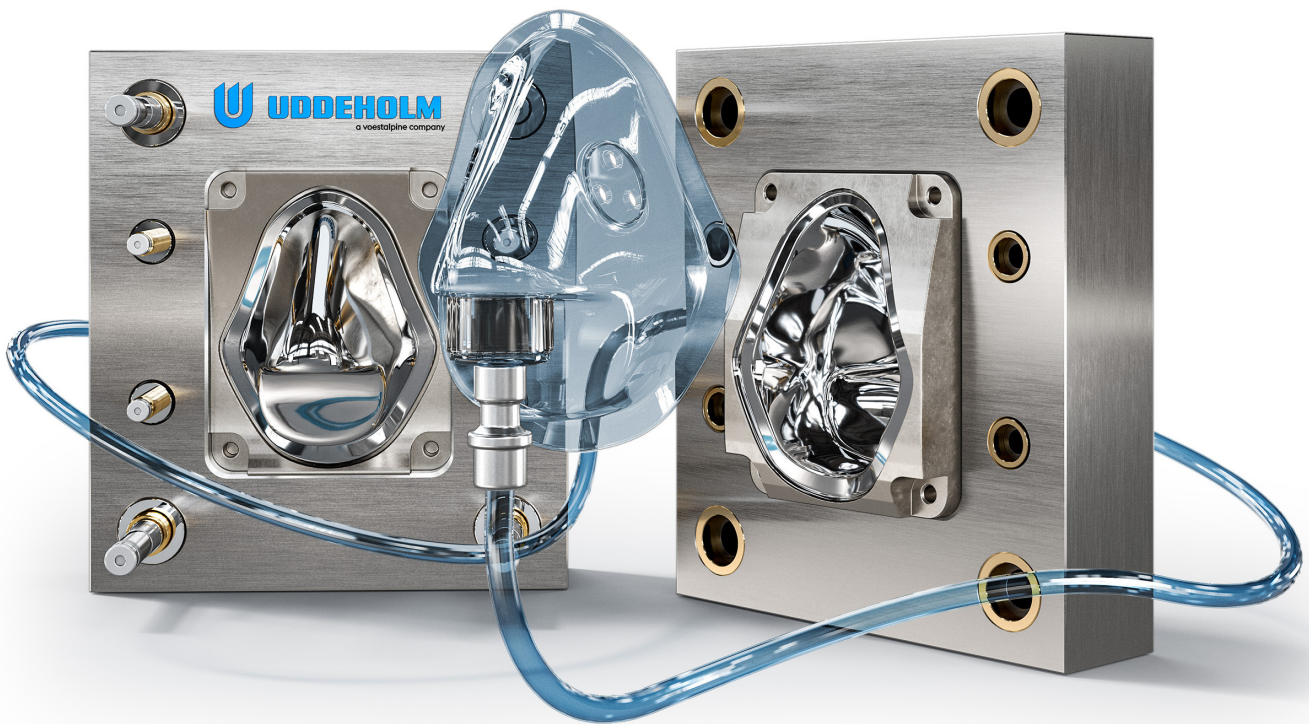


UDDEHOLM TOOL STEELS FOR

PLASTIC MOULDING



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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 17, 03.2021



Selecting a tool steel supplier is a key decision for all parties, including the tool maker, the tool user and the end user. Thanks to superior material properties, Uddeholm's customers get reliable tools and components. Our products are always state-of-the-art. Consequently, we have built a reputation as the most innovative tool steel producer in the world.

Uddeholm produce and deliver high quality Swedish tool steel to more than 100,000 customers in over 100 countries.

Wherever you are in the manufacturing chain, trust Uddeholm to be your number one partner and tool steel provider for optimal tooling and production economy.

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STEEL AFFECTS US IN MILLIONS OF WAYS

Plastic moulding is a part of our everyday lives. Car parts, mobile phones, spectacles and computer chassis are all manufactured in moulds. However, the materials needed to make these moulds often require unique and demanding characteristics. This is why it is crucial to select the correct steel grade for your specific mould.

Many of the most well-known brands use Uddeholm tool steel in their manufacturing processes, as harsh environments puts extreme demands on the mould steel. The problems are well-known, choosing the right tool steel is the solution.

A moulder knows that the cost of excessive mould maintenance, e.g. major repolishing, cleaning and replacing of worn or broken parts has to be taken into account. The costs of production and downtime, overtime payment, late-delivery penalties and loss of customer goodwill also needs to be considered. The moulders also know that they have to

solve the problem of maximizing the life and performance of the production tool, e.g. the mould, to achieve the lowest possible total tooling cost per part produced. The cost of the tool steel in a mould usually represents only 5–10% of the tool costs. The effect on the total cost will be even less.

The drive to find new solutions, ongoing development and research are the hallmark of Uddeholm as a business partner.

Continuous improvements and new product development are possible because we understand and listen to our customers needs.

Wherever production calls for precision and optimum performance, Uddeholm's world leading tool steel is used.

In this brochure we present all our high quality material used for production of plastic parts. We also focus on important factors that contribute to an economical production.



PRODUCT DESIGN

We at Uddeholm can help the product designer to ensure that the final moulding matches his original concept.

Our worldwide marketing organization is able to provide high quality mould steel to meet every plastics moulding and extrusion requirement.

Our Technical Support will give competent technical advice and information on the selection of the appropriate steel, heat treatment and application techniques.

THE IMPORTANT ROLE OF THE PRODUCT DESIGNER

When setting out to create a new moulded part, a product designer faces many criteria that have to be satisfied.

Apart from its purely functional performance, the moulding is often required to match high standards of surface finish and tolerances over a long production run.

Whether these requirements are successfully met or not depends to a large extent on good component design, good mould design, good mould making and the selection of the best mould steel for the job.

CHOOSING THE BEST MOULD STEEL FOR THE JOB

Thus, the product designer is involved in a lot of important decisions that sooner or later will relate to the selected mould steel. He has to ask himself questions such as:

How important is the surface finish?

Does it need to be a mirror or optical finish?

(On page 10 you can see where we can be of assistance in helping him to answer these questions.)

Will the mould for the part be patterned by photo etching? Are there several patterned parts to be matched, e.g. car interiors?

(On page 13 you can see what Uddeholm has to offer in this field.)

Will the moulding material be corrosive, abrasive or both?

(For further information on how we tackle these problems see page 22.)

How critical is it that the tolerances are held within close limits? What quantities have to be produced?

(The answer is important since the production quantity will affect the degree of wear resistance and other properties required in the mould material.)

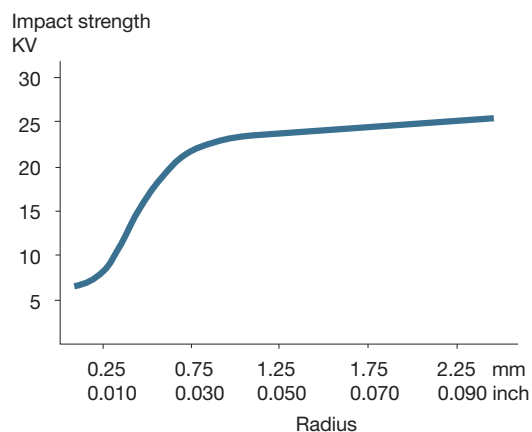
AVOID SHARP CORNERS AND STAY OUT OF TROUBLE!

Avoiding sharp corners and edges wherever possible is one example of how an experienced product designer can improve mould life and moulding productivity.

Sharp inner corners in moulds results in stress concentrations that may cause premature failure of the mould.

By increasing the corner radii of moulded parts, a product designer significantly improves the impact strength of the mould.

The result is a stronger mould, much better able to resist high clamping forces and injection pressures.



*Effect of increasing radius on impact strength.
(Steel type: AISI H13 at 46–47 HRC. Sample taken from surface, in the longitudinal direction.)*

MOULD DESIGN

The mould designer can significantly contribute to the tooling economy by specifying a steel grade with optimized properties for the intended application.

THE IMPORTANT ROLE OF THE MOULD DESIGNER

To produce the best possible mould, a mould designer faces several criteria that have to be satisfied.

Together with the mouldmaker, he shares the heavy responsibility of producing a mould that gives a reliable and economical production of the part conceived by the product designer.

He also endeavours to ensure that the mould can be constructed as easily and economically as possible by the mouldmaker.

Whether these requirements are successfully met or not depends to a large extent on specifying the best mould steel and hardness for the mould concerned.

CHOOSING THE OPTIMUM MOULD STEEL FOR BEST TOOLING AND PRODUCTION ECONOMY

The choice of steel grade and supplier is often made at the design stage in order to simplify and speed up the delivery of the mould. This means that the material and parts can be ordered in good time and that the work can be better planned.

This is not always a simple task. In many cases the choice of steel grade is a compromise between the wishes of the mouldmaker and the moulder.

The mouldmaker is primarily interested in the machinability of the steel, its polishability, heat treatment and surface treatment properties.

The moulder is looking for a mould with good wear and corrosion resistance, high compressive strength etc.



MOST COMMONLY USED MOULD STEEL

The steel types most commonly used are:

- prehardened mould and holder steel
- through-hardening mould steel
- corrosion resistant mould steel

(For further information on these steel types and their properties see pages 21–22.)

WHEN TO USE PREHARDENED MOULD AND HOLDER STEEL

These steel are mostly used for:

- large moulds
- moulds with low demands on wear resistance
- extrusion dies
- high strength holder plates

These steels are delivered in the hardened and tempered condition, usually within the 270–400 HB range. No heat treatment is necessary before the mould is put into use.

The surface hardness can be increased in many cases (see “Why Heat Treatment” on page 11).

Prehardened mould steels are generally used for large moulds and for moulds with moderate production runs.

UDDEHOLM PREHARDENED MOULD AND HOLDER STEEL

Uddeholm Impax Supreme (AISI P20 modified), which is refined by the vacuum degassing technique, offers good machinability and homogeneity, good polishability and consistent photo-etching properties due to a low sulphur content.

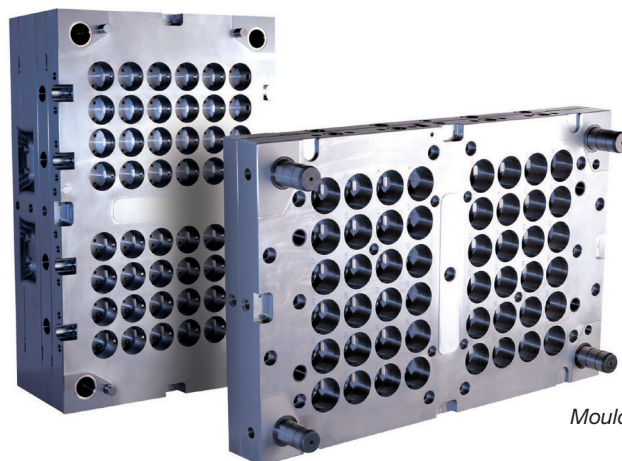
Uddeholm Nimax ESR is a low carbon, ESR remelted steel with excellent toughness, weldability and polishability. This material is also available without ESR as Uddeholm Nimax.

Uddeholm Holdax (AISI 4140 modified), often recommended for high strength holder blocks and large moulds with low requirements on polishability, offers excellent machinability enabling high metal removal rates for deep forms and insert cavity recesses.

Uddeholm Mirrax 40, ESR remelted, offers corrosion resistance, good homogeneity, cleanliness and excellent polishability.

Uddeholm Impax Supreme and Uddeholm Holdax are delivered at 290–330 HB. Uddeholm Nimax ESR, Uddeholm Nimax and Uddeholm Mirrax 40 are delivered at 360–400 HB.

Uddeholm Ramax HH (high hard, AISI 420 F modified) and Uddeholm RoyAlloy are prehardened stainless holder steels sulphurized for improved machinability. The delivery hardness of Uddeholm Ramax HH is approx. 340 HB and of Uddeholm RoyAlloy approx. 310 HB. They are both ideal partners for Uddeholm Stavax ESR, Uddeholm Mirrax ESR, Uddeholm Mirrax 40, Uddeholm Polmax, Uddeholm Tyrax ESR, Uddeholm Corrax, Uddeholm Elmax SuperClean and Uddeholm Vanax SuperClean when a completely stainless mould package is desired.



Mould base in Uddeholm RoyAlloy.

WHEN TO USE THROUGH-HARDENED STEEL

These steels are mostly used:

- for long productions runs
- to resist abrasion from abrasive plastic compounds
- to counter high closing or injection pressures
- for high pressure processes like compression moulding

The steels are delivered in the soft annealed condition. They are usually rough-machined, stress-relieved, semi-finish machined, hardened and tempered to the required hardness, final-machined and often polished or photo-etched.

Through-hardened steel, used for cavity and core inserts, are usually placed in holder blocks of prehardened steels such as Uddeholm Holdax, Uddeholm RoyAlloy or Uddeholm Ramax HH.

By using through-hardened mould or cavity inserts, e.g. in the range 48–60 HRC, you'll obtain better wear resistance, resistance to deformation and indentation in combination with better polishability.

Better wear resistance is especially important when compounds that contains a lot of fillers or reinforcements, such as glas fibres, are used. Resistance to deformation and indentation in the cavity, gate areas and parting lines helps to maintain part quality.

Better polishability is important when a mirror surface finish is required on the moulded part.

UDDEHOLM THROUGH-HARDENING STEEL

Uddeholm Stavax ESR (AISI 420 modified), Uddeholm Mirrax ESR, Uddeholm Polmax (AISI 420 modified), Uddeholm Tyrax ESR, Uddeholm Orvar Supreme (AISI H13 improved), Uddeholm Vidar 1 ESR (AISI H11) and Uddeholm Unimax are all typical through-hardening steels.

Our powder-metallurgy tool steels, Uddeholm Vanadis 4 Extra SuperClean, Uddeholm Vanadis 8 SuperClean and Uddeholm Elmax SuperClean, are our most wear resistant steels.

Uddeholm Vancron SuperClean's low friction properties can reduce problems with sticking of plastic to the mould surface.

Uddeholm Vanax SuperClean is the perfect choice for applications where a combination of excellent corrosion resistance and wear resistance are required.

WHEN TO USE CORROSION RESISTANT MOULD STEEL

If a mould is likely to be exposed to corrosion, a stainless steel is strongly recommended.

The increased initial cost of this steel is often less than the cost involved in a single repolishing.

Plastic moulds and dies can be affected by corrosion in several ways:

- plastic materials can produce corrosive by-products, e.g. PVC
- corrosion leads to increased cycle times when cooling channels become corroded or completely blocked
- condensation caused by prolonged production stoppages, humid operating or storage conditions, often leads to corrosion

UDDEHOLM CORROSION RESISTANT MOULD STEEL

Uddeholm Stavax ESR and Uddeholm Mirrax ESR are corrosion resistant mould steels that offers excellent polishability combined with good wear and indentation resistance. Uddeholm Mirrax ESR is developed to meet the increased requirements on good toughness and hardenability for larger sections.

Uddeholm Polmax is also a corrosion resistant mould steel specially developed to meet the high demands on polishability.

Uddeholm Tyrax ESR is developed for abrasive and corrosive compounds, such as glass fibre reinforced plastics containing halogen free flame retardants.

Uddeholm Mirrax 40 is a corrosion resistance prehardened mould steel with good polishability.

Uddeholm Corrax is a precipitation hardening mould steel with excellent corrosion resistance, easy heat treatment and good weldability.

Uddeholm Elmax SuperClean is a powder-metallurgy mould steel with high wear and corrosion resistance.

Uddeholm Vanax SuperClean is the ultimate problem solver for extreme demands, where neither corrosion or wear resistance can be compromised.

OTHER MATERIAL

Alumec 89 is recommended for prototype moulds and for short runs with low demands on strength and wear resistance. It is also a

suitable material to use for low pressure processes like blow moulding or foam moulding.

The beryllium copper alloy Uddeholm Coolmould is used in moulds when high thermal conductivity is needed. Uddeholm Coolmould can be used either by itself or in combination with other insert materials.

FINDING THE CORRECT WORKING HARDNESS FOR THE MOULD

The chosen working hardness and the heat treatment affect a lot of properties, such as toughness, compression strength, wear and corrosion resistance.

Generally it can be said that increased hardness results in better resistance against wear, plastic deformation and indentations, while a reduced hardness leads to better toughness.

A normal working hardness for a through-hardening steel is 46–60 HRC. The optimum working hardness used depends on the chosen steel, the mould size, layout and shape of the cavities, the moulding process, plastic material etc.

For recommended steel grades and working hardness related to various plastic materials and processes, see page 23–25.

For further information about heat treatment of tool steels, see the Uddeholm publication “Heat Treatment of Tool Steels”.

Uddeholm Tyrax ESR is an excellent choice for optical applications with extremely high demands on surface finish.



MOULDMAKING

A substantial part of the total tooling cost is connected to the manufacturing of the mould. It is therefore of great importance that the mouldmaking process should be as straightforward as possible.

THE IMPORTANT ROLE OF THE MOULDMAKER

A well equipped machine shop with competent personnel is an essential part of the mould-making process.

An experienced mouldmaker places high demands on the steel supplier when it comes to steel quality and properties as well as availability.

CHOOSING THE OPTIMUM MOULD STEEL

The mouldmaker is looking for a mould steel free from defects, easy to machine and polish, stable in heat treatment and suitable in many cases for EDM and/or photo-etching.

WITHOUT DEFECTS

All material supplied by Uddeholm has been subjected to various external and internal inspection procedures, including ultrasonic testing. This ensures that high and even quality standards are met.

GOOD MACHINABILITY—GOOD ECONOMY

The cost of machining accounts for roughly 1/3 of the total cost of mould manufacture, so a good and uniform machinability is of utmost importance.

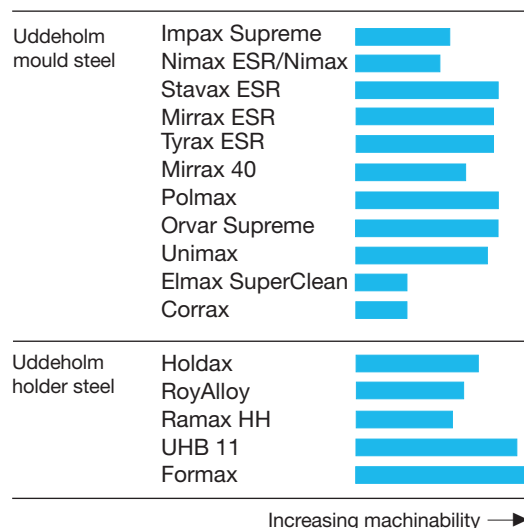
Most of Uddeholm's mould steels are supplied in soft annealed condition enabling the best possible material removal rates for the type of steel concerned.

The only exceptions are the Uddeholm steels Impax Supreme (AISI P20 modified), Holdax (AISI 4140 modified), Nimax ESR, Nimax, RoyAlloy, Ramax HH, Corrax and Mirrax 40 which are delivered pre-hardened.

Alumec 89 has an excellent machinability, i.e. high cutting speed, which leads to lower mould cost and shorter delivery time.

A machinability comparison guide for a number of grades of Uddeholm steel is shown below.

The guide is based on tool wear tests.



The Uddeholm steel grades Impax Supreme, Holdax, Nimax ESR, Nimax, Ramax HH, RoyAlloy and Mirrax 40 were tested in the prehardened condition.



Electrolux vacuum cleaner.

HOW IMPORTANT IS GOOD POLISHING?

Polishing sometimes accounts for up to 30% of the total mould cost. This is no surprise, since it is a very time consuming and expensive process.

The result obtained depends to a large extent on the polishing techniques and a few other factors, such as the cleanliness of the steel, i.e. the type, distribution, quantity and size of non-metallic inclusions, the homogeneity of the steel, the hardness of the steel and, for hardened steel, how the heat treatment has been carried out.

Non-metallic inclusions are reduced to a minimum if the steel is vacuum-degassed and Electro Slag Remelted (ESR process) during production. The ESR treatment results in improved homogeneity and minimal amount of inclusions compared to conventional steel production processes.

WHY HEAT TREATMENT?

The purpose of heat treatment of a finished tool is to obtain suitable mechanical properties such as hardness, toughness and strength. However, there are some problems associated with heat treatment. Problems like distortion and dimensional changes has to be solved.

SOLVING THE DISTORTION PROBLEM

The tool should be stress-relieved after rough-machining in order to minimize distortion problems. By doing this, the stresses induced by the machining-operations are relieved and any distortion is then rectified in the semi-finish machining before the heat treatment.

However, when using through-hardening steel at maximum hardness levels, the requirement for minimum distortion may have to be sacrificed. The reason is that higher hardening temperatures and rapid quenching rates are necessary. This is especially the case when heavy sections are involved. The safest way of avoiding distortion is to use a prehardened steel such as Uddeholm Impax Supreme, Uddeholm Nimax ESR, Uddeholm Nimax or Uddeholm Mirrax 40 — where no additional heat treatment is required.

Different types of surface treatments can increase the surface hardness.

HOW TO DEAL WITH DIMENSIONAL CHANGES

It is true that some dimensional changes are inevitable during hardening. However, it is also possible to limit and control these changes to a certain extent. Slow uniform heating to the austenitizing temperature, by using a temperature that is not too high, by using a suitable quenching medium or a step-quenching procedure are all ways to minimize the dimensional changes of the mould.

Uddeholm Corrax needs only an aging process at 500–600°C (930–1110°F) and no quenching. This means that no distortion will occur, only a linear and homogenous shrinkage in the order of 0.1%. Since the shrinkage is totally predictable, it is easy to compensate for this shrinkage by adding stock before the heat treatment.

A high polished mould for production of car headlights.



TAKE THE SHORT CUT TO PRODUCTIVITY

Purchasing steel in a prefinished form is a smart way of releasing toolmaking capacity for the more skilled machining operations. Many grades of steel are obtainable in a number of forms and finishes. In addition, many of them have been pre-machined to a greater or lesser degree. Uddeholm tool steel are available as machined bars.

It is always possible to find a suitable stock size for the work in hand, thus reduce the amount of unnecessary and expensive machining.

A plus machining allowance is made on all sizes to allow final finishing to a standard dimension.

MACHINED BAR

By using machined bars as starting material, a tool maker gets considerable benefits which have an effect on the total cost of the steel.

- Less material by weight can be purchased, which means that waste is considerably reduced.
- No machining costs for removal of the decarburized surface layers are involved.
- The manufacturing time is shortened, which makes planning simpler and calculations more accurate.

ELECTRICAL DISCHARGE MACHINING (EDM)

A couple of important points should be kept in mind to obtain satisfactory results prior to the EDM operation. The surface of the tool will be remelted, leaving a very hard and brittle layer behind. This layer is often referred to as the white layer and will contain networks of micro-cracks. In addition, the material beneath this remelted layer will be rehardened due to the heat from the EDM process. This may result in cracking and shortened tool life. To avoid this problem the following precautions should be taken.

- Finish the EDM operation by fine sparking, i.e. using low currents and high frequencies.
- The affected surface layer should be removed by polishing or stoning.

- The mould should be retempered at a temperature $\sim 25^{\circ}\text{C}$ below the previous tempering temperature if the spark eroded surface is to be used as texturing.
- If the spark eroded surface is to be textured by photo-etching, it is important that all of the affected surface layer is carefully removed by stoning etc.

For further information, see the Uddeholm publication "Electrical Discharge Machining (EDM) of Tool Steel".



WIRE EDM'ING

This process makes it easy to cut complicated shapes from hardened steel blocks, for example during manufacturing of extrusion dies. However, hardened steel always contains residual stresses and when large volumes of steel are removed in a single operation, distortion or even cracking may occur. These difficulties can be reduced by conventional machining of the work piece prior to the heat treatment operation to a shape near the final form. This allows the work piece to adjust to the final shape and stress pattern during heat treatment.

WHY THE PHOTO-ETCHING PROCESS HAS BECOME SO POPULAR

Plastic mouldings with a textured surface have become increasingly popular. Texturing by photo-etching is frequently used as a finish on moulding tools instead of polishing.

The photo-etching process gives the product an attractive, easily held surface, relatively insensitive to minor scratches and damage.

POINTS TO BE OBSERVED WHEN PHOTO-ETCHING

The results obtained by photo-etching do not entirely depend on the process technique and the selected mould material. The way in which the tool has been treated during manufacture is also of great importance. Therefore, the following points should be observed.

- If a number of moulding inserts are included in a tool and these are to be etched with the same pattern, the mould material and the rolling direction should be the same for these parts (preferably from the same bar or block).
- Complete the machining operation by stress-relieving, followed by finish-machining.
- There is generally no advantage in using finer abrasives than 220 grit on a surface that is to be photo-etched.
- Spark eroded surfaces should always be grinded or polished. If not, rehardened surface layers from the spark erosion will cause a poor etching result.
- Flamehardening should be avoided prior to photo-etching.
- Welded areas can in some cases be photo-etched, provided that the same material is used in the weld as in the tool itself. In such

cases, the welded area should be indicated to the photo-etcher.

- Nitriding of the tool must be carried out after photo-etching.
- The surface area of a mould cavity is greatly increased by texturing, which may cause ejection problems. Early consultation with the photo-etching specialist is recommended to determine the optimum draft angle for the shape and pattern concerned.

UDDEHOLM MOULD STEEL SUITABLE FOR PHOTO-ETCHING

Uddeholm Impax Supreme (AISI P20 modified), Uddeholm Nimax ESR, Uddeholm Nimax, Uddeholm Unimax, Uddeholm Orvar Supreme (AISI H13 improved) and Uddeholm Vidar 1 ESR (AISI H11) yield particularly good and consistent results due to their very low sulphur contents.

Uddeholm Stavax ESR, Uddeholm Mirrax ESR, Uddeholm Elmax SuperClean, Uddeholm Corrax, Uddeholm Polmax, Uddeholm Mirrax 40 and Uddeholm Tyrax ESR can be photo-etched to the required pattern but will require a slightly different etching technique because of their corrosion resistance.



There are several textured parts in a car interior.

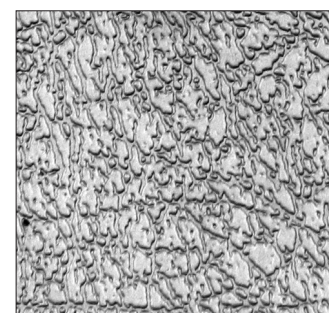
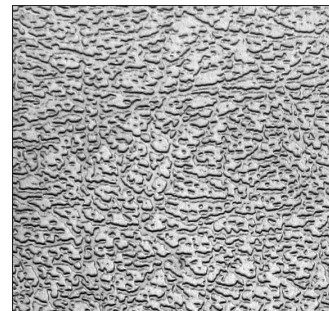


Photo-etched surfaces.

MOULDING

By specifying Uddeholm material, the moulder can take an important step towards a reliable and productive tool.

THE DEMANDS OF THE TOOL USER

The tool user expects the mould to be delivered on time. He or she expects it to produce a certain quantity of parts at a specified quality level and at the lowest possible cost. The tool user's essential demands are:

- a reliable mould delivery date, implying the ready availability of suitable mould materials
- a reliable mould performance in terms of a high production rate, uniform quality of plastic parts, long mould life and low mould maintenance costs
- availability of replacement materials and components

All these demands can be summarized as tool reliability.

TOOL RELIABILITY

Tool reliability depends on such factors as the ready availability of suitable mould material and components, the performance of the mould steel and the interchangeability of mould components.

AVAILABILITY OF MOULD STEEL

The ready availability is determined by local stocks, reliable delivery service and comprehensive product and size range.

LOCAL STOCKS

The location of stock is important if good delivery service is to be maintained.

With our worldwide marketing organization, we place great emphasis on matching our stock size programme and our stock levels to the local needs of each individual market.

RELIABLE DELIVERY SERVICE

Our widespread network of Uddeholm warehouses and our complete range of products form the basis for our delivery service. Each of our stock locations has a well established distribution system.

COMPREHENSIVE PRODUCT RANGE

To sum it up, we are able to offer a wide range of mould and holder steels. To use competent technical advice and printed material on the selection, heat treatment and application of mould materials, EDM, polishing and surface texturing of tool steel are very important aspects of our service.

MOULD STEEL PERFORMANCE AND TOOL RELIABILITY

The performance of the mould steel has a decisive influence on the reliability of the tool. Mould cavity and insert materials are therefore selected according to the types of plastics to be moulded, length of production run, moulding process used and the nature of the product.

The performance of the mould steel depends on wear resistance, compressive strength, corrosion resistance, thermal conductivity and toughness.

We have concentrated our mould steel programme on a few steel grades, each suited for specific applications. This assures not only ready availability but also gives the mould-maker and the tool user an opportunity to become more readily familiar with the characteristics of each steel (e.g. machinability, heat treatment response etc.) and performance.

WEAR RESISTANCE

The level of wear resistance required will depend on the type of resin to be used, mould process, amount and type of additives and fillers, length of production, tolerances etc.

Mould steel cover a wide range of wear resistance and compressive strength. In principle, they fall into two categories:

- Pre-hardened mould steels for moderate demands, e.g. Uddeholm Impax Supreme, Uddeholm Nimax ESR, Uddeholm Nimax, Uddeholm Mirrax 40, Uddeholm Holdax, Uddeholm Ramax HH and Uddeholm RoyAlloy.
- Through hardened tool steels are suitable for severe demands, e.g. Uddeholm Stavax ESR, Uddeholm Mirrax ESR, Uddeholm Polmax, Uddeholm Corrax, Uddeholm Orvar Supreme, Uddeholm Vidar 1 ESR, Uddeholm Unimax and

Uddeholm Tyrax ESR.

- The powder metallurgy grades, Uddeholm Elmax SuperClean, Uddeholm Vanadis 4 Extra SuperClean, Uddeholm Vanadis 8 SuperClean and Uddeholm Vanax SuperClean are extremely wear resistant. They are recommended for small moulds, inserts and cores subjected to abrasive wear. Uddeholm Vancron SuperClean's low friction properties can reduce problems with sticking of plastic to mould surface.

Prehardened mould steels can be surface treated to obtain greater wear resistance, for instance by nitriding. However, through-hardened steels give the best combination of wear resistance and compressive strength.

The wear resistance of fully hardened steels can be further improved by surface treatment or surface coating, such as nitriding, hard chrome plating, PVD etc.

Such surface treatments are preferably applied only after the mould has been fully approved, since further machining can be difficult.

It should be noted that the corrosion resistance of Uddeholm mould steels Stavax ESR, Tyrax ESR, Mirrax ESR, Mirrax 40, Polmax, Corrax and Elmax SuperClean is reduced by nitriding.

COMPRESSIVE STRENGTH

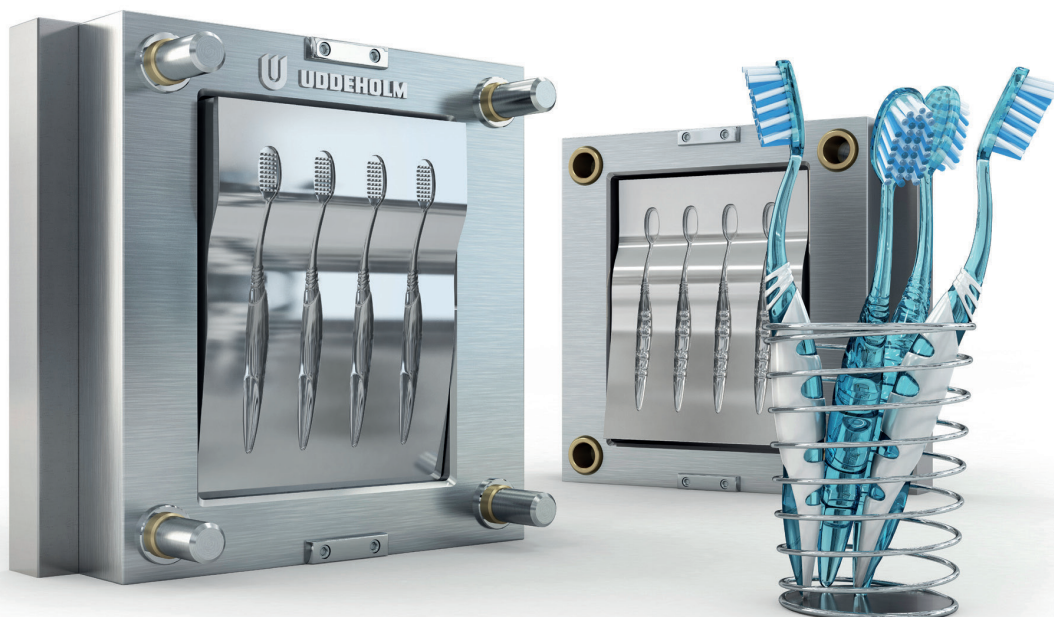
The compressive strength required is determined by the plastic moulding process, the injection and closing pressures and the tolerances of the finished moulding. During moulding, compressive forces are concentrated on the parting faces of the tool.

Local hardening, e.g. flamehardening, can give the required increase in compressive strength when a prehardened steel is used.

CORROSION RESISTANCE

The moulding surfaces should not deteriorate during production if you want to produce plastic mouldings at a high and constant rate of production and at a uniform level. Corrosion, with a consequent threat to production efficiency can be experienced in several ways:

- Certain types of plastics can emit corrosive by-products during production. An example is the hydrochloric acid emitted from PVC upon heating. This effect can be minimized by not exceeding the recommended moulding temperature for this material, usually about 160°C (320°F).
- The cooling medium can be corrosive. This can result in a loss of cooling efficiency or even in the total blockage of the cooling channels.
- Production or storage in a humid atmosphere may cause corrosion attacks on the mould steel.



All the problems mentioned above create a demand for inserts and holder materials with some degree of resistance to corrosion. Uddeholm Corrax, which has excellent corrosion resistance, is used wherever corrosion is the main problem, i.e. processing corrosive plastics. Uddeholm Stavax ESR, Uddeholm Mirrax ESR and Uddeholm Mirrax 40 pre-hardened are corrosion resistant mould steels with high cleanliness. Uddeholm Polmax and Uddeholm Tyrax ESR can meet the highest demands on polishability combined with corrosion resistance. Uddeholm Elmax SuperClean combines moderate corrosion resistance with extremely high wear resistance. Uddeholm RoyAlloy or Uddeholm Ramax HH are corrosion resistant holder steels with very good machinability. By using Ramax HH or RoyAlloy for the holders, the stainless properties are extended to the full mould. Uddeholm Vanax SuperClean combines superior corrosion resistance with excellent wear resistance.

THERMAL CONDUCTIVITY

The production rate of a mould depends mostly on the ability to transfer the heat from the moulded plastic to the cooling medium.

In highly alloyed steel, the coefficient of thermal conductivity is reduced to some degree compared to a low alloyed steel. However, investigations clearly indicate that it is the plastic in the moulded part that dominates the heat flux due to its very low thermal conductivity compared to steel.

A good corrosion resistance is also of great importance when aiming for a high and uniform production rate. Corrosion in the cooling channels has a negative impact on the thermal conductivity. Even though the thermal conductivity of corrosion resistant steels are slightly lower, it is often advantageous to choose one to avoid corrosion within the cooling channels. Mould steels such as Uddeholm Stavax ESR, Uddeholm Mirrax ESR, Uddeholm Tyrax ESR or Uddeholm Mirrax 40 is often the answer.

When mould materials with good corrosion resistance, combined with very high thermal conductivity are required, we can supply Uddeholm Coolmould.

Uddeholm Coolmould is a high strength beryllium copper alloy with high thermal conductivity, good corrosion and wear resistance in combination with good polishability.

TOUGHNESS

Development of cracks is the worst thing that can happen to a mould.

Complicated cavities with small radii, sharp corners, thin walls and severe changes of section are commonplace today. Toughness is therefore one of the most important properties a mould steel should possess.

The fracture toughness of a material is a measure of its capacity to withstand crack propagation from stress raisers when subjected to tensile stresses. These stress raisers occur as surface defects from machining operations, incipient fatigue cracks, inclusions or as faulty structure due to improper heat treatment.

We are fully aware of the importance of toughness. We utilize state of the art metallurgical technology to give the mould steel optimum toughness. By utilizing such techniques as vacuum degassing, special refining processes and electro-slag remelting, the toughness properties of all our steels are the highest currently available. This improved toughness is evident not only at the surface but also in the centre of the steel.

FRICTION

In injection moulding applications where a high surface quality is required, as for optical parts, sticking may appear between the plastic component and the steel mould surface. Strong adhesive forces can lead to difficulties with part ejection, but also to a deteriorated surface finish of the plastic part. Uddeholm Vancron SuperClean is a PM material with low friction properties, emanating from a dense nitride particle distribution. Reduced problems of sticking is noted for injection moulding of e.g. PC, POM and COC (Cyclic Olefin Copolymers).

The low content of non-metallic inclusions and the structure of small nitride precipitates give good conditions to perform high gloss polishing of Uddeholm Vancron SuperClean.

INJECTION MOULDING

Injection moulding is a high production moulding procedure where a liquid thermoplastic or thermoset material is injected under high pressure into a mould for solidification. The moulds can be extremely complicated and expensive.

PERFORMANCE OF MOULDS

It is well known that the tool steel selection has a big impact on the following:

- mould life
- quality of the plastic part
- productivity

MOULD LIFE

The mould life may be determined by different mechanisms such as:

- wear
- surface defects
- deformation
- corrosion

Wear may occur because of reinforced plastic or very long runs. Surface defects may appear already during mould manufacturing as a result of polishing or EDM defects. Deformations can be a result of high clamping forces. Corrosion may of course be a problem when moulding corrosive resins like PVC, but may also be the result of aggressive cooling water or humid atmosphere.

QUALITY OF THE PLASTIC PART

The quality of the plastic part is a matter of the aesthetic of the part, as well as the function of the part.

Steel selection is important for high polished moulds. The steel must be clean and have a very low amount of inclusions. Tolerances may be affected because of uneven mould temperatures, which of course is very much dependent on the cooling channels size and position but also on the selection of mould material. Material like aluminium or copper alloys, with high thermal conductivity, may in some cases be beneficial as mould material.

PRODUCTIVITY

Even productivity can sometimes be affected by the selection of mould materials. The most obvious situation is the selection of high thermal conductivity materials.

MOULD MATERIAL REQUIREMENTS

The requirements of the mould material depends on factors such as the number of shots, plastic material used, size of the mould and desired surface finish. Following basic mould material properties must be considered:

- strength and hardness
- toughness
- wear resistance
- cleanliness
- corrosion resistance
- thermal conductivity

COMPRESSION MOULDING

Compression moulding is a technique mainly for thermoset moulding. The plastic compound is placed in the open mould cavity, the mould is subsequently closed and heat in combination with pressure are applied until the material is cured.

Compression moulding is often used for moulding of glass fibre reinforced plastics.

There are several advantages with compression moulding:

- no waste of plastic material (no gate or runner system)
- minimum of internal stresses in the part
- can be used for very heavy parts
- less expensive equipment.

Limitations are:

- difficulties to mould complex parts with undercuts or small holes
- fair tolerances
- flashes can be a problem

MOULD MATERIAL REQUIREMENTS

Important properties are:

- wear resistance
- strength and hardness

High hardness steel is normally used. However, pre-hardened materials with high hardness inserts at sensitive areas are used for very large moulds.

BLOW MOULDING

Blow moulding is a process for shaping thermoplastic into a hollow product. A hot thermoplastic tube is stretched with air pressure and cooled against a mould surface.

A variety of blow moulding techniques exist for different applications:

- extrusion blow moulding
- injection blow moulding

In extrusion blow moulding a hollow tube (parison) is extruded. The tube is then positioned in a mould, where compressed air forces the plastic material to press against the cool walls where it takes the shape of the mould surface. Extrusion moulding exists as continuous extrusion and intermittent extrusion.

Injection blow moulding involves the manufacturing of a preform by injection moulding, which is subsequently blown into the desired shape.

MOULD MATERIAL REQUIREMENTS

Blow moulding is a low pressure method where strength and wear demands are very moderate. Some parts of the mould, like shut-off areas and/or neck rings, may require higher strength material. PVC is a common material for bottles and may cause corrosion problems. Blow moulding is a very high productivity method why cycle times are of great importance.

Important properties are:

- moderate strength demands
- corrosion resistance
- thermal conductivity

The most common mould materials are aluminium alloys, with inserts of higher hardness materials.

Steel is also used, sometimes even in soft annealed condition.

EXTRUSION

A continuous operation in which hot plasticized material is forced through a die opening that produces a profile of the desired shape.

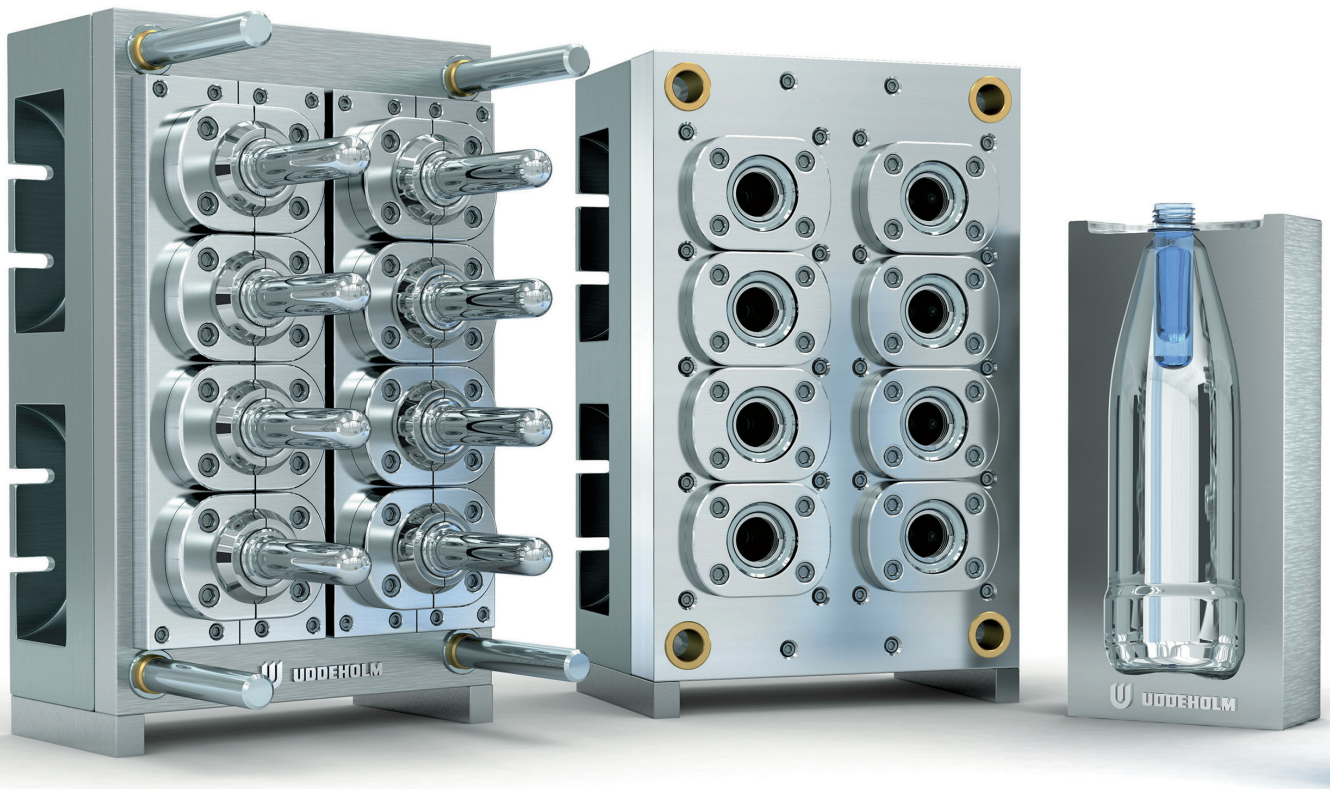
The plastic material is placed into a hopper, that is connected to the back of the extrusion barrel. A rotating screw plasticize and transport the material through the barrel and force it through a die of a proper shape. The extruded profile is transported through a cooling media, and when cooled sufficiently it is cut to the desired length.

Normally a special calibrator unit is used to give the profile its final size. The cooling is a sensitive process in order to keep tolerances and avoid warpage.

DIE MATERIAL REQUIREMENTS

The die is normally produced in steel. The strength requirements are moderate. However, corrosion resistance is needed for extrusion of PVC profiles and wear resistance for reinforced profiles.

Normally prehardened grades have enough strength for normal extrusion. The dies are sometimes nitrided for increased wear resistance.



*The PET bottles are produced in two steps:
first injection moulding of the preforms and then blow
moulding of the preforms to the finished bottle.
Uddeholm Stavax ESR is a recommended tool steel for
production of the preforms.*

THE SAME CONSISTENT QUALITY STEEL, THE SAME DEPENDABLE TECHNICAL SERVICE, AVAILABLE TO YOU WORLDWIDE. ONLY FROM UDDEHOLM!

COMPLETE LOCAL STOCKS

From our long experience serving the plastic mould industry we have become familiar with the sizes, grades and tolerances most frequently used. We have stocked these in strategically located Service Centers.



WELDING CONSUMABLES

It is of uttermost importance to match the consumables with the mould steel to ensure successful repair welding, especially if the welded surface is to be photo-etched or polished.

We offer welding consumables for the Uddeholm tool steels Impax Supreme, Nimax ESR, Nimax, Unimax, Mirrax, Corrax, Stavax ESR, Tyrax ESR, Coolmould and RoyAlloy. They are available as TIG-wire.

Uddeholm Impax Supreme is also available as coated electrode for MMA welding.

We also offer laser welding wire for Uddeholm Nimax ESR, Uddeholm Nimax, Uddeholm Mirrax ESR, Uddeholm Tyrax ESR and Uddeholm Dievar.

ONE SOURCE FOR ALL YOUR TOOL STEEL NEEDS

Cold work tool steel including precision ground flat stock, drill rod and hollow bar, plastic mould steel, die casting die steel and hot work steel.

Printed material on the selection, heat treatment and application of mould materials, EDM, polishing and surface texturing of tool steel are very important aspects of our service.



OUTSTANDING TECHNICAL SERVICE

Our staff of metallurgists and field specialists can help you with material selection at the design stage and later with recommendations on heat treatment, grinding and machining.



PRODUCT PROGRAMME FOR PLASTIC MOULDING

UDDEHOLM MOULD STEELS Impax Supreme (AISI P20, modified)	A prehardened Ni-Cr-Mo steel, supplied at ~310 HB, with good polishing and photo-etching properties. Suitable for a wide range of injection moulds, blow-moulds and extrusion dies.
Nimax ESR	A low carbon steel, delivery hardness ~380 HB. Excellent toughness, machinability and weldability. The ESR process also gives very good polishability and etching properties.
Nimax	A low carbon steel, delivery hardness ~380 HB. Excellent toughness, machinability and weldability. Good polishing and etching properties.
Stavax ESR / Mirrax ESR (AISI 420, modified)	Through-hardening corrosion resistant mould steel with very good polishability.
Mirrax 40	A prehardened corrosion resistant mould steel supplied at ~380 HB with good machinability, very good toughness and very good polishing properties.
Polmax (AISI 420, modified)	A through hardened corrosion resistance mould steel with excellent polishability.
Tyrax ESR	A through hardened corrosion resistant and wear resistant steel with excellent polishability.
Corrax	A precipitation hardening steel with excellent corrosion resistance, easy heat treatment and good weldability. Also available as powder for additive manufacturing (AM).
Orvar Supreme (AISI H13, improved)	A versatile through-hardening 5% Cr mould and die steel with good wear resistance and polishability.
Vidar 1 ESR (AISI H11)	A 5% Cr mould and die steel with very good hardenability. Suitable for general hot work and plastic mould applications, specially large plastic moulds with requirements on high toughness in combination with very good polishability and texturing properties.
Unimax	A steel with very good hardenability, suitable for surface coating. The unique combination of toughness and wear resistance makes it suitable for long run moulding and moulding of reinforced plastics.
Elmax SuperClean Vanadis 4 Extra SuperClean Vanadis 8 SuperClean	Powder metallurgically produced mould steels characterized by very good dimension stability, good polishability and wear resistance. Elmax SuperClean is corrosion resistant, Vanadis 4 Extra SuperClean has the highest toughness and Vanadis 8 SuperClean the best wear resistance. Recommended for long production runs of smaller and complicated shapes and/or abrasive plastics.
Vancron SuperClean	Uddeholm Vancron SuperClean is a nitrided powder metallurgical tool steel offering an excellent combination of galling resistance and adhesive wear resistance. The low friction properties can reduced problems with sticking of plastic to mould surface.
Vanax SuperClean	Powder metallurgically produced steel with excellent corrosion and wear resistance.

Cont.

Cont.

UDDEHOLM HOLDER STEELS Holdax (AISI 4130/35, modified)	A prehardened steel with very good machinability and high tensile strength.
Ramax HH (AISI 420 F modified), RoyAlloy	Prehardened stainless holder steels with good machinability, high tensile strength and good corrosion resistance.
ALUMINIUM Alumec 89	A high strength Al-alloy supplied at ~160 HB. Recommended for prototype moulds and for short runs with low demands on strength and wear resistance.
COPPER ALLOY Coolmould	A high strength copper mould alloy with high thermal conductivity. For applications like pinch offs and neck rings for blow moulds, cores and inserts in injection moulds and injection nozzles and manifolds for hot runner systems.

CHEMICAL COMPOSITION

UDDEHOLM MOULD STEELS	TYPICAL ANALYSIS %									APPROX. SUPPLIED HARDNESS Brinell
	C	Si	Mn	Cr	Ni	Mo	V	S		
Impax Supreme	0.37	0.3	1.4	2.0	1.0	0.2	–	–		310
Nimax ESR	0.1	0.3	2.5	3.0	1.0	0.3	–	–		380
Nimax	0.1	0.3	2.5	3.0	1.0	0.3	–	–		380
Mirrax 40	0.21	0.9	0.45	13.5	0.6	0.2	0.25	–	+N	380
Corrax	0.03	0.3	0.3	12.0	9.2	1.4	–	–	Al 1.6	330
AM Corrax**	0.03	0.3	0.3	12.0	9.2	1.4	–	–	Al 1.6	–
Vidar 1 ESR	0.38	1.0	0.4	5.0	–	1.3	0.4	–		180
Orvar Supreme	0.39	1.0	0.4	5.2	–	1.4	0.9	–		180
Stavax ESR	0.38	0.9	0.5	13.6	–	–	0.3	–		190
Mirrax ESR	0.25	0.3	0.5	13.3	1.3	0.3	0.3	–	+N	250
Polmax	0.38	0.9	0.5	13.6	–	–	0.3	–		190
Unimax	0.5	0.2	0.5	5.0	–	2.3	0.5	–		185
Tyrax ESR	0.4	0.2	0.5	12.0	–	2.3	0.5	–	+N	190
Elmax*	1.7	0.8	0.3	18.0	–	1.0	3.0	–		280
Vanadis 4 Extra*	1.4	0.4	0.4	4.7	–	3.5	3.7	–		230
Vanadis 8*	2.3	0.4	0.4	4.8	–	3.6	8.0	–		≤ 270
Vanax SuperClean*	0.36	0.3	0.3	18.2	–	1.1	3.5	–	+N	260
UDDEHOLM HOLDER STEELS										
Ramax HH	0.12	0.2	1.3	13.4	1.6	0.5	0.2	0.1	+N	340
RoyAlloy	0.05	0.4	1.2	12.6	–	–	–	0.12	+N +Cu	310
Holdax	0.4	0.4	1.5	1.9	–	0.2	–	0.07		310

*Uddeholm PM SuperClean tool steels. ** Solutions treatment 850°C 30 minutes.

PROPERTIES

PROPERTY	Impax Supreme	Nimax ESR	Nimax	Mirrax 40	Corrax	Vidar 1 ESR	Orvar Supreme	Stavax ESR	Mirrax ESR	Tyrax ESR	Polmax	Unimax	Elmax	Vanadis 4 Extra	Vanadis 8	Vanax	Ramax HH	RoyAlloy	Holdax
Normal hardness HRC (HB)	(~310)	(380)	(380)	(380)	46	48	52	52	52	57	52	58	58	62	62	60	(~340)	(~310)	(~310)
Wear resistance	1	2	2	2	3	4	5	5	5	6	5	6	8	9	10	7	2	1	1
Toughness	8	10	10	6	4	8	6	5	6	6	5	6	3	5	4	4	3	4	4
Compressive strength	4	5	5	5	6	6	7	7	7	8	7	8	9	10	10	9	5	4	4
Corrosion resistance	1	1	1	6	9	2	2	7	8	7	7	2	5	1	1	10	6	6	1
Machinability**	5	5	5	6	4	9	9	8	7	7	8	7	3	5	4	4	6	7	7
Polishability	7	8	7	8	7	8	8	9	9	10	10	9	8	8	8	8	4	4	4
Weldability	6	7	7	5	6	4	4	4	4	4	4	4	2	2	2	–	5	4	6
Nitriding ability	6	5	5	–	–	10	10	–	–	–	–	8	–	8	8	–	–	–	5
Etchability	8	9	8	8*	8*	9	9	8*	8*	8*	8*	9	8*	8	8	8*	3	3	3

* Special process required

**Tested in delivery condition

The properties of the main mould and holder steel grades have been rated from 1–10, where 10 is the highest rating. Such comparisons must be considered as approximate, but can be a useful guide to steel selection.

Note: It is not possible to make valid “total comparisons” between steel grades by adding their respective “points”—it is only intended that individual properties be compared.



MOULD STEEL SELECTION

GENERAL RECOMMENDATIONS

PROCESS/ MATERIAL		UDDEHOLM STEEL GRADES	HARDNESS HRC (HB)
INJECTION MOULDING	Thermoplastics – Prehardened mould steel	Alumec 89* Impax Supreme Ramax HH Mirrax 40 Nimax ESR Nimax	(~160) 33 (~310) 37 (~340) 40 (~380) 40 (~380) 40 (~380)
	– Through-hardened mould steel	Corrax Mirrax ESR Orvar Supreme Stavax ESR Polmax Vidar 1 ESR Unimax Tyrax ESR Elmax Vanadis 4 Extra	36–50 45–50 45–52 45–52 45–52 45–52 50–58 55–58 56–60 58–64
	Thermoset plastics	Unimax Tyrax ESR Elmax Vanadis 4 Extra	52–58 55–58 56–60 58–64
COMPRESSIONS/ TRANSFER MOULDING	Thermoset plastics	Mirrax ESR Stavax ESR Orvar Supreme Unimax Tyrax ESR Elmax Vanadis 4 Extra	45–50 45–52 45–52 52–58 55–58 56–60 58–62
BLOW MOULDING	General	Alumec 89 Impax Supreme Nimax	(~160) 33 (~310) 40 (~380)
	PVC	Corrax Ramax HH Mirrax 40 Stavax ESR Mirrax ESR	36–50 37 (~340) 40 (~380) 45–52 45–50
EXTRUSION	General	Impax Supreme Nimax ESR Nimax	33 (~310) 40 (~380) 40 (~380)
	PVC	Corrax Ramax HH Mirrax 40 Mirrax ESR Stavax ESR	36–50 37 (~340) 40 (~380) 45–50 45–52
HOLDER MATERIAL	1. High strength, prehardened, free-machining	Holdax	33 (~310)
	2. As 1, plus corrosion resistance for low-maintenance production runs. Also for “hygienic” operating conditions. No plating required.	RoyAlloy** Ramax HH	(~310) 37 (~340)

* Alumec 89 is produced by Arconic. **Uddeholm RoyAlloy is produced and patented by Edro Specialty Steels, USA.
Elmax and Vanadis 4 Extra are Uddeholm PM SuperClean tool steels.

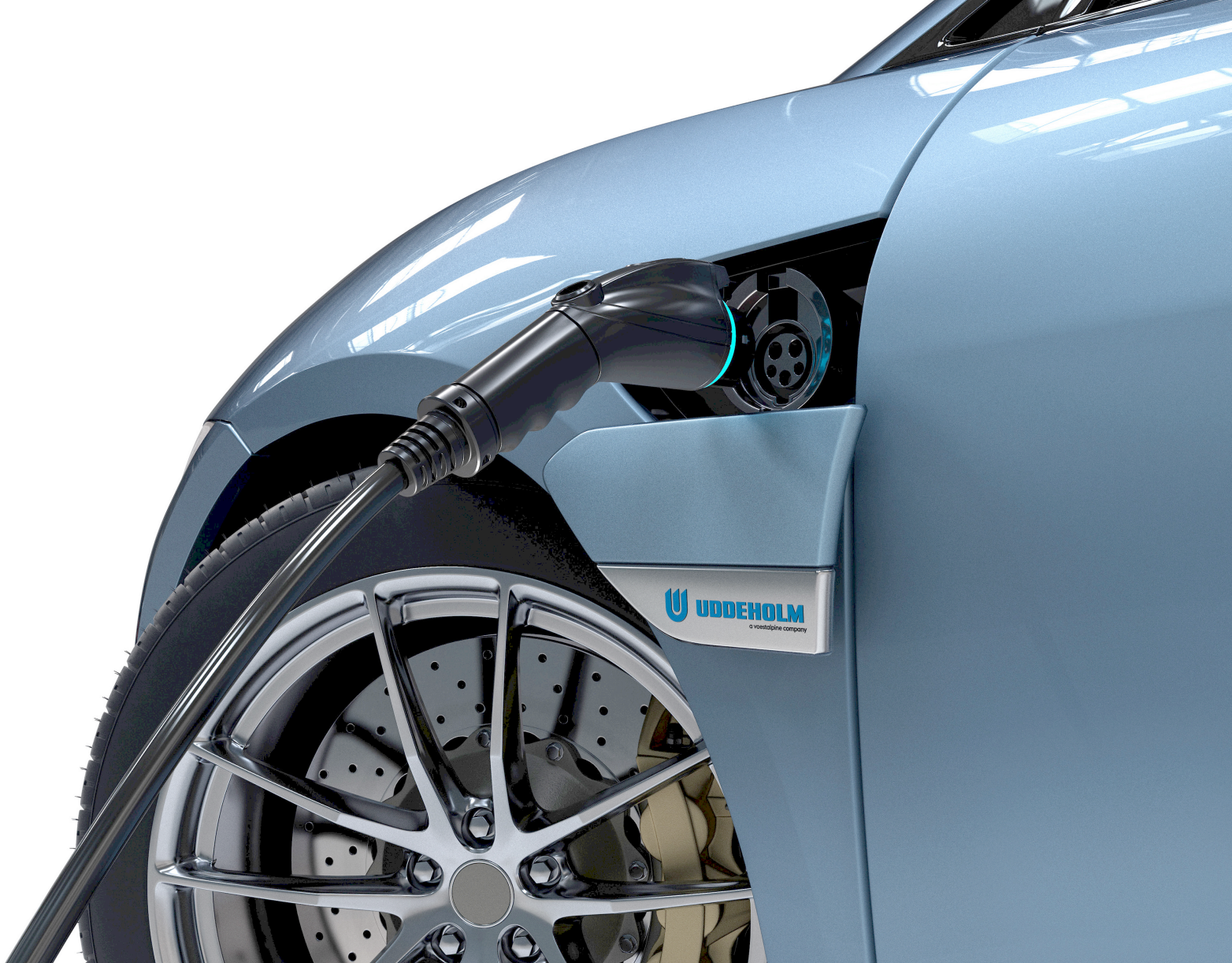
SPECIAL RECOMMENDATIONS

SPECIAL REQUIREMENT OR DEMAND		UDDEHOLM STEEL GRADES	HARDNESS HRC (HB)
LARGE MOULD SIZE	For automotive components, including panels, bumpers, fascias, etc.	Alumec 89 Impax Supreme Corrax Mirrax ESR Orvar Supreme Vidar 1 ESR Mirrax 40 Nimax ESR Nimax	(~160) 33 (~310) 36–46 36–50 36–50 36–50 40 (~380) 40 (~380) 40 (~380)
	As above, with low demands on surface finish	Holdax Ramax HH	33 (~310) 37 (~340)
HIGH SURFACE FINISH	For moulding optical/medical parts, clear covers/panels	Nimax ESR Mirrax 40 Mirrax ESR Stavax ESR Polmax Orvar Supreme Vidar 1 ESR Unimax Tyrax ESR Elmax Vanadis 4 Extra	40 (~380) 40 (~380) 45–50 45–52 45–52 45–52 45–52 54–58 55–58 56–60 58–62
COMPLEX SHAPES	1. For large automobile/household components	Mirrax ESR Corrax Mirrax 40 Nimax ESR Nimax Vidar 1 ESR	36–50 34–46 40 (~380) 40 (~380) 40 (~380) 45–50
	2. For small parts with low wear demands	Impax Supreme Corrax Mirrax 40 Nimax ESR Nimax	33 (~310) 34–46 40 (~380) 40 (~380) 40 (~380)
	3. For small parts with high wear demands, e.g. electrical/electronic mouldings	Mirrax ESR Orvar Supreme Stavax ESR Unimax Tyrax ESR Elmax Vanadis 4 Extra Rigor Vanadis 8	48–50 50–52 50–52 54–58 55–58 56–60 58–64 60–62 60–64
ABRASIVE MOULDING MATERIALS	Reinforced/filled moulding materials; engineering resins	Mirrax ESR Orvar Supreme Stavax ESR Unimax Tyrax ESR Elmax Vanadis 4 Extra Vanadis 8	48–50 50–52 50–52 54–58 55–58 56–60 58–64 60–64

Elmax and the Vanadis steel grades mentioned in the table are Uddeholm PM SuperClean tool steels.

SPECIAL RECOMMENDATIONS

SPECIAL REQUIREMENT OR DEMAND		UDDEHOLM STEEL GRADES	HARDNESS HRC (HB)
LONG PRODUCTION RUNS	For thermoplastic parts, including disposable cutlery, containers and packaging	Mirrax ESR	45–50
		Stavax ESR	45–52
		Orvar Supreme	45–52
		Vidar 1 ESR	45–52
		Unimax	54–58
		Tyrax ESR	55–58
		Elmax	56–60
		Vanadis 4 Extra	58–64
CORROSION RESISTANCE	1. For corrosive moulding materials, including PVC 2. For humid moulding/mould storage conditions 3. General resistance to surface staining/rusting 4. Resistance to corrosion of cooling channels	Corrax	34–50
		RoyAlloy	(~310)
		Ramax HH	37 (~340)
		Mirrax 40	40 (~380)
		Mirrax ESR	45–50
		Stavax ESR	45–52
		Tyrax ESR	55–58
		Elmax	56–60
PHOTO-ETCHING	1. Prehardened steel	Impax Supreme	33 (~310)
		Mirrax 40	40 (~380)
		Nimax ESR	40 (~380)
		Nimax	40 (~380)
	2. Through-hardened steel	Mirrax ESR	45–50
		Orvar Supreme	45–52
		Vidar 1 ESR	45–52
		Stavax ESR	45–52
		Unimax	54–58
		Tyrax ESR	55–58
		Elmax	56–60
		Vanadis 4 Extra	58–64
HIGH THERMAL CONDUCTIVITY	For injection and blow moulds, cores and inserts; parts for hot runner systems.	Coolmould	~40



WELCOME TO UDDEHOLM

Uddeholm is the world's leading manufacturer of tool steel for industrial tools. And that is no accident. We put our hearts into every piece of steel and every step of the process, from raw material to finished product. Technology is important, just as know-how and product development. But equally vital are desire and courage, power and a forward-looking spirit.

It's about the passion within us – the love of steel!

For more information, please visit www.uddeholm.com

Manufacturing solutions for generations to come

SHAPING THE WORLD

Since 1668 we have been providing a wide range of innovative cutting-edge solutions for our customers in demanding segments. Our dedicated employees work in almost ninety countries and together we deliver improved competitiveness to clients worldwide. Welcome to Uddeholm.