STEELS FOR MOULDS

COLD WORK | **PLASTIC** MOULDING | **HOT** WORK | **HIGH** PERFORMANCE STEEL

UDDEHOLM

Contents

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The cost of the tool steel in a mould usually represents only 5–10% of the tool cost. And it is an even smaller part of the *total tooling cost.*

The moulder knows this and he also knows that the cost of excessive mould maintenance, e.g. major repolishing, cleaning, replating and replacing of worn or broken parts has to be taken into account. And so do the costs of production and down time. At worst they may even cause overtime payments, late-delivery penalties and loss of customer goodwill.

Put briefly, the moulder knows that he has 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.

He also knows from experience that one of the major decisions is to specify the best possible mould steel for the job.

We at Uddeholm have developed a range of high quality mould steels so that moulders can use the best possible steels for their jobs.

In this brochure we present these high quality steels. We also focus on important factors that contribute to economical production of plastics mouldings.

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 steels 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 finish and tolerance 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 mouldmaking and the selection of the best mould steel for the job.

CHOOSING THE BEST MOULD STEEL FOR THE JOB

The product designer is thus involved in lot of important decisions. Decisions that sooner or later will relate to the mould steel selected. 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 photoetching?
Are there several patterned parts to be matched, e.g. mouldings in a car interior?

(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 19.)

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.)

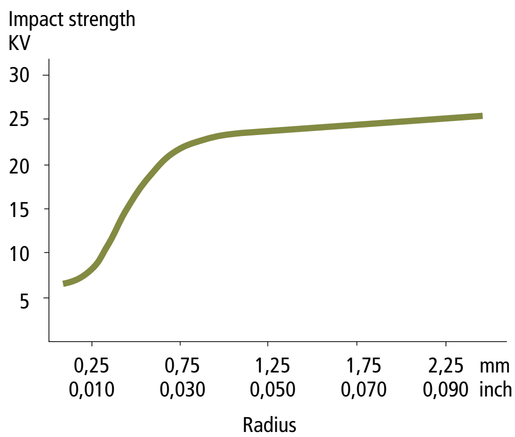
AVOID SHARP CORNERS AND STAY OUT OF TROUBLE!

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

Sharp corners in mouldings and therefore in the mould are always potential stress-raising points. Points likely to cause cracking and failure of both moulding and mould.

By increasing the radius of the corners 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 locking 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 optimum tooling economy by thinking standard, i.e. using standard steel grades, standard steel sizes and standard machined plates.

THE IMPORTANT ROLE OF THE MOULD DESIGNER

In seeking 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 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.

A clever mould designer can also add a valuable service to all concerned by thinking standard.

TAKE A SHORT CUT TO PRODUCTIVITY BY THINKING STANDARD!

Most mould designers are used to specifying a whole range of standard parts such as guide pins and bushings, ejector pins etc. Since these parts are available quickly at competitive prices they help the mouldmaker save valuable time.

But there is even more time and money to be saved. Time and cost savings can be further improved by extending this standard thinking to standard steel sizes, machined plates and steel grades.

In fact, by specifying readily available steel grades in standard sizes the mouldmaker can ensure prompt deliveries while keeping initial machining costs and material losses to a minimum.

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 STEELS

The steel types most commonly used are:

- **prehardened mould and holder steels**
- **through-hardening mould steels**
- **corrosion resistant mould steels**

(For further information on these steel types and their properties see pages 18–19.)

WHEN TO USE PREHARDENED MOULD AND HOLDER STEELS?

These steels are mostly used for:

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

The steels are delivered in the hardened and tempered condition, usually within the 270–350 Brinell range. No heat treatment is necessary before the mould is put into use.

The surface hardness can be increased in many cases by flamehardening or nitriding (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 STEELS

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

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.

Both Impax Supreme and Holdax are prehardened steels with a delivered hardness of 290–330 Brinell.

Ramax 2 (AISI 420 F modified) is a pre-hardened, free-machining, stainless holder steel. It has a delivery hardness of approx. 340 Brinell and offers excellent machinability and corrosion resistance. It is also an ideal partner for Stavax ESR, Stavax Supreme, Polmax and Elmax.

WHEN TO USE THROUGH-HARDENED STEELS?

These steels are mostly used:

- **for long productions runs**
- **to resist abrasion from certain moulding materials**
- **to counter high closing or injection pressures**

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

Through-hardened steels, used for cavity and core inserts, are usually placed in holder blocks of prehardened steels such as Holdax or Ramax 2.

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

Better wear resistance is especially important when filled or reinforced plastic materials 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 high surface finished are required on the moulded part.

UDDEHOLM THROUGH-HARDENING STEELS

Stavax ESR (AISI 420 modified), Stavax Supreme, Polmax (AISI 420 modified), Orvar Supreme (AISI H13 improved) and Grane (AISI L6) are all typical Uddeholm through-hardening steels.

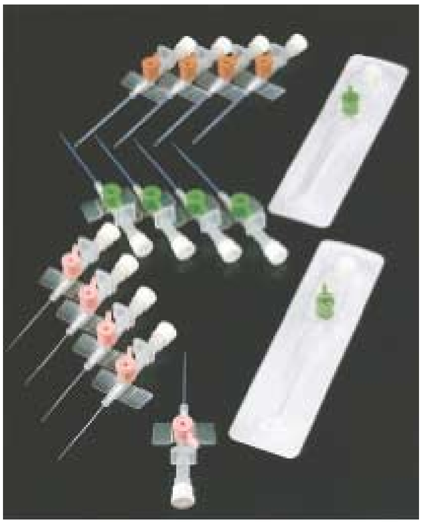
Calmax, Rigor (AISI A2) and Elmax are other steels that we recommend for mould with high wear resistance.

Vanadis 10, our powder-metallurgy high speed steel, is our most wear resistant steel.

WHEN TO USE CORROSION RESISTANT MOULD STEELS?

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

The increased initial cost of this steel is often less than the cost involved in a single repolishing or replating operation of a mould from conventional steel.



Plastic moulds can be affected by corrosion in several ways:

- **Plastic materials can produce corrosive by-products, e.g. PVC.**
- **Corrosion leads to reduced cooling efficiency when water channels become corroded or completely blocked.**
- **And, of course, condensation caused by prolonged production stoppages, humid operating or storage conditions, often leads to corrosion.**

UDDEHOLM CORROSION RESISTANT MOULD STEELS

Stavax ESR and Stavax Supreme, are corrosion resistant mould steels offering excellent polishability combined with good wear and indentation resistance. Stavax Supreme is developed to meet the increased requirements on good toughness and through hardenability in larger sections.

Polmax is also a corrosion resistant mould steel specially developed to meet the high demands on polishability from producers of such high-tech products as CDs, memory discs and lenses.

Elmax, finally, is a powder-metallurgy mould steel with high wear and corrosion resistance.

Corrax is a precipitation hardening mould steel with un-matched corrosion resistance, easy heat treatment and good weldability.

OTHER MATERIAL

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

Beryllium copper Moldmax HH and Protherm are used in moulds when high thermal conductivity is needed.

FINDING THE CORRECT WORKING HARDNESS FOR THE MOULD

The chosen working hardness for the mould and the heat treatment method used to achieve it affect a lot of properties. Properties such as toughness, compression strength, wear and corrosion resistance.

Generally it can be said that increased hardness results in better resistance against wear, pressure and identation and that decreased hardness leads to better toughness.

A normal working hardness for a through-hardening steel is 48–60 Rockwell C. 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 19–20.

And for information on heat treating plastic moulds ask for the Uddeholm publication "Heat Treatment of Tool Steels".

Mouldmaking

A substantial part of the total tooling cost is that incurred in the making of the mould. It is therefore of great importance that the mouldmaking process should be as straight-forward as possible.

THE IMPORTANT ROLE OF THE MOULDMAKER

A well equipped machine shop with competent and experienced personnel is an essential part of the mouldmaking process.

The significant investment that this process represents is ultimately focused on the mould material. An experienced mouldmaker, therefore, places high demands on his steel supplier and his product when it comes to steel quality and properties as well as steel finish and 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 photoetching.

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

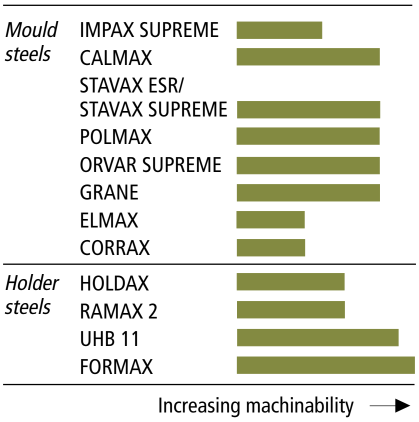
The cost of machining accounts for roughly 1/3 of the total cost of mould manufacture. So a good and uniform machinability is of outmost importance.

Most of Uddeholms mould steels are supplied in the fully annealed condition enabling the best possible metal removal rates for the type of steel concerned.

The only exceptions are Impax Supreme (AISI P20 modified), Holdax (AISI 4140 modified) and Ramax 2 (AISI 420F modified).

A machinability comparison guide for a number of grades of Uddeholm steels is shown below. The guide is based on tool wear tests.

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



IMPAX SUPREME, HOLDAX and RAMAX 2 were tested in the prehardened condition.

HOW IMPORTANT IS GOOD POLISHING?

Polishing sometimes accounts for up to 30% of the total mould cost. Not surprisingly, 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. 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/or Electro Slag Refined (ESR process) during production. This ESR treatment results in improved homogeneity and freedom from inclusions compared to conventional steel production processes.

DON'T POLISH MORE THAN NECESSARY!

It is pointless to polish beyond a certain level de-pending on the heat treatment process to be used.

The table, to the right, shows the smallest recommended grain size of abrasive to be used in a surface prior to being hardened and tempered by various methods.

For further information ask for the Uddeholm publication "Polishing of Tool Steel".

Surface finish prior to heat treatment

Uddeholm grade	Vacuum	Cast Iron Chips	Salt Bath	Protective Gas
STAVAX ESR STAVAX SUPREME POLMAX ORVAR SUPREME CALMAX GRANE RIGOR ELMAX	400 grain	180–200 grain or coarser	180 grain or coarser	220–400 grain
SVERKER 21	400 grain	180 grain or coarser	60 grain	220–400 grain

Smallest recommended grain size of abrasive to be used prior to hardening and tempering.

WHY HEAT TREATMENT?

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

SOLVING THE DISTORTION PROBLEM

The tool should be stress-relieved after rough-machining in order to minimize distortion problems. In this way the stresses induced by the machining-operations are relieved. And any distortion is then rectified in the final machining.

When using through-hardening steels at maximum hardness levels, however, 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 Impax Supreme—a steel for which no additional heat treatment is required.

Flame hardening of parting surfaces can locally increase surface hardness to approx. 55 Rockwell C.

HOW TO DEAL WITH DIMENSIONAL CHANGES

It is true that some dimensional changes are inevitable during hardening. But it is also possible to limit and control these changes to a certain extent. For instance by slow, uniform heating to the austenitizing temperature, by using a temperature that is not too high and a suitable quenching medium.

Stavax ESR, Stavax Supreme, Calmax, Grane, Orvar Supreme, Polmax, Elmax and Rigor can all be air hardened when dimensional stability is important.

Corrax needs only an aging process at 500–600°C (930–1110°F) and no quenching. This means that no distortion will occure, only an linear and homogenous shrinkage in the order of 0,1%. Since it is totally predictable it is easy to compensate for this shrinkage by adding stock before the heat treatment.

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. And many of them have been premachined to a greater or lesser degree.

Uddeholm tool steels are available as machined bar and as fine machined mould steel.

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

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

MACHINED BAR

By using machined bar 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 considerable reduced.
- No machining costs for removal of the decarburized surface layers are involved.
- And the manufacturing time is shortened, which makes planning simpler and calculations more accurate.

MACHINED STEEL PLATES

Machining costs can be reduced already at the design state. One way of doing this is to construct a tool from machined steel plates, i.e. ground to specific dimensions on all sides.

Uddeholm Service Centers are equipped with a full line of processing machinery, including grinders, cut-off saws and other equipment.

ELECTRICAL DISCHARGE MACHINING (EDM)

When spark eroding cavities, one or two important points should be noted in order to obtain satisfactory results. During the operation the surface layer of the steel is rehardened and consequently in a brittle state. 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 current and high frequency.**
- **The affected surface layer should be removed by polishing or stoning.**
- **If the spark eroded surface texture is to be used in the finished mould it should be retempered at a temperature ≈ 25°C below that used previously.**
- **If the spark eroded surface is to be textured by photoetching it is important that all of the surface layer affected is carefully removed by stoning etc.**

For further information see the Uddeholm publication "Electrical Discharge Machining of Tool Steels".

Graphite electrode in dielectric medium.

WIRE EDM'ING

This process makes it easy to cut complicated shapes from hardened steel blocks. However, hardened steels always contain stresses and when large volumes of steel are removed in a single operation, distortion may be caused or even cracking. These difficulties can be reduced by conventionally machining the work piece before heat treatment 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 PHOTOETCHING PROCESS HAS BECOME SO POPULAR

Plastic mouldings with a textured surface have become increasingly popular. And texturing by photoetching is frequently used as a finish on moulding tools instead of polishing.

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

POINTS TO BE OBSERVED WHEN PHOTOETCHING

The results obtained by photoetching 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 grain on a surface that is to be photoetched.**
- **Spark eroded surfaces should always be ground or polished otherwise rehardened surface layers from the spark erosion will cause a poor etching result.**
- **Flamehardening should be avoided prior to photoetching.**
- **In some cases a welded tool can be photoetched 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 photoetcher.**
- **If a tool is to be nitrided this must be done after photoetching.**
- **The surface area of a mould cavity is greatly increased by texturing, which may cause ejection problems. Early consultation with the photoetching specialist is recommended to determine the optimum draft angle for the shape and pattern concerned.**

UDDEHOLM MOULD STEELS SUITABLE FOR PHOTOETCHING

Impax Supreme (AISI P20 modified) pre-hardened mould steel and Orvar Supreme (AISI H13 improved) through-hardened steel yield particularly good and consistent results due to their very low sulphur contents.

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

Moulding

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

THE DEMANDS OF THE MANUFACTURER OF PLASTIC MOULDINGS

The manufacturer expects his mould to be delivered on time. And he expects it to produce a certain quantity of components at a specified quality level and at lowest possible cost.

The manufacturer'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 uniform, high rate of production, uniform quality of mouldings, 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 STEELS

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 us 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 im-portant 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 materi-

als 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 to specific applications. This assures not only ready availability but also gives the mouldmaker and the moulder 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 demanded will depend on the type of resins to be used, the filling agent, amount of additives, length of production run, tolerances etc.

Mould steels cover a wide range of wear resistance and compressive strength. In principle, they fall into two categories: *prehardened mould steels* for moderate demands, e.g. Impax Supreme, Holdax and Ramax 2 and *through-hardening mould steels* for severe demands, e.g. Stavax ESR, Stavax Supreme, Polmax, Corrax, Orvar Supreme, Elmax, Calmax and Grane.

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 chromium plating 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 Stavax ESR, Stavax Supreme, Polmax, Corrax and Elmax is reduced by nitriding.

The powder metallurgy grades, Elmax, Vanadis 4, Vanadis 6 and Vanadis 10, are extremely wear-resistant. They are recommended for small moulds, inserts and cores subjected to abrasive wear.

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 prehardened steels are 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 produced from PVC. 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.**
- **Productions in a humid or corrosive atmosphere or prolonged storage may cause surface damage by water, condensation and eventually rust in the cavities with loss of surface finish on the products.**

All the problems mentioned above create a demand for insert and holder materials with some degree of resistance to corrosion. Corrax which has the best corrosion resistance is used wherever corrosion is the main problem, i.e. processing corrosive plastics. Stavax ESR and Stavax Supreme are corrosion resistant mould steels with high cleanliness, Polmax can meet the highest demands on polishability combined with corrosion resistance. Elmax is combining the corrosion resistance with wear resistance and Ramax 2 is a corrosion resistant holder steel with very good machinability. By using Ramax 2 for the holders the stainless properties are extended to the full mould.

THERMAL CONDUCTIVITY

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

In a 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 in a mould due to its very low thermal conductivity compared to steel.

However, good corrosion resistance is of much greater importance when aiming for a high and uniform production rate. This has a beneficial effect on the resultant heat transfer properties in the cooling channels. The use of a stainless mould steel such as Stavax ESR or Stavax Supreme is often the answer.

When mould materials with good corrosion resistance, combined with very high thermal conductivity are required, we can supply several grades of copper mould alloys.

Moldmax HH and Moldmax XL are high-strength grades with high thermal conductivity, good corrosion and wear resistance and good polishability.

Protherm is a moderate strength grade that offers even higher thermal conductivity for maximum heat transfer effect.

TOUGHNESS

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

Complicated cavities, 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. In practice 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 center of the steel.

INTERCHANGEABILITY OF STEEL AND COMPONENTS

By thinking standard a mould designer can make a significant contribution to keeping mould maintenance costs to a minimum.

By selecting readily available steel grades, standard sizes and stock components from the outset he can help to minimize the time and cost of putting a mould back into service. Furthermore, the use of identical material and parts made to close tolerances will ensure that the tool performance will remain unchanged.

By using standard parts and components wherever possible in the mould design the ease and speed of repair and maintenance will be significantly increased.

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.

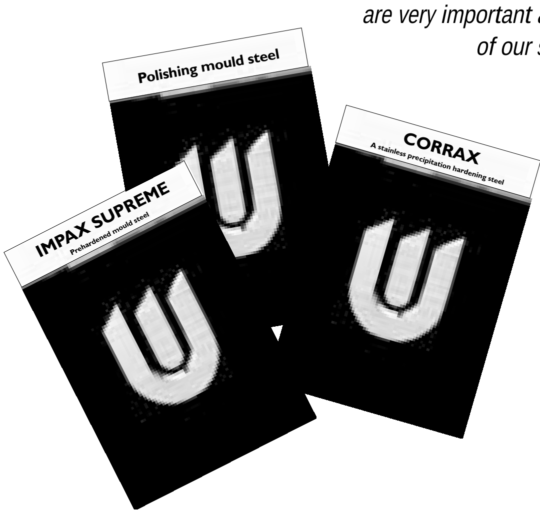
OUTSTANDING TECHNICAL SERVICE

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.

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.



WELDING CONSUMABLES

To ensure successful repair welding it is of outmost importance to exactly match the consumables to the mould steel. Especially if the welded surface is to be photoetched or polished.

We offer welding consumables for Impax Supreme, Stavax ESR and Calmax. They are available as TIG-wire or as coated electrodes for MMA welding.

Corrax consumables are available as TIG-wire only.

Product Programme

Mould steels IMPAX SUPREME (AISI P20, modified)	A prehardened Ni-Cr-Mo steel, supplied at 290–330 Brinell, with excellent polishing and photo-etching properties. Suitable for a wide range of injection moulds, blow-moulds, extrusion dies.
CALMAX GRANE	A steel recommended for injection-, compression- and transfer-moulds requiring good wear resistance and compressive strength.
STAVAX ESR/SUPREME (420, modified)	A through-hardening stainless mould steel with good corrosion resistance and very good polishability.
POLMAX (420, modified)	A through-hardening stainless mould steel with good corrosion resistance and extremely good polishability.
CORRAX	A precipitation hardening steel with exceptionally good corrosion resistance, easy heat treatment and good weldability.
ORVAR SUPREME (H13, improved)	A versatile through-hardening 5% Cr mould and die steel with good wear resistance and polishability.
RIGOR (A2)	A through-hardening steel, recommended for very long production runs of smaller, complicated mouldings.
ELMAX VANADIS 4 VANADIS 6 VANADIS 10	Powder metallurgically produced mould steels characterized by very good dimension stability, good polishability and wear resistance. Elmax is corrosion resistant, Vanadis 4 has the highest toughness and Vanadis 10 the best wear resistance. Recommended for long production runs of smaller and complicated shapes and/or abrasive plastics.
Holder steels HOLDAX (AISI 4130/35, modified)	A prehardened steel with very good machinability and high tensile strength.
RAMAX 2 (420F, modified)	A prehardened stainless holder steel with excellent machinability, high tensile strength and good corrosion resistance.
Aluminium ALUMEC	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 alloys MOLDMAX HH MOLDMAX XL	High strength copper mould alloys 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.
Beryllium copper alloy PROTHERM	A high conductivity beryllium copper mould alloy. For applications requiring very high thermal conductivity but with moderate strength demands.

Chemical composition

Uddeholm grade	Analysis % C	Si	Mn	Cr	Ni	Mo	V	S	Supplied hardness Brinell
Mould steels									
IMPAX SUPREME	0,37	0,3	1,4	2,0	1,0	0,2	–	<0,01	~310
CALMAX	0,6	0,35	0,8	4,5	–	0,5	0,2	–	200
GRANE	0,55	0,3	0,5	1,0	3,0	0,3	–	–	~230
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	–	215
STAVAX SUPREME	Cr-Ni-Mo-V alloyed								250
POLMAX	0,38	0,9	0,5	13,6	–	–	0,3	–	215
CORRAX	0,03	0,3	0,3	12,0	9,2	1,4	–	Al 1,6	~320
RIGOR	1,0	0,2	0,8	5,3	–	1,1	0,2	–	215
ELMAX	1,7	0,8	0,3	18,0	–	1,0	3,0	–	~240
VANADIS 4	1,5	1,0	0,4	8,0	–	1,5	4,0	–	230
VANADIS 6	2,1	1,0	0,4	6,8	–	1,5	5,4	–	255
VANADIS 10	2,9	0,5	0,5	8,0	–	1,5	9,8	–	275
Holder steels									
HOLDAX	0,4	0,4	1,5	1,9	–	0,2	–	0,07	~310
RAMAX 2	Cr-Ni-Mo-V-S alloyed								~340

Properties

Property	IMPAX SUPREME	CALMAX	GRANE	ORVAR SUPREME	STAVAX ESR	STAVAX SUPREME	POLMAX	CORRAX	ELMAX	RIGOR	VANADIS 4	VANADIS 6	HOLDAX	RAMAX 2
Normal hardness HRC (HB)	(~310)	58	56	52	52	52	52	46	58	60	58	62	(~310)	(~340)
Wear resistance	3	8	7	7	7	7	7	5	9	9	9	10	3	4
Toughness	9	5	5	6	5	6	5	7	4	3	5	4	7	7
Compressive strength	4	8	7	7	7	7	7	6	9	9	9	10	4	5
Corrosion resistance	2	3	3	3	9	9	9	10	7	2	2	2	2	8
Machinability	5**	8	8	9	8	8	8	3	3	4	3	4	7**	6**
Polishability	8	8	8	8	9	9	10	8	8	7	8	8	4	4
Weldability	6	4	4	4	4	4	4	6	2	2	2	2	6	5
Nitriding ability	6	8	6	10	–	–	–	–	–	8	8	8	5	–
Photoetchbility	9	8*	8	8*	8*	8*	8*	8*	8*	5	8	5	3	4

**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		Steel grade	Hardness HRC (HB)
Injection moulding	Thermoplastics – Prehardened mould steel	ALUMEC IMPAX SUPREME	(~160) 33 (~310)
	– Through-hardened mould steel	CALMAX GRANE ORVAR SUPREME STAVAX ESR/SUPREME POLMAX CORRAX ELMAX, VANADIS 4 VANADIS 6	45–58 45–56 45–52 45–52 45–52 36–50 58–60 60–64
	Thermoset plastics	CALMAX GRANE RIGOR, ELMAX, VAN. 4 VANADIS 6	52–58 52–56 58–60 60–64
Compressions/ Transfer moulding	Thermoset plastics	CALMAX GRANE STAVAX ESR/SUPREME ORVAR SUPREME ELMAX, VANADIS 4 VANADIS 6	52–58 52–56 45–52 45–52 58–60 60–64
Blow moulding	General	ALUMEC IMPAX SUP.	(~160) 33 (~310)
	PVC	STAVAX ESR/SUPREME RAMAX 2 CORRAX	45–52 37 (~340) 36–50
Extrusion	General	IMPAX SUPREME	33 (~310)
	PVC	STAVAX ESR/SUPREME RAMAX 2 CORRAX	45–52 37 (~340) 36–50
Holder material	1. High strength, prehardened, free-machining	HOLDAX	33 (~310)
	2. As 1, plus corrosion resistance for low- maintenance production runs. Also for "hygenic" operating conditions. No plating required.	RAMAX 2	37 (~340)

Special recommendations

Special requirement or demand		Steel grade	Hardness HRC (HB)
Large mould size	For automotive components, including panels, bumpers, fascias, etc.	ALUMEC IMPAX SUPREME CORRAX STAVAX SUPREME ORVAR SUPREME	(~160) 33 (~310) 36–46 36–50 36–50
	As above, with low demands on surface finish	HOLDAX RAMAX 2	33 (~310) 37 (~340)
High surface finish	For moulding optical/medical parts, clear covers/panels	STAVAX ESR/SUPREME POLMAX ELMAX, VANADIS 4 ORVAR SUPREME	45–52 45–52 58–60 45–52
Complex shapes	1. For large automobile/household components	IMPAX SUPREME CORRAX STAVAX SUPREME	33 (~310) 34–46 36–52
	2. For small parts with low wear demands	IMPAX SUPREME CORRAX	33 (~310) 34–46
	3. For small parts with high wear demands, e.g. electrical/ electronic mouldings	RIGOR CALMAX ORVAR SUPREME STAVAX ESR/SUPREME ELMAX, VANADIS 4 VANADIS 6	60–62 52–58 50–52 50–52 58–60 60–62
Abrasive moulding materials	Reinforced/filled moulding materials; engineering resins	RIGOR CALMAX ORVAR SUPREME STAVAX ESR/SUPREME VANADIS 4, ELMAX VANADIS 6	58–62 52–58 50–52 50–52 58–60 60–64
Long production runs	For thermoplastic parts, including disposable cutlery, containers and packaging	STAVAX ESR/SUPREME VANADIS 4, ELMAX VANADIS 6 CALMAX GRANE ORVAR SUPREME	45–52 58–60 60–64 45–58 52–56 45–52
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	STAVAX ESR/SUPREME ELMAX RAMAX 2 CORRAX	45–52 58–60 37 (~340) 34–50
Photoetching	1. Prehardened steel	IMPAX SUPREME	33 (~310)
	2. Through-hardened steel	GRANE ORVAR SUPREME STAVAX ESR/SUPREME VANADIS 4, ELMAX VANADIS 6	45–56 45–52 45–52 58–60 60–64
High thermal conductivity	For injection and blow moulds, cores and inserts; parts for hot runner systems.	MOLDMAX HH MOLDMAX XL PROTHERM	40 30 (~190)

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