

# Welding Reference Chart

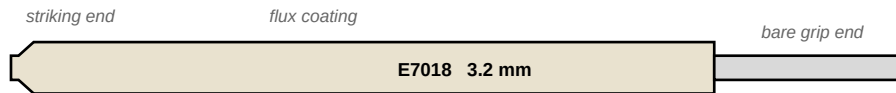
Mining and Industrial Suppliers (Pvt) Ltd

No 2 Hood Road, Southerton, Harare

Stick (MMA) electrodes - reading the code and choosing a rod.

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## AWS A5.1 / A5.5 code

**E**

**Electrode**  
Arc welding electrode

**70**

**Tensile strength**  
x 1000 psi: 60 = 60 ksi (414 MPa), 70 = 70 ksi (482 MPa)

**1**

**Position**  
1 all positions  
2 flat and horizontal  
4 all, vertical down

**8**

**Coating & current**  
Read the last two digits together (18)  
- see the table below

## EN ISO 2560-A code

**E 42 4 B 42 H5**

42 - yield strength 420 MPa minimum  
4 - 47 J impact at -40°C (0 = 0°, 2 = -20°)  
B - coating: B basic, R rutile, C cellulose,  
RB / RC / RR mixed, A acid  
4 - recovery and current type  
2 - positions: 1 all, 2 all but vertical down, 3 - 4 flat, 5 vertical down  
H5 - hydrogen, ml per 100 g weld metal

## Coating and current - the last two digits

| Last 2 digits | Coating                    | Current     | Arc / use                                      |
|---------------|----------------------------|-------------|------------------------------------------------|
| 10            | High cellulose, sodium     | DC+         | Deep digging arc - pipe root runs, dirty steel |
| 11            | High cellulose, potassium  | AC or DC+   | As 10, runs on an AC set                       |
| 12            | Rutile, sodium             | AC or DC-   | Medium penetration, gap bridging, sheet        |
| 13            | Rutile, potassium          | AC or DC+/- | Soft arc, light penetration, neat finish       |
| 14            | Rutile + iron powder       | AC or DC+/- | Faster fill, easy slag                         |
| 15            | Low hydrogen, sodium       | DC+         | Crack-resistant welds, DC only                 |
| 16            | Low hydrogen, potassium    | AC or DC+   | Crack-resistant welds on AC                    |
| 18            | Low hydrogen + iron powder | AC or DC+   | Structural and pressure work - keep dry        |
| 20            | High iron oxide            | AC or DC+/- | Flat and horizontal fillets                    |
| 24            | Rutile + heavy iron powder | AC or DC+/- | Fast flat fillets, drag technique              |
| 27            | Iron oxide + iron powder   | AC or DC+/- | Deep flat fillets                              |
| 28            | Low hydrogen + iron powder | AC or DC+   | Fast low-hydrogen flat fillets                 |

## Common electrodes

| Electrode  | Type                 | Current    | Positions    | Use it for                                          | ISO 2560-A (approx.) |
|------------|----------------------|------------|--------------|-----------------------------------------------------|----------------------|
| E6010      | Cellulose            | DC+        | All          | Pipe root runs, rusty or painted steel              | E 38 3 C 21          |
| E6011      | Cellulose            | AC / DC+   | All          | General repair on AC sets, dirty steel              | E 38 2 C 11          |
| E6013      | Rutile               | AC / DC+/- | All          | General mild steel, sheet, gates, light fabrication | E 42 0 RC 11         |
| E7014      | Rutile + iron powder | AC / DC+/- | All          | Faster fill on mild steel, good finish              | E 42 0 RR 32         |
| E7016      | Low hydrogen         | AC / DC+   | All          | Structural steel on AC, crack-sensitive joints      | E 42 4 B 12 H10      |
| E7018      | Low hydrogen         | AC / DC+   | All          | Structural, pressure, high-strength and thick steel | E 42 4 B 42 H5       |
| E7024      | Iron powder rutile   | AC / DC+/- | Flat, horiz. | Fast large fillets in the flat                      | E 42 0 RR 73         |
| E308L-16   | Stainless (rutile)   | AC / DC+   | All          | 304 / 304L stainless                                | E 19 9 L R 12        |
| E316L-16   | Stainless (rutile)   | AC / DC+   | All          | 316 / 316L stainless (acid, marine)                 | E 19 12 3 L R 12     |
| E309L-16   | Stainless (rutile)   | AC / DC+   | All          | Stainless to mild steel, buffer layers              | E 23 12 L R 32       |
| E312-16    | Stainless 29/9       | AC / DC+   | All          | Unknown or hard-to-weld steels, tool steel repair   | E 29 9 R 12          |
| ENi-CI     | Nickel (99%)         | AC / DC+   | All          | Cast iron repair - machinable                       | E C Ni-CI 3          |
| ENiFe-CI   | Nickel-iron (55%)    | AC / DC+   | All          | Cast iron to steel, stronger cast iron joints       | E C NiFe-CI 3        |
| Hardfacing | Various              | AC / DC+   | Flat         | Wear surfaces - buckets, teeth, crusher parts       | EN 14700             |

# Welding Reference Chart

Mining and Industrial Suppliers (Pvt) Ltd

No 2 Hood Road, Southerton, Harare

Stick settings, rod storage, preheat and shielding gases.

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## Amps by rod diameter (flat position - drop 10 - 15% vertical and overhead)

| Rod dia mm | Inch  | E6013     | E7018     | E6010 / 6011 | Stainless | Plate mm |
|------------|-------|-----------|-----------|--------------|-----------|----------|
| 1.6        | 1/16" | 25 - 45   | -         | -            | 25 - 45   | 1 - 2    |
| 2.0        | 5/64" | 40 - 70   | 50 - 75   | -            | 35 - 55   | 1.5 - 3  |
| 2.5        | 3/32" | 60 - 95   | 70 - 100  | 50 - 85      | 50 - 75   | 2 - 5    |
| 3.2        | 1/8"  | 90 - 130  | 100 - 140 | 75 - 125     | 75 - 110  | 3 - 8    |
| 4.0        | 5/32" | 130 - 180 | 140 - 190 | 110 - 170    | 100 - 150 | 5 - 12   |
| 5.0        | 3/16" | 180 - 240 | 190 - 260 | 140 - 215    | 140 - 190 | 8 +      |
| 6.0        | 1/4"  | 240 - 320 | 250 - 330 | -            | -         | 12 +     |

## Drying and storing electrodes

| Rod type                  | Re-dry                        | Hold / quiver | Notes                                                      |
|---------------------------|-------------------------------|---------------|------------------------------------------------------------|
| Low hydrogen (7016, 7018) | 300 - 350°C, 1 - 2 h          | 100 - 150°C   | Once out of the oven or a sealed tin, use within about 4 h |
| Rutile (6013, 7014, 7024) | 70 - 100°C, 1 h, only if damp | Dry store     | Damp rods give porosity and a stubborn arc                 |
| Cellulose (6010, 6011)    | Do not re-dry                 | Dry store     | The coating needs its moisture to work                     |
| Stainless                 | 250 - 300°C, 1 - 2 h          | 100 - 150°C   | Porosity and cracking if damp                              |
| Cast iron (nickel)        | 100 - 150°C, 1 h              | Dry store     |                                                            |

## Preheat guide (CE = C + Mn/6 + (Cr+Mo+V)/5 + (Ni+Cu)/15)

| Material                   | Typical CE  | Preheat / interpass                  | Rods / notes                                    |
|----------------------------|-------------|--------------------------------------|-------------------------------------------------|
| Mild steel (S275, A36)     | 0.35 - 0.40 | None under 25 mm; 50 - 100°C thicker | E6013 / E7018, ER70S-6                          |
| Structural S355            | 0.40 - 0.47 | 50 - 100°C over 20 mm                | Low hydrogen                                    |
| EN8 / 1045 medium carbon   | 0.55 - 0.65 | 150 - 250°C                          | E7018, slow cool                                |
| EN19 / 4140 CrMo           | 0.85 - 0.95 | 250 - 350°C                          | Low hydrogen or E312, slow cool, stress relieve |
| EN24 / 4340 NiCrMo         | 0.85 - 1.0  | 300 - 350°C                          | As EN19 - check the heat treatment              |
| Cast iron                  | -           | 250 - 400°C, or cold                 | Nickel rods; cold: short runs, peen, let cool   |
| Manganese steel (Hadfield) | -           | None - keep under 250°C              | Austenitic Mn or 29/9 rods, short runs          |
| Stainless 304 / 316        | -           | None - interpass under 150°C         | Keep heat input low                             |
| Aluminium                  | -           | 100 - 150°C on thick sections        | Not over 200°C on heat-treated alloys           |

## Shielding gases

| Shielding gas                    | Process  | Use it for                                                              |
|----------------------------------|----------|-------------------------------------------------------------------------|
| Argon + 15-20% CO2 (M21)         | MAG      | General mild steel - good all-rounder, low spatter                      |
| Argon + 5-8% CO2 (M20)           | MAG      | Thin steel and spray transfer, smooth finish                            |
| 100% CO2 (C1)                    | MAG      | Deep penetration on mild steel, cheap - more spatter                    |
| Argon + 2% CO2 or O2 (M12 / M13) | MAG      | Stainless steel                                                         |
| 100% Argon (I1)                  | TIG, MIG | All TIG welding; MIG on aluminium and bronze                            |
| Argon + 25-70% Helium (I3)       | TIG, MIG | Thick aluminium and copper - hotter arc                                 |
| Flow rate                        |          | MIG 12 - 18 L/min, TIG 6 - 12 L/min; more outdoors or with a larger cup |

# Welding Reference Chart

Mining and Industrial Suppliers (Pvt) Ltd

No 2 Hood Road, Southerton, Harare

MIG / MAG and TIG - wires, settings and tungstens.

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## MIG / MAG wires

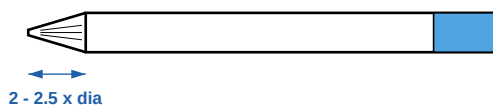
| Wire (AWS)        | EN ISO                        | Gas                                              | Use it for                                        |
|-------------------|-------------------------------|--------------------------------------------------|---------------------------------------------------|
| ER70S-6           | G3Si1 / G 42 4 M21 3Si1 (SG2) | Ar + 15-20% CO <sub>2</sub> , or CO <sub>2</sub> | Mild and structural steel - the everyday wire     |
| ER70S-3           | G2Si1 (SG1)                   | Ar + CO <sub>2</sub>                             | Clean mild steel                                  |
| E71T-1            | T 46 2 P M 1                  | Ar + CO <sub>2</sub> or CO <sub>2</sub>          | Gas-shielded flux-cored - all-position structural |
| E71T-11 / E71T-GS | T 42 Z Z N                    | None (gasless)                                   | Outdoor and site work on thin mild steel (DC-)    |
| ER308LSi          | G 19 9 L Si                   | Ar + 2% CO <sub>2</sub> or O <sub>2</sub>        | 304 stainless                                     |
| ER316LSi          | G 19 12 3 L Si                | Ar + 2% CO <sub>2</sub> or O <sub>2</sub>        | 316 stainless                                     |
| ER309LSi          | G 23 12 L Si                  | Ar + 2% CO <sub>2</sub>                          | Stainless to mild steel                           |
| ER4043            | S Al 4043 (AlSi5)             | Argon                                            | Aluminium castings, 6xxx alloys, crack-resistant  |
| ER5356            | S Al 5356 (AlMg5)             | Argon                                            | 5xxx and marine aluminium, anodises better        |
| CuSi3             | S Cu 6560                     | Argon                                            | MIG brazing galvanised and coated sheet           |

## MIG settings for mild steel, short arc, Ar + CO<sub>2</sub> (fillet or butt, flat position)

| Plate mm  | Wire mm   | Amps      | Volts   | Wire m/min | Notes                                        |
|-----------|-----------|-----------|---------|------------|----------------------------------------------|
| 0.8 - 1.0 | 0.6 - 0.8 | 40 - 60   | 15 - 16 | 2.5 - 3.5  | Tack and stitch to stop burn-through         |
| 1.5       | 0.8       | 60 - 80   | 16 - 17 | 3.5 - 4.5  |                                              |
| 2.0       | 0.8       | 80 - 110  | 17 - 18 | 4.5 - 6    |                                              |
| 3.0       | 0.8 - 1.0 | 110 - 140 | 18 - 19 | 5 - 7      |                                              |
| 4.0       | 1.0       | 140 - 170 | 19 - 21 | 5.5 - 7    |                                              |
| 5.0       | 1.0       | 160 - 190 | 20 - 22 | 6.5 - 8    |                                              |
| 6.0       | 1.0 - 1.2 | 180 - 230 | 22 - 24 | 7 - 9      | Bevel over 6 mm for full penetration         |
| 8.0       | 1.2       | 230 - 280 | 25 - 28 | 6 - 8      | Multi-pass; spray transfer needs Ar-rich gas |
| 10 +      | 1.2       | 250 - 320 | 27 - 31 | 7 - 10     | Multi-pass, flat or horizontal               |

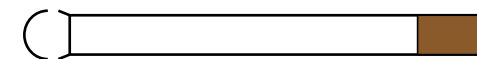
## TIG tungsten preparation

DC - steel, stainless, copper



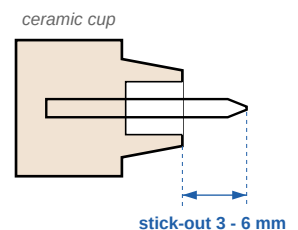
Grind to a point along the rod, never around it. Leave a tiny flat on the tip. Colour band at the far end.

AC - aluminium



Balled end, about the rod diameter. Zirconiated, lanthanated or E3 rods. Too big a ball = too much current.

Cup and stick-out



Cup number = bore in 1/16" (#6 = 3/8", 9.5 mm).

## Tungsten electrodes (ISO 6848 colour codes)

| Colour | ISO 6848 | Oxide          | Current | Notes                                                  |
|--------|----------|----------------|---------|--------------------------------------------------------|
|        | WP       | Pure tungsten  | AC      | Balls easily - older AC aluminium work                 |
|        | WT20     | 2% thorium     | DC      | Long-lasting DC steel work - radioactive grinding dust |
|        | WC20     | 2% cerium      | AC / DC | Good low-amp starts, thin sheet                        |
|        | WL10     | 1% lanthanum   | AC / DC |                                                        |
|        | WL15     | 1.5% lanthanum | AC / DC | Good all-rounder, thoriated replacement                |
|        | WL20     | 2% lanthanum   | AC / DC | Best all-rounder - steel, stainless and aluminium      |
|        | WZ3      | 0.3% zirconium | AC      | Aluminium - holds a clean ball                         |
|        | WZ8      | 0.8% zirconium | AC      | Aluminium, higher current                              |
|        | E3       | Rare-earth mix | AC / DC | Long life, easy starts on everything                   |

## TIG current and filler

| Tungsten mm | Inch   | DC- amps  | AC amps   | Cup size | Filler mm |
|-------------|--------|-----------|-----------|----------|-----------|
| 1.0         | 0.040" | 15 - 80   | 15 - 60   | #4 - #5  | 1.0 - 1.6 |
| 1.6         | 1/16"  | 70 - 150  | 60 - 120  | #5 - #6  | 1.6 - 2.4 |
| 2.4         | 3/32"  | 150 - 250 | 100 - 180 | #6 - #8  | 2.4 - 3.2 |
| 3.2         | 1/8"   | 250 - 400 | 160 - 250 | #8 - #10 | 3.2 - 4.0 |

| Filler rod                | Use it for                                                       |
|---------------------------|------------------------------------------------------------------|
| ER70S-2 / ER70S-6         | Mild steel (70S-2 has extra deoxidisers - better on dirty steel) |
| ER308L / ER316L           | 304 / 316 stainless                                              |
| ER309L                    | Stainless to mild steel                                          |
| ER4043 / ER5356           | Aluminium - as for MIG wire                                      |
| ERCuSi-A (silicon bronze) | Bronze, copper, galvanised steel, cast iron brazing              |
| ER80S-B2 (CrMo)           | 1.25 Cr 0.5 Mo boiler and pressure steels                        |

# Welding Reference Chart

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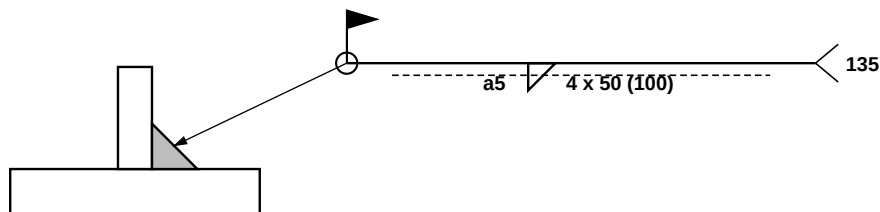
No 2 Hood Road, Southerton, Harare

Weld symbols (ISO 2553 / AWS A2.4), lens shades and process numbers.

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Arrow points at the joint. Symbol below the line = weld on the arrow side; above the line = the other side; both = both sides.  
ISO 2553: the dashed line marks the other side (AWS has none).  
Size left of the symbol (a5 = 5 mm throat, z5 = 5 mm leg),  
length right: 4 x 50 (100) = four 50 mm welds at 100 mm pitch.  
Circle = weld all round. Flag = site / field weld.  
Tail = process number (ISO 4063) or procedure.



|          |                   |             |               |              |              |
|----------|-------------------|-------------|---------------|--------------|--------------|
|          |                   |             |               |              |              |
| Fillet   | Fillet both sides | Square butt | Single-V butt | Double-V (X) | Single bevel |
|          |                   |             |               |              |              |
| Single-U | Single-J          | Plug / slot | Spot          | Seam         | Surfacing    |

## Lens shade (EN 169 / AWS F2.2) and process numbers

| Process               | Current           | Lens shade           |
|-----------------------|-------------------|----------------------|
| MMA (stick)           | Under 60 A        | 7 - 9                |
|                       | 60 - 160 A        | 10 - 11              |
|                       | 160 - 250 A       | 11 - 12              |
|                       | 250 - 550 A       | 13 - 14              |
| MIG / MAG             | Under 60 A        | 7 - 10               |
|                       | 60 - 160 A        | 10 - 11              |
|                       | 160 - 250 A       | 11 - 12              |
|                       | 250 - 500 A       | 12 - 14              |
| TIG                   | Under 50 A        | 8 - 10               |
|                       | 50 - 150 A        | 10 - 12              |
|                       | 150 - 500 A       | 12 - 14              |
| Plasma cutting        | Under 300 A       | 8 - 9                |
|                       | 300 - 400 A       | 9 - 12               |
| Oxy-fuel cutting      | Plate to 25 mm    | 3 - 4                |
|                       | Plate 25 - 150 mm | 4 - 5                |
| Gas welding / brazing |                   | 4 - 6                |
| Grinding / helpers    |                   | Clear or shade 2 - 3 |

| ISO 4063 | Process                            |
|----------|------------------------------------|
| 111      | Manual metal arc (MMA, stick)      |
| 114      | Self-shielded flux-cored (gasless) |
| 121      | Submerged arc (SAW)                |
| 131      | MIG - inert gas                    |
| 135      | MAG - active gas, solid wire       |
| 136      | MAG - flux-cored wire              |
| 141      | TIG                                |
| 15       | Plasma arc welding                 |
| 311      | Oxy-acetylene welding              |
| 912      | Flame brazing                      |