

Stainless Steels

DATA SHEET

B-33

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NON-MAGNETIC 316L

Alloy type

Nil-ferrite, modified 316L alloy for non-magnetic, cryogenic and nitric acid applications.

Materials to be welded

For type 316L and similar parent materials where ferrite-free and non-magnetic weld metal is required; also suitable for 304/304L and 316/316L for cryogenic service.

May be suitable for welding 200 series stainless steels, eg. UNS S20910 (XM-19), Nitronic 50 (Armco) and other nitrogen strengthened stainless steels.

Applications

The high nickel and nitrogen levels provide a fully austenitic and non-magnetic weld deposit with maximum magnetic permeability of 1.01. A typical tensile strength above 600MPa is also achieved by means of the controlled level of nitrogen. A high manganese content ensures freedom from micro-fissuring in the ferrite-free weld metal.

Applications exploiting non-magnetic properties include welding of 316L fittings for **minesweepers** and **offshore downhole instrumentation collars**.

The fully austenitic microstructure gives excellent strength and toughness at cryogenic temperatures for joining 304L and 316L **LPG** and **LNG storage vessels**. Useful toughness is also maintained down to liquid helium temperatures -269°C (4°K) for superconducting applications. Impact testing procedures at this temperature are complex and expensive, with results of questionable validity. To qualify the toughness of weld metal for service at 4°K, the ASME Code Committee has proposed >0.53mm (21mils) at -196°C (77°K). This proposal is based on correlations between fracture toughness and Charpy data at these temperatures.

Unlike conventional 316L weld metal containing ferrite, which suffers preferential attack in concentrated **nitric acid**, the nil-ferrite alloy has excellent resistance and is suitable for deposition directly onto CMn steel to provide **corrosion resistant overlays**.

Microstructure

Fully austenitic.

Welding guidelines

No preheat required, and maximum interpass temperature 150°C.

Additional information

ASTM A262 practice C (Huey) corrosion test (immersion in boiling, 65%, nitric acid for five 48 hour periods): typical corrosion rates are 0.7–1.2µm/48hr (0.13–0.22mm/year). Stamicarbon requirement is 3.3µm/48hr.

Related alloy groups

The 310L and 904L alloys may also be useful for low magnetic permeability applications.

Products available

| Process | Product | Specification |
|---------|------------------------|-------------------------|
| MMA | Ultramet 316NF | BS EN E 1815 3 L R |
| | Ultramet B316NF | BS EN E 1815 3 L B |
| TIG/MIG | ER316MnNF | BS EN 20 16 3 Mn L |
| FCW | Supercore 316NF | (BS EN T 18 16 5 N L R) |

General Data for all MMA Electrodes

| Storage | <p>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.</p> <p>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.</p> | | | | | | | | | | | | | | |
|------------------|---|-----|----|------|-----|--------------------------|-----|--------------------------|---|----|-----|---|------|----|---|
| Fume data | <p>Fume composition, wt % typical:</p> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="border-bottom: 1px solid black;">Fe</th> <th style="border-bottom: 1px solid black;">Mn</th> <th style="border-bottom: 1px solid black;">Ni</th> <th style="border-bottom: 1px solid black;">Cr</th> <th style="border-bottom: 1px solid black;">Cu</th> <th style="border-bottom: 1px solid black;">F *</th> <th style="border-bottom: 1px solid black;">OES (mg/m³)</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">8</td> <td style="text-align: center;">10</td> <td style="text-align: center;">1.5</td> <td style="text-align: center;">5</td> <td style="text-align: center;"><0.2</td> <td style="text-align: center;">16</td> <td style="text-align: center;">1</td> </tr> </tbody> </table> <p>* F=28% for basic coated Ultramet B316NF but this does not affect OES.</p> | Fe | Mn | Ni | Cr | Cu | F * | OES (mg/m ³) | 8 | 10 | 1.5 | 5 | <0.2 | 16 | 1 |
| Fe | Mn | Ni | Cr | Cu | F * | OES (mg/m ³) | | | | | | | | | |
| 8 | 10 | 1.5 | 5 | <0.2 | 16 | 1 | | | | | | | | | |


ULTRAMET 316NF

All-positional rutile MMA electrode

| | | | | | | | | | | | | | |
|---|--|--------|-------------------|------|-------|-------|------------------------|-----------|-----|-------|----------|--|--|
| Product description | <p>Rutile (low silica) flux on high purity 304L core wire. Special control of residuals coupled with a high manganese content ensures freedom from microfissuring.</p> <p>Recovery is about 120% with respect to core wire, 65% with respect to whole electrode.</p> | | | | | | | | | | | | |
| Specifications | BS EN 1600 | | E 18 15 3 L R 3 2 | | | | | | | | | | |
| | BS 2926 | | 18.15.3.LMnR | | | | | | | | | | |
| | DIN 8556 | | E 18 15 3 L R 23 | | | | | | | | | | |
| | AWS A5.4 | | (E316LMn-16) | | | | Nearest classification | | | | | | |
| ASME IX Qualification | QW432 F-No -, QW442 A-No - | | | | | | | | | | | | |
| Composition (weld metal wt %) | | C | Mn | Si | S | P | Cr | Ni | Mo | Cu | N | | |
| | min | -- | 2.5 | -- | -- | -- | 16.5 | 14.0 | 2.5 | -- | 0.1 | | |
| | max | 0.04 | 4.0 | 0.9 | 0.025 | 0.030 | 19.5 | 17.0 | 3.5 | 0.5 | 0.2 | | |
| | typ | < 0.03 | 3.0 | 0.4 | 0.01 | 0.02 | 18 | 16 | 2.8 | < 0.1 | 0.15 | | |
| | Maximum magnetic permeability 1.01. | | | | | | | | | | | | |
| All-weld mechanical properties | As welded | | | | | | min | typical | | | | | |
| | Tensile strength | | | | | | MPa | 560 | 610 | | | | |
| | 0.2% Proof stress | | | | | | MPa | 300 | 430 | | | | |
| | Elongation on 4d | | | | | | % | -- | 38 | | | | |
| | Elongation on 5d | | | | | | % | 30 | 35 | | | | |
| | Reduction of area | | | | | | % | -- | 54 | | | | |
| | Impact energy | | | | | | - 196°C * | J | -- | 60 | | | |
| | Lateral expansion | | | | | | - 196°C * | mm (mils) | -- | 0.7mm | (28mils) | | |
| * Useful impact properties are maintained down to 4°K (-269°C) and exceeds proposed ASME Code recommendation. | | | | | | | | | | | | | |
| Operating parameters | DC +ve or AC (OCV: 50V min) | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | ∅ mm | | 2.5 | 3.2 | 4.0 | 5.0 | | | | | | | |
| | min A | | 60 | 75 | 100 | 130 | | | | | | | |
| max A | | 90 | 120 | 155 | 210 | | | | | | | | |
| Packaging data | ∅ mm | | 2.5 | 3.2 | 4.0 | 5.0 | | | | | | | |
| | length mm | | 300 | 350 | 350 | 350 | | | | | | | |
| | kg/carton | | 13.5 | 15.0 | 15.0 | 16.5 | | | | | | | |
| | pieces/carton | | 684 | 402 | 267 | 189 | | | | | | | |

ULTRAMET B316NF

Basic all-positional MMA pipe welding electrode

| | | | | | | | | | | | |
|---------------------------------------|--|--|-----|-----------|-------|-------|---|------|---------|----------|------|
| Product description | Basic carbonate-fluoride flux on high purity 304L core wire. Special control of residuals coupled with a high manganese to ensure freedom from microfissuring. Recovery is about 120% with respect to core wire, 65% with respect to whole electrode. | | | | | | | | | | |
| Specifications | BS EN 1600 | E 18 15 3 L B 4 2 | | | | | | | | | |
| | BS 2926 | 18.15.3.LMnB | | | | | | | | | |
| | DIN 8556 | E 18 15 3 L B 20+ | | | | | | | | | |
| | AWS A5.4 | (E316LMn-15) Nearest classification | | | | | | | | | |
| ASME IX Qualification | QW432 F-No -, QW442 A-No - | | | | | | | | | | |
| Composition (weld metal wt %) | | C | Mn | Si | S | P | Cr | Ni | Mo | Cu | N |
| | min | -- | 2.5 | -- | -- | -- | 16.5 | 14.0 | 2.5 | -- | 0.1 |
| | max | 0.04 | 4.0 | 0.9 | 0.025 | 0.030 | 19.5 | 17.0 | 3.5 | 0.5 | 0.2 |
| | typ | < 0.03 | 3.5 | 0.4 | 0.01 | 0.02 | 18 | 16 | 2.8 | < 0.1 | 0.15 |
| | Maximum magnetic permeability 1.01. | | | | | | | | | | |
| All-weld mechanical properties | As welded | | | | | | min | | typical | | |
| | Tensile strength | | | | | MPa | 560 | 610 | | | |
| | 0.2% Proof stress | | | | | MPa | 300 | 440 | | | |
| | Elongation on 4d | | | | | % | -- | 38 | | | |
| | Elongation on 5d | | | | | % | 30 | 35 | | | |
| | Reduction of area | | | | | % | -- | 50 | | | |
| | Impact energy | - 196°C * | | | | J | -- | 50 | | | |
| | Lateral expansion | - 196°C * | | mm (mils) | | | -- | 0.6 | | (24mils) | |
| | * Useful impact properties are maintained down to 4°K (-269°C) and exceeds proposed ASME Code recommendation. | | | | | | | | | | |
| Operating parameters | DC +ve | | | | | |  | | | | |
| | ø mm | 2.5 | | 3.2 | | 4.0 | | | | | |
| | min A | 60 | | 75 | | 100 | | | | | |
| | max A | 90 | | 120 | | 155 | | | | | |
| Packaging data | ø mm | 2.5 | | 3.2 | | 4.0 | | | | | |
| | length mm | 300 | | 350 | | 350 | | | | | |
| | kg/carton | 12.0 | | 13.5 | | 13.5 | | | | | |
| | pieces/carton | 678 | | 393 | | 252 | | | | | |

ER316MnNF

Non-magnetic solid wire for TIG and MIG

| | | | | | | | | | | | |
|---------------------------------------|---|------------|-------------------------------|-----------------|------|-----------------------|-----------|--------------------------|----------|------|------|
| Product description | Solid wire for TIG and MIG. | | | | | | | | | | |
| Specifications | AWS A5.9 | | ER316LMn | | | | | | | | |
| | BS EN ISO 14343-A | | 20 16 3 Mn L | | | | | | | | |
| | DIN 8556 | | SG-X2CrNiMnMoN 20 16 (1.4455) | | | | | | | | |
| ASME IX Qualification | QW432 F-No - QW442 A-No - | | | | | | | | | | |
| Composition (wire wt %) | | C | Mn | Si | S | P | Cr | Ni | Mo | Cu | N |
| | min | -- | 6.0 | 0.30 | -- | -- | 19.0 | 15.0 | 2.5 | -- | 0.12 |
| | max | 0.025 | 8.0 | 0.65 | 0.02 | 0.030 | 21.0 | 18.0 | 3.5 | 0.3 | 0.20 |
| | typ | 0.02 | 7 | 0.5 | 0.01 | 0.02 | 20 | 16 | 3 | 0.15 | 0.15 |
| | Maximum magnetic permeability 1.01. | | | | | | | | | | |
| All-weld mechanical properties | Typical values as welded | | | | | | TIG | | | | |
| | Tensile strength | | | | | | MPa | 732 | | | |
| | 0.2% Proof stress | | | | | | MPa | 527 | | | |
| | Elongation on 4d | | | | | | % | 39 | | | |
| | Elongation on 5d | | | | | | % | 34 | | | |
| | Reduction of area | | | | | | % | 68 | | | |
| | Impact energy | | | | | | - 100°C | J | 140 | | |
| | Impact energy | | | | | | - 196°C * | J | 95 | | |
| | Lateral expansion | | | | | | - 196°C * | mm (mils) | 1.0 (40) | | |
| | Hardness cap/mid | | | | | | HV | 175/220 | | | |
| | * Useful impact properties are maintained down to 4°K (-269°C) and exceeds proposed ASME Code recommendation. | | | | | | | | | | |
| Typical operating parameters | | TIG | | | | MIG | | | | | |
| | Shielding | Argon | | | | Ar+2%O ₂ * | | | | | |
| | Current | DC- | | | | DC+ | | | | | |
| | Diameter | 2.4mm | | | | 1.2mm | | | | | |
| | Parameters | 100A, 12V | | | | 260A, 26V | | | | | |
| | * Proprietary Ar and Ar-He gas mixtures with <3%CO ₂ also suitable. | | | | | | | | | | |
| Packaging data | ø mm | TIG | | | | MIG | | | | | |
| | 1.0 | -- | | | | 15kg spool | | | | | |
| | 1.2 | -- | | | | 15kg spool | | | | | |
| | 1.6 | 2.5kg tube | | | | -- | | | | | |
| | 2.4 | 2.5kg tube | | | | -- | | | | | |
| Fume data | MIG fume composition (wt %) (TIG fume negligible) | | | | | | | | | | |
| | | Fe | Mn | Cr ³ | Ni | Mo | Cu | OES (mg/m ³) | | | |
| | | 26 | 22 | 15 | 13 | 1.5 | < 0.5 | 3.3 | | | |

SUPERCORE 316NF

Rutile flux cored wire

| | | | | | | | | | | | |
|--|--|----------------------|-----|-----|-----------------|-----------------|---------------|----------|--------------------------|------|--|
| Product description | <p>Flux cored wire made with an austenitic stainless steel sheath and rutile flux system designed primarily for downhand welding.</p> <p>Metal recovery is about 90% with respect to the wire.</p> | | | | | | | | | | |
| Specifications | <p>AWS A5.22 (E316LT0-1/4) nearest equivalent BS EN ISO 17633-A (T 18 16 5 NL R C/M 3) nearest equivalent Approval TÜV</p> | | | | | | | | | | |
| ASME IX Qualification | <p>QW432 F-No -, QW442 A-No -</p> | | | | | | | | | | |
| Composition (weld metal wt %) | | C | Mn | Si | S | P | Cr | Ni | Mo | N | |
| | min | -- | 2.0 | 0.2 | -- | -- | 17.0 | 14.0 | 2.5 | 0.08 | |
| | max | 0.04 | 3.0 | 1.0 | 0.025 | 0.03 | 19.0 | 16.0 | 3.5 | 0.20 | |
| | typ | 0.03 | 2.5 | 0.4 | 0.01 | 0.025 | 18 | 15 | 3 | 0.12 | |
| <p>Maximum magnetic permeability 1.01.</p> | | | | | | | | | | | |
| All-weld mechanical properties | As welded | | | | | min | | typical | | | |
| | Tensile strength | | | | | MPa | 560 | 605 | | | |
| | 0.2% Proof stress | | | | | MPa | 300 | 410 | | | |
| | Elongation on 4d | | | | | % | 30 | 37 | | | |
| | Elongation on 5d | | | | | % | 25 | 34 | | | |
| | Impact energy | | | | | - 196°C * J | -- | 50 | | | |
| | Lateral expansion | | | | | - 196°C * mm | 0.38 (15mils) | 0.6 | | | |
| | Hardness | | | | | HV | -- | 185 | | | |
| <p>* Useful impact properties are maintained down to 4°K (-269°C) and exceeds proposed ASME Code recommendation.</p> | | | | | | | | | | | |
| Operating parameters | <p>Shielding gas: 80% Ar-20% CO₂ at 20-25l/min. Proprietary gases may be used but argon should not exceed 80%. The wire is suitable for use on 100% CO₂ with some loss of cosmetic appearance and increased spatter.</p> <p>Current: DC+ve parameters as below (for 100% CO₂ increase voltage by ~3V):</p> | | | | | | | | | | |
| | ø mm | amp-volt range | | | | typical | | stickout | | | |
| | 1.2 | 130A-25V to 280A-34V | | | | 180A-29V | | 12-20mm | | | |
| Packaging data | <p>Spools vacuum-sealed in barrier foil with cardboard carton: 12.5kg</p> <p>The as-packed shelf life is virtually indefinite.</p> <p>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.</p> <p>Where possible, preferred storage conditions are 60% RH max, 18°C min.</p> | | | | | | | | | | |
| Fume data | <p>Fume composition (wt %)</p> | | | | | | | | | | |
| | | Fe | Mn | Ni | Cr ³ | Cr ⁶ | Cu | F | OES (mg/m ³) | | |
| | | 12 | 18 | 2 | 4 | 4 | < 1 | 6 | 1.2 | | |