead. Long-term inhalation causes chronic lung disease and, with hexavalent chromium, a higher risk of lung cancer.

GALVANIZED AND PAINTED

Welding or cutting galvanized steel releases zinc oxide fume, which causes "metal fume fever" (chills, fever, malaise). Old paint can contain lead. Remove the coating around the weld with the angle grinder, wearing your respirator while you grind, then weld with local exhaust and a suitable respirator. The same applies to stainless steel, which can release hexavalent chromium (OSHA 29 CFR 1910.1026).

Heat and spatter. Molten spatter can reach more than 2,700 °F (1,500 °C) and sparks travel as far as 35 ft (11 m), a fire and burn risk. A freshly welded part looks like a cold one and can be at 930 °F (500 °C). Mark what you just welded with "HOT" in chalk and never pick up work without gloves.

Electrical hazards. Welding machines work at voltages that can turn lethal in damp conditions or on contact with bare conductors. The open-circuit voltage is typically 50 to 90 V, enough for a fatal shock in some conditions: sweaty hands, wet clothes, a soaked floor.

ELECTRICAL DANGER

Never weld with wet gloves or clothes, or standing in water. Cables with damaged insulation are replaced, not patched with tape. Read the machine nameplate (input voltage, input current, duty cycle) and match the breaker and wiring to it. Typical shop power is 120 V (15 or 20 A circuits) and 240 V (30 or 50 A circuits). Avoid long, thin extension cords, use GFCI protection where required, and have a licensed electrician add or modify circuits according to the National Electrical Code (NEC, NFPA 70).

Fire and containers. Sparks hide in cracks, wood, cardboard, oily rags and synthetic clothes. Clear everything flammable from a 35 ft (11 m) radius or cover it with fire-resistant blankets, keep an extinguisher at hand and, when you finish, keep watching the area for at least 30 minutes (longer if your site rules or NFPA 51B call for it). Many fires start after the welder has gone home.

TANKS AND DRUMS

Never weld or cut a drum, tank or container that has held fuel, oil, paint or solvent unless it has been cleaned and made safe by a proper procedure. Residual vapors explode even in an "empty" container. Work inside tanks and other confined spaces requires an entry permit, air monitoring and an attendant outside.

2.2 Eye and Face Protection

The welding helmet protects the face, eyes and neck from radiation, spatter and heat. It must meet ANSI Z87.1 and carry the right lens shade. There are two main types:

- **Fixed-shade (passive) helmet:** a lens that is always dark. Cheaper, durable and battery-free. A good choice for learning.
- **Auto-darkening helmet:** sensors detect the arc, darken the lens in a tiny fraction of a second and clear it when the arc stops. It adds speed and comfort, especially on jobs with many stops and tack welds. Shade is usually adjustable between 9 and 13.

Table 2.1 — Recommended lens shade by process

Process	Current (A)	Recommended shade
Stick (SMAW)	60-160 A	Shade 10-11
Stick (SMAW)	160-300 A	Shade 12-13
MIG/MAG	60-300 A	Shade 10-12
TIG	15-80 A	Shade 9-11
Submerged arc (SAW)	300-800 A	Shade 12-14
Plasma cutting	Up to 400 A	Shade 11-14
Oxyacetylene	—	Shade 5-7 (gas welding goggles)

The US shade scale matches the DIN scale. If you cannot see the puddle comfortably, go one shade lighter; if the arc feels harsh, go darker. Never go below the range in the table.

Wear clear safety glasses under the helmet and whenever you grind, chip slag or clean. Chipped slag flies at high speed and the helmet does not stop it when flipped up. Shop rule: helmet up, glasses stay on.

2.3 Hands, Arms and Body

Gloves for arc welding are heavy leather. For TIG, thinner, softer gloves (goatskin or deerskin) give better finger feel. Rubber or nylon gloves are forbidden: they melt and stick to the skin. Leather sleeves protect your forearms when your jacket or apron does not.

A leather apron or jacket protects the torso and legs. For heavy arc work and oxyacetylene use leather; for light MIG on thin sheet, a heavy flame-resistant cotton jacket may be enough. Clothes must be natural fiber (cotton or wool) and flame resistant. Synthetics (polyester, nylon, acrylic) are forbidden: they melt on contact with sparks and make burns worse. Wear long sleeves, trousers without cuffs (cuffs collect spatter) and no open pockets.

- ☐ Leather welding gloves (arc) or thin leather TIG gloves, without holes.
- ☐ Leather sleeves or jacket when the apron does not cover your arms.
- ☐ Leather apron or flame-resistant jacket.
- ☐ Cotton or flame-resistant clothes, long sleeves, no cuffs, no open pockets.

2.4 Feet, Lungs and Ears

Wear leather safety boots with a steel or composite toe and a heat-resistant sole. Trousers go over the boots, never tucked in, so spatter cannot collect in the boot top. Never weld in sneakers, sandals or open shoes.

Respiratory protection is often skipped, yet it matters most in the long run:

- **Disposable P100 filtering facepiece (NIOSH-approved):** filters particles from metal fume but not gases. Suits well-ventilated areas and moderate fume. A plain dust mask or an N95 alone is not designed for welding fume.
- **Half-mask elastomeric respirator with P100 filters:** add organic vapor or acid gas cartridges when gases are present. For heavy fume and limited ventilation.
- **Powered air-purifying respirator (PAPR) or supplied-air respirator:** a PAPR with a welding helmet is comfortable for long days; supplied air from a compressor and hose is required in confined spaces without ventilation, such as tanks and vessels.

A respirator only works if it seals. Facial hair under the seal breaks it. At work, fit testing is part of the employer's program.

VENTILATION COMES FIRST

The best respiratory protection is good ventilation. A fume extractor placed close to the pool (ideally 6–8 in, or 15–20 cm) captures fume before it reaches your breathing zone. Local exhaust complements, and does not replace, personal respirators. And keep your head out of the plume of smoke rising from the work.

Submerged arc, plasma cutting and grinding make noise that can pass 85 dB(A), the level at which hearing protection programs begin. Use earplugs or earmuffs in these situations.

INSPECT YOUR PPE

Before every shift, inspect everything: cracks, holes, torn seams, defective parts. A holed glove or a cracked lens does not protect you. Replace damaged items immediately and store PPE clean and dry.

- ☐ Helmet with the correct shade for the process and current (Table 2.1).
- ☐ Safety glasses under the helmet.
- ☐ Gloves, sleeves and apron suitable and undamaged.
- ☐ Boots with toe protection and trousers over them.
- ☐ NIOSH-approved respirator and exhaust running.
- ☐ Hearing protection for grinding, plasma and submerged arc.
- ☐ Extinguisher at hand and the area clear of flammables.
- ☐ Eye protection marked ANSI Z87.1.