Surfit®

Designing for abrasive environments

– Ni SF alloy mixes with tungsten carbides

Prolong operating life with Surfit®

Höganäs provides a comprehensive choice of Surfit powder mixes with Ni Self-Fluxing (SF) alloys and tungsten carbides for hardfacing. Coating with these materials is an effective way to achieve higher wear resistance performance on exposed metallic surfaces.

Metal components handling with hard granular particles has abrasive wear as the major failure mode, accounting for more than 50% of failures. By coating the components, operating life can be prolonged significantly. Common surface coating techniques are PTA (Plasma Transferred Arc), laser cladding and thermal spraying, such as flame spraying, HVOF (High Velocity Oxy-Fuel), plasma spraying and powder welding. These techniques can be used on both new and damaged parts and bring you the benefits of:

- saving both cost and time for part replacement
- reducing environmental pollution by limiting metal loss
- saving energy by re-hardfacing instead of scrap re-melting

Ni SF alloy mixes with tungsten carbides are the most commonly used materials for high wear resistance hardfacing of parts. The metal matrix works as a binder providing toughness, while the carbides provide wear resistance. This group of materials is widely used in different industries, such as oil and gas, agriculture, mining, construction and cement.

Höganäs offers full technical support and capabilities covering material, processes and applications.

Höganäs ArcX

Are you looking for the perfect surface coating solution that fits your needs? Our ArcX centres serve customers all over the world and are strategically located in Europe, Asia, North and South America.


DANGER
PINCH POINT

Remedies for abrasive wear

There are different solutions to effectively protect against abrasive wear. Hardfacing materials can involve different amounts and formulations of Ni SF alloys and carbides to suit a particular application environment.

Tailored to the type of abrasion

Ground engaging tools (GET) and grainy solid conveying components are the two main types of mechanical components that come into contact with hard granular particles, i.e. soil, sand and minerals. Examples of GETs are oil exploration equipments, tractor ploughshares, excavator teeth, rock drilling heads and sand mill rollers, while examples of grainy solid conveing components include excavator buckets, truck buckets and screw-, belt- or pneumatic pipes.

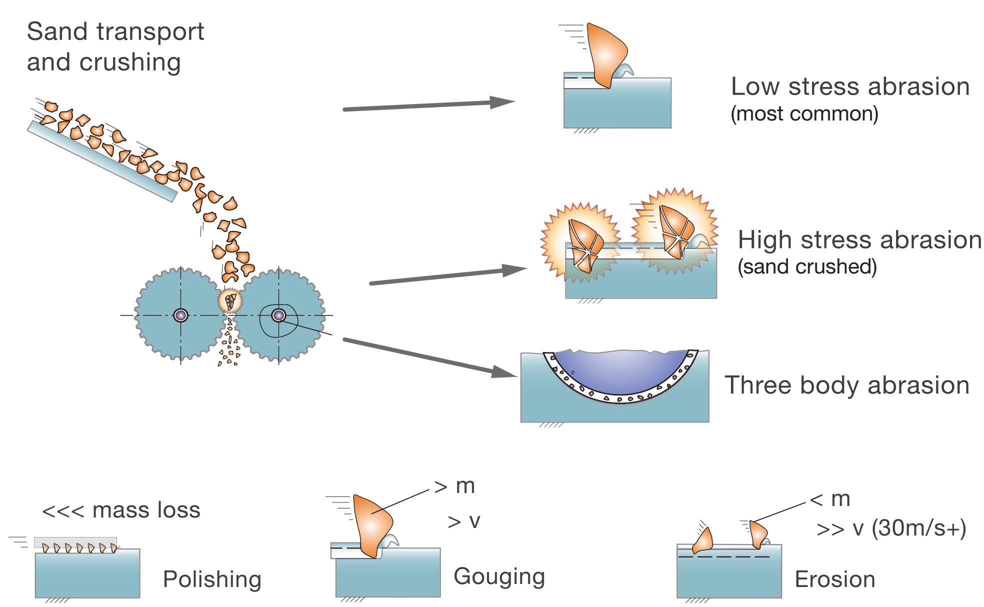
Hard granular particles vary in size, morphology and hardness and their abrasive action on the components occurs with varied velocity and load. Accordingly, we differentiate between low and high stress abrasion, three body abrasion, polishing, gouging, erosion and a combination of these. The most frequently occurring abrasive wear type is low stress abrasion.

To suit hardfacing and application

Almost any hardface with hardness higher than the component's base metal, often a structural low carbon steel, will cause some improvement in abrasive wear resistance. However, to gain cost effective improvements in abrasive wear resistance, hardfacing must suit the application.

Ni SF alloy mixes with tungsten carbides are among the most wear resistant coating materials in the industry. To balance the abrasive wear resistance with impact wear resistance for a particular application, you should consider the combination of high hardness, the right material and the right deposition method.

Our experts combine great knowledge within metal powder technology wear applications with long experience from the field and offer you support to find the best solution to fit your requirements.



Abrasive wear types illustrated.

Material choice

Combining a metal matrix with carbides yields a material with high wear resistance. The selection of metal matrix and carbide powder depends on application requirements and the available deposition method. Höganäs offers several types of Ni SF alloys and tungsten carbides to serve different deposition methods and applications.

Höganäs' tungsten carbide mixes

Mixes group	Matrix	Carbide type	Amount of carbides (wt%)[1]	Suitable deposition method
Surfit®38WPL	1538-40	4570, 4580, 4590	35-60%	PTA, laser cladding
Surfit 40WPL	1540-00	4570, 4580, 4590	35-60%	PTA, laser cladding
Surfit 59WPL	1559-40	4570, 4580, 4590	35-60%	PTA, laser cladding
Surfit 53WHV	Multiple matrix	46712-10	35-50%	HVOF
Surfit 60WHV	1660-02, 1660-22	4670, 46712-10, 46712-12	35-50%	HVOF
Surfit 60WFS	1260-00, 1360-00	4370, 44712-10	35-50%	Flame spray
Surfit 60WPW	1060-00	4070, PA2	40-60%	Powder welding

1) Recommended amount of carbides in the mixes. It is possible to customise mixes to meet your needs.

Höganäs' tungsten carbide mixes provide better alternatives to in-house mixes in both overlay welding and thermal spray with improved consistency. Höganäs' mixing process know-how and thorough quality control ensure a good consistency of both chemistry and particle size distribution between lots.

Choosing Höganäs' tungsten carbides mixes can help you improve operational excellence in many ways.

Discover benefits such as even powder filling or uniform distribution of tungsten carbides all over the coating, both of which reduce scrap rates as well as total costs. The possibility to avoid in-house mixing can also reduce the environmental impact of the manufacturing process. Every mixes group offers special benefits and is optimised for different deposition methods, as well as applications with a considerate selection of Ni SF matrix alloys and tungsten carbides.

Ordering information

a. Standard package size: 5kg plastic bottles, 25kg metal pails.

b. Available globally, based on order.

Handling and safety recommendation

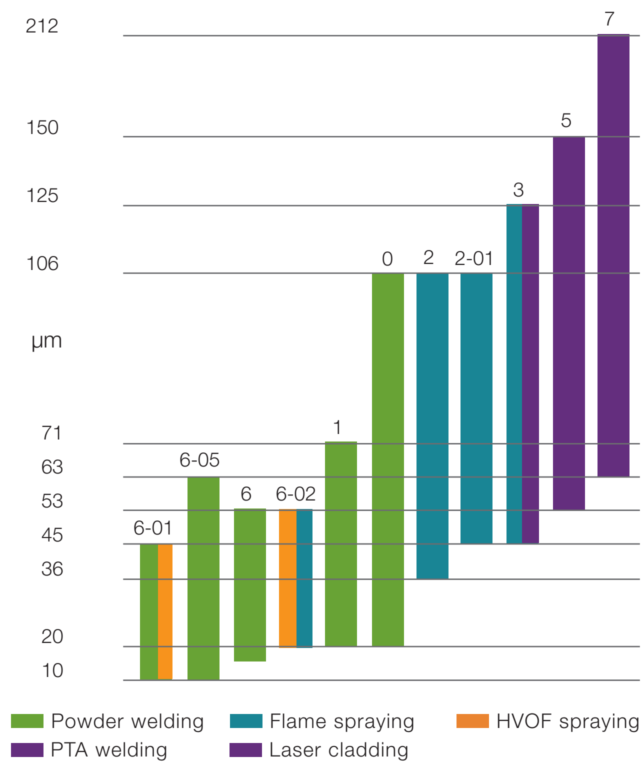
Follow Höganäs' common powder handling and safety guidelines. Contact nearest sales office to get the documents.

Ni SF alloys

There are several reasons for using NiSiB or NiCrSiB alloys as matrix material in coating with tungsten carbides:

- **Low affinity of carbon to nickel**, which decreases the driving force for dissolution of the tungsten carbides in the melt pool.
- **Presence of silicon and boron** lowers the melting point of nickel and reduces the energy required to melt it. This lowers the risk for dissolution of the tungsten carbides.
- **The reaction of boron and silicon with nickel**, which can form hard nickel borides and nickel silicides, increases the wear resistance of the metal matrix.

Particle size range



Grade	C%	Si%	B%	Fe%	Cr%	Ni%	HRC	Particle size (µm)
1538-40	<0.06	3	2.3	<0.8	<0.5	Bal.	38	53-150
1540-00	0.25	3.5	1.6	2.5	7.5	Bal.	40	53-150
1559-40	<0.06	3	2.9	<0.5	<0.5	Bal.	49	53-150
1660-02	0.75	4.3	3.1	3.7	14.8	Bal.	61	20-53
1660-22	0.90	4.3	3.3	4.2	16.3	Bal.	820 (HV30)[(2)]	20-53
1X60-00	0.75	4.3	3.1	3.7	14.8	Bal.	61	20(36)-106, 45-125
X is equivalent to 0, 2 and 3.								

[2)] Measured as fused.

Powder designations

1	6	20	–	1	1
A	**B**	**C**	**–**	**D**	**E**

A: Alloy base
1 = Nickel (Ni)
2 = Cobalt (Co)
3 = Iron (Fe)
4 = Tungsten Carbide (WC)

B: Standard particle size range
0 = 20 – 106 µm
1 = 20 – 71 µm
2 = 36 – 106 µm
3 = 45 – 125 µm
5 = 53 – 150 µm
6 = 15 – 53 µm
7 = 63 – 212 µm

C: Average hardness
Rockwell C

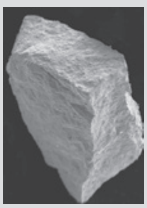
D: Chemical composition
1–9 = modified

E: Particle size range
1–9 = modified

Tungsten carbides

Type	Grade name
Cast and crushed	4X[3] 70

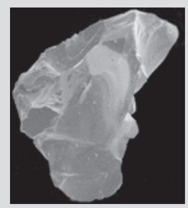
- Hard and dense
- Wide use, both spraying and cladding



Cast and crushed carbides are a eutectic mixture of W_2C/WC phases and reach up to 2300 HV0.1 in hardness. Melting point exceeds 2500°C. Carbon content is around 4%.[4]

Type	Grade name
Macrocrystalline	4580

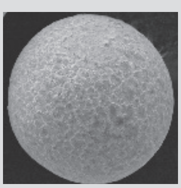
- High thermal stability
- High corrosion resistance



Macrocrystalline carbides consist of hexagonal WC carbide with irregular block-like shape. Macrocrystalline carbides are thermodynamically more stable, have a higher melting point of about 2870°C, lower density and reach up to 2100 HV0.1 in hardness. Carbon content is about 6.1%.[4]

Type	Grade name
Spherical	4590

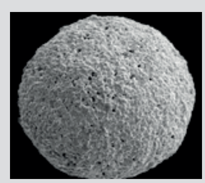
- Very hard and dense
- Good flow properties



Spherical carbides are often produced from spheroidising cast and crushed carbides. These are a eutectic mixture of W_2C/WC but reach up to 2600 HV0.1 in hardness. Melting point exceeds 2500°C. Carbon content is about 4%.[4]

Type	Grade name
Agglomerated and sintered	4X[3] 712

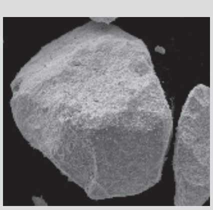
- For thermal spray deposition
- Higher surface finishing



A mix of fine powder with a binder, typically 12% cobalt, is spray dried and then sintered. Typical carbon content is around 5-6%.[4]

Type	Grade name
Sintered and crushed	PA2[5]

- Cost effective
- Good ductility



Sintered and crushed WC-Co carbides with WC and 6-8%[4] Co-binder. Carbon content is about 5.7%.[4]

Footnotes

[3] Available in different size distribution. X can be 1-7

[4] Weight percent

[5] Available in different size distribution

Coatings with tungsten carbide mixes applied by overlay welding

Overlay welding methods, PTA and laser cladding, offer high deposition rate and metallurgical bonding of the coating to substrate. These methods, combining Ni SF alloy mixes with carbides, are widely used in severely abrasive wear environment for applications such as down-hole drilling tools in the oil and gas industry, guided rollers in the steel industry, wear plates and mining teeth. The choice of coating is based on matrix alloy properties, carbide type and coating process parameters.

Carbide amount and type

The properties of overlay welded nickel-based coatings with tungsten carbides depend on the volume fraction of carbides in the clad, but also on the shape and microstructure of the carbide particles and the chemistry of the matrix material.

The abrasive wear resistance of PTA and laser cladded coatings based on 1559-40, with different amounts and types of tungsten carbides deposited by PTA and laser, is illustrated in Figure 1. The average volume loss is typically in the range of 5-10 mm^3. Increasing the amount of tungsten carbides slightly increases the abrasive wear resistance of the coating. Macrocrystalline carbides (4580) are thermally more stable, which results in slightly lower wear.

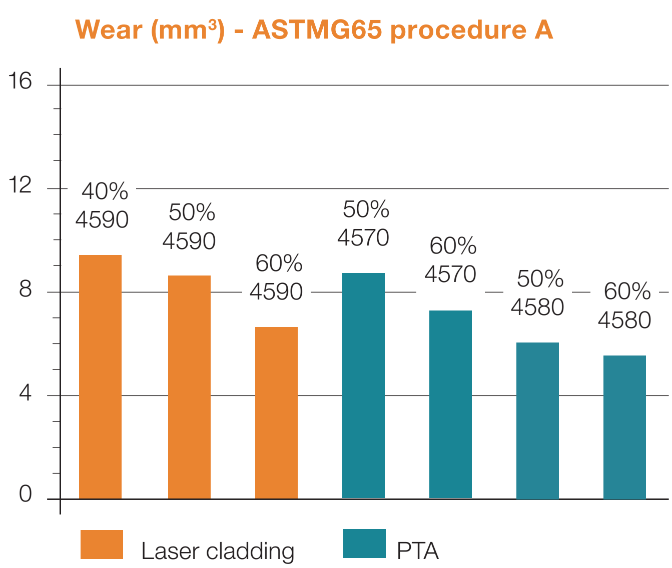


Figure 1. The diagram shows the abrasive wear of 1559-40 with different types and amounts (wt.%) of tungsten carbides as laser cladded and PTA welded.

Distribution of carbides

The distribution of tungsten carbides in the clad is one factor during cladding that affects the final coating properties. The high density of the tungsten carbides, combined with the low melting point and large solidification interval of nickel self-fluxing alloys, allow enough time for the tungsten carbide particles to sink to the bottom of the melt pool.
The lower the heat input, the faster cooling rate and the higher amount of tungsten carbides in the mixes, it will lead to less risk of carbides sinking.

Figure 2 shows a clad with even carbides and a clad with uneven carbide distribution due to sinking of carbides. More extensive wear can be observed at the area with less carbides in Figure 2 b), while wear is more even for clad in Figure 2 a).

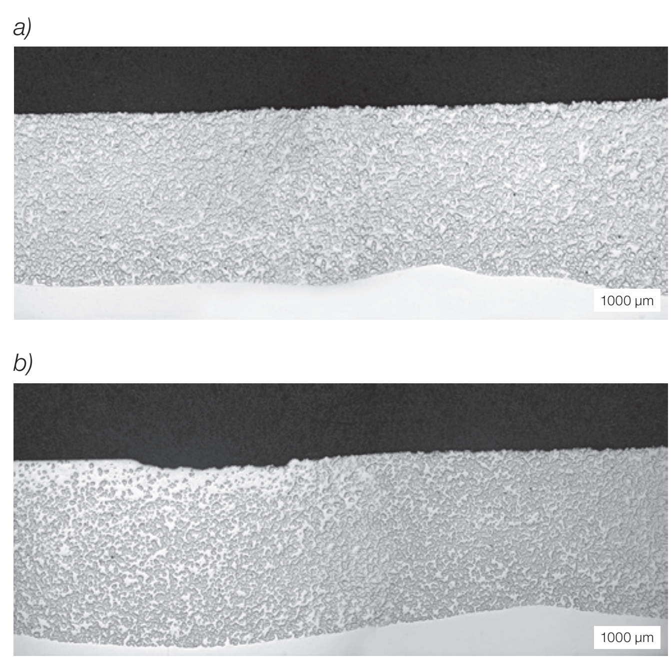


Figure 2. The micrographs show the cross section of clads after wear testing.
a) Clad with even carbides distribution
b) Clad with uneven carbides distribution

Dissolution of carbides

Tungsten carbides can dissolve in the liquid nickel-based matrix. This is another factor that influences the final coating properties. The larger the degree of dissolution, the lower the abrasive wear resistance and impact wear of the final coating.

Low heat input and fast solidification rate suppress the dissolution of the tungsten carbide particles. As illustrated in figure 3, a) and c), lower heat input from laser cladding results in lower dissolution of carbides. Chemical composition of the matrix, the microstructure and the amount, size and shape of the carbide particles can also affect the dissolution. For example macrocrystalline carbides are thermally more stable than other types of carbides, illustrated in figure 3, a) and b).

The selection of correct process parameters is fundamental in affecting coating properties. In order to achieve sound clads with limited dissolution and good distribution of the tungsten carbides, the process parameters must be optimised for each mix.

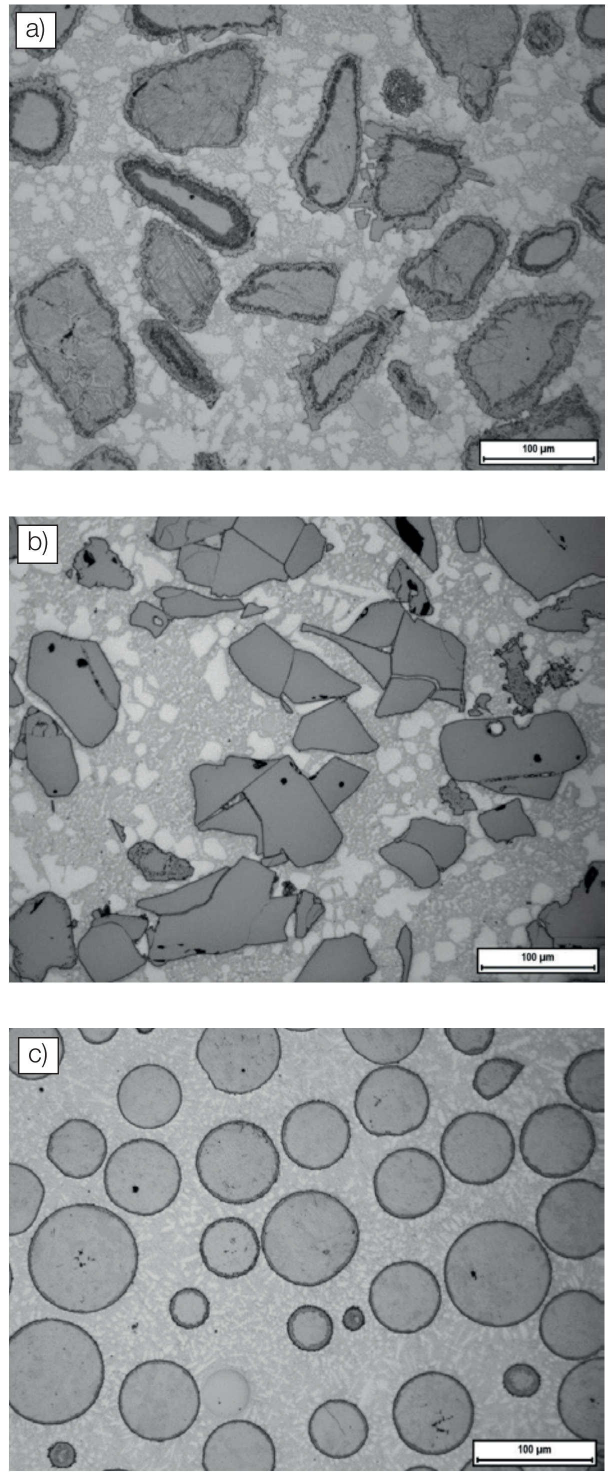


Figure 3. The micrographs show the microstructure of clads based on 1559-40 with 50wt%
a) 4570, PTA welded
b) 4580 PTA welded
c) 4590, laser cladded.
The samples were oxide polished.

Coatings with tungsten carbide mixes applied by thermal spray

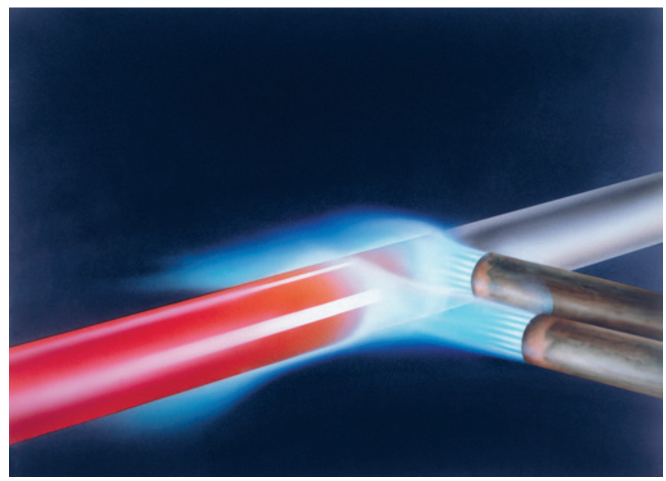
Compared to overlay welding methods, thermal spray methods create thinner coating layers and have lower heat input, which allows using more types of carbides and harder Ni matrix with low tendency to crack.

Flame spraying

Flame spraying (spray and fuse) is a two-step process. The material is first applied by thermal spray and then fused to achieve a dense coating with minimal porosity.

Agglomerated WC-Co and cast and crushed carbides are commonly used in the mix. With the limited heat created by the oxygen/acetylene flame, there is almost no dissolution of the carbide particles during the fusing process.

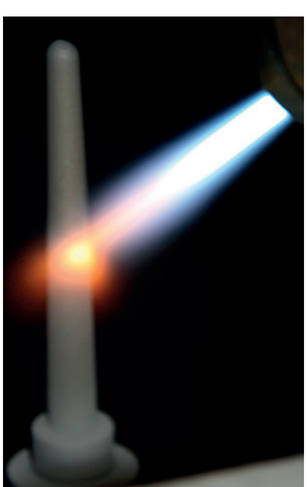
Surfit®60WFS, which has a very hard Ni matrix (HRC60), is often used for applications such as agriculture harvesting components, turbomachinery and petrochemical parts, for example pump seals and plug gages.



Flame spraying.

HVOF spraying

HVOF (High Velocity Oxygen Fuel) spraying pure agglomerated and sintered tungsten carbides is widely applied in many different industries. Ni SF alloy mixes with carbides are mostly used for applications where sliding wear at high temperature is encountered.



Narrow Neck plunger HVOF-sprayed and fused with Surfit 53WHV.

One example is plungers in glass industry where the sprayed coating has to be fused with an oxygen/acetylene flame directly after spraying.

Typical mixes are Surfit 53WHV and Surfit 60WHV, which both have a harder matrix. Carbides used in these mixes are agglomerated and sintered.

Powder welding

A typical mix you can employ by powder welding is Surfit 60WPW, which has a matrix with hardness HRC60, and carbides in a range of 30-65%. Depending on application requirements, both cast and crushed and sintered and crushed carbides can be used.

Powder welding is a manual process often used for applications in the agriculture industry.

Power of Powder®

Metal powder technology has the power to open up a world of possibilities. The inherent properties of metal powders provide unique possibilities to tailor solutions to match your requirements. This is what we call Power of Powder, a concept to constantly widen and grow the range of metal powder applications.
With its leading position in metal powder technology, Höganäs is perfectly placed to help you explore those possibilities as your application project partner.

Höganäs is an independent powder manufacturer providing a full range of surface coating products. A comprehensive choice of high quality powder solutions enhances the potential for surface coating industry applications. Having knowledge about materials, processes, applications and long experience working within the field, Höganäs offers support to enable your success.
To find out how you can apply the Power of Powder, please contact your nearest Höganäs office.

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