ASSAB

PVD COATINGS

The best of two worlds

ASSAB

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TAKE THE NEXT STEP IN TOOLING

THE BEST OF TWO WORLDS

The main reason for coating a tool is to enhance wear resistance, minimise the risk for adhesion and decrease sticking between tool and workpiece. The result is often a combination of increased productivity and a higher quality of processed components.

Surface coating of tool steel has become a common practice, physical vapour deposition (PVD) being the most commonly used technique. The coating is typically a thin ceramic layer (< 4 µm) characterised by very high hardness and low friction.

The efficacy of a PVD-coated tool is strongly dependent on the physical and mechanical properties of the steel. High hardness and compressive strengths are necessary to avoid the "glass-on-snow" effect, where the brittle layer cracks easily over a soft substrate. A high tempering temperature is recommended in order to ensure dimensional stability after the coating process. It is also possible to combine PVD with a plasma nitriding treatment (Duplex) to increase the load-bearing capacity of the coating.

The coating should also be defect-free and with a smooth surface in order to effectively reduce sticking and friction. Tool materials with higher cleanliness and improved polishability can guarantee the homogeneity of the coating and a better surface finish on the components.

Within the tool industry there is no "one solution fits all". Therefore, it is of paramount importance that material and coating selection goes hand in hand.

ALLOW THE COATING TO DO ITS JOB IN THE BEST WAY

ASSAB premium cold work steel have been found to be particularly suitable for PVD coatings. The uniform microstructure and high cleanliness in these steel facilitate bonding of the coating and reduces the spread of dimensional changes resulting from hardening. This, together with the materials' high strength allows the coating to do its job in the best way.

CHOOSE THE RIGHT COMBINATION

When choosing the combination of tool steel and PVD coating for a cold work application there are four crucial factors to consider:

1. **FAILURE TYPE** find the dominating wear mechanism
2. **TOOLING QUALITY** surface finish in active surfaces and other areas exposed to high loads
3. **TOOL STEEL AND COATING SELECTION** choose steel and/or coating for the dominating wear mechanism
4. **HEAT TREATMENT** make sure that the heat treatment and coating process fit together

1. FAILURE TYPE

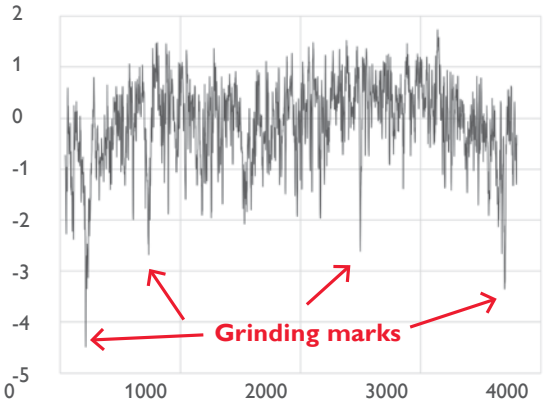
	Solved by substrate	Solved by coating	
Choose steel with enough chipping resistance	 Chipping	 Abrasive wear	Choose a coating with high hardness and wear resistance
Choose steel with higher compressive strength (hardness)	 Plastic deformation	 Adhesive wear/galling	Choose a coating with fine surface and low friction properties

2. TOOLING QUALITY

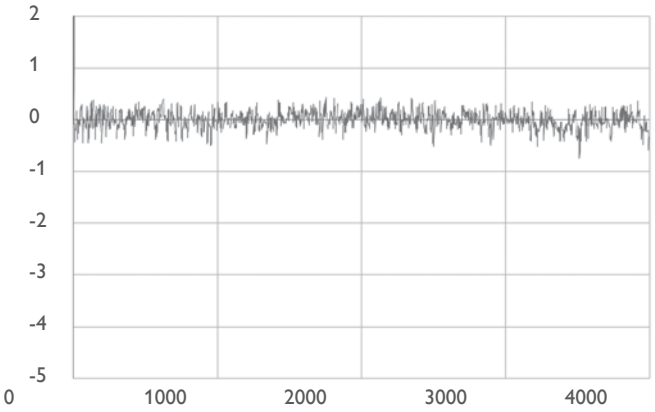
Before coating the tool, the surface quality has to be adjusted to the needs of the application, especially in the active areas of the tool.

The active areas of the tool should be smooth and free from corrosion and white layers in order to obtain the best performance. After grinding, a typical surface finish of Ra~0.5 µm is obtained, which is not smooth enough for a high performance tool in cold work application. A rough surface (by e.g. grinding marks) may lead to inhomogeneous coating layers and cracks in the PVD coating. Thus, polishing to Rz <1 µm in active areas is recommended before a PVD coating is applied. For critical applications, even finer. Furthermore, depending on the application, a post-treatment of the coated tool may be recommended and should be discussed with ASSAB representatives.

SURFACE

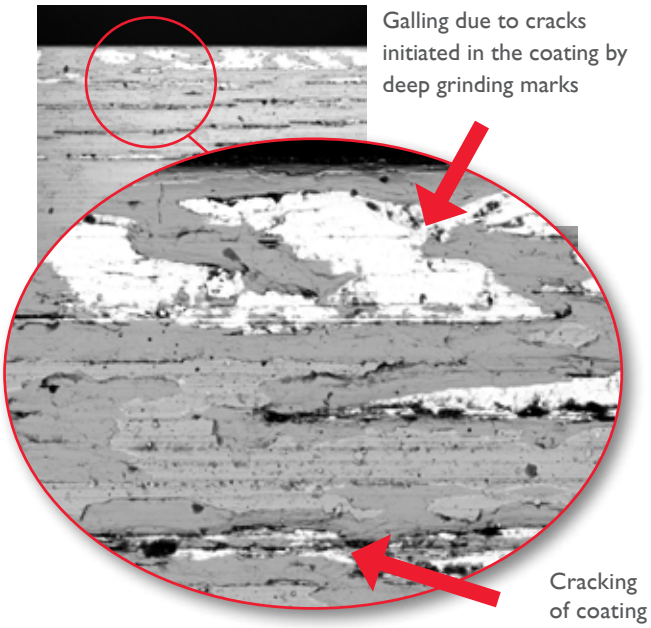


Surface profile with deep grinding marks, Ra=0.5 µm, Rz=4.0 µm



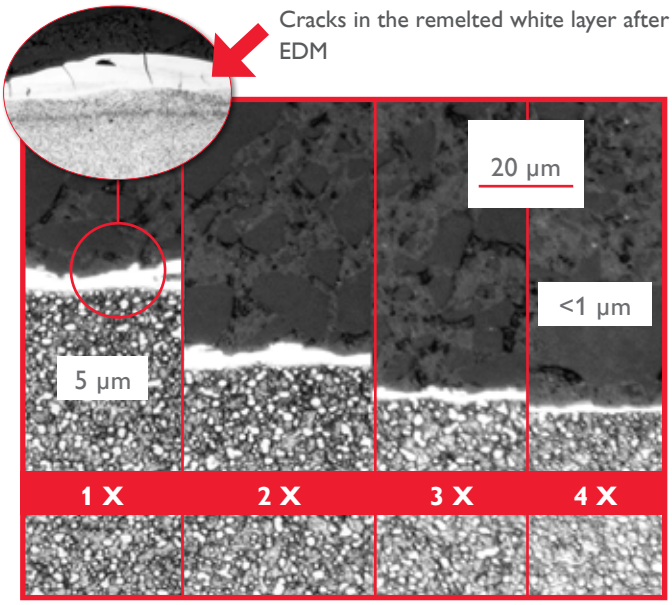
Same surface profile after polishing with #600 grit, Ra=0.1 µm, Rz=1.0 µm

CRACKING



Galling due to cracks initiated in the coating by deep grinding marks

Cracking of coating



Heat affected surfaces from WEDM need to be removed and 3–4 passes are needed to reduce the heat affected zone that have small cracks and high stress level.

3. TOOL STEEL AND COATING SELECTION

Example of suitable cold work tool steel for PVD coating

TOOL STEEL FOR PVD COATING

ASSAB STEEL GRADE	CHIPPING RESISTANCE	COMPRESSIVE STRENGTH	TYPICAL HARDNESS RANGE
Ref. steel AISI D2 / W.-Nr. 1.2379	■	■	58–61 HRC
Caldie	■■■■■	■■	58–61 HRC
ASSAB 88	■■■	■■■	60–64 HRC
Vanadis 4 Extra SuperClean	■■■■■	■■■	60–64 HRC
Vanadis 8 SuperClean [1)]	■■■■	■■■	60–64 HRC
Vancron SuperClean [2)]	■■■■	■■■	60–64 HRC
ASSAB PM 30 SuperClean	■■■	■■■■	65–67 HRC
ASSAB PM 60 SuperClean	■■	■■■■■	67–69 HRC

Reference steel ■ OK ■■ GOOD ■■■ BETTER ■■■■ BEST ■■■■■

[1)] first choice if abrasive wear resistance of the steel is important

[2)] first choice if adhesive wear resistance of the steel is important

EXAMPLE OF SUITABLE PVD COATINGS

COATING	COLOUR	APPLICATION
Duplex-VARIANTIC-700	Old rose	Forming and trimming of uncoated high-strength sheets < 700 N/mm²
Duplex-VARIANTIC-1000	Dark golden red	Forming of uncoated high-strength sheets < 1000 N/mm²
Duplex-VARIANTIC-1400	Golden	Forming and trimming of uncoated high-strength sheets < 1400 N/mm²
Duplex-TIGRAL	Dark grey	Forming of electrogalvanised high-strength sheets < 1200 N/mm²
DUMATIC	Reddish grey	Broadband coating for forming of stainless steel
CARBON-X	Black	Forming of aluminium
CROSAL-plus	Slate grey	Fine blanking

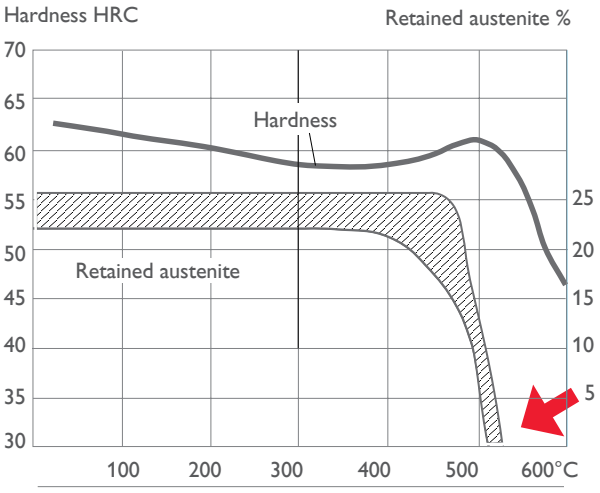
4. HEAT TREATMENT

The most important part of the heat treatment is to temper the steel at a temperature higher than both the coating process (typically 450°C) and the retained austenite area (see diagram to the right).

A common problem with standard AISI D2 / W.-Nr. 1.2379 tool steel is dimensional growth, due to the usage of a low tempering temperature (~500-510°C) for keeping a high hardness. Retained austenite will remain in the microstructure and this will transform into martensite during the coating process or in use of the tool. This results in a volume expansion of the tool, which may exceed the desired geometrical tolerances.

Due to a relatively wide range in chemical composition of a AISI D2 / W.-Nr. 1.2379 steel the minimum tempering temperature for avoiding retained austenite is not well defined. Hence a safe margin is necessary.

For more details see technical product brochures for the steel grades.

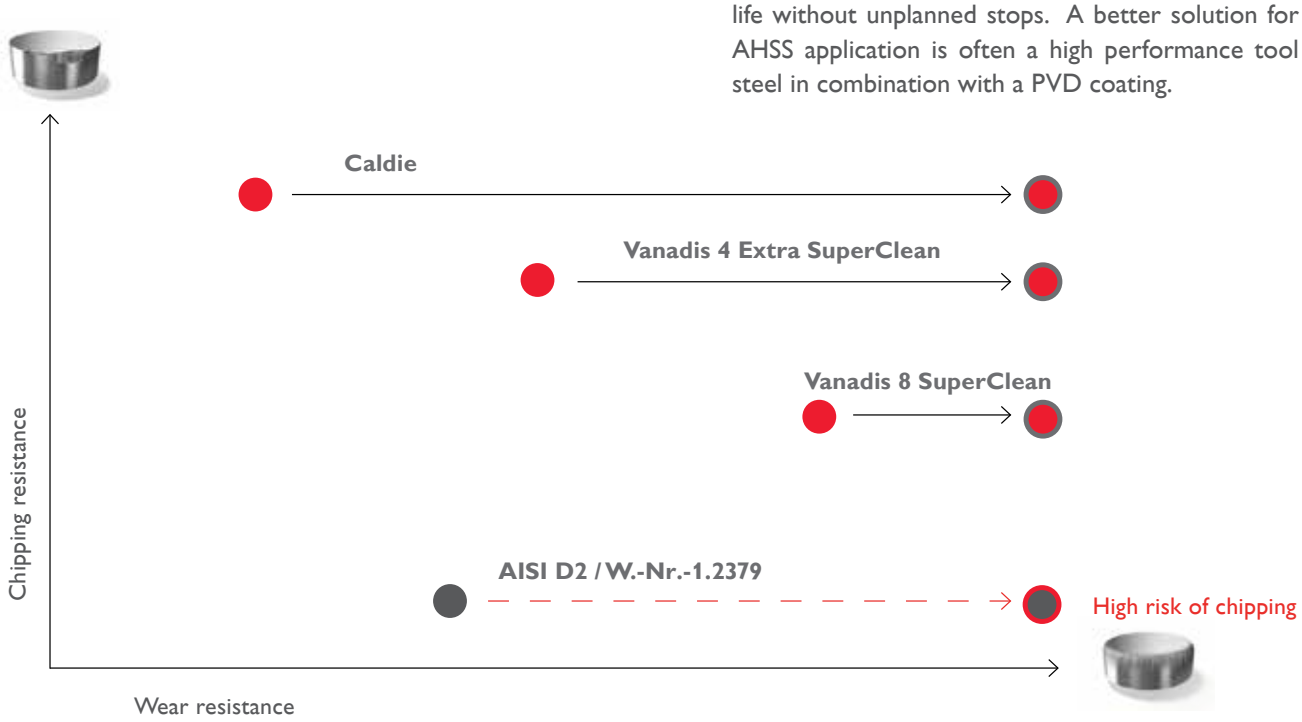


The arrow shows the minimum tempering temperature to avoid retained austenite in AISI D2 / W.-Nr. 1.2379 steel.

APPLICATION EXAMPLE, FORMING AND TRIMMING OF AHSS

The use of AHSS (Advanced High-Strength Steel) has increased significantly in the cars body in white (BIW) structures. Hence, from a tooling perspective the demand for better tool steel has also been growing rapidly.

Most of the traditional tool steel and high speed steel can perhaps fulfil one good property, for example high wear resistance with low chipping resistance. This will cause a high risk of breakage due to the high cyclic load on the tool when working in higher strength steel. A much wider property profile is necessary to secure a high productivity and predictable tool life without unplanned stops. A better solution for AHSS application is often a high performance tool steel in combination with a PVD coating.



BETTER CHIPPING AND WEAR RESISTANCE

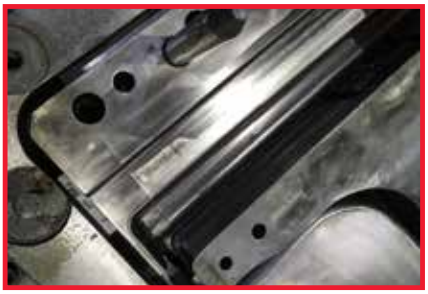
Caldie is often used in demanding forming and trimming operations of AHSS sheets in combination with a PVD coating. To the right is a traditional tool compared with Caldie coated with a Duplex PVD coating after trimming 100 000 parts of CR1000Y1370T-CH, t=1.5 mm.

If higher compressive strength or better wear resistance are needed from the tool steel without losing too much of chipping resistance Vanadis 4 Extra SuperClean and Vanadis 8 SuperClean are good alternatives.

AISI D2 / W.-Nr.-1.2379, uncoated

Caldie + Duplex-VARIANTIC 1000

Below is a tool after forming of 1400 B-Pillars made of CR850Y1180T-DH sheet. Comparison is made with a traditional tooling solution.



AISI D2 W.-Nr. 1.2379 uncoated with clear wear marks.

Caldie + Duplex-VARIANTIC 1000 with no visible wear. [1)]

1) Sheet material from voestalpine Steel Division. Tool manufacturing and forming are made by voestalpine Metal Forming Division.


UDDEHOLM


UDDEHOLM

ASSAB PLASTIC MOULDS

ALLOW THE COATING TO DO ITS WORK IN THE BEST WAY

It is important to choose the right steel grade for the moulding since plastic moulding is a demanding process.

ASSAB CAN OFFER DIFFERENT TYPES OF MOULD STEEL FOR PLASTIC MOULDING

- Prehardened mould and holder steel.
- Through-hardened mould steel.
- Corrosion resistant mould steel.

PVD coating of plastic moulds is a way to improve the mould life for moulds used for injection moulding, extrusion, vacuum forming and blow moulding. It is important to have a good support material with sufficient hardness, uniform microstructure and cleanliness for a successful PVD coating. ASSAB plastic mould steels fulfil these demands and thus make an excellent choice for PVD coating.

FAILURES THAT CAN BE SOLVED BY THE STEEL

- Cracks and/or gross cracking caused by high static or dynamic loads. The solution in this case is an upgrade to a steel grade with a better toughness.
- Plastic deformation due to loads higher than the yield strength of the material can only be solved by choosing a steel with a higher hardness.

FAILURES THAT CAN BE SOLVED BY PVD COATING

- Abrasive wear caused by hard particles in the plastic resin like glass fibre.
- Release problem due to sticking of plastic.
- Adhesive wear, galling between sliding parts.
- Diesel effect, corrosive off-gassing created by plastic material such as PVC or halogenated or halogen free fire retardants.
- Problem to clean, due to that additives like fire retardants cause deposits to stick on the mould cavity surface.

EXAMPLE OF SUITABLE PLASTIC MOULD STEELS FOR PVD COATING

ASSAB STEEL GRADE	CORROSION RESISTANCE	TOUGHNESS	COMPRESSIVE STRENGTH	TYPICAL HARDNESS RANGE
Nimax	■■	■■■■■	■■	*360-400 HBW
Mirrax 40	■■■	■■■	■■	*360-400 HBW
Stavax ESR	■■■■	■■	■■■	**50-52 HRC
Mirrax ESR	■■■■■	■■■	■■■	**48-50 HRC
Tyrax ESR	■■■■	■■■	■■■■■	**54-58 HRC
Unimax	■■	■■■	■■■■■	**54-58 HRC

* Delivered in prehardened condition no further heat treatment is needed.

** Delivered in soft annealed condition and needs to be sent for heat treatment after machining of the mould to achieve requested hardness.

EXAMPLE OF SUITABLE PVD COATINGS FOR PLASTIC MOULDING

COATING	WEAR RESISTANCE	STICKING RESISTANCE	COLOUR	TYPICAL CHARACTERISTICS OR EXAMPLE OF APPLICATION	TYPICAL THERMO-PLASTICS
CrN	■■■■	■■■■	Silver grey	● Very good chemical resistance ● High temperature resistance in air (up to 600°C) ● Improvement of the mould release ● Thicker layers possible	PA, PC, PBT, PET, PEEK, PPS, PSU, PES, PPE, PPO, TPU
TiN	■■■■■	■■■	Gold	● High hardness ● Good chemical resistance ● Good temperature resistance in air (up to 500°C) ● Resistant to abrasive wear of e.g.; mineral filled organic materials	PS, SB, SAN, ABS, ASA, PA, PC, PBT, PET, PMMA, CA, CP, CAP
CARBON-X (DLC) * A sputter machine needed for this type of coating	■■■	■■■■■	Dark grey	● Good chemical resistance ● Smooth surface ● Low temperature coating process (~200°C) ● Very low coefficient of friction ● Recommended for sliding elements	PE, PP, PA

OK ■■ GOOD ■■■ BETTER ■■■■ BEST ■■■■■

ASSAB HOT WORK STEEL

ALLOW THE COATING TO DO ITS WORK IN THE BEST WAY

When choosing a hot work tool steel suitable for hot work applications the properties of that steel are very important. There are many different applications within hot work, such as HPDC (High Pressure Die Casting), Forging, Extrusion and Hot stamping. These different segments have very different demands on the tool steel. Therefore the correct tool steel must be selected, as certain steels can solve these issues better than others.

DESIRABLE PROPERTIES NEEDED IN HOT WORK

- GOOD DUCTILITY
- HIGH HOT STRENGTH
- GOOD TEMPER RESISTANCE
- HIGH HOT HARDNESS

FAILURES THAT CAN BE SOLVED BY THE STEEL

- Gross cracking, heat checking and indentations are failures which can be solved or reduced by changing the steel grade or the hardness level.

FAILURES THAT CAN BE SOLVED BY PVD COATING

- Erosion, corrosion or soldering problems on cores, ejector pins and cavities (with simple geometry).
- Abrasive wear in Hot Stamping.

EXAMPLE OF COATINGS FOR HOT WORK STEEL

COATING	COATING TYPE	COLOUR	KEY PROPERTIES	THERMAL LIMIT
Duplex-TIGRAL	AlCrTiN	Grey	• Excellent oxidation resistance • High hot hardness • Outstanding soldering resistance • High erosion resistance	900°C
Duplex-CROSAL-plus	AlCrN	Slate grey	• Excellent hot hardness • High oxidation resistance • Outstanding erosion resistance • High soldering resistance	1100°C

Not all application areas are suitable for coatings as each tool must be judged on its merits. However, targeted use of certain coatings can help extend die life. An example would be in HPDC with water jacket inserts and core pins. When selecting a coating or surface treatment, the hardness levels should be over >48 HRC to achieve the best possible surface finish.

FAILURE EXAMPLES	TOOL PART	TOOL STEEL EXAMPLES	TYPICAL HARDNESS RANGE	COATING EXAMPLES
Soldering in HPDC	Core pin	QRO 90 Supreme	44 - 50 HRC	Duplex-TIGRAL
Erosion in HPDC	Gate insert	Unimax	50 - 54 HRC	Duplex-CROSAL-plus

ALLOW THE COATING TO DO ITS JOB IN THE BEST WAY

By using premium ASSAB tool steel in components, you will increase the productivity and extend the time between maintenance. By adding a suitable PVD coating the life of the component can be increased even further.

ASSAB STEEL GRADE	CHIPPING RESISTANCE	COMPRESSIVE STRENGTH	TYPICAL HARDNESS RANGE	COATING	COLOUR
Vanadis 4 Extra SuperClean	■■■■	■■■■■	60-64 HRC	VARIANTIC	Old rose
Caldie	■■■■	■■■■	58-61 HRC	VARIANTIC	Old rose
Unimax	■■■■■	■■■	54-57 HRC	TiN	Gold

GOOD ■■■ BETTER ■■■■ BEST ■■■■■

MEAT PROCESSING

Hole plates in Vanadis 4 Extra SuperClean + VARIANTIC coating is an excellent choice for mincing of meat.

- The combination of high hardness and low friction gives a long tool life
- Less maintenance and higher productivity

MACHINING OF HARD METALS AND HARD STEELS

Elevated temperatures, aggressive machining parameters and extremely hard workpiece materials – the requirements for the machining of hard materials continue to evolve creating both challenges and opportunities.

CHALLENGES

When workpieces are made from hardened steel (up to 66 HRc), tools quickly reach their limit. These extreme conditions are now commonplace in the aerospace industry, in mould building for the plastics industry and in plant engineering.

As a result, cutting tools are exposed to extreme temperatures and mechanical forces, this in turn means they wear out prematurely particularly when used in dry machining. PVD coatings currently in the market provide little benefit when faced with these increasingly demanding requirements.

This challenge provided us with an opportunity to optimise one of our coatings to meet the specific requirements of machining on very hard metallic substrates — SISTRAL-plus.

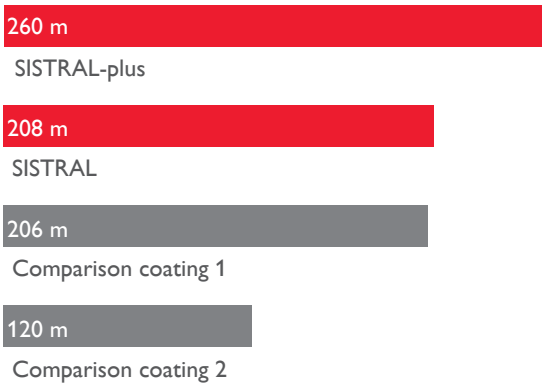
SOLUTIONS

In finding a solution our team produced a modified version of our highly successful SISTRAL coating.

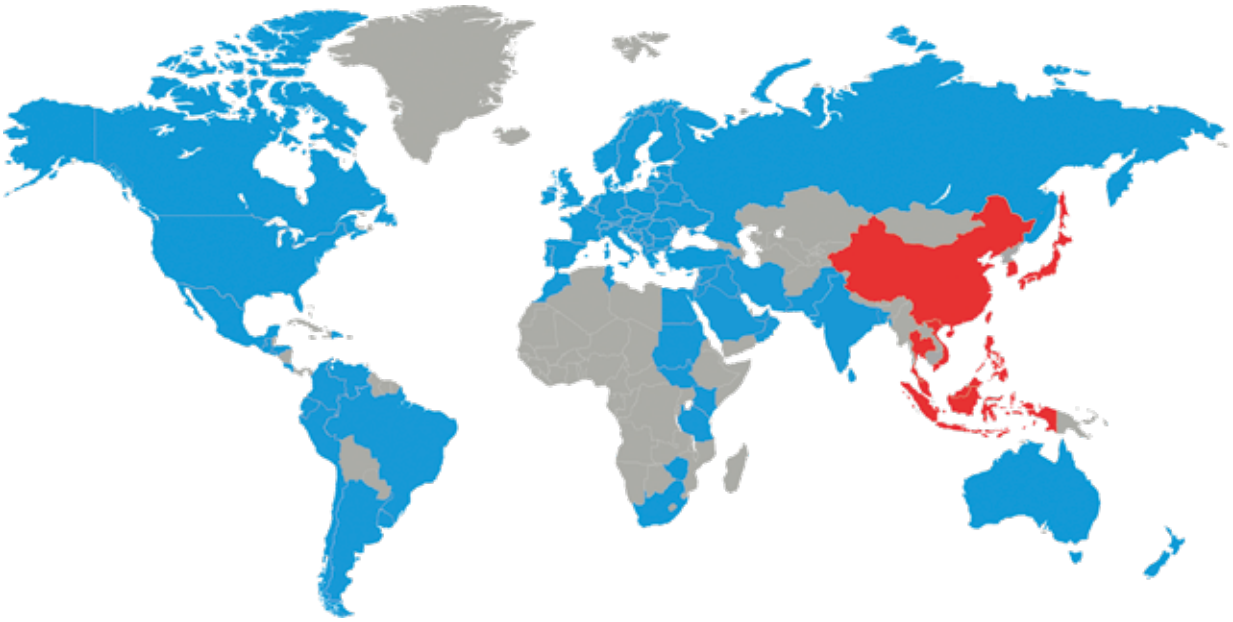
The new SISTRAL-plus utilises a nanostructured architecture much like its predecessor. The new SISTRAL-plus's unique architecture provides superior adhesion on tungsten carbide cutting tools and utilises a friction reducing top layer. This nanostructured coating system combines optimal wear resistance at elevated temperatures while maintaining its insensitivity towards high pressure loads.

The innovative top coat, in teal colour, reduces friction and assists in good chip removal from the workpiece.

SISTRAL-plus coating demonstrated consistently longer service lives by around 30 % more on average.



COATING	COLOUR	LAYER THICKNESS
SISTRAL-plus	Teal	2 - 4 µm
SISTRAL	Anthracite	2 - 4 µm



Choosing the right steel is of vital importance. ASSAB engineers and metallurgists are always ready to assist you in your choice of the optimum steel grade and the best treatment for each application. ASSAB not only supplies steel products with superior quality, we offer state-of-the-art machining, heat treatment and surface treatment services to enhance steel properties to meet your requirement in the shortest lead time. Using a holistic approach as a one-stop solution provider, we are more than just another tool steel supplier.

ASSAB and Uddeholm are present on every continent. This ensures you that high quality tool steel and local support are available wherever you are. Together we secure our position as the world's leading supplier of tooling materials.

For more information, please visit
www.assab.com

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