utp maintenance
by voestalpine

Single Thin-Layer Electroslag Strip Cladding of Alloy 625

voestalpine Böhler Welding
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ONE STEP AHEAD.

S355JR base material with a single layer Alloy 625 overlay, clad with the new strip / flux combination SOUDOTAPE 625 / RECORD EST 625-1 LD. Flat beads and smooth overlaps require minimal machining.

New Solution for Major Savings on Cladding Time and Costs

voestalpine Böhler Welding adds a new dimension to the productivity of the electroslag strip cladding process (ESSC), with new solutions for the single layer cladding of alloy 625 with reduced clad layer thickness and/or increased travel speed (patent pending). The new strip/flux combination cuts down on cladding time and the use of cladding materials, while meeting all prevalent industry requirements for the deposited metal. Savings are obtained in two different ways:

- Alloy 625

Composition with Fe <10 % requirement can be realized in a single layer with reduced thickness compared with the traditional industry solution.

- Alloy 625

Composition with Fe <7 % requirement can be realized in a single layer, where two layers are needed with the traditional industry solution.

This brochure highlights results obtained with a new strip / flux combination in a typical application within the chemical and petrochemical industries – the cladding of Alloy 625 onto EN 10025-2: S355JR base material. Chemical composition and productivity are compared with conventional ESSC solutions and results of relevant corrosion testing are reported.

Electro Slag Strip Cladding at New Economy Levels

The new UTP branded strip / flux combination from voestalpine Böhler Welding is:

- SOUDOTAPE 625 / RECORD EST 625-1 LD for cladding of Alloy 625

It increases the economy of the ESSC process through a reduced strip consumption. Tables 1 - 2 show the economy data for two typical applications in the chemical and petrochemical processing industries. The welding parameters were applied in the preparation of samples for corrosion testing.

Tables 1 - 2 compare the new strip / flux combination with conventional consumables for the ESSC cladding of Alloy 625 composition with respectively < 10 % Fe and < 7 % Fe.

The < 7 % Fe requirement is often stipulated in agreement with ASME II part C SFA 5.11[2].

With conventional consumables, two layers are needed to satisfy this requirement. To enable the deposition of Alloy 625 composition with traditional ESSC solutions in one layer, this limit is often stretched to max. 10 % Fe.

In the case of the < 10 % Fe requirement, Alloy 625 composition can be reached in a substantially thinner layer at comparable travel speed. The increase in cladding economy materializes in approx. 30% lower consumption of high alloyed nickel-base strip (Table 1).

In the case of the < 7 % Fe requirement, Alloy 625 composition can be reached in a single layer, whereas two layers are needed with a conventional strip / flux combination. Not only strip consumption is substantially reduced, also the overlay time in h/m² is dramatically lowered (Table 2).

Table 1: Welding parameters and productivity for cladding Alloy 625 with target **Fe <10%** onto EN 10025-2: S355JR base material. Strip dimension: 60 x 0.5 mm

No. of layers	Current (A)	Voltage (V)	Travel speed (cm/min.)	Over thickness (mm)	Covered surface (h/m²)	Strip consumption (kg/m²)
Conventional strip / flux combination: SOUDOTAPE 625 / RECORD EST 625-1						
1	1250	24	20	**5.0**	1.3	42.2
New strip / flux combination: SOUDOTAPE 625 / RECORD EST 625-1 LD						
1	900	24	18	**3.6**	1.4	30.4

Table 2: Welding parameters and productivity for cladding Alloy 625 with target **Fe <7%** onto EN 10025-2: S355JR base material. Strip dimension: 60 x 0.5 mm

No. of layers	Current (A)	Voltage (V)	Travel speed (cm/min.)	Over thickness (mm)	Covered surface (h/m²)	Strip consumption (kg/m²)
Conventional strip / flux combination: SOUDOTAPE 625 / RECORD EST 201						
2	1100	24	16	**8.4**	3.1	70.9
New strip / flux combination: SOUDOTAPE 625 / RECORD EST 625-1 LD						
1	1150	24	16	**4.8**	1.6	40.5

Alloy 625 Cladding meets Industry Requirements

Table 3 gives an overview of the Alloy 625 type strip used for preparing the samples for the investigation. Table 4 shows chemical composition requirements for Alloy 625 base material.

The new strip / flux combination dependably meets the composition requirements of Alloy 625 and satisfies the industry requirements for the Fe content. Tables 5 and 6 show the chemical composition measured at the surface of claddings made with respectively the conventional fluxes RECORD EST 201 and RECORD EST 625-1 compared with the new flux RECORD EST 625-1 LD for the Fe <10 % and Fe <7 % targets. The deposits obtained with RECORD EST 625-1 LD show a slightly higher percentage of Cr and Mo, resulting in a higher Pitting Resistance Equivalent Number (PREN).

The through-thickness analysis is shown in Figure 1 where the main chemical elements in weight % are reported from fusion line to top surface. **As can be expected with the ESSC process, the chemical analysis is quite stable already from 250 µm from the fusion line, resulting in 3.6–4.8 mm of deposit with the desired chemistry.**

Table 3: Chemical composition of strips, wt. %. All strips were 60 x 0.5 mm (width x thickness).

Strip	C	Mn	Si	Cr	Ni	Mo	Nb	Al	Fe	Cu	Ti
SOUDOTAPE 625 SFA 5.14: EQ NiCrMo-3	0.01	0.01	0.06	22.1	Bal.	8.5	3.4	0.14	0.14	<0.01	0.15

Table 4: Chemical composition requirements Alloy 625 according ASME IIC SFA 5.11: ENiCrMo3

Strip	C	Mn	Si	Cr	Ni	Mo	Nb+Ta	Al	Fe	Ti	Cu	Other
Alloy 625 ENiCrMo3	≤0.10	≤1.0	≤0.75	20.0-23.0	≥55.0	8.0-10.0	3.15-4.15	≤0.40	≤7.0	≤0.40	≤0.50	≤0.50

Table 5: Single layer surface analysis for ESSC of Alloy 625 with **Fe <10 %** target, wt. %.

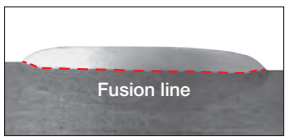
ESSC combination	C	Mn	Si	Cr	Ni	Nb	Mo	Fe	N	PREN
SOUDOTAPE 625 / RECORD EST 625-1	0.025	0.20	0.30	21.5	Bal.	3.5	9.0	7.9	0.006	51.3
SOUDOTAPE 625 / RECORD EST 625-1 LD	0.022	0.12	0.35	22.4	Bal.	3.6	9.7	8.0	0.006	54.5

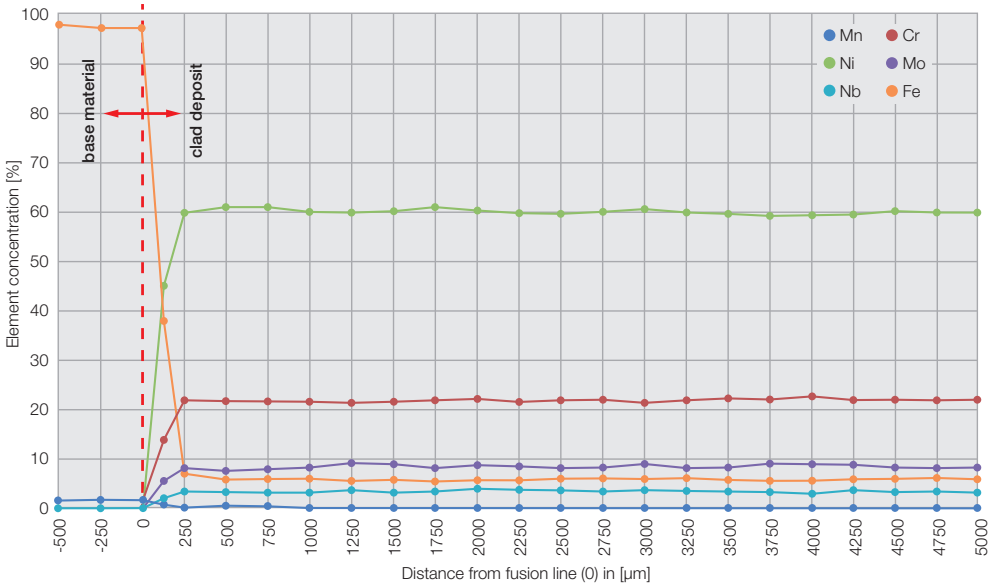
Table 6: Single layer surface analysis for ESSC of Alloy 625 with **Fe <7 %** target, wt. %.

ESSC combination	C	Mn	Si	Cr	Ni	Nb	Mo	Fe	N	PREN
SOUDOTAPE 625 / RECORD EST 201*	0.020	0.10	0.30	21.5	Bal.	3.2	8.8	2.5	0.007	50.7
SOUDOTAPE 625 / RECORD EST 625-1 LD**	0.019	0.12	0.32	22.3	Bal.	3.6	9.6	6.1	0.007	54.1

* Two layers / ** One layer

Figure 1: Chemical analysis survey from base material to top surface of cladding with RECORD EST 625-1 LD, <7 % Fe scenario.





Corrosion testing

For Alloy 625, a corrosion test program was conducted for the Fe <7 % target, comparing the properties of single layer claddings produced with the conventional flux RECORD EST 625-1 and the new flux RECORD EST 625-1 LD. Following tests were performed:

- Pitting corrosion detection according to ASTM G48 Method A with samples exposed for 72 h at 50 °C.
- Intergranular corrosion detection in the presence of reducing media, according to ASTM G28 Method A, with a sensitization treatment of 675 °C x 1 hour and 120 hours exposure time. Samples were taken in BSM position (sample taken in the middle of the bead) and BSL position (sample taken between 2 beads containing a bead overlap).

Table 7: Corrosion test results for alloy 625 with **Fe <7%**
Results are fully satisfactory and meeting the industry requirements.

Strip cladding combination	ASTM G48A (72 h @ 50 °C) Corrosion rate [mm/yr]	ASTM G48 A CPT (°C)	ASTM G28 A (120 h) Corrosion rate BSL* [mm/yr]	ASTM G28 A (120 h) Corrosion rate BSM** [mm/yr]
SOUDOTAPE 625 / RECORD EST 625-1	0	85	0.650	0.680
SOUDOTAPE 625 / RECORD EST 625-1 LD	0	84	0.420	0.529

*BSL: sample taken between 2 beads in the overlap. / **BSM: sample taken in the middle of the bead

Bend tests

Side bend test were performed in both as welded and post weld heat treated conditions according to ASTM E190. The specimen thickness was 10 mm.

10 mm sample (3x)

Figure 2: Side bend test, 180° bending angle on 40 mm mandrel. Cladding deposit produced with RECORD EST 625-1 LD after PWHT at 670 °C for 24 h.

No cracks were found with the cladding deposits realized with RECORD EST 625-1 LD, both in the as welded condition and after severe PWHT at 670 °C for 24 hours, showing soundness and integrity of the weld overlay.

Table 8: Side bend tests conditions.

Specimen position	
Sample thickness	10 mm
Bending angle	180°
Mandrel diameter	40 mm

Excellent cladding characteristics for alloy 625 confirmed by field tests.

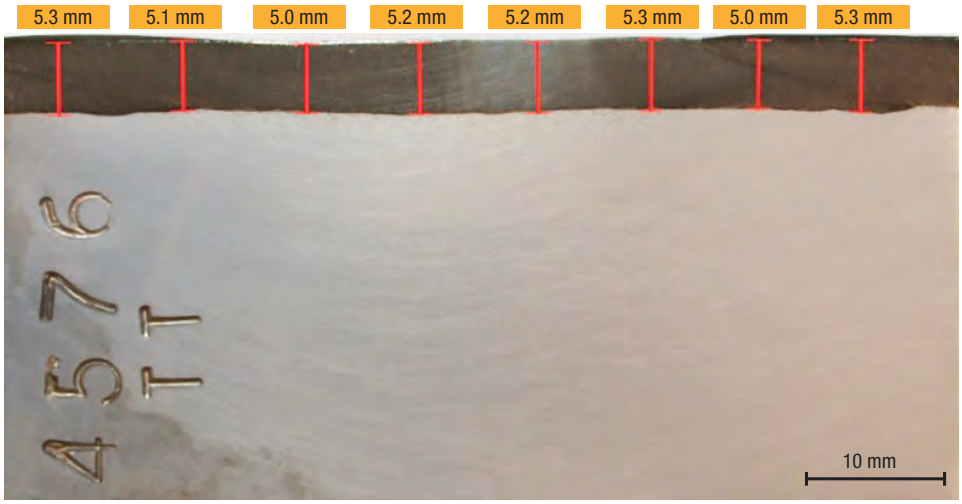


Figure 3: Bead profile of cladding with RECORD EST 625-1 LD, with <7% Fe scenario.

The strip / flux combination SOUDOTAPE 625 / RECORD EST 625-1 LD has excellent cladding characteristics. The fusion line is flat and free of defects. The total thickness (including penetration) is around 5.2 mm and the relief of the top surface varies within a few tenth of a millimeter, which reduces the amount of machining necessary. The ratio penetration / total thickness equals a geometrical dilution of 5.8 % matching with 6.0 % Fe.

Also the micro structure reveals a smooth transition from the ferritic non-alloyed base material to the austenitic nickel-base structure of Alloy 625.

Slag detachability is fully satisfactory with self-lifting slag without remainders and the deposit appearance features flat beads and straight edges.

These qualities have been confirmed by field tests in the cladding of reactors shells under industrial conditions.

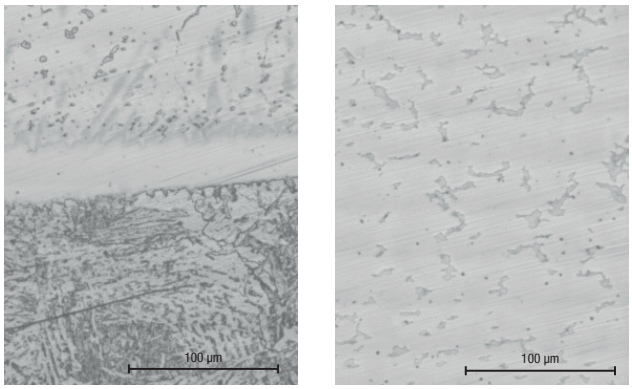


Figure 4: Micrographs. RECORD EST 625-1 LD cladding as welded.
Left: fusion line area / Right: middle of bead

Figure 5: Cladding with RECORD EST 625-1 LD: self-releasing slag.

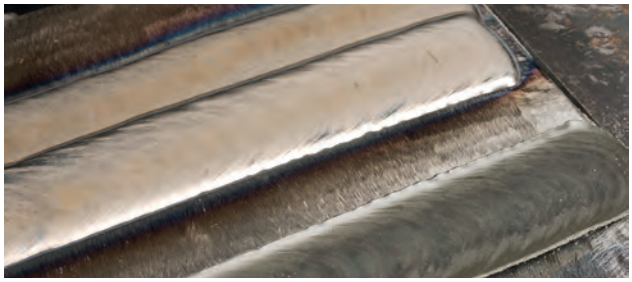


Figure 6: Cladding with RECORD EST 625-1 LD: flat beads, straight edges, no slag adherences.

Flux RECORD EST 625-1 LD comes in sealed steel drums.
Available strip sizes are 20, 30, 60, 90 and 120 x 0.5 mm. Other sizes on request.

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