



Guide for repair of a deep eroded wear on martensitic stainless steel CA-6NM or X5CrNi 13 4									
Base metal Martensitic stainless steel		Filler alloys CastoMag 45516 solid wire (E309L) CaviTec GMA flux cored wire				Filler Classification: AWS A5.9 Class ER309L and CaviTec GMA			
Welding Process Semi-automatic GMA		Shielding Gas 98%Ar-2%CO ₂ for 309L 100% Ar / or / 92%Ar8%CO ₂ for Cavitec ¹		Feed Rolls V shape for ER309 U shape Cavitec GMA		Welding Position All Positions			
Complete penetration		NDT: Liquid Penetrant		Preheating min: 50°C ER309L – 100°C CaviTec Maximum and interpass temperature: 200°C					
Joint Preparation 					Layers sequence 				
Filler	No of Layers	Wire Ø mm	Current (A)	Voltage (V)	Wire Speed lpm m/min	Weld Speed mm/s	Stickout mm	Linear energy J/cm	Torch angle (degrees)
CastoMag 45516	1 to 4	1,2	100-200	17-27			12-20		0 to 15
Cavitec GMA	5,6,7	1,2	150-200 pulsed	27-29	350-400 8,9-10,1		12-20		0 to 15

Notes :

Cushion Layer of Castolin 33700 (309L)

In order to reduce the porosity, do not put more than 2 layers of CaviTec. The more the layers, the more the porosities and the bigger they are. Fill up with 309L and keep 6 mm to add 2 layers of CaviTec;

It is important to determine whether there are cracks or porosities:

Porosities in reasonable quantities with Cavitec is rather normal and usual;

Post Weld Heat Treatment:

No post weld heat treatment has been performed on turbines repaired on site. Experiment of heat treatment (590-620°C) on coupons of Cavitec welded on CA6NM showed no reduction of cavitations' resistance, but a reduction of the bending angle to 15° in comparison to 20° to 40° on non heat treated samples have been observed.

1) Both gases have been used. Porosity level may vary from one to the other. See additional note at the end

Repair of a deep eroded wear (> 10mm) on a martensitic stainless steel CA-6NM / or 13/4

1) Identify the area to be repaired;

2) Gouging;

- A) Remove all spongy or pitted metal by arc air gouging with a flat carbon electrode or with plasma gouging nozzle
- B) Gouged zone must exceed around 25mm the eroded zone to prolong the service life
- C) As illustrated on the sketch of the surface preparation, the gouging of the edges must be done to provide 60° angle minimum;
- D) Grind to white metal all gouged areas to remove splatters, oxidized or carburized layer and all copper traces;

3) Preheat

A preheat of the zone to repair of 100°C is mandatory for the following reasons:

- Eliminates moisture and related hydrogen embrittlement of base metal
- Reduce risk of porosities
- Reduce residual stress
- Improve GMAW welding
- A preheat before gouging is also recommended
- Keep interpass temperature between 100 and 200°C

4) Filler material

On the surface where erosion wear is deep (>10mm) on the martensitic steel CA-6NM or 13/4 a cushion layer of Castolin 33700 (E309L) thick enough but allowing a Cavitec layer thicker than 6 mm (two passes). No peening is necessary on both 33700 and Cavitec SMA.

5) Grinding

On large surface to repair, use a template to retrieve the original profile. Use Zirconium grinding disc

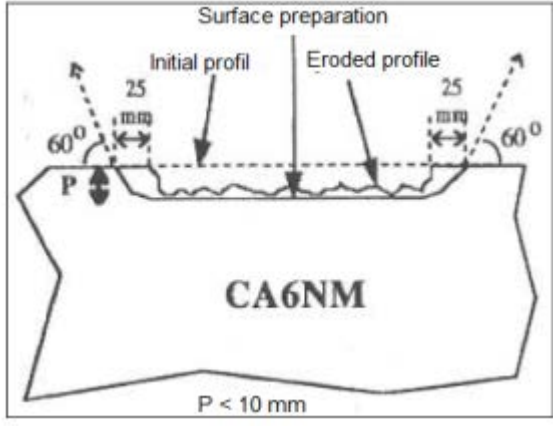
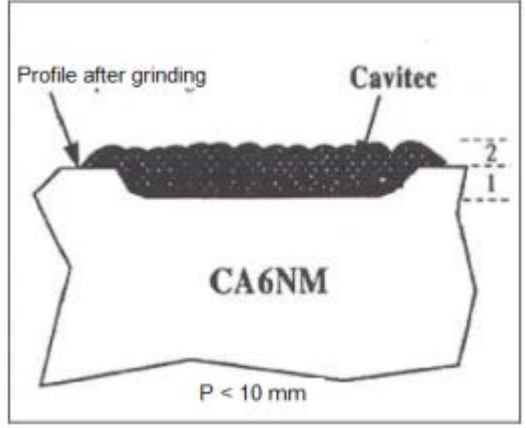
6) Quality control

- A) Visual inspection on the whole repair and verify the regularity of the profile
- B) Perform a liquid penetrant test on zones where cracks are anticipated
- C) The forman provide a brief report with the following details:

- Repair duration
- Gouging, welding and grinding duration
- Quantity of filler alloy required
- Quality Control results

*Castolin Eutectic disclaim all responsibility for welding and subsequent life of this piece of equipment.
This information is given in good faith to assist the customer in his undertaking.*



Guide for repair of shallow eroded wear (< 10mm) on a martensitic stainless steel CA-6NM or X5CrNi 13 4									
Base metal Martensitic stainless steel		Filler alloys CaviTec GMA flux cored wire				Filler Classification: CaviTec GMA			
Welding Process Semi-automatic GMAW		Shielding Gas 100% Ar / or / 92%Ar8%CO ₂ for Cavitec ¹		Feed Rolls U shape Cavitec		Welding Position All Positions			
Complete penetration		NDT: Liquid Penetrant		Preheating min: 100°C CaviTec Maximum and interpass temperature: 200 °C					
<p style="text-align: center;">Joint Preparation</p> 					<p style="text-align: center;">Layers sequence</p> 				
Filler	No of Layers	Wire Ø mm	Current (A)	Voltage (V)	Wire Speed lpm m/min	Weld Speed mm/s	Stickout mm	Linear energy J/cm	Torch angle (degrees)
Cavitec GMA	1,2	1,2	150-200	27-29	350-400 8,9-10,1		12-20		0 to 15

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No post weld heat treatment has been performed on turbines repaired on site. Experiment of heat treatment (590-620°C) on coupons of Cavitec welded on CA6NM showed no reduction of cavitations' resistance, but a reduction of the bending angle to 15° in comparison to 20° to 40° on non heat treated samples have been observed.

1) Both gases have been used. Porosity level may vary from one to the other. See additional note at the end

1) Identify the area to be repaired;

2) Gouging;

A) Remove all spongy or pitted metal by arc air gouging with a flat carbon electrode or with plasma gouging nozzle; grinding can be use as well

B) Gouged zone must exceed around 25mm the eroded zone to prolong the service life
Moreover, it has to be deep enough to allow a build up thicker than 6mm (\approx two passes).

C) As illustrated on the sketch of the surface preparation, the gouging of the edges must be done to provide a 60° angle minimum;

D) Grind to white metal all gouged areas to remove splatters, oxydised or carburized layer and all copp er traces;

3) Preheat

A preheat of the zone to repair of 100oC is mandatory for the following reasons:

Eliminates moisture and related hydrogen embrittlement of base metal

Reduce risk of porosities

Reduce residual stress

Improve GMAW welding

A preheat before gouging is also recommended

Keep interpass temperature between 100 and 200°C

4) Filler material

On the surface where erosion wear is shallow ($>$ 10mm) on the martensitic stainless steel CA-6NM, apply Cavitec layer thicker than 6mm (\approx two passes). No peening is necessary on CaviTec.

5) Grinding

On large surface to repair, use a template to retrieve the original profile. Use Zirconium grinding disc.

6) Quality control

A) Visual inspection on the whole repair and verify the regularity of the profile

B) Perform a liquid penetrant test on zones where cracks are anticipated

C) the forman provide a brief report with the following details:

Repair duration

Gouging, welding and grinding duration

Quantity of filler alloy required

Quality Control results

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Additional notes :

- Welding gas: Welders who do the cavitations' repair, use the shielding gas either 100%Ar or 92%Ar-8%CO₂ with goods results. They still have some porosity, but very little and this is very acceptable. Moreover, they use a warming system for the spools on the feeder. They have made an isolated enclosure using air-encapsulated plastic (cell bubble sheeting) that fit around the feeder and the wire. Hence the wire remains hot.

- It is recommended to perform a comparative test with 100% Ar and Ar-CO₂: Porosity level may vary from one to the other. Bending Test are lower with the mix Ar-CO₂ than pure Argon;

- Pulse Mode: Latest XUPERARC welding machines with a program adapted for CaviTec is used.

Weld in pulse mode.

With another power source, pulse program must be adapted. Current's peak and low can be set for the pulsed. This needs test in the shop. (From a power source to another, results may be different. Fine tuning is necessary). For testing, use plate from martensitic stainless steel or mild steel with buffer layer CastoMig 45516.

- Mean optimum parameters:

Efficient current: 185A, Voltage: 28.5V, Wire feed: 9,9 m/min;

- Overhead position:

Efficient current: 170A, Voltage: 28.5V, Wire feed: 9 m/min;

- Voltage has a little effect on porosity:

It is preferable to have an arc a little bit less stable, but that makes a quality deposit. Welders have tendency to weld with a too long arc to limit the splatters, this increase risks of porosities.

- During tests carried out manually:

The stick out varied from 12 to 20 mm. In overhead position a shorter stick out is recommended

- It is important to determine whether there are cracks or porosities:

Porosities in reasonable quantities with Cavitec is rather normal and usual;

- Post Weld Heat Treatment:

No post weld heat treatment has been performed on turbines repaired on site.

Experiment of heat treatment (590-620°C) on coupons of Cavitec welded on CA6NM showed no reduction of cavitations' resistance, but a reduction of the bending angle to 15o in comparison to 20o to 40o on non heat treated samples have been observed.

When using a mix Ar-CO₂, weldability appealing may increase, but welding fumes increases as well. Adequate ventilation is mandatory.