# Repair & Maintenance

**DATA SHEET** **E-20**

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# ARMOUR WELDING CONSUMABLES

## Alloy type

20%Cr-10%Ni-2.5%Mo weld metal composition designed for welding armour plate.

## Materials to be welded

**Armour plate:**
MVEE 816 (MoD)
Armox 816 (Swedish Steel)
Compass B555 (Sleeman)

**13%Mn (Hadfield steel):**
Abro M (Cresuot)
Red Diamond 14
(Spartan Redheugh)

**< 0.4%C hardenable steels:**
BS970 709M40 (En19), 817M40 (En24), 826M40 (En26), 897M39 (En40C), etc

**Wear-resistant steels:**
Hardox 400 & 500 (Swedish Steel)
ARQ360, A-R-COL (Corus)
Creusabro 4000, Abro 360 and 500 (Creusot)
ABR 500 (Taysteel)
Red Diamond 20, 21, 22 (Spartan Redheugh)

**ASTM:**
CF8M

Also for **dissimilar combinations** between the above and to standard **stainless steels** and **CMn steels**.

## Applications

These consumables are well-established and approved for **armour welding**. They deposit a modified austenitic stainless weld metal with moderately high ferrite content, giving strong, tough and crack-resistant welds in many other **hardenable steels**, often without the need for preheat. Applications include **tanks**, other **military** and **security vehicles**, **general engineering** components.

They are also useful for welding many **wear and abrasion-resisting steels**, to avoid the need for 'hydrogen control' procedures, particularly for heavier sections and the harder types. In addition, the high **work-hardening** rate gives these welds good resistance to impact wear and scuffing. This feature can also be exploited for **overlays** combined with **corrosion** and **wet abrasion resistance**.

Although the resistance to gouging abrasion of **13%Mn Hadfield steel** is unique and arises from its extreme work-hardenability, these consumables have a long and successful history for the build-up and reclamation of this steel. It is an economic ductile **buffer layer** prior to **hardfacing** with high alloy weld metals such as chromium carbide types.

## Microstructure

Austenite with ferrite 10 – 25FN, typically about 20FN.

## Welding guidelines

Preheat not generally required for CMn and low alloy steels with up to 0.3%C. However 50-200°C is recommended progressively with increasing base material thickness, hardenability and restraint.

## Additional information

Because of the high ferrite level (20 FN) and moderate carbon content (0.06%), these consumables are not suitable for cryogenic applications or structural service at temperatures exceeding about 300°C. Some loss of ductility will occur if weldments are post weld heat treated. They should not be confused with low carbon austenitic and duplex stainless alloys specifically designed for corrosion resistance. However, AWS A5.4 and A5.22 include the related E308MoL which may be used for ASTM CF3M castings when a higher ferrite type than 316L is required for improved stress-corrosion resistance.

These consumables are used successfully for steels which are judged 'difficult to weld' on the basis of their carbon equivalent (CE). For example, armour plate and En26 have CE ~ 1, potentially up to 1.36 maximum for classical armour with nominal 0.3%C-2%Cr-0.5%Ni-0.4%Mo. Some proprietary armour steels are leaner, with CE 1 max. The greatly hardened HAZ of these steels is only partially tempered in a multipass weldment, resulting in high sensitivity to hydrogen (cold) cracking. By using a specially balanced austenitic consumable this problem is avoided, because very little hydrogen can diffuse from the weld into the HAZ. It is still helpful to apply some preheat since this will encourage self-tempering and reduce peak HAZ hardness. However, the presence of a hardened HAZ should be considered in relation to service conditions.

## Related alloy groups

There is no equivalent solid wire but the 307 types (data sheet E-21) provide the best alternative if required. For dissimilar joints etc. the 309L (B-50), 309Mo (B-51), 307 (E-21) and 29.9 types (E-22) may also be suitable.

## Products available

| Process | Product | Specification |
|---|---|---|
| MMA | **Armet 1** | AWS E308Mo-16 |
| FCW | **Supercore 20.9.3** | AWS E308MoT0-4 |
| | **Supercore 20.9.3.P** | AWS E308MoT1-4 |

# ARMET 1

Rutile MMA electrode for welding armour plate

**Product description**

Rutile MMA electrode made on austenitic stainless steel core wire. High moisture resistance, designed and manufactured with low hydrogen technology to give weld metal with low potential hydrogen content.

Recovery is about 110% with respect to core wire, 65% with respect to whole electrode.

**Specifications**

| | |
|---|---|
| **AWS A5.4** | (E308Mo-16)* |
| **BS EN 1600** | E 20 10 3 R 32 |
| **BS 2926** | (19.9.3.R) |
| **DIN 8556** | (E 20 10 3 R 26) |
| **Approvals:** | MoD MVEE 1050 Class 1A and 1B |

*Mn: 2.0 – 3.0 for AWS standard

**ASME IX Qualification**

**QW432** F-No 5, **QW442** A-No 8

**Composition (weld metal wt %)**

| | C | Mn | Si | S | P | Cr | Ni | Mo | Cu | FN |
|---|---|---|---|---|---|---|---|---|---|---|
| min | 0.03 | 0.5 | -- | -- | -- | 18.5 | 9.0 | 2.0 | -- | 10 |
| max | 0.08 | 2.5 | 1.0 | 0.025 | 0.030 | 21.0 | 12.0 | 3.0 | 0.75 | 25 |
| typ | 0.06 | 1.1 | 0.7 | 0.010 | 0.025 | 20 | 9.5 | 2.5 | 0.1 | 15 |

**All-weld mechanical properties**

| As welded | | | min | typical |
|---|---|---|---|---|
| Tensile strength | | MPa | 620 | 670-780 |
| 0.2% Proof stress | | MPa | 400 | > 520 |
| Elongation on 4d | | % | 35 | > 40 |
| Elongation on 5d | | % | 30 | > 30 |
| Reduction of area | | % | -- | > 25 |
| Impact energy | + 20°C | J | -- | > 55 |
| Impact energy | - 50°C | J | -- | > 45 |
| Hardness | | HV | -- | 220 * |

* Increases to about 400 – 450HV on work hardening

**Operating parameters**

DC +ve or AC (OCV: 70V min)

| ø mm | 2.5 | 3.2 | 4.0 | 5.0 |
|---|---|---|---|---|
| min A | 60 | 70 | 100 | 150 |
| max A | 90 | 120 | 170 | 230 |

**Packaging data**

| ø mm | 2.5 | 3.2 | 4.0 | 5.0 |
|---|---|---|---|---|
| length mm | 300 | 350 | 350 | 350 |
| kg/carton | 11.4 | 13.5 | 13.5 | 16.5 |
| pieces/carton | 660 | 408 | 261 | 228 |

**Storage**

**3 hermetically sealed ring-pull metal tins** per carton, with unlimited shelf life. Direct use from tin is satisfactory for longer than a working shift of 8h. Excessive exposure of electrodes to humid conditions will cause some moisture pick-up and increase the risk of porosity.
For electrodes that have been exposed:
**Redry** 200 – 300°C/1-2h to restore to as-packed condition. Maximum 400° C, 3 cycles, 10h total.
**Storage** of redried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended. Recommended ambient storage conditions for opened tins (using plastic lid): < 60% RH, > 18°C.

**Fume data**

Fume composition, wt % typical:

| Fe | Mn | Ni | Cr | Cu | F | OES (mg/m$^3$) |
|---|---|---|---|---|---|---|
| 8 | 5 | 1 | 4 | < 0.2 | 16 | 1.2 |

# SUPERCORE 20.9.3

Downhand rutile flux cored wire for welding armour plate

**Product description**

Rutile flux cored wire made with an austenitic stainless steel sheath and rutile flux system designed primarily for downhand and horizontal welding, giving a mitred fillet profile. The 1.2mm diameter wire is also suitable for all-positional welding.

Metal recovery is approximately 90% with respect to wire.

**Specifications**

| | **Supercore 20.9.3** | **Supercore 20.9.3.P** |
|---|---|---|
| **AWS A5.22** | E308MoT0-1/4 | E308MoT1-1/4 |
| **BS EN ISO 17633-A** | T 20 10 3 R M 3 | T 20 10 3 P M 2 |
| **BS EN ISO 17633-B** | TS308Mo-FM0 | TS308Mo-FM1 |
| **Approvals:** | MoD MVEE 1050 Class VII | MoD MVEE 1050 Class VII |

**ASME IX Qualification**

**QW432** F-No 6, **QW442** A-No 8

**Composition (weld metal wt %)**

| | C | Mn | Si | S | P | Cr | Ni | Mo | Cu | FN |
|---|---|---|---|---|---|---|---|---|---|---|
| min | -- | 0.5 | -- | -- | -- | 19.5 | 9.0 | 2.0 | -- | 10 |
| max | 0.08 | 2.5 | 0.9 | 0.025 | 0.035 | 21.0 | 11.0 | 3.0 | 0.3 | 25 |
| typ | 0.06 | 1.2 | 0.5 | 0.01 | 0.03 | 20 | 9.5 | 2.8 | 0.05 | 17 |

**All-weld mechanical properties**

| As welded | | | min | typical |
|---|---|---|---|---|
| Tensile strength | | MPa | 620 | 720 |
| 0.2% Proof stress | | MPa | 400 | 520 |
| Elongation on 4d | | % | 25 | 35 |
| Elongation on 5d | | % | 30 | 33 |
| Impact energy | + 20°C | J | -- | 60 |
| Impact energy | - 50°C | J | -- | 50 |
| Hardness | | J | -- | 230 * |

* Increases to about 400 – 450HV on work-hardening.

**Operating parameters**

**Shielding gas:** 80%Ar-20%$CO_2$ at 20-25 l/min. Proprietary gas mixtures may be used but argon should not exceed 85%.

The wire is suitable for use on 100%$CO_2$ but with some loss of cosmetic appearance and increased spatter.

**Current:** DC+ve ranges as below, with Ar-20%$CO_2$ (when using $CO_2$, voltages need to be increased by 2-3V):

| ø mm | amp-volt range | typical | stickout |
|---|---|---|---|
| 1.2 | 130A-25V to 250A-32V | 180A-29V | 15-20mm |
| 1.6 | 200A-28V to 330A-34V | 230A-30V | 15-25mm |

**Packaging data**

Spools vacuum-sealed in barrier foil with cardboard carton: Supercore 20.9.3 - 15.0kg (1.2/1.6mm), Supercore 20.9.3.P - 12.5kg (1.2mm).
The as-packed shelf life is virtually indefinite.
Resistance to moisture absorption is high, but to maintain the high integrity of the wire surface and prevent any possibility of porosity, it is advised that part-used spools are returned to polythene wrappers.
Where possible, preferred storage conditions are 60% RH max, 18°C min.

**Fume data**

Fume composition (wt %)

| | Fe | Mn | Ni | $Cr^3$ | $Cr^6$ | F | OES ($mg/m^3$) |
|---|---|---|---|---|---|---|---|
| Ar+20%$CO_2$ | 14 | 11 | 1 | 8 | 4 | 5 | 1.2 |
| $CO_2$ | 17 | 10 | 1 | 9.5 | 1 | 5 | 5 |