

Hardfacing Manual



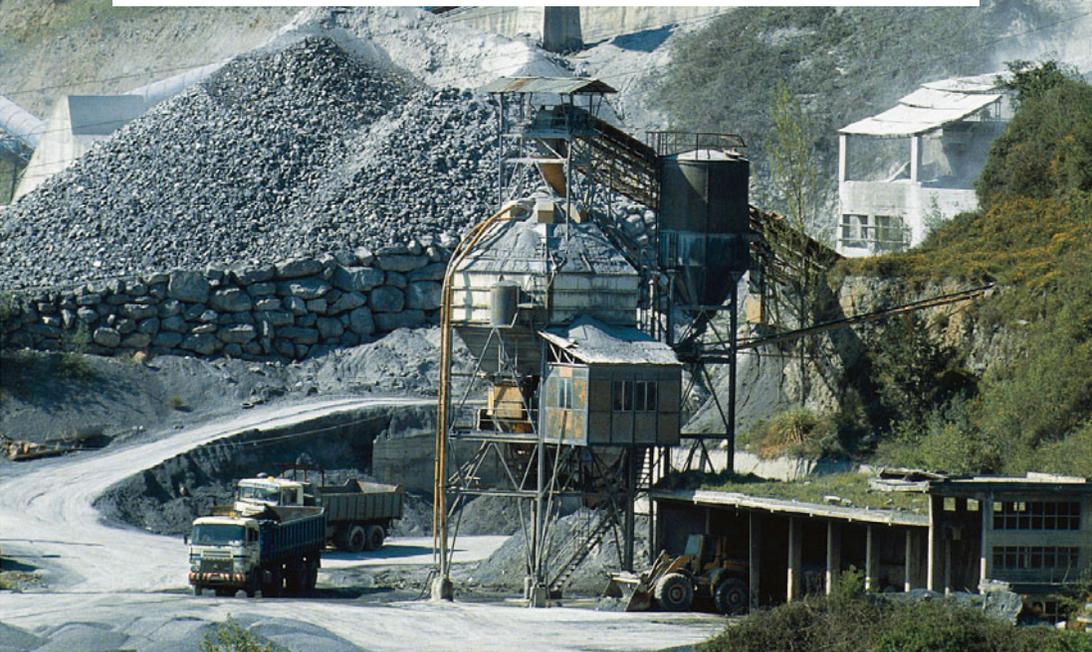
Maintenance of industrial equipment is a key component of production costs.

Hardfacing, especially using arc welding, is one of the principal ways of reducing mechanical wear and tear. Welding technology provides a very broad array of products and processes that solve wear and tear problems effectively.

This guide aims to specify a set of specific hardfacing use-cases for welders that will let them solve most of your arc hardfacing problems.

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INTRODUCTION

Reconditioning and hardfacing

The reconditioning of worn parts, implicates normally three different processes which are selected according to base material, condition of parts and surfacing properties to achieve.

The three processes are:

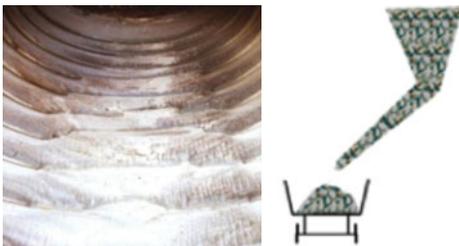
- **Buildup:** this is applied on used parts, when it is necessary to bring back the original shape and dimensions of metallic parts with large areas worn. In this case the mechanical properties and composition of weld metal is similar to those of base material.
- **Buttering:** the objective is to laydown a layer which through the dilution with base material will result in a deposit which reduce the propagation of cracks starting in the hard deposit. Application of hardfacing is done on this buffer layer.
- **Hardfacing:** the final step which will allow to achieve the desired surfacing properties in terms of resistance to abrasion / corrosion.

Type of wear

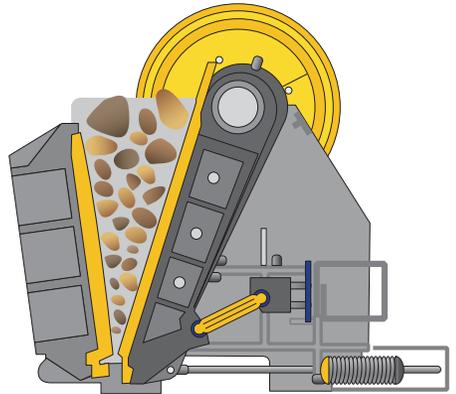
The choice of correct welding consumables to avoid unnecessary expensive hardfacing solutions, cannot be done without knowing the type of wearing and environment conditions where metallic parts work.

It is possible to identify the following type of wearing and in most cases the wearing is a combination of some of them :

- **Low stress (scratching) wearing:** the abrasive material doesn't break in contact with the metallic parts.



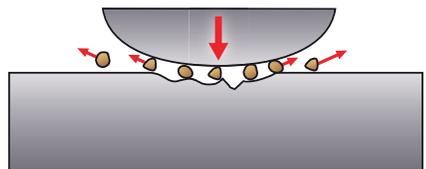
- **High stress wearing:** when abrasive material is crushed, so the metallic parts are subjected to wearing accompanied by heavy compression and moderate impact.



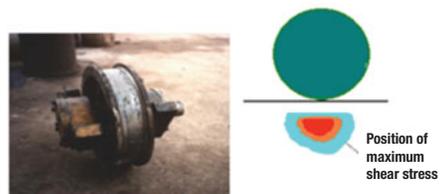
- **Gouging wearing (combination of high stress and impact):** when large abrasive material impacting the metallic parts surface have a cutting effect.



- **Wearing by impact:** when the pressure done by material overmatch the yield strength of metallic parts creating a plastic deformation on them, and material is broken.

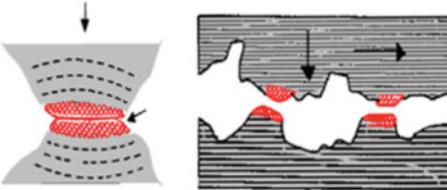


- **Delamination:** the local pressure overmatch the maximum shear stress causing cracks under the surface contact (Hertzian stress).

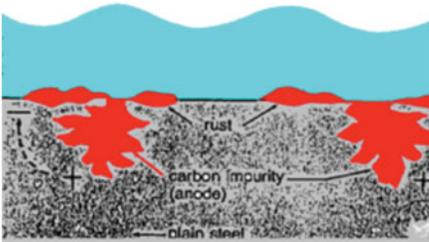


INTRODUCTION

- **Adherence:** during the sliding of two metallic surfaces, some part of surface reach a temperature higher than forging temperature and micro welding are created.

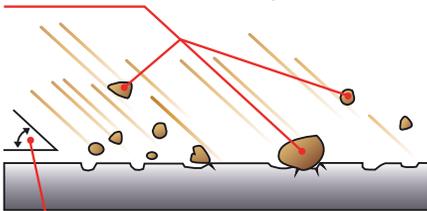


- **Corrosion:** when in presence of corrosive environment and abrasion phenomenon, the protective corrosion layer is worn and so metallic parts are rapidly corroded.



- **Erosion:** when the abrasive material is in movement into a fluid media. The wearing will mainly occurs in correspondence of variation in fluid direction.

Hard particles carried by liquid or gas strike surface and produce pitting



Erosion increases with angle of impingement



Entity of wearing depends also by temperature. Metallic parts working at medium high temperature need to be surfaced by appropriate layers resistant to heat.

■ Welding processes

Manual welding, partially mechanized and automatic welding processes are commonly used for hardfacing. The choice depends from several factors like dimensions of pieces, accessibility, possibility to use positioners, frequency of hardfacing.

Air Liquide Welding, as global provider supplies not only consumables but equipment and tools to facilitate the surfacing process.

- **Manual welding process**, which involves the use of stick electrodes, is still the most diffused technology because reasonably economic, can be used to weld in all positions, so is particularly adapted for applications on field even in remote areas; doesn't need large investment for in power sources.
- **Partially mechanized process**, is realized using continuous wire filler metal (solid wire, flux cored wire). The possibility to use outershield flux cored wires, makes this process the perfect solution to combine investment for equipment and productivity.
- **Automatic process**, means mainly submerged arc welding is the most appropriate technology to use for restoring large parts thanks to the higher deposition rate it can provide. The hardfacing is done either using neutral fluxes in combination with alloying wires or alloying fluxes in combination with middle / low alloyed wires. Due to the high penetration of this process, the effect of dilution with base material shall be highly considered.

Other welding process like Plasma arc (PAW) or FCAW (with / without shielding gas) can be used in automatic mode.

HARDFACING DESIGN AND EXECUTION

Hardfacing shape

What shape should the wear layer have?

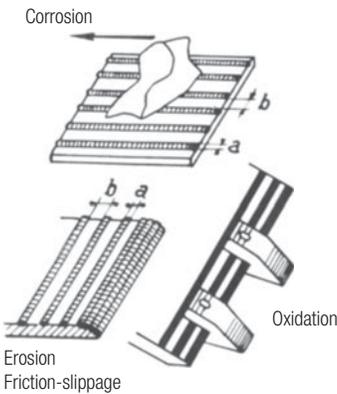
The required shape depends on:

- the part's operating conditions, eg type and wear and tear environment
- the part's dimensions, ie to prevent cracks or unacceptable deformations.

Hardfacing geometry

• **Continuous hardfacing**, is required if wear is due to:

- Corrosion
- Oxidation
- Erosion
- Friction-slippage



• **Hardfacing strips** are used for combined abrasion and impacts, with separate or in-line beads:

- in the direction of travel only for coarse abrasives (rocks) or rubbing solid blocks,
- perpendicular to the direction of travel for powdery abrasives: sand/gravel + mud.

Examples:

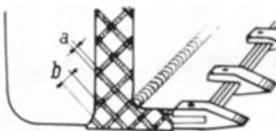
Guide plates, skip edges, etc: $b = (1-2) \times a$.

Example: bucket edges $a \ll b$.

Checkerboard, spot-welds, squares - mainly applied to heterogeneous environments.

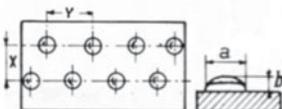
• **Checkerboard:** Secondary wearing plates.

- $a = 6-12 \text{ mm}$
- $b = (2-3) \times a$



• **Spots:** Buckets, blade undersides, crusher cones.

- $a = 8-20 \text{ mm}$
- $b = 4-8 \text{ mm}$
- $x = \sim y$

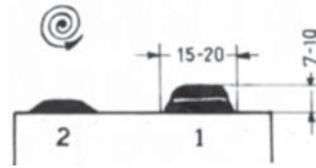


• **Squares:** Edges subject to impacts, shaker baskets, skip edges and rear

The last two designs provide minimum deformations and enable subsequent hardfacing without affecting the existing or worn deposit.

• **Spot-welding:**

Electrode: start by turning to keep the deposit completely liquid. Make a second/third spot, then return to the first. Deposit a second layer.



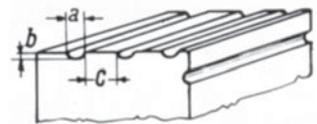
• **Strip deposits:**

Wear strip deposits can be protected from shearing if they are embedded in slots made in the base metal.

This is especially important where violent impacts cause the deposits to detach, eg on primary hammers.

Preparation: by graphite electrode gouging, using the special CITOCUT electrode.

- $a = 10-15 \text{ mm}$
- $b = 5-8 \text{ mm}$
- $c = (1-2) \times a$

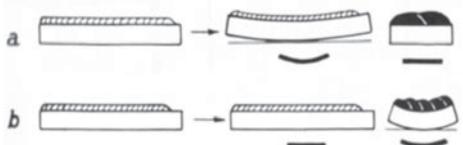


• **Filling:** single-pass with 2-3 mm extra thickness.



Reduce the deformations

• **Bead shape**



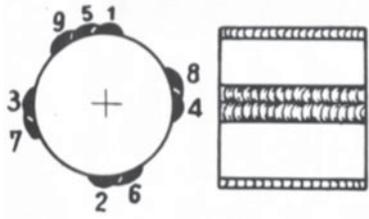
$a =$ Larger beads yield maximum deformation along the length of the part.

$b =$ Smaller beads yield maximum deformation along the width of the part.

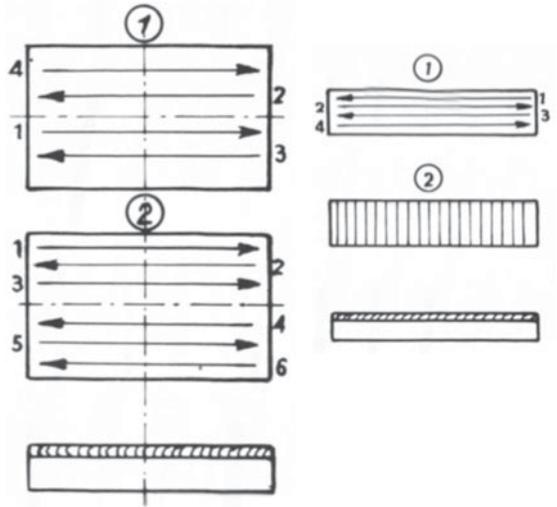
HARDFACING DESIGN AND EXECUTION

- Symmetrical arrangements of the beads to reduce deformations

1 = OK - 2 = not recommended



axis
long part



APPLICATIONS

EXCAVATOR BUCKETS

Description:

CLADDING THE NEW BUCKET

Buckets are made of cast steel and the manganese steel lips are shaped using welds.

Generally, users protect new buckets from wear and tear with 14% manganese steel plates.

Products:

Electrode:

SUPERCITO, CITOCUT,
SUPRAMANGAN / SUPRAMANGAN CR,
FERINOX 307, SUPRADUR V1000, ABRACITO 62S.

Innershield flux cored wire:

FLUXODUR 58TiC-0, FLUXODUR 63-0.

Outershield flux cored wire:

FLUXOFIL 66.

Preparation:

Clean the surface.

Welding procedure:

First pass into the angle with the FERINOX 307 electrode, which will allow the plates to wear down completely without detaching. Subsequent passes use SUPRAMANGAN or SUPRAMANGAN Cr.

Weld with pulled beads in different places to prevent local overheating; do not exceed 200 °C.

In certain exposed areas, especially the edges of the lips between the teeth, where lining is not possible, texturing followed by embossing with the SUPRADUR V1000 or ABRACITO 62S electrode will be required.



BUCKET TO BE RELINED AND REPAIRED AFTER USE

a) Cracks in the bucket

Cracks are removed with the CITOCUT.

Repairs are made with the SUPERCITO.

b) Lining plates practically worn and need to be replaced

Use the CITOCUT to gouge and bevel the bucket and to remove old welds and lining plates.

Place new cladding using the procedure for new buckets.



APPLICATIONS

TRACTOR WHEELS, SPUR GEARS, TRACK ROLLERS

■ Description:

CLADDING THE NEW BUCKET

Wheels and track rollers are subject to metal-on-metal wear and tear, with interposed powdery material, low-level impacts.

Welding products are selected based on the relative difficulty and on the cost of the parts in contact. Generally, the easiest part to remove and hardface will be scrapped, ie the wheel rather than the rolling track.

The consumables will deposit metal with a homogeneous structure, with a lower hardness than the part prior to hardfacing. This difference will be approximately 10 HRC.

■ Products:

• Electrode:

SUPRADUR 400 (*rutile coating*),
SUPRADUR 400B (*basic coating*).

• Submerged arc welding:

OE S2Mo dia 3.2mm and OP1350A flux.

• Outershield wire:

FLUXOFIL 52.

■ Preparation:

Clean the surface.

If necessary, remove the work-hardened metal.

Mount the driving wheel on a horizontal axis.

If a blow with a hammer does not leave a mark on the part, it is recommended to preheat it to 150 °C.

Use a template to check the shape and thickness of the hardfacing.

■ Welding procedure:

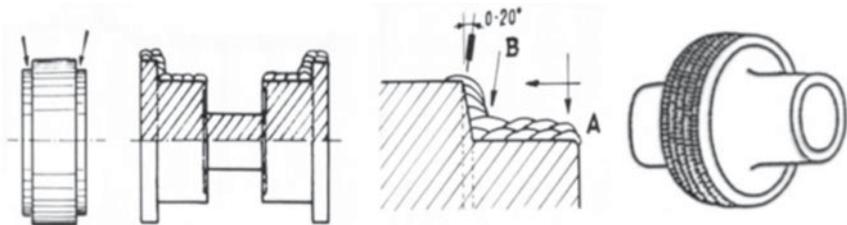
Submerged arc automatic hardfacing is preferred.

Deposit 1-3 layers flat.

Generally, the parts can be reassembled without further machining.

Recondition edge B.

The same operation is possible using cored wire for gas metal arc or submerged arc semi-automatic or automatic welding.



APPLICATIONS

DRIVE WHEELS

■ Description:

Reconditioning the surfaces in contact with the track rollers and spur gears.

Wheels and track rollers are subject to metal-on-metal wear and tear, with interposed powdery material, impacts are not significant, but pressures are high.

■ Products:

- **Electrode:**
SAFER 345B, SUPRADUR 400.
- **Outershield flux cored wire:**
FLUXOFIL 52.

■ Preparation:

Remove the wheels or place the tractor on jacks so the wheel can freely turn and be worked on flat.

Make a gauge, modelled on a new wheel.

Clean the surfaces by brushing and grinding.

If necessary, remove the work-hardened metal.

■ Welding procedure:

Mount the driving wheel on a horizontal axle.

Weld with pulled beads in different places to prevent local overheating; do not exceed 200 °C.

Use a template to check the thickness of the hardfacing.

If the hardfacing was done carefully, light texturing with a hand grinder should be sufficient before commissioning.



APPLICATIONS

TRACTOR TRACK LINKS AND TRACK SHOES

■ Description:

Reconditioning the surfaces in contact with the track rollers and spur gears.

■ Products:

- **Electrode:**
SUPRADUR 400 & SUPRADUR 600 (*rutile version*)
SUPRADUR 400B & SUPRADUR 600B (*basic version*)
- **Outersheild flux cored wire:**
FLUXOFIL 52.

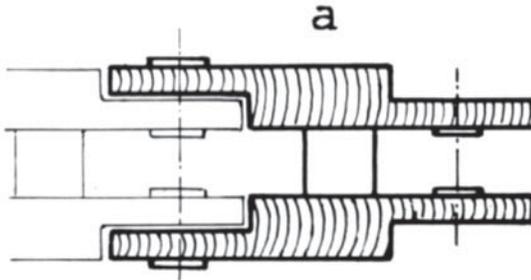
■ Preparation:

Clean the surfaces by brushing and grinding.

■ Welding procedure:

Deposit pulled welding beads on the edges (A), Fill (B).

- **Using an electrode:** fill by weaving on narrow edges and with welding beads on wide areas.
- **Using wire:** weave beads over the entire width (up to 50 mm wide). If the hardfacing is done carefully, no further machining is required.



APPLICATIONS

TRACTOR TRACK SHOES

■ Description:

Reshaping the nose (A) and hardfacing the edge (B).
Reconditioning the surfaces in contact with the ground.

■ Products:

• Electrode:

SUPERCITO, CITOCUT,
SUPRAMANGAN, FERINOX 307,
SUPRADUR V1000, SAFER NF 510A.

• Innershield flux cored wire:

FLUXODUR 58TIC-0, FLUXODUR 63-0.

• Outershield flux cored wire:

FLUXOFIL 66.



■ Preparation:

Clean the surfaces by brushing and grinding.
Grind the nose - adapt the 60-70 kg steel flat plate
- thickness same as the nose.
Make a gauge, modelled on a new part.

■ Welding procedure:

If there were any cracks in the pad, bevel them with the CITOCUT electrode, then weld them with the SAFER NF 510A.

Assemble the nose with the SUPERCITO.

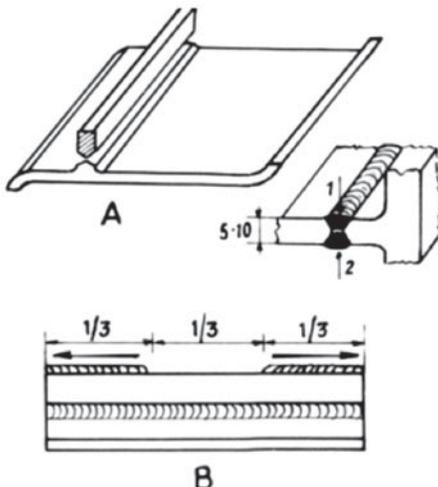
Hardface the edge of the nose with one layer, using SUPRADUR V1000.

Only on 1/3 of the nose's width, but twice (B).

Check the dimensions and shape using the gauge.

Hardface the surfaces in contact with the drive wheel using the SUPRADUR 400B, and FLUXODUR 58TIC-0, or FLUXOFIL 66.

Check the profile with the template.



APPLICATIONS

BULLDOZER BLADES

■ Description:

Reconditioning the surfaces in contact with the ground.

Reshaping the nose (A) and hardfacing the edge (B).

Reinforce the inner nose (C) and the inside of the blade at (D).

■ Products:

• Electrode:

SUPERCITO, SUPRADUR V1000, ABRACITO 62S.

• Outershield flux cored wire:

FLUXOFIL 66.

• Innershield flux cored wire:

FLUXODUR 58 TIC-O, FLUXODUR 63-O.

■ Preparation:

Clean the surfaces by brushing and grinding.

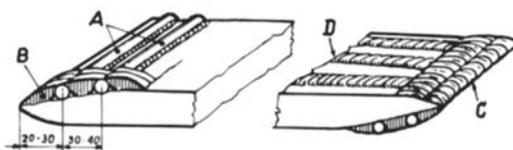
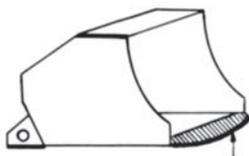
■ Welding procedure:

If there are any cracks, bevel them with the CITOCUT electrode, then weld them with the SUPERCITO.

Recondition the underside of the blade with bars (A) then fill with woven layers (B) using a SUPRADUR V1000 or ABRACITO 62S electrode.

Strengthen the inner nose with the same products (C).

Strengthen the inside of the blade with pulled welding beads, using the same products (D).



APPLICATIONS

MANGANESE STEEL EXCAVATOR BUCKET TEETH AND SPIKES

■ Description:

Reconditioning the surfaces in contact with the ground.
Reshaping the nose (A), protecting the sides (B) and the keyhole (C).

■ Products:

- **Electrode:**
SUPERCITO, SUPRADUR V1000, ABRACITO 62S, CITOCUT, FERINOX 307.

■ Preparation:

Clean the surfaces by brushing and grinding.

■ Welding procedure:

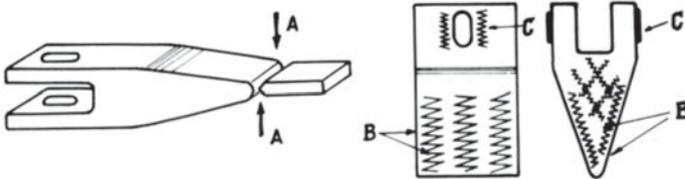
The welder is to grind or hardface several parts together, changing electrodes for each part so as not to exceed 100 °C.

For significant wear and tear: for the nose insert (A) assemble with 307 or 309.

Restoring the dimensions of the nose: use electrode 307 (FERINOX 307), single-layer hardfacing with ABRACITO 62S. Or two layers, with SUPRADUR V1000 and strengthening.

Single layer hardfacing with reinforcement of the nose and protection of the sides (B) and keyhole (C).

Hardfacing strips are used for abrasion combined with impacts, with separate or in-line beads, in the direction of movement only for coarse abrasives (rocks) or perpendicular to the direction of movement for powdery abrasives: sand/gravel + mud.



APPLICATIONS

LIFT BUCKET EDGES

■ Description:

Making fixed or removable wear edges from semi-hard steels.

■ Products:

• Electrode:

SUPERCITO, SUPRADUR V1000, ABRACITO 62S, CITOCUT.

• Outershield flux cored wire:

FLUXOFIL 66.

• Innershield flux cored wire:

FLUXODUR AP-0, FLUXODUR 58TIC-0, FLUXODUR 63-0.

■ Preparation:

Clean the surfaces by brushing and grinding.
Use a semi-hard steel plate.

■ Welding procedure:

If there are any cracks, bevel them with the CITOCUT electrode, then weld them with the SUPERCITO.

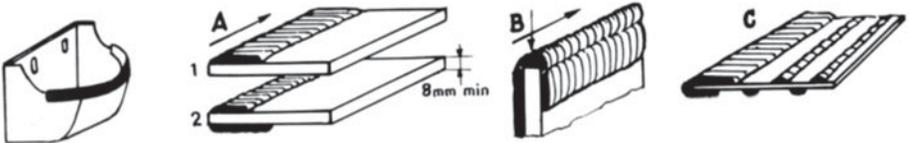
Mount the plate onto the bucket by welding with 307
Deposit the wear layer (A) directly on the flat portions by woven layers.

1. inside
2. outside

On the worn, non-removable edge, remake the incorrect size area with bars or plates, or by hardfacing with 307.

The area close to the edges is strengthened with:

- Lightly woven beads on the edge, in 2 layers if possible (see B).
- Pulled beads to the inside (see C).



APPLICATIONS

CRUSHER JAWS

■ Description:

Crusher jaws are generally made of 14% manganese steel.

Reconditioning the edges.

■ Products:

• Electrode:

SUPRAMANGAN / SUPRAMANGAN CR,
SUPRADUR V1000, ABRACITO 62S,
FERINOX 307.

• Outershield flux cored wire:

FLUXOFIL 66.

• Innershield flux cored wire:

FLUXODUR AP-0, FLUXODUR 63-0.

■ Preparation:

Clean the surfaces by brushing and grinding.

Make a gauge, modelled on a new part.

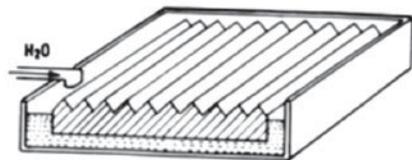
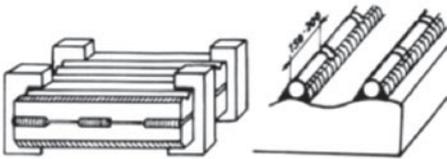
Mount the part in the water tank, or clamp two jaws back-to-back with a clamp or with weld beads. FERINOX 307.

■ Welding procedure:

Recondition severely worn areas with manganese steel bars or plates, length ± 150 to 200 mm (A).

Use SUPRAMANGAN CR to fill the surfaces with pulled beads evenly spread over the part to keep it as cold as possible.

Use SUPRADUR V1000 or ABRACITO 62S to apply a final layer.



APPLICATIONS

14% MANGANESE STEEL FREE SWINGING HAMMERS

■ Description:

Free swinging hammers can be made of manganese steel or C Mn Cr cast steel.

■ Products:

- **Electrode:**
SUPRAMANGAN, SUPRADUR V1000, ABRACITO 62SE, FERINOX 307.
- **Outersheild flux cored wire:**
FLUXOFIL 66.
- **Innersheild flux cored wire:**
FLUXODUR AP-0, FLUXODUR 63-0.

■ Preparation:

Clean the surfaces by brushing and grinding.
Determine the type of steel with a magnet: manganese steel is not magnetic.

■ Implementation:

If wear is severe, restore the profiles using the SUPRAMANGAN electrode and working on several electrodes to prevent the temperature from rising above a maximum of 150°C, using the SUPRADUR V1000 or ABRACITO 62S, hardface the leading edge with a woven layer.

To prevent rotor deterioration, balance the hammers before reassembly.



APPLICATIONS

CRUSHER BARS

Description:

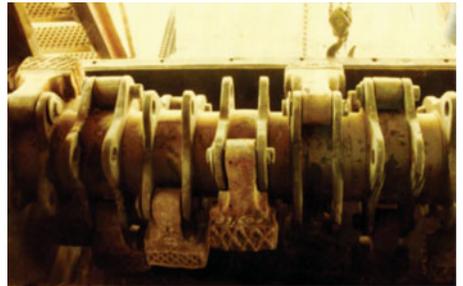
Repairing HAZEMAG crusher bars and grizzly screen bars. In general, these are made of 14% Mn.

Products:

- **Electrode:**
SUPRAMANGAN, SUPRADUR V1000, ABRACITO 62S, FERINOX 307.
- **Outershield flux cored wire:**
FLUXOFIL 66.
- **Innershield wire:**
FLUXODUR AP-0, FLUXODUR 63-0.

Preparation:

Clean the surfaces by brushing and grinding.
Determine the type of steel with a magnet: manganese steel is not magnetic.

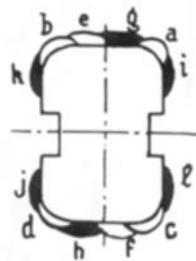
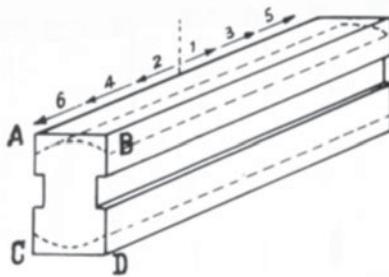


Implementation:

If wear is severe, restore the profile using the SUPRAMANGAN electrode, working on several bars to prevent the temperature from rising too high.

Use the SUPRADUR V1000 or the ABRACITO 62S for hardfacing the leading edges with two woven layers.

Hardface the edge from the inside to the outside. Turn the part frequently (a-d-e-b-l-e-hg, etc) to control deformations.



APPLICATIONS

C MN CR CAST STEEL FREE SWINGING HAMMERS

■ Description:

Free swinging hammers can be made of manganese steel or C Mn Cr cast steel.

■ Products:

• Electrode:

SAFER 345 B, SUPRADUR V1000, ABRACITO 62S, CITOCUT, FERINOX 307.

• GMAW solid wire:

CARBOFIL A 600.

• Outershield flux cored wire:

FLUXOFIL 52, FLUXOFIL 56, FLUXOFIL 58, FLUXOFIL 66.

• Innershield flux cored wire:

FLUXODUR AP-0, FLUXODUR 58 TIC-0, FLUXODUR 63-0.

■ Preparation:

Clean the surfaces by brushing and grinding.

Determine the type of steel with a magnet: manganese steel is not magnetic.

C Mn Cr cast steel hammers will require hollowing by gouging (1) (2).

On work-hardened hammers, use a FERINOX 307 sub-layer.

■ Implementation:

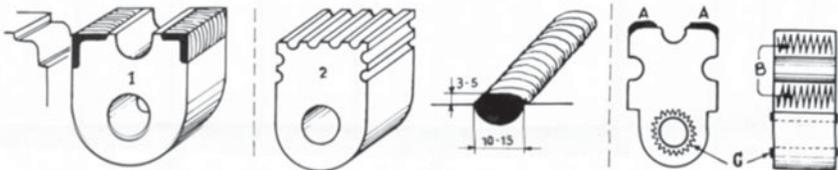
If wear is severe, restore the profile using the SAFER 345B electrode.

If possible, work by following a copper gauge to keep the required distances between the hammers and the crusher plates.

No pre-heating is required, but a welding temperature of 250°C must be maintained throughout.

Use the SUPRADUR V1000 or the ABRACITO 62S for hardfacing the leading edges with one or two woven layers (A).

Strengthen the lateral sides (B) and the edge of the axle fastening hole (C).



APPLICATIONS

CRUSHER ROTORS AND DISKS

■ Description:

Crusher rotors or disks are usually made of C Mn Cr cast steel.

■ Products:

• Electrode:

SAFER 345 B, SUPRADUR V1000, ABRACITO 62S, CITOCUT, FERINOX 307.

• GMAW solid wire:

CARBOFIL A 600.

• Outershield flux cored wire:

FLUXOFIL 52, FLUXOFIL 56, FLUXOFIL 58, FLUXOFIL 66.

• Innershield flux cored wire:

FLUXODUR AP-0, FLUXODUR 58 TIC-0, FLUXODUR 63-0.

■ Preparation:

Clean the surfaces by brushing and grinding.

Determine the type of steel with a magnet: manganese steel is not magnetic.

■ Implementation:

If wear is severe, restore the profile using the SAFER 345B electrode.

No pre-heating is required, but a welding temperature of 250°C must be maintained between passes.

Use the SUPRADUR V1000 or the ABRACITO 62S for hardfacing with one or two woven layers.



APPLICATIONS

SHAFTS

■ Description:

Rolling bearing shafts and seats are generally made of low C Mn Cr alloy steel.

■ Products:

• Electrode:

SAFER 345 B, SUPRADUR 400 (*rutile coating*), SUPRADUR 400B (*basic coating*).

• Outershield flux cored wire:

FLUXOFIL 52, FLUXOFIL 56.

■ Preparation:

Clean the surfaces by brushing.

If possible, machine-turn work-hardened surfaces and round off angles.

Pre-heating: if possible, and depending on the base metal's composition (hardness) = 150-200°C.

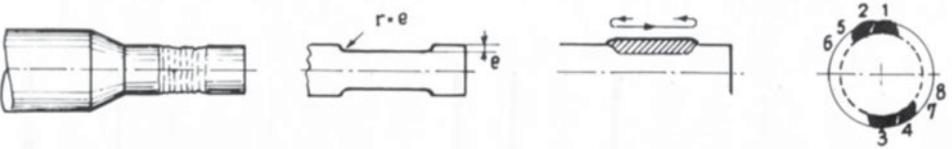
■ Implementation:

Hardfacing with pulled welding beads along the axis of the shaft.

Spread the beads evenly to minimise deformations. Take care over the beginnings and when stopping, go back so that the crater protrudes. Any such defects will be removed by subsequent machining.

If the part can be mounted so it can rotate, helical (*continuous*) depositing can be used.

In order to limit the temperature when welding ends, we recommend you start hardfacing at the free end of the shaft .



APPLICATIONS

BORES

■ Description:

The structures in which the rolling bearing shafts fit are generally made of low C Mn Cr alloy steel.

■ Products:

• Electrode:

SAFER 345 B, SUPRADUR 400 (*rutile coating*), SUPRADUR 400B (*basic coating*).

• Outershielded flux cored wire:

FLUXOFIL 52.

■ Preparation:

Clean the surfaces by brushing

If possible, remove work-hardened surfaces and round off angles.

Pre-heating: if possible, and depending on the base metal's composition (hardness) = 150-200°C.

■ Implementation:

Hardfacing with pulled welding beads

Spread the beads evenly to minimise deformations. Take care over the beginnings and when stopping, go back so that the crater protrudes. Any such defects will be removed by subsequent machining.

Make sure it protrudes enough for proper machining.



APPLICATIONS

SCREW CONVEYORS

■ Description:

Screw conveyors are generally made of low C Mn Cr alloy steel.

They are mainly subject to abrasion.

In practice, spiral thicknesses below 4 mm are not hardfaced.

■ Products:

• Electrode:

SAFER 345 B, SUPRADUR 400, SUPRADUR B600, SUPRADUR V10000.

• GMAW solid wire:

CARBOFIL A 600.

• Outershield flux cored wire:

FLUXOFIL 52, FLUXOFIL 56, FLUXOFIL 58, FLUXOFIL 66.

• Innershield flux cored wire:

FLUXODUR 58 TiC-O, FLUXODUR 63-O.

■ Preparation:

Clean the surfaces by brushing.

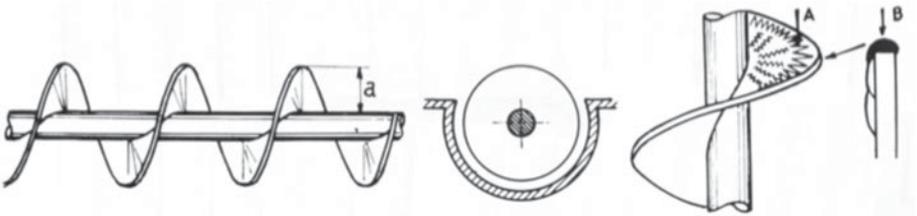
No pre-heating is required, but a welding temperature of 250°C must be maintained between passes.

■ Implementation:

Hardface the surfaces over a 3-4cm width.

The spiral is mounted vertically. The work is performed downwards to provide a smooth, thin deposit (A). For large-diameter screws, surfaces next to the core must be strengthened with a pulled bead, to be deposited as regularly as possible to avoid damaging the channel where the screw is to be fitted.

In general, this bead is to be deposited by automated means.



APPLICATIONS

STEEL GEARS

■ Description:

Repairing parts and rebuilding teeth.

■ Products:

- Electrode:

SAFER 345B, SAFER R400.

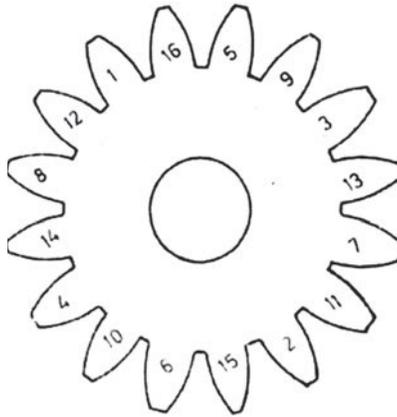
■ Preparation:

In general, gears are coated with grease or oil, which must be carefully removed, either with

trichloroethylene or by burning off with a blowtorch. This safety measure is mainly necessary for cast iron gears.

■ Implementation:

Steel gears present no problems. Their profile just needs to be rebuilt with the electrode used for hardfacing. To prevent the temperature from rising too much between passes, hardfacing of the teeth must be done in the order specified in the diagram below, so that the tooth can cool sufficiently.



APPLICATIONS

CAST IRON COLD WELDING

Cold-welding is the assembly method used most often for repairing cast iron parts. During this process, the temperature gradient between the weld and the surrounding areas will be at most 50°C. The technique consists of depositing short beads (2-3 cm) followed by hammering to compensate for the shrinkage of the bead just deposited.

There are several variants of cold welding, depending on which electrode is chosen: Nickel or ferronickel electrodes and bronze electrodes.

Ferronickel electrodes are most frequently used, even though its welds are less suitable for machining than those made with pure nickel electrodes. Monel electrodes are more sensitive to cracking and no longer used.

In all three cases, light and uniform pre-heating increases the chances of success.

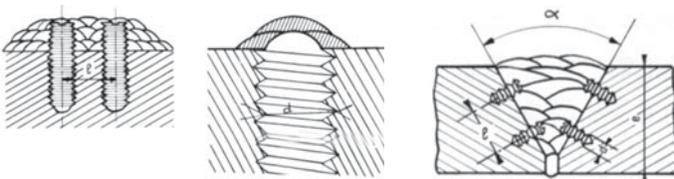
The decisive factor is the reaction between impurities and the coating; tests for welding suitability will determine the type of electrode to be used.

Pure nickel and ferronickel electrodes can both be used for this assembly mode. The choice will depend on the mechanical properties of the cast iron to be assembled, or on its surface finish. There are many technological factors to take into account for successfully making welds on cast iron.

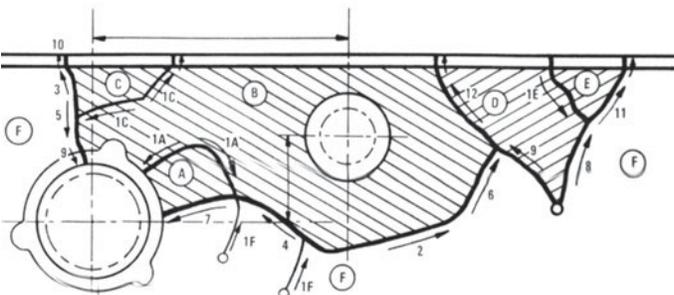
Here is some practical advice for making a good repair.

- Find the end of a crack and stop it by means of a hole drilled all the way through. Never weld over a crack.
- Always bevel a crack all the way down. Use the ARC AIR process or the CITOCUT electrode.
- Round off all the angles of the item.
- Deposit short beads (2-3 cm) followed by hammering with a round-head hammer; never use a pistol needle scaler.
- For X-shaped bevels, the first bead must be welded to penetrate completely.
- Weld from the flanged parts towards the unflanged parts.
- Never point the electrode towards the edges of the bevel to reduce the heating of the ZAT.
- Whenever possible, avoid flat linking areas.
- When possible, increase the gripping surface with suitable gouging.
- When the cast iron is hard to weld, use a steel electrode with a basic or graphite coating as a sub-layer.
- Reinforce parts subject to heavy stress as much as possible.

Repairing cast steel or cast iron parts



Remedies r1 - r2 - r3 - r4 (for cast iron parts)



Rebuild assemblies (A + B + C) (D + E), which will be welded after F.

Hardface the bores for re-boring (respecting centreline distances).

Re-weld from the flanged parts towards the unflanged parts; weld 1 F; then assemble (A + B + C) over F; then (D + E) over the assembly. Follow the order - 1 to 12.

APPLICATIONS

CAST IRON GEARS

■ Description:

Repairs to broken teeth.

■ Products:

• Electrode:

SAFER 345B, SUPRADUR 400.

■ Preparation:

Clean the surfaces by brushing.

Remove remaining oil by heating with a blowtorch.

Use penetrant testing to find cracks and drill a hole at each end to stop them growing.

Bevel them with Air carbon arc cutting.

Round off angles with a grinder and remove all traces of oxides.

■ Implementation:

For low thicknesses, use the Ni electrode for the entire join. For higher thicknesses, the FN electrode can be used for the remaining two-thirds of the join.

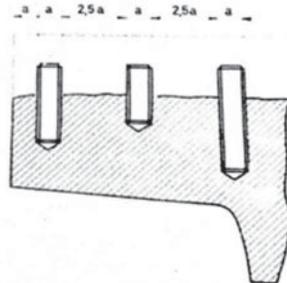
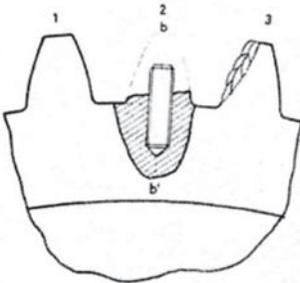
We recommend reducing the welding power:

use the smallest-available diameter, weld beads approximately 10x the diameter of the electrode core in length and 2x the diameter of the core in width, with as short an arc as possible.

The smaller beads will be deposited from the inside towards the outside and will be hammered immediately with a round-head hammer to reduce the stresses that come on cooling.

Pay attention to the thermal regime! Cast iron is cold-welded. You must take care not to exceed 70°C between passes. Consequently, you must wait until one bead has cooled before depositing the next bead. To avoid wasting time, follow the order of the numbers in the diagram opposite to alternate the hardfacing of the teeth; this will leave time for the tooth to cool sufficiently.

To rebuild teeth subject to heavy stress or on poor-quality cast iron, it is sometimes necessary to strengthen the bond between the deposit and the cast iron by gouging, drilling and threading holes in the cast iron, then wedging studs in them and then rebuilding the profile. The diagram below shows the process to be followed.



LIST OF PRODUCTS GROUPED PER PROCESS

COLOR LEGENDA

ABRASION + IMPACT	IRON BASED MARTENSITIC STEEL
IMPACT	MANGANESE AUSTENITIC STEEL
ABRASION + SERVICE AT MEDIUM TEMPERATURE (300-500 °C)	TOOL STEEL
ABRASION	CHROMIUM CARBIDE STRUCTURE
ABRASION + SERVICE AT HIGH TEMPERATURE (500-700 °C)	COBALT CARBIDE STRUCTURE
BUTTERING	AUSTENITIC STRUCTURE

STICK ELECTRODES

Type	Brand		Classification	Hardness	Main alloys >5%												
	OERLIKON	SAF-FRO			C	Mn	Si	Fe	Cr	Ni	Mo	Nb	V	W	Co	Ti	
SMAW	ABRACITO 62S	SAFDUR 800 E	EN 14700: E Fe16	62 HRC	5				x		x	x					
SMAW	SUPRADUR 2015		EN ISO 14700: E Z (Fe1)	48-52 HRC	0,25												
SMAW		SAFER 345 B	EN 14700: E Fe13	300 HB	0,07												
SMAW	SUPRADUR 400	SAFER R 400	EN 14700: E Fe1	240-290 HB	0,1												
SMAW	SUPRADUR 400B		EN 14700: E Fe1	375-450 HB	0,2												
SMAW		SAFER B 400	EN 14700: E Fe1	375-450 HB	0,2												
SMAW		SAFER R 600	EN ISO 14700: E Z (Fe2)	550-650 HV	0,6				x								
SMAW	SUPRADUR 600		EN ISO 14700: E Z (Fe2)	550-650 HV	0,6												
SMAW	SUPRADUR 600B		EN ISO 14700: E Z (Fe2)	57-62 HRC	0,5				x								
SMAW		SAFER B 600	EN ISO 14700: E Z (Fe2)	57-62 HRC	0,4				x								
SMAW	SUPRADUR 600RB		EN ISO 14700: E Z (Fe2)	57-64 HRC	0,5				x								
SMAW	SUPRADUR V1000	SUPERSAFOR 60	EN ISO 14700: E Z (Fe14)	58-63 HRC	4,3				x								
SMAW	SUPRADUR 600T	TOOLFRO	EN ISO 14700: E Z (Fe2)	60 HRC	1,5		x				x						
SMAW	CITORAIL		EN 14700: E Fe1	300 HB	0,14												
SMAW	CITOCUT																
SMAW	SUPER CUT																
SMAW	FERINOX 307		EN 14700 : E Fe10	180 HB	0,07	x			x	x							
SMAW	SUPRANOX RS 312		AWS A5.4: E 309Mo-26	220 HB	0,08				x	x							
SMAW	SUPRAMANGAN	SAFMANGA	EN ISO 14700: E Z (Fe9)	175-225 HB	0,6	x											
SMAW	SUPRAMANGAN CR		EN ISO 14700: E Z (Fe9)	175-225 HB	0,6	x			x								
SMAW	SUPRASTELL 6		AWS A5.13: E CoCr-A	40-45 HRC	1,1				x							x	

LIST OF PRODUCTS GROUPED PER PROCESS

SOLID WIRE AND TIG RODS (other products available on request)

Type	Brand		Classification	Hardness		Main alloys >5%												
	OERLIKON	SAF-FRO				C	Mn	Si	Fe	Cr	Ni	Mo	Nb	V	W	Co	Ti	
GMAW	CARBOFIL A350		EN 14700 S-Fe 2	325-380	HB	0,7												
GMAW	CARBOFIL A600	FILCORD 58	EN 14700 S-Fe 8	57-62	HRC	0,5		x		x								
GTAW	CITOLIT 6CT		A5.21 - ERCoCr-A	39-43	HRC	1,2				x								x
GTAW	CITOLIT 12CT		A5.21 - ERCoCr-B	47-50	HRC	1,4				x							x	x

FLUX CORED WIRE AND ALLYING FLUXES FOR SAW PROCESS

Type	Brand		Classification	Hardness		Main alloys >5%												
	OERLIKON	SAF-FRO				C	Mn	Si	Fe	Cr	Ni	Mo	Nb	V	W	Co	Ti	
FCAW (MC)	CITOFILUX H06	SAFDUAL 560	EN 14700 T-Fe 8	58	HRC	0,4		x		x								
FCAW (Basic)	FLUXOFIL 50		EN 14700 S-Fe 1	225-275	HB	0,2												
FCAW (Basic)	FLUXOFIL 51		EN 14700 S-Fe 1	275-325	HB	0,2												
FCAW (Basic)	FLUXOFIL 52		EN 14700 S-Fe 1	325-375	HB	0,25												
FCAW (Basic)	FLUXOFIL 54	STEELCORED 54	EN 14700 TZ-Fe7	37-42	HRC	0,07				x								
FCAW (Basic)	FLUXOFIL 56		EN 14700 T-Fe 8	52-57	HRC	0,4				x								
FCAW (Basic)	FLUXOFIL 58	STEELCORED 58	EN 14700 T-Fe 8	57-62	HRC	0,5				x								
FCAW (MC)	FLUXOFIL M58	STEELCORED M 58	EN 14700 T-Fe 8	57-62	HRC	0,6				x								
FCAW (MC)	FLUXOFIL 66		EN 14700 T-Fe 8	57-62	HRC	1,4				x			x					
FCAW	FLUXOLIT G6		EN 14700 T-Co 2	36-39	HRC	0,9				x								x
FCAW	FLUXOLIT G21		EN 14700 T-Co 1	30-34	HRC	0,25				x			x					x
FCAW - open arc	FLUXODUR 58 TIC-O		EN 14700 T-Fe 8	58-60	HRC	1,8				x								x
FCAW - open arc	FLUXODUR 62-O		EN 14700 TZ Fe14	57-62	HRC	5,0				x								
FCAW - open arc	FLUXODUR 63-O		EN 14700 T-Fe 15	62-65	HRC	5,0				x				x				
FCAW - open arc	FLUXODUR A2-O		EN ISO 17633-A: T18 8 Mn UN 3	175-225	HB	0,03	x			x		x						
FCAW - open arc	FLUXODUR AP-O		EN 14700 T-Fe 9	210-240	HB	0,4	x			x								

FLUX AND WIRE COMBINATIONS

Type	Brand		Classification	Hardness		Main alloys >5%												
	OERLIKON	SAF-FRO				C	Mn	Si	Fe	Cr	Ni	Mo	Nb	V	W	Co	Ti	
SAW	FLUXOCORD 50 (OP 122)		EN 14700: T Fe1	225-275	HB	0,14												
SAW	FLUXOCORD 51 (OP 122)		EN 14700: T Fe1	275-325	HB	0,18												
SAW	FLUXOCORD 52 (OP 122)		EN 14700: T Fe1	375-450	HB	0,22												
SAW	FLUXOCORD 54 (OP 122)		EN 14700: T Fe2 (approx)	34-38	HRC	0,06												
SAW	FLUXOCORD 54-6 (OP 122)		EN 14700: T Fe1	37-42	HRC	0,08				x								
SAW	FLUXOCORD 58 (OP 122)		EN 14700: T Fe8	56-58	HRC	0,5				x								
SAW	OP 1250A (OE-S2M0)		EN ISO 14174: SA CS 3	260	HB	0,1												
SAW	OP 1300A (OE-S2M0)		EN ISO 14174: SA CS 3	360	HB	0,1												
SAW	OP 1350A (OE-S2M0)		EN ISO 14174: SA CS 3	390	HB	0,1												
SAW	OP 1450A (OE-S2M0)		EN ISO 14174: SA CS 3	450	HB	0,2												

TECHNICAL DATA

SAFER 345 B

Description

- Basic coated hardfacing electrode.
- Hardfacing parts subject to impacts or significant compression loads.
- Sub-layer over ferritic steel before hard hardfacing.
- Rebuilding profiles.
- AC or DC+.

Suitable for

- Electrode approved by SNCF for hardfacing rails with hardness of 700 and 900.
- Hardfacing end of coupling shafts, lamination cylinders, gear teeth, drive wheels and crane and tractor chain shoes, etc.

Properties of the deposited metal

- Structure: bainitic.
- Hardness: 320 HB.
- Suitability for machining: excellent.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				

SUPRADUR 400

Description

- Rutile electrode for hardfacing.
- Rebuilding profiles, sub-layer over ferritic steel before «hard» hardfacing.
- High resilience to impacts.
- Hardfacing of parts requiring high toughness and easy machining.
- AC or DC+ flat-position welding.

Suitable for

- Rail ends and curves, travelling crane rollers, wheel treads, laminating cylinders, gear teeth, rolling bearing parts, shafts, etc.

Properties of the deposited metal

- Structure: bainitic.
- Hardness: straight from welding 250HB ; tempered and quenched: 400 HV.
- Suitability for machining: very good.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				

SUPRADUR 400B

Description

- Basic electrode for hardfacing.
- Rebuilding profiles, sub-layer over ferritic steel before «hard» hardfacing.
- High resilience to impacts.
- Hardfacing of parts requiring high toughness and easy machining.
- AC or DC+ flat-position welding.

Suitable for

- Rail ends and curves, travelling crane rollers, wheel treads, laminating cylinders, gear teeth, rolling bearing parts, shafts, etc.

Properties of the deposited metal

- Structure: martensitic.
- Hardness: straight from welding 400 HB.
- Suitability for machining: possible with plate tools.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				

TECHNICAL DATA

SUPRADUR 600B

Description

- Rutile/basic hardfacing electrode.
- Excellent resistance to impacts and compressive stress.
- Good resilience to abrasion.
- Excellent ability to weld, even in difficult places.
- AC or DC+ flat-position welding.

Suitable for

- Tractor and crane parts, excavator teeth, crusher hammers, crusher parts, etc.

Properties of the deposited metal

- Structure: martensitic.
- Hardness: 60 HRC.
- Machining: with a grinder.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				

SUPRADUR 600T

Description

- Basic hardfacing electrode.
- Very good for welding in all positions except on ceilings and downward verticals.
- Hardfacing parts subject to metal-on-metal wear, without significant thermal shocks.
- Maximum operating temperature: 550 °C.
- Manufacturing or repairing high-speed steel tools, hardfacing edges.
- 120% yield.
- AC or DC+ flat-position welding.

Suitable for

- Cold shear blades, wire-guides, bending guides, machining and milling tools, etc.

Properties of the deposited metal

- Structure: fine carbide precipitation in a martensitic matrix.
- Hardness: straight from welding: 58 HRC; tempered and quenched: 65 HRC.
- Machining: by grinding or after softening.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				

SUPRAMANGAN

Description

- Basic coated hardfacing electrode.
- Hardfacing parts made of 14% manganese steel, or carbon parts subject to significant impacts or compaction.
- Assembly of 14% Mn steels.
- Sub-layer over 14% Mn steel before «hard» hardfacing.
- AC or DC+ flat-position welding.

Suitable for

- Mn steel sets of railway points.
- Heavy-duty crushing equipment: pendulum crushing hammers, toothed rollers for cylinder crushers, crowns for ore crushers, excavator and dredger buckets, etc.

Properties of the deposited metal

- Structure: austenitic.
- Hardness: straight from welding: 200 HB, then, after work-hardening: 450 HB.
- Machining: possible if not work-hardened.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				

TECHNICAL DATA

SUPRADUR V1000

Description

- Rutile hardfacing electrode.
- Hardfacing parts subjected to severe abrasion and non-violent impacts.
- Auto-cracking deposit, generally limited to a maximum of 3 layers.
- AC or DC+ flat-position welding.
- 160% yield.

Suitable for

- Crushing and earthworks equipment, soft ore crushers, screw conveyors, teeth and lips on buckets.

Properties of the deposited metal

- Structure: austenitic + chromium carbides.
- Hardness: 60 HRC.
- Machining: with a grinder.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				
Corrosion				

ABRACITO 62S

Description

- Basic coated hardfacing electrode.
- Auto-cracking deposit, generally limited to a maximum of 3 layers.
- Hardfacing of parts subjected to extreme abrasion with moderate-strength impacts.
- Maximum operating temperature: 650 °C.
- AC or DC+ flat-position welding.
- 200% yield.

Suitable for

- Ore shredder spikes, cement ovens, channels, agglomerate crushers and ventilators, blast furnaces.

Properties of the deposited metal

- Structure: austenitic with Nb, Cr, Mo, W and V carbides.
- Hardness: 2 layers: 62 HRC.
- Machining: with a grinder.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				
Corrosion				

CITOCUT

Description

- Electrode with special coating for gouging most steels, cast irons, base nickel, etc.
- Excellent performance, even with inferior welding machines.
- Small amount of slag.
- Instant start and restart.
- AC or DC+.

Suitable for

- Cutting, piercing and bevelling carbon steels, low alloy steels, cast iron, base nickel.

TECHNICAL DATA

CARBOFIL A 600

Description

- Solid wire for hardfacing under gas protection.
- Hard texturing of parts subject to abrasion with high-level impacts or with compressive stress.
- DC+.

Suitable for

- Crusher hammers, crushers, mixers, dredging parts, cutting tools, etc.

Properties of the deposited metal

- Structure: martensitic.
- Hardness: 60 HRC.
- Machining: with a grinder.

Protective gas

- Ar - CO₂, Ar - O₂ or CO₂ gas mixture.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				

FLUXOFIL 52

Description

- Copper flux cored wire hardfacing under gas protection.
- Rebuilding profiles, sub-layer over ferritic steel before "hard" hardfacing.
- High resilience to impacts.
- Hardfacing of parts requiring high toughness and easy machining.
- DC+.

Suitable for

- Rail ends and curves, travelling crane rollers, wheel treads, laminating cylinders, gear teeth, rolling bearing parts, shafts, etc.

Properties of the deposited metal

- Structure: bainitic.
- Hardness: straight from welding 350HB.
- Suitability for machining: very good.

Protective gas

- Ar - CO₂, Ar - O₂ or CO₂ gas mixture.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				

FLUXOFIL 56

Description

- Copper flux cored wire hardfacing under gas protection.
- Excellent resistance to impacts and compressive stress.
- Good resilience to abrasion.
- DC+.

Suitable for

- Tractor and crane parts, excavator teeth, crusher hammers, crusher parts, etc.

Properties of the deposited metal

- Structure: martensitic.
- Hardness: straight from welding 55 HRC.
- Machining: with a grinder.

Protective gas

- Ar - CO₂, Ar - O₂ or CO₂ gas mixture.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				

TECHNICAL DATA

FLUXOFIL 58

Description

- Copper flux cored wire hardfacing under gas protection.
- Excellent resistance to impacts and compressive stress.
- Good resilience to abrasion from metallic friction.
- DC+.

Suitable for

- Tractor and crane parts, excavator teeth, crusher hammers, crusher parts, tool steel, cylinders, etc.

Properties of the deposited metal

- Structure: martensitic.
- Hardness: straight from welding 60 HRC.
- Machining: with a grinder.

Protective gas

- Ar - CO₂, Ar - O₂ or CO₂ gas mixture.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				

FLUXOFIL 66

Description

- Copper flux cored wire hardfacing under gas protection.
- Hardfacing parts subjected to severe abrasion and impacts.
- Deposit, generally limited to a maximum of 3 layers.
- Very good resilience to abrasion by gouging and erosion.
- DC+.

Suitable for

- Crushing and earthworks equipment, soft ore crushers, screw conveyors, teeth and lips from buckets, scraper blades.

Properties of the deposited metal

- Structure: martensitic + Niobium carbides.
- Hardness: 60 HRC.
- Machining: with a grinder.

Protective gas

- Ar - CO₂, Ar - O₂ or CO₂ gas mixture.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				

FLUXODUR AP-0

Description

- Self-shielding cored wire for hardfacing.
- Hardfacing parts made of 14% manganese steel, or carbon parts subject to significant impacts or compaction.
- Assembly of 14% Mn steels or carbon steel.
- Sub-layer over 14% Mn steel before "hard" hardfacing.
- DC+.

Suitable for

- Mn steel sets of railway points. Rail crossings, curves and ends.
- Heavy-duty crushing equipment: pendulum crushing hammers, toothed rollers for cylinder crushers, crowns for ore crushers, excavator and dredger buckets, crusher hammers, laminator parts, crusher cylinders, gyratory crusher cones.

Properties of the deposited metal

- Structure: austenitic.
- Hardness: straight from welding: 200 HB, then, after work-hardening: 450 HB.
- Machining: possible if not work-hardened.

Protective gas

- None.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				

TECHNICAL DATA

FLUXODUR 58 TiC-O

Description

- Self-shielding cored wire for hardfacing.
- Hardfacing parts subjected to severe abrasion and impacts.
- Deposit, generally limited to a maximum of 3 layers.
- Very good resilience to abrasion. by gouging and erosion.
- DC-.

Suitable for

- Crushing and earthworks equipment, soft ore crushers, screw conveyors, teeth and lips from buckets, scraper blades.

Properties of the deposited metal

- Structure: martensitic + Niobium carbides.
- Hardness: 60 HRC.
- Machining: with a grinder.

Protective gas

- None.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				

FLUXODUR 63-0

Description

- Self-shielding cored wire for hardfacing.
- Auto-cracking deposit, generally limited to a maximum of 3 layers.
- Hardfacing of parts subjected to extreme abrasion with moderate-strength impacts.
- Maximum operating temperature: 450 °C.
- DC-.

Suitable for

- Brick press screws, oil extracting machine screw, shielding plates, bucket teeth and edges for excavators working on iron ore extraction, ore shredder screens, sieves, mixer blades, etc.

Properties of the deposited metal

- Structure: austenitic with Nb, Cr carbides.
- Hardness: 2 layers: 62 HRC.
- Machining: with a grinder.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				
Corrosion				

FLUXODUR 51-0

Description

- Self shielding cored wire to realize build-up & buffer layers before depositing hardfacing ones.
- Deposit as much as possible layers to rebuilt the workpiece at its original form.
- Very good resistance to impact and pressure wears.
- DC-.

Suitable for

- Hammers, crushers, excavators teeth, cold shearing tools, etc...

Properties of the deposited metal

- Ferrite pearlite microstructure.
- Hardness 300HB.

Criteria

	Medium	Good	Very good	Excellent
Impact				
Abrasion				
Temperature				
Suitability for machining				

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