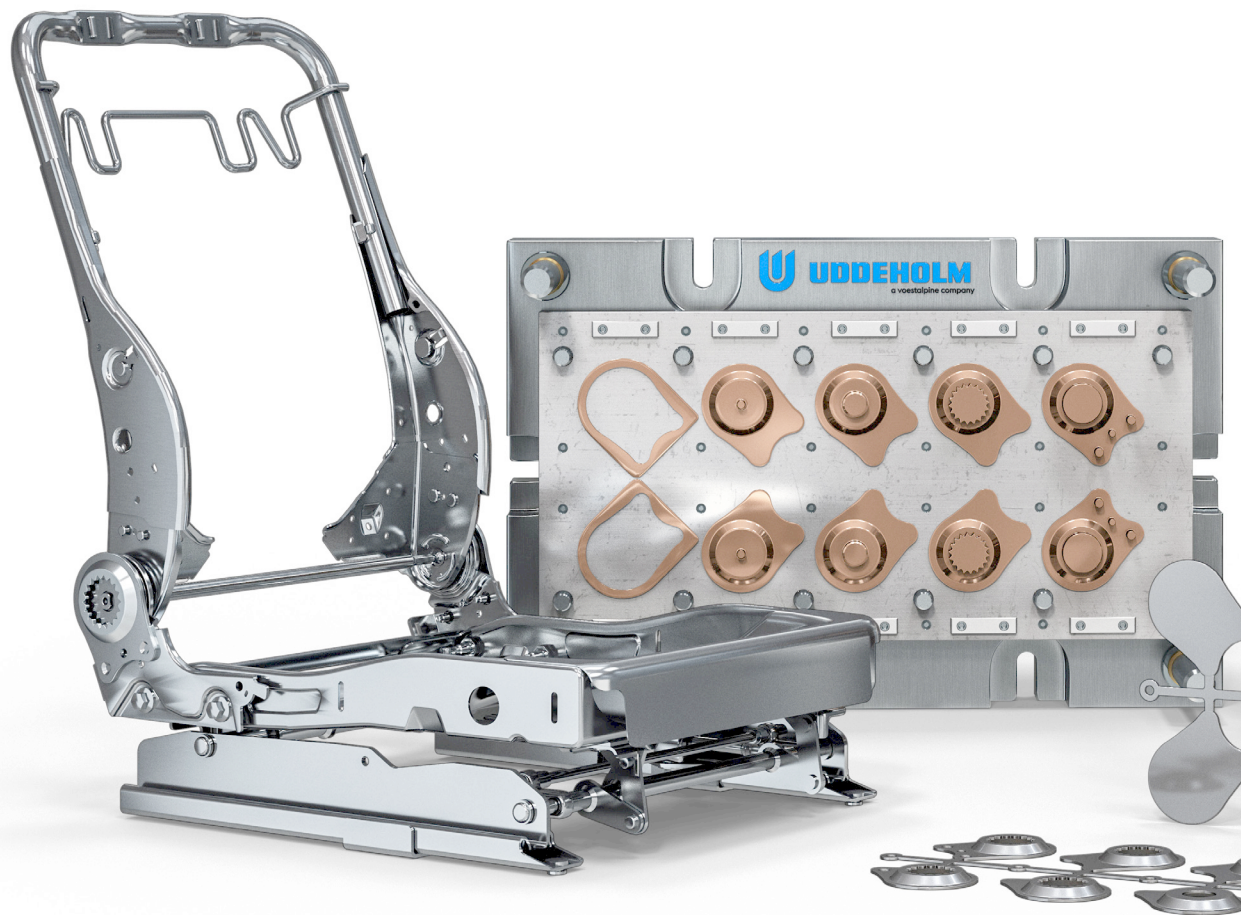


Uddeholm  
tool steels for

# PVD COATINGS

The best of two worlds



© UDDEHOLMS AB

No part of this publication may be reproduced or transmitted for commercial purposes without permission of the copyright holder.

---

This information is based on our present state of knowledge and is intended to provide general notes on our products and their uses. It should not therefore be construed as a warranty of specific properties of the products described or a warranty for fitness for a particular purpose.

Classified according to EU Directive 1999/45/EC  
For further information see our "Material Safety Data Sheets".

Edition 4, 09.2020



## 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 practise, physical vapour deposition (PVD) being the most commonly used technique. The coating is typically a thin ceramic layer ( $< 4 \mu\text{m}$ ) 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.

The aim with this brochure is to present some combinations of tool steels and PVD coatings that have proven to be highly successful. More detailed information about tool steels and coatings can be found in other technical brochures from Uddeholm and voestalpine eifeler Coating GmbH. For optimization of complex tooling solutions we still recommend you to contact Uddeholm for questions about steels and voestalpine eifeler Coating GmbH for coating questions.



UDDEHOLM PREMIUM COLD WORK STEEL

# ALLOW THE COATING TO DO ITS JOB IN THE BEST WAY

The Uddeholm premium cold work steels have been found to be particularly suitable for PVD coatings. The uniform microstructure and high cleanliness in these steels 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.

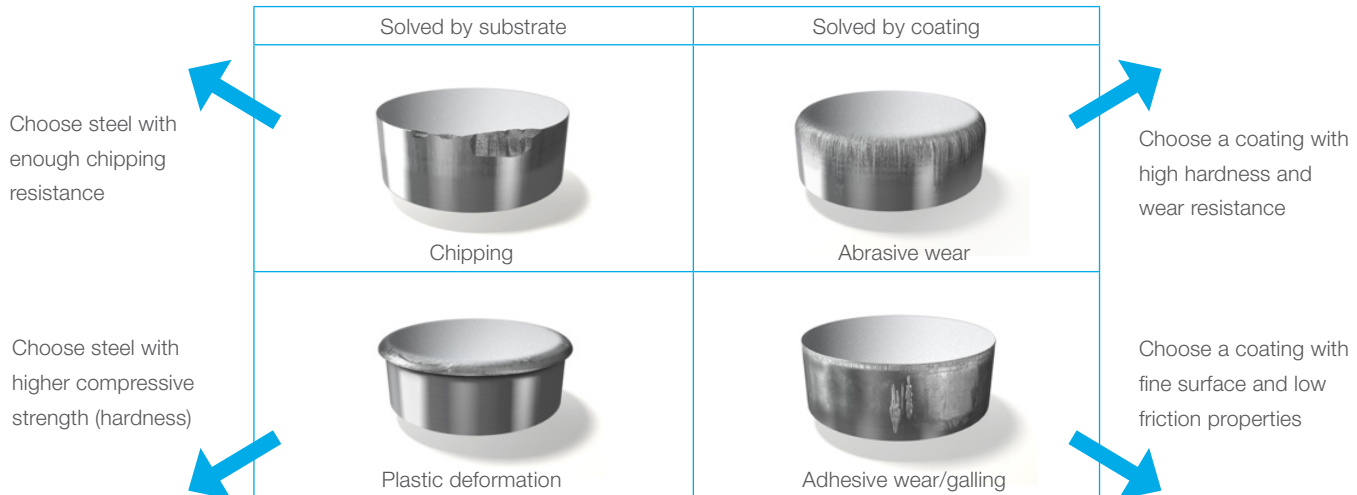


## CHOOSE THE RIGHT COMBINATION

When choosing the combination 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

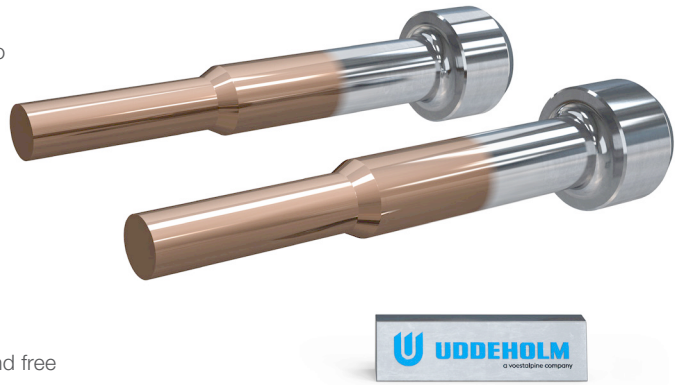
### 1. FAILURE TYPE





## 2. TOOLING QUALITY

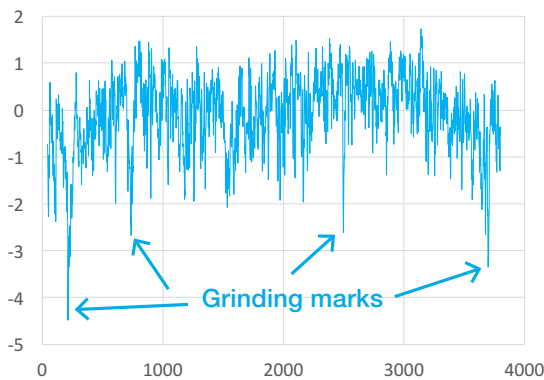
Before coating the tool, the surface quality has to be adjusted to the needs of the application, especially in the active areas of the tool.



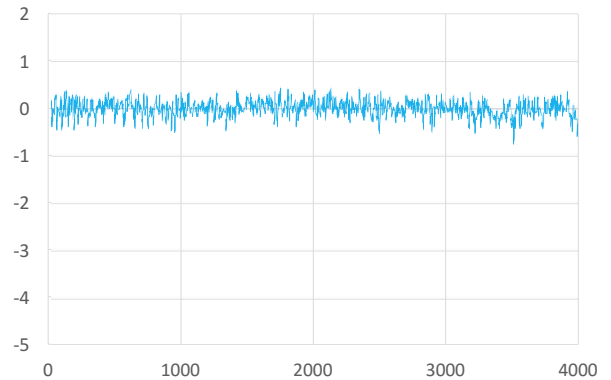
The active areas of the tool should be smooth and free from corrosion and white layers in order to obtain the best performance result. After grinding, a typical surface finish of  $Ra \sim 0.5 \mu m$  is obtained, which is not smooth enough for a high performance tool in cold work application. A rough surface (by e.g. grinding marks) may lead to inhomogeneous coating layers and cracks in the PVD coating. Thus, polishing to  $Ra < 0.2 \mu m$  in

active areas is recommended before a PVD coating is applied. For critical applications, even finer  $Ra < 0.05 \mu m$ . Furthermore, depending on the application, a post-treatment of the coated tool may be recommended and should be discussed with the respective sales contact at voestalpine eifeler Coating GmbH.

### SURFACE

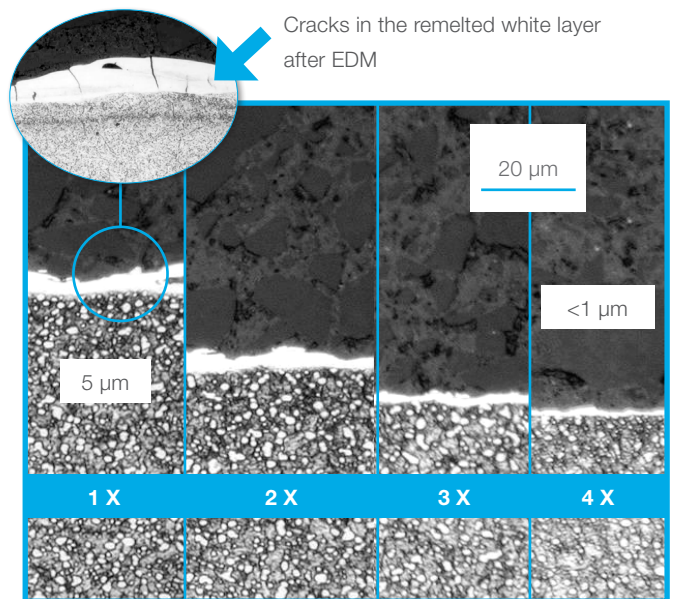
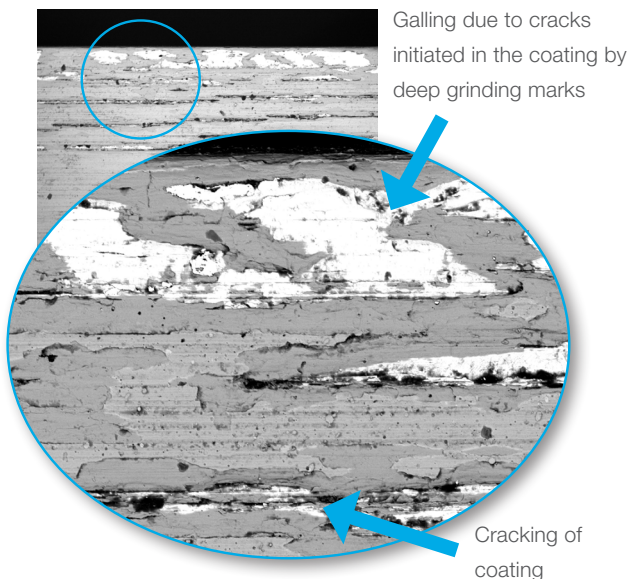


Surface profile with deep grinding marks,  $Ra = 0.5 \mu m$ ,  $Rz = 4.0 \mu m$



Same surface profile after polishing with #600 grit,  $Ra = 0.1 \mu m$ ,  $Rz = 1.0 \mu m$

### CRACKING



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 tool steels for PVD coating

#### TOOL STEELS FOR PVD COATING

UDDEHOLM STEEL GRADE	CHIPPING RESISTANCE	COMPRESSIVE STRENGTH	TYPICAL HARDNESS RANGE
Ref. steel AISI D2 / W.-Nr. 1.2379	■	■	58–61 HRC
Uddeholm Caldie®	■■■■■	■■■	58–61 HRC
Uddeholm Sleipner®	■■■	■■■	60–64 HRC
Uddeholm Vanadis® 4 Extra SuperClean	■■■■■	■■■	60–64 HRC
Uddeholm Vanadis® 8 SuperClean <sup>1)</sup>	■■■■■	■■■	60–64 HRC
Uddeholm Vancron® SuperClean <sup>2)</sup>	■■■■■	■■■	60–64 HRC
Uddeholm Vanadis® 30 SuperClean	■■■	■■■■■	65–67 HRC
Uddeholm Vanadis® 60 SuperClean	■■	■■■■■	67–69 HRC

Reference steel ■ OK ■■ GOOD ■■■ BETTER ■■■■ BEST ■■■■■ <sup>1)</sup> first choice if abrasive wear resistance of the steel is important  
<sup>2)</sup> first choice if adhesive wear resistance of the steel is important

#### EXAMPLE OF SUITABLE PVD COATINGS

COATING	COLOUR	APPLICATION
Duplex-VARIANTIC® -700	Old rose	High-strength sheets < 700 MPa
Duplex-VARIANTIC® -1000	Dark redish gold	High-strength sheets < 1000 MPa
Duplex-VARIANTIC® -1400	Gold	High-strength sheets < 1400 MPa
Duplex-TIGRAL®	Dark grey	Electrogalvanized high-strength sheets < 1200N/mm <sup>2</sup>
DUMATIC®	Reddish grey	Broadband coating for stainless steel
CARBON-X®	Black	Aluminium
Duplex-CROSAL®-plus	Slate grey	Fineblanking

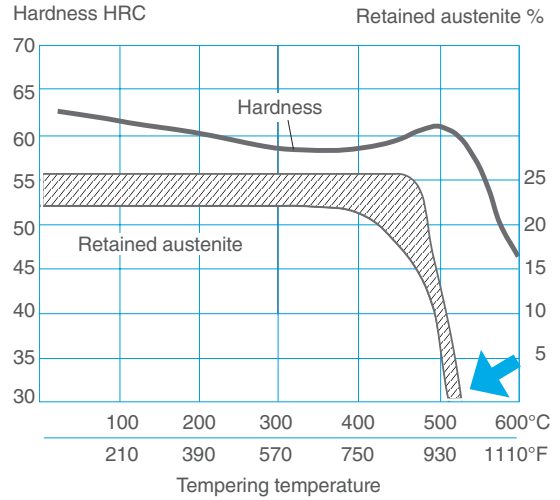
#### 4. HEAT TREATMENT

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.



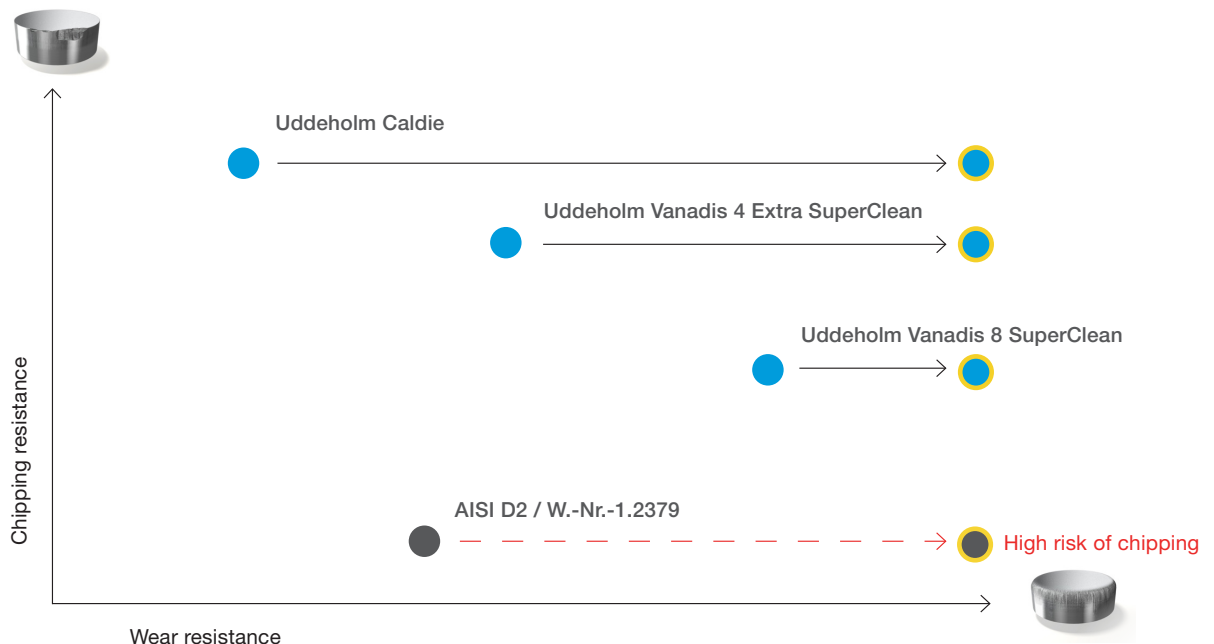
The arrow shows the minimum tempering temperature to avoid retained austenite in AISI D2 / W.-Nr. 1.2379 steel.

#### APPLICATION EXAMPLE, FORMING AND TRIMMING OF AHSS

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

Most of the traditional tool steels and high speed steels can perhaps fulfil one good property, for example high

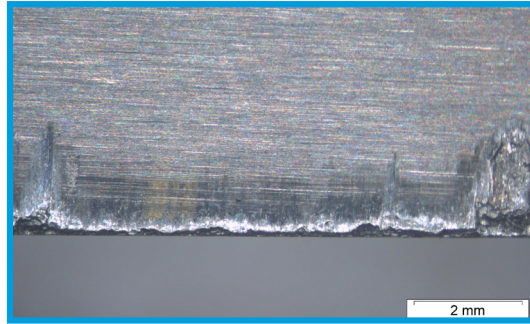
wear resistance with low chipping resistance. This will cause a high risk of breakage due to the high cyclic load on the tool when working in higher strength steels. A much wider property profile is necessary to secure a high productivity and predictable tool life without unplanned stops. A better solution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



### BETTER CHIPPING AND WEAR RESISTANCE

Uddeholm 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 Uddeholm Caldie coated with a Duplex PVD coating after trimming 100 000 parts of CR1000Y1370T-CH,  $t=1.5$  mm.

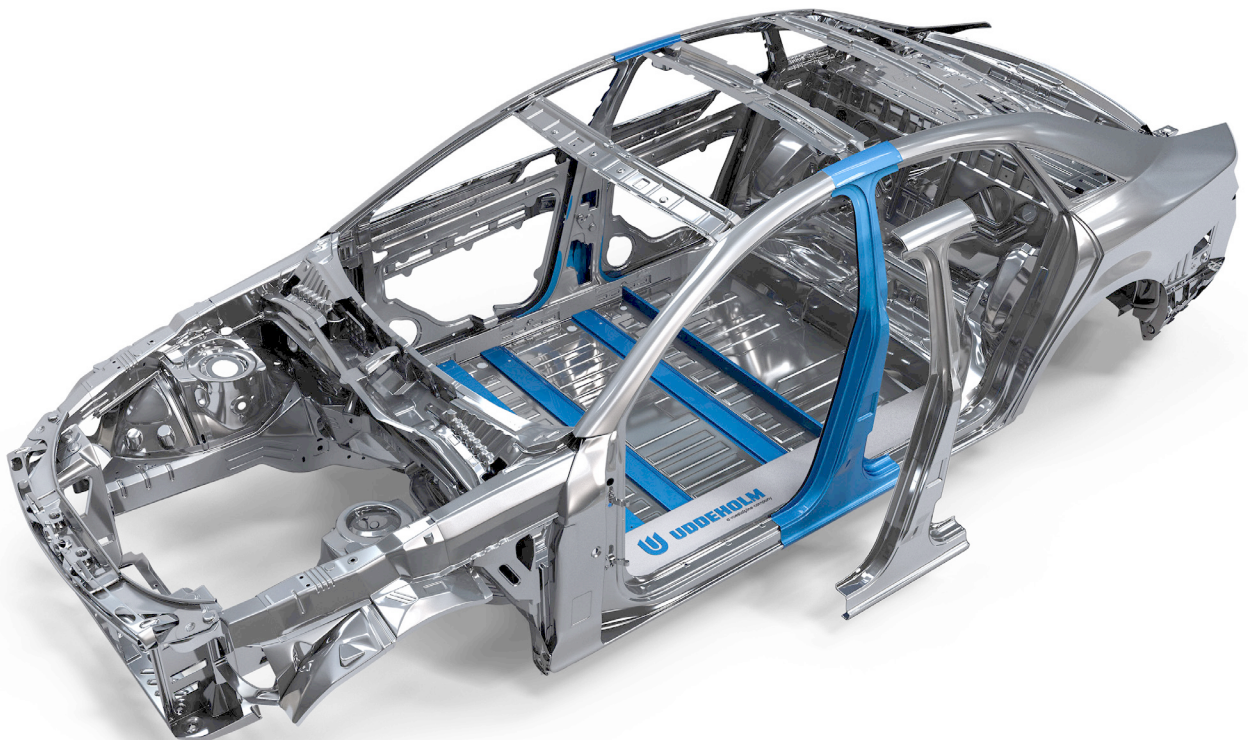
If higher compressive strength or better wear resistance are needed from the tool steel without losing too much of chipping resistance Uddeholm Vanadis 4 Extra SuperClean and Uddeholm Vanadis 8 SuperClean are good alternatives.



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

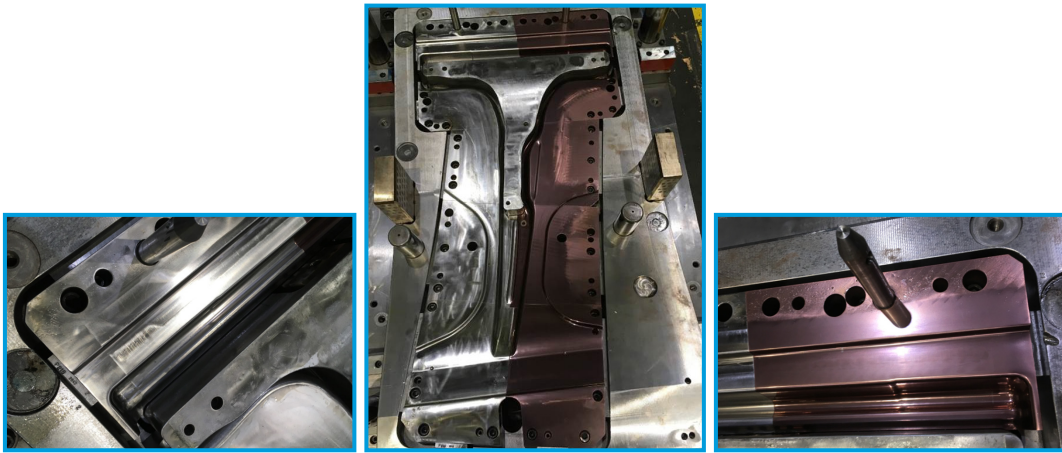


Uddeholm Caldie + Duplex-VARIANTIC 1000





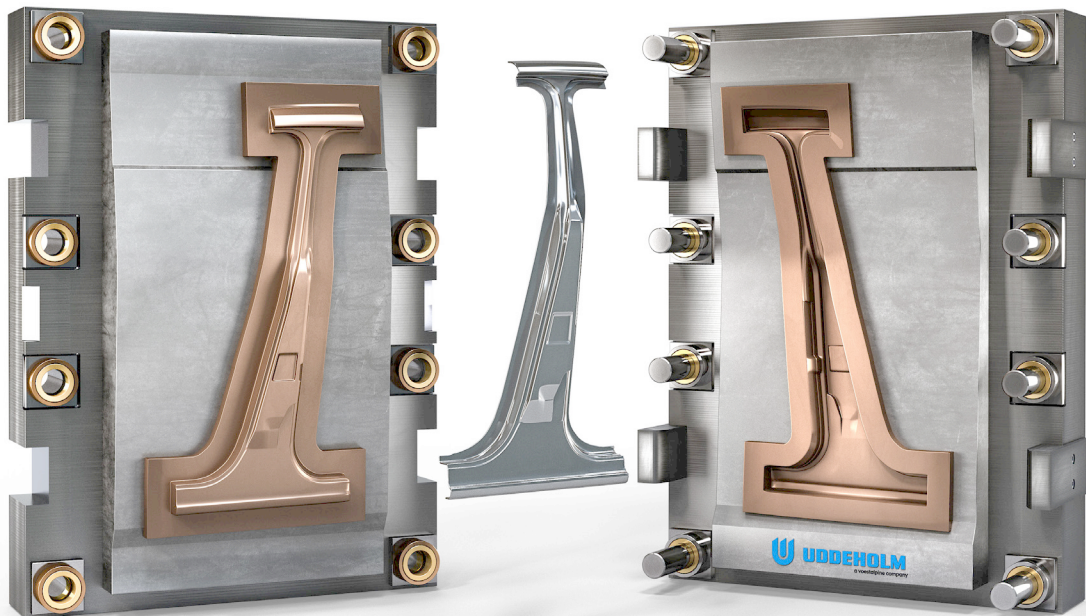
Below is a tool after forming of 1400 B-Pillars made of CR850Y1180T-DH sheet. Comparison is made with a traditional tooling solution.



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

Uddeholm Caldie + Duplex-VARIANTIC 1000 with no visible wear. <sup>1)</sup>

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



UDDEHOLM TOOL STEEL IN COMPONENTS

# ALLOW THE COATING TO DO ITS JOB IN THE BEST WAY

By using premium Uddeholm 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.

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

GOOD ■■■■    BETTER ■■■■■    BEST ■■■■■■

## MEAT PROCESSING

Hole plates in Uddeholm 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
- Uddeholm steel grades and coatings from voestalpine eifeler Coating GmbH are certified acc. to EC No 1935/2004 for food contact



## UDDEHOLM 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.

### UDDEHOLM 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. Uddeholm plastic mould steels fulfill 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

UDDEHOLM STEEL GRADE	CORROSION RESISTANCE	TOUGHNESS	COMPRESSIVE STRENGTH	TYPICAL HARDNESS RANGE
Uddeholm Nimax®	■ ■	■ ■ ■ ■ ■ ■	■ ■	*360-400 HBW
Uddeholm Mirrax 40®	■ ■ ■	■ ■ ■	■ ■	*360-400 HBW
Uddeholm Stavax ESR®	■ ■ ■ ■	■ ■	■ ■ ■	**50-52 HRC
Uddeholm Mirrax ESR®	■ ■ ■ ■ ■ ■	■ ■ ■	■ ■ ■	**48-50 HRC
Uddeholm Unimax®	■ ■	■ ■ ■	■ ■ ■ ■ ■ ■	**54-58 HRC
Uddeholm Tyrax ESR®	■ ■ ■ ■	■ ■ ■	■ ■ ■ ■ ■ ■	**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	<ul style="list-style-type: none"> <li>• High hardness and adhesion</li> <li>• Very good chemical resistance</li> <li>• High temperature resistance in air (up to 600°C)</li> <li>• Thicker layers possible</li> </ul>	PA, PC, PBT, PET, PEEK, PPS, PSU, PES, PPE, PPO, TPU
TiN	■ ■ ■ ■ ■	■ ■ ■ ■ ■ ■ ■ ■	Gold	<ul style="list-style-type: none"> <li>• Good chemical resistance</li> <li>• Good temperature resistance in air (up to 500°C)</li> <li>• Resistant to abrasive wear of e.g.; mineral filled organic materials</li> <li>• Improvement of the mold release</li> </ul>	PS, SB, SAN, ABS, ASA, PA, PC, PBT, PET, PMMA, CA, CP, CAP
CARBON-X® (DLC) <small>* A sputter machine needed for this type of coating</small>	■ ■ ■	■ ■ ■ ■ ■ ■	Dark grey	<ul style="list-style-type: none"> <li>• Good chemical resistance</li> <li>• Smooth surface</li> <li>• Low temperature coating process (~200°C)</li> <li>• Very low coefficient of friction</li> <li>• Recommended for sliding elements</li> </ul>	PE, PP, PA

OK ■ ■    GOOD ■ ■ ■ ■    BETTER ■ ■ ■ ■ ■ ■    BEST ■ ■ ■ ■ ■ ■ ■ ■



## UDDEHOLM 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

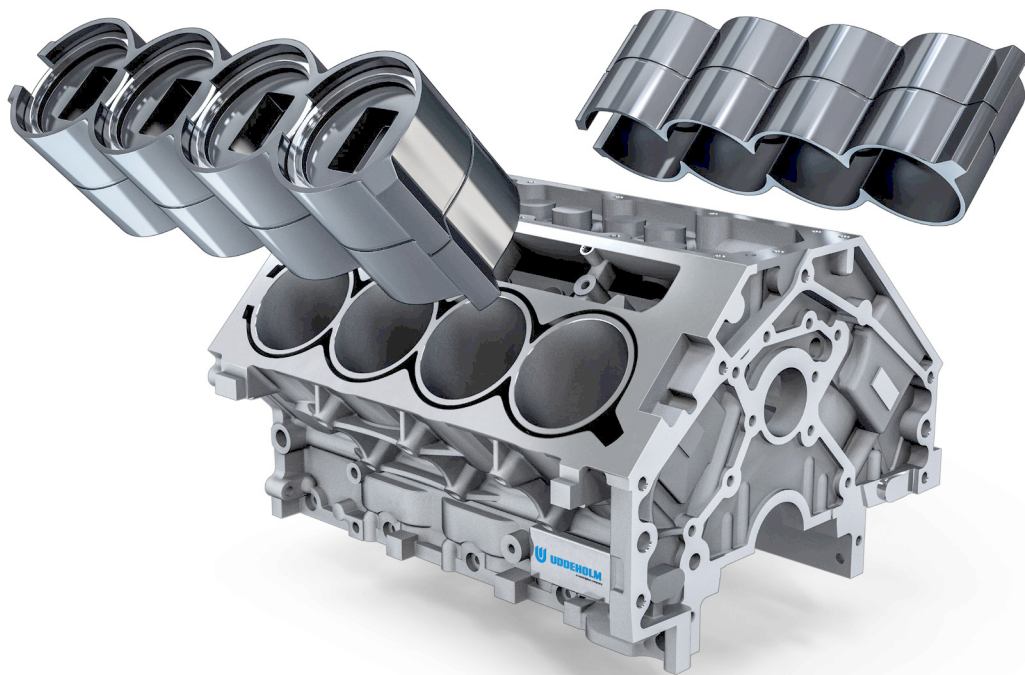
- GOOD DUCTILITY
- HIGH HOT STRENGTH
- GOOD TEMPER RESISTANCE
- HIGH HOT HARDNESS

### 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 STEELS

COATING	COATING TYPE	COLOUR	KEY PROPERTIES	THERMAL LIMIT
CROSAL®-plus	AlCrN	Slate grey	<ul style="list-style-type: none"> <li>High oxidation resistance</li> <li>Outstanding hot hardness</li> </ul>	1100°C (2012°F)
Duplex-TIGRAL®	AlCrTiN	Grey	<ul style="list-style-type: none"> <li>High hot hardness</li> <li>Excellent oxidation resistance</li> <li>Excellent abrasion resistance</li> </ul>	900°C (1650°F)
Duplex-VARIANTIC®	TiAlCN	Old rose	<ul style="list-style-type: none"> <li>Good chemical resistance</li> <li>Low friction</li> <li>Good oxidation resistance in semi-warm-forming</li> </ul>	800°C (1470°F)

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 waterjacket 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	Uddeholm QRO® 90 Supreme	44-50 HRC	Duplex-TIGRAL®
Erosion in HPDC	Gate insert	Uddeholm Unimax®	50-54 HRC	CROSAL®-plus
Abrasive Wear in Hot stamping	Forming insert	Uddeholm Unimax®	55-58 HRC	Duplex-VARIANTIC®

Manufacturing solutions for generations to come

# SHAPING THE WORLD®

We are shaping the world together with the global manufacturing industry. Uddeholm manufactures steel that shapes products used in our every day life. We do it sustainably, fair to people and the environment. Enabling us to continue shaping the world – today and for generations to come.