

Bismuth-free Stainless Flux-Cored Wires for High Service Temperatures





Lasting Connections

Creating lasting connections is the most important part of the welding process. Böhler Welding offers a globally unique product portfolio for all conventional arc welding processes and our best-in-class welding consumables ensure these lasting connections – even in the most challenging applications and industries.

These merits are also valid for our new range of bismuth-free, stainless cored wires for joining and cladding applications in the power generation and process industry, complying with API Standard RP 582 for austenitic weld metal for service temperatures above 538°C and similar recommendations in AWS standard A5.22 for stainless steel cored wires. Packed with decades of application experience, these welding consumables are designed to bring you productivity, weld quality and – above all – security.

Why bismuth-free?

The flux formulation of stainless steel flux-cored wires usually contains small amounts of bismuth in the form of Bi_2O_3 to improve slag detachability. The resulting bismuth content in the weld metal is about 180-200 ppm. At service temperatures below roughly 500 °C there are no detrimental effects from bismuth on quality and mechanical properties of the weld, but at higher temperatures segregation of bismuth to the grain boundaries occurs. The following issues have been experienced:

- Reduced ductility at temperatures above 650°C
- Inter-granular cracks at temperatures above 700°C with fracture surface showing presence of bismuth

The vast majority of stainless steel weld deposits are put into service below about 250°C, but within power generation and process industries, extended service can exceed temperatures of 500°C. It is in these weldments that bismuth creates problems, which may also occur when carrying out a post weld heat treatment (PWHT) when weld overlaying carbon steel or after repair of castings.

When needed?

Bi-free stainless cored wires are needed when joining alloys such as 347, 347H, 321, 321H or 308H

intended for high temperature service and also when cladding over creep resistant steels.

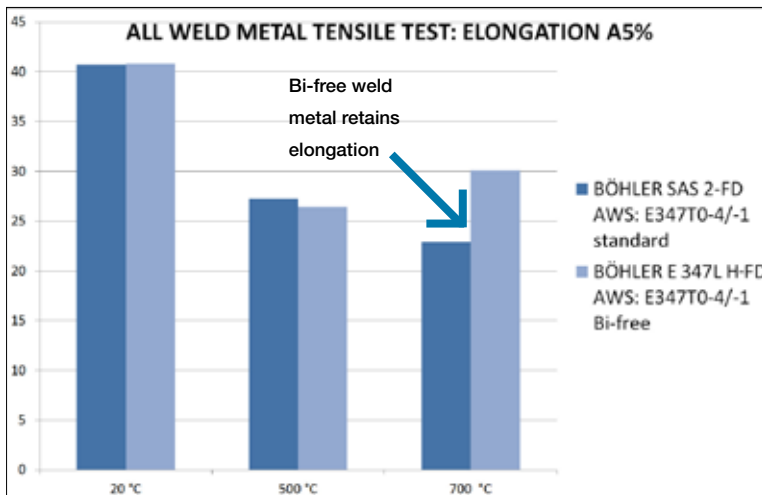
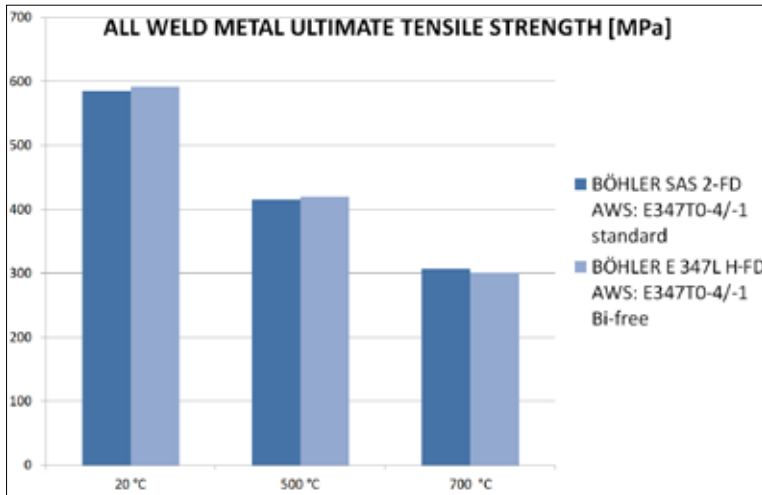
Cladding applications are often found in the petrochemical industry. The operating temperature of petrochemical critical process equipment is usually below 538 °C with the exception of Fluid Catalytic Cracking (FCC) units. These operate at 716 °C. Other units may have service temperatures below 538 °C, but they utilize clad creep resistant steel requiring a post weld heat treatment above this critical temperature.

For instance, main critical process equipment, such as hydro-treating, hydro-cracking and hydro-desulpharization reactors as well as effluent heat exchangers are constructed from CRA clad grade 11, grade 22 or grade 22V, needing PWHT. Some areas, such as the inside of nozzles and fittings, cannot be covered by clad plates and/or strip cladding and need separate overlay welding. This can be efficiently done using the FCAW process.



Flux-cored wires can be efficiently used for completing claddings inside nozzles, fittings and weld overlay build-up of internal supports. Example of uncovered areas to be restored on a dished-end.

The Böhler Welding range of bismuth-free stainless cored wires



Comparison between Bi-containing and Bi-free 347 type weld metal. At high temperatures, the Bi-free weld metal retains its elongation properties.

Böhler Welding offers two series of bismuth-free stainless steel cored wires. These have the same weldability and slag detachability as bismuth alloyed stainless cored wires. Low-temperature CVN impact toughness and lateral expansion are also at the same level.

The two series are:

- All-positional rutile FCW for joining
- Flat-horizontal rutile FCW for joining and cladding

All-positional rutile cored wires feature excellent weldability in all positions. They are used for joining

high-temperature resistant stainless steel. The fast freezing slag system allows relatively high amperes in positional welding.

Flat-horizontal rutile cored wires are optimized to maximize the parameters, and consequently are used for high deposition rate, in flat-horizontal positions. They are ideal for cladding low-alloyed, creep resistant steels but can be used also for joining high-temperature resistant stainless steel when welding in flat position.

Both type of wires are easy to operate – both in manual and mechanized welding– and show excellent welding characteristics with conventional non-pulse power sources.

The weld deposit is scaling resistant and- because of the controlled low delta ferrite content - highly resistant to sigma phase embrittlement.

The wires are developed for use in M21 (Ar + 18% CO₂) shielding gas, but they are also suitable when welding in 100% CO₂.

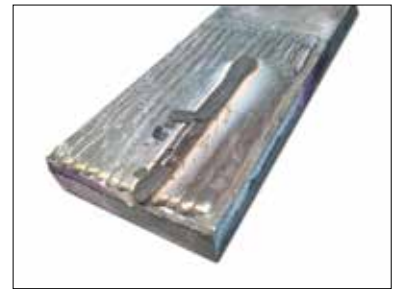
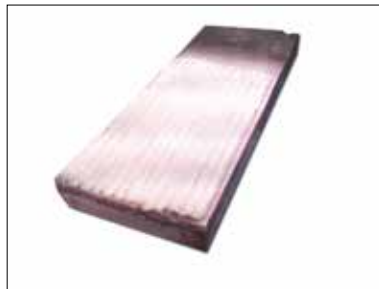
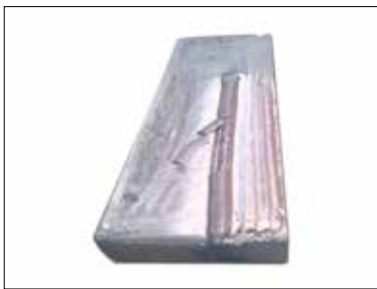
They are welder-friendly and operate with a powerful penetrating spray arc and minimum spatter formation. Productivity advantages over solid wire pulse arc welding are easily obtained, while using simple non-pulse power sources.

Additional cost efficiency is realized through the use of cheaper shielding gases, good wetting (less grinding), little oxidation (less pickling), and safe penetration and smooth and clean welds (less repair and cleaning).

Product Overview of Bi-free Flux-Cored Wires

| | Product Name | Mechanical properties, all weld metal, typical values | | | | | | | |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|-------------|------------|----------|---------------|----------|----------|--------|
| | | Condition | Rp0.2 (MPa) | Rm (MPa) | A5 (%) | CVN (J) +20°C | -60°C | -120°C | -196°C |
| All-positional rutile FCW | BÖHLER E 308 H PW-FD EN ISO 17633-A: T Z 19 9 H P M21 1 T Z 19 9 H P C1 1 EN ISO 17633-B: TS 308H-F M21 1 TS 308H-F C1 1 AWS A5.22: E308HT1-4 E308HT1-1 | AW (as welded) | 370 (≥350) | 560 (≥550) | 45 (≥25) | 90 (≥32) | | | |
| | BÖHLER E 309L H PW-FD EN ISO 17633-A: T23 12 L P M21 1 EN ISO 17633-B: TS 309L F M21 1 TS 309L-F C1 1 AWS A5.22: E309LT1-4 E309LT1-1 | AW | 390 (≥350) | 530 (≥520) | 35 (≥30) | 80 (≥47) | 60 (≥32) | | |
| | BÖHLER E 347 H PW-FD EN ISO 17633-A: T 19 9 Nb P M21 1 AWS A5.22: E347HT1-4 E347HT1-1 | AW | 410 (≥350) | 580 (≥550) | 38 (≥25) | 95 (≥47) | | 55 (≥32) | 35 |
| Flat-horizontal rutile FCW | BÖHLER E 308 H-FD EN ISO 17633-A: T Z 19 9 H R M21 3 T Z 19 9 H R C1 3 EN ISO 17633-B: TS 308H-F M21 0 TS 308H-F C 1 0 AWS A5.22: E308HT0-4 E308HT0-1 | AW | 360 (≥350) | 560 (≥550) | 45 (≥25) | 85 (≥32) | | | |
| | BÖHLER E 309L H-FD EN ISO 17633-A: T 23 12 L R M21 3 T 23 12 L R C1 3 EN ISO 17633-B: TS 309L-F M21 0 TS 309L-F C1 0 AWS A5.22: E309LT0-4 E309LT0-1 | AW | 390 (≥320) | 530 (≥520) | 35 (≥25) | 65 (≥47) | 45 (≥32) | | |
| | BÖHLER E 347L H-FD EN ISO 17633-A: T 19 9 Nb R M21 3 T 19 9 Nb R C1 3 EN ISO 17633-B: TS 347L-F M21 0 TS 347L-F C1 0 AWS A5.22: E347T0-4 E347T0-1 | AW | 420 (≥350) | 580 (≥550) | 35 (≥25) | 90 (≥47) | | 50 (≥32) | 35 |

Two-layer cladding on base material 10CrMo 9 10 (ASTM A387 gr. 22)



Chemistry at the surface of the 1st and 2nd layer

| | C | Si | Mn | Cr | Mo | Ni | Nb | Ferrite measured* | Welding Parameter |
|-----------------------|-------|------|------|------|------|------|-------|-------------------|------------------------------------------|
| 1 st layer | 0.048 | 0.53 | 1.30 | 19.8 | 0.15 | 10.3 | 0.004 | 8–9 FN | 1 st Layer BÖHLER E 309L H-FD |
| 2 nd layer | 0.034 | 0.59 | 1.49 | 19.3 | 0.08 | 10.2 | 0.39 | 6.5–7.5 FN | 2 nd Layer BÖHLER E 347L H-FD |

Undiluted chemistry of the wires

| | C | Si | Mn | Cr | Mo | Ni | Nb | Ferrite measured* | Welding Parameter |
|--------------------|-------|-----|-----|------|------|------|------|-------------------|-----------------------------------------|
| BÖHLER E 309L H-FD | 0.030 | 0.6 | 1.3 | 23.0 | 0.04 | 12.2 | 0.01 | 15 FN | Interpass-Temperature: max. 150°C |
| BÖHLER E 347L H-FD | 0.030 | 0.6 | 1.3 | 18.8 | 0.04 | 10.5 | 0.45 | 5–9 FN | Shielding gas: Ar + 18% CO ₂ |
| | | | | | | | | | Amperage: 230 - 240 A |
| | | | | | | | | | Wire feed speed: 12m/min |
| | | | | | | | | | Overlapping: ~50% |

* with Fisher Ferriscope MP30

voestalpine Böhler Welding

Welding know-how joins steel

With over 100 years of experience, voestalpine Böhler Welding is the global innovator for the daily welding challenges in joining, wear and corrosion protection as well as brazing. Customer proximity is guaranteed by more than 40 subsidiaries in 25 countries, with the support of 2,200 employees, and through more than 1,000 distribution partners worldwide. And with individual consultation by our application technicians and welding engineers, we make sure that our customers master the most demanding welding challenges. voestalpine Böhler Welding offers three specialized and dedicated brands to cater our customers' and partners' requirements.



Lasting Connections – More than 2,000 products for joint welding in all conventional arc welding processes are united in a product portfolio that is unique throughout the world. Creating Lasting Connections is the brand's philosophy in welding and between people.



Tailor-Made Protectivity™ – Decades of industry experience and application know-how in the areas of repair of cracked material, anti-wear and cladding, combined with innovative and custom-tailored products, guarantee customers an increase in the productivity and protection of their components.



In-Depth Know-How – Through deep insight into processing methods and ways of application, Fontargen Brazing provides the best brazing and soldering solutions based on proven products with German technology. The expertise of this brand's application engineers has been formulated over many years of experience from countless application cases.

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