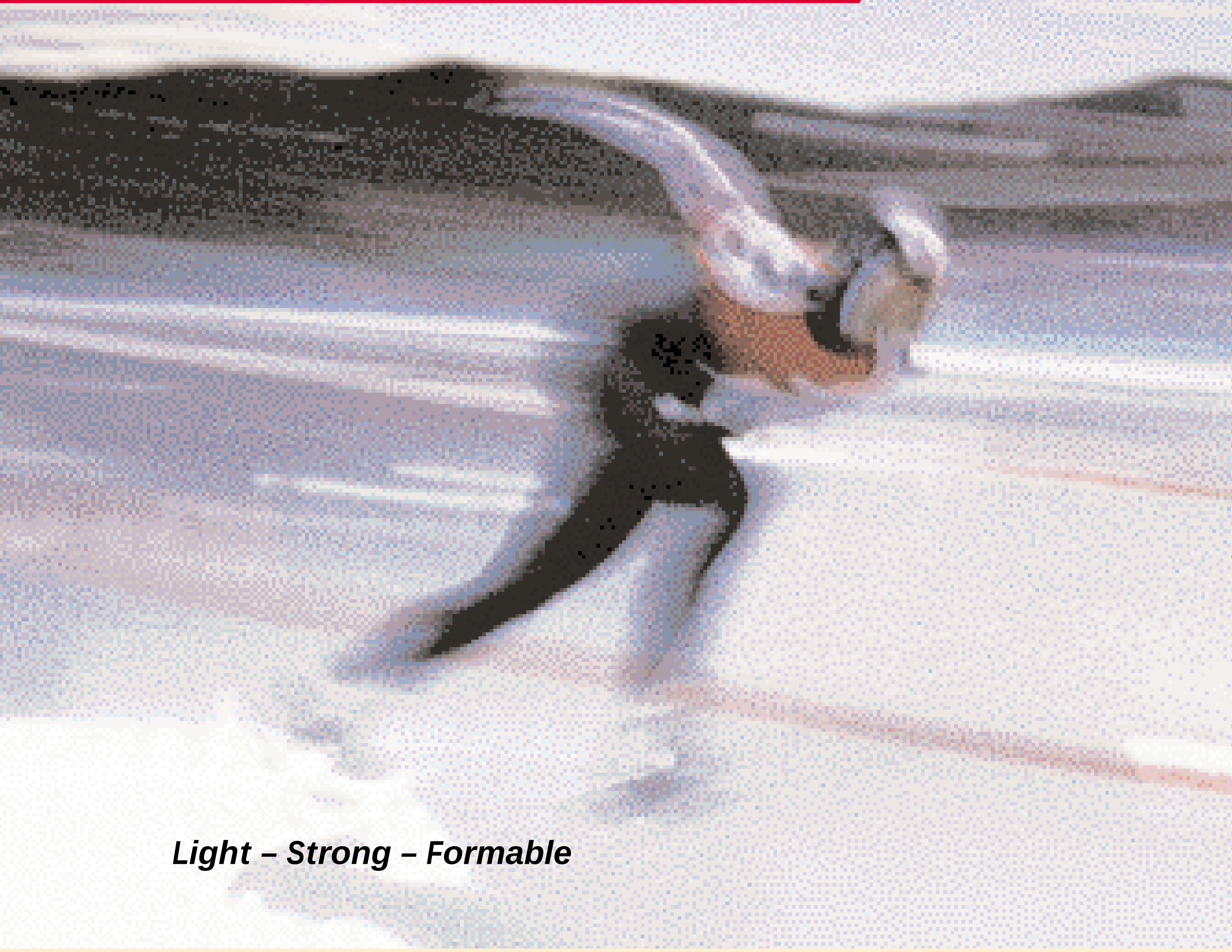
DOCOL®

Docol UHS – Cold reduced Ultra High Strength Steels



Light – Strong – Formable

SSAB TUNNPLÅT

Docol UHS pushes back the boundaries of strength, weight saving and environmental benefits

The cold reduced, ultra high strength steels from SSAB Tunnplåt – designated Docol UHS – have guaranteed minimum tensile strengths ranging between 800 N/mm^2 and 1400 N/mm^2, and yield strengths in excess of 550 N/mm^2.

Docol UHS steels offer many competitive benefits.

DOCOL UHS CAN HALVE YOUR MATERIAL COSTS

The high yield strengths of Docol UHS steels enable you to reduce the sheet thickness of your product, at the same time lowering your material costs.

Since strength is an important property which is paid for when buying steel, consider how much you are paying for every N/mm^2 instead of just the cost per kilogram. The higher the yield strength you choose, the lower the cost per N/mm^2. So by deciding on Docol UHS steels, you will be buying a much higher yield strength for a lower cost.

DOCOL UHS GIVES ENVIRONMENTAL BENEFITS

The high strength of Docol UHS steels offers opportunities for vast weight savings which, in turn, offers

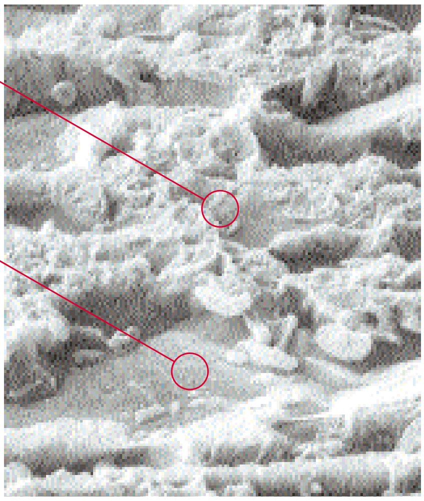
great environmental benefits, both during steelmaking and throughout the useful life of the finished product. Environmental benefits also stem from Docol UHS steels being delivered at the required strength level. This ensures energy savings and reduced emissions at the customer's plant, since no heat treatment furnaces, pickling baths or tumbling are needed.

NEW DESIGN SOLUTIONS

A thinner material also enables you to develop entirely new designs that would have been impossible in the past.

CONTENTS

Unique properties open up unique opportunities



Micrograph of Docol 800 DP steel taken in a scanning electron microscope (X 500). The micrograph shows the martensite and ferrite phases.

The cold reduced, ultra high strength steels – designated Docol UHS – acquire their unique properties in the SSAB Tunnplåt continuous annealing line.

The steels are annealed at temperatures between 750°C and 850°C, depending on the grade of steel, and are then hardened by quenching in water.

Tempering is the next stage, in which the steel is heated to 200–400°C and then acquires its final structure to which the steel owes it toughness and good formability. This unique annealing procedure produces a tempered martensitic structure that accounts for the high strength of the steel.

Both annealing and tempering are carried out in an inert atmosphere to prevent the steel from oxidizing, and the steel strip runs through a pickling bath between quenching and tempering, in order to remove the thin oxide film formed in the quenching process.

MICROSTRUCTURE OF THE STEELS

The microstructure of the steels consists of martensite, which is a hard phase, and ferrite, which is soft. The strength of the steel increases with increasing content of the hard martensitic phase.

The proportion of martensite is determined by the carbon content of the steel and the temperature cycle to which the steel is subjected in the continuous annealing process.

PURE MATERIAL WITH GOOD PROPERTIES

Due to the fast water-quenching process, very low contents of alloying elements are needed for producing Docol UHS steels. Only small quantities of carbon, silicon and manganese are added to achieve the required hardenability.

The resulting steel has good weldability and formability and consistent mechanical properties. Docol UHS steels can be cut, formed and welded by traditional methods.

SUITABLE FOR FLOW-ORIENTED PRODUCTION

Docol UHS steels are suitable for use in modern flow-oriented production, in which the parts can be worked in an uninterrupted flow, without breaks for heat treatment.

Docol UHS steels in flow-oriented production can cut handling costs, lower the energy costs for heating, improve efficiency and shorten the lead time.

Since Docol UHS steels are already hardened and tempered before they are delivered, they need not be heat treated and can therefore replace high carbon steels.

GOOD FORMABILITY

In spite of its high strength, Docol UHS steels have good formability and can be formed in traditional processes.

In many cases, Docol UHS steel is used to save weight by replacing a thicker, lower strength material. The Docol UHS steel can then often be processed in the same way as the material it replaces, since thickness is one of the factors that determine the pressing, bending and shearing forces.

Docol UHS steels perform excellently in roll forming. Car bumpers, for example, are roll formed from Docol 1400 DP steel.

BENEFICIAL TO THE ENVIRONMENT

Using Docol UHS steels offers many environmental benefits. If the weight of a product is lowered, less material will be needed and energy will be saved in production.

Less energy will also be needed for transporting the steel.

If Docol UHS steel is used for reducing the weight of a vehicle, the energy consumption and exhaust emissions of the vehicle will also be reduced.

Docol UHS steel is hardened while it is being produced. This eliminates the costs of heating the heat treatment furnaces and the environmental risks associated with such furnaces. Moreover, steel is fully recyclable in existing systems.

MANY APPLICATIONS

Their high strength makes Docol UHS steels suitable for many applications in the automotive industry, particularly for safety parts.

The automotive industry uses Docol UHS steels for components such as side impact beams, bumpers, seats and other parts that demand the highest possible strength, least possible weight and high energy absorption capacity.

Docol UHS steels are also used in applications demanding high resistance to impact, shocks and abrasion, such as theftproofing cases for computers, and conveyor belts. For further application examples, see the next spread.

Advanced steels for many applications

Docol UHS steels are high-tech steels with advanced properties.

But this does not confine the use of Docol UHS steels to advanced applications.

On the contrary, you can use Docol UHS steels even for your simplest products.

Changing over to Docol UHS steels is simple, since they can be formed and worked in the same way as the materials you are now using, with the same processes and the same equipment you are using today.

Docol UHS steels enable you to cut your material and production costs, while achieving a product that is lighter and stronger, and has better environmental properties.

The following illustrations show examples of the use of Docol UHS steels for both simple and advanced parts.

But you probably have the best examples closer to home…

Child seats for cars
Truck load stays
Sill kick-plates
Venetian blinds
Clutch plates
Hedge cutters
Concrete mixers
Springs
Knives
Tubular steel furniture
Tape measures
Train seats
Saw blades
Side impact beams
Boot toe-caps
Chains
Child prams
Car seat rails
Containers
Clips

Docol UHS – grades and sizes

Docol UHS steels combine high strength with excellent drawability.

The steels are supplied with guaranteed minimum tensile strengths ranging between 800 N/mm^2 and 1400 N/mm^2.

An appreciably higher yield strength of the finished part can be achieved by utilising the work-hardening and bake-hardening properties of the steels.

DP AND DL STEELS

The Docol UHS group of steels includes both DP and DL steels.

DP steels have a high ratio of yield strength to tensile strength, which means that they have good ability to distribute the strain experienced during working.

DL steels are produced so that the difference between yield strength and tensile strength is greater than in DP steels. As a result, DL steels have even better formability than DP steels.

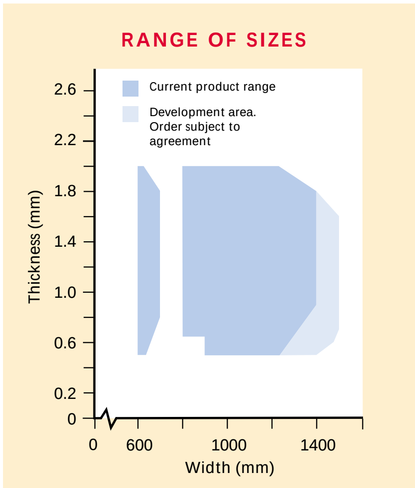
The numbers in the steel designation specify the minimum tensile strength. The difference between yield strength and tensile strength is normally high in the as-rolled condition, but is reduced substantially by cold forming.

MECHANICAL PROPERTIES					
Steel grade	**Yield strength $R_{p0.2}$, N/mm², min.-max.**	**Yield strength after bake-hardening, $R_{p2.0}$+BH** min.**	**Tensile strength R_m, N/mm², min.-max.**	**Elongation A_{80} min. %**	**Min recommended bending radius in 90 degree bend**
Docol 800 DP	500–(650)	650	800–950	8	1 x sheet thickness
Docol 800 DL*	390	–	800–950	13	1 x "
Docol 1000 DP	700–(950)	850	1000–1200	5	3 x "
Docol 1000 DL*	550	–	1000–1200	8	3 x "
Docol 1200 DP	950–(1200)	1150	1200–1400	4	4 x "
Docol 1400 DP	1150–(1400)	1350	1400–1600	3	4 x "

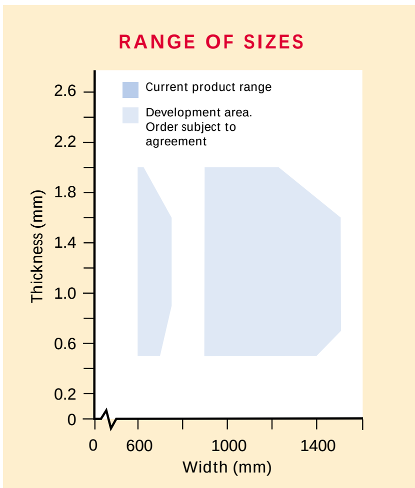
* In the course of development
** BH = bake-hardening after 2% elongation and heating to 170°C for 20 min
( ) = values that are not guaranteed

CHEMICAL COMPOSITION (TYPICAL VALUES)							
Steel grade	**C**	**Si**	**Mn**	**P**	**S**	**Nb**	**Al tot**
Docol 800 DP	0.12	0.20	1.50	0.015	0.002	0.015	0.04
Docol 800 DL*	0.14	0.20	1.70	0.015	0.002	0.015	0.04
Docol 1000 DP	0.15	0.50	1.50	0.015	0.002	0.015	0.04
Docol 1000 DL*	0.15	0.50	1.50	0.015	0.002	0.015	0.04
Docol 1200 DP	0.12	0.20	1.60	0.015	0.002	0.015	0.04
Docol 1400 DP	0.17	0.50	1.60	0.015	0.002	0.015	0.04

* In the course of development

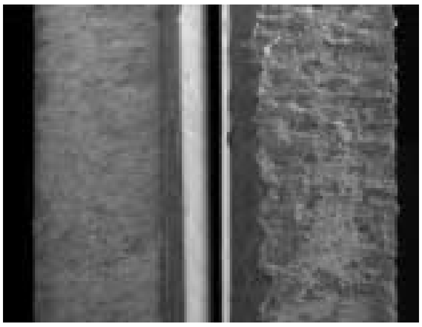


Docol 800 DP and Docol 1000 DP



Docol 800 DL, Docol 1000 DL, Docol 1200 DP and Docol 1400 DP

Technical properties



10% of sheet thickness 6% of sheet thickness

Significance of the cutting clearance to the appearance of the cut edge on Docol 1400 DP

Technical properties

SHEARING AND PUNCHING

When a high strength material is sheared, the shearing operation must be adapted to suit the hardness, thickness and shear strength of the steel, and the design, rigidity and wear of the power shears or machine being used.

Correct cutting clearance of the power shear blades is particularly important. Cutting clearance is governed by the sheet thickness, strength of the steel and demands on the appearance of the sheared edge. The thicker the material and the higher the strength, the larger must be the cutting clearance. A cutting clearance of 6% of the sheet thickness is normally used for mild steels and steels of medium strength. A cutting clearance of about 10% of the sheet thickness is recommended for Docol UHS steels. A larger cutting clearance gives a neater cut surface, but a somewhat larger rollover zone.

The cutting force in Newtons can be calculated from the following expression:

$$F = \frac{K_{sk} \cdot t^2}{2 \cdot \tan \eta}$$

where F = cutting force (N)
K_{sk} = cutting strength (e times tensile strength)
η = cutting angle in power shears
t = sheet thickness

The factor e varies with the tensile strength of the material. Mild steels such as DC01 have e = 0.8, while Docol UHS steels have e = 0.6. The necessary cutting force increases with tensile strength. Changing to a steel with a higher strength usually leads to reduced thickness, and the necessary cutting force is thereby substantially reduced. A chamfered punch can reduce the necessary force by up to 50%.

The cutting clearance is very important to wear during punching. A smaller clearance increases the tool wear which means that the tools must be sharpened more often.

LASER CUTTING

Parts made of Docol UHS steel may often have complex geometrical shapes. Laser cutting enables these shapes to be achieved directly in the cutting process, without the need for subsequent machining. Laser cutting is a high-quality cutting process that produces a cut surface of high quality and high dimensional accuracy. To achieve this, strict demands are made on the settings of the cutting equipment and also on the material to be cut. One of the factors that affect the cutting results is the surface of the workpiece material.

RELATIVE THICKNESS

From steel grade / To steel grade	DC01	DC04	Docol 220 BH	Docol 260 BH	Docol 300 BH	Docol 280 YP	Docol 350 YP	Docol 800 DP	Docol 1000 DP	Docol 1200 DP	Docol 1400 DP
DC01	1.00	1.14	1.03	0.95	0.89	0.92	0.82	0.69	0.58	0.50	0.45
DC04	0.88	1.00	0.90	0.83	0.77	0.80	0.72	0.60	0.51	0.44	0.40
Docol 220 BH	1.12	1.12	1.00	0.95	0.90	0.96	0.91	0.65	0.58	0.53	0.49
Docol 260 BH	1.05	1.20	1.09	1.00	0.93	0.96	0.86	0.72	0.61	0.52	0.48
Docol 300 BH	1.13	1.29	1.17	1.07	1.00	1.04	0.93	0.77	0.65	0.56	0.51
Docol 280 YP	1.09	1.25	1.13	1.04	0.97	1.00	0.89	0.75	0.63	0.54	0.49
Docol 350 YP	1.22	1.39	1.26	1.16	1.08	1.12	1.00	0.84	0.71	0.61	0.55
Docol 800 DP	1.46	1.67	1.51	1.39	1.29	1.34	1.20	1.00	0.85	0.73	0.66
Docol 1000 DP	1.73	1.97	1.78	1.64	1.53	1.58	1.41	1.18	1.00	0.86	0.78
Docol 1200 DP	2.01	2.30	2.08	1.91	1.78	1.84	1.65	1.38	1.16	1.00	0.91
Docol 1400 DP	2.21	2.53	2.29	2.10	1.96	2.03	1.81	1.52	1.28	1.10	1.00

RELATIVE CUTTING FORCE

From steel grade / To steel grade	DC01	DC04	Docol 220 BH	Docol 260 BH	Docol 300 BH	Docol 280 YP	Docol 350 YP	Docol 800 DP	Docol 1000 DP	Docol 1200 DP	Docol 1400 DP
DC01	1.00	1.31	1.35	1.27	1.22	1.15	1.02	1.04	0.93	0.82	0.79
DC04	0.77	1.00	1.03	0.97	0.93	0.88	0.78	0.80	0.71	0.63	0.61
Docol 220 BH	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.75
Docol 260 BH	0.79	1.03	1.06	1.00	0.96	0.90	0.80	0.82	0.73	0.65	0.62
Docol 300 BH	0.82	1.07	1.10	1.04	1.00	0.94	0.84	0.86	0.77	0.68	0.65
Docol 280 YP	0.87	1.14	1.17	1.11	1.06	1.00	0.89	0.91	0.81	0.72	0.69
Docol 350 YP	0.98	1.28	1.32	1.25	1.20	1.13	1.00	1.02	0.91	0.81	0.78
Docol 800 DP	0.96	1.25	1.29	1.22	1.17	1.10	0.98	1.00	0.89	0.79	0.76
Docol 1000 DP	1.07	1.40	1.44	1.36	1.31	1.23	1.09	1.12	1.00	0.88	0.85
Docol 1200 DP	1.21	1.58	1.63	1.54	1.48	1.39	1.24	1.27	1.13	1.00	0.96
Docol 1400 DP	1.26	1.64	1.69	1.60	1.53	1.45	1.28	1.31	1.17	1.04	1.00

Using the table: On changing from DC04, for example, to Docol 800 DP, the thickness can be reduced by 60% of the original thickness. As a result, the cutting force will be 80% of that necessary for cutting the DC04 material.

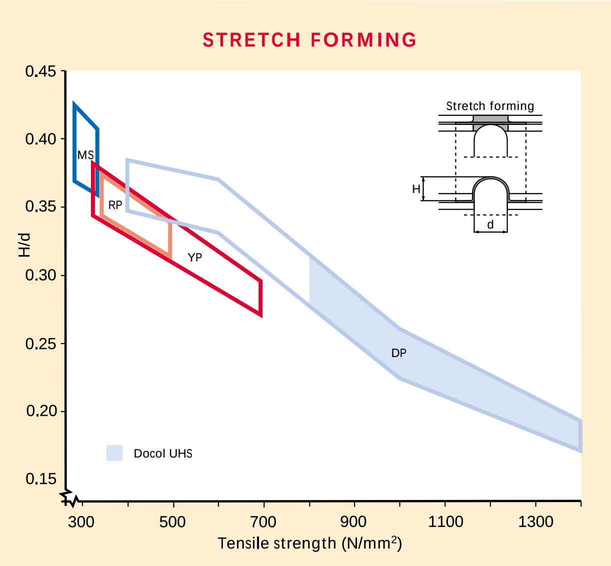
Surface

The cleanliness of the sheet surface is one of the most important factors for achieving high quality of the cut surface, i.e. small angular deviation (conicity μ) and a smooth surface of the cut (Rz). A clean surface produces the best cutting properties as regards both cut quality and production economy.

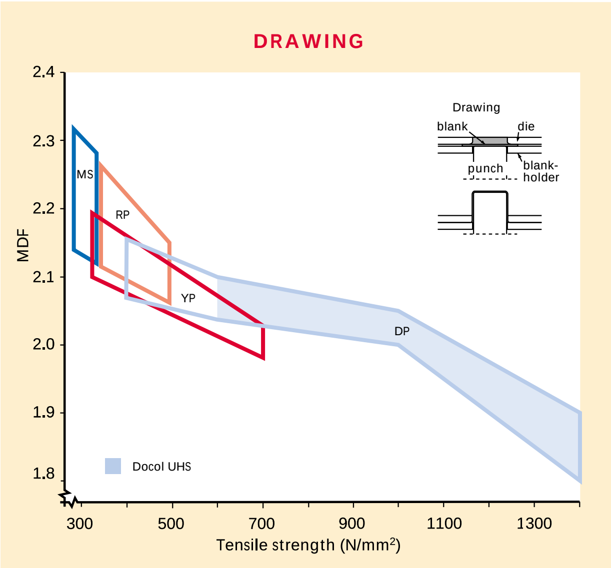
Test results

Cutting by laser has grown in popularity as a cutting method in recent years. SSAB Tunnplåt has therefore undertaken studies of the laser cutting properties of Docol UHS steels, both through our own research and by gathering the experience accumulated in companies that employ laser cutting. The results of these studies can be summarized as follows:

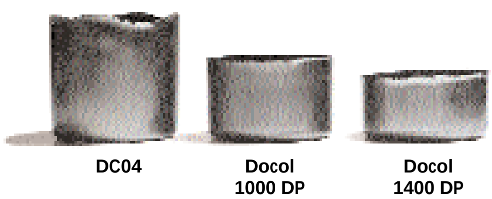
- No special cutting parameters are needed for Docol UHS steels.
- Docol UHS steels conform to the standard for the highest class in accordance with DIN 2310, part 5, for laser cut edges. This applies to both surface smoothness and conicity.
- Docol UHS steels contain no macro-inclusions that could have a detrimental impact on the cutting results.
- Hardness changes occur only in a narrow zone nearest to the cut edge. The heat affected zone from laser cutting is narrow. The zone is so close to the edge and is so narrow that it will be eliminated by the subsequent welding operation.



Stretch-formability, H/d, as a function of the tensile strength of mild steels (MS) and Docol YP, RP and DP steels. The figure shows the good stretch-formability of Docol UHS steels.



Limiting Drawing Ratio (LDR) as a function of the tensile strength of mild steels (MS) and of Docol YP, RP and DP steels. The figure shows the good drawability of Docol UHS steels.



The figure shows the good drawability of Docol UHS steels.

FORMING

In spite of their high hardness, Docol UHS steels have good formability and can be formed in the traditional way. The somewhat poorer formability compared to mild steels can almost always be compensated by modifying the design of the component.

Stretch forming

In stretch forming, the material is clamped by the blankholder, and all plastic deformation occurs over the punch. The material is subjected to a biaxial strain, which results in a thickness reduction. Failure will occur if local deformation is excessive. The stretch-forming properties depend mainly on the capability of the material to redistribute strain.

There is a close relationship between the stretch-forming properties of the material and its work-hardening properties, i.e. the greater the work-hardening of the material, the better the distribution of strains and thus the better the stretch-forming properties.

Since Docol UHS steels undergo high work-hardening, the material also has better stretch-forming properties than other steels of comparable strength.

Drawing

Drawing is characterized by the whole of the blank or most of it being forced through the die and the blankholder pressure being set so that wrinkling will be prevented.

The ability of the material to withstand drawing is determined principally by two factors:

- Ability of the material to deform plastically in the plane of the sheet, i.e. how easily the flange material flows and changes over into side-wall material during drawing.
- The side wall material must be able to withstand plastic deformation in the thickness direction, so that the risk of failure will thereby be reduced.

The drawability of Docol UHS steels is as good as, or somewhat better than, that of other steels of comparable strength.

Flanging

The ratio of hole diameter after and before flanging is known as the flanging ratio.

The blanks should be positioned so that the shearing burr faces towards the punch. This is because the outer fibres of the material sustain the heaviest deformation and because cold working during shearing lowers the ductility of the cut edge.

Since the outer fibre of a thin material deforms less than that of a thick material, a thinner material can withstand a higher flanging ratio than a thicker material at the same inside diameter of the flanged hole.

To achieve the best results in flanging operations on Docol UHS steel, a larger foot radius (1.5–2 t) is recommended than that used for mild steels. In practice, a larger clearance is used between the punch and die.

Bending

In bending, a bending moment is applied to the sheet, and the outside of the sheet then experiences tensile strain while the inside undergoes compression. The bendability decreases with increasing strength. The difference in the bendability of Docol UHS steels along and across the direction of rolling is relatively large. The right punch radius combined with the right die opening is therefore particularly important in bending Docol UHS steels.

Result from a research on bendability for Docol UHS, thickness 1.5 mm. For safety reasons we recommend that the bending operation is done with the minimum inner radius shown in the table on page 9.

BENDABILITY ACROSS THE DIRECTION OF ROLLING. 1.5 MM THICK SHEET

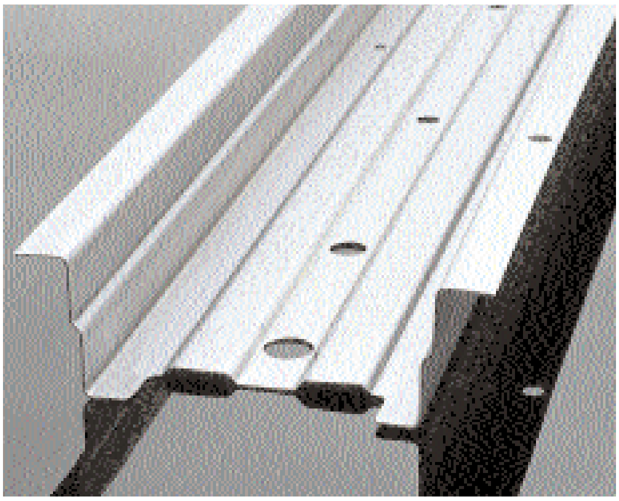
Punch radius. R (mm)	R/t	Die opening width. W (mm)	W/t	Docol 800 DP	Docol 1000 DP	Docol 1200 DP	Docol 1400 DP
1	0.67	9	6.0	Satisfactory	Satisfactory	Local contraction/cracks	Local contraction/cracks
1		12	8.1	Satisfactory	Satisfactory	Local contraction/cracks	Local contraction/cracks
1		16	10.8	Satisfactory	Satisfactory	Local contraction/cracks	Local contraction/cracks
1		24	16.2	Satisfactory	Satisfactory	Local contraction/cracks	Local contraction/cracks
3	2.00	12	8.1	Satisfactory	Satisfactory	Local contraction/cracks	Local contraction/cracks
3		16	10.8	Satisfactory	Satisfactory	Local contraction/cracks	Local contraction/cracks
3		24	16.2	Satisfactory	Satisfactory	Local contraction/cracks	Local contraction/cracks
5	3.33	12	8.1	Satisfactory	Satisfactory	Satisfactory	Satisfactory
5		16	10.8	Satisfactory	Satisfactory	Satisfactory	Satisfactory
5		24	16.2	Satisfactory	Satisfactory	Satisfactory	Satisfactory

Satisfactory   Local contraction/cracks   t = thickness

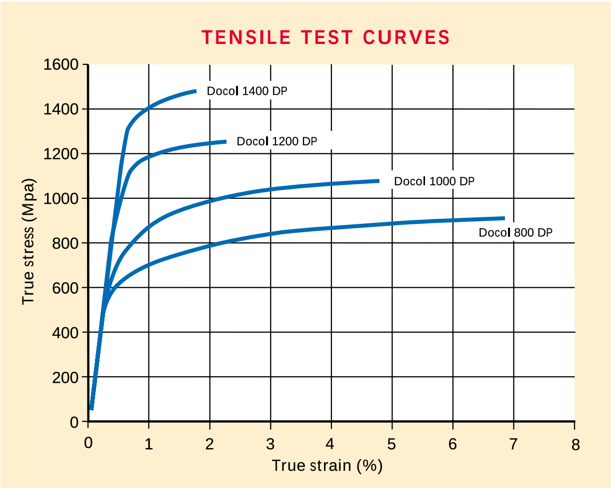
BENDABILITY ALONG THE DIRECTION OF ROLLING. 1.5 MM THICK SHEET

Punch radius. R (mm)	R/t	Die opening width. W (mm)	W/t	Docol 800 DP	Docol 1000 DP	Docol 1200 DP	Docol 1400 DP
1	0.67	9	6.0	Local contraction/cracks	Local contraction/cracks	Local contraction/cracks	Local contraction/cracks
1		12	8.1	Satisfactory	Local contraction/cracks	Local contraction/cracks	Local contraction/cracks
1		16	10.8	Satisfactory	Local contraction/cracks	Local contraction/cracks	Local contraction/cracks
1		24	16.2	Satisfactory	Satisfactory	Local contraction/cracks	Local contraction/cracks
3	2.00	12	8.1	Satisfactory	Local contraction/cracks	Local contraction/cracks	Local contraction/cracks
3		16	10.8	Satisfactory	Satisfactory	Local contraction/cracks	Local contraction/cracks
3		24	16.2	Satisfactory	Satisfactory	Local contraction/cracks	Local contraction/cracks
5	3.33	12	8.1	Satisfactory	Satisfactory	Satisfactory	Satisfactory
5		16	10.8	Satisfactory	Satisfactory	Satisfactory	Satisfactory
5		24	16.2	Satisfactory	Satisfactory	Satisfactory	Satisfactory

Satisfactory   Local contraction/cracks   t = thickness



Beam for Volvo truck in Docol 800 DP, thickness 1.25 mm.



Roll forming

Roll forming is a method of forming that is well suited for Docol UHS steels. The process is less demanding on the material than pressbrake bending, and therefore enables profiles of complicated cross-sections and tight radii to be produced.

Roll forming can be combined with simultaneous or subsequent operations such as punching, welding and bending.

Due to the high strength of Docol UHS steel, its springback is larger than that of mild steels, and this also applies to roll forming. If used for Docol UHS steels, a production line originally intended for a soft material must therefore generally be adapted to suit the higher strength of Docol UHS steels.

Tensile test curves

Curves from conventional tensile testing are usable for various types of Finite Element Method (FEM) analysis, e.g. calculations for the load-carrying capacity or energy absorption of a part being designed. In true stress/strain curves, the stress and strain levels are compensated for the reduction in area during testing. Steel of a higher strength will have a higher level of stress for a given strain.

Forming limit curves

The forming limit curve (FLC) shows the amount of deformation that the material can sustain at a certain deformation path or a certain deformation condition.

The FLC can be used for documentation or as an aid in solving difficult pressing operations.

A chequered pattern is etched on the sample material, which is then pressed. The change in size is measured in two directions, i.e. that which is biggest, designated e-max, and that right angles to this direction, designated e-min.

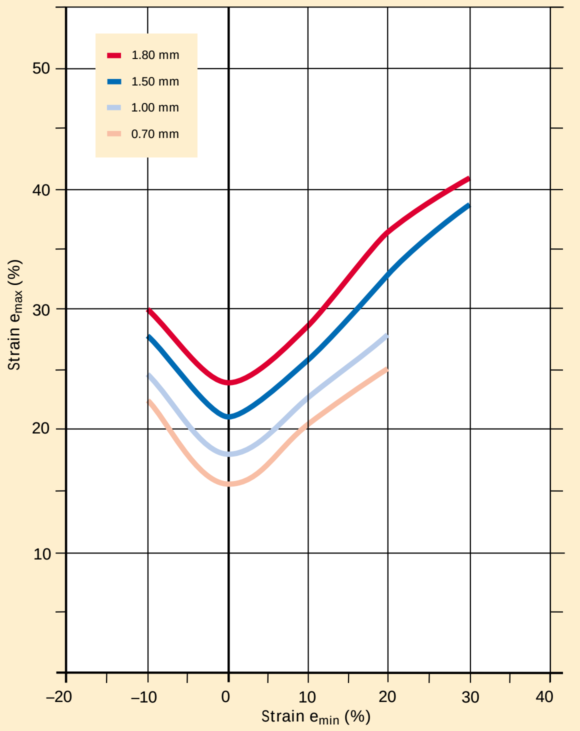
If a positive change has occurred in both directions, the process is stretch forming, which is plotted to the right of the zero line in the FLC graph.

The values that have a negative e-min and a positive e-max are plotted to the left of the zero line, which denotes a drawing process.

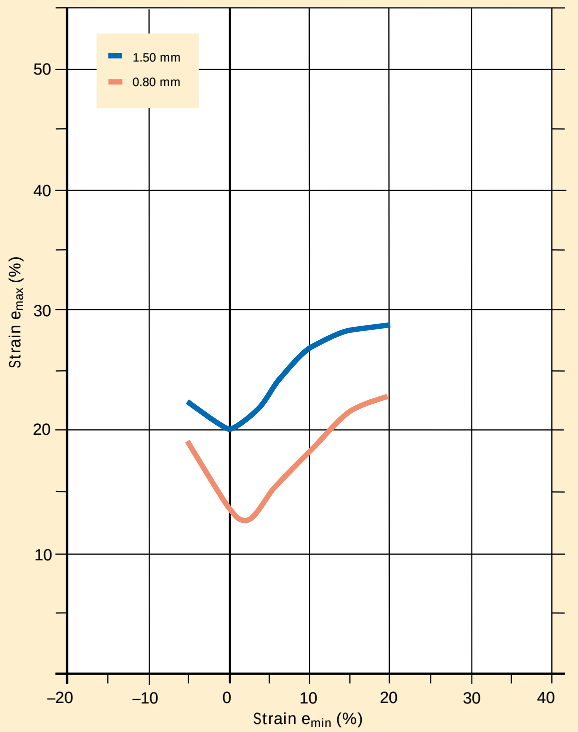
The curves are dependent on the thickness of the material, and must therefore be recalculated to the relevant thicknesses. The results for a given pressing operation are plotted in the graph and are compared with the material curve. If the result is below the curve, the relevant material can withstand the deformation.

FORMING LIMIT CURVES (FLC) FOR DOCOL UHS TRUE STRAIN

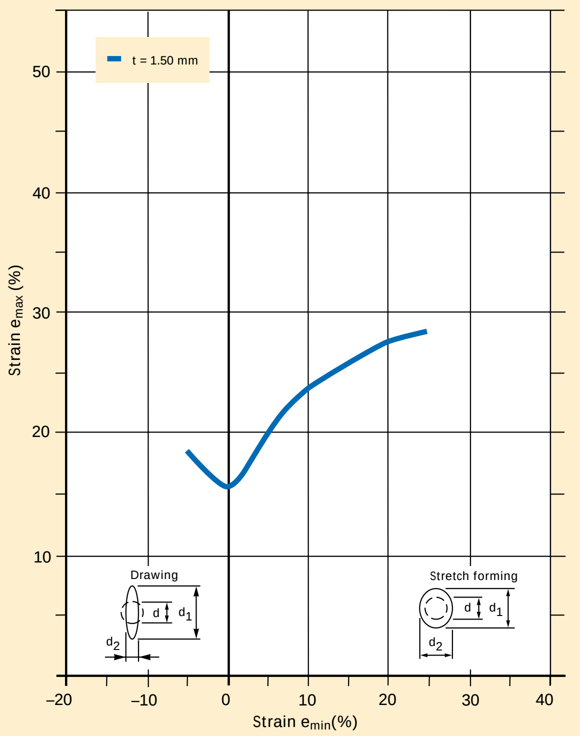
DOCOL 800 DP



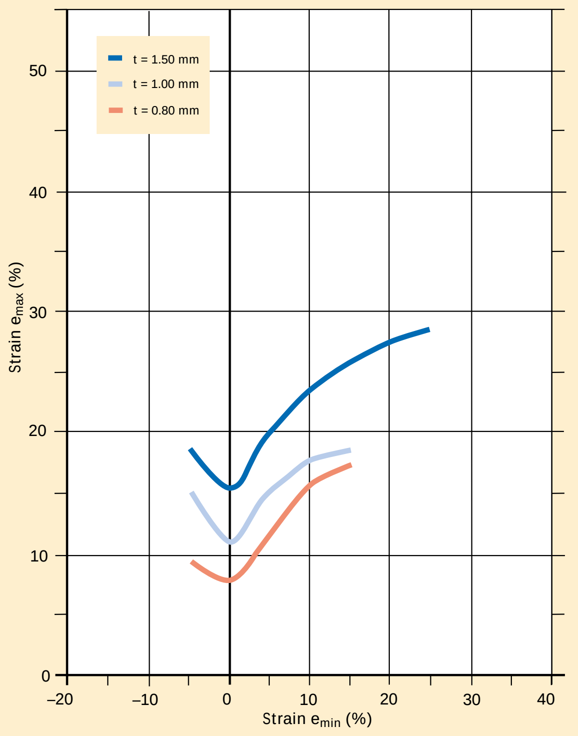
DOCOL 1000 DP

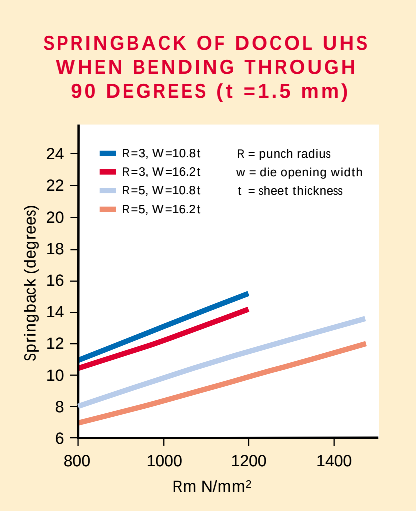


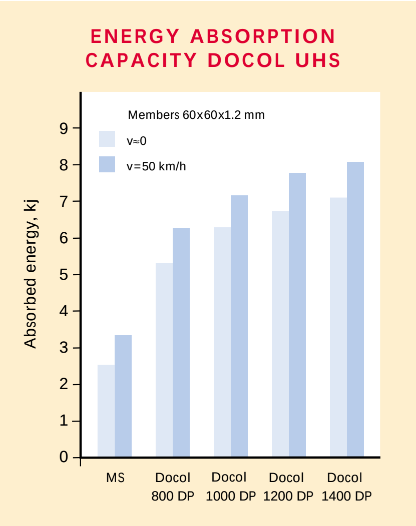
DOCOL 1200 DP



DOCOL 1400 DP







The bar chart above shows the energy absorption of a member 60x60x1.2 mm at two different rates.

Springback

The springback will increase on change-over from mild steel to a steel of a higher strength. Springback is affected not only by the strength of the material, but also by the tooling used. An increase in strength, punch radius or die opening width will cause increased springback. A decrease in thickness will also increase springback for a given radius.

Springback can be compensated by increasing the plastic deformation of the material at the bend. This can be done by over-bending of the material or by reducing the punch radius or die opening width. It can also be reduced by the introduction of stiffeners.

ENERGY ABSORPTION

The energy absorption capacity of various safety components of cars is dependent on the strength of the steel used for the component. As a result, the sheet thickness of components such as axially loaded side beams and door impact beams can be substantially reduced by using Docol UHS steel instead of mild steel.

As a rule of thumb, the weight can be reduced by 30–40 percent if Docol 1000 DP is used, and by 40–50 percent if Docol 1400 DP is used instead of mild steel in energy-absorbing components.

The cross-sectional geometry, the sheet thickness and the strength of the steel are the factors that affect the energy absorption capacity of the component.

The mechanical properties of the steel are improved by high rates of deformation. As a result, the energy absorption capacity increases in an actual crash situation.

The energy absorption capacity of a component can be estimated by means of FEM analysis. Various combinations of materials and geometry can be simulated before the prototype is produced.

One way of measuring the energy absorption capacity of finished car door beams is by means of a static three-point bending test. The force is measured as a function of the deformation up to a predetermined deformation value, and the energy can then be calculated.

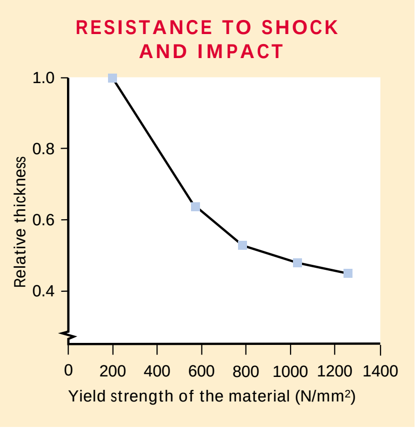
AGEING

Docol UHS steel does not age, which is due to the structure of the material. This type of steel consists of two phases, one of which is hard (martensite) and other is soft (ferrite).

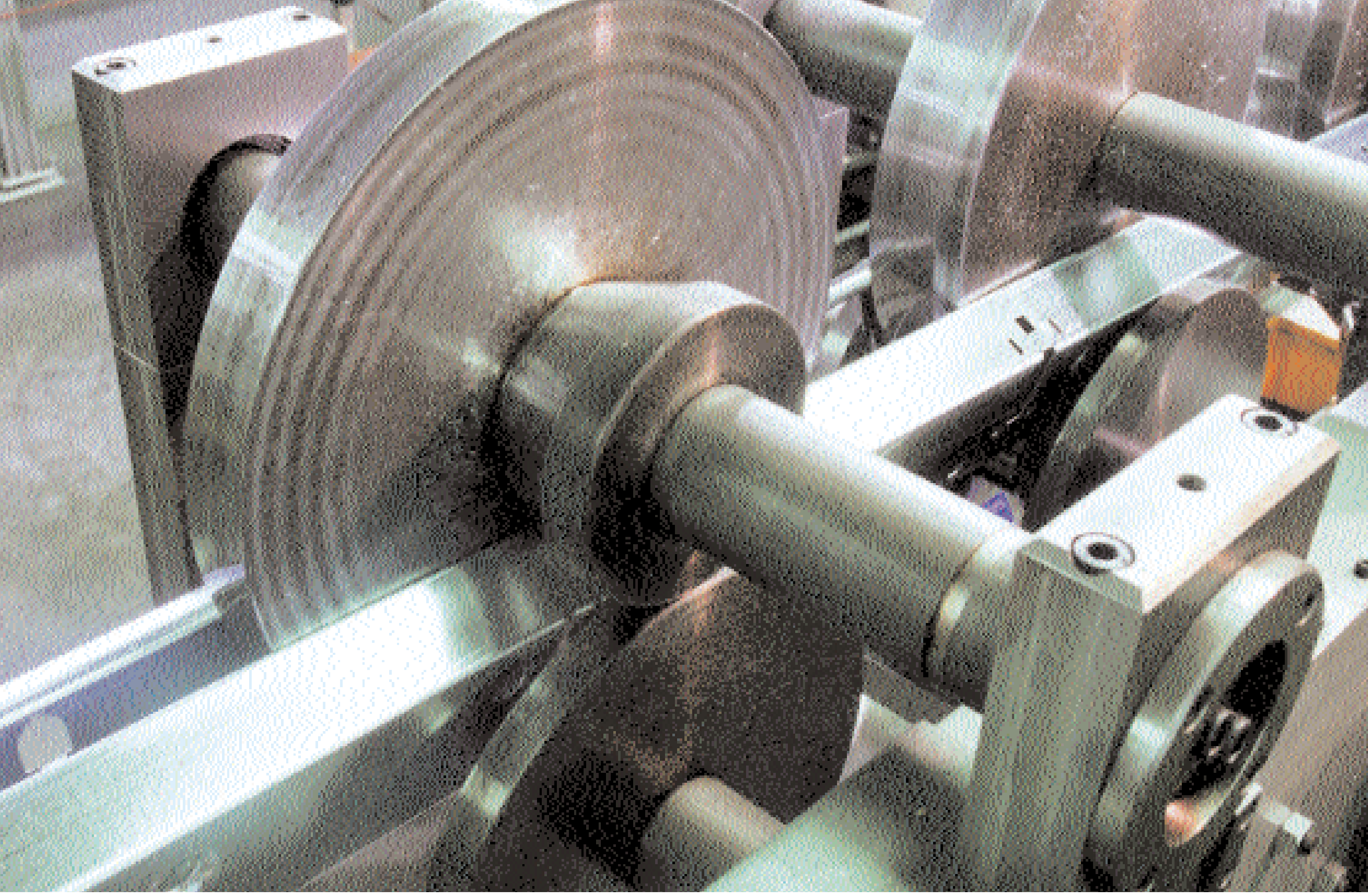
The difference in hardness between these two phases counteracts the occurrence of normal ageing phenomena, such as increase in the yield strength and restoration of the yield point extension after storage under normal temperature conditions.

RESISTANCE TO SHOCKS AND IMPACT

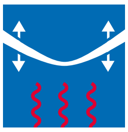
Large areas of steel sheet subjected to shock and impact incur serious risk of permanent deformation. The roof of a car, for example, must be able to withstand moderate shock and impact load without permanent deformation. The yield strength of the material determines the resistance of the sheet area to impact. The figure shows the relative thickness at which Docol UHS steel has equivalent or the same shock and impact resistance as a mild steel (yield strength of 220 N/mm²), i.e. indirectly how much material can be saved by changing over to Docol UHS steels.



The increased springback of Docol UHS steels can be put to use for improving a product. The theft-proofing case for computers is made of Docol 1000 DP and Docol 1400 DP. In addition to being much more difficult to saw than a mild steel, the springback of Docol UHS steel makes the case much more difficult to prise open. It snaps back like a mousetrap.



WORK-HARDENING AND BAKE-HARDENING



A substantial increase in yield strength can be achieved by utilising the work-hardening and bake-hardening properties of Docol UHS steels.

The work-hardening caused by a strain of 2% can increase the yield strength of Docol UHS steels by more than 100 N/mm^2. Work-hardening is highly dependent on the amount of deformation and on the steel type.

The degree of work-hardening is of greater importance to the total yield strength increase of Docol UHS steel than the heat treatment time and temperature.

Work-hardening of 10% increases the yield strength of Docol 800 DP by around 400 N/mm^2.

Bake-hardening by soaking the material at 170°C for 20 minutes increases the yield strength by a further 30 N/mm^2 or thereabouts.

Pressing and painting

Whenever steel sheet parts are pressed and then painted, the work-hardening and bake-hardening properties of Docol UHS steels can be put to good use.

Work-hardening occurs during pressing, and bake-hardening takes place when the paint is being cured, if the curing is done at elevated temperature.

Tube forming and roll forming

Tube forming and other roll forming are typical operations in which the work-hardening properties of Docol UHS steels can be put to good use.

Controlled deformation of the material takes place in these operations, which leads to an increase in the yield strength and tensile strength of the finished part.

Since the magnitude of the deformation is known and controlled, the strength increase can be used in the design of the finished part.

If the finished parts are heat treated, e.g. in conjunction with surface treatment, a further increase in strength can be expected.

Sizing

Work-hardening and bake-hardening can always be put to full use in static design.

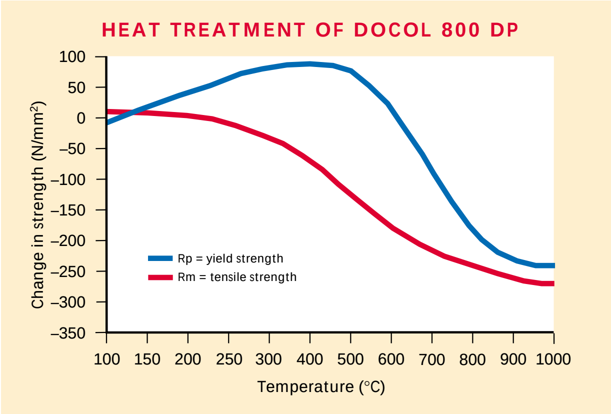
The increase in yield strength can normally also be put to use in designing for fatigue.

HEAT TREATMENT

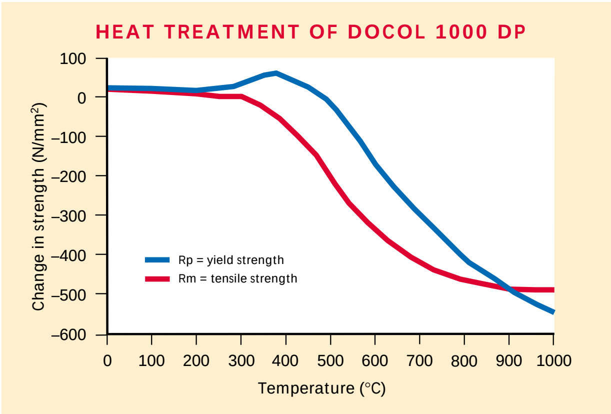
300°

Docol 800 DP and Docol 1000 DP can be heated up to 300°C without their strength properties being impaired. If the steel is heated beyond this point, its strength will gradually decline with increasing temperature.

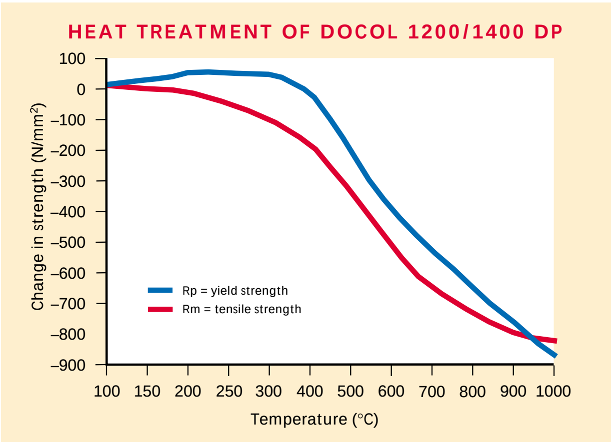
Docol 1200 DP and Docol 1400 DP can be heated at temperatures of up to about 200°C, but their strength properties will be impaired. If heated to above 200°C, the strengths of these steels will decrease by more than those of Docol 800 DP and Docol 1000 DP.



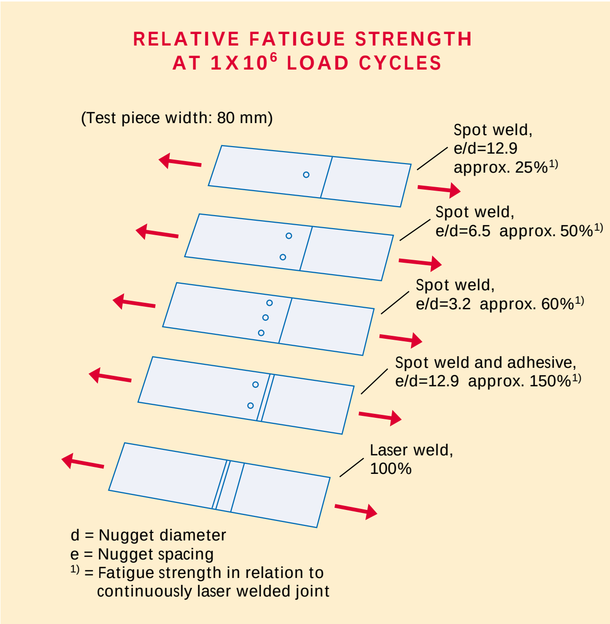
The graph shows how the strength of Docol 800 DP is changed by heating



The graph shows how the strength of Docol 1000 DP is changed by heating



The graph shows how the strengths of Docol 1200 DP and Docol 1400 DP are changed by heating



FATIGUE

Careful analysis of the fatigue load, i.e. the form and number of loading cycles of the load spectrum, together with good design, e.g. low stress-raiser effect in joints, serve as a basis for good material utilization in high strength steels.

Assuming constant maximum load amplitude, substantial over-design would result, since real-life components are usually subjected to loads of varying amplitude (narrow spectrum load). The milder the load spectrum and the fewer the number of loading cycles, the more beneficial it will be to use high strength steels, even in welded structures.

Good design:

- use the stressed skin action wherever possible
- ensure uniform load distribution throughout the structure
- avoid sudden stiffness changes or abrupt changes in cross-section
- load application is often critical – design with care
- ensure that welded joints are correctly located and designed
- accumulation of stress raisers must be avoided in all structures
- ensure that the weld quality is good (actual production quality must be kept under control)

For thin sheets of materials such as Docol UHS steel, a typical good design will include:

- using reinforcements (such as flutes and edge reinforcements) in order to counteract buckling and thus improve the material utilization
- using reinforcements to prevent local bending of the sheet, e.g. at load application points
- increasing the spot-weld nugget diameters and reducing the spacing of the spot welds in order to lower the stress in the weld and thus raise the fatigue strength of the entire structure
- using spot welds in combination with bonded joints (weld-bonding) in order to increase the fatigue strength
- using laser welded joints, since these have much higher fatigue strength than spot welds.

WELDING OF DOCOL UHS

Docol UHS steels are normally welded to mild steel sheet (welding of hard to soft). Docol UHS steels are sometimes also welded to similar steels (welding of hard to hard), such as different types of enclosed profiles.

All conventional welding methods can be used for Docol UHS

Docol UHS steels can be welded using all of the common welding methods, such as spot welding, MAG welding, laser welding or high frequency welding.

Docol UHS steel owes its good weldability to the fact that these steels have very low contents of alloying elements in relation to their high strength, which minimizes the risk of cracking and other defects.

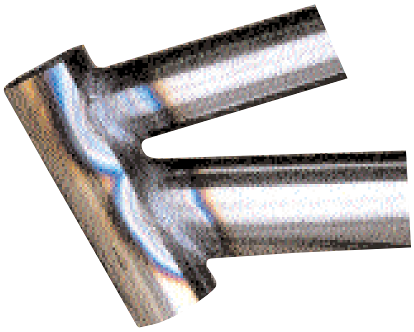
Spot welding

Spot welding is a form of resistance welding, and the method is most commonly used for welding cold reduced, high strength steels.

To enable a steel to be satisfactorily spot welded, it is important that the allowed current range should be sufficiently wide. The range should be at least 1 kA.

Spot welding of Docol UHS steels to mild steels causes no problems. The allowed current range is wide, and full plug failure will be obtained in a peel test (i.e. a plug will be pulled out of one of the sheets during testing). The strength of the weld is the same as that of the mild steel.

When a UHS steel is welded to the same steel (welding of hard to hard), the allowed current range is also wide. On Docol UHS steels of the highest strength, full plug failure during peel testing will not always occur. Failure sometimes occurs partially through the weld, which is known as partial plug failure.



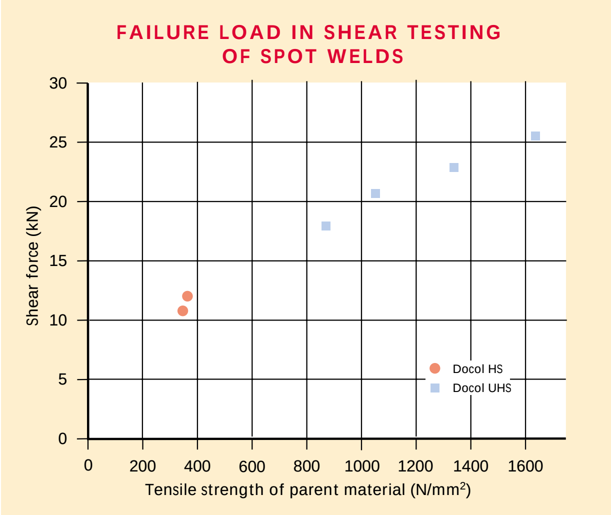
Welded detail in Docol UHS

Typical measured welding current ranges that produce good spot welds in Docol UHS steels are given in the table below. Results are available from welding of hard to soft and hard to hard. The measured current ranges are very wide throughout, i.e. wider than 2.0 kA in all cases.

MEASURED ALLOWED CURRENT RANGES IN SPOT WELDING[3] OF DOCOL UHS

Steel 1	Steel 2	Thickness (steel 1/ steel 2) (mm)	Available welding current[1] Range. (kA)	Available welding current[1] min–max (kA)	Welding data: Electrode diameter (mm)	Welding data: Electrode force (N)	Welding data: Welding time (cycles)	Welding data: Holding time (cycles)	Remarks
Docol 800 DP	Docol 800 DP	1.0/1.0	2.0	6.4–8.4	6	4000	12	10	Hard/hard
Docol 800 DP	Docol 220 DP	1.5/1.5	2.6	5.9–8.5	6	3500	15	10	Hard/soft
Docol 800 DP	Docol 800 DP	1.5/1.5	2.1	5.7–7.8	6	4000	20	10	Hard/hard
Docol 800 DP	DC01	2.0/2.0	3.4	9.9–13.3	9	6300	20	10	Hard/soft
Docol 800 DP	Docol 800 DP	2.0/2.0	3.0	7.8–10.8	9	6300	20	10	Hard/hard
Docol 1000 DP	DC01	0.8/0.8	2.5	5.2–7.7	5	3000	8	10	Hard/soft
Docol 1000 DP	Docol 1000 DP	0.8/0.8	3.0	4.7–7.7	5	3000	11	10	Hard/hard
Docol 1000 DP	Docol 1000 DP	1.5/1.5	2.2	5.8–8.0	6	4500	19	10	Hard/hard
Docol 1000 DP	Dogal 220 RP[2]	2.0/2.0	3.0	7.4–10.4	8	5600	19	10	Hard/soft
Docol 1000 DP	Docol 1000 DP	2.0/2.0	2.4	7.8–10.2	9	6300	20	10	Hard/hard
Docol 1200 DP	DC01	1.5/1.5	2.7	9.4–12.1	8	5000	15	10	Hard/soft
Docol 1200 DP	Docol 1200 DP	1.5/1.5	2.5	6.2–8.7	6	4500	15	10	Hard/hard
Docol 1400 DP	Docol 220 DP	1.5/1.5	2.5	7.5–10.0	8	3500	15	10	Hard/soft
Docol 1400 DP	Docol 1400 DP	1.5/1.5	3.2	8.6–11.8	8	6000	17	10	Hard/hard

1) Minimum value: Current that gives a plug diameter of 70% of electrode diameter. Max. value: Highest current without splash
2) Zinc coated Z140 (10 µm)
3) The spot welds are produced in single-phase AC machines. The measurements are based on cross-tension test.



Failure load in shear testing of spot welds in Docol UHS steels compared to other high strength steels. Plug diameter: approx. 5.5 mm. Sheet thickness: 1.5–1.6 mm.

EXAMPLES OF FILLER METALS FOR DOCOL UHS

Manual metal arc welding (MMA)	Gas metal arc welding (MAG) Solid wire	Manufacturer
OK 75.75	OK Autrod 13.13 OK Autrod 13.29 OK Autrod 13.31	ESAB
Filarc 118		Filarc
P 110 MR	Elgamatic 135	ELGA
Maxeta 110 Tenacito 80	Carbofil NiMoCr Spoolcord TD-T90	Oerlikon

Strengths of spot welds

The shear strengths of spot welds in Docol UHS steels are higher than those of spot welds in steels of lower strengths. This is illustrated by the above graph. The various steels have been welded to the same grades of steels, i.e. hard to hard. This clearly illustrates that the shear strength of the spot welds increases with increasing strength of the steels being welded. The peel strength is lower than the shear strength of the spot welds, and the design should therefore be such that the spot welds are subjected to shear loading. This also enables the higher strength of Docol UHS steels to be put to use.

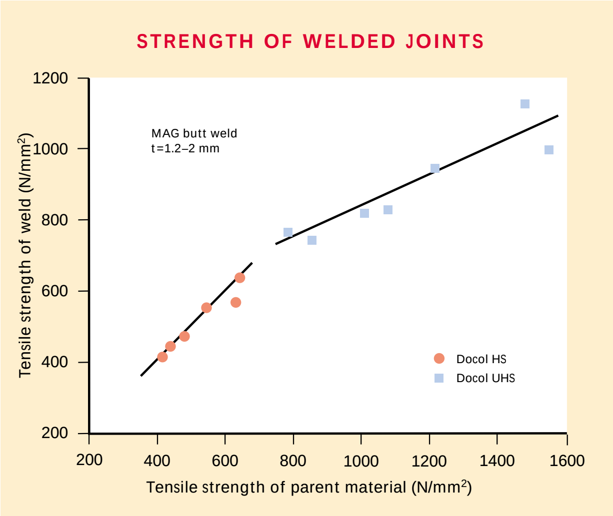
Recommended welding data for spot welding

When Docol UHS steels are spot welded to mild steels, the same welding data as for the mild steel can normally be used. However, the electrode force should be increased by 20–30%. To ensure good welding results when Docol UHS steel is welded to Docol UHS steel (hard to hard), the electrode force should be increased by 40–50% compared to the force used when welding mild steels, and the welding time should also be somewhat longer.

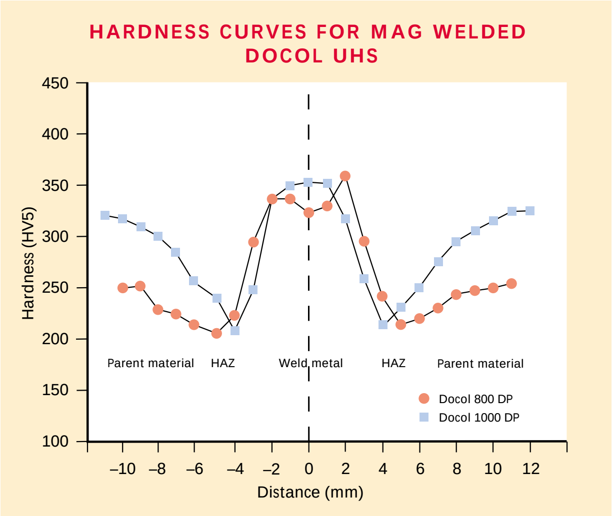
Fusion welding

No problems of cracking or other defects normally occur in ordinary fusion welding of Docol UHS steels, such as MAG, TIG or plasma welding, since the steels have low contents of alloying elements. This applies to welding both to a mild steel and to the same grade of steel.

When welding to a mild steel, the strength of the welded joint will be determined by the softer steel.



Strength of the welded joint in Docol UHS steels compared to other high strength Docol steels (two identical steels welded to one another, loaded across the weld, and weld reinforcement removed).
Welding data: MAG, matching solid wire, one run, mixed shielding gas, heat input of 0.11–0.17 kJ/mm.



Hardness curves for MAG welded Docol UHS (Docol 800 DP, t = 2.0 mm and Docol 1000 DP, t = 2.0 mm). Butt welds, two steels of the same grade welded to one another. Welding data: matching solid wire, mixed shielding gas, one run, heat input of approx. 0.16 kJ/mm.

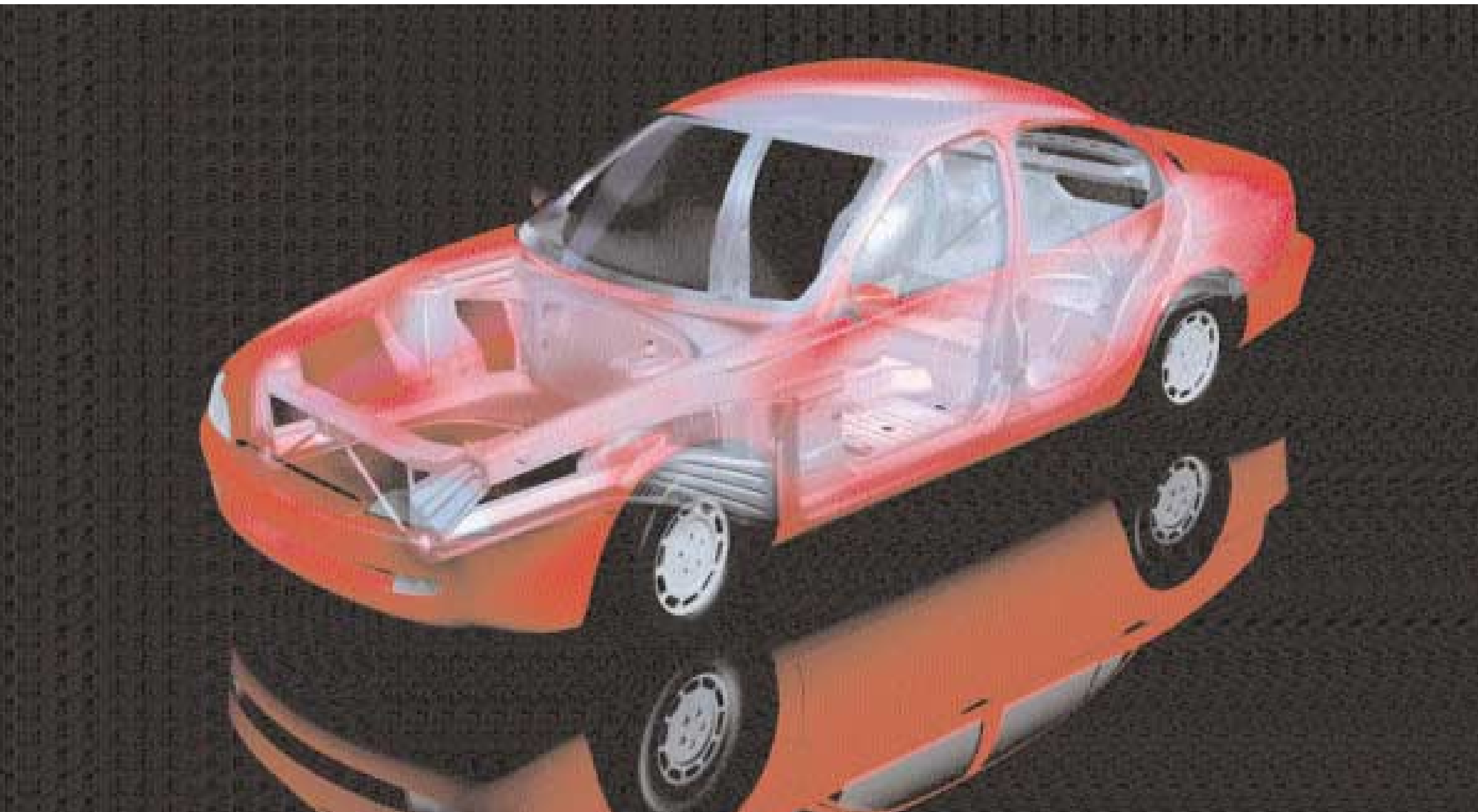
When Docol UHS steel is fusion welded to the same grade of steel, the strength of the welded joint will be much higher than that in other high strength steels.

The above graph shows the results of MAG welding of Docol UHS steel and other high strength steels. This clearly illustrates that Docol UHS steels have a higher strength than the other steels.

However, the strength of the weld in Docol UHS steels does not reach the same level as that of the parent material.

The reason is that soft zones occur adjacent to the weld, and these lower the strength (see the hardness curves in the above graph). The strength is highest for Docol 1400 DP, which also has the highest strength of the parent material.

When MAG welding Docol UHS steels, the same welding parameters can be used as for mild or high strength steels.



Laser welding

Docol UHS steels can be welded by laser both to a mild steel and to a steel of the same grade. From the welding aspect, laser welding of Docol UHS steels is no different from welding of mild steels. One of the benefits of laser welding is that the strength of the weld in Docol UHS steel can be raised compared to ordinary MAG welding.

Laser welded joints in Docol 800 DP and Docol 1000 DP show the same strength as the parent material. It is only on Docol 1200 DP and Docol 1400 DP that the strength of the weld is not quite as high as the strength of the parent material.

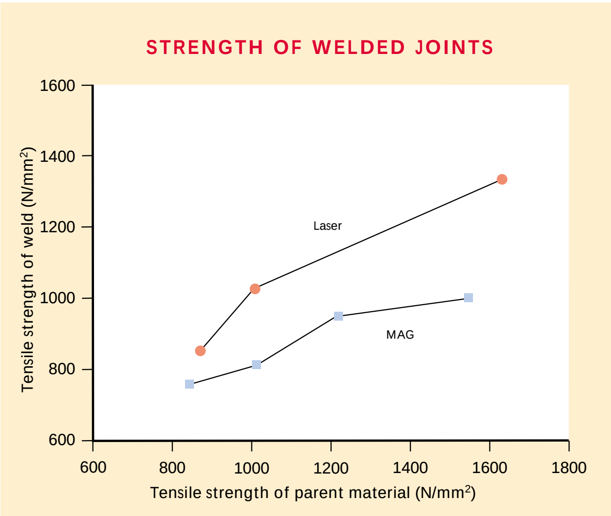
The reason that the strength is higher in laser welding is that the heat input is much lower than in MAG welding, and the material is therefore less affected by heat. The figure below shows hardness curves for laser welded Docol 800 DP and Docol 1000 DP steels. The hardness curves show that the laser welds are narrow and there are basically no soft zones. As a result, the strength of laser welds is higher than that of MAG welds.

High-frequency welding

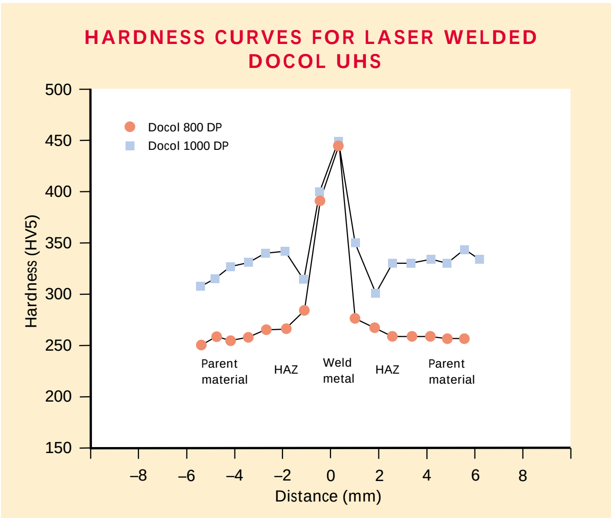
High-frequency welding is a very common and efficient method for welding tubes.

The high-frequency current quickly heats the edges of the sheet to a high temperature. When the edges are then pressed together at high pressure, the molten material will be pressed out and a strong joint will result.

High-frequency welding can be used for welding Docol UHS steels. The strength of the welded joint is determined principally by the properties achieved in the heat affected zone (HAZ).



Strength of the welded joint in Docol UHS. Comparison between MAG and laser welded joints (butt weld, 1.5–2.0 mm sheet thickness, two steels of the same grade welded to one another, loading across the weld).



Hardness curves for laser welded Docol UHS steels (Docol 800 DP, 1.0 mm thick sheet, and Docol 1000 DP, 2.0 mm thick sheet). Butt welds, no filler metal, heat input of about 0.05 kJ/mm.

Safety curtain from Ansa Protection in Docol 1000 DP. The curtain got a citation in Swedish Steel Prize 1999.

SURFACE TREATMENT

Docol UHS steels can be protected against corrosion in the same way as mild steels, i.e. by painting, electro galvanizing, or other types of coatings containing zinc and/or aluminium.

In electro galvanizing, the sensitivity of the steel to hydrogen embrittlement must be taken into account.

Comprehensive studies in laboratory tests and full-scale trials have shown that Docol UHS steels can be electro galvanized without the risk of hydrogen embrittlement. However, many factors could affect the sensitivity of the steel and, for critical applications, such as safety parts, we recommend evaluation in the proposed surface treatment plant.

Hydrogen embrittlement relief treatment after electro galvanizing (see the ISO 2081 standard) also assists in making the material less sensitive to hydrogen embrittlement.

As an alternative, surface treatment that does not generate hydrogen can be used, such as Dacromet (Dacrolit) or Delta MKS. The risk of hydrogen embrittlement will then be entirely eliminated. However, these processes include a curing stage for the surface coating, and the maximum recommended heat treatment temperature for the relevant steel grade must then be taken into account if the steel is to retain its high strength.

Tool steels

TOOL STEELS FOR PUNCHING AND FORMING DOCOL UHS

As in all industrial production, it is important that the forming and shearing operations on steel sheet parts should be trouble-free. The chain from tool design to tool maintenance comprises many stages, as illustrated by the schematic below.

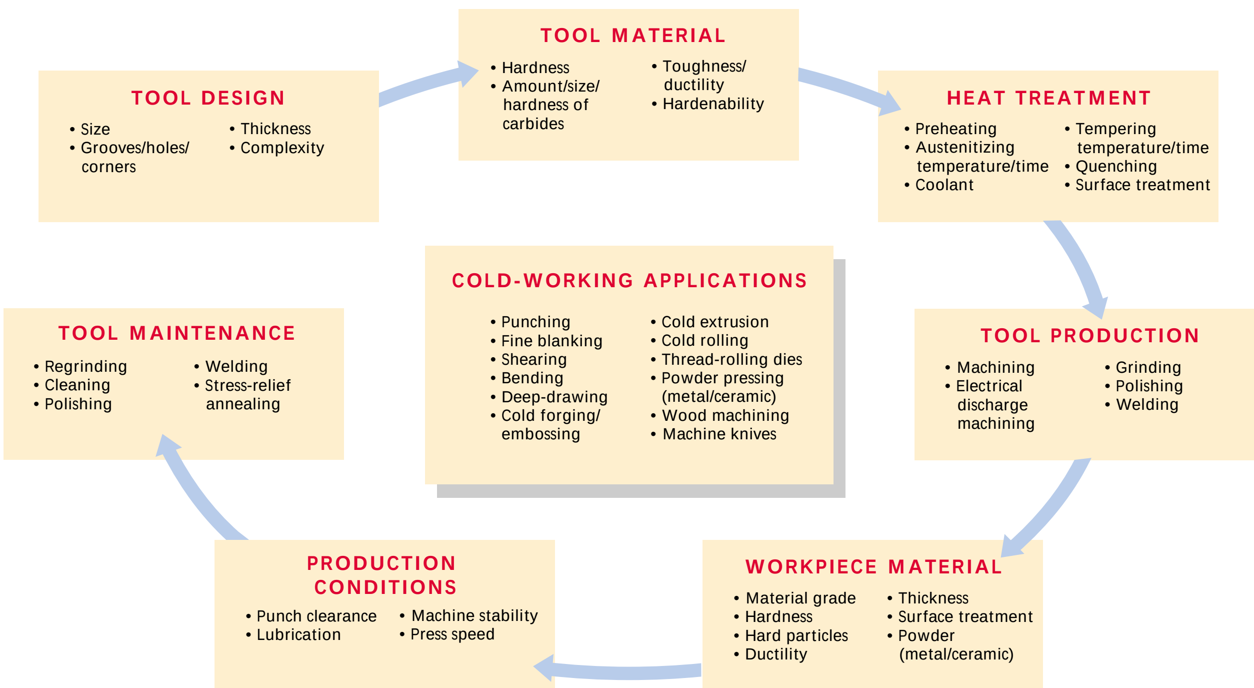
A prerequisite for achieving good productivity and production economy is that all stages are correctly performed. It is therefore vitally important to select the right tool steels for a given cutting or shearing operation.

To be able to select the correct steel, it is important to identify the failure mechanisms that may arise during shearing and/or forming and that may lead to the tool becoming unusable or breaking down after only a short period of use.

There are basically five failure mechanisms that may occur in the active parts of the tool:

- **Wear,** either abrasive or adhesive, associated with the workpiece material, the type of forming operation and the frictional forces in sliding contact.

- **Plastic deformation** occurs in the event of an inappropriate relationship between the stresses and the compressive yield strength (hardness) of the tool material.



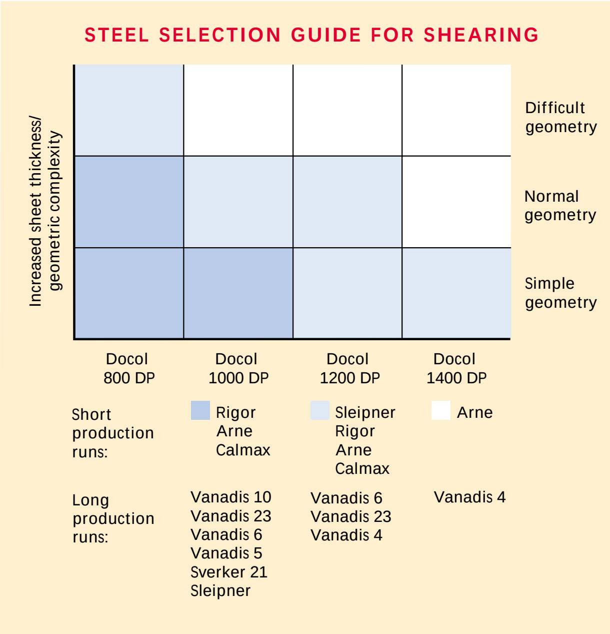
RELATIVE RESISTANCE TO FAILURE MECHANISMS								
Tool steel grade	Standards			Hardness	Wear resistance		Resistance to fatigue	
	SS	ISO	DIN	Plastic deformation	Abrasive	Adhesive	Crack initiation	Crack propagation
							Ductility – resistance to chipping	Toughness – resistance to total breakage
Arne	2140	W.-Nr. 1.2510	AISI O1					
Calmax		W.-Nr. 1.2358						
Rigor	2260	W.-Nr. 1.2363	AISI O2					
Sleipner								
Sverker 21	2310	W.-Nr. 1.2379	AISI D2					
Sverker 3	2312	W.-Nr. 2436	AISI D6					
Vanadis 4								
Vanadis 23		W.-Nr. 1.3344	AISI M3.2					
Vanadis 6								
Vanadis 10								

- **Edge chipping** may occur as a result of an inappropriate match between the stresses and the ductility of the tool material
- **Cracking** may occur as a result of an inappropriate match between the stresses and the toughness of the tool material
- **Pick-up** may occur as a result of an inappropriate match between the workpiece material and the frictional forces occurring on sliding contact. The pick-up mechanism is closely related to adhesive wear.

Plastic deformation, edge chipping and cracking are forms of failure that often result in serious and costly production stoppages. Wear and pick-up are more predictable and can largely be handled by systematic maintenance of the tools. A consequence of this is that it may be worthwhile to allow more wear than to end up with edge chipping or cracking.

The special feature in forming and shearing Docol UHS steels is that, for a given sheet thickness, the forces must be higher than for mild steels, since the higher yield strength must be overcome during forming and the higher shear strength must be exceeded during shearing. This means that the stresses increase and the demands on the wear resistance and strength of the tool material thus also increase. The shearing operation is most sensitive, since it demands a combination of high wear resistance and high resistance to edge chipping/tool breakage, while the forming operation demands only wear resistance.

A relative comparison between cold-working steels from Uddeholm Tooling as regards resistance to these particular damage mechanisms on tools is shown in the above table.



In all cases, the hardness should be at least 58 HRC, since the risk of plastic deformation could otherwise be present.

Compared to other steels, the VANADIS steels have a good combination of wear resistance and resistance to edge chipping. The reason is that the steels are produced by powder metallurgical methods, while others are produced by conventional metallurgical methods. The difference in properties is due mainly to the fact that the powder-metallurgical method produces small, uniformly distributed carbides that protect against abrasion. Moreover, by being small, the carbides are less dangerous as initiation points for fatigue cracks. As opposed to this, conventional steels with good wear resistance have large carbides that are arranged in streaks and that impair the mechanical strength of the material.

STEEL SELECTION GUIDE FOR SHEARING DOCOL UHS

It is difficult to give accurate advice for the selection of tool steels for a specific production situation, since no production system is exactly the same as the next. If possible, a better approach is to try to build on past experience from in-house production in the same mechanical equipment, and gradually improve the choice of steel by comparing the performance of different steels. If the user has no in-house experience, the chart to the left may be used as a guide.

All tool steels in the table on page 27 can be used for the lower strength grades of Docol UHS steels, thinner sheet and simpler geometries, whereas only a few of the steels are usable for the highest strengths grades, mainly due to the risk of early tool breakage caused by edge chipping.

In tool design and production, it is important to avoid sharp corners, small radii and poorly machined surfaces. The high working stresses combined with the high hardness of tool steels give rise to stress concentrations in such areas.

STEEL SELECTION GUIDE FOR FORMING DOCOL UHS

Wear, which is mainly abrasive in nature, is the main damage mechanism in forming operations, although adhesive wear may also occur due to the high frictional forces involved in the forming of Docol UHS steels. Powder steels have the best performance, but no special information other than that included in the failure mechanism table is necessary for selecting tool steels. Due to the fact that ultra high strength steels are not as formable as mild steel , the parts produced cannot be given radii that are as tight as those in mild steel sheet, which is beneficial in the context of tools.

Docol UHS in your design work

High strength is the foremost property of Docol UHS steels. The steels can withstand a high degree of deformation before plastic deformation occurs.

This can be put to use for creating benefits in a wide variety of designs and products.

The new ultra high strengths materials offer scope for designing and manufacturing products with even higher performance, from both cost and competitive viewpoints.

WHEN CAN DOCOL UHS BE OF BENEFIT TO YOU?

When you want to achieve:

!

Weight reduction. Various products, including those that are regarded as “simple”, can often be made lighter and more economical by using Docol UHS steels. Much thinner material is enough to carry the same load as a product made from conventional steels.

!

High energy absorption, e.g. crash protection safety parts for cars. Due to their high strength, Docol UHS steels absorb high amounts of energy while deforming.

!

Resistance to impact and shocks. This is another area where the high yield strength plays the principal role. Docol UHS steels can withstand substantial deformation before permanent dents and dimensional changes occur. As a result, Docol UHS steels are suitable for products that must be able to withstand rough handling or parts that are mounted in exposed areas.

!

Resilience and various snap functions. These can be incorporated directly into products made of Docol UHS steels due to the springback properties of the steels.

!

Reduced local stresses. Docol UHS steels can be used with the aim of manufacturing products that are more elastic and thereby have a longer useful life. In many cases, a resilient structure balances out the force flows better than a rigid structure.

!

High wear resistance. Docol UHS steels have high resistance to abrasion. They are therefore suitable for products that are subjected to abrasive wear.

!

Robust products for which extreme strength is required.

WHAT SHOULD THE DESIGNER BEAR IN MIND?

The high strength of Docol UHS steels offers scope for designing lightweight, thin-wall products. However, bear in mind that the ultimate properties of the product are determined by the geometrical design in combination with the properties of the material.

The ability to carry loads and the stiffness in bending of beams, profiles, etc. are significantly affected by the section height and various reinforcements. Reinforcements such as flutes and folded edges are used for thin steel sheet components, since they reduce the buckling tendency, add rigidity and enable the material to be put to full use.

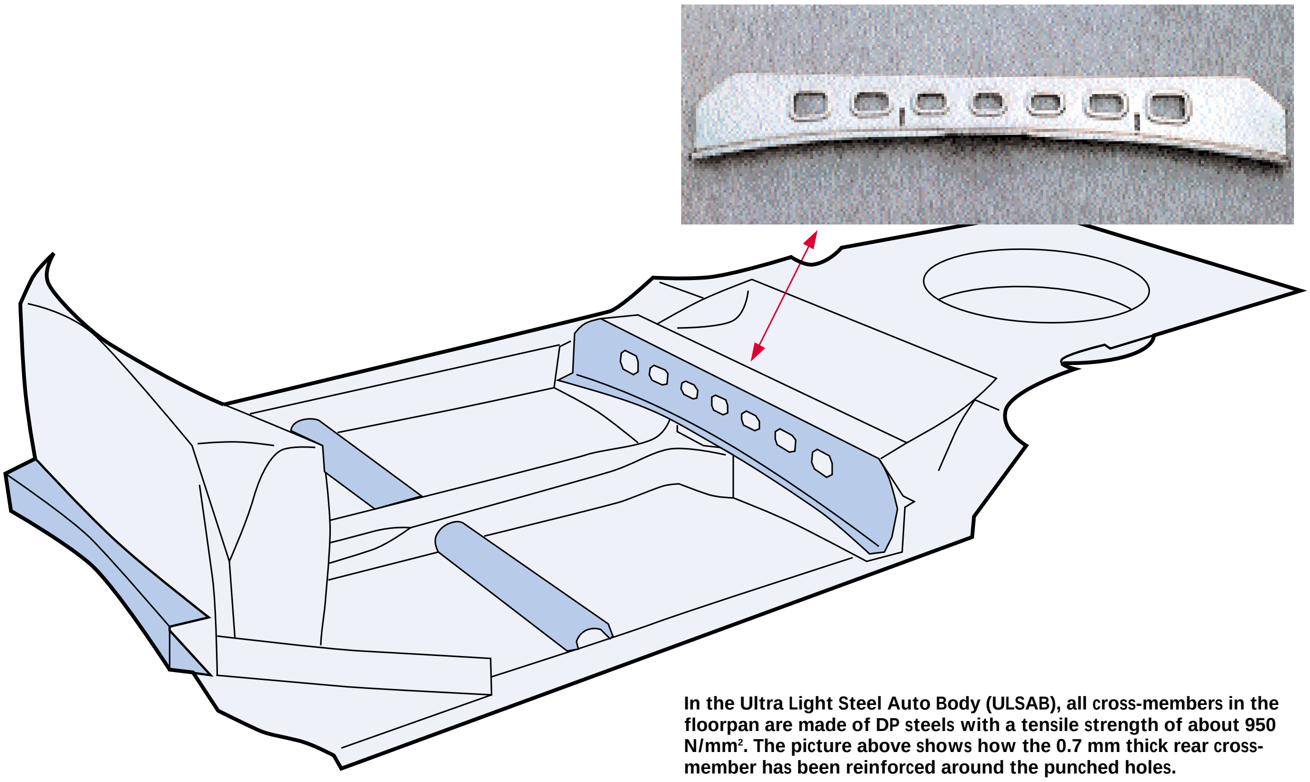
Reinforcements are particularly important in the design of energy-absorbing parts, such as side impact protection beams for car bodies, in which buckling should be avoided, even during plastic deformation.

Flutes and reinforcements can be pressed directly into parts made of Docol UHS steel. The pressability of these materials is good in relation to their high strength. But make sure that edge radii are sufficiently large and the drawing depth is moderate.

Roll forming is particularly well suited for producing profiles in long production runs. In roll forming, flutes and edge folds can be located in suitable areas directly in the forming process. Due to their high yield strengths, Docol UHS steels can be formed in fewer stages during roll forming, without residual stresses being built in.

For forming parts of Docol UHS steel, thought should be given to producing the design so that adequate compensation can be made for springback. This is also important in the design of the forming tools.

Using stressed slice action in designs of steel sheet enables the material to be put to better use. Do your best to avoid structural parts of steel sheet acting as plates with local deflection and consequently high bending stresses.



In the Ultra Light Steel Auto Body (ULSAB), all cross-members in the floorpan are made of DP steels with a tensile strength of about 950 N/mm². The picture above shows how the 0.7 mm thick rear cross-member has been reinforced around the punched holes.

Let us help you put to use the benefits of ultra high strength steels

When changing over to Docol UHS steels, it is important to integrate the material selection, design and production considerations right from the start. The product will then be optimized, and so will production from the technical and economic viewpoints.

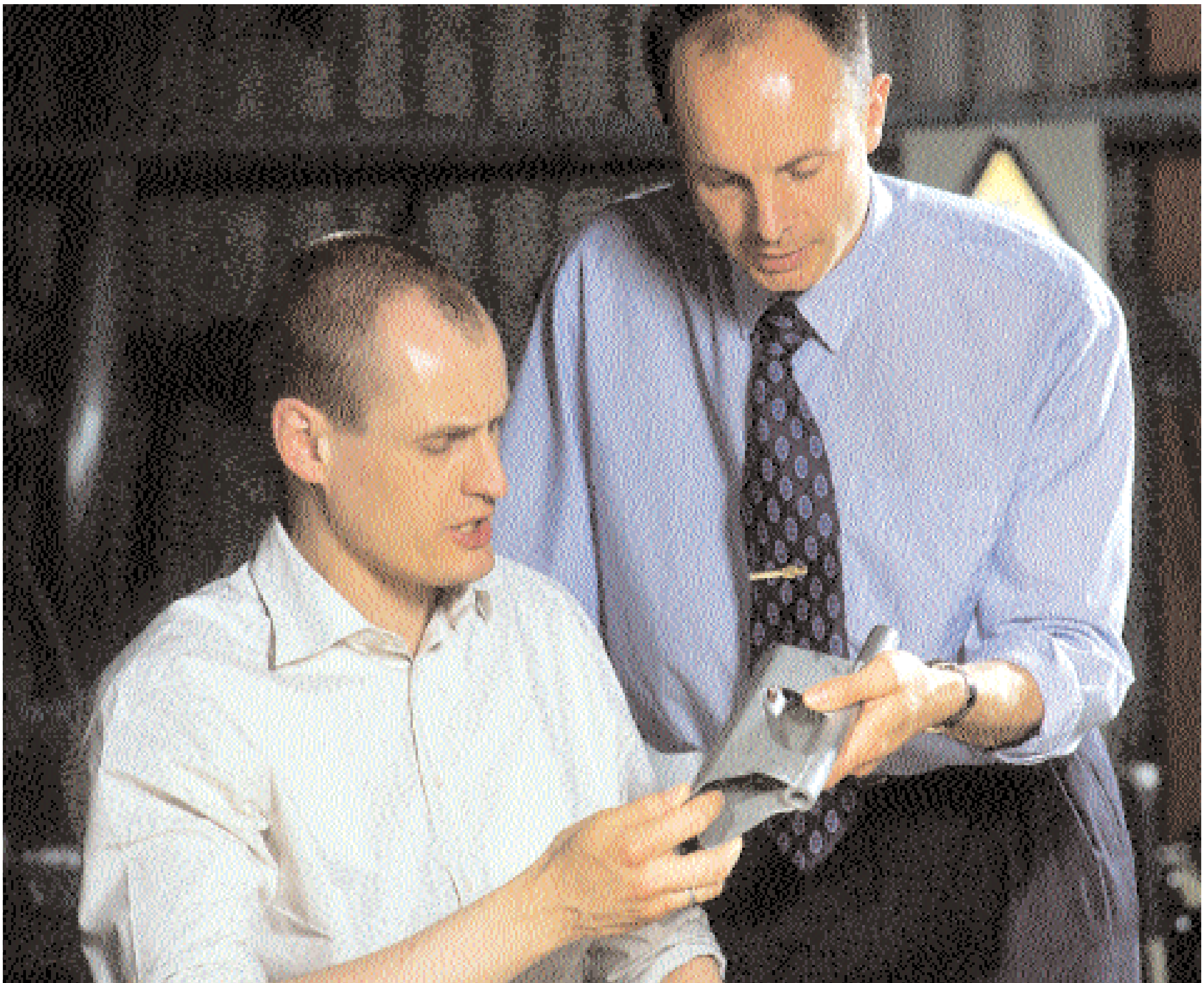
SSAB Tunnplåt has many experts who have long practical experience of ultra high strength steels. All of these experts are at the disposal of our customers:

- Our experts in the *Technical Customer Service Department* have a broad range of knowledge of materials and their working and machining. For immediate answers to your technical questions, phone +46 243 72929 (direct line) or e-mail them on teknisk.kundservice@ssab.com.
- Our experts in the *Applications Engineering Department* have spearhead knowledge of sizing, forming, jointing and surface treatment.

USE OUR MODERN ANALYSIS TOOLS

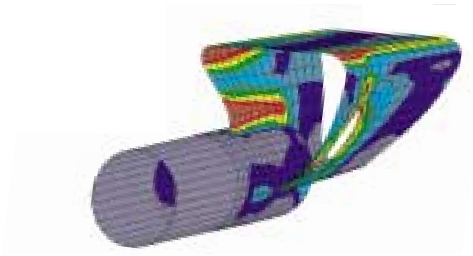
We use the very latest tools that enable us to assist our customers in selecting the right grade of steel and the right design, e.g.:

Finite Element Method (*FEM*) analysis that can be used for simulating all of the steps in the development of a part, e.g. selection of steel grade, form of the raw

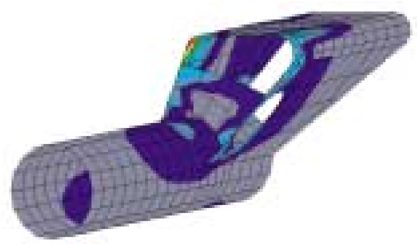


material blank, method of working and final design of the part. FEM analysis can also be used for calculating the energy absorption capacity of an automotive part in a crash situation.

We can undertake computerized simulation of all conceivable variants of tool design, radii, part design, thickness and steel grade, in order to find the optimum solution.



FEM analysis shows that the stresses in the material are too high in several areas.



After a few relatively simple changes to the design and planned production, the analysis shows that the tow lug bracket can meet all of the requirements.

ASAME equipment enables us to check quickly that a customer has chosen the right combination of steel grade and design. ASAME measures the strain distribution in pressed parts. The information is then processed in a powerful computer program to obtain particulars of how the tools, production methods and design affect the material. The ASAME equipment can carry out very detailed analyses of complicated forming operations.

COURSES AND SEMINARS

SSAB Tunnplåt regularly arranges courses and seminars dealing with the ways of putting to use the many opportunities offered by ultra high strength steels, such as:

- The steel sheet course that provides fundamental knowledge of the production of steels and the properties and applications of the various steel grades.
- Seminars that offer more detailed knowledge of the sizing, design, machining, forming and jointing of ultra high strength steels.
- Seminars that are tailored to the needs of individual companies.

HANDBOOKS

Detailed knowledge of the many opportunities offered by ultra high strength steels is contained in our handbooks:

- The *Sheet Steel Handbook* provides information for design and fabrication, and also gives production engineering advice.
- The *Sheet Steel Forming Handbook* provides increased knowledge of plastic forming and machining.

TEST SHEETS

Place your order for sheets with our Test Sheet Stores if you wish to find out how a new grade of steel performs in your production equipment or in the intended product.

PRODUCT INFORMATION

Our product brochures and product leaflets contain information on all of our steel grades and how they can be used, worked and machined.

CERTIFICATES

SSAB Tunnplåt has gained certification to ISO 9002 and QS 9000.

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www.ssabtunnplat.com
www.steelprize.com
www.businessteel.com

Important to know

- Changing over to Docol UHS steels very seldom demands investments in new machinery. In most cases, resetting the machines correctly is all that is needed.

- There are no major production engineering differences between Docol UHS steels and mild steels. But bear in mind the following:

  – Tool wear increases after change-over to Docol UHS steels. The wear can be reduced by better lubrication and higher quality of the tool steel.

  – The springback is higher than that of mild steels. In bending, this can be compensated by increased over-bending or by reducing the plunger radius or the width of the die opening. In pressing operations, the springback can be reduced by over-crowning of the punch or by increased blankholder force.

  – The drawability of Docol UHS steels is not as good as that of mild steels. This can often be compensated by larger radii, reduced friction or adjustment of the press parameters.

  – Docol UHS steels can be spot-welded to the same material. However, the welding data (electrode force/welding time) should be altered compared to mild steel. The mechanical properties of the joint are good, but it may be difficult to measure the diameter of the weld nugget in the usual way.

- The modulus of elasticity of Docol UHS steels is the same as that of mild steels, and the stiffness of the part will therefore be lower if the material thickness is reduced. However, if increased deflection is not acceptable, the stiffness loss can be compensated by changes to the cross-sectional shape. In addition, flat sheet surfaces can be stiffened by flutes.

- Beams and profiles with a width in excess of about 20 times the sheet thickness may sustain buckling. Buckling means that the sheet steel buckles when a compressive load is applied. When the load is relieved, the buckles will disappear.

- Heat treatment of Docol UHS steels to a temperature above the tempering temperature will cause a strength reduction that increases with increasing temperature. In surface treatment processes that involve a curing stage, such as Dacromet or Delta MKS, the maximum recommended heat treatment temperatures must not be exceeded if the steels are to retain their high strength.

- Caution is required if Docol UHS steels are used in products that are subjected to fatigue loads, which applies particularly to welded structures. Knowledge is needed of how the welded joints should be located. Welds should not be located in highly stressed areas.

The environment and recycling

Steel is one of the world's most widely recycled materials. Almost half of the world production of steel is based on recycled steel.

SSAB Tunnplåt is already supplying Docol UHS steels to customers who make strict environmental demands and companies that plan to obtain certification for their environmental work.

Today's products must be able to become new products in the future. The key lies in designing products for recycling. This involves selecting materials, production processes, surface treatment and jointing methods that will meet today's and tomorrow's requirements on recycling, and will reduce the material consumption.

ENVIRONMENTAL BENEFITS OF STEEL

Steel is magnetic and can therefore easily be sorted. Steel always contains recycled material. Steel is 100% recyclable.

The infrastructure for collecting and recycling steel scrap has long been in place and is economical. About 90% of all automotive scrap is recovered. In both new production and recycling of steel, less energy is needed than that required for producing competing materials.

SSAB Tunnplåt AB is the largest Scandinavian steel sheet manufacturer and a leader in Europe in the development of high strength, extra and ultra high strength steels.

SSAB Tunnplåt, which is a member of the SSAB Swedish Steel Group, has a turnover of SEK 9 billion and has around 4400 employees in Sweden. The company's annual production capacity is around 2.5 million tonnes of steel sheet.

Our environmental policy is focused on continual improvement of the environmental conditions of the manufacturing process and pollution control equipment. Our products are constantly being improved towards minimal environmental impact in a life cycle perspective.

We manufacture the following steels in our modern, highly efficient production lines and rolling mills for strip products:

- **DOMEX** hot-rolled steel sheet
- **DOCOL** cold-reduced steel sheet
- **DOGAL** hot-dip galvanized steel sheet
- **ALUZINK** aluminium-zinc coated steel sheet
- **PRELAQ** prepainted steel sheet

We assist our customers in selecting the steels that are best able to improve their competitiveness. Our strength lies in the quality of our products, our reliability of supply, and our flexible technical customer service.

SSAB TUNNPLÅT

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