



**WELDING CONSUMABLES  
FOR THERMAL POWER STATIONS**

BÖHLER WELDING provides welding solutions for thermal power stations since 1927. An assortment of world class filler metals is available for the fabrication of boilers, nuclear reactors, casings for steam and gas turbines and other components. Whenever high temperature- and creep resistance are essential, BÖHLER WELDING is the competent partner and supplier.

In addition, BÖHLER WELDING offers a comprehensive range of corrosion resistant alloys, such as stainless steel and nickel base welding consumables for the construction of flue gas desulphurisation units and other applications.

Increased environmental requirements and the need for higher thermal efficiencies are driving the development of new materials for power stations. BÖHLER WELDING develops the matching filler metals in close cooperation with leading steel

manufacturers. The latest developments can always be related to state-of-the-art base material like the steel grades T/P23 and T/P24, T/P91 and T/P92.

High demanding industries call for advanced product standards, consistent product quality and best operating characteristics to guarantee safe operating conditions and extend the life of today's modern plant operations. That's why BÖHLER WELDING's high temperature and creep resisting welding consumables have achieved a leading market position. A comprehensive worldwide sales network of well-stocked partners ensures rapid and punctual delivery in more than 80 countries, on every continent.

Your nearest sales partner can be found on the Internet at [www.boehler-welding.com](http://www.boehler-welding.com)

**BÖHLER WELDING consumables are available in moisture resistant and hermetically sealed packs.**







# Selection guide

|  | Base metals<br>AISI/UNS/ASTM              | Welding processes    |                     |                |                  |                       | Page     |
|--|---|----------------------|---------------------|----------------|------------------|-----------------------|----------|
|  |   | SMAW                 | FCAW                | GTAW           | GMAW             | SAW                   |          |
| <b>Mild steels</b><br>Re ≤ 380 MPa                 | SA106A+B                                  | FOX EV 50            | Ti 52-FD            | EMK 6          | EMK 6            | EMS 2+BB 24           | 5        |
| <b>High strength steels</b><br>Re ≤ 500 MPa        | SA508 Cl.2                                | FOX EV 65            |                     |                | NiMo 1-IG        | 3 NiMo 1-UP+BB 24     | 6        |
| <b>High Temperature and creep resistant steels</b> |   |                      |                     |                |                  |                       |          |
| 0,5Mo  | P/T1                                      | FOX DMO Ti, Kb       | (DMO)               | DMO-IG         | DMO-IG           | EMS 2Mo+BB 24         | 7        |
| 1Cr 0,5Mo  | P/T11                                     | FOX DCMS Ti, Kb      | (DCMS)              | DCMS-IG        | DCMS-IG          | EMS 2 CrMo+BB 24      | 7, 8     |
| 1,25Cr 1Mo+V                                       | –   | FOX DCMV             |                     |                |                  |                       | 8        |
| 0,5Cr 1Mo +V                                       | –   | FOX DMV 83Kb         |                     | DMV 83-IG      | DMV 83-IG        |                       | 9        |
| 2,25Cr 1Mo   | P/T22                                     | FOX CM 2Kb           |                     | CM 2-IG        | CM 2-IG          | CM 2-UP+BB 24         | 9        |
| 2,25Cr 1Mo (mod.)                                  | P/T23                                     | FOX P 23             |                     | P 23-IG        |                  | P 23-UP+BB 430        | 10       |
|  | P/T24                                     | FOX P 24             |                     | P 24-IG        |                  | P 24-UP+BB 430        | 10       |
| 5Cr 0,5Mo  | P/T5                                      | FOX CM 5Kb           |                     | CM 5-IG        | CM 5-IG          | CM 5-UP+BB 24         | 11       |
| 9Cr 1Mo  | P/T9                                      | FOX CM 9Kb           |                     | C M 9-IG       |                  |                       | 11       |
| 9Cr 1Mo +V(W)                                      | P/T91                                     | FOX C 9 MV           |                     | C 9 MV-IG      | C 9 MV-IG        | C 9 MV-UP+BB 910      | 11, 12   |
|  | –   | FOX C 9 MVW          |                     | C 9 MVW-IG     | C 9 MV-MC        |                       | 12       |
|  | P/T92                                     | FOX P 92             |                     | P 92-IG        |                  | P 92-UP+BB 910        | 12, 13   |
| 12Cr 1Mo +VW                                       | –   | FOX 20 MVW           |                     | 20 MVW-IG      | CN 18/11-IG      | 20 MVW-UP+BB 24       | 13       |
| 18Cr 11Ni  | 304H                                      | FOX CN 18/11         |                     | CN 18/11-IG    |                  | CN 18/11-UP+BB 202    | 14, 15   |
|  |   | FOX E 308 H          | E 308 H-FD          | ER 308 H-IG    |                  |                       | 15       |
|  |   |                      | E 308 H PW-FD       |                |                  |                       | 15       |
| 18Cr 10Ni +Nb                                      | 347H                                      | FOX E 347 H          |                     |                |                  |                       | 15       |
| <b>Special applications</b>                        |   |                      |                     |                |                  |                       |          |
| 18Cr 8Ni Mn  | dissimilar joints, repair and maintenance | FOX A 7<br>FOX A 7-A | A 7-FD<br>A 7 PW-FD | A 7 CN-IG      | A 7-IG<br>A 7-MC | A 7 CN-UP+BB 203      | 16<br>16 |
| <b>Heat resistant</b>                              |   |                      |                     |                |                  |                       |          |
| 25Cr 4Ni   | 327                                       | FOX FA               |                     | FA-IG          | FA-IG            |                       | 17       |
| 22Cr 12Ni  | 309                                       | FOX FF<br>FOX FF-A   |                     | FF-IG          | FF-IG            |                       | 17<br>17 |
| 25Cr 20Ni  | 310                                       | FOX FFB<br>FOX FFB-A |                     | FFB-IG         | FFB-IG           |                       | 17<br>17 |
| 21Cr 33Ni Mn                                       | N08810/800H                               | FOX CN 21/33 Mn      |                     | CN 21/33 Mn-IG | CN 21/33 Mn-IG   |                       | 18       |
| <b>Nickel base alloys</b>                          |   |                      |                     |                |                  |                       |          |
| Alloy 800  | N06600                                    | FOX NIBAS 70/15      |                     |                |                  |                       | 19       |
| Alloy 600  | N06600                                    | FOX NIBAS 70/20      | NIBAS 70/20-FD      | NIBAS 70/20-IG | NIBAS 70/20-IG   | NIBAS 70/20-UP+BB 444 | 19       |
| Alloy 625  | N06625                                    | FOX NIBAS 625        | NIBAS 625-FD        | NIBAS 625-IG   | NIBAS 625-IG     | NIBAS 625-UP+BB 444   | 20       |
| Alloy 617  | N06617                                    | FOX NIBAS 617        |                     | NIBAS 617-IG   | NIBAS 617-IG     | NIBAS 617-UP+BB 444   | 20       |

# Mild steels

| BÖHLER<br>Standard<br>EN<br>AWS   | Welding<br>process | Typical<br>analysis<br><br>%       | Typical<br>mechanical<br>properties  | Sizes<br><br>mm                        | Approvals  | Characteristics and applications   | Base metals  |
|---|--------------------|------------------------------------|--|--|--|--|--|
| <b>FOX EV 50</b><br>E 42 5 B 42 H5<br>E7018-1H4R                                | SMAW               | C 0.07<br>Si 0.5<br>Mn 1.1         | Re 490 N/mm <sup>2</sup><br>Rm 560 N/mm <sup>2</sup><br>A5 27%<br>Av 190 J<br>100 J...-50 °C                               | 2.0<br>2.5<br>3.2<br>4.0<br>5.0<br>6.0 | TÜV-D,<br>DB, UZ,<br>ÖBB,<br>TÜV-A,<br>ABS, BV,<br>CL, DNV,<br>FI, GL,<br>ISPESL,<br>LR, RMR,<br>RINA,<br>UDT,<br>LTSS,<br>VUZ,<br>SEPROZ,<br>ITI, PDO,<br>CRS | Basic coated electrode engineered for high-quality welds. Excellent strength and toughness properties down to -50 °C. Metal recovery approx. 110 %. Good weldability in all position except for vertical-down. Very low hydrogen content (acc. AWS condition HD < 4 ml/100 g).<br><br>Suitable for welding steels with low purity and high carbon content. Welding in steel construction, boiler and tank manufacture, vehicle construction, shipbuilding, and machine construction as well as for buffer layers on build ups on high carbon steels. Especially suitable for off-shore construction, CODT tested at -10 °C. It can be used in sour gas applications (HIC-Test acc. NACE TM-02-84). Test values for SSC-test are available too. | Steels up to a yield strength of 420 N/mm <sup>2</sup> (60 KSI).<br><br>e.g. P235G1TH,<br>P265GH – P295GH<br>P310GH, P355T1, P355NH<br><br><b>ASTM</b> e.g.<br>SA106A + B<br>SA515 Gr.60-70<br>SA516 Gr.55-70  |
| <b>EMK 6</b><br>G3Si1(GMAW)<br>W3Si1(GTAW)<br>ER70S-6                           | GMAW<br><br>GTAW   | C 0.1<br>Si 0.9<br>Mn 1.4          | Re 440 N/mm <sup>2</sup><br>Rm 530 N/mm <sup>2</sup><br>A5 30%<br>Av 160 J<br>80 J...-40 °C<br>Ar +15-25 % CO <sub>2</sub> | 0.8<br>1.0<br>1.2<br>1.6               | TÜV-D,<br>DB, UZ,<br>ÖBB, FI,<br>TÜV-A, GL,<br>ABS, CWB,<br>LR, UDT,<br>LTSS,<br>SEPROZ  | GMAW wire and GTAW rod for joints in boiler and vessel fabrication as well as in structural steel engineering.<br><br>Thanks to the good mechanical properties this filler wire is optimally suited for welding thick-walled components.<br><br>The non copper coated version of the solid wire BÖHLER EMK 6 TOP is designed for low spatter formation and excellent feeding properties for extremely high wire feed rates. These types are especially suited for robotic welding.   |  |
| <b>Ti 52-FD</b><br>T 46 2 P M 1 H10<br>T 42 2 P C 1 H5<br>E71T-1H4<br>E71T-1MH8 | FCAW               | C 0.06<br>Si 0.5<br>Mn 1.2<br>Ti + | Re 490 N/mm <sup>2</sup><br>Rm 580 N/mm <sup>2</sup><br>A5 26%<br>Av 180 J<br>90 J...-40 °C                                | 1.2<br>1.6                             | TÜV-D,<br>TÜV-A,<br>ABS, BV,<br>DNV, GL,<br>LR, UDT,<br>CRS  | All-position rutile flux-cored wire with fast freezing slag system. User friendly welding characteristics in all positions with one wire diameter 1.2 mm and same parameter setting. Excellent mechanical properties, easy slag removal, low spatter loss, smooth, finely rippled bead surface, high X-ray safety.<br><br>The product performs to the highest productivity with significant savings in time and economical aspects when used for positional welding.   | Steels up to a yield strength of 460 N/mm <sup>2</sup> (60 KSI).<br><br>e.g. P235G1TH,<br>P265GH – P295GH,<br>P310GH, P355T1, P355NH<br><br><b>ASTM</b> e.g.<br>SA106 A+B<br>SA515 Gr.60-70<br>SA516 Gr.55-70  |
| <b>Wire: EMS 2</b><br>S2<br>EM12K<br><b>Flux: BB 24</b><br>SA FB 1 65 DC H5     | SAW                | C 0.07<br>Si 0.25<br>Mn 1.05       | Re 440 N/mm <sup>2</sup><br>Rm 520 N/mm <sup>2</sup><br>A5 33%<br>Av 185 J<br>140 J...-60 °C                               | 2.0<br>2.5<br>3.0<br>3.2<br>4.0        | TÜV-D<br>UDT<br><br><b>Wire:</b><br>TÜV-D,<br>TÜV-A,<br>UZ, DB,<br>ÖBB,<br>KTA 1408.1<br>SEPROZ  | Universally applicable for constructional steels and fine grained steels, e.g. in shipbuilding, structural steel work, and pressure vessel fabrication. The flux reacts metallurgically Mn-neutral.<br><br>The sub-arc wire/flux combination produces very good low temperature impact properties down to -60 °C. Excellent slag detachability, smooth beads, good wetting and low hydrogen contents (≤ 5 ml/100 g) are further important features. The combination is ideally suited for multi-pass welding of thick plates.  | Steels up to a yield strength of 400 N/mm <sup>2</sup> (60 KSI).<br><br>e.g. P235G1TH,<br>P265GH – P295GH,<br>P310GH, P355T1, P355NH<br><br><b>ASTM</b> e.g.<br>SA106 A+B<br>SA515 Gr.60, 65<br>SA516 Gr.55-65 |

# High strength steels

| <b>BÖHLER</b><br>Standard<br>EN<br>AWS   | <b>Welding process</b> | <b>Typical analysis</b><br><br>%                   | <b>Typical mechanical properties</b>  | <b>Sizes</b><br><br>mm | <b>Approvals</b>                           | <b>Characteristics and applications</b>  | <b>Base metals</b>  |
|--|------------------------|--|---|------------------------|--|--|---|
| <b>FOX EV 65</b><br>E 55 6 1 NiMo B 42 H5<br>E8018-GH4R                                      | SMAW                   | C 0.06<br>Si 0.3<br>Mn 1.2<br>Ni 0.8<br>Mo 0.35    | Re 600 N/mm <sup>2</sup><br>Rm 650 N/mm <sup>2</sup><br>A5 25%<br>Av 180 J<br>80 J...-60 °C   | 2.5<br>3.2<br>4.0      | TÜV-D,<br>UDT,<br>SEPROZ                   | Basic coated electrode with high ductility and crack resistance, for high-strength fine-grained steels. Ductile down to -60 °C. Resistant to ageing.<br><br>Easy to handle in all positions except vertical-down. Preheating and interpass temperature, as well as post weld heat treatment as required by the base metal.<br><br>Very low hydrogen content (acc. AWS condition HD < 4 ml/100 g).  | Constructional steels, pipe- and vessel steels, cryogenic fine-grained steels and special grades.<br><br>E295-E360, P355NL1-P460NL1, P355 NL2-P460NL2, S380N-S500N, S355NH-S460NH, S380NL-S500NL, S380NL1-S500NL1, 15NiCuMoNb5S (WB 36), 20MnMoNi5-5, 17MnMoV6-4 (WB 35), 22NiMoCr4-7<br><br>ASTM:<br>A302 Gr.A-D<br>A225 Gr.C<br>A508 Cl.2<br>A572 Gr.65 |
| <b>NiMo 1-IG</b><br>G 55 6 M Mn3Ni1Mo<br>G 55 4 C Mn3Ni1Mo<br>ER90S-G                        | GMAW                   | C 0.08<br>Si 0.6<br>Mn 1.8<br>Ni 0.9<br>Mo 0.3     | Re 620 N/mm <sup>2</sup><br>Rm 700 N/mm <sup>2</sup><br>A5 23%<br>Av 140 J<br>>47 J...-60 °C<br>(80 % Ar/20 % CO <sub>2</sub> )<br><br>Re 590 N/mm <sup>2</sup><br>Rm 680 N/mm <sup>2</sup><br>A5 25%<br>Av 120 J<br>>47 J...-40 °C<br>(100 % CO <sub>2</sub> ) | 1.0<br>1.2             | DB, UZ,<br>ÖBB,<br>GL, UDT,<br>SEPROZ      | GMAW wire for high strength, quenched and tempered fine-grained constructional steels.<br><br>The wire is suited for joint welding in boiler, pressure vessel, pipeline, and crane construction as well as in structural steel engineering.<br><br>Due to the precise addition of micro alloying elements NiMo 1-IG wire features excellent ductility and crack resistance in spite of its high strength. Good cryogenic impact energy down to -60 °C, low hydrogen contents in the deposit, best feedability and low copper contents are other advantages of this wire. Preheating and interpass temperature as required by the base metal. | Pipe steels and fine grained steels, quenched and tempered fine-grained steels.<br><br>S380N-S500N, S380NL-S500NL, S500NC-S550NC, N-A-XTRA 56-70, BHV 70, PAS 600, HSM 600, 20MnMoNi5-5<br><br>ASTM:<br>A517 Gr.A,B,C,E,F,H,J,K,M,P<br>A225 Gr.C<br>A633 Gr.E<br>A572 Gr.65   |
| <b>Wire: 3 NiMo 1-UP</b><br>SZ3Ni1Mo<br>EF3 (mod.)<br><b>Flux: BB 24</b><br>SA FB 1 65 DC H5 | SAW                    | C 0.08<br>Si 0.45<br>Mn 1.55<br>Ni 0.95<br>Mo 0.55 | Re 580 N/mm <sup>2</sup><br>Rm 650 N/mm <sup>2</sup><br>A5 21%<br>Av 180 J<br>60 J...-40 °C   | 4.0                    | TÜV-D,<br>UDT<br><br><b>Wire:</b><br>TÜV-D | SAW wire/flux combination for joint welding of high strength and low temperature steels.<br><br>The flux reacts metallurgically Mn-neutral.<br><br>The sub-arc wire/flux combination produces very good low temperature impact properties down to -40 °C. Excellent slag detachability, smooth beads, good wetting and low hydrogen contents (≤ 5 ml/100 g) are further important features.<br><br>The combination is ideally suited for multi-pass welding of thick plates.   |   |



# High temperature and creep resistant steels

| BÖHLER<br>Standard<br>EN<br>AWS   | Welding<br>process | Typical<br>analysis<br><br>%                   | Typical<br>mechanical<br>properties  | Sizes<br><br>mm                 | Approvals   | Characteristics and applications  | Base metals   |
|---|--------------------|--|--|---------------------------------|---|---|---|
| <b>FOX DMO Ti</b><br>E Mo R 12<br>–   | SMAW               | C 0.06<br>Si 0.3<br>Mn 0.6<br>Mo 0.5           | Re 500 N/mm <sup>2</sup><br>Rm 570 N/mm <sup>2</sup><br>A5 23%<br>Av 90 J                        | 2.0<br>2.5<br>3.2<br>4.0        | TÜV-D,<br>UZ,<br>TÜV-A,<br>CL, DNV,<br>BV, DB,<br>UDT,<br>Statoil,<br>RMR,<br>ÖBB, VUZ  | Rutile coated electrode for 0.5 % Mo alloyed boiler and tube steels up to +550 °C service temperature. It offers excellent striking and restriking characteristics, easy slag removal, smooth beads, AC/DC weldability and produces first class X-ray quality welds in all positions.   | S355J2G3, E295, P255G1TH, L320-L415NB, L320MB-L415MB, S255N, P235GH-P310GH, P255-P355N, P255NH-P355NH 1.5415 16Mo3<br><br>ASTM:<br>A335, Gr.P1<br>A161-94 Gr.T1<br>A182M, Gr.F1<br>A250M, Gr.T1   |
| <b>FOX DMO Kb</b><br>E Mo B 42 H5<br>E7018-A1H4R                                | SMAW               | C 0.08<br>Si 0.4<br>Mn 0.8<br>Mo 0.5           | Re 550 N/mm <sup>2</sup><br>Rm 600 N/mm <sup>2</sup><br>A5 25%<br>Av 200 J<br>≥32 J...-50 °C     | 2.5<br>3.2<br>4.0<br>5.0        | TÜV-D, UZ,<br>TÜV-A, FI,<br>ÖBB, DB,<br>ABS, DNV,<br>GL, RMR,<br>Statoil,<br>CL, LTSS,<br>UDT,<br>KTA 1408.1<br>ITI, VUZ,<br>SEPROZ | Basic coated low hydrogen electrode for 0.5 % Mo alloyed boiler and tube steels up to +550 °C service temperature. For high quality welds of long term stressed components with reliable mechanical properties under high and low service temperature conditions. HD ≤ 4 ml/100 g acc. AWS condition. Low temperature toughness proven down to -50 °C.  | S355J2G3<br>L320-L415NB<br>L320MB-L415MB, P255G1TH, P235GH-P310GH, P255NH, 1.5415 16Mo3, 1.5429 22Mo4 1.5403 17MnMoV6-4, 1.6755 22NiMoCr4-7, 1.6310 20MnMoNi5-5, 1.6368 15NiCuMoNb5, 1.6311 20MnMoNi4-5, GE240-GE300, S255N-S460N, P255NH-P460NH, ageing resistant and resistant to caustic cracking.<br><br>ASTM:<br>A335 Gr.P1<br>A217 Gr.WC1<br>A182M Gr.F1<br>A250M Gr.T1 |
| <b>DMO-IG</b><br>W Mo Si (GTAW)<br>G Mo Si (GMAW)<br>ER70S-A1                   | GTAW<br><br>GMAW   | C 0.1<br>Si 0.6<br>Mn 1.2<br>Mo 0.5            | Re 520 N/mm <sup>2</sup><br>Rm 630 N/mm <sup>2</sup><br>A5 27%<br>Av 200 J<br>≥47 J...-30 °C     | 1.6<br>2.0<br>2.4<br>3.0<br>3.2 | TÜV-D, UZ,<br>TÜV-A, FI,<br>DB, BV,<br>CL, UDT,<br>DNV,<br>KTA 1408.1<br>ÖBB, LRS   | GTAW rod and GMAW wire for 0.5 % Mo alloyed boiler and tube steels as well as in pressure vessel and structural steel engineering.<br><br>Recommended for service in the temperature range -30 °C (GTAW) or -40 °C (GMAW) up to 550 °C.   | ASTM:<br>A335 Gr.P1<br>A217 Gr.WC1<br>A182M Gr.F1<br>A250M Gr.T1  |
| <b>Wire: EMS 2 Mo</b><br>S2 Mo<br>EA2<br><b>Flux: BB 24</b><br>SA FB 1 65 DC H5 | SAW                | C 0.08<br>Si 0.25<br>Mn 1.15<br>Mo 0.45        | Re ≥470 N/mm <sup>2</sup><br>Rm ≥550 N/mm <sup>2</sup><br>A5 ≥24%<br>Av ≥140 J<br>≥47 J...-40 °C | 2.0<br>2.5<br>3.0<br>4.0        | TÜV-D, UDT<br><br><b>Wire:</b><br>TÜV-D,<br>TÜV-A, Ü,<br>DB, ÖBB,<br>KTA 1408.1<br>SEPROZ   | SAW wire/flux combination. Mainly for high temperature 0.5 % Mo alloyed steels up to service temperatures of +550 °C but also for low temperature conditions due to good toughness behaviour of the weld metal.<br>BOHLER BB 24 is metallurgically Mn-neutral and produces very good low temperature impact properties.<br><br>Low hydrogen contents (HD < 5 ml/100 g). The combination is ideally suited for multi-pass welding of thick plates. | 1.5415 16Mo3<br>P275T1-P355T1, WB25, P315NH-P420NH, P310 GH<br><br>ASTM:<br>A335 Gr.P1<br>API X52-X65   |
| <b>DMO</b><br>O IV<br>R60-G   | OAW                | C 0.12<br>Si 0.15<br>Mn 1.0<br>Mo 0.5          | Re 330 N/mm <sup>2</sup><br>Rm 470 N/mm <sup>2</sup><br>A5 24%<br>Av 60 J                        | 2.0<br>2.5<br>3.2<br>4.0        | TÜV-D, Ü,<br>ÖBB, DB,<br>SEPROZ,<br>UDT   | Mo alloyed gas welding rod recommended for mild steels and 0.5 % Mo alloyed steels. High viscous weld puddle. Easy to operate. Approved in long-term condition up to +500 °C service temperature.<br><br>Preheating and post weld heat treatment as required by the base metal.   | High temperature steels, same alloyed.<br>16Mo3, P285NH, P295NH, P255G1TH, P295GH<br><br>ASTM:<br>A335 Gr.P1<br>A36 Gr.all<br>A283 Gr.B,C,D<br>A285 Gr.B;<br>A414 Gr.C<br>A442 Gr.60<br>A515 Gr.60<br>A516 Gr.55,60<br>A570 Gr.33,36,40   |
| <b>FOX DCMS Ti</b><br>ECrMo1 R 12<br>E8013-G                                    | SMAW               | C 0.06<br>Si 0.4<br>Mn 0.6<br>Cr 1.1<br>Mo 0.5 | PWHT a 680 °C/2h<br>Re 510 N/mm <sup>2</sup><br>Rm 610 N/mm <sup>2</sup><br>A5 21%<br>Av 100 J   | 2.5<br>3.2<br>4.0               | TÜV-D,<br>UZ,<br>TÜV-A,<br>ÖBB, DB,<br>DNV, GL,<br>ABS, CL,<br>SEPROZ,<br>UDT   | Rutile coated electrode for 1 % Cr 0.5 % Mo alloyed boiler plate and tube steels up to +570 °C service temperature. Easy to operate. Fully alloyed core wire. Specifically preferred for thin walled welds and root pass welding in all positions and first class X-ray quality.  | 1.7335 13CrMo4-5<br>1.7262 15CrMo5<br>1.7728 16CrMoV4<br><br>ASTM:<br>A335 Gr.P11<br>A335 Gr.P12<br>A193 Gr.B7  |

# High temperature and creep resistant steels

| BÖHLER<br>Standard<br>EN<br>AWS   | Welding<br>process | Typical<br>analysis<br><br>%  | Typical<br>mechanical<br>properties  | Sizes<br><br>mm  | Approvals  | Characteristics and applications   | Base metals   |
|---|--------------------|---|--|--|--|--|---|
| <b>FOX DCMS Kb</b><br>E CrMo1 B 42 H5<br>E8018-B2H4R                                | SMAW               | C 0.07<br>Si 0.4<br>Mn 0.8<br>Cr 1.1<br>Mo 0.5<br>P ≤0.010<br>As ≤0.005<br>Sb ≤0.005<br>Sn ≤0.005   | PWHT a 680 °C/2h<br>Re 530 N/mm <sup>2</sup><br>Rm 630 N/mm <sup>2</sup><br>A5 23%<br>Av 160 J   | 2.5<br>3.2<br>4.0<br>5.0                                 | TÜV-D,<br>TÜV-A,<br>Ü, FI,<br>ÖBB, DB,<br>DNV, GL,<br>CL, LTSS,<br>UDT, ABS,<br>VUZ,<br>SEPROZ           | Basic coated low hydrogen electrode for 1% Cr 0.5 % Mo alloyed boiler and tube steels up to +570 °C service temperature. For high quality welds, suitable for Step-Cooling treatments, fully alloyed core wire which will provide reliable creep rupture properties for the whole service life of a boiler plant. HD ≤ 4 ml/100 g acc. AWS condition.  | 1.7335 13CrMo4-5<br>1.7262 15CrMo5<br>1.7728 16CrMoV4<br>1.7357 G17CrMo5-5<br>1.7354 G22CrMo5-4<br><br>Furthermore: Steels resistant to caustic cracking, quenched and tempered steels up to 780 N/mm <sup>2</sup> tensile strength, case hardening and nitriding steels.<br><br>ASTM:<br>A335 Gr.P11<br>A335 Gr.P12<br>A193 Gr.B7<br>A217 Gr.WC6 |
| <b>DCMS-IG</b><br>W CrMo1 Si (GTAW)<br>G CrMo1 Si (GMAW)<br>ER80S-G                 | GTAW<br><br>GMAW   | C 0.11<br>Si 0.6<br>Mn 1.0<br>Cr 1.2<br>Mo 0.5<br>P ≤0.012<br>As ≤0.010<br>Sb ≤0.005<br>Sn ≤0.006   | PWHT a 680 °C/2h<br>Re 490 N/mm <sup>2</sup><br>Rm 590 N/mm <sup>2</sup><br>A5 25%<br>Av 250 J<br><br>Re 460 N/mm <sup>2</sup><br>Rm 570 N/mm <sup>2</sup><br>A5 23%<br>Av 150 J | 1.6<br>2.0<br>2.4<br>3.0<br><br>0.8<br>1.0<br>1.2<br>1.6 | TÜV-D,<br>TÜV-A, FI,<br>UDT,<br>SEPROZ<br><br>TÜV-D, UZ,<br>TÜV-A,<br>DB, CL, FI,<br>ÖBB, UDT,<br>SEPROZ | GTAW rod and GMAW wire for 1% Cr 0.5 % Mo alloyed boiler and tube steels up to +570 °C service temperature. Suitable for Step-Cooling treatments (GTAW). The weld metal meets all prerequisites for reliable long term creep properties without embrittlement due to very low content of trace elements.   |   |
| <b>Wire: EMS 2 CrMo</b><br>S CrMo1<br>EB2<br><b>Flux: BB 24</b><br>SA FB 1 65 DC H5 | SAW                | C 0.08<br>Si 0.25<br>Mn 1.0<br>Cr 1.0<br>Mo 0.45<br>P ≤0.012<br>As ≤0.005<br>Sb ≤0.005<br>Sn ≤0.005 | PWHT a 680 °C/2h<br>Re ≥460 N/mm <sup>2</sup><br>Rm ≥550 N/mm <sup>2</sup><br>A5 ≥22%<br>Av ≥47 J  | 2.5<br>3.0<br>4.0  | TÜV-D,<br>UDT<br><br><b>Wire:</b><br>TÜV-D,<br>TÜV-A,<br>SEPROZ  | SAW wire/flux combination for 1% Cr 0.5 % Mo alloyed boiler and tube steels up to +570 °C service temperature. Suitable for Step-Cooling treatments. The weld metal meets all pre-requisites for reliable long term creep properties without embrittlement due to very low content of trace elements.<br><br>BÖHLER BB 24 is metallurgically Mn-neutral and produces very good lowtemperature impact properties. Low hydrogen contents (HD < 5 ml/100 g). The combination is ideally suited for multi pass welding of thick plates.  |   |
| <b>DCMS</b><br>0 V<br>R65-G   | OAW                | C 0.12<br>Si 0.15<br>Mn 0.9<br>Cr 1.0<br>Mo 0.5   | PWHT a 680 °C/2h<br>Re ≥315 N/mm <sup>2</sup><br>Rm ≥490 N/mm <sup>2</sup><br>A5 ≥18%<br>Av ≥47 J  | 2.5<br>3.0   | TÜV-D,<br>UDT,<br>SEPROZ   | CrMo-alloyed gas welding rod for high temperature boiler and tube steels equivalent to 13CrMo4-5 (1.25 % Cr 0.5 % Mo). Approved in long-term condition up to +500 °C service temperature.<br><br>High viscous weld puddle.<br><br>Wall thicknesses over 6 mm should be preheated to 100-200 °C and tempered at 660-700 °C for at least 30 minutes followed by cooling in still air.  |   |
| <b>FOX DCMV</b><br>E ZCrMoV1 B 42 H5<br>E 9018-G                                    | SMAW               | C 0.12<br>Si 0.35<br>Mn 0.9<br>Cr 1.35<br>Mo 1.0<br>V 0.22  | PWHT a 680 °C/8h<br>Re 680 N/mm <sup>2</sup><br>Rm 770 N/mm <sup>2</sup><br>A5 19%<br>Av 90 J  | 4.0<br>5.0   | TÜV-D,<br>LTSS,<br>UDT,<br>SEPROZ  | Basic coated electrode for highly stressed joint and production welds on G17CrMoV5-10 type high temperature cast steel used in the construction of steam turbines and valve casings. Approved in long-term condition up to +600 °C service temperature.<br><br>High creep rupture strength thanks to the C, Cr, Mo and V-content. High fracture toughness, low hydrogen content, good welding characteristics. The deposit is heat treatable. Metal recovery approx. 115 %.<br><br>Preheat and interpass temperatures 300-350 °C, stress relieving >20 °C below the tempering temperature of the cast steel, but not less than 680 °C. | Similar alloyed high temperature steels and cast steels<br><br>1.7706 G17CrMoV5-10  |



# High temperature and creep resistant steels

| BÖHLER<br>Standard<br>EN<br>AWS  | Welding<br>process | Typical<br>analysis<br><br>%   | Typical<br>mechanical<br>properties   | Sizes<br><br>mm          | Approvals   | Characteristics and applications  | Base metals   |
|--|--------------------|--|---|--------------------------|---|---|---|
| <b>FOX DMV 83 Kb</b><br>E MoV B 42 H5<br>E9018-G                                 | SMAW               | C 0.05<br>Si 0.4<br>Mn 1.1<br>Cr 0.4<br>Mo 0.9<br>V 0.5  | PWHT a 720°C/2h<br>Re 510 N/mm <sup>2</sup><br>Rm 660 N/mm <sup>2</sup><br>A5 22%<br>Av 200 J     | 2.5<br>3.2<br>4.0        | TÜV-D,<br>TÜV-A,<br>UDT,<br>SEPROZ  | Basic coated core wire alloyed stick electrode with special suitability for 0.5 Cr 1 Mo-steels. Approved in long-term condition up to 580 °C service temperature. Crack resistant and ductile deposit, low hydrogen content. Good weldability in all positions except vertical down. Metal recovery approx. 115%. Preheating and interpass temperature 200-300 °C. PWHT at 700-720 °C min. 2 hrs, cooling in furnace down to 300 °C and still air.  | High temperature steels and similar alloyed cast steels.<br><br>1.7715 14MoV6-3<br>1.7733 24CrMoV5-5<br>1.7709 21CrMoV5-7<br>1.8070 21CrMoV5-11<br>1.7706 G17CrMoV5-10<br><br>ASTM:<br>A389 Gr.C23/C24<br>A405 Gr.P24<br><br>UNS:<br>I21610 |
| <b>DMV 83-IG</b><br>W MoV Si (GTAW)<br>G MoV Si (GMAW)<br>ER80S-G                | GTAW<br><br>GMAW   | C 0.08<br>Si 0.6<br>Mn 0.9<br>Cr 0.45<br>Mo 0.85<br>V 0.35   | PWHT a 700 °C/2h<br>Re 520 N/mm <sup>2</sup><br>Rm 670 N/mm <sup>2</sup><br>A5 24%<br>Av 220 J    | 2.4                      | TÜV-D,<br>TÜV-A,<br>UDT, LTSS,<br>SEPROZ  | GTAW rod and GMAW wire for boiler, plate and tube steels. Designed specially for 14MoV6-3 (0.5 Cr 0.5 Mo 0.25 V). Approved in long-term condition up to +560 °C service temperature. Tough, cracking resistant deposit with good creep rupture strength. The wire shows very good feeding characteristics, resulting in smooth welding and wetting behaviour.   |   |
|  |                    | C 0.08<br>Si 0.6<br>Mn 0.9<br>Cr 0.45<br>Mo 0.85<br>V 0.35   | Re 610 N/mm <sup>2</sup><br>Rm 710 N/mm <sup>2</sup><br>A5 20%<br>Av 80 J                         | 1.2                      | TÜV-D,<br>TÜV-A,<br>UDT,<br>SEPROZ  | Preheating and interpass temperatures 200-300 °C. PWHT at 700-720 °C for at least 2 hrs followed by cooling in furnace down to 300 °C and still air.  |   |
| <b>FOX CM 2 Kb</b><br>E CrMo2 B 42 H5<br>E9018-B3H4R                             | SMAW               | C 0.07<br>Si 0.3<br>Mn 0.8<br>Cr 2.3<br>Mo 1.0<br>P ≤0.010<br>As ≤0.005<br>Sb ≤0.005<br>Sn ≤0.005    | PWHT a 720 °C/2h<br>Re 510 N/mm <sup>2</sup><br>Rm 640 N/mm <sup>2</sup><br>A5 22%<br>Av 180 J    | 2.5<br>3.2<br>4.0<br>5.0 | TÜV-D,<br>UZ,<br>TÜV-A, FI,<br>DB, DNV,<br>CL, UDT,<br>ABS, GL,<br>ÖBB,<br>SEPROZ,<br>VUZ | Basic coated electrode for 2,25 % Cr 1 % Mo alloyed boiler and tube steels up to +600 °C service temperature. For high quality welds suitable for Step-Cooling treatments, alloyed core wire which will provide reliable creep rupture properties for the whole service life of a boiler plant. HD ≤ 4 ml/100 g acc. AWS condition. Preheating and interpass temperature 200-350 °C. PWHT at 700-750 °C min. 2 hrs, cooling in furnace down to 300 °C and still air.  | 1.7380 10CrMo9-10<br>1.8075 10CrSiMoV7<br>1.7379 G17CrMo9-10<br><br>High temperature steels and similar alloyed cast steels, similar alloyed case hardening steels, nitriding steels.   |
| <b>CM 2-IG</b><br>W CrMo2 Si (GTAW)<br>G CrMo2 Si (GMAW)<br>ER90S-G              | GTAW<br><br>GMAW   | C 0.06<br>Si 0.7<br>Mn 1.1<br>Cr 2.6<br>Mo 1.0<br>P ≤0.010<br>As ≤0.010<br>Sb ≤0.005<br>Sn ≤0.006    | PWHT a 720 °C/2h<br>Re 470 N/mm <sup>2</sup><br>Rm 600 N/mm <sup>2</sup><br>A5 23%<br>Av 190 J    | 1.6<br>2.0<br>2.4<br>3.0 | TÜV-D,<br>TÜV-A,<br>CL, UDT,<br>SEPROZ,<br>FI   | GTAW rod and GMAW wire for 2,25 % Cr 1 % Mo alloyed boiler and tube steels up to +600 °C service temperature. BÖHLER CM 2-IG (GTAW) meets the requirements for Step-Cooling. The weld metal meets all prerequisites for reliable long term creep properties without embrittlement due to very low content of trace elements.  | ASTM:<br>A335 Gr.P22<br>A217 Gr.WC9   |
|  |                    | C 0.07<br>Si 0.25<br>Mn 0.80<br>Cr 2.30<br>Mo 0.95<br>P ≤0.012<br>As ≤0.015<br>Sb ≤0.005<br>Sn ≤0.01 | Re 440 N/mm <sup>2</sup><br>Rm 580 N/mm <sup>2</sup><br>A5 23%<br>Av 170 J                        | 0.8<br>1.0<br>1.2        | TÜV-D,<br>TÜV-A,<br>FI, UDT,<br>SEPROZ  | Preheating and interpass temperatures 200-350 °C. PWHT at 700-750 °C for at least 2 hrs followed by cooling in furnace down to 300 °C and still air.  |   |
| <b>Wire: CM 2-UP</b><br>S CrMo2<br>EB3<br><b>Flux: BB 24</b><br>SA FB 1 65 DC H5 | SAW                | C 0.07<br>Si 0.25<br>Mn 0.80<br>Cr 2.30<br>Mo 0.95<br>P ≤0.012<br>As ≤0.015<br>Sb ≤0.005<br>Sn ≤0.01 | PWHT a 720 °C/2h<br>Re ≥460 N/mm <sup>2</sup><br>Rm ≥530 N/mm <sup>2</sup><br>A5 ≥22%<br>Av ≥47 J | 2.5<br>3.0<br>4.0        | TÜV-D,<br>UDT<br><br><b>Wire:</b><br>TÜV-D,<br>TÜV-A,<br>KTA 1408.1<br>SEPROZ             | SAW wire/flux combination for 2.25 % Cr 1 % Mo alloyed boiler and tube steels up to +600 °C service temperature. Particularly for cracking plants in the crude oil industry. Suitable for Step-Cooling treatments, Bruscato ≤ 15 ppm. The weld metal meets all pre-requisites for reliable long term creep properties without embrittlement due to very low content of trace elements. BÖHLER BB 24 is metallurgically Mn-neutral. Preheat, interpass and PWHT temperature are determined by the base material. | 1.7380 10CrMo9-10<br><br>ASTM:<br>A335 Gr.P22   |

# High temperature and creep resistant steels

| <b>BÖHLER</b><br>Standard<br>EN<br>AWS                                   | <b>Welding process</b> | <b>Typical analysis</b><br><br>%  | <b>Typical mechanical properties</b>   | <b>Sizes</b><br><br>mm                 | <b>Approvals</b> | <b>Characteristics and applications</b>  | <b>Base metals</b>                             |
|--|------------------------|---|--|--|------------------|--|--|
| <b>FOX P 23</b><br>E ZCrWV2 1.5 B 42 H5<br>E9018-G                       | SMAW                   | C 0.06<br>Si 0.2<br>Mn 0.5<br>Cr 2.3<br>W 1.5<br>V 0.22<br>Nb 0.04                      | PWHT a 740°C/2h<br>Re 520 N/mm <sup>2</sup><br>Rm 620 N/mm <sup>2</sup><br>A5 19%<br>Av 130 J      | 2.5<br>3.2<br>4.0                      | TÜV              | Basic coated core wire alloyed stick electrode for welding bainitic steels such as P23/T23 (ASTM A213, code case 2199), pipe material.<br><br>For high quality welds, which will provide reliable creep rupture properties for the whole service life of a boiler plant. Preheat and interpass temperature depends on wall thickness. PWHT at 740 °C for 2 hrs.                  | HCM2S, P/T23<br>(ASTM A213 code case 2199)     |
| <b>P 23-IG</b><br>W ZCrWV2<br>ER90S-G                                    | GTAW                   | C 0.07<br>Si 0.3<br>Mn 0.5<br>Cr 2.2<br>W 1.7<br>V 0.22<br>Nb 0.05<br>N 0.01<br>B 0.002 | PWHT a 740°C/2h<br>Re 450 N/mm <sup>2</sup><br>Rm 585 N/mm <sup>2</sup><br>A5 17%<br>Av 120 J      | 1.0<br>1.2<br>1.6<br>2.0<br>2.4<br>3.2 | TÜV              | For manual or automatic GTAW-welding of creep resistant steels such as HCM2S (P23/T23 acc. to ASTM A 213 code case 2199), pipe or tube material.<br><br>Preheat and interpass temperature depends on wall thickness. PWHT at 740 °C for 2 hrs.   |  |
| <b>Wire: P 23-UP</b><br>S ZCrWV2<br><b>Flux: BB 430</b><br>SA FB 1 55 AC | SAW                    | C 0.05<br>Si 0.27<br>Mn 0.9<br>Cr 2.05<br>W 1.6<br>V 0.20<br>Nb 0.04<br>N 0.01          | PWHT a 740 °C/2h<br>Re ≥450 N/mm <sup>2</sup><br>Rm ≥600 N/mm <sup>2</sup><br>A5 ≥15%<br>Av ≥100 J | 2.0<br>2.5<br>3.0                      | TÜV              | Böhler P 23-UP is a matching filler metal for welding high temperature and creep resistant steels such as HCM2S (P23/T23 acc. to ASTM A213 code case 2199), pipe or tube material. Preheat and interpass temperature: 200-300 °C. Heat input ≤ 2.0 kJ/mm. BB 430 is an agglomerated welding flux of the fluoride-basic type with high basicity (2.9).                            |  |
| <b>FOX P 24</b><br>E Z CrMoVNbB21 B 42 H5<br>E9018-G                     | SMAW                   | C 0.08<br>Si 0.4<br>Mn 0.5<br>Cr 2.4<br>Mo 1.0<br>V 0.22<br>Nb 0.03<br>B 0.003          | PWHT a 740°C/2h<br>Re 560 N/mm <sup>2</sup><br>Rm 660 N/mm <sup>2</sup><br>A5 18%<br>Av 100 J      | 2.5<br>3.2<br>4.0                      | TÜV              | Basic coated core wire alloyed stick electrode for welding bainitic steels like 7CrMoVTiB10-10 (P24/T24 acc. to ASTM A 213 Draft).<br><br>For high quality welds, which will provide reliable creep rupture properties for the whole service life of a boiler plant.<br><br>Preheat and interpass temperature depends on wall thickness. PWHT at 740 °C for 2 hrs.               | 7CrMoVTiB10-10, P/T24 acc. to ASTM A213 Draft. |
| <b>P 24-IG</b><br>W ZCrMoV2  | GTAW                   | C 0.05<br>Si 0.3<br>Mn 0.5<br>Cr 2.2<br>Mo 1.0<br>V 0.22<br>Ti 0.05<br>B 0.003          | PWHT a 740°C/2h<br>Re 540 N/mm <sup>2</sup><br>Rm 620 N/mm <sup>2</sup><br>A5 15%<br>Av 120 J      | 1.0<br>1.2<br>1.6<br>2.0<br>2.4<br>3.2 | TÜV              | For manual or automatic GTAW-welding of creep resistant steels such as 7CrMoVTiB10-10 (P24/T24 acc. to ASTM A 213 Draft), pipe or tube material.<br><br>Preheat and interpass temperature depends on wall thickness. PWHT at 740 °C for 2 hrs.   |  |
| <b>Wire: P 24-UP</b><br>S ZCrWV2<br><b>Flux: BB 430</b><br>SA FB 1 55 AC | SAW                    | C 0.06<br>Si 0.2<br>Mn 0.7<br>Cr 2.2<br>Mo 1.0<br>V 0.22<br>Ti 0.027<br>B 0.003         | PWHT a 740 °C/2h<br>Re 500 N/mm <sup>2</sup><br>Rm 620 N/mm <sup>2</sup><br>A5 15%<br>Av 100 J     | 2.0<br>2.5<br>3.0                      | TÜV              | Böhler P 24-UP is a matching filler metal for welding high temperature and creep resistant steels such as 7CrMoVTiB10-10 (P24/T24 acc. to ASTM A213 Draft). Böhler B 430 is an agglomerated welding flux of the fluoride-basic type with high basicity (2.9). Grain size: EN 760: 3-16 (0.3 – 1.6 mm). Preheating and interpass temperature: 200-300 °C. Heat input ≤ 2.0 kJ/mm. |  |

# High temperature and creep resistant steels

| BÖHLER<br>Standard<br>EN<br>AWS  | Welding<br>process | Typical<br>analysis<br><br>%   | Typical<br>mechanical<br>properties   | Sizes<br><br>mm          | Approvals   | Characteristics and applications  | Base metals  |
|--|--------------------|--|---|--------------------------|---|---|--|
| <b>FOX CM 5 Kb</b><br>E CrMo5 B 42 H5<br>E8018-B6H4R                             | SMAW               | C 0.07<br>Si 0.4<br>Mn 0.8<br>Cr 5.0<br>Mo 0.5                               | PWHT a 730°C/2h<br>Re 520 N/mm <sup>2</sup><br>Rm 620 N/mm <sup>2</sup><br>A5 21%<br>Av 90 J      | 2.5<br>3.2<br>4.0        | TÜV-D,<br>TÜV-A,<br>CLL, UDT,<br>LTSS, VUZ,<br>SEPROZ | Basic coated core wire alloyed stick electrode, preferably used for X12CrMo5 (5 Cr 0.5 Mo) steels. Approved in long-term condition up to +650 °C service temperature. High crack resistance, very low hydrogen content (acc. AWS condition HD < 4 ml/100 g). Good weldability in all positions except vertical down. The deposit is heat treatable. Metal recovery approx. 115 %. Preheat and interpass temperatures 300-350 °C. PWHT at 730-760 °C for at least 1 hour followed by cooling in furnace down to 300 °C and still air.  | High temperature steels and similar alloyed cast steels.<br><br>1.7362 X12CrMo5<br>1.7363 GX12CrMo5<br><br>ASTM:<br>A213, Gr.T5<br>A217, Gr.C5<br>A335, Gr.P5        |
| <b>CM 5-IG</b><br>W CrMo5 Si (GTAW)<br>G CrMo5 Si (GMAW)<br>ER80S-B6             | GTAW<br><br>GMAW   | C 0.08<br>Si 0.4<br>Mn 0.5<br>Cr 5.8<br>Mo 0.6                               | PWHT a 730 °C/2h<br>Re 510 N/mm <sup>2</sup><br>Rm 620 N/mm <sup>2</sup><br>A5 20%<br>Av 200 J    | 1.6<br>2.0<br>2.4<br>3.0 | TÜV-D,<br>TÜV-A,<br>UDT,<br>SEPROZ                    | GTAW rod and GMAW wire for 5 % Cr 0.5 % Mo steels and steels for hot hydrogen service, particularly for application in oil refineries and the base metals X12CrMo5 / P5. Approved in long-term condition up to +600 °C (GTAW 650 °C) service temperature.<br><br>The GMAW wire shows very good feeding characteristics, resulting in smooth welding and flow behaviour. Uniform copper bonding with low total copper content.<br>Preheating and interpass temperatures 300-350 °C. Tempering at 730-760 °C at least 1 hr followed by cooling in furnace down to 300 °C and still air.   |  |
| <b>Wire: CM 5-UP</b><br>S CrMo5<br>EB6<br><b>Flux: BB 24</b><br>SA FB 1 65 DC H5 | SAW                | C 0.05<br>Si 0.5<br>Mn 0.75<br>Cr 5.5<br>Mo 0.55                             | PWHT a 740 °C/4h<br>Re ≥450 N/mm <sup>2</sup><br>Rm ≥590 N/mm <sup>2</sup><br>A5 ≥18%<br>Av ≥47 J | 4.0                      | UDT<br><br><b>Wire:</b><br>TÜV-D,<br>TÜV-A,<br>SEPROZ | SAW wire/flux combination suited for 5 % Cr 0.5 % Mo alloyed steels, particularly for hot hydrogen service. High temperature strength at service temperatures up to +600 °C. The weld deposit exhibits good mechanical properties. Easy slag detachability and smooth bead surface are additional quality features. Preheating, interpass temperature and PWHT are determined by the base metal.  |  |
| <b>FOX CM 9 Kb</b><br>E CrMo9 B 42 H5<br>E8018-B8                                | SMAW               | C 0.07<br>Si 0.4<br>Mn 0.7<br>Cr 9.0<br>Mo 1.0                               | PWHT a 760°C/1h<br>Re 610 N/mm <sup>2</sup><br>Rm 730 N/mm <sup>2</sup><br>A5 20%<br>Av 70 J      | 2.5<br>3.2<br>4.0        | TÜV-D,<br>TÜV-A,<br>UDT,<br>VUZ,<br>SEPROZ            | Basic coated alloyed core wire electrode for high temperature steels and steels for hot hydrogen service, particularly in the petrochemical industry. Preferably used for 9 % Cr 1 % Mo steels (e.g. X12CrMo9-1 Approved in long-term condition up to +650 °C service temperature.<br><br>The weld metal is heat treatable. Metal recovery approx. 115 %.<br><br>Preheating and interpass temperatures 250-350 °C. PWHT at 710-760 °C for at least 1 hr followed by cooling in furnace down to 300 °C and still air.  | Similar alloyed creep resistant steels.<br><br>1.7386 X12CrMo9-1<br>1.7388 X7CrMo9-1<br>1.7389 GX12CrMo10-1<br><br>ASTM:<br>A217 Gr.C12<br>A234 Gr.WP9<br>A335 Gr.P9 |
| <b>CM 9-IG</b><br>W CrMo9 Si<br>ER80S-B8   | GTAW               | C 0.07<br>Si 0.5<br>Mn 0.5<br>Cr 9.0<br>Mo 1.0                               | PWHT a 760°C/2h<br>Re 530 N/mm <sup>2</sup><br>Rm 670 N/mm <sup>2</sup><br>A5 24%<br>Av 250 J     | 1.6<br>2.0<br>2.4        | TÜV-D,<br>TÜV-A,<br>SEPROZ                            | GTAW rod for 9 % Cr 1 % Mo high temperature steels and steels for hot hydrogen service, particularly for application in oil refineries and the base metals X12CrMo9-1 (P9). Approved in long-term condition up to +600 °C service temperature. Preheating and interpass temperature 250-350 °C. Tempering at 710-760 °C for at least 1 hr followed by cooling in furnace down to 300 °C/air.  |  |
| <b>FOX C 9 MV</b><br>E CrMo91 B 42 H5<br>E9015-B9                                | SMAW               | C 0.09<br>Si 0.3<br>Mn 0.5<br>Cr 9.0<br>Mo 0.9<br>Ni 0.9<br>V 0.2<br>Nb 0.05 | PWHT a 760 °C/2h<br>Re 500 N/mm <sup>2</sup><br>Rm 720 N/mm <sup>2</sup><br>A5 19%<br>Av 60 J     | 2.5<br>3.2<br>4.0<br>5.0 | TÜV-D,<br>CL, UDT,<br>SEPROZ                          | Basic coated core wire alloyed, for creep resisting, heat treatable 9 Cr steels (P/T91) in turbine and boiler construction as well as in the chemical industry. Service temperatures up to +650 °C. High creep rupture strength and very good toughness under long term stress. Low hydrogen content (< 4 ml/100 g acc. AWS condition).<br><br>Preheating and interpass temperatures 200-300 °C. After welding the joint should be cooled down below 80 °C to finish martensite formation. PWHT at 760 °C for at least 2 hrs, max. 10 hrs. Heating and cooling rates up to 550 °C max. 150 °C/h, above 550 °C max. 80 °C.<br><br>For optimised toughness values a welding technology should be applied which produces thin welding layers (approx. 2 mm). | 1.4903 X10CrMoVNb9-1<br><br>ASTM:<br>A335 Gr.P91<br>A213 Gr.T91<br>A199 Gr.T91   |

# High temperature and creep resistant steels

| BÖHLER<br>Standard<br>EN<br>AWS  | Welding<br>process   | Typical<br>analysis<br><br>%  | Typical<br>mechanical<br>properties  | Sizes<br><br>mm                     | Approvals                     | Characteristics and applications   | Base metals   |
|--|----------------------|---|--|-------------------------------------|-------------------------------|--|---|
| <b>C 9 MV-IG</b><br><br>W CrMo91<br>G CrMo91<br><br>ER90S-B9   | GTAW<br><br><br>GMAW | C 0.12<br>Si 0.3<br>Mn 0.5<br>Cr 9.0<br>Mo 0.9<br>Ni 0.7<br>V 0.2<br>Nb 0.05                    | PWHT a 760 °C/2h<br>Re 660 N/mm <sup>2</sup><br>Rm 760 N/mm <sup>2</sup><br>A5 17%<br>Av 55 J  | 2.0<br>2.4<br>3.0<br><br>1.0<br>1.2 | TÜV-D,<br>CL,<br>UDT<br><br>- | GTAW rod and GMAW wire for high temperature, creep resistant martensitic 9-12 % chromium steels. Especially designed for the ASTM steels P/T91. Approved in long-term condition up to +650 °C service temperature. Preheating and interpass temperature 200-300 °C. After welding, the weld joint should cool down below 80 °C to finish the martensite transformation. In case of greater wall thickness or complex components the possibility of residual stresses must be considered. The following post weld heat treatment is recommended: annealing 760 °C/min. 2 hrs, max. 10 hrs, heating and cooling rates below 550 °C max. 150 °C/hr, above 550 °C max. 80 °C/hr. For optimised toughness values a welding technology should be applied which produces thin welding layers (approx. 2 mm).  | 1.4903 X10CrMoVNb9-1<br><br>ASTM:<br>A335 Gr.P91<br>A213 Gr.T91<br>A199 Gr.T91                                      |
| <b>C 9 MV-MC</b><br><br>T CrMo91<br><br>EC90S-B9   | GMAW                 | C 0.10<br>Si >0.3<br>Mn 0.6<br>Cr 9.0<br>Mo 1.0<br>Ni 0.7<br>V 0.2<br>Nb 0.055<br>N 0.04        | PWHT a 760 °C/3h<br>Re 690 N/mm <sup>2</sup><br>Rm 760 N/mm <sup>2</sup><br>A5 18%<br>Av 60 J<br><br>Shielding gas:<br>Ar +2.5 % CO <sub>2</sub> | 1.2                                 | -                             | Metal cored wire for high temperature, creep resistant martensitic 9-12 % chromium steels. Especially designed for the ASTM steels P/T91. For optimised toughness values a welding technology should be applied which produces thin welding layers (approx. 2 mm), also a decisive influence on toughness values is given by the used shielding gas. Our recommendation is Ar +2.5 % CO <sub>2</sub> . Preheating and interpass temperature 200-300 °C. After welding, the weld joint should cool down below 80 °C to finish the martensite transformation. In case of greater wall thickness or complex components the possibility of residual stresses must be considered. The following post weld heat treatment is recommended: annealing 760 °C/min. 2 hrs, max. 10 hrs, heating and cooling rates below 550 °C max. 150 °C/hr, above 550 °C max. 80 °C/hr.   |   |
| <b>Wire: C 9 MV-UP</b><br><br>S CrMo91<br><br>EB9<br><br><b>Flux: BB 910</b><br><br>SA FB 2 55 DC H5 | SAW                  | C 0.11<br>Si 0.3<br>Mn 0.6<br>Cr 9.0<br>Mo 0.8<br>Ni 0.7<br>V 0.2<br>Nb 0.05                    | PWHT a 760 °C/2h<br>Re 610 N/mm <sup>2</sup><br>Rm 740 N/mm <sup>2</sup><br>A5 20%<br>Av 40 J  | 2.5<br>3.0                          | TÜV-D,<br>UDT, CL,<br>SEPROZ  | Sub-arc wire/flux combination suited for creep resistant 9 % Cr steels, especially for T91/P91 acc. ASTM A335. Approved in long-term condition up to +650 °C service temperature. The wire and flux are precisely balanced to consistently meet the highest technical requirements. Preheating and interpass temperature 200-300 °C. After welding the joint should cool down below 80 °C in order to finish the martensitic transformation. Pipe welds with wall thickness up to 45 mm can be cooled down to room temperature. For heavier wall thicknesses or stressed components, unfavourable possible stress condition must be considered. The recommended post weld heat treatment is annealing after welding at 760 °C/min. 2 hrs, max. 10 hrs, heating/cooling-rates below 550 °C max. 150 °C/hr, above 550 °C max 80 °C/hr. For optimised toughness properties a technology which ensures thin welding layers is recommended. |   |
| <b>FOX C 9 MVW</b><br><br>E ZCrMoWV911 B 42 H5<br><br>E9015-B9(mod.)                                 | SMAW                 | C 0.1<br>Si 0.25<br>Mn 0.7<br>Cr 8.5<br>Mo 1.0<br>Ni 0.7<br>W 1.0<br>V 0.2<br>N 0.05<br>Nb 0.05 | PWHT a 760 °C/2h<br>Re 560 N/mm <sup>2</sup><br>Rm 720 N/mm <sup>2</sup><br>A5 15%<br>Av 40 J  | 3.2<br>4.0<br>5.0                   | TÜV-D,<br>UDT,<br>SEPROZ      | Basic coated core wire alloyed Cr-Mo-Ni-V-W-Nb-electrode for the welding of high temperature martensitic steels like e.g. X11CrMoWVNb9-1-1 (P/T911). Approved in long-term condition up to +650 °C service temperature. Good welding properties in all positions except vertical down. Preheating and interpass temperature 200-300 °C. After welding the joint should be cooled down below 80 °C to finish the martensite transformation. In case of greater wall thickness or complex components the possibility of residual stresses must be considered. The following post weld heat treatment is recommended: annealing 760 °C/min. 2 hrs, max. 10 hrs, heating and cooling rates up to 550 °C max. 150 °C/h, above 550 °C max. 80 °C/h. For optimised toughness values a welding technology should be applied which produces thin welding layers (approx. 2 mm).   | Similar alloyed creep resistant steels.<br><br>1.4905 X11CrMoWVNb9-1-1<br><br>ASTM:<br>A335 Gr.P911<br>A213 Gr.T911 |



# High temperature and creep resistant steels

| <b>BÖHLER</b><br>Standard<br>EN<br>AWS  | <b>Welding<br/>process</b> | <b>Typical<br/>analysis</b><br><br>%   | <b>Typical<br/>mechanical<br/>properties</b>   | <b>Sizes</b><br><br>mm | <b>Approvals</b>         | <b>Characteristics and applications</b>   | <b>Base metals</b>  |
|---|----------------------------|--|--|------------------------|--------------------------|---|---|
| <b>C 9 MVW-IG</b><br>W ZCrMoWVNb911<br>ER90S-B9(mod.)   | GTAW                       | C 0.11<br>Si 0.35<br>Mn 0.45<br>Cr 9.0<br>Ni 0.75<br>Mo 0.98<br>V 0.2<br>Nb 0.06<br>W 1.05<br>N 0.07 | PWHT a 760 °C/2h<br>Re 660 N/mm <sup>2</sup><br>Rm 790 N/mm <sup>2</sup><br>A5 16%<br>Av 50 J  | 2.0<br>2.4             | TÜV-D,<br>UDT            | GTAW-rod for high temperature, creep resistant martensitic 9 % chromium steels, especially designed for the steel P/T911 according to ASTM A335. Approved in long-term condition up to +650 °C service temperature. Preheating and interpass temperature 200-300 °C. After welding the joint should be cooled down below 80 °C to finish the martensite transformation. In case of greater wall thickness or complex components the possibility of residual stresses must be considered. The following post weld heat treatment is recommended: annealing 760 °C/min. 2 hrs, max. 10 hrs, heating and cooling rates below 550 °C max. 150 °C/h, above 550 °C max. 80 °C/hr. For optimised toughness values a welding technology should be applied which produces thin welding layers (approx. 2 mm).  | Similar alloyed creep resistant steels.<br><br>1.4905 X11CrMoWVNb9-1-1<br><br>ASTM:<br>A335 Gr.P911<br>A213 Gr.T911 |
| <b>FOX P 92</b><br>E ZCrMoWVNb9<br>0.5 2 B 42 H5<br>E9015-B9(mod.)                                    | SMAW                       | C 0.10<br>Si 0.3<br>Mn 0.7<br>Cr 9.1<br>Mo 0.55<br>Ni 0.7<br>W 1.7<br>V 0.2<br>N 0.045<br>Nb 0.05    | PWHT a 760 °C/2h<br>Re 690 N/mm <sup>2</sup><br>Rm 810 N/mm <sup>2</sup><br>A5 19%<br>Av 55 J  | 3.2<br>4.0             | TÜV-D,<br>UDT,<br>SEPROZ | Basic coated Cr-Mo-Ni-V-W-Nb alloyed electrode suited for welding of high temperature steel 9 % Cr-1.5 % W-Mo-Nb-N (P92, NF616). Approved in long-term condition up to +650°C service temperature. The stick electrode features a stable arc, good striking and re-striking properties, low spatter loss and an easy removable slag. Preheating and interpass temperature 200-300 °C. After welding the joint should cool down below 80 °C, to finish the martensite transformation. The following post-weld heat treatment is recommended: Annealing 760 °C/min. 2 hours, max. 10 hours, heating/cooling rate up to 550 °C max. 150 °C/h, above 550 °C max. 80 °C/h. In case of heat treatments less than 2 hours the requirements have to be proved by a procedure test. For optimised toughness values a welding technology should be applied which produces thin welding layers (approx. 2 mm). | Similar alloyed creep resistant steels.<br><br>NF 616<br><br>ASTM:<br>A335 Gr.P92 (T92)<br>A213/213M Gr.T92         |
| <b>P 92-IG</b><br>W ZCrMoWVNb9 0.5 2<br>ER90S-B9(mod.)  | GTAW<br>G                  | C 0.10<br>Si 0.4<br>Mn 0.4<br>Cr 8.6<br>Ni 0.6<br>Mo 0.4<br>V 0.2<br>Nb 0.05<br>W 1.5<br>N 0.05      | PWHT a 760 °C/2h<br>Re 710 N/mm <sup>2</sup><br>Rm 820 N/mm <sup>2</sup><br>A5 19%<br>Av 77 J<br><br>PWHT a 760 °C/6h<br>Re 650 N/mm <sup>2</sup><br>Rm 770 N/mm <sup>2</sup><br>A5 20%<br>Av 70 J | 2.0<br>2.4             | TÜV-D,<br>UDT            | GTAW rod especially designed for the welding of a 9 % Cr 1.5 % W Mo-Nb-N / P92, NF616-steels. Approved in long-term condition up to +650 °C service temperature. Preheating and interpass temperature 200-300 °C. After welding the joint should cool down below 80 °C to finish the martensite transformation. In case of greater wall thickness or complex components the possibility of residual stresses must be considered. The following postweld heat treatment is recommended: annealing 760 °C/min. 2 hours, max. 10 hours, heating/cooling rate below 550 °C max. 150 °C/h, above 550 °C max. 80 °C/h. In case of heat treatments less than 2 hours the requirements have to be proved by a procedure test. For optimised toughness values a welding technology should be applied which produces thin welding layers (approx. 2 mm).  |   |
| <b>Wire: P 92-UP</b><br>S ZCrMoWVNb9 0.5 1.5<br>EB9 (mod.)<br><b>Flux: BB 910</b><br>SA FB 2 55 DC H5 | SAW                        | C 0.09<br>Si 0.45<br>Mn 0.4<br>Cr 8.6<br>Ni 0.6<br>Mo 0.35<br>W 1.5<br>V 0.2<br>Nb 0.04              | PWHT: 760°C/2h<br>Re 660 N/mm <sup>2</sup><br>Rm 780 N/mm <sup>2</sup><br>A5 20%<br>Av 60 J  | 3.0                    | TÜV-D,<br>UDT            | SAW wire/flux combination designed for 9 % Cr creep resistant steel, especially for P92/NF616. Approved in long-term condition up to +650 °C service temperature. Preheating and interpass temperature 200-300 °C. After welding the joint should cool down below 80 °C in order to finish the martensite transformation. Pipe welds with wall thickness up to 45 mm can be cooled down to room temperature. For heavier wall thicknesses or stressed components, unfavourable possible stress condition must be considered. The recommended post weld heat treatment is annealing at 760 °C/min. 2 hrs, max. 10 hrs., heating/cooling rates below 550 °C max. 150 °C/hr, above 550 °C max 80 °C/h. For optimised toughness properties a technology which ensures thin welding layers is recommended.   |   |

# High temperature and creep resistant steels

| <b>BÖHLER</b><br>Standard<br>EN<br>AWS                                      | <b>Welding process</b> | <b>Typical analysis</b><br>%   | <b>Typical mechanical properties</b>  | <b>Sizes</b><br>mm       | <b>Approvals</b>  | <b>Characteristics and applications</b>   | <b>Base metals</b>   |
|---|------------------------|--|---|--------------------------|---|---|--|
| <b>FOX 20 MVW</b><br>E CrMoWV12 B 42 H5<br>–                                | SMAW                   | C 0.18<br>Si 0.3<br>Mn 0.6<br>Cr 11.0<br>Mo 1.0<br>V 0.3<br>W 0.5<br>Ni 0.6    | PWHT a 760 °C/4h<br>Re 610 N/mm <sup>2</sup><br>Rm 800 N/mm <sup>2</sup><br>A5 18%<br>Av 45 J     | 2.5<br>3.2<br>4.0<br>5.0 | TÜV-D, UZ,<br>TÜV-A, CL,<br>DB, LTSS,<br>UDT,<br>KTA 1408.1<br>SEPROZ,<br>ÖBB | <p>Basic coated, core wire alloyed electrode for high temperature, heat treatable 12 % chromium steels in turbine and boiler construction as well as in the chemical industry. Preferably used for X20CrMoV12-1. Approved in long-term condition up to +650 °C service temperature.</p> <p>High creep rupture strength and excellent toughness under long-term stresses. Optimum chemical composition ensures a high quality weld metal. Low hydrogen content (HD &lt; 5 ml/100 g). Good weldability in all positions except vertical down. The weld metal deposit is heat treatable. Metal recovery approx. 115 %.</p> <p>Preheating and interpass temperatures 400-450 °C (austenitic welding) or 250-300 °C (martensitic welding). Root passes should principally be welded in the martensitic range. Lower preheat and interpass temperatures are possible, yet must be approved by practical welding tests and process qualification tests.</p> <p>After welding cooling down to 90±10 °C, followed by tempering at 720-760 °C for three minutes/mm wall thickness (at least for 2 hours). Tempering, if specified, at 1050 °C for 0.5 hour/oil and annealing at 760 °C for 2 hours.</p> | 1.4922 X20CrMoV12-1<br>1.4935 X20Cr MoWV12-1<br>1.4923 X22CrMoV12-1<br>1.4913 X19CrMoVNb11-1<br>1.4931 GX22CrMoV12-1 |
| <b>20 MVW-IG</b><br>W CrMoWV12Si<br>–                                       | GTAW                   | C 0.21<br>Si 0.4<br>Mn 0.6<br>Cr 11.3<br>Mo 1.0<br>V 0.3<br>W 0.45             | PWHT a 760 °C/2h<br>Re 610 N/mm <sup>2</sup><br>Rm 780 N/mm <sup>2</sup><br>A5 18%<br>Av 60 J     | 2.0<br>2.4               | TÜV-D, Ü,<br>TÜV-A, DB<br>CL, UDT,<br>KTA 1408.1<br>SEPROZ,<br>ÖBB            | <p>GTAW rod for creep resistant, quenched and tempered 12 % Cr steels in turbine and boiler fabrication and in the chemical industry. Preferably used for the base metal X20CrMoV12-1. Approved in long-term condition up to +650 °C service temperature. The deposit exhibits high creep rupture strength and good toughness properties under long term stresses. Preheating and interpass temperatures 400-450 °C (austenitic welding) or 250-300 °C (martensitic welding). Root passes should principally be welded in the martensitic range. Lower preheat and interpass temperatures are possible, yet must be approved by practical welding tests and process qualification tests. After welding cooling down to 90±10 °C, followed by tempering at 720-760 °C for three minutes/mm wall thickness (at least for 2 hours). Tempering, if specified, at 1050 °C for 0.5 hour/oil and annealing at 760 °C for 2 hours.</p>  |  |
| <b>Wire: 20 MVW-UP</b><br>CrMoWV12<br><b>Flux: BB24</b><br>SA FB 2 65 DC H5 | SAW                    | C 0.16<br>Si 0.3<br>Mn 0.8<br>Cr 10.3<br>Mo 0.85<br>Ni 0.4<br>W 0.45<br>V 0.25 | PWHT a 760 °C/4h<br>Re ≥550 N/mm <sup>2</sup><br>Rm ≥660 N/mm <sup>2</sup><br>A5 ≥15%<br>Av ≥47 J | 3.0                      | TÜV-D,<br>KTA 1408.1,<br>TÜV-A,<br>SEPROZ                                     | <p>SAW wire/flux combination suited for analogous and similar creep resistant steels in turbine and steam boiler construction as well as in the chemical industry. Approved in long-term condition up to +650 °C service temperature. Preheating and interpass temperature 400-450 °C (austenitic welding) or 250-300 °C (martensitic welding). Root passes should principally be welded in the martensitic range. Lower preheat and interpass temperatures are possible, yet must be approved by practical welding tests and process qualification tests. After welding cooling to 90±10 °C, followed by tempering at 760 °C for three minutes/mm wall thickness at least for 2 hours. Tempering, if specified, at 1050 °C for 0.5 hour/oil and annealing at 760 °C for 2 hours. Further details on the welding technology available on request.</p>   |  |
| <b>FOX CN 18/11</b><br>E 19 9 B 42 H5<br>E308-15                            | SMAW                   | C 0.05<br>Si 0.3<br>Mn 1.3<br>Cr 19.0<br>Ni 10.3                               | Re 420 N/mm <sup>2</sup><br>Rm 580 N/mm <sup>2</sup><br>A5 40%<br>Av 85 J                         | 2.5<br>3.2<br>4.0        | TÜV-D,<br>TÜV-A,<br>KTA 1408.1<br>UDT,<br>LTSS, CL,<br>SEPROZ                 | <p>Basic coated, core wire alloyed electrode with controlled delta ferrite content (3-8 FN) for austenitic CrNi steels with increased carbon contents (e.g. 1.4948 / 304H), in the boiler, reactor and turbine fabrication. Approved in long-term condition up to +700 °C service temperature (300 °C in the case of wet corrosion). Resistant to hot cracking, scaling and corrosion. Excellent weldability in all positions except vertical down. Preheating is not required, only in case of wall thickness above 25 mm preheat up to 150 °C. Interpass temperature should not exceed 200 °C. Also suitable for German material no. 1.4550 and 1.4551, which are approved for temperatures up to 550 °C.</p>   | 1.4948 X6CrNi18-11<br>1.4949 X3CrNi18-11<br><br>AISI:<br>304H<br>(321H)<br>(347H)                                    |

# High temperature and creep resistant steels

| BÖHLER<br>Standard<br>EN<br>AWS   | Welding<br>process | Typical<br>analysis<br><br>%                                | Typical<br>mechanical<br>properties  | Sizes<br><br>mm   | Approvals                                  | Characteristics and applications  | Base metals   |
|---|--------------------|---|--|-------------------|--|---|---|
| <b>CN 18/11-IG</b><br>W 19 9 H (GTAW)<br>G 19 9 H (GMAW)<br>ER19-10H                  | GTAW               | C 0.05<br>Si 0.6<br>Mn 1.4<br>Cr 18.8<br>Ni 9.8             | Re 420 N/mm <sup>2</sup><br>Rm 620 N/mm <sup>2</sup><br>A5 40%<br>Av 150 J<br>≥32 J...-10 °C | 2.0<br>2.4<br>3.0 | TÜV-D,<br>TÜV-A,<br>KTA 1408.1,<br>CL, UDT | GTAW rod and GMAW wire with controlled ferrite content (3-8 FN). For austenitic CrNi steels with increased carbon contents (e.g. 1.4948 / 304H), in the boiler, reactor and turbine fabrication. Approved in long-term condition up to +700 °C service temperature (300 °C in the case of wet corrosion). Preheating is not required, only in case of wall thickness above 25 mm preheat up to 150 °C. Interpass temperature should not exceed 200 °C. Steels to German material no. 1.4550 and 1.4551 which are approved for the high temperature range up to 550 °C, can also be welded.  |   |
|   | GMAW               | C 0.05<br>Si 0.6<br>Mn 1.4<br>Cr 18.8<br>Ni 9.8             | Re 400 N/mm <sup>2</sup><br>Rm 580 N/mm <sup>2</sup><br>A5 38%<br>Av 120 J<br>≥32 J...-10 °C | 1.2               | TÜV-D,<br>CL, UDT,<br>SEPROZ               |   |   |
| <b>Wire: CN 18/11-UP</b><br>S 19 9 H<br>ER19-10H<br><b>Flux: BB 202</b><br>SA FB 2 DC | SAW                | C 0.05<br>Si 0.55<br>Mn 1.2<br>Cr 18.4<br>Ni 9.3            | Re ≥320 N/mm <sup>2</sup><br>Rm ≥550 N/mm <sup>2</sup><br>A5 ≥35%<br>Av ≥80 J                | 3.0               | UDT  | SAW wire/flux combination for high quality joint weld on high temperature austenitic CrNi-steels at service temperature up to 700 °C (300 °C in the case of wet corrosion). The controlled ferrite content (3-8 FN) ensures hot cracking resistance. The deposit is insusceptible to sigma phase embrittlement. Preheating is not required, only in case of wall thickness above 25 mm preheat up to 150 °C. The interpass temperature should not exceed 200 °C. Steels to German material no. 1.4550 and 1.4551 which are approved for the high temperature range up to 550 °C, can also be welded.  |   |
| <b>FOX E 308 H</b><br>E 19 9 H R 42 H5<br>E308H-16                                    | SMAW               | C 0.05<br>Si 0.6<br>Mn 0.7<br>Cr 19.4<br>Ni 10.4            | Re 420 N/mm <sup>2</sup><br>Rm 580 N/mm <sup>2</sup><br>A5 40%<br>Av 75 J                    | 2.5<br>3.2<br>4.0 | UDT,<br>SEPROZ                             | Rutile-basic coated, core wire alloyed electrode for the use of high temperature CrNi austenitic steel for service temperatures up to 700 °C. Specially designed for the base metal AISI 304H (V. no. 1.4948). Controlled ferrite content of 3-8 FN. The deposit is less susceptible to embrittlement and is scaling resistant. Excellent weldability in all position except vertical down. Preheating is not required, only in case of wall thickness above 25 mm preheat up to 150 °C. Interpass temperature should not exceed 200 °C.  | Similar alloyed creep resistant steels.<br><br>1.4948 X6CrNi18-11<br>1.4878 X12CrNiTi18-9<br><br>AISI:<br>304<br>304H<br>(321H)<br>(347H) |
| <b>ER 308 H-IG</b><br>W 19 9 H<br>ER308H  | GTAW               | C 0.06<br>Si 0.4<br>Mn 1.7<br>Cr 20.0<br>Ni 9.5<br>Mo 0.2   | Re ≥350 N/mm <sup>2</sup><br>Rm ≥550 N/mm <sup>2</sup><br>A5 ≥35%<br>Av ≥70 J                | 1.6<br>2.0<br>2.4 | -  | GTAW rod for high quality joints for the use of high temperature CrNi austenitic steel for service temperatures up to 700 °C. Specially designed for the base metal AISI 304H (V. No. 1.4948). Controlled ferrite content of 3-8 FN. The deposit is less susceptible to embrittlement and is scaling resistant.   |   |
| <b>E 308 H-FD</b><br>T Z 19 9 H R M (C) 3<br>E308HT0-4/-1                             | FCAW               | C 0.06<br>Si 0.5<br>Mn 1.1<br>Cr 19.4<br>Ni 10.1            | Re ≥390 N/mm <sup>2</sup><br>Rm ≥585 N/mm <sup>2</sup><br>A5 ≥42%<br>Av ≥80 J                | 1.2               | UDT  | Flux cored wire with rutile slag characteristic for GMAW of austenitic CrNi steels like 1.4948 / AISI 304H. This wire is designed mainly for downhand and horizontal welding positions. The weld metal is suitable for service temperatures up to approx. 700 °C. This product achieves high productivity and is easy to operate achieving excellent welding characteristics, almost no spatter formation and temper discoloration, smooth weld finish and safe penetration. Increased travel speeds as well as little demand for cleaning and pickling provide considerable savings in time and money. The weld deposit is scaling resistant and because of the controlled low delta ferrite content (3-8 FN) less susceptible to embrittlement. BÖHLER E 308 H PW-FD is a rutile flux cored welding wire with fast freezing slag providing excellent positional welding characteristics and fast travel speeds. |   |
| <b>E 308 H PW-FD</b><br>T Z 19 9 H P M (C) 1<br>E308HT1-4/-1                          | FCAW               | C 0.06<br>Si 0.5<br>Mn 1.1<br>Cr 19.4<br>Ni 10.1            | Re ≥390 N/mm <sup>2</sup><br>Rm ≥585 N/mm <sup>2</sup><br>A5 ≥42%<br>Av ≥90 J                | 1.2               | -  | Flux cored wire with rutile slag characteristic for GMAW of austenitic CrNi steels like 1.4948 / AISI 304H. This wire is designed mainly for downhand and horizontal welding positions. The weld metal is suitable for service temperatures up to approx. 700 °C. This product achieves high productivity and is easy to operate achieving excellent welding characteristics, almost no spatter formation and temper discoloration, smooth weld finish and safe penetration. Increased travel speeds as well as little demand for cleaning and pickling provide considerable savings in time and money. The weld deposit is scaling resistant and because of the controlled low delta ferrite content (3-8 FN) less susceptible to embrittlement. BÖHLER E 308 H PW-FD is a rutile flux cored welding wire with fast freezing slag providing excellent positional welding characteristics and fast travel speeds. |   |
| <b>FOX E 347 H</b><br>E 19 9 Nb B<br>E347-15  | SMAW               | C 0.05<br>Si 0.3<br>Mn 1.3<br>Cr 19.0<br>Ni 10.0<br>Nb ≥8xC | Re 440 N/mm <sup>2</sup><br>Rm 620 N/mm <sup>2</sup><br>A5 35%<br>Av 85 J                    | 2.5<br>3.2<br>4.0 | -  | Basic coated, core wire alloyed electrode for the use of high temperature CrNi austenitic steel for service temperatures exceeding 400 °C. Specially designed for the base metal AISI 347H. Controlled ferrite content of 3-8 FN. The deposit is less susceptible to embrittlement and is scaling resistant.  | AISI:<br>321H<br>347H   |

# Special applications

| BÖHLER<br>Standard<br>EN<br>AWS   | Welding<br>process | Typical<br>analysis<br><br>%                             | Typical<br>mechanical<br>properties  | Sizes<br><br>mm                 | Approvals  | Characteristics and applications   | Base metals   |
|---|--------------------|--|--|---------------------------------|--|--|---|
| <b>FOX A 7</b><br>E 18 8 Mn B 22<br>E307-15(mod.)                                       | SMAW               | C 0.1<br>Si 0.7<br>Mn 6.5<br>Cr 18.8<br>Ni 8.8           | Re 460 N/mm <sup>2</sup><br>Rm 660 N/mm <sup>2</sup><br>A5 38%<br>Av 90 J<br>≥32 J...-110 °C   | 2.5<br>3.2<br>4.0<br>5.0<br>6.0 | TÜV-D,<br>DNV, GL,<br>UDT,<br>LTSS,<br>PRS, VUZ,<br>SEPROZ | Basic resp. rutile basic coated stainless steel electrodes. Very popular for numerous applications. The weld deposit offers exceptionally high ductility and elongation together with crack resistance. There is no fear of embrittlement when operating between -110 °C and +850 °C and can be PWHT without any problems. The deposit will work harden and offers good resistance against cavitation. Ductility is good even after high dilution when welding problem steels or when subjected to thermal shock or scaling. An excellent alloy providing cost effective performance.  | For fabrication, -repair and maintenance!<br><br>Dissimilar joints, tough buffer and intermediate layers prior to hardfacing, 14 % manganese steels, 13-17 % Cr heat resistant steels, armour plates, high carbon and quenched & tempered steels, surfacing of gears, valves, turbine blades etc. |
| <b>FOX A 7-A</b><br>EZ 18 9 Mn Mo R 32<br>E307-16(mod.)                                 | SMAW               | C 0.1<br>Si 1.2<br>Mn 4.2<br>Cr 19.5<br>Ni 8.5<br>Mo 0.7 | Re 520 N/mm <sup>2</sup><br>Rm 720 N/mm <sup>2</sup><br>A5 35%<br>Av 75 J<br>≥32 J...-100 °C   | 2.5<br>3.2<br>4.0<br>5.0        | TÜV-D,<br>UDT,<br>SEPROZ                                   | BÖHLER FOX A7-A is suitable for both AC and DC.  |   |
| <b>A 7 CN-IG</b><br>W 18 8 Mn<br>ER307(mod.)  | GTAW               | C 0.08<br>Si 0.9<br>Mn 7.0<br>Cr 19.2<br>Ni 9.0          | Re 460 N/mm <sup>2</sup><br>Rm 660 N/mm <sup>2</sup><br>A5 38%<br>Av 120 J<br>≥32 J...-110 °C  | 1.6<br>2.0<br>2.4<br>3.0        | TÜV-D,<br>DNV, GL,<br>UDT                                  | GTAW rod and GMAW wire. Very popular stainless steel wires for numerous applications. The weld deposit offers exceptionally high ductility and elongation together with crack resistance. There is no fear of embrittlement when operating between -110 °C and +850 °C and can be PWHT without any problems. The deposit will work harden and offers good resistance against cavitation. Ductility is good even after high dilution when welding problem steels or when subjected to thermal shock or scaling. An excellent alloy providing cost effective performance.  |   |
| <b>A 7-IG</b><br>G 18 8 Mn<br>ER307(mod.)   | GMAW               | C 0.08<br>Si 0.9<br>Mn 7.0<br>Cr 19.2<br>Ni 9.0          | Re 430 N/mm <sup>2</sup><br>Rm 640 N/mm <sup>2</sup><br>A5 36%<br>Av 110 J<br>≥32 J...-110 °C  | 0.8<br>1.0<br>1.2<br>1.6        | TÜV-D,<br>DB, UDT,<br>Ü, ÖBB,<br>SEPROZ                    |  |   |
| <b>A 7-MC</b><br>T 18 8 Mn MM1<br>EC307(mod.)   | GMAW               | C 0.10<br>Si 0.6<br>Mn 6.3<br>Cr 18.8<br>Ni 9.2          | Re 400 N/mm <sup>2</sup><br>Rm 600 N/mm <sup>2</sup><br>A5 42%<br>Av 70 J<br>30 J...-110 °C<br><br>Shielding gas:<br>Ar +2.5 % CO <sub>2</sub> | 1.2                             | -  | Metal cored wire of type T 18 8 Mn/ EC307 for numerous applications. The weld metal offers exceptionally high ductility and elongation together with outstanding crack resistance. There is no fear of embrittlement when operating down to service temperatures of -110 °C or above +500 °C. The scaling resistance goes up to +850 °C. When working at service temperatures above +650 °C please contact the supplier. The weld metal can be post weld heat treated without any problems. The deposit will work harden and offers good resistance against cavitation. Ductility is good even after high dilution when welding problem steels or when subjected to thermal shock or scaling. An excellent alloy providing cost effective performance, excellent welding characteristics, smooth almost spatter free weld finish. The wider arc, in comparison to solid wire, will reduce the risk of lack of fusion and is less sensitive against misalignment of edges and different gap widths. |   |
| <b>A 7-FD</b><br>T 18 8 MnRM (C) 3<br>E307T0-G  | FCAW               | C 0.1<br>Si 0.8<br>Mn 6.8<br>Cr 19.0<br>Ni 9.0           | Re 420 N/mm <sup>2</sup><br>Rm 630 N/mm <sup>2</sup><br>A5 39%<br>Av 60 J<br>≥32 J...-100 °C   | 1.2<br>1.6                      | -  | Rutile flux cored welding wire. These products achieve high productivity and are easy to operate achieving excellent welding characteristics, self releasing slag, almost no spatter formation and temper discolouration, smooth weld finish and safe penetration. The weld deposit offers exceptionally high ductility and elongation together with crack resistance. There is no fear of embrittlement when operating between -100 °C and +850 °C and can be PWHT without any problems.  |   |
| <b>A 7 PW-FD</b><br>T 18 8 MnPM (C) 2<br>E307T1-G                                       | FCAW               | C 0.1<br>Si 0.8<br>Mn 6.8<br>Cr 19.0<br>Ni 9.0           | Re 420 N/mm <sup>2</sup><br>Rm 630 N/mm <sup>2</sup><br>A5 39%<br>Av 60 J<br>≥32 J...-100 °C   | 1.2                             | -  | A7 PW-FD is a rutile flux cored welding wire with fast freezing slag providing positional welding characteristics and fast travel speeds.  |   |
| <b>Wire: A 7 CN-UP</b><br>S 18 8 Mn<br>ER307(mod.)<br><b>Flux: BB 203</b><br>SA FB 2 DC | SAW                | C 0.08<br>Si 0.9<br>Mn 6.8<br>Cr 18.5<br>Ni 8.8          | Re ≥390 N/mm <sup>2</sup><br>Rm ≥620 N/mm <sup>2</sup><br>A5 ≥36%<br>Av ≥95 J<br><br>≥40 J...-100 °C   | 3.0                             | UDT<br><br><b>Wire:</b><br>TUV-D                           | SAW wire/flux combination for numerous applications. BÖHLER A 7 CN-UP / BB 203 yields a weld deposit offering exceptionally high ductility and elongation together with outstanding crack resistance. There is no fear of embrittlement when operating down to service temperatures of -100 °C or above 500 °C. The scaling resistance goes up to 850 °C. When working at service temperatures above 650 °C please contact the supplier. The weld metal can be post weld heat treated without any problems. The deposit will work harden and offers good resistance against cavitation. Ductility is good even after high dilution when welding problem steels or when subjected to thermal shock or scaling. An excellent alloy providing cost effective performance. Preheating and post weld heat treatment as required by the base metal. BÖHLER BB 203 is a fluoride-basic, agglomerated flux providing good operating characteristics, smooth beads and a low hydrogen weld metal.           |   |



# Heat resistant

| BÖHLER<br>Standard<br>EN<br>AWS                                     | Welding<br>process | Typical<br>analysis<br><br>%                     | Typical<br>mechanical<br>properties  | Sizes<br><br>mm          | Approvals                            | Characteristics and applications   | Base metals  |
|---|--------------------|--|--|--------------------------|--------------------------------------|--|--|
| <b>FOX FA</b><br>E 25 4 B 22  | SMAW               | C 0.1<br>Si 0.5<br>Mn 1.2<br>Cr 25.0<br>Ni 5.4   | Re 520 N/mm <sup>2</sup><br>Rm 680 N/mm <sup>2</sup><br>A5 22%<br>Av 45 J  | 2.5<br>3.2<br>4.0        | UDT,<br>SEPROZ                       | Basic coated core wire alloyed electrode for heat resistant steels and service temperatures up to +1100 °C. An excellent product when increased resistance against reducing and oxidizing, sulphur containing gases is required. Can also be used for the capping of joint welds which have been carried out with higher nickel alloyed filler metals (e.g. FOX FF-A, FOX FFB) where better joint toughness is required. Preheating and interpass temperatures 200-400 °C, depending on the relevant base metal and material thickness.  | Ferritic-Austenitic:<br>1.4821 X20CrNiSi25-4<br>1.4823*) GX40CrNiSi27-4<br><br>Ferritic-Perlitic:<br>1.4713 X10CrAl7<br>1.4724 X10CrAl13<br>1.4742 X10CrAl18<br>1.4762 X10CrAl25<br>1.4710*) X30CrSi6<br>1.4740*) GX40CrSi17 |
| <b>FA-IG</b><br>W 25 4 (GTAW)<br>G 25 4 (GMAW)<br>—                 | GTAW<br><br>GMAW   | C 0.08<br>Si 0.8<br>Mn 1.2<br>Cr 25.7<br>Ni 4.5  | Re 540 N/mm <sup>2</sup><br>Rm 710 N/mm <sup>2</sup><br>A5 22%<br>Av 70 J  | 2.4                      | UDT                                  | GTAW rod and GMAW wire for heat resistant steels and service temperatures up to +1100 °C. An excellent product when increased resistance against reducing and oxidizing, sulphur containing gases is required. Also for the capping of joints which have been welded with higher nickel alloyed filler metals (e.g. FF-IG, FFB-IG) where better joint toughness is required. Preheating and interpass temperatures 200-400 °C, depending on the relevant base metal and material thickness.  | *) limited weldability<br><br>AISI:<br>327<br><br>ASTM:<br>A297HC  |
| <b>FOX FF</b><br>E 22 12 B 22<br>E309-15(mod.)                      | SMAW               | C 0.1<br>Si 1.0<br>Mn 1.1<br>Cr 22.5<br>Ni 11.5  | Re 440 N/mm <sup>2</sup><br>Rm 600 N/mm <sup>2</sup><br>A5 35%<br>Av 80 J  | 2.5<br>3.2<br>4.0        | TÜV-D,<br>TÜV-A,<br>UDT,<br>SEPROZ   | Basic coated resp. rutile coated (FOX FF-A) alloyed-core wire electrodes for welding analogous, heat resistant rolled, forged and cast steels as well as heat resistant ferritic CrSiAl steels, e.g. in annealing plants, hardening plants, steam boiler construction, the crude oil industry and the ceramics industry. For weld joints exposed to reducing, sulphurous gases, the final layer has to be deposited by means of FOX FA, or FA-IG. Scaling resistant up to +1000 °C. Preheating and interpass temperatures for ferritic steels 200-300 °C.  | Austenitic:<br>1.4828 X15CrNiSi20-12<br>1.4826 GX40CrNiSi22-9<br>1.4833 X7CrNi23-14<br><br>Ferritic-Perlitic:<br>1.4713 X10CrAl7<br>1.4724 X10CrAl13<br>1.4742 X10CrAl18<br>1.4710*) GX30CrSi6<br>1.4740*) GX40CrSi17        |
| <b>FOX FF-A</b><br>E 22 12 R 32<br>E309-17                          | SMAW               | C 0.1<br>Si 0.8<br>Mn 1.0<br>Cr 22.5<br>Ni 12.5  | Re 460 N/mm <sup>2</sup><br>Rm 610 N/mm <sup>2</sup><br>A5 37%<br>Av 60 J  | 2.5<br>3.2<br>4.0        | TÜV-D,<br>UDT, ABS,<br>SEPROZ        | For weld joints exposed to reducing, sulphurous gases, the final layer has to be deposited by means of FOX FA, or FA-IG. Scaling resistant up to +1000 °C. Preheating and interpass temperatures for ferritic steels 200-300 °C.   | *) limited weldability   |
| <b>FF-IG</b><br>W 22 12 H (GTAW)<br>G 22 12 H (GMAW)<br>ER309(mod.) | GTAW<br><br>GMAW   | C 0.08<br>Si 1.1<br>Mn 1.6<br>Cr 23.0<br>Ni 12.5 | Re 480 N/mm <sup>2</sup><br>Rm 620 N/mm <sup>2</sup><br>A5 34%<br>Av 110 J | 1.6<br>2.0<br>2.4        | TÜV-A,<br>UDT,<br>SEPROZ             | GTAW rod and GMAW wire for analogous, heat resisting rolled, forged and cast steels as well as for heat resisting, ferritic CrSiAl steels, e.g. in annealing shops, hardening shops, steam boiler construction, the crude oil industry and the ceramics industry. Austenitic deposited with a ferrite content of approx. 8 %. Preferably used for applications involving the attack of oxidizing gases. The final layer of joint welds in CrSiAl steels exposed to sulphurous gases must be deposited by means of FOX FA or FA-IG. Scaling resistance up to +1000 °C. Preheating and interpass temperatures for ferritic steels 200-300 °C.  | AISI:<br>305<br><br>ASTM:<br>A297HF  |
| <b>FOX FFB</b><br>E 25 20 B 22<br>E310-15 (mod.)                    | SMAW               | C 0.11<br>Si 0.6<br>Mn 3.5<br>Cr 26.0<br>Ni 20.5 | Re 420 N/mm <sup>2</sup><br>Rm 600 N/mm <sup>2</sup><br>A5 36%<br>Av 100 J | 2.5<br>3.2<br>4.0<br>5.0 | TÜV-D,<br>UDT,<br>Statoil,<br>SEPROZ | Basic coated resp. rutile coated (FOX FFB-A) alloyed-core wire electrode for analogous, heat resisting rolled, forged and cast steels e.g. in annealing plants, hardening plants, steam boiler construction, the crude oil industry and the ceramics industry. Joint welds in heat resisting CrSiAl steels exposed to sulphurous gases should be given a final layer deposited by means of FOX FA. Scaling resistant up to +1200 °C. Cryogenic resistance down to -196 °C. The service temperature range between + 650 and +900 °C should be avoided owing to the risk of embrittlement. Preheating and interpass temperatures for ferritic steels 200-300 °C.   | Austenitic:<br>1.4841 X15CrNiSi25-20<br>1.4845 X12CrNi25-21<br>1.4828 X15CrNiSi20-12<br>1.4840 GX15CrNi25-20<br>1.4846 GX40CrNi25-21<br>1.4826 GX40CrNiSi22-9  |
| <b>FOX FFB-A</b><br>E 25 20 R 32<br>E310-16                         | SMAW               | C 0.12<br>Si 0.5<br>Mn 2.2<br>Cr 26.0<br>Ni 20.5 | Re 430 N/mm <sup>2</sup><br>Rm 620 N/mm <sup>2</sup><br>A5 35%<br>Av 75 J  | 2.0<br>2.5<br>3.2<br>4.0 | Statoil,<br>UDT,<br>SEPROZ,<br>VUZ   | Cryogenic resistance down to -196 °C. The service temperature range between + 650 and +900 °C should be avoided owing to the risk of embrittlement. Preheating and interpass temperatures for ferritic steels 200-300 °C.  | Ferritic-Perlitic:<br>1.4713 X10CrAl7<br>1.4724 X10CrAl13<br>1.4742 X10CrAl18<br>1.4762 X10CrAl25<br>1.4710*) X30CrSi6<br>1.4740*) G-X40CrSi17   |
| <b>FFB-IG</b><br>G (W) 25 20 Mn<br>ER310(mod.)                      | GTAW<br><br>GMAW   | C 0.12<br>Si 0.9<br>Mn 3.2<br>Cr 25.0<br>Ni 20.5 | Re 420 N/mm <sup>2</sup><br>Rm 630 N/mm <sup>2</sup><br>A5 33%<br>Av 85 J  | 1.6<br>2.0<br>2.4        | UDT,<br>SEPROZ                       | GTAW rod and GMAW wire for analogous, heat resisting, rolled, forged and cast steels, e.g. in annealing shops, hardening shops, steam boiler construction, the crude oil industry and the ceramics industry. Fully austenitic deposit. Preferably employed for applications involving the attack of oxidizing, nitrogen-containing or low-oxygen gases. The final layer of joint welds in heat resisting CrSiAl steels exposed to sulphurous gases must be deposited by means of FOX FA or FA-IG. Scaling resistance up to +1200 °C. Cryogenic toughness down to -196 °C. Preheating and interpass temperatures for ferritic steels 200-300 °C. The Mn-content is above the maximum limit of AWS ER 310 to provide much better hot cracking resistance of the fully austenitic weld metal than a similar AWS corresponding type. | *) limited weldability<br><br>AISI:<br>314<br>310<br>305<br><br>ASTM:<br>A287HJ<br>A297HF  |

# Heat resistant

| <b>BÖHLER</b><br>Standard<br>EN<br>AWS                                | <b>Welding process</b> | <b>Typical analysis</b><br><br>%                                      | <b>Typical mechanical properties</b>   | <b>Sizes</b><br><br>mm | <b>Approvals</b>       | <b>Characteristics and applications</b>   | <b>Base metals</b>  |
|---|------------------------|---|--|------------------------|------------------------|---|---|
| <b>FOX CN 21/33 Mn</b><br><br>E Z21 33 B 42                           | SMAW                   | C 0.14<br>Si 0.3<br>Mn 4.5<br>Cr 21.0<br>Ni 33.0<br>Nb 1.3<br>Fe bal. | Re >410 N/mm <sup>2</sup><br>Rm >600 N/mm <sup>2</sup><br>A5 >25%<br>Av 70 J | 2.5<br>3.2<br>4.0      | TÜV-D,<br>TÜV-A,<br>CL | Basic coated electrode for joining and surfacing of heat resistant steels and cast steels of the same or similar chemical composition. Suitable for operating temperatures up to 1050 °C in carburized low-sulphur gas. Typical alloy for welding of pyrolysis furnace tubes. | 1.4876 X10NiCrAlTi32-20<br>1.4859 GX10NiCrNb32-20<br>1.4958 X5NiCrAlTi31-20<br>1.4959 X8NiCrAlTi31-21<br><br>Alloy 800 H<br>Alloy 800 |
| <b>CN 21/33 Mn-IG</b><br><br>W Z21 33 Nb (GTAW)<br>G Z21 33 Nb (GMAW) | GTAW                   | C 0.2<br>Si 0.2<br>Mn 2.3<br>Cr 22.0<br>Ni 33.0<br>Nb 1.7<br>Fe bal.  | Re 430 N/mm <sup>2</sup><br>Rm 620 N/mm <sup>2</sup><br>A5 17%<br>Av 50 J    | 2.0<br>2.4<br>3.2      | TÜV-D                  | GTAW rod and GMAW wire are also best suited to meet all before mentioned characteristics. For GMAW shielding gas Ar +2.5 CO <sub>2</sub> is recommended.  | UNS:<br>N08800<br>N08810<br>N08811  |
|   | GMAW                   |   | Re 400 N/mm <sup>2</sup><br>Rm 600 N/mm <sup>2</sup><br>A5 25%<br>Av 50 J    | 1.0<br>1.2             |                        |   |   |

# Nickel base alloys

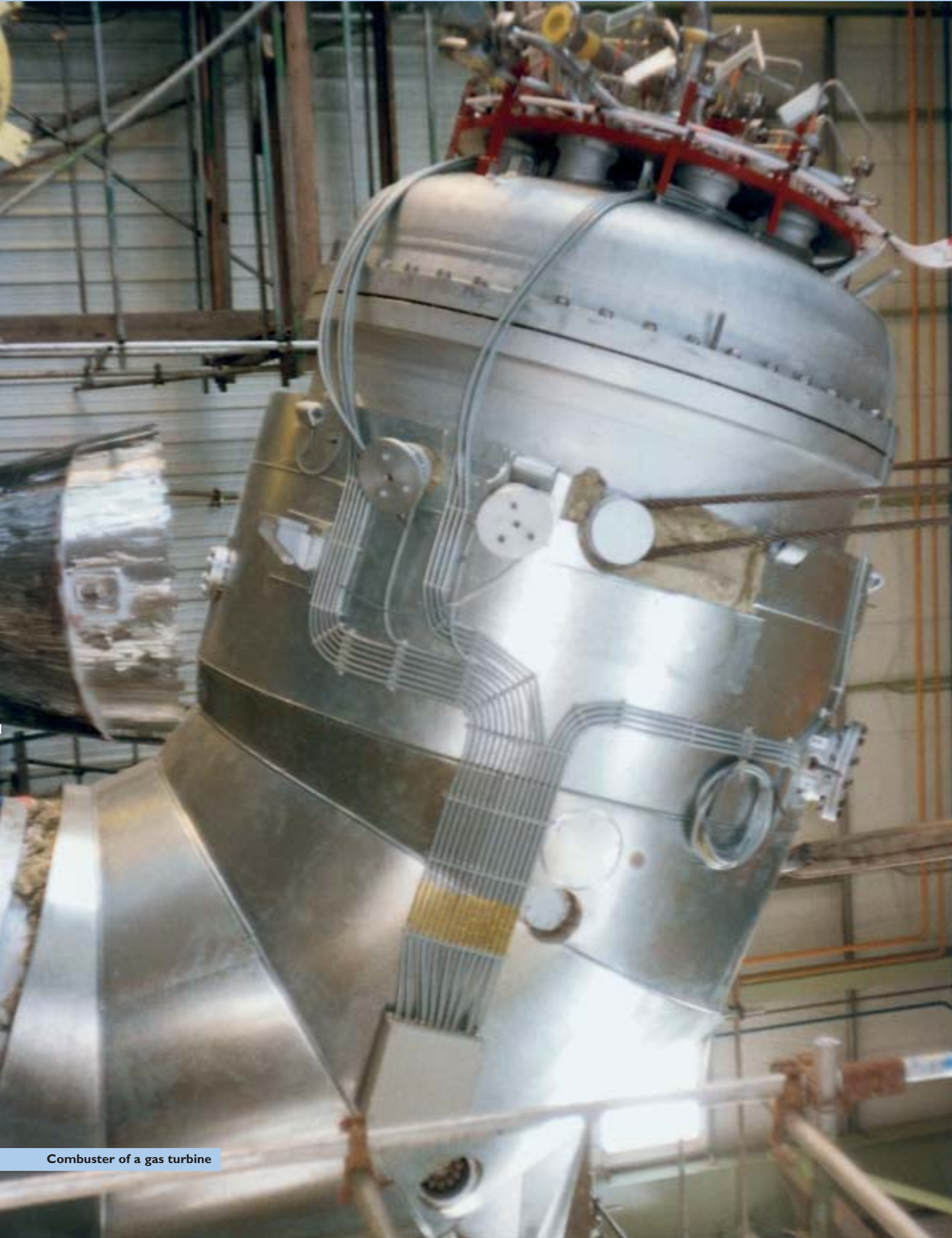
| BÖHLER<br>Standard<br>EN<br>AWS  | Welding<br>process | Typical<br>analysis<br><br>%   | Typical<br>mechanical<br>properties   | Sizes<br><br>mm                            | Approvals  | Characteristics and applications   | Base metals  |
|--|--------------------|--|---|--|--|--|--|
| <b>FOX NIBAS 70/15</b><br>E Ni 6182 (NiCr15Fe6Mn)<br>ENiCrFe-3   | SMAW               | C 0.025<br>Si 0.4<br>Mn 6.0<br>Cr 16.0<br>Ni ≥67.0<br>Nb 2.2<br>Fe 6.0<br>Co ≤0.08<br>Ta ≤0.08<br>Ti + | Re 400 N/mm <sup>2</sup><br>Rm 670 N/mm <sup>2</sup><br>A5 40%<br>Av 120 J<br>80 J...-196 °C  | 2.5<br>3.2<br>4.0                          | TÜV-D,<br>UDT  | Basic coated core wire alloyed electrode for high quality welding of nickel base alloys, high temperature and creep resisting steels, heat resisting and cryogenic materials, dissimilar joints and low alloy problem steels. Suitable in pressure vessel fabrication for -196 °C to +650 °C, scaling resistance temperature of +1200 °C (S-free atmosphere). Electrode and weld metal meet highest quality requirements.  | NiCr 15 Fe (Inconel 600)<br>UNS N06600, ASTM B168,<br>as well as Ni-alloys of similar<br>or same chemical composition;<br>non alloy and low alloy<br>steels for elevated temperatures,<br>e.g. P235GH, P265GH,<br>S255NB, P235GH-P355GH,<br>16Mo3, high temperature<br>steels as well as constructional<br>steels with comparable<br>tensile strength; creep<br>resistant austenitic steels,<br>e.g. X8CrNiNb16-13,<br>X8CrNiMoNb16-16,<br>X8CrNiMoVNB16-13,<br>Ni-steels containing 1.5 %<br>up to and including 5 % Ni;<br>low alloyed constructional<br>and pressure vessel steels,<br>also X20CrMoV12-1 and<br>X20CrMoWV12-1 on<br>stainless and creep resistant<br>austenitic steels; also<br>suitable for Incoloy 800. |
| <b>FOX NIBAS 70/20</b><br>E Ni 6082 (NiCr20Mn3Nb)<br>ENiCrFe-3(mod.)   | SMAW               | C 0.025<br>Si 0.4<br>Mn 5.0<br>Cr 19.0<br>Mo ≤1.2<br>Ni ≥67.0<br>Nb 2.2<br>Fe 3.0<br>Co ≤0.08<br>Ti +  | Re 420 N/mm <sup>2</sup><br>Rm 680 N/mm <sup>2</sup><br>A5 40%<br>Av 120 J<br>80 J...-196 °C  | 2.5<br>3.2<br>4.0<br>5.0                   | TÜV-D,<br>UDT, VUZ,<br>TUV-A,<br>SEPROZ<br>Statoil,<br>LTSS,<br>Kotlandzör                   | Basic coated core wire alloyed electrode corresponding to DIN EL-NiCr 19 Nb for high-grade welding of nickel-base alloys, high-temperature and creep resisting steels, heat resisting and cryogenic materials, low-alloyed problem steels and dissimilar joints. Ferritic-austenitic joints for service temperatures above +300 °C or for applications where a post weld heat treatment is required. Suitable in pressure vessel fabrication for -196 °C to +650 °C, otherwise up to the scaling resistance temperature of +1200 °C (S-free atmosphere). Insusceptible to embrittlement, highly resistant to hot cracking, furthermore, C-diffusion at high temperature or during heat treatment of dissimilar joints is largely reduced. Thermal shock resistant, stainless, fully austenitic, low coefficient of thermal expansion between the coefficient values of C-steel and austenitic CrNi (Mo)-steel. Excellent welding characteristics in all positions except vertical-down, easy slag removal, high resistance to porosity, absence of undercuts, high degree of purity. Electrode and weld metal meet highest quality requirements. | 2.4816 Ni Cr 15 Fe<br>2.4817 LC-NiCr 15 Fe<br>Inconel 600<br>Inconel 600 L<br><br>UNS:<br>N06600<br><br>ASTM:<br>B168<br><br>Nickel and nickel alloys,<br>low-temperature steels up<br>to 5 % Ni steels, unalloyed<br>and alloyed, high-temperature,<br>creep resisting, high-alloy Cr-<br>and CrNiMo-steels particularly<br>for joint welding of dissimilar<br>steels, and nickel to<br>steel combinations; also re-<br>commended for Incoloy 800.  |
| <b>NIBAS 70/20-IG</b><br>S Ni 6082(NiCr20Mn3Nb)<br>ERNiCr-3  | GTAW<br><br>GMAW   | C ≤0.03<br>Si ≤0.3<br>Mn 3.0<br>Cr 20.0<br>Nb 2.5<br>Fe ≤1.7<br>Ni ≥67.0<br>Ti +                       | Re 440 N/mm <sup>2</sup><br>Rm 680 N/mm <sup>2</sup><br>A5 42%<br>Av 190 J<br>100 J...-196 °C<br><br>Re 420 N/mm <sup>2</sup><br>Rm 680 N/mm <sup>2</sup><br>A5 40%<br>Av 160 J<br>80 J...-196 °C | 1.6<br>2.0<br>2.4<br><br>0.8<br>1.0<br>1.2 | TÜV-D,<br>TUV-A,<br>Statoil,<br>SEPROZ<br><br>TÜV-D,<br>TUV-A,<br>Statoil,<br>UDT,<br>SEPROZ | GTAW rod and GMAW wire for welding of nickel base alloys, high-temperature and creep resisting steels, heat resisting and cryogenic materials, low-alloyed problem steels and dissimilar joints. Ferritic-austenitic joints for service temperatures above +300 °C or for applications where a post weld heat treatment is required. Suitable in pressure vessel fabrication from -196 °C to +550 °C, otherwise resistant to scaling up to +1200 °C (S-free atmosphere). Not susceptible to embrittlement, C-diffusion at elevated temperatures largely inhibited. Resistant to thermal shocks, corrosion resistant, fully austenitic, low coefficient of thermal expansion. between the coefficient values of C-steel and austenitic CrNi (Mo)-steel.   |  |
| <b>NIBAS 70/20-FD</b><br>Type Ni 6082<br>(NiCr20Mn3Nb)<br>ENiCr-3T0-4  | FCAW               | C 0.03<br>Si 0.4<br>Mn 3.2<br>Cr 20.0<br>Nb 2.5<br>Fe 2.0<br>Ni ≥67.0                                  | Re 400 N/mm <sup>2</sup><br>Rm 650 N/mm <sup>2</sup><br>A5 39%<br>Av 135 J<br>110 J...-196 °C   | 1.2<br>1.6                                 | TÜV-D  | Rutile/basic flux cored welding wire for downhand and horizontal welding positions.<br><br>It provides very good operating characteristics, good side wall wetting, safe penetration and a smooth weld finish. The shielding gas should be Argon +15-25 % CO <sub>2</sub> .  |  |
| <b>Wire:<br/>NIBAS 70/20-UP</b><br>S Ni 6082<br>(NiCr20Mn3Nb)<br>ERNiCr-3<br><b>Flux: BB 444</b><br>SA FB 2 AC | SAW                | C 0.010<br>Si 0.15<br>Mn 3.2<br>Cr 20.5<br>Ni bal.<br>Nb 2.6<br>Fe <2.0                                | Re 350 N/mm <sup>2</sup><br>Rm 600 N/mm <sup>2</sup><br>A5 35%<br>Av 80 J<br>≥32 J...-196 °C  | 1.6<br>2.0<br>2.4                          | TÜV-D  | SAW wire/flux combination for welding of Ni base alloy metals and special metals if the use of wire electrodes with high Ni content is requested. The weld metals show excellent mechanical properties with high hot cracking resistance. It is applicable for chemical apparatus construction on high temperature metals as well as in low temperature sections down to -196 °C.<br><br>BB 444 is an agglomerated fluoride basic welding flux with high basic slag characteristics.   |  |

# Nickel base alloys

| BÖHLER<br>Standard<br>EN<br>AWS  | Welding<br>process | Typical<br>analysis<br><br>%  | Typical<br>mechanical<br>properties   | Sizes<br><br>mm                     | Approvals  | Characteristics and applications   | Base metals  |
|--|--------------------|---|---|-------------------------------------|--|--|--|
| <b>FOX NIBAS 625</b><br><br>E Ni 6625<br>(NiCr22Mo9Nb)<br><br>ENiCrMo-3  | SMAW               | C 0.025<br>Si 0.4<br>Mn 0.7<br>Cr 22.0<br>Mo 9.0<br>Ni ≥60.0<br>Nb 3.3<br>Fe 0.5<br>Co ≤0.05<br>Al ≤0.4<br>PREn >52 | Re 530 N/mm <sup>2</sup><br>Rm 800 N/mm <sup>2</sup><br>A5 40%<br>Av 80 J<br>45 J...-196 °C   | 2.5<br>3.2<br>4.0                   | TÜV-D,<br>TÜV-A,<br>Statoil,<br>UDT,<br>LTSS,<br>SEPROZ                                      | Basic coated electrode suitable for welding of 6 % Mo superaustenitic grades S31254, N08926, N08367 and the matching alloy 625. Electrode and weld metal meet highest quality and corrosion requirements. Extremely resistant to stress corrosion cracking and pitting. The pitting resistance equivalent is >52. Highly resistant to hot cracking. Due to the weld metal embrittlement between 600-850 °C, this temperature range should be avoided.<br><br>GTAW rod and GMAW wire and weld metal meet highest quality and corrosion requirements. Extremely resistant to stress corrosion cracking and pitting. The pitting resistance equivalent is >52. Highly resistant to hot cracking. For GTAW shielding gas 100 % Ar or Ar + He mixtures. For GMAW shielding gas Argon +40 % He or Ar + He + small amounts of active gas. | 2.4856 NiCr 22 Mo 9 Nb<br>2.4858 NiCr 21 Mo<br>2.4816 NiCr 15 Fe<br>1.4583 X10CrNiMoNb18-12<br>1.4876 X10NiCrAlTi32-20H<br>1.4876 X10NiCrAlTi32-20<br>1.4529 X1NiCrMoCuN25-20-7<br>X2CrNiMoCuN20-18-6<br>2.4641 NiCr 21 Mo 6 Cu<br><br>Joint welds of listed materials with non alloy and low alloy steels, e.g P265GH, P285NH, P295GH, 16Mo3, S355N, X8Ni9<br><br>ASTM:<br>A553 Gr.1<br>B443<br>B446<br><br>UNS:<br>N06625<br><br>Inconel 600<br>Inconel 625<br>Incoloy 800 |
| <b>NIBAS 625-IG</b><br><br>S Ni 6625<br>(NiCr22Mo9Nb)<br><br>ERNiCrMo-3  | GTAW<br><br>GMAW   | C ≤0.02<br>Si ≤0.2<br>Mn ≤0.3<br>Cr 21.5<br>Mo 9.0<br>Ni ≥60.0<br>Nb 3.6<br>Fe ≤2.0<br>PREn >52                     | Re 540 N/mm <sup>2</sup><br>Rm 800 N/mm <sup>2</sup><br>A5 38%<br>Av 160 J<br>130 J...-196 °C<br><br>Re 510 N/mm <sup>2</sup><br>Rm 780 N/mm <sup>2</sup><br>A5 40%<br>Av 130 J<br>80 J...-196 °C | 1.6<br>2.0<br>2.4<br><br>1.0<br>1.2 | TÜV-D,<br>TÜV-A,<br>Statoil,<br>SEPROZ<br><br>TÜV-D,<br>TÜV-A,<br>Statoil,<br>SEPROZ,<br>UDT | Rutil FCAW wire of type E NiCrMo-3 suitable for welding in all positions except vertical down. Extremely resistant to stress corrosion cracking and pitting. Shielding gases Ar +15-25 % CO <sub>2</sub> .   |  |
| <b>NIBAS 625-FD</b><br><br>NiCr22Mo9Nb<br><br>ENiCrMo-3T0-4  | FCAW               | C 0.05<br>Si 0.4<br>Mn 0.4<br>Cr 22.0<br>Mo 8.5<br>Ni ≥60.0<br>Nb 3.3<br>Fe <5.0                                    | Re 480 N/mm <sup>2</sup><br>Rm 750 N/mm <sup>2</sup><br>A5 30%<br>Av 60 J   | 1.2                                 | -  | SAW wire/flux combination, which meet highest quality and corrosion requirements. Extremely resistant to stress corrosion cracking and pitting. The pitting resistance equivalent is >52.<br><br>NIBAS 625 alloys are best suited for cladding of finned tube walls.   |  |
| <b>Wire:<br/>NIBAS 625-UP</b><br><br>S Ni 6625<br>(NiCr22Mo9Nb)<br><br>ERNiCrMo-3<br><br><b>Flux: BB 444</b><br><br>SA FB 2 AC | SAW                | C 0.012<br>Si 0.16<br>Mn 0.2<br>Cr 21.8<br>Mo 9.0<br>Ni ≥60.0<br>Nb 3.2<br>Fe 1.5<br>PREn >52                       | Re 420 N/mm <sup>2</sup><br>Rm 700 N/mm <sup>2</sup><br>A5 40%<br>Av 130 J<br>80 J...-196 °C  | 2.4                                 | TÜV-D  |  |  |
| <b>FOX NIBAS 617</b><br><br>E Ni 6617<br>(NiCr21Co12Mo)<br><br>ENiCrCoMo-1(mod.)   | SMAW               | C ≤0.06<br>Si 0.7<br>Mn 0.1<br>Cr 21.0<br>Mo 9.0<br>Ni bal.<br>Co 11.0<br>Al 0.7<br>Ti 0.3<br>Fe 1.0                | Re >450 N/mm <sup>2</sup><br>Rm >700 N/mm <sup>2</sup><br>A5 >35%<br>Av >100 J  | 2.5<br>3.2<br>4.0                   | TÜV-D  | Basic coated NiCrCoMo electrode suitable for joining and surfacing application on high-temperature and similar nickel-base alloys, heat resistant austenitic and cast alloys. The weld metal is resistant to hot-cracking and scale-resistance up to +1100 °C, high temperature resistant up to 1000 °C. High resistance to hot gases in oxidizing and carburized atmospheres, e.g. gas turbines, ethylene production plants.<br><br>GTAW rod and GMAW wire of type ERNiCrCoMo-1 are also best suited to meet all before mentioned characteristics.  | 2.4851 NiCr23Fe<br>2.4663 NiCr23Co12Mo<br>1.4876 X10NiCrAlTi32-20<br>1.4859 GX10NiCrNb32-20<br><br>UNS:<br>N06007<br><br>ASTM:<br>B582<br>B622<br><br>Alloy 617  |
| <b>NIBAS 617-IG</b><br><br>S Ni 6617<br>(NiCr22Co12Mo9)<br><br>ERNiCrCoMo-1  | GTAW<br><br>GMAW   | C 0.05<br>Si 0.1<br>Mn 0.1<br>Cr 21.5<br>Mo 9.0<br>Ni bal.<br>Co 11.0<br>Al 1.0<br>Ti 0.5<br>Fe 1.0                 | Re 450 N/mm <sup>2</sup><br>Rm 700 N/mm <sup>2</sup><br>A5 30%<br>Av 60 J<br><br>Re 400 N/mm <sup>2</sup><br>Rm 700 N/mm <sup>2</sup><br>A5 40%<br>Av 100 J                                       | 2.0<br>2.4<br><br>1.0<br>1.2        | TÜV-D<br><br>-   | For GMAW shielding gas 100 % Ar, Ar +28 % He or Ar +30 % He +0.5 % CO <sub>2</sub> .<br><br>Nickel base wire/flux combination for welding of similar Ni base alloys, heat resistant austenitic and cast alloys, e.g. alloys 617, N06007, 2.4663. High resistance to hot gases in oxidizing resp. carburizing atmospheres.  |  |
| <b>Wire:<br/>NIBAS 617-UP</b><br><br>(UP-NiCr22Co12Mo9)<br><br>ERNiCrCoMo-1<br><br><b>Flux: BB 444</b><br><br>SA FB 2 AC       | SAW                | <b>Wire:</b><br>C 0.07<br>Si 0.2<br>Mn 0.2<br>Cr 20.5<br>Mo 8.8<br>Ni bal.<br>Co 10.4<br>Fe <2.0                    | Re >420 N/mm <sup>2</sup><br>Rm >700 N/mm <sup>2</sup><br>A5 >35%<br>Av >80 J   | 2.0                                 | -  |  |  |



## References



Combuster of a gas turbine



# References

Segment of a boiler with circulating fluidized bed combustion.



Heat exchanger.





# References

Manifold.



Tube to manifold joint welds of a waste heat recovery boiler.



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