

The primary aims in die-cutting are quality, economy and output. No matter how accurate the shape of a die or the strength of its construction, the key factor is the quality of the rule die steel (RDS) strip that is used to make it. Selecting the correct RDS profile and dimension for a specific application is, therefore, critical.

A guide to good die-cutting

High deformation resistance paired with good bendability: a die maker looks for the opposite mechanical properties in RDS to a die user. He requires steel with high bendability, whereas the user needs high deformation resistance. Although it is not possible to fully satisfy both requirements at the same time, the steel strip's microstructure can be optimised for both.

The cross section comprises three zones (Figure 1), each with a specific microstructure fulfilling a specific task:

- A uniform fine grained bainitic body-structure of medium hardness
- A soft ferritic zone just beneath the surface to provide bendability without compromising deformation resistance
- A very hard martensitic zone at the cutting edge to ensure a long tool life

It is also possible to produce the steel with a modified hardness of structure to increase deformation resistance for high cutting pressures or very large dies.

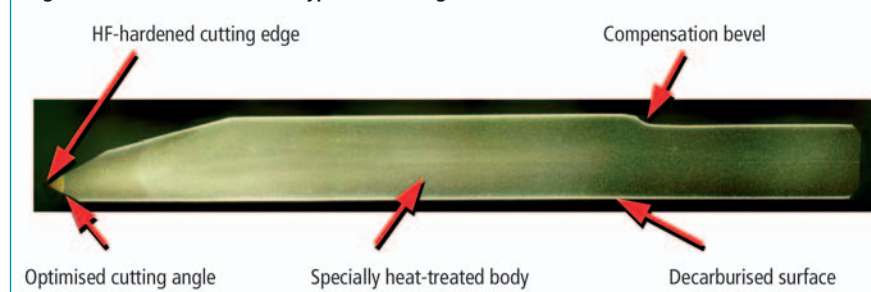
Quality RDS has a specification for hardness (body and edge) and a guaranteed bendability (angle and radius) that is typically as follows:

- Body hardness 38 HRC
- Edge hardness 50 HRC
- Guaranteed bending angle of 60 degrees (enclosed angle at 2mm thickness)
- Guaranteed bending radius 1mm

Edge hardened steel (HF)

Edge hardening (high frequency induction hardening) provides the steel with a wear-resistant edge. To avoid

Figure 1: Cross section of RDS type BE showing various microstructures



compromising the bending properties, the area of hardening only extends to about 0.7mm from the tip of the cutting edge. HF steel is usually identifiable by a blue oxide layer on the cutting bevels. However, progressive wear during factory use of a die can partially remove it. On some serrated steel, the serration is ground into the edge after hardening, which removes the oxide layer on the surface.

Non-edge-hardened RDS steel is also referred to as normal or through hardened. Its drawback is that since no extra edge hardening is applied, the cutting edge is of the same hardness as the body and unintentional edge damage and rapid blunting is highly likely. Moreover, although hardened RDS does have a hardness factor, it is usually about 5 HRC higher than the body hardness of HF steel, which affects the bendability.

Figure 2: Double edge profile BD 19 x 2



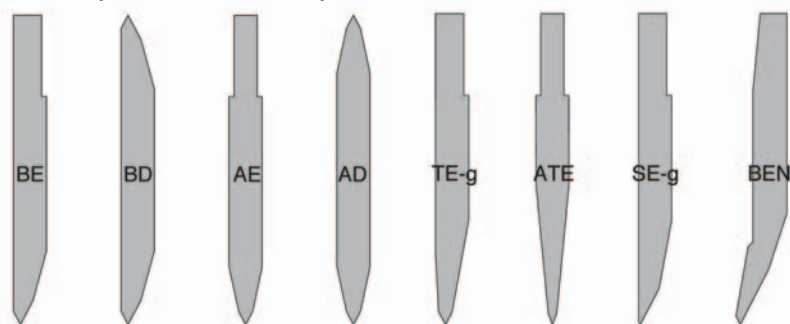
Surface and geometry

The steel's surface should be free from scratches, grooves, and lead (Pb) residues. Longitudinal grooves, especially on the bevels, can lower the quality of the edges of cut components. Residues from the lead-quenching bath indicate deficiencies in production process control and can represent a health hazard in the daily use of the die.

Close tolerances on dimensions and shape are particularly critical as they allow the die maker to produce an economical top quality die. For instance, during the actual cutting operation, the rear edge of the steel strip is in contact with the top plate of the press and takes the full load. Only a smooth and uniform rear edge will be in solid contact with the press and allow a controlled load transfer to the cutting edge via the strip's body. A burr-less rear edge also allows trouble free handling of the die and reduces the risk of injuries.

Cutting dies made from double edge steel (Figure 2) have only one of the edges bent exactly to the pattern, as the highly symmetrical steel profile ensures total accuracy. ➤

Figure 3: Comparison of different RDS profiles



Choosing the right profile

Die cutting is the most widely used shaping process in the soft goods industries. To cope with the variety of materials that are cut, a broad range of different profiles, dimensions and edge geometries is available, from versatile standard profiles to tailored ones for specific applications. Serrated profiles for cutting textiles and gimp-steel for gimped-cut edges on shoe upper sections are good examples.

The correct selection of an RDS profile and dimension primarily depends on the material to be cut. Also to be considered are: pattern size, degree of complexity, number of cuts, expected cutting pressure and whether the material is to be cut in single or multiple layers. Therefore, when ordering a set of dies, the profile and dimension of the RDS should be clearly specified. Alternatively, the material to be cut can be indicated and the options discussed with the die maker.

A large variety of different RDS profiles exist (Figure 3), from versatile types to very specific ones serving very specific needs:

- BE single layer cutting (leather)
- BD single layer cutting, double edge for cutting left- and right-hand parts with only one die
- AE symmetric profile for slitting knives
- AD symmetric double edge steel
- TE-g multi-layer cutting (textile, fleece, lining, leatherette)
- SE-g rigid material cutting (insole)
- ATE cutting heavy textile materials in several layers
- BEN back clearing dies (outsole)

The use of double edge steel (BD) reduces the number of dies needed for a particular shoe. Symmetrical—but otherwise identical—parts can be cut using a single die made from double edge steel.

However, in this instance an actual cutting edge is taking the pressure from the press, so special care has to be taken not to damage the edges during handling and storing. If an edge does become damaged, higher pressure is needed in order to cut through the material. This increases the load on the edge in contact with the press plate and this, in turn, can start a vicious circle of continuously increasing the cutting pressure, leading to premature blunting of both edges.

The use of excess pressure must be avoided with BD in order to achieve optimum performance and to take full advantage of the full saving potential.

Matching the material to be cut

Upper leather – natural leather for shoe uppers is cut in a single layer, so profiles BE or BD are the most economic solution in this case (Figure 4).

Insoles, counters & reinforcements – stiff materials like leatherboard or cellulose boards are best cut with an SE-g/SE-w type profile. The very small inside bevel of this profile reduces the internal pressure in the die and facilitates die clearing.

Textiles – woven and nonwoven textiles are usually cut in multi-layers. Profile TE-g is recommended for easy penetration of the stacked material with reduced cutting pressure. Serrated steel like TES-G (Figure 5) reduces the cutting pressure even further and is used for 'difficult to cut' textiles and on high stacks of multiple layers to avoid 'under-cutting'.

Back clearing dies – sole leather, heavy leatherboard and plastic sheet require high cutting pressures and dies with back-clearing capability. Profile BE-N (Figure 6) offers a lightweight alternative

Figure 4: Die from BE 32 x 2 with punches and gimping



Figure 5: Serrated edge TES-G strip



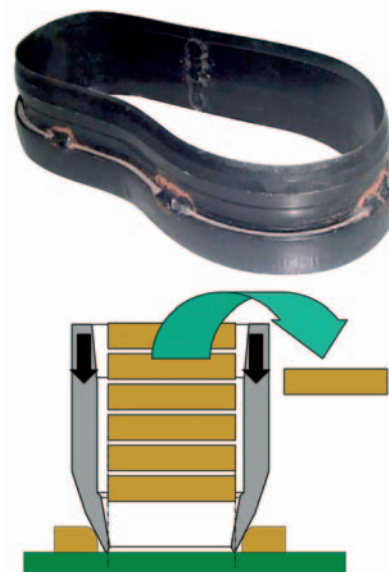
to the traditional heavy forged steel die.

Profile influences cut quality

In (Figure 7 a-e) we can see the influence of the profile on the cutting result for some typical situations:

- Cutting of leather with type BE. Correct set-up with good cutting result.
- BE used to cut stiff leatherboard in two layers. The board is over-compressed laterally and creates pressure inside the die pushing the steel to the outside. Cut parts become stuck, there is an 'over-cut' size difference between parts from different layers and the die can be deformed.
- The same set-up using SE-g where

Figure 6: Back-clearing die BE-N



Small but essential

Punch tubes are very much taken for granted. They are there, in the knife, they cut decorative or functional holes in upper sections, they break or lose their edge and are replaced. The fact that there are many variations in type and that their manufacture is highly specialised is seldom thought about.

One of the leading producers is the family-owned business of Gerdins AB in Sweden. Established some 50 years ago, at first it produced forged steel cutting dies for local shoe factories. It added strip steel knives in 1959 when Sandvik introduced this revolutionary new technology. Punch tubes were bought in from Germany until, in 1965, the company's founder, Yngve Gerdin, decided to make his own. The company now has a library of over 2,500 sizes and shapes and produces more than a million punch tubes and prickers per month, which it exports all over the world for a variety of industries.

The footwear industry requires punch tubes capable of making clean cuts in

leather, fabrics and rubber. As these materials vary so much, careful consideration has to be paid to the design of the tube that is to be used. It goes without saying that the accuracy and quality of steel must be to a high standard in order to ensure a tight fit in the knife and to maintain a sharp cutting edge.

Equally important is the ejection of cut pieces. If waste is not removed freely, a build-up of material inside the tube creates increasing pressure until the tube splits. This will result in spoilt upper sections, until the fault is detected, and lost production time while the tube is replaced. Punch tubes are therefore made with different internal profiles to match the material to be cut.

Prickers for use with leather also exhibit a wide variety of edges depending on the intended application.

The next time you are buying a set of

Standard punch tube types

Punch type	Height (mm)	Size (mm)
Single & double edge (side ejection)	19.0 & 32.0	0.8 - 5.0
Single edge (back ejection)	9.7 & 12.7	0.6 - 10.0
	19.0	0.8 - 10.0
	32.0	1.0 - 10.0
Single edge (side ejection-rear)	19.0	1.2 - 6.5
	32.0	2.0 - 10.0
Shoulder tube	15.5	0.8 - 4.5
Single edge (back ejection/milled)	19.0	0.8 - 4.0
	32.0	1.0 - 4.0

Standard pattern pricker types and their applications

Pricker type	Height (mm)	Size (mm)
Face standard	19.0 & 32.0	2.5 & 3.0
Face sharp	19.0 & 32.0	2.5 & 3.0
Face blunt	18.8	2.5 & 3.0
Face standard	19.0	2.5 & 3.0
Face sharp	19.0	2.5 & 3.0
Face flat	18.0 & 31.0	2.5 & 3.0

press knives, spare a thought for the tubes and prickers and make sure you are using the correct type. 

Details courtesy of Gerdins AB, Mjallom, Sweden.

the small inside bevel on this profile allows a straight cut through the layers of carton and easy clearing of the die.

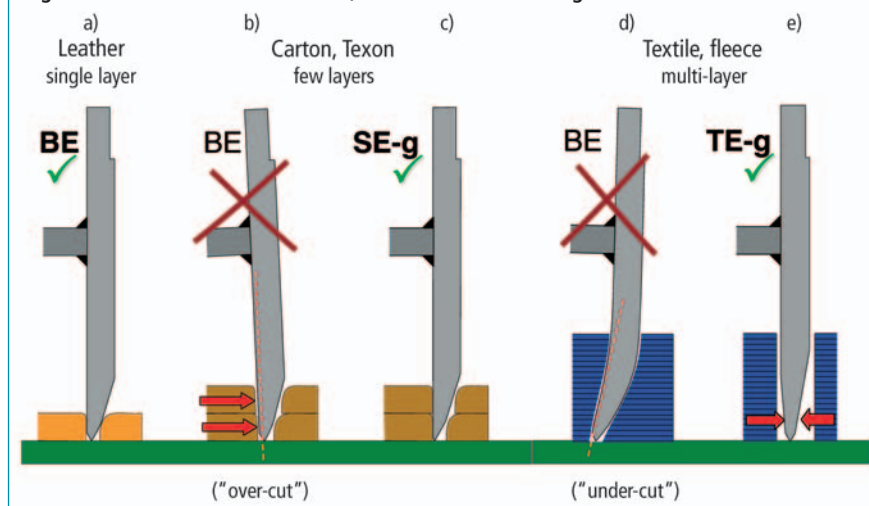
- d. A stack of textile layers cut using RDS type BE.
- e. TE-g used for the same task. This profile has a deep bevel on the inside to counteract the pressure created by the outside bevel. This permits a straight cut through the many layers without the 'under-cut' effect shown in d.

Select the right dimension

In order to avoid the need to frequently change the cutting press stroke distance, the RDS height is usually chosen according to factory preference. 32mm steel has higher stability, but 19mm is normally quite adequate. Moreover, 19mm dies are lighter to handle, need less storage space and are more economically priced.

Where 32mm or even 50mm steel is essential is when cutting high stacks of multi-layered material, as the available

Figure 7: Profile selection for leather, insole and textile cutting



space in the die must accommodate both the compressed stack of layers and an ejection rubber. Deep die steel is also needed when edge-trimming 3D moulded components.

RDS thickness also influences the stability of a die, but without the need to change the press stroke distance. It also influences bending properties, so 2mm is

a good compromise between bendability and stability. 2.5mm can be used to add stability to large area dies or when very high pressures are expected. However, small bending radii, small angle corners and intricate shapes will be very difficult to achieve in this case. 

Details and images courtesy of Böhler Uddeholm GmbH & Co KG