

### Why TUF-COTE hardfacing is better:

- Increases the lifetime of the tools by 3 to 10 times.
- Contains big tungsten carbide particles ranging in size up to 1,6 mm which bring the highest abrasion resistance (not possible with TIG, MIG, electrodes, spray and fuse).
- The use of hard steels or special and expensive steels is not necessary.
- Has the lowest volume loss with ASTM G65 test compared to other wear-resistant metals.
- Decreases maintenance frequency.
- No capital investment is required to apply TUF-COTE brazing flexi-cord (only a flame torch is required).
- TUF-COTE application procedure is easy to learn.
- TUF-COTE can be applied on the job site or in the job shop.
- It is possible to rebuild TUF-COTE on a previous TUF-COTE layer.

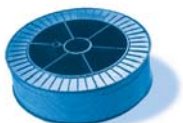
### Conclusion:

With spray materials and cladding, Kennametal brings new dimensions to coating technology. You will experience improved spray rates, improved spray efficiencies, and improved coating life. Call us today – our engineers can assess your needs and recommend a system that is right for you!

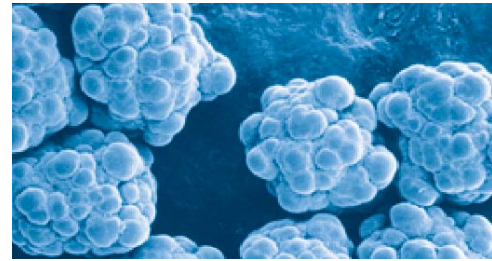
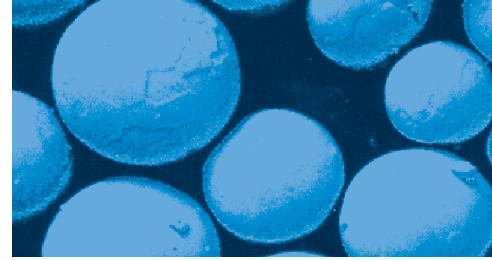
*Engineering Your  
Competitive Edge*



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Engineering Your  
Competitive Edge



## Engineered Products Coating Solutions

*TUF-COTE Hardfacing*



# Engineered Products Coating Solutions

## TUF-COTE

Kennametal® Coating Solutions has been solving severe wear-problems for over 60 years in many industries such as oil, drilling, mining, dredging, bricks and tiles, cement, and woodworking. We know that every wear problem does not necessarily involve the same solution, and we carefully study each case to offer the optimum product and application. Factors we consider are:

- The type of wear: abrasion, erosion, friction metal/metal, impact, etc.
- The abrasive material involved: sand, rocks, wood, metals, etc.
- The dimension, geometry, and metal of the tool to be hardfaced.
- The conditions of operation: temperature, environment, etc.
- The performance of equipment and the customer's expectations.

All of these factors must be taken into account in order to select the most suitable product from our range of TUF-COTE and hardfacing powders SF-WC.

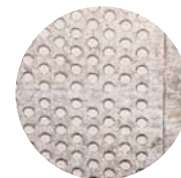
TUF-COTE, the hardfacing with a flexible cord wire made of cast tungsten carbides in NiCrBSi matrix, can be welded on mild steel, low alloyed steel, stainless steel, lamellar grey cast iron, spheroid cast iron. It can also be brazed on certain types of manganese steel with precautions. TUF-COTE is weldable on itself, making local repair or recycling of parts possible.



**Extrusion**



**Feeding**



**Screening**



**Tunneling-Drilling**



Kennametal is setting the standard in coating technology!

*Let us prove it.*

## TUF-COTE Composition:

TUF-COTE is a continuous flexible cord, made of case tungsten carbide particles mixed within a self-fluxing nickel matrix. The tungsten carbides are cast and crushed. On request, we supply: sintered carbides, spherical shaped carbides, different matrix compositions and different matrix hardness.

*The main flexible cord is composed of:*

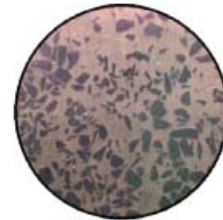
**Carbides CW/CW2: 60 to 68% in weight** Hardness: 2200 a 2400 Hv

Different grade: Grade A grain size max 1,6 mm

Grade M/N grain size max 0,8 mm

Grade F grain size max 0,4 mm

Grade MS grain size spherical CW



TUF-COTE A:	<i>Recommended for severe abrasive wear. Corrosion resistant. Recommended for civil works, mining drilling, etc.</i>
TUF-COTE M/N:	<i>Recommended for severe abrasive and erosive wear from powders or clay. Corrosion resistant. Grade M may be ground.</i>
TUF-COTE F:	<i>Recommended for severe erosive or friction wear from powders, metals, clay, etc. Corrosion resistant. Grade F may be ground.</i>

*Contact us for other available grades.*

**Matrix: 30 to 40% in weight** Hardness 40 to 60 HRC

NiCrBSi Self fluxing alloy, atomized powder

**Organic binder: 0.5% in weight**

Organic binder used for the skin burns during brazing.

**Packaging of the cord:**

TUF-COTE is packaged on a spool, weighing 38 lbs to 40 lbs each depending on diameter.



## TUF-COTE is available with:

- Different diameters: 4 mm; 4,75 mm; 6,35 mm and 8 mm.
- Different max tungsten particles sizes: 400  $\mu\text{m}$ ; 800  $\mu\text{m}$  and 1600  $\mu\text{m}$ .
- Different morphology of tungsten particles: angular or spherical.
- Different matrix from 40 HRC to 60 HRC, with different composition.
- Different percentages of tungsten carbide contents.

## Markets and Applications:

- **Brick making:** edges of molding screws, pulverizer mill scrapers, cones, combs, crushing hammers, mixer blades
- **Drilling:** stabilizer blades, roc drilling bits, guides/sleeves
- **Steel making:** fan blades, hopper liners, screens, dosing valves, guides, teeth and crushing hammers
- **Foundries:** hopper lining, screens, scrapers, dosing valves, feeder screws, crushing hammers
- **Dredging:** scrapers and bucket teeth, scraper blades, buckets liner, teeth of dredging bits
- **Civil works:** scrapers and bucket teeth, bucket liners, drilling bits, blades of mixer for asphalt machine, wear plates, tunneling tools
- **Cement plants:** feeding screws, fan blades, mixer blades, mixing scrapper, dosing valves
- **Mines:** scrapers and bucket teeth, hopper linings, screens, feeder rolls, crushing hammer
- **Food:** sugar cane crushers, screw edges for sugar beets and palm oil presses, mixer blades
- **Agriculture and forestry:** barking blades and tools, wear parts for farming tools, screws for feeding fertilizers, feeding screws for wood barks
- **Waste treatment:** scrapers, blades of centrifugal machines and mixers, edges of screws for water treatment equipment
- **Ceramic industry:** mixer blades, scrapers of pulverizer mills, feeding screws, crushing hammers, extrusion dies, screws



**Digging/Dredging**



**Crushing/Pulverizing**



**Lining**



**Mixing**



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*Let us prove it.*

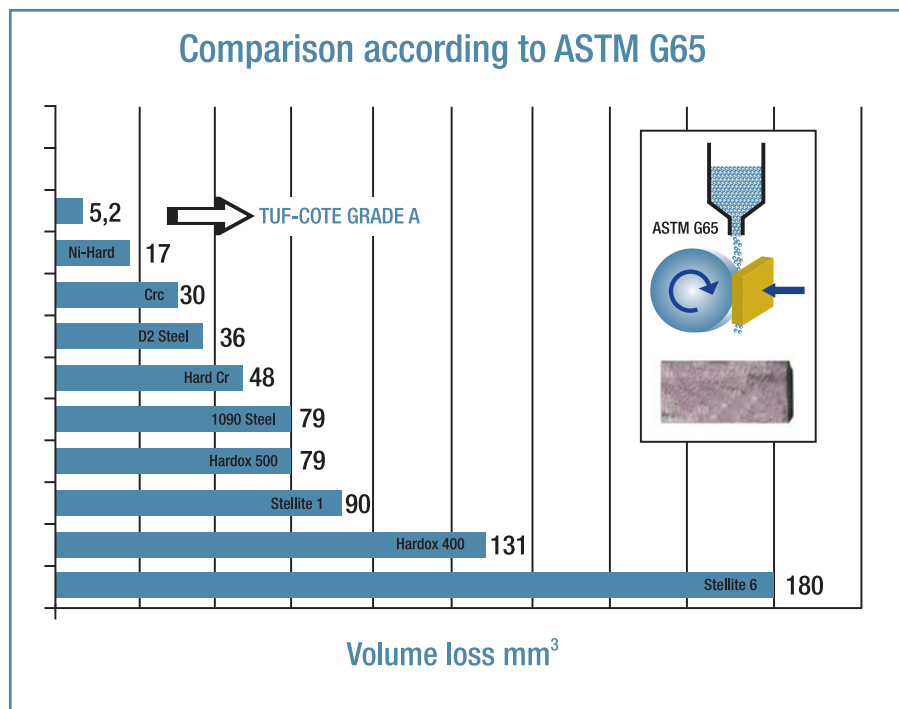
### TUF-COTE recommendations:

#### Acceptable alloys for hardfacing

- Stainless steels 18/8, 25/20, Z30C13
- Construction steel E24, A42, XC35 up to the grade 42CD4 (%C<0,42)
- Lamelar grey cast iron, spheroidal cast iron
- INCONEL: cold brazing possible at 100°C to 150°C with a bond coat
- 3% Cr and 4% Mn steels, possible hardfacing if %C<0,4%

#### Unacceptable alloys for hardfacing

- INVAR or Ni-hard cast iron with 25%Cr
- 13%Mn steel (possible with intermediate layer)



## STEP 1 Choose the Oxygen / Acetylene Torch Nozzle

### Oxygen – acetylene brazing torch with powder bowl

The welder may choose whichever torch he prefers based on the following considerations:

- TUF-COTE diameter 8 mm - torch is set with nozzle N°4 (Φ2,2 mm) or N°5 (Φ3,0 mm).
- TUF-COTE diameter 6,35 mm - torch is set with nozzle N°3 (Φ1,75 mm) or nozzle N°4 (Φ2,2 mm).
- TUF-COTE diameter below 6,35 mm - torch is set with nozzle N°3 (Φ1,75 mm).

### Gas and oxygen cylinder and pressure regulators (not supplied)

Oxygen and acetylene cylinders are required. Oxygen is set from 2.1 to 4 bars (30 to 60 PSI) and acetylene is set at 0.8 bars (12 PSI).

### Flexi-cord holder (not supplied)

Holder should be manufactured with copper tube ID 12 mm. The radius of the curve should be between 20 cm (8 in) to 30 cm (12 in).

### Flexi-cord choice

Make sure that the appropriate flexi-cord grade and diameter have been chosen.

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TUF-COTE M/N:	<i>Recommended for severe abrasive and erosive wear from powders or clay. Corrosion resistant. Grade M may be ground.</i>
TUF-COTE F:	<i>Recommended for severe erosive or friction wear from powders, metals, clay, etc. Corrosion resistant. Grade F may be ground.</i>



TUF-COTE hardfacing flexi-cord



Gas and oxygen



Holder

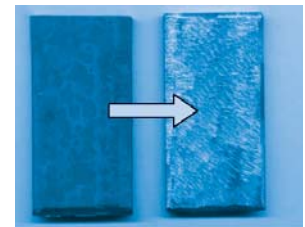
TUF-COTE diameter	Thickness of the coating		
	mm (inch)	mm	inch
4,75 mm (3/16 in)	2 mm to 3 mm	0.08 in to 0.12 in	
6,35 mm (1/4 in)	3 mm to 4 mm	0.12 in to 0.16 in	
8 mm (5/16 in)	4 mm to 5 mm	0.16 in to 0.20 in	

*Data only for information, depends on welder.*

## STEP 2 Preparation of the Parts



- Preparation of the parts is an important step for coating performance and bonding.
- A slight grinding operation or sand blasting operation is necessary before application of the TUF-COTE. The surface must be clean and free of oxidation, grease, surface contamination, old coating, etc.
- All edges must be cut by grinding in order to help edge build-up.



STEP 2

### STEP 3 Recommendation Before Brazing

- The welder should find a comfortable position in order to ensure the homogeneity and accuracy of the TUF-COTE layer.
- Make sure the hoses are not exposed to the flame, to the heat from the work-piece, and to eventual hot metal particles.
- Install the TUF-COTE spool on an appropriate support. Do not install the spool in the proximity of a heat source.



- Work in a sufficiently ventilated area.
- Use dark glasses (level 5) for the optimal process view and eye protection.
- Wear non-flammable clothes.
- Wear ear plugs to avoid excessive noise.
- Wash your hands after brazing.

### STEP 4 Under-layer with SF NI 40 or SF NI 60

Before brazing TUF-COTE, an under-layer 100 to 300  $\mu\text{m}$  thick may be applied with the torch. The under-layer is composed of self-fluxing nickel alloy having hardness between 40 to 60 HRc.



#### Advantages of the under-layer:

- Avoids oxidation of the surface during brazing.
- Prevents chromium migration to the surface (risk of sticking).
- Increases the diffusion between the coating and the substrate.
- Makes the TUF-COTE deposition easier and progressive.
- Provides higher thickness accuracy.

Preheat the work-piece up to 150° to 300°C, and then apply a layer of SF NI 40 or SF NI 60. If required, the under-layer can be fused before brazing.

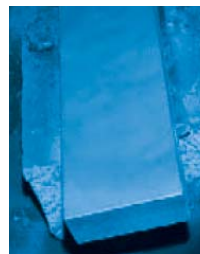
**Note:** For experienced welders, the under-layer may not need to be fused before TUF-COTE brazing.



STEP 4



As sprayed



As fused



## STEP 5 Preheating Before Brazing

Preheat the work-piece with the torch before brazing TUF-COTE.

**Low carbon steel:** preheat the work-piece area to 450°C (840°F).

**Cast iron or Mn steel (Mn%>0.5):** preheat up to 600°C (1112°F).

**Other steel:** refer to the recommendation of the steel supplier.

Before starting any hardfacing operation, the welder must consider the thermal mass of the work-piece to be hardfaced, its shape, and its composition. When the thermal mass of the work-piece is low, proceed to a local preheating. The temperature of the work-piece will increase by itself when brazing TUF-COTE.

During the brazing time, the work-piece should be maintained at the appropriate temperature in order to prevent excessive cracking or damage at the coating's interface with the work-piece. For the largest size, an additional torch or burner is required.

## STEP 6 Setting the Torch Flame Parameter

The flame should be adjusted to bring enough energy by limiting the work-piece oxidation. The flame must not overheat the work-piece.

Adjust a stoichiometric flame setting: neutral flame or carburizing flame.

### STEP 6



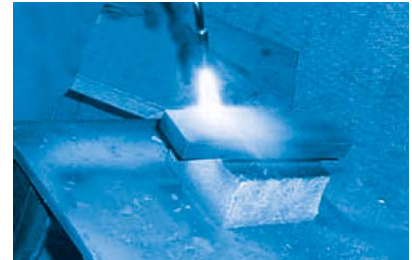
Flame is very short,  
too much oxygen =  
oxidizing flame (not recommended).



Flame is very long,  
not enough oxygen =  
flame doesn't provide  
enough heat (not recommended).



Flame is short, less oxygen  
makes a carburizing flame =  
recommended, prevents decarburizing.



STEP 5

## STEP 7 Brazing

Before beginning the job, pay attention to what the start-point and the end-point of the welding operation will be. TUF-COTE will be easier to weld with a motion parallel to the main axis of the work-piece. The advantage is to reduce the number of start-points and end-points, which are critical for the coating shape and metallurgy.

- Insert the TUF-COTE flexi-cord in the holder. A length of 10 cm to 15 cm (4 in to 6 in) should be out of the holder.

### STEP 7a

With the torch, preheat locally the edge of the work-piece up to red color at 600°C (1112°F).

### STEP 7b

Apply droplets of TUF-COTE on the edge and build up the width of the first pass. The thickness should be reached in one pass. The standoff between the torch and the pool of TUF-COTE should be 5 mm to 10 mm. Apply TUF-COTE on a surface of 25 mm x 10 mm (1 in x 1/2 in).



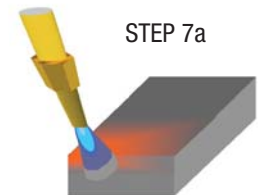
Do not overheat the tungsten carbide particles, as it will adversely affect the lifetime of the TUF-COTE coating.

### STEP 7c

Create a pool of molten metal. Feed TUF-COTE in order to create an area of molten metal 25 mm x 25 mm (1 in x 1 in). If required, stop feeding TUF-COTE and make sure the pool is totally liquid.

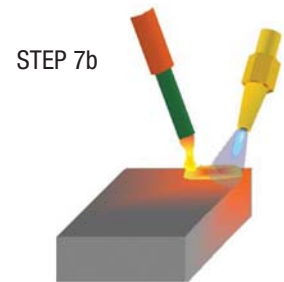


- The flexi-cord must not be directly in contact with the pool.
- The hot zone of the flame should not be in contact with the pool.
- Control the flame power and readjust according to your need.



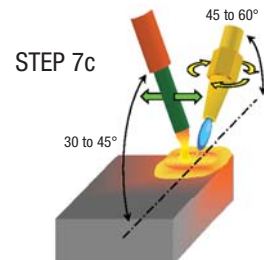
STEP 7a

*Preheat the edge to red color.*



STEP 7b

*Start brazing on the edge.*



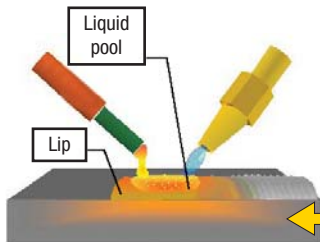
STEP 7c

*Create the pool.*



## STEP 7 Brazing (cont'd)

### STEP 7d




When the pool is liquid, start the progression of the coating by pushing the pool with the flame of the torch.


 The liquid pool must be located behind the lip of the coating.

The torch flame must form an angle of about 45° with the work-piece surface as well as the TUF-COTE cord at the opposite angle. The coating formation must be continuous and smooth. To accomplish that, the flame must swing according to a horizontal and elliptic movement at the surface of the pool.

 Never use a pull movement of the torch to weld TUF-COTE.


Feed the TUF-COTE flexi-cord regularly to the pool through the holder (4 in to 6 in at a time). The tip of the cord should not be lowered or lifted during the brazing. When you feed the TUF-COTE through the holder again, heat the pool with the torch again.

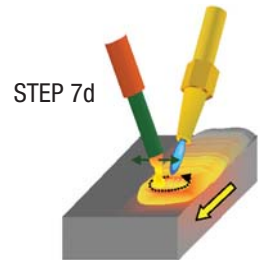
 If the work-piece gets too hot during brazing and it is difficult to stabilize the pool, decrease the angle of the torch and increase the angle of the flexi-cord which will increase the deposition rate.

 If the pool is too cold, remove the flexi-cord out of the heat zone and heat the pool again until it is liquid. If the pool is not significantly liquid, you will have a bad diffusion between the TUF-COTE layer and the part to be hard-faced, or the distribution of tungsten carbides particles will be not homogenous inside the TUF-COTE layer.

### STEP 7e

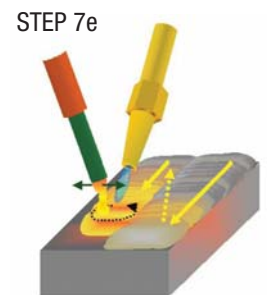
If a second layer of TUF-COTE is required, begin from the same origin side as for the first layer. Fuse the side of the first welded layer. When finishing a layer, maintain a large and smooth pool of molten metal for a few seconds, which will increase diffusion.

 If a butt of TUF-COTE falls inside the bath, continue to heat this area carefully because some porosity may be hidden behind an agglomeration of tungsten carbides.



STEP 7d

*Weld TUF-COTE by pushing the pool.*



STEP 7e

*Weld from the origin point.*

## STEP 8 Cooling

*TUF-COTE has a different thermal coefficient of expansion compared to most steels.*

Cooling should be homogeneous, slow, and without a cold air stream. If required, you must use insulation granulate or rock wool to cool the larger work-piece slowly.

*Slow cooling will reduce the internal stresses and thus decrease the risk of cracking inside the coating, at the interface, or at the surface of the work-piece.*

- The work-piece must be considered hot until the internal temperature is at room temperature.
- For work-pieces made from cast iron or manganese steel, a post heating is required and a controlled down-ramp of temperature is required. The ramp-temperature and the speed of cooling must follow the steel manufacturer's recommendations.
- For the work-pieces with a low thermal mass and a simple shape, air-cooling should be sufficient.



Cracks can appear in the coating. This phenomenon depends on the base material and the size of the work-piece. The cracks help to release internal stresses. If the cracks are not parallel to the surface, they are not detrimental to the coating lifetime. Follow the recommendation of the steel supplier.

## Additional Comments and Recommendations

- If the flexi-cord is not required to be fed inside the pool, you must remove the holder from the flame area.
- Never let the tip of the flexi-cord burn as it will cause the butt to fall.
- The welding procedure should take into account the thickness of the coating to provide maximum wear-resistance. Also, modify your parameters according to the thermal mass of the work-piece.
- The machining of TUF-COTE is possible only with a diamond-grinding wheel.
- The movement of the torch must be slow and regular and should follow an elliptical movement. This slow movement will guarantee a coating free of porosity and the usual metallurgical defects.
- For TUF-COTE d8 mm grade A with a #5 torch, the maximum deposition rate is about 2 kg/hour (4.2 lbs/hour) and can reach 3,5 kg/hour (7.7 lbs/hour).
- The welder should take frequent breaks to consume water.

