

Toolholding

GENERAL HINTS ON TOOL HOLDERS

INTRODUCTION

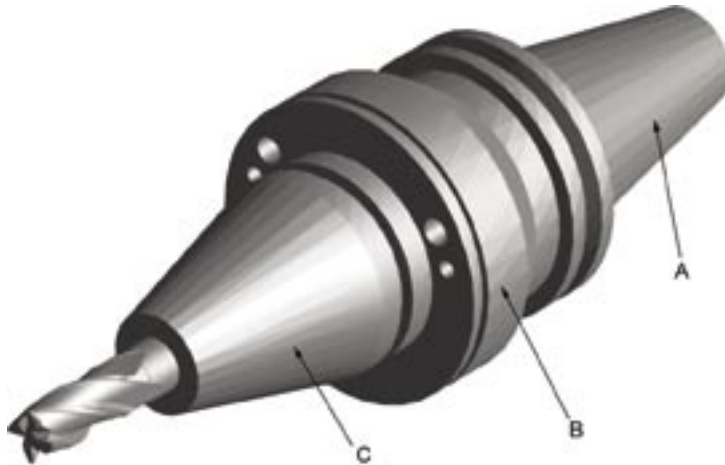
To define tool holder quality, one must first consider the function of a tool holder. A tool holder can be defined as follows:

A device that acts as an interchangeable interface between a machine tool spindle and a cutting tool such that the efficiency of either element is not diminished.

To hold with this definition, four separate elements are essential:

1. **Concentricity** - The rotational axis of the machine spindle and of the cutting tool must be maintained concentrically.
2. **Holding Strength** - The cutting tool must be held securely to withstand rotation within the tool holder.
3. **Gauges** - The tool holder must be consistent. The application of proper gauges assures consistency from holder to holder.
4. **Balancing** – Tool holders must be balanced as finely as the spindles in which they are installed.

As you can see it is possible to split the holder into three separate parts: the interface with spindle (**taper, A**), the **balancing device (B)** and the part to clamp the tool (**holding mechanism, C**).



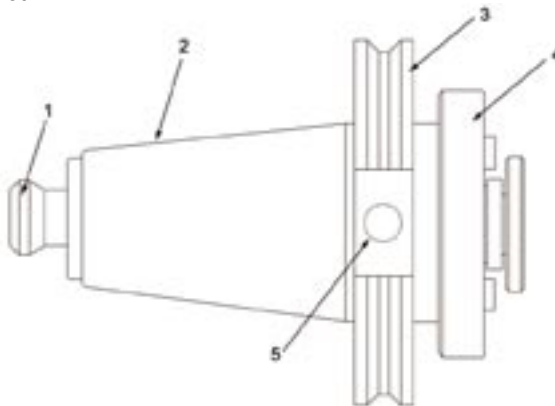
TYPES OF TAPER

- **Steep Taper** (CAT, BT, TC, ISO)
- **HSK** (Hollow Shank Taper). For more information please see the HSM (High Speed Machining) section
- **Floating holders** (only for tapping and reaming)
- **Other** (Morse Taper, Automotive Shank, Cylindrical 1835 A, Cylindrical B+E, ABS, Wohlhaupter)

Large manual machines and CNC machines use tool holders that have been precisely ground with a male taper that mates with the machine's specific female taper. There is also a way to secure the tool holder in place with a pull stud or a draw bar thread. With CNC machines, the pull stud is more popular because it allows for easier automatic tool changing.

A tool holder consists of five basic components (see figure below):

1. Pull Stud
2. Tapered Shank
3. Flange
4. Adapter
5. Opposed Slot



TAPERED SHANK

The tapered shank fits the tool holder to the spindle.

The standard defines six basic taper shank sizes including #30, #35, #40, #45, #50, and #60. Larger machines use tool holders that have larger shank taper numbers. The taper of the shank is made to 3.5 in./ft (or a ratio of 7:24).

The proper Taper Shank for the Type of Machine

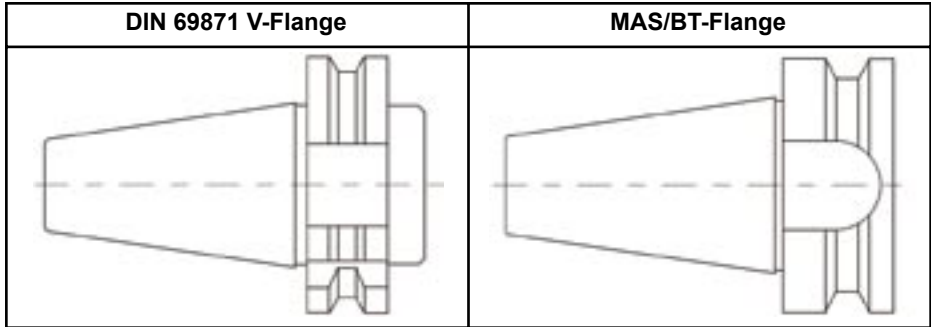
- #60 Very large machines
- #50 Medium size machines
- #40 Small size machines
- #30 Very small machines

Toolholding

FLANGE TYPE

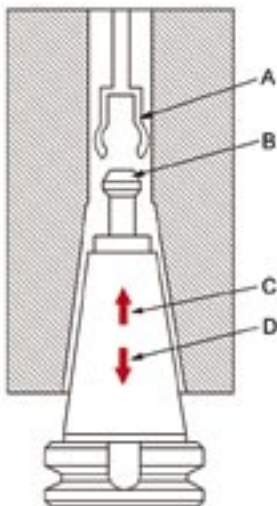
The flange allows the tool holder to be grabbed by the tool gripper or the machine spindle. There are two commonly used flange types: V-flange and BT-flange.

BT-flange holders have metric threads for the pull stud, but their adapters can be designed to accommodate a wide range of inch-dimensioned cutting tools. BT-flange holders are widely used in Japanese and European-made machining centres.



PULL STUD

The pull stud allows the locking drawbar (A) of the spindle to pull the tool holder firmly into the spindle and to release the tool holder automatically. Pull studs (B) are made in various styles and sizes. They are not necessarily interchangeable. Only use the pull studs that are specified by the machine tool manufacturer.






- A Locking Drawbar
- B Pull stud
- C Clamping
- D Unclamping

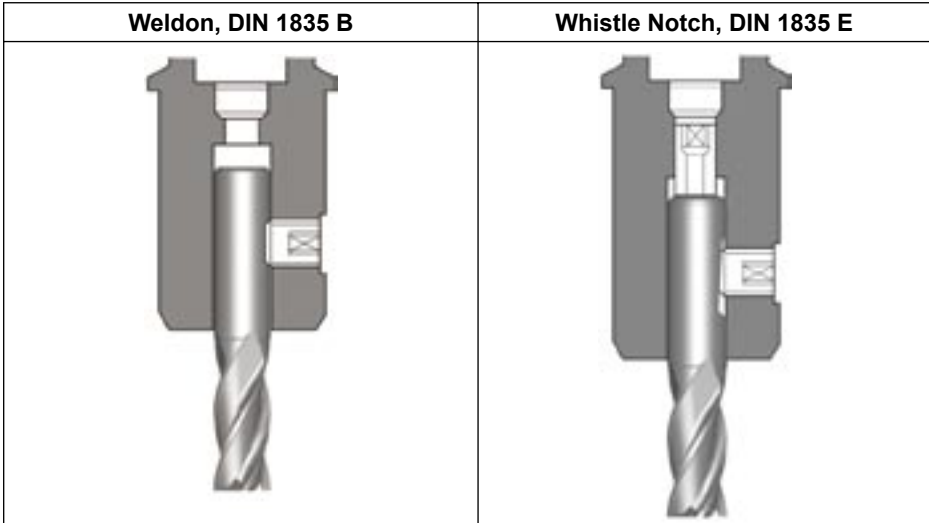
CLAMPING SYSTEMS

There are four different types of clamping systems:

1. Collet DIN 6388 and DIN 6499
2. Hydraulic Chuck
3. Shrink Fit
4. Weldon and Whistle Notch

Collet DIN 6388, DIN 6499	Hydraulic Chuck	Shrink Fit
		
<p>A metal collet around the cylindrical shank is tightened with a nut.</p>	<p>A hydraulic tool holder uses a reservoir of oil to equalise clamping pressure around the tool. Turning a screw increases the pressure on this oil, causing an expanding sleeve to grip the tool shank.</p>	<p>A shrink fit tool holder works in conjunction with a specialised heater. The tool holder takes advantage of thermal expansion and contraction to clamp the tool. At normal shop temperature, the bore in which the tool locates is slightly undersize compared to the tool shank. Heating the tool holder opens up this bore, allowing the tool to be inserted. As the tool holder cools, the bore shrinks around the tool to create a concentric and rigid clamp.</p>

Toolholding



For weldon and whistle notch holders, a radial screw is in contact with the tool and holds it in place. The tool needs to have a flat ground onto the shank.

Characteristics	Collet	Weldon Whistle Notch	Hydraulic	Shrink Fit
Machining	Milling (Tapping) Drilling Reaming Boring	Milling (Tapping) Drilling Reaming Boring	Milling Tapping Drilling Reaming Boring	Milling Drilling Reaming Boring
End Mill Shank	Plain Shank HSS (DIN 1835A) Carbide (DIN 6535HA) Screwed Shank HSS (DIN 1835D)	Weldon Shank HSS (DIN 1835B) Carbide (DIN 6535HB) Whistle Notch HSS (DIN 1835E) Carbide (DIN 6535HE)	Plain Shank HSS (DIN 1835A) Carbide (DIN 6535HA)	Plain Shank HSS (DIN 1835A) Carbide (DIN 6535HA)
Runout	About 25 microns for a quality holder and collet	Around 10 microns	Around 5 microns	Around 4 microns
Rigidity	Good	Very Good	Fair	Excellent

Characteristics	Collet	Weldon Whistle Notch	Hydraulic	Shrink Fit
Balance	Different types of collets exist in relationship to the concentricity	Asymmetric design creates unbalance, but tool holder can be manufactured to remove weight where appropriate to compensate for this	Asymmetric design creates unbalance, but tool holder can be manufactured to remove weight where appropriate to compensate for this	Best – With no screws or other asymmetrical features, holder is inherently well-balanced
Vibration	No advantage	No advantage	The fluid reservoir may offer some capacity to damp vibration	No advantage
Ease of use	Low – the accuracy is dependent on the operator	Good	Better – the accuracy is consistent but clamping mechanism is easy to damage	High – low skill operators can use effectively
Cost	Normal	Normal	More expensive	Holders are cheap, but the need for a heater means there is a high start-up investment

Toolholding

BALANCING OF THE SYSTEM TOOL HOLDER/CUTTER

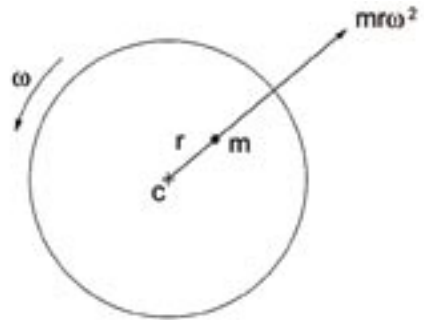
Unbalance occurs when the mass centre and the geometric centre do not coincide with each other.

Unbalance amount is expressed as

$$U = m * r$$

$$e = \frac{U}{M} = \frac{m * r}{M}$$

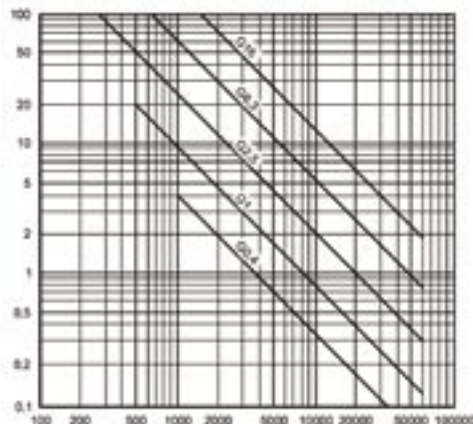
$$G = \frac{e * 2 * \pi * n}{60.000}$$



Quantity	Symbol	Unit
Specific permissible unbalance	e	gmm/Kg
Balance Grade Code	G	mm/s
Unbalance mass	m	g
Constant angular speed	ω	rad/s
Rotor mass	M	Kg
Distance from unbalance mass to centreline	r	mm
Total permissible unbalance	U	gmm
Rotation speed	n	rpm

BALANCE QUALITY BASED ON STANDARDISED TABLES

G Quality Grade (the inclined lines in the diagram below) relates max. surface rotational speed (X-axis) to the specific permissible unbalance e (Y-axis).



For a specific grade, as the rotational speed of the cutter increases, the permissible unbalance e decreases.

Balance quality grades are separated from each other by a factor 2.5.

$0,4 \times 2,5 = 1$ $1 \times 2,5 = 2,5$ $2,5 \times 2,5 = 6,25$ $6,25 \times 2,5 = 15,625$.

Some standards about this have been produced.

ISO 1940-1:2003 gives specifications for rotors in a constant (rigid) state. It specifies balance tolerances, the necessary number of correction planes, and methods for verifying the residual unbalance.

Recommendations are also given concerning the balance quality requirements for rotors in a constant (rigid) state, according to their machinery type and maximum surface speed. These recommendations are based on worldwide experience.

ISO 1940-1:2003 is also intended to facilitate the relationship between the manufacturer and user of rotating machines, by stating acceptance criteria for the verification of residual unbalance.

Detailed consideration of errors associated with balancing and verification of residual unbalance are given in ISO 1940-2.

Usually the balancing of the tool holder is carried out without the tool and is verified with it.

It is necessary to know what "G" rating the tool holder is balanced to and at what speed (rpm). These two components define the maximum permissible vibration displacement of the centre of mass. The higher the speed, the smaller the vibration displacement must be for a given "G" grade.

Some tool holders are advertised as "production balanced tool holders" for speeds up to 20,000 rpm without being actually specified to the ISO 1940 tolerance grade. When tested, many of these tool holders are found to fail to meet quality G6.3 standards, much less the more stringent G2.5 grade often specified for tool holders.

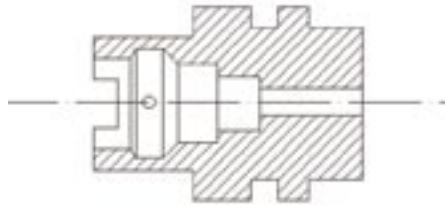
Toolholding

HSK

The German consortium of machining centre manufacturers, end users and tooling manufacturers, in conjunction with the Machine Tool Laboratory at the University of Aachen, developed the revolutionary HSK, Hollow Shank Kegel (German word for taper) tool holder connection.

In total, six separate standards were created for HSK Shanks DIN 69893 and six standards for matching Spindle Receivers DIN 69063.

DIN 69893-1. HOLLOW TAPER SHANKS – HSK WITH FLAT CONTACT SURFACE; TYPE A AND C



Form A

- Standard type for machining centres and milling machines
- For automatic tool change
- Coolant supply through centre via coolant tube
- Drive keys at the end of HSK taper
- Hole for data carrier DIN STD 69873 in the flange.

Form C

- For transfer lines, special machines and modular tooling systems
- For manual tool change
- Coolant supply through centre
- Drive keys at the end of HSK taper
- Since all Form A holders are equipped with side holes for manual tool change, they can also be used as Form C holders.

DIN 69893-2. HOLLOW TAPER SHANKS – HSK WITH FLAT CONTACT SURFACE; TYPE B AND D

Form B

- For machining centres, milling and turning machines
- With enlarged flange size for rigid machining
- For automatic tool change
- Coolant supply through the flange
- Drive keys at the flange
- Hole for data carrier DIN STD 69873 at the flange.

Form D

- For special machines
- With enlarged flange size for rigid machining
- For manual tool change
- Coolant supply through the flange
- Drive keys at the flange.

DIN V 69893-5. HOLLOW TAPER SHANKS – HSK WITH FLAT CONTACT SURFACE;
TYPE E

Form E

- For high-speed applications
- For automatic tool change
- Coolant supply through centre via coolant tube is possible
- Without any drive keys for absolute symmetry.

DIN V 69893-6. HOLLOW TAPER SHANKS – HSK WITH FLAT CONTACT SURFACE;
TYPE F

Form F

- For high-speed applications mainly in woodworking industries
 - With enlarged flange size for rigid machining
 - For automatic tool change
 - Coolant supply through centre via coolant tube is possible
 - Without any drive keys for absolute symmetry.
-
- DIN 69063-1. Tool Receiver for Hollow Taper Shanks - HSK Type A and C
 - DIN 69063-2. Tool Receiver for Hollow Taper Shanks - HSK Type B and D
 - DIN 69063-5. Tool Receiver for Hollow Taper Shanks - HSK Type E
 - DIN 69063-6. Tool Receiver for Hollow Taper Shanks - HSK Type F

HSK benefits to the user include:

- High static and dynamic rigidity. Bending load is 30% to 200% greater than steep taper tool holders.
- High precision axial and radial reproducibility. The tool holder does not have the tendency to “suck in” like a steep taper holder.
- Low mass, low stroke length when tool changing.
- Centered clamping with twice the force.

Toolholding

TAPPING ATTACHMENTS

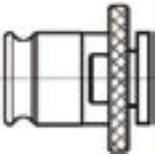
Typically a tapping attachment has to resolve the following problems:

1. Simple holding of the tap with quick tool change
2. Limit the maximum torque in relationship with the thread size
3. Compensate for the pitch errors of the machine tool

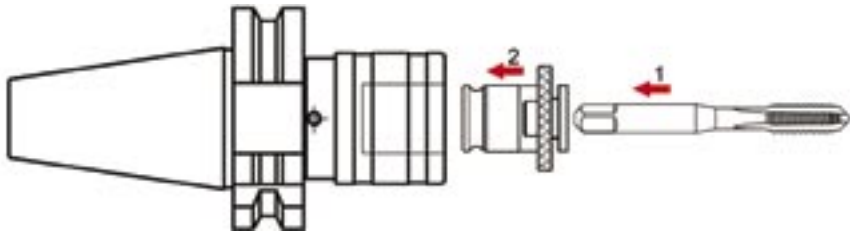
So there are different devices that supply these functions.

QUICK TOOL CHANGE DEVICES

• Tap holder without clutch

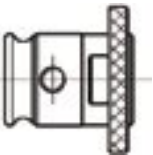


Sequence of operations

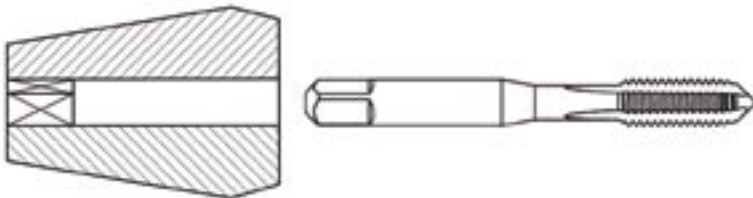


1. Insert the tap in the tap holder
2. Insert the tap holder in the end part of the tool holder

• Tap holders without clutch and with threaded grain



• Tap holder collet with back square

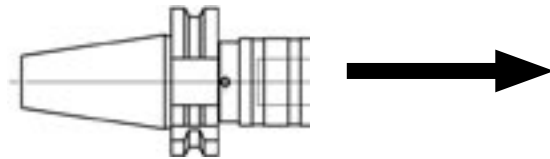


TAPPING ATTACHMENTS

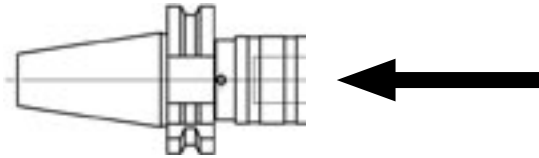
The process of tapping is a complex balance of rotational and axial movements of the tool. It is sometimes necessary to restrict the axial movements of the tool.

If the axial movement is not accurately controlled, the leading or trailing flanks of the tap may be forced to progressively “shave” one flank of the component thread, thus producing a thin and oversize thread in the component.

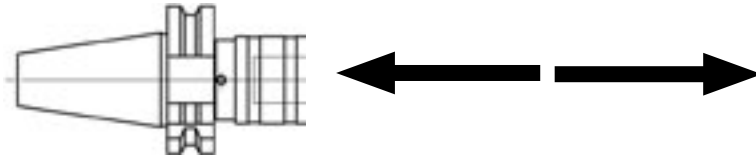
Tension – forward float capability allows the tap to progress into the component without interference from the axial feed of the machine spindle.



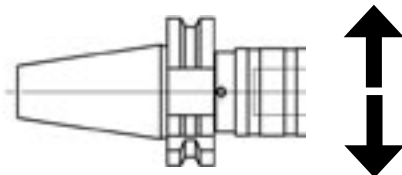
Compression – backward float capability, acts as a cushion and allows the tap to commence cutting at its own axial feed independent of the machine spindle.



Compression / Tension – float is designed to negate any external forces during the machining operation.



Radial float – allows for slight misalignment of the machine spindle axis and hole axis prior to tapping. This is not recommended manufacturing practice and should be avoided.



Toolholding

SETTING VALUES FOR TAP HOLDERS WITH A SAFETY CLUTCH

Tap holders with a safety clutch are preset to the following values dependent upon the recommended thread size.

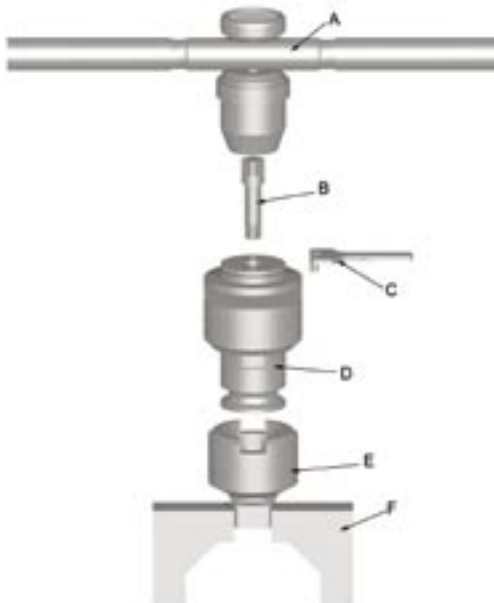
Thread size	Torque setting (Nm)
M3	0,50
M3,5	0,8
M4	1,20
M4,5	1,60
M5	2,0
M6	4,0
M8	8,0
M10	16,0
M12	22,0
M14	36,0

Thread size	Torque setting (Nm)
M16	40,0
M18	63,0
M20	70,0
M22	80,0
M24	125,0
M30	220,0
M33	240,0
M39	320,0
M45	480,0
M48	630,0

Setting of torque on tap-holder with safety clutch

Note: Clockwise setting increases the torque

Counter clockwise setting decreases the torque



- A Torque wrench
- B Setting shank adaptor
- C Key
- D Tap holder with clutch
- E Hexagonal socket shank
- F Vice

TORQUE CALCULATIONS

$$M_d = \frac{P^2 * D * Kc}{8000}$$

Md = Torque
P = Pitch

D = Nominal diameter in mm
Kc = specific cutting force

Values from this formula are valid for new cutting taps. A worn-out tap gives approximately a double torque value.

When using a forming tap the torque calculation has to be multiplied by 1.8.

Application Material Groups			Kc Specific cutting force N/mm ²
1. Steel	1.1	Magnetic soft steel	2000
	1.2	Structural steel, case carburizing steel	2100
	1.3	Plain Carbon steel	2200
	1.4	Alloy steel	2400
	1.5	Alloy steel, Hardened and tempered steel	2500
	1.6	Alloy steel, Hardened and tempered steel	2600
	1.7	Alloy steel, Heat treated	2900
	1.8	Alloy steel, Hardened & Wear resistant steel	2900
2. Stainless Steel	2.1	Free machining, Stainless Steel	2300
	2.2	Austenitic	2600
	2.3	Ferritic + Austenitic, Ferritic, Martensitic	3000
3. Cast Iron	3.1	Lamellar graphite	1600
	3.2	Lamellar graphite	1600
	3.3	Nodular graphite, Malleable Cast Iron	1700
	3.4	Nodular graphite, Malleable Cast Iron	2000
4. Titanium	4.1	Titanium, unalloyed	2000
	4.2	Titanium, alloyed	2000
	4.3	Titanium, alloyed	2300
5. Nickel	5.1	Nickel, unalloyed	1300
	5.2	Nickel, alloyed	2000
	5.3	Nickel, alloyed	2000
6. Copper	6.1	Copper	800
	6.2	β-Brass, Bronze	1000
	6.3	α-Brass	1000
	6.4	High Strength Bronze	1000
7. Aluminium Magnesium	7.1	Al, Mg, unalloyed	700
	7.2	Al alloyed, Si < 0.5%	700
	7.3	Al alloyed, Si > 0.5% < 10%	800
	7.4	Al alloyed, Si > 10% Whisker reinforced Al-alloys Mg-alloys	1000
8. Synthetic materials	8.1	Thermoplastics	400
	8.2	Thermosetting plastics	600
	8.3	Reinforced plastic materials	800
9. Hard material	9.1	Cermets (metals-ceramics)	>2800
10. Graphite	10.1	Graphite	600