



**TECHNICAL  
DATA  
MANUAL**



**NOTE:** It is important to remember that all of the technical information which is reproduced in this technical data manual and given by our staff has been taken from reliable sources and is given in good faith. But in the case of error or omission, we cannot be held responsible. All of the processes we mention should be carried out within the meaning of the Health and Safety at Work Act of 1974 and the other appropriate federal, state and local legislation and regulation.



# Technical Data Manual

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GENERAL INFORMATION

MACHINING PROPERTIES

SURFACE TREATMENTS

DIE MAKING

MOLD MAKING

QUESTIONS & ANSWERS

## Reliability with FORTAL

- Savings on Tool Costs
- Higher Speed-Machining
- Higher Spark-Erosion
- Higher Strength
- Higher Stability
- Higher Safety
- Higher Surface Finish
- Lower Scrap Rate
- Lower Tool Weight
- Lower Tooling Costs
- Lower Delivery Time

## Higher Productivity with FORTAL

**Energy Absorption:** Fortal's modulus of elasticity is 1/3 that of steel. Therefore, it ABSORBS THREE TIMES AS MUCH energy, shock & vibration.

**No Deformation:** All Fortal material is delivered FREE of tensions and stresses and will RARELY deform during machining or use.

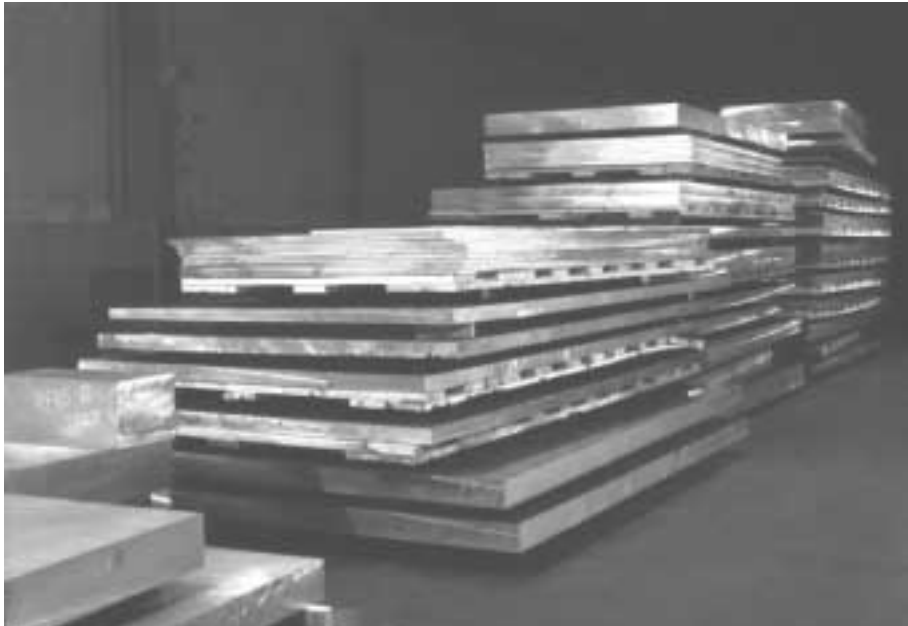
**Cost:** Machining time is CUT by three or more.

## Fortal's Origin

FORTAL was originally developed to be used in the aerospace industry, and can be found whenever a structure is highly solicited and doesn't require a very high ratio of resistance/mass. This criteria becomes even more important when mechanical tooling, working under severe conditions and moving, must be slowed down or stopped with minimum energy (as in the structure of the wing of a plane). FORTAL offers remarkable machinability, high resistance to corrosion, and leads to increased productivity. Thus, it increases your competitiveness ! The two grades of FORTAL (HR - up to 100mm thickness and HP - from 100mm to 200mm thickness), offer the user the necessary properties in whichever thickness is needed. Consequently, the characteristics are guaranteed up to 200mm thickness since the mechanical properties are uniform throughout the cross section of the material. The modulus of elasticity is also of major importance, since the tooling is working under constant shocks. Since FORTAL's modulus of elasticity is one third (1/3) that of steel, it can absorb three times as much shock and vibration in its elastic phase, so it is simple to see why FORTAL works so well under shock and RARELY sustains any deformation. FORTAL is a high strength, lightweight, easy to machine alloy. Stronger than 1020 steels, FORTAL is an ideal material for all types of products and tooling. FORTAL is solution heat treated, stabilized, artificially aged and stress relieved by stretching.

## Fortal's Chemical Composition

Copper (Cu).....	1.6	Chromium (Cr).....	.23	Aluminum (Al).....	90.07
Manganese (Mg).....	2.5	Zinc (Zn).....	5.6		



## Dimensional Data

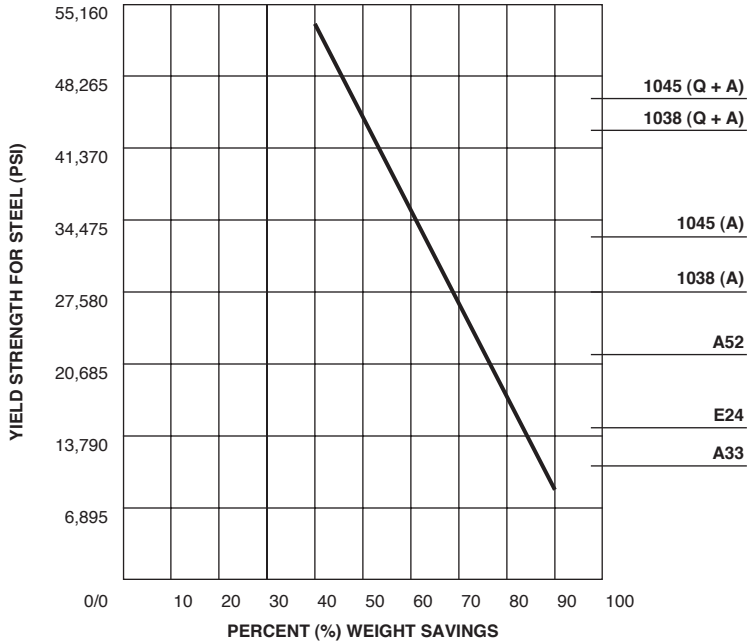
DIMENSIONS (mm)	STOCK RAW PLATE (W x L)						
	1,500 x 3,000	1,250 x 2,500	1,200 x 2,500	1,060 x 2,500	900 x 2,500	900 x 2,500	810 x 2,500
14.0		HR					
18.5	HR						
22.5	HR						
28.0	HR						
35.5	HR						
39.0	HR						
43.5	HR						
46.0	HR						
53.5	HR						
65.0	HR						
72.0	HR						
82.0	HR						
92.0	HR						
102.0		HP					
127.0			HP				
152.0				HP			
162.0					HP		
182.0						HP	
202.0							HP

**NOTE:** 1mm = .03937 inches; 1 inch = 25.4mm — Larger sizes are available upon request.

# FORTAL®

GENERAL INFORMATION

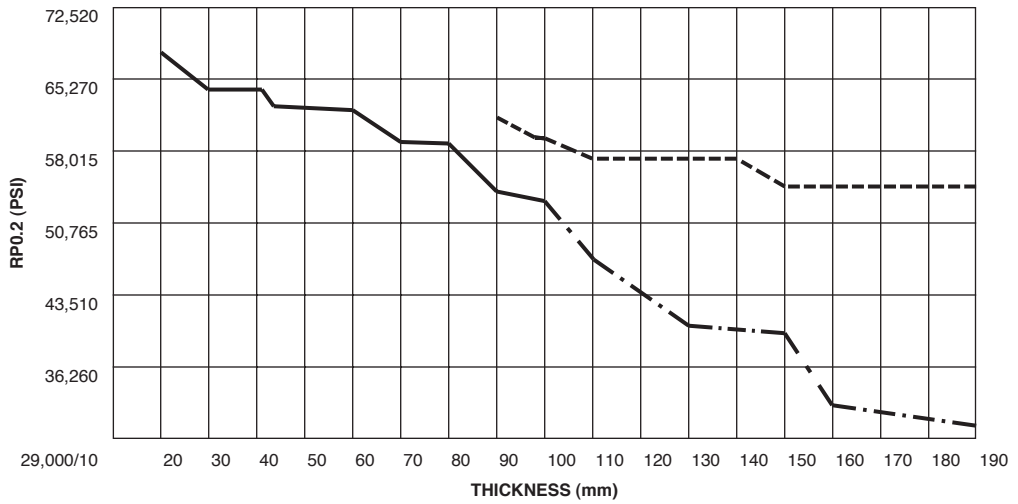
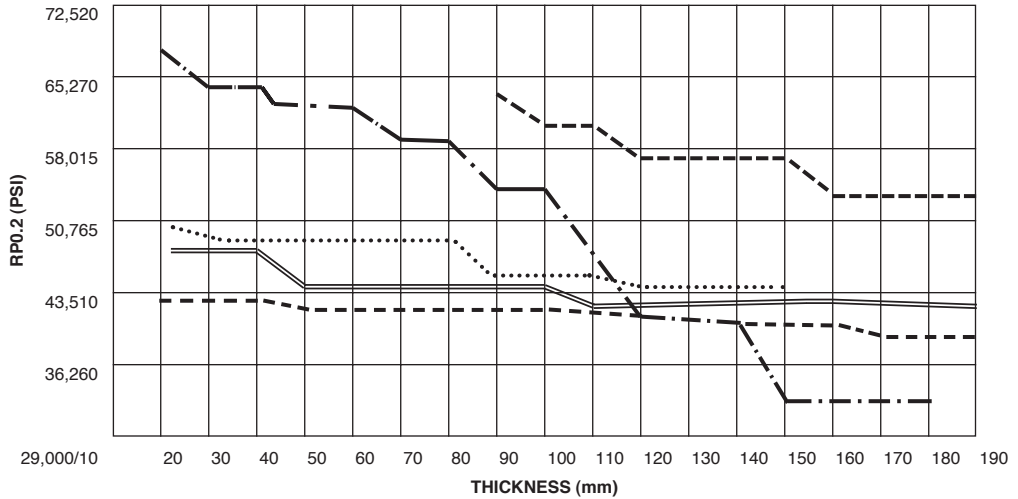
PARAMETERS	FORTAL HR (typical)	FORTAL HP (typical)	STEEL 1020 HR
Thickness (mm)	≤ 92	> 92	—
Tensile Strength (PSI)	78,320	74,000	64,000
Yield Strength (PSI)	69,600	63,800	50,200
Shear Strength (PSI)	48,000	48,000	48,000
Hardness Brinell	150	150	142
Density (pounds/inch <sup>3</sup> )	0.1	0.1	0.2833
Modulus of Elasticity (pounds/inch <sup>2</sup> )	10.44 x 10 <sup>6</sup>	10.3 x 10 <sup>6</sup>	30 x 10 <sup>6</sup>
Lineal Coefficient of Expansion (10 <sup>-6</sup> x °F) between 68° and 212°F	13.05	12.78	6.30
Thermal Conductivity (W/m x k)	130	160	40



NOTE: (Q + A) = Quenched and Annealed; (A) = Annealed

## Comparison of Mechanical Properties

(0.2% Yield Strength)



-----	.....
FORTAL HP T7651	E36 (A52)
=====	=====
FORTAL HR T651	1045 ANNEALED
-.-.-.-.-	-.-.-.-.-
FORTAL HR T651	1038 ANNEALED

GENERAL INFORMATION

## Fatigue Resistance

Tests have been performed on an ALKAN machine with ALKAN test bars (Diameter 22mm) undergoing rotatious flexius. At  $10^8$  cycles we have obtained:

Test bars unnotched:  $(K_t = 1) = | 160 \text{ MPA} = 23200 \text{ psi}$

Test bars notched:  $(K_t = 3) = | 80 \text{ MPA} = 11600 \text{ psi}$

It is recommended to avoid sharp corners and irregular surfaces.

## Heat Transfer

FORTAL HR-HP like most aluminum alloys is a very good conductor of heat. For the moldmaker this means that:

The tool heats and cools faster, effectively reducing cycle times and improving the quality of the molded components.

The coefficient of thermal conductivity of FORTAL HR-HP at  $20^\circ\text{C}$   $\text{W/m}^\circ\text{C}$  is 121 (steel is about 55).

The rate of heat transfer is expressed as:  $Q = \frac{KAT}{x}$

x

Q = rate of heat transfer

K = coefficient of thermal conductivity

A = conducting area

T = temperature difference required

x = thickness of the material

FORTAL has a thermal conductivity 4 times higher than that of steel, which means it very rapidly dissipates the heat calories and limits the effects of thermal expansion. Therefore a similar mold tool made from FORTAL HR-HP will heat and cool 2.21 (121.55) times faster than the steel one. For the tool maker this means that:

- 1) The heat generated at the point of contact during machining is dissipated quickly through the work piece or through the chips.
- 2) Overheating with its associated loss of tool hardness and shortened tool life is consequently avoided.



## Specific Heat Capacity

FORTAL HR-HP has a specific heat capacity of .229 btu/lb°F whereas Tool Steels have a specific heat capacity of about .114 btu/lb°F.

Though more energy is required to heat a kilogram of FORTAL HR-HS than one of Tool Steel, a mold tool of FORTAL would require 33% less energy than a mold tool of the same size in steel due to the light weight of aluminum.

## Thermal Expansion

The coefficient of thermal expansion for FORTAL HR-HP between 68°and 212°F is  $13.05 \times 10^{-6}$  and  $12.78 \times 10^{-6}$  respectively, which is approximately twice that of steel and should be considered on mixed assemblies. On press tools which operate at a maximum of 90°F it can show that the thermal expansion is of no significance.

To acquire a lineal measurement in comparing steel and FORTAL, multiply the corresponding factor by temperature difference, and then multiply by the distance involved.

### Example:

piece length = 10"

Temperature difference = 30°F

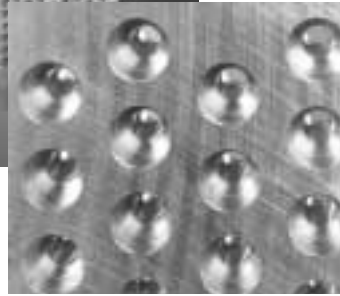
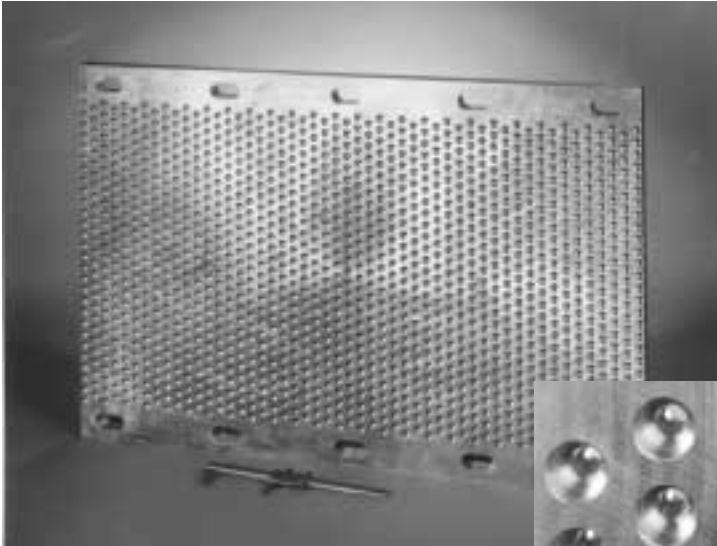
### FORTAL:

$$.000013 (X) 10" (X) 30^{\circ}F = .0039"$$

### STEEL:

$$.000006 (X) 10" (X) 30^{\circ}F = .0018"$$

However, since the thermal conductivity is some four times greater in FORTAL over that of steel, FORTAL will dissipate the heat (cold) calories faster and prevent the lineal expansion from occurring. For each of your specific applications, you should consider the effects of thermal expansion as good design practice.



## General Machining Properties

FORTAL HR-HS machines at much higher speeds than tool steel and more easily than most other well known aluminum alloys due to the small discontinuous chips produced. Cutting speeds of up to 500ft/min are not uncommon, but adjustments have to be made to give different rakes and greater chip-breakers.

Embossing and fine machining can be achieved with a high degree of accuracy by punching, engraving and chasing. FORTAL HR-HP is ideally suited for electrical discharge machining (EDM) and photo-chemical processes.

As a general rule it has been found that the following procedure produces the best results:

- 1) Rough machine parts oversize.
- 2) Leave to stabilize for about 24 hours.
- 3) Finish machine to give a perfect flatness where required.
- 4) Sharp corners and irregular surfaces should be avoided.

## Tool Design and Material Properties

- A high quality tool steel is recommended but cemented carbide tipped or those fitted with carbide throw-away tips are ideal.
- Standard tools used for machining steels are suitable provided that close attention is paid to the different rakes and adequate chips.
- Carbide tools are suitable for roughing cuts up to 1,000 m/min and finishing up to 2,000 m/min but should not be used at speeds less than 600 m/min or there will be build-up on the cutting edge which will damage the work piece. Coolants should not be used with ceramic tools.
- Diamond-tipped cutting tools can be used to obtain fine finishes. In certain circumstances finishes of 0.025 microns have been obtained.
- Correct tool grinding and finishing is essential to machining of all metals. FORTAL HR-HS requires keen edges and highly polished surfaces to ensure the long unbroken edge to provide a smooth finish. In addition polished surfaces both prolong the life of the tool and assist in the removal of chips from the cutting edge.

The information above is provided from our own experience without commitment, but suppliers of tooling and lubricants should be consulted for your specific needs.

## Effect of Temperature

Where tooling is maintained over a long period (1,000/10,000 hours) at temperatures between 302° and 392°F this is a drop in the strength of FORTAL HR-HP but as this depends on the combination of the temperature, the time the temperature is maintained and the speed of heating and cooling, no definite figures can be given.

## Compressive Yield Strength

The compressive yield strength is equal to the tensile strength which is 28,320 psi.

## Properties of FORTAL HR-HP Influencing Characteristics

FORTAL's high thermal conductivity (121 W/m°C) allows the heat generated at the point of contact with the tool to be dissipated quickly either through chips or the work piece. Therefore, there is no overheating which avoids the loss of tool hardness and prolonging tool life.

Supplemental use of a cutting lubricant is recommended especially in operations such as deep drilling where the contact between the tool and the chips are long.

FORTAL's high coefficient of thermal expansion ( $13.05 \times 10^{-6} \text{°F}$ ) is about twice that of steel. A rise of  $212 \text{°F}$  would expand a 25mm diameter bar by 0.0023in (0.059mm). However, the effect of thermal conductivity dissipating the heat reduces this to an insignificant level. Further assistance is given by a supply of cutting fluid and tools with the sharp cutting edges and correct rake and clearance angles. The cutting fluid should be so directed as to remove the maximum amount of heat while assisting the flow of chips.

FORTAL's low modulus of elasticity ( $10.44 \times 10^6 \text{ PSI}$ ) helps where there are interrupted cuts since the shock loading is more easily absorbed.

FORTAL's low shear modulus makes the removal of chips easier and as the cutting forces required to machine FORTAL HR-HP are low in comparison to steel only moderate clamping and chucking forces are required. Therefore there are less chances of dimensional inaccuracies due to pressure.

FORTAL's high coefficient of friction on steel means the tools should be kept sharp and highly polished and assisted by lubrication.

## Fatigue Strength

When a material is subjected to many cycles of stress reversal or fluctuation, failure may occur even though the maximum stress at any cycle is considerably less than the value at which failure would occur if the stress were constant. Fatigue properties are determined by subjecting test specimens to stress cycles and counting the number of cycles until failure. The fatigue strength is defined as the stress value corresponding to a specific number of stress reversals.

Tests carried out by a mill laboratory on a standard FORTAL HR 22mm diameter bar sample for 100,000,000 cycles gave the following results which are not static but give a fair indication.

smooth sample = 160 Mpa approximately = 23,200 PSI

notched sample = 80 Mpa approximately = 11,600 PSI

It is therefore worth noting that an improper design (notch or sharp angle) could reduce the fatigue strength quite significantly. If possible, sharp corners and irregular surface machining, etc. should be avoided.

# FORTAL®

Tensile Strength:	78,300 PSI typical for FORTAL HR-HS
0,2 Proof Stress:	69,600 PSI typical for FORTAL HR-HS
Elongation:	10%
Brinell Hardness	145

## For FORTAL HR:

High speed steel cutting tool:	1,000' - 2,000'/min
Carbide (K10) cutting tool:	3,300'/min

It is necessary to use cutting tools whose geometric shapes are specifically designed to machine aluminum and aluminum alloys. Compared to those used to machine steel, they must have a larger cutting angle.

## For FORTAL HR and HP

High speed steel cutting tool:	20° - 25°
Carbide (K10) cutting tool:	15° - 25°

Because of the high cutting speed, nothing should prevent or slow down the evacuation of the chips. This makes it necessary to use cutting tools with ground flutes and smaller edges, 40° helix drills (instead of 28° for steel), and ground-thread taps without a heel. Draft angles must be between 6° and 12° (generally 8°). Because of the modulus of elasticity, it is not possible to have an excessive cutting width. In regards to this, especially when pre-machining, it is recommended to increase the cutting speed and the cutting depth, rather than the cutting width (depending upon the power of the machine). It is not recommended to take more than a cutting width of 0.3mm (0.01") for each tool and for each single rotation.

**LUBRICATION:** It is possible to use either cutting oils or emulsions. Cutting oils are generally used to reduce friction during machining (drilling, jig boring), combined with a stream of compressed air to facilitate the evacuation of chips. Emulsions are preferable when it is necessary to cool down the cutting tools in pre-machining. As for emulsions, don't use products which are too alkaline (Ph greater than 7), because they could damage the surface of the material. In this case, an inhibitor is to be added to the emulsion. Also, liquids containing CHLORIDE (CL) must be avoided. When completing any machining process, a cleaning with water and a thorough drying is recommended.

**GRINDING:** It is possible to obtain a high surface finish (Ra 0.6) directly from milling, but it is also possible to grind FORTAL plates. Aluminium alloys are non-magnetic. Therefore, it is necessary to mount your FORTAL plate on: a vacuum

chuck plate, a magnetic grinding table with block plates against the side edges, a magnetic vise. It may be necessary to also use two lateral fixation plates. Due to the weight of the plate, if not properly maintained, they could move upward. However, it is possible to prevent this phenomena by using a very thin, double-faced tape (for instance 400 S from 3M). This technique allows you to maintain a 0.01mm (.0004”) tolerance. Aluminum flatness has limits based on thickness, width and length ratios.

## Machining Process and Tools

The following information is used as general recommendations.

### Milling

Milling cutters fitted for aluminum alloy machining are characterized by a number of teeth smaller than normally used for

TOOLING	PREMACHINING		FINISH	
	HSS	CARBIDE K20	HSS	CARBIDE K20
Rake Angle	20°	15°	20°	25°
Cutting Speed (fpm)	1,000 to 2,000	≥ 3,300	≥ 3,300	≥ 3,300
Feed (in/rev)	0.004 to 0.012	0.12 to 0.6	0.012 to 0.12	0.0012 to 0.004
Depth of cut (in)			0.02 max	0.02 max

steel. Milling cutters used for steel do not allow working at high cutting speeds because the number of teeth is too important and cutting rake angle is too low. Clearance angle is about 8° and helical rake angle should not exceed 30°, while pre-machining feed depends upon the power of the machine.

### Turning

Clearance angle is about 8°.

TOOLING	PRE-MACHINING		FINISH	
	HSS	CARBIDE K20	HSS	CARBIDE K20
Rake Angle	20°	25°	20°	25°
Cutting Speed (fpm)	1,000 to 2,000	≥ 3,300	≥ 3,300	≥ 3,300
Feed (in/rev)	0.008 to 0.024	0.012 to 0.024	0.002 to 0.008	0.002 to 0.008
Depth of Cut (in)	0.12 to 0.6	0.12 to 0.6	0.012 to 0.12	0.012 to 0.12

### Drilling

Twist drills used in drilling aluminum alloys present helix angles and point angles bigger than those used to drill steel. Point angle varies from 120° to 140°, depending upon the shape of the flutes, with a lip relief angle of 8° and helix angle of 42°. Cutting speed varies from 100 fpm to 270 fpm with HSS drills to 165 fpm to 330 fpm with carbide drills. Feed depends upon the diameter of the hole and goes from 0.0008 in/rev for small diameters to 0.02 in/rev for larger diameters.

## Boring/Pre-machining

TOOLING	HSS	CARBIDE K20
Helix Angle	20° - 30°	15° - 20°
Tip Relief Angle	8°	6°
Cutting Speed (fpm)	66 - 132	100 - 200
Feed (in/rev)	0.008 - 0.012	0.004 - 0.012

To obtain a finished diameter (Df) with a drill, the hole diameter (Dp) should be:

$$Dp = Df - 0.08'' \text{ (Df < 0.8'')}$$

$$Dp = Df - 0.16'' \text{ (Df > 0.8'')}$$

Precision varies from 0.0008" to 0.002". For higher precision (0.0004"), it is necessary to calibrate the hole after drilling. Calibrated diameter (Dc) should be:

$$Dc = Df - 0.08'' \text{ (Df < 0.8'')}$$

$$Dc = Df - 0.16'' \text{ (Df ≥ 0.8'')}$$

## Finish Boring

TOOLING	MACHINE		
	MANUAL	HSS	MET. CARBIDE
Along Angle	5° to 7°	5° to 7°	5° to 7°
Lip Relief Angle	6° to 8°	6° to 8°	6°
Cutting Angle	45°	30°	30°
Cutting Speed (fpm)	—	50	66 to 132
Feed (in/rev)	—	—	—
Diameter < 1"	—	0.001 to 0.004	0.002 to 0.008
1" Diameter < 1.6"	—	0.004 to 0.008	0.004 to 0.012
Diameter > 1.6"	—	0.008 to 0.012	0.008 to 0.016

## Tapping

Holes must be drilled at a smaller diameter than in steel. Use only ground flute taps without land. Lubricate with a special lubricant adapted to tapping. Cutting speeds between 33 and 165 fpm depending upon the power of the machine; point angle 15° for through holes and 45° for blind holes (See page 17 for complete tapping specifications).

SIZE	PITCH (mm)	DRILLED HOLES (mm)
M3	0.5	2.5
M4	0.7	3.2
M5	0.8	4.0
M6	1.0	4.8
M8	1.25	6.5
M10	1.5	8.2
M12	1.75	9.9
M14	2.0	11.6
M16	2.0	13.6
M18	2.5	14.9
M20	2.5	16.9
M22	2.5	18.9
M24	3.0	20.3
M27	3.0	23.3
M30	3.5	25.7

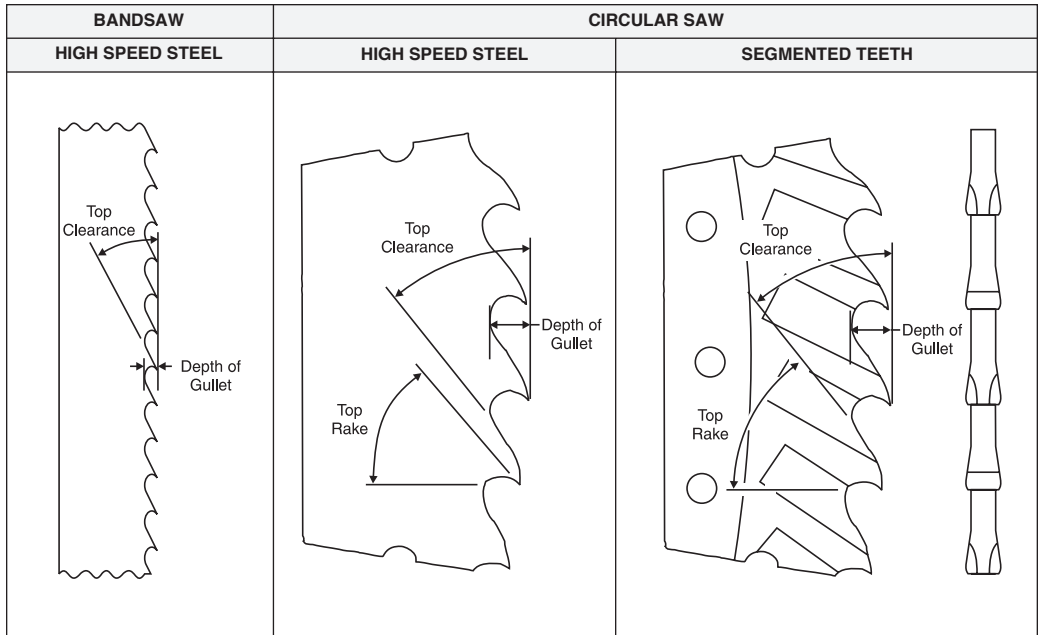
## Sawing

Superior provides FORTAL HR-HP cut to size. FORTAL HR-HP can be sawn with circular saws and bandsaws. When ordering blades the supplier should be informed that they are for cutting strong aluminum alloys.

**Circular Saws:** The teeth should be spaced well apart with large well curved and smoothly finished gullets with the correct rake clearance angles. Provision must be made for angle clearance between the saw body and the slot cut by the teeth. We use only carbide tipped blades but understand the high speed steel blades have proven to be satisfactory at lower speeds. The carbide tipped blades can operate up to 4,500m/min and produce good finishes whereas the HSS blades can operate up to 2,400m/min. Lubrication is essential and we prefer a spray mist.

**Bandsaws:** Blades should have skip teeth with 4 teeth/inch. Cutting speeds of 600m/min for 25mm and thicker are satisfactory. Lubrication is essential but lubricant should be used sparingly. Bandsawing is a good method of removing bulk waste quickly before profile milling. The scrap price should also be better for cuttings than for chips.



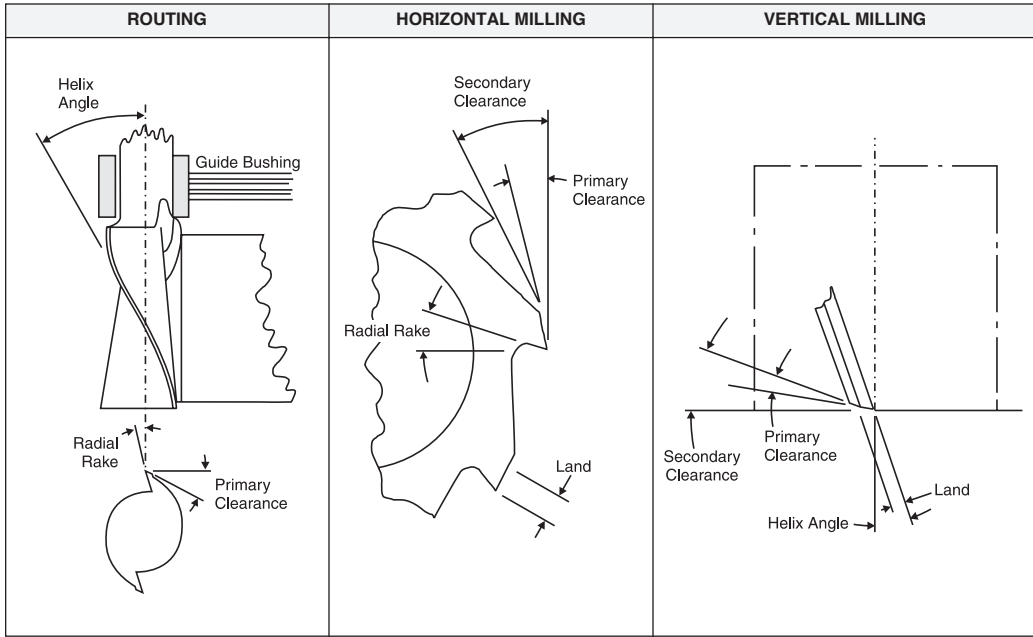


**MACHINING PROPERTIES**

SPECIFICATIONS	CIRCULAR BLADE		BANDSAW
	HSS •	CT **	SPRING TEMPER
<b>BLADE SIZE</b>			
Diameter (mm)	250 - 460	560 - 1,200	12.7 - 38
(in)	10 - 18	22 - 48	0.5 - 1.5
Thickness (mm)	2.3 - 3.7	6.4 - 12.7	0.9 - 1.0
(in)	0.09 - 0.13	0.25 - 0.50	0.036 - 0.040
<b>CUTTING SPEED</b>			
(m/min)	1,500 - 2,400	1,200 - 4,500	600 - 1,800
(ft/min)	5,000 - 8,000	4,000 - 15,000	2,000 - 6,000
<b>TEETH</b>			
Type	Hollow Ground	Coarse w/ChipBreaker	Spring Temper
Pitch (mm)	8.5 - 13	25 - 50	5 - 6
Teeth (in)	2.3	fi - 1	4 - 5
<b>GULLET DEPTH</b>			
(mm)	6.4 - 12.7	12.7 - 57	4
(in)	/ - fi	fi - 2'	5/32
<b>TOP RAKE ANGLE</b>			
Hand Feed	12° - 18°	5° - 12°	0°
Power Feed	15° - 24°	10° - 20°	30° - 45°
<b>TOP CLEARANCE</b>			
Hand Feed	20° - 30°	7° - 9°	0°
Power Feed	25° - 35°	5° - 7°	30° - 45°
<b>SIDE CLEARANCE</b>	1° - 2°	1° - 2°	fi Blade Thickness

• High Speed Tool    \*\* Carbide Tipped

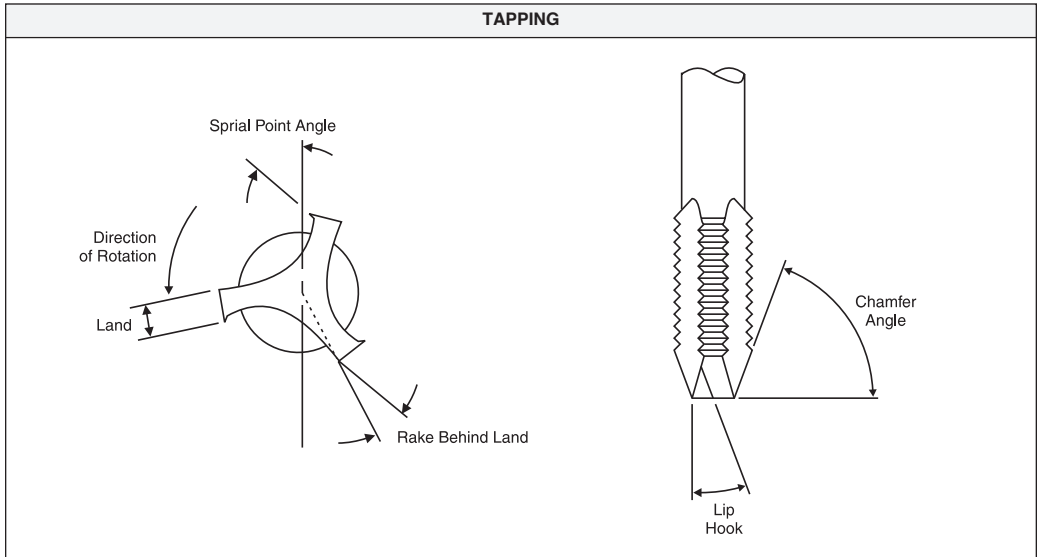
## Milling and Routing



SPECIFICATIONS	ROUGHING		FINISHING	
	HSS •	CT ••	HSS •	CT ••
Radial Rake (1)	25°	25°	25°	25°
Radial Rake (2)	25°	25°	25°	25°
Axial Rake	0°	0°	0°	0°
Side Clearance	8°	8°	8°	8°
Helix Angle	30° max	30° max	30° max	30° max
Cutting Speed (m/min)	> 1,500	> 4,500	> 1,500	> 4,500
(ft/min)	> 5,000	> 15,000	> 5,000	> 15,000
Feed (mm/tooth)	0.1/0.3	0.1/0.3	0.5 max <sup>(1)</sup>	1.00 <sup>(2)</sup>
(in/tooth)	0.004/0.012	0.004/0.012	0.020 max <sup>(2)</sup>	0.040 <sup>(2)</sup>
Lubrication	Cutting Fluid or Paste	Cutting Fluid or Paste	Cutting Fluid or Paste	Cutting Fluid or Paste

• High Speed Tool      •• Carbide Tipped  
<sup>(1)</sup> Edge Profile Cutter      <sup>(2)</sup> Face Milling Cutter

## Tapping



**MACHINING PROPERTIES**

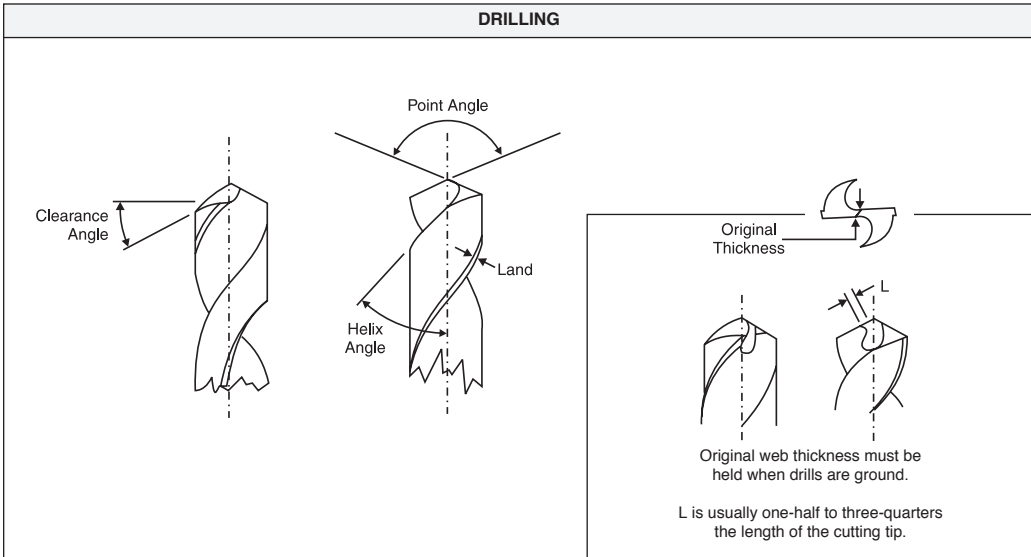
SPECIFICATIONS	ADJUSTED TAPS NOT RELIEVED
Radial Rake	20°
Entry Chamber	8° Clearance
- Through Holes	30°
- Blind Holes	90°
Cutting Speed (m/min)	10 to 50
(ft/min)	30 to 150

Lubrication is essential and special tapping cutting fluids should be used to prevent clogging and overheating. The hole should be predrilled a little smaller than the core diameter and the following table is offered as a guide.

Diameter (mm)	M3	M4	M5	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24	M27	M30
Pitch (mm)	0.5	0.7	0.8	1.0	1.25	1.5	1.75	2.0	2.0	2.5	2.5	2.5	3.0	3.0	3.5
Predrill Hole (mm)	2.5	3.2	4.0	4.8	6.5	8.2	9.9	11.6	13.6	14.9	16.9	18.9	20.3	23.3	25.7

Standard taps are suitable for quality production but a little more rake will give better results. Taps should have ground threads and deep wide flutes to provide for chip clearance and spiral taps may be found to be better than the straight fluted type.

## Drilling



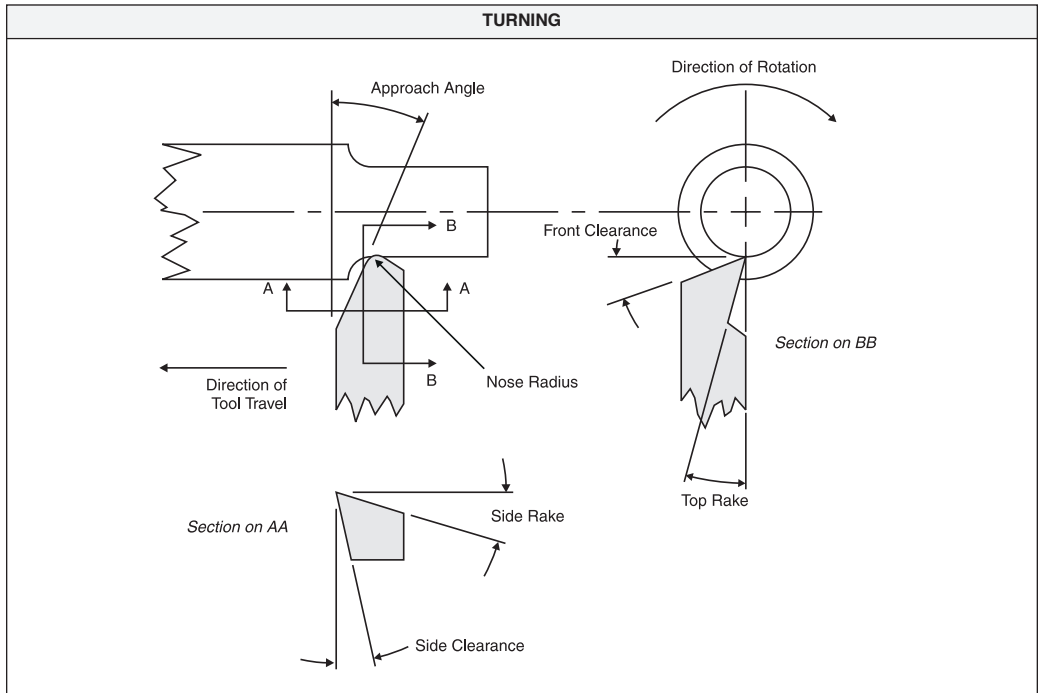
SPECIFICATIONS	DRILLING	
	HSS •	CT **
Helix Angle	25°	25°
Clearance Angle	8°	8°
Point Angle	118° (130° - 150° deep)	118° (130° - 140° deep)
Cutting Speed (m/min)	30/80	50/150
(ft/min)	150 - 250	150 - 500

• High Speed Tool    \*\* Carbide Tipped

Standard twist drills are effective even with extensive hole depths as they do not break off as easily as special aluminum drills. The special aluminum drills are advantageous in producing a good finish and increasing the speed of feeds which results in better chip clearance. Another point to watch when drilling deep holes is that if excessive heat is generated, the subsequent contraction of the hole will decrease its size, especially on large diameter holes.

DRILLING FEED RATES			
DRILL DIAMETER (mm)	FEED (mm)	DRILL DIAMETER (in)	FEED (in)
up to 4	0.10 - 0.15	up to 1/8	0.004 - 0.006
4 - 10	0.15 - 0.20	1/8 - 3/8	0.006 - 0.008
10 - 20	0.20 - 0.35	3/8 - 3/4	0.008 - 0.014
20 - 40	0.30 - 0.45	3/4 - 1 1/2	0.014 - 0.018
over 40	0.40 - 0.60	over 1 1/2	0.016 - 0.024

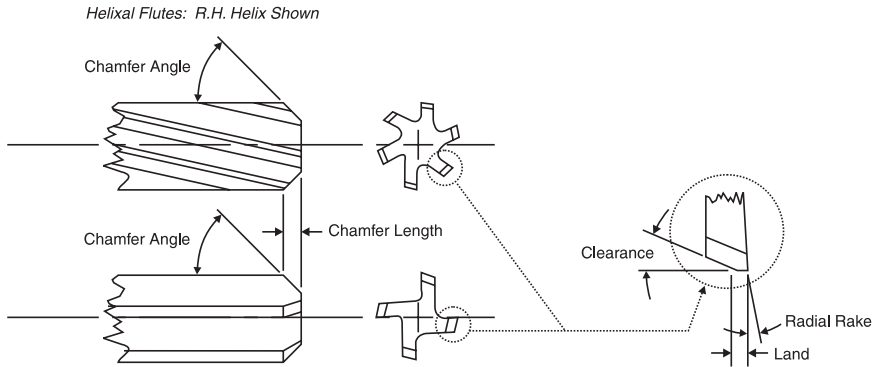
## Turning



SPECIFICATIONS	ROUGHING		FINISHING	
	HSS ·	CT **	HSS ·	CT **
Approach Angle	30°	30°	30°	25°
Clearance	8°	8°	8°	8°
Cutting Speed (m/min)	500 - 800	800 - 2,500	500 - 800	800 - 2,500
(ft/min)	1,500 - 2,500	2,500 - 7,500	1,500 - 2,500	1,500 - 7,500
Feed (mm/min)	0.3 max	0.3	0.05/0.20	0.05/0.20
(ft/min)	0.012 max	0.012 max	0.002/0.008	0.002/0.008
Cutting Depth (mm)	3 - 15	3 - 15	0.3 - 1.0	0.3 - 1.0
(in)	1/8 - 5/8	1/8 - 5/8	0.012 - 0.040	0.012 - 0.040
Top and Side Rake	5° - 10° Positive	5° - 10° Positive	5° - 10° Positive	5° - 10° Positive
Nose Radius (mm)	0.25 - 0.40	0.25 - 0.40	0.25 - 0.40	0.25 - 0.40
(in)	0.010 - 0.015	0.010 - 0.015	0.010 - 0.015	0.010 - 0.015
Lubrication	Cutting Fluid or Paste	Cutting Fluid or Paste	Cutting Fluid or Paste	Cutting Fluid or Paste

· High Speed Tool      \*\* Carbide Tipped (Roughing K20, Finishing K10)

## Reaming



SPECIFICATIONS	STANDARD REAMER (ROUGHING)		NICKED TEETH REAMER (ROUGHING)	
	HSS •	CT **	HSS •	CT **
Helix or Chamfer Angle	20° - 30°	15° - 20°	20° - 30°	15° - 20°
Clearance	8°	8°	8°	8°
Cutting Speed (m/min)	20 - 40	30 - 60	1,000	1,000
(ft/min)	60 - 120	100 - 180	3,000	3,000
Feed (mm/rev)	0.02 - 0.03	0.02 - 0.03	0.005 - 0.20	0.005 - 0.20
(in/rev)	0.0008 - 0.001	0.0008 - 0.001	0.0002 - 0.008	0.0002 - 0.008
Cutting Depth (mm)	—	—	0.5/2.0	0.5/2.0
(in)	—	—	0.020 - 0.080	0.020 - 0.080
Lubrication	Cutting Fluid	Cutting Fluid	Cutting Fluid	Cutting Fluid

SPECIFICATIONS	STANDARD REAMER (FINISHING)	
	HSS •	CT **
Chamfer Angle	30° - 90°	30° - 90°
Clearance	6°	6°
Radial Rake	3°	3°
Cutting Speed (m/min)	15	20 - 40
(ft/min)	45	60 - 120
Feed (mm/tooth)	0.02/0.05	0.02/0.05
(in/tooth)	0.0008/0.002	0.0008/0.002
Lubrication	Cutting Fluid	Cutting Fluid

• High Speed Tool    \*\* Carbide Tipped

Roughing and finishing reamers are often used and the roughing reamers often have picked teeth to prevent the formation of long unbroken chips. Accurate holes should be predrilled but the reaming allowance should be rather more than on steel in order to allow the reamer to make a positive cut. If there is too little allowance, a burnishing action will take place especially if the cutting edges have become dulled. As a guide for Fortal HR-HP allow 3% of the diameter but not less than 0.2mm (0.008"). The land separating the flutes should be as narrow as possible to reduce heat generation by allowing the swarf to pass freely. To counteract shrinkage, reamers for use on Fortal HR-HP should be made from 0.013mm (0.0005") to 0.025mm (0.001") larger than the top limit specified for the diameter. Since reaming is a finishing operation overheating should be avoided at all costs. Therefore, ample cooling fluid should be provided at all times.

## Grinding

Grinding can be used as a method for metal removal, abrasive cutting, and precision finishing.

**Metal removal:** It is essential to provide a good heavy duty soluble oil.

**Abrasive Cutting:** The discs are capable of being used at speeds up to 5,000 m/min (16,000 ft/min). Silicon carbide discs of medium hardness with 24 - 30 grit, medium density and resin bonded are preferable but aluminum oxide may be found to be better. These are guidelines and you will need to determine which abrasive cutting material best suits your application.

**Precision Finishing:** The disc or belt should be selected in relation to the depth of cut, area to be ground, and finish required. Silicon carbide discs of medium hardness (24 - 30 grit) are suitable for rough grinding while finish grinding will be found to be better with softer vitrified bonded wheels with a smaller grit. Hand finishing can be done with emery paper with 180 grit.

PROCESS	ROUGHING	CYLINDRICAL	SURFACE
Speed (m/min)	2,900	2,000	1,500
(ft/min)	9,000	6,500	4,500
Bond Type	Resinoid	Vitrified	Vitrified

Two types of grinding wheels may be used: grinding wheels with resinoid binding and alumine grinding powder (for instance, A36 M6B specially treated), or a vitrified binding product and silicium carbide powder (for instance, C36 K 5V or C46 I5V).



**Grinding Wheel Speed:** 100ft/s

**Rotating Speed of the Ground Part:** 150ft/s

**Tangential Speed:** 100ft/S (30m/s)

**Grinding Wheel:** TYROL IT — Type 87 A 46 H8 V 217

**Lubricant:** WINN'S — Type V 915 M

**Filter:** PARATEX — Type III/40

**Note:** Never use a grinding wheel previously used for grinding steel. Metallic particles could encrust the FORTAL part and allow it to corrode per galvanization (“Battery effect”). For the same reason, cutting lubricant should be filtered by magnetic separation to avoid recycling steel particales in the lubricant.

**Standard Marking System:** BS 1814 provides for a standard marking system for grinding wheels of which an example is given below.

GRAIN SIZE				STRUCTURE	
COARSE	MEDIUM	FINE	VERY FINE	DENSE TO OPEN	
8	30	80	220	1	9
10	36	100	240	2	10
12	46	120	280	3	11
14	54	160	320	4	12
18	60	180	400	5	13
20			500	6	14
24			600	7	15
				8	etc.

PREFIX	ABRASIVE	GRAIN SIZE	GRADE	STRUCTURE	BOND TYPE	SUFFIX
W	C	40	K	S	V	17

ABRASIVE TYPE  
A = Aluminum Oxide  
C = Silicon Carbide

SOFT    MEDIUM    HARD  
ABCDEFGHIJKLMN**OP**QRSTUVWXYZ

BOND TYPE  
B = Resinoid  
E = Sheline  
R = Rubber  
S = Shellac  
V = Vitrified

Manufacturer's  
Wheel Type

## EDM Machining

FORTAL can also be cut (wire EDM) and machined (ramtype EDM) with the same electrode as used for steel, but at speeds up to five (5) times faster than that used for steel.

**NOTE:** Cutting of FORTAL can be by wire EDM, conventional EDM, or plasma. Flamecutting and welding of FORTAL is not recommended.

SURFACE TREATMENTS



## Corrosion Resistance

FORTAL HR-HP gives a good resistance to chemical attack and unlike the steels for mold tooling it needs no protection against PVC and propellant bearing polyurethane. Anodizing FORTAL also helps prevent corrosion.

## Polishing

FORTAL HR-HP gives an excellent polish finish and finesse of detail superior to that of tool steels. The usual grinding and polishing tools are suitable and a finish of between 3 micron and 5 micron can be obtained. Boron carbide abrasive mixed with a carrier of heavy oil or petroleum jelly will give fast and satisfactory results.

FORTAL HR-HP polishes much better than other aluminum alloys and considerably faster than steel. A surface of 200mm x 200mm can be polished to 0.003 finish in two to three hours compared to one and one-half days for the equivalent area of steel. The usual polishing pastes (clay compounds, stearline), high gloss polishing chalk, soft fabrics and leather can be used. See Mold Finish Kit on page 32 for surface finishes.

## Photo-Chemical Etching

The Mold-Tech division of Standex International approves FORTAL HR-HP as an aluminum alloy which they can engrave.

## Anodizing

Wear resistance can be improved by hard coat anodizing. The part will increase by half of the anodic film thickness and allowance should be made for this when machining. Under stress conditions hard anodized parts show up to 50% less wear than case hardened steel parts.

Anodizing also allows for an increase in the surface hardness of the FORTAL plates. This treatment consists of elaborating an oxide layer on the surface of the material; a very hard layer whose thickness can reach 50 microns (0.004in). On FORTAL stock thickness up to 200mm, reports indicate that oxide layers have been achieved with a hardness value of 60 Rockwell (700 VPN) by diamond indent. Often it is found that the abrasive resistance value is considerably higher. This allows an increase in resistance to any friction when it is followed by an oily impregnation. Nevertheless, anodizing does not increase the resistance to repeated shock, since the material underneath the surface keeps its initial hardness. FORTAL can also be color anodized.

In all cases we recommend that users consult a specialist anodizer before any decisions are made.

## Plating

**Hard Chromium Electroplating:** This method produces a very hard, highly polished surface on FORTAL HR-HP with hardness up to 85 Rockwell (1,000 VPN). Layer thicknesses are between 0.01 and 0.2mm.

**Hard Nickel Electro-Plating:** This is suitable where hard layers are required in hollows, bores, etc., as the coating is of a uniform thickness and gives a true reproduction of the original surface. The normal hardness produced is about 500 VPN. However, the higher temperatures needed to obtain the layer hardness and adhesion lower the properties of the base metal.

**Electroless Nickel Deposition:** This is suitable for FORTAL HR-HP and is useful where localized protection is required. The process is specialized and advice should be sought on the methods and safety precautions.

**Other Surface Treatments:** FORTAL can also be black oxidized and TEFLON® coated with excellent results.

## Welding

FORTAL HR-HP can be repaired by TIG or MIG resistance. The filler rods to be used are 5356 or preferably 4043A. There will be some reduction of the physical properties in the area of the weld. However, **FORTAL HR-HP cannot be welded (even TIG or MIG) to attach handling devices (e.g. eye bolts)!** It is necessary to affix them in tapped holes. Any heat treatment will destroy the quenching. Flame-cutting, as used for steel, is also to be avoided. However, plasma cutting can be performed. Cutting saws or cutting mills are preferable.

**General Welding Information:** FORTAL is a high strength aluminum-based material alloyed with zinc, chromium, magnesium and copper. Its high strength is achieved by a multiple step heat treating and stretching process with the final step being an aging treatment at approximately 250°F. If the material is exposed to temperatures exceeding the final aging temperature, the mechanical properties (tensile strength, yield strength, and hardness) will be reduced. Therefore, a reduction in properties occurs adjacent to any weld and is unavoidable unless the component is re-heat treated, including both the solutionizing and aging cycles. Most codes and specifications including AWS D1.2, "Structural Welding Code — Aluminum," and the "Specifications for Aluminum Structures Construction Manual Series," published by the Aluminum Association, require for design purposes that the properties within one inch of any weld be assumed to be equal those of the material in the annealed condition. For this material, the annealed tensile strength is approximately 33,000 psi and

the yield strength 15,000 psi. FORTAL was developed to provide maximum mechanical properties and was not intended for use in welded structures. In addition to the unavoidable softening in the heat affected zone, (a condition which occurs with any heat treated or cold worked aluminum alloy), FORTAL has a wide solidification range (“mushy zone”) making it prone to microfissuring adjacent to a weld fusion line. These voids further lower the strength in the weld area. **For these reasons, welding of FORTAL is generally not recommended.**

Recognizing that welding may be the most economical process for repair or attachment of small brackets, clips or other relatively low stressed connections, the following information provides guidelines to be used when welding is performed. Considering the aforementioned difficulties in welding this material, welds must be limited to low stressed areas, and as with any welding process, some type of mechanical testing is recommended to ensure that the procedure used provides the required strength.

**Surface Preparation:** All aluminum alloys are covered with a tightly adherent oxide layer which naturally forms from atmospheric exposure. This oxide layer is both a thermal and electrical insulator and, in addition, melts at temperatures approximately three times that of the base metal. For these reasons, any good aluminum welding procedure includes removal of this oxide layer by chemical or mechanical means just prior to welding.

As with welding of any aluminum alloy, surface contamination, especially any oils, greases or other hydrocarbons, must be removed. The hydrogen from these materials is absorbed in the aluminum and on solidification forms porosity. The following is a recommended method for preparing a surface to be welded (just prior to welding).

Clean the weld area with a solvent to remove all soil, grease, oil or cutting fluids, and then remove the oxide layer using a powered stainless steel wire brush (chemical means can also be used for removing the oxide layer, however, these are generally better suited to high production applications).

**Joint Design:** If groove welding is to be performed, the groove angles, root openings, etc. must be sufficient to allow proper manipulation of the arc to obtain good fusion. Refer to AWS D1.2, “Structural Welding Code — Aluminum,” for recommended joint designs.

**Pre-Heating:** Pre-heating is not normally used for gas tungsten arc welding of aluminum alloys less than  $\frac{3}{16}$ ” thick or gas metal arc welding of materials less than 1” thick. Above these thicknesses, pre-heating can be advantageous to improve fusion and penetration. A 200°F pre-heat is normally sufficient. In order to reduce the

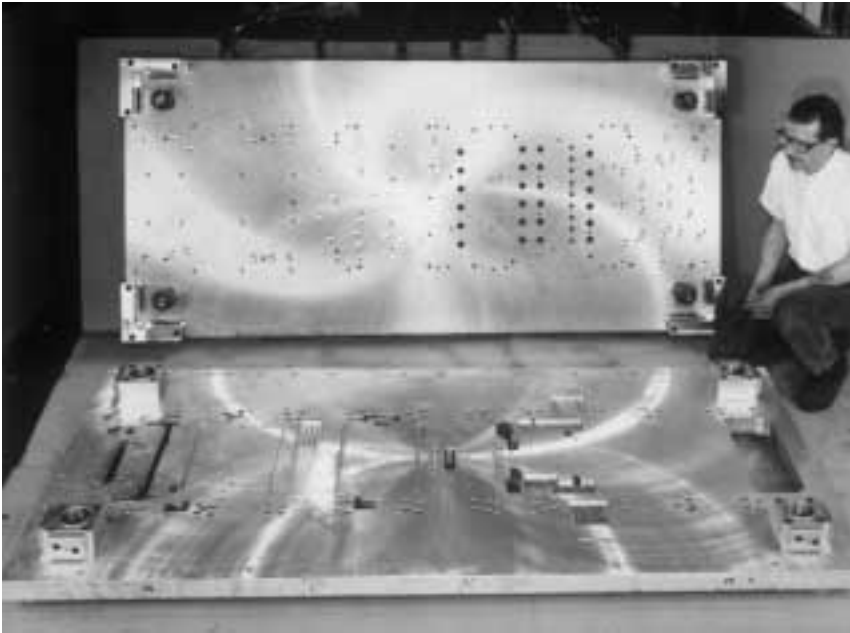
width of the heat affected zone and to not degrade the mechanical properties, pre-heating should not exceed 250°F. If pre-heating is used, the temperature should be controlled, preferably with a precision controlled tempering furnace, a contact pyrometer or with temperature-indicating crayons. Any areas that reach temperatures exceeding 250°F should be assumed to be of decreased mechanical properties.

**Welding Processes:** Both the gas tungsten arc welding (GTAW) and gas metal arc welding (GMAW) processes can be used. The GTAW process is much more controllable and generally produces welds of higher quality than the GMAW process. Due to the higher deposition rates attainable with the GTAW process, it is usually considered when a large volume of deposited weld metal is required.

For thinner sections, alternating current is usually used with the GTAW process with a straight argon shielding. Depending upon the welding gun size, argon flow rates are usually in the range of 30 to 70 CFH. For larger welds in heavier sections, DC straight polarity can be used normally with a helium shielding gas. Although the arc is less stable, helium increases penetration. Since helium is lighter than air, the flow rates must be increased to 60 to 140 CFH. Mixtures of the two gases can also be used with 75% helium — 25% argon and flow rates of 50 to 110 CFH being common. The gas tungsten arc welding process would be most appropriate for the welding of small brackets and other attachments.

For gas metal arc welding, direct current reverse polarity is used with either straight argon, straight helium, or mixtures of the two. As with gas tungsten arc welding, penetration is raised with increasing helium content, but at the sacrifice of some arc stability, gas metal arc welding would be appropriate for large repairs.

**Filler Metals:** As with the base metal, the filler metals for aluminum welding must be as clean and oxide free as possible. For this reason, filler metals should be stored in covered, preferably desiccated plastic bags. Contamination by shop soil or excessive exposure to moisture can result in weld porosity. Several filler metals can be used for welding FORTAL with either the GMAW or GTAW welding processes, depending upon the properties desired. The best selection for ease of weldability is 4043, because smooth weld profiles and good fusion can easily be obtained with proper techniques and parameters. Type 4145 is similar in both ease of weldability and mechanical properties. If higher strength is required, magnesium alloyed fillers such as 5356 or 5556 may be used, however, at a decrease in weldability. Higher heat inputs are often required to obtain good penetration and fusion. In addition, 5356 and 5556 are not recommended if the service temperature is above 150°F.



## Advantages of FORTAL over steel used in die sets

- **Weight is reduced up to 50-60%**
- **Inertial of the ram of the press is reduced by as much or more.**

This allows you to:

- Increase the speed of the press.
  - Increase the integrity of the tool.
  - Increase the thickness of the die shoes (if applicable).
  - Stop the die before LDC (Lower Dead Center).
- **Easier Handling and Die Set-up**
  - **Final cost of the die set can be reduced.**
  - **Other Advantages**
    - Machining time is cut by one third or more.
    - Less wear on the working elements of the press (breaks, clutches, etc.)
    - Save on energy to run the press.
    - Save on freight costs.

Die sets have always been made from steel (generally 1018 or 1025). Today die sets can be made of a revolutionary new aluminum alloy:

## FORTAL HR & HP

FORTAL has been used now for more than 10 years to manufacture die sets, and our intention is to share this vast experience with you. There are several reasons for using FORTAL die sets:

- It improves integrity of the tool.
- It improves productivity and the quality of manufactured parts.
- It helps reduce the total cost of the die set.

### **FORTAL Improves the Integrity and the Reliability of Stamping Production**

- Risks of damaging the die are greatly reduced.
- The production reliability of the die set is increased.
- The die set is lighter in weight which is easier to handle and set-up.
- The die set experiences no geometrical change or deformation.

Upper and lower die shoes made of steel account for the major portion of the weight of the tooling. The weight of the die and the speed of the press induce an inertial force which is difficult to control, as the weight of the die and the speed of the press are important. This can be a definite handicap in the event of a malfunction in the die. Furthermore, dies are equipped with sensors and security systems which are used to detect these malfunctions and give the order via relays to the press to stop. If halting the press proves to be impossible because of its inertia, the die can be badly damaged, if not destroyed.

The low density of FORTAL HR-HP (about  $\frac{1}{3}$  that of steel, see page 4) allows for a reduction of the weight of the die 50 to 60%. The inertia of the press is consequently reduced by as much, and the die can be stopped before the ram reaches the lower dead center (LDC), thus avoiding the potential for breaking elements in the die.

### **FORTAL Improves the Productivity of the Die**

- FORTAL dies can work at higher speeds (produce more).
- Handle and set-up easier (save time).
- Experience no geometrical variations of the die (better shaped parts).
- Have thicker die shoes with longer die springs (less maintenance and repair).
- Have increased rigidity because of thicker die shoes (higher accuracy).

For the same reasons as mentioned previously, the reduced weight of the die set allows for an increase in the speed of the press, which increases hourly production. Because the weight of the die shoe and punch holder is reduced as well, it is possible to increase their thickness. This makes it possible to use longer die springs, which last longer, require less maintenance, and help increase productivity by requiring fewer changes. Increased thickness means higher rigidity of the die shoes (since FORTAL has the same mechanical properties as 1025). This means that it is now possible to have higher precision and more consistent production of the part. Furthermore, FORTAL has a modulus of elasticity that is about one-third ( $\frac{1}{3}$ ) that of steel. This means that it can absorb three times as much shock and vibration as steel, which again increases the precision of the die. It should also be said that this alloy is “stress free,” and will not deform while being machined or in production. The mechanical properties are obtained through the heat treatment of the material (quenching and annealing). This would be sufficient to obtain a tension and stress free material without a special mechanical treatment occurring after quenching and before annealing, which consists of stretching the block with the use of a very powerful stretching machine (7000T).

## **FORTAL Reduces the Total Cost of the Die and Press Operation Costs**

- FORTAL die sets reduce machining costs.
- Reduce wear of the rotating parts of the press (breaks, clutches, etc.)
- Handling and set-up quicker and easier.
- Save energy to run the press and handle the dies.
- Require lighter storage rack structures. • Shipping costs are lower.
- Require less time to break down and set the ram of the press.

Aluminum can be machined three times faster than steel. On the average, machining time is reduced by about 35-45%, and since cutting tool wear is also reduced, the total cost of the die set can be reduced, despite the increased cost in raw materials. Another advantage of FORTAL is that it does not oxidate, so no protection of the die set is necessary.

## **Technical Data**

FORTAL undergoes complete heat treatment including: Solution heat treatment, Quenching, Controlled mechanical traction, and Annealing. At this stage, it has mechanical properties comparable to those of normalized 1018 or 1025 steel and similar steel commonly used for die sets.

## Die Design

Special attention is devoted to the design of the die sets made from FORTAL, especially for portions of the die set, or for the parts, undergoing fatigue constraints. It is necessary to put a radius on the inside angle to order to eliminate the risk of cracks. Since the coefficient of expansion is larger for FORTAL than it is for steel, and if the die is going to undergo an increase in temperature, the die must be designed so that the punch and die are constantly aligned. It is possible to achieve this by having different operating functions within the tooling. If the strip is piloted, it will be repositioned on each module, and the expansion of the die set is compensated by the elastic deformation of the strip. Advantages of this concept include:

- Every module can freely expand because of the heat without losing its alignment with the counterpart.
- Smaller elements to machine are consequently easier to machine because of less deformation, high precision, smaller machines, less cost, faster production, easier handling and maintenance repair.

## Bushing

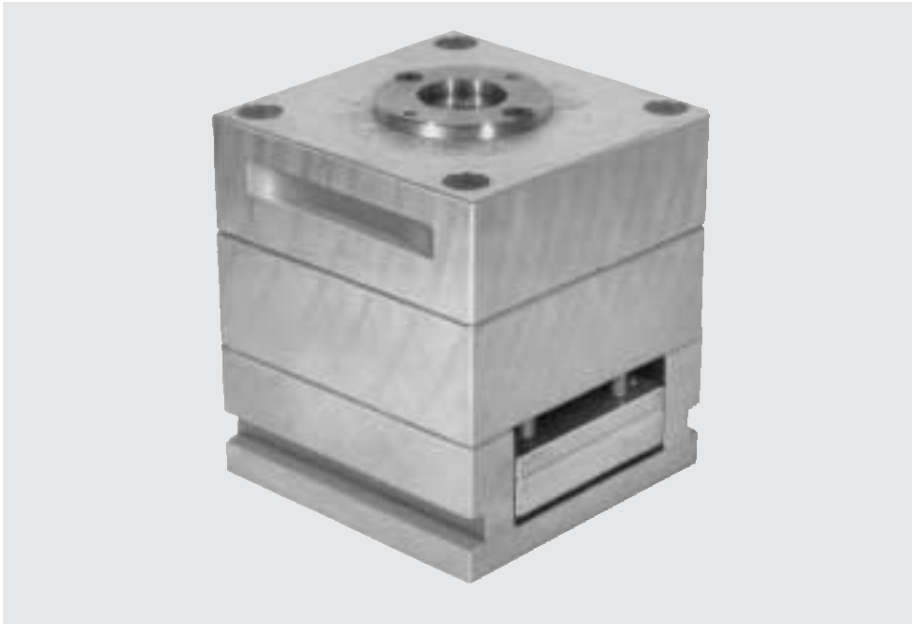
Tolerance to mount the bushing on the die set

- Bushing H4
- Boring in the die set N5

## Mounting Punches and Die

Punch holders and die holders can be recommended to increase the life of the tooling. This also brings with it the advantage of making any repair of the tool quicker and easier. Pressure or chock pads are not necessary for the punch if the surface is maintained. Sleeves or dowels are not necessary, but it may be recommended, as it sometimes is for steel die sets. Bottom pin holes and pins are tightly adjusted. Threaded holes do not require inserts (Helicoils™) unless mounting and demounting is frequent. Length should be bigger than twice the diameter.





## Advantages of Fortal Used In Mold Tooling

FORTAL is ideal for low production and prototype tooling applications. Reduce your mold lead time by using fewer electrodes, having faster EDM burn time, machine up to five times faster, and have easier polishability over conventional mold steels. Consistent material characteristics throughout FORTAL's cross section make it ideal for deep pocket machining. Use FORTAL for excellent wear and abrasion resistant components. FORTAL's ability to absorb shock and vibration assures accuracy of molded parts and less chance of rejects. Some helpful recommendations are:

- If sliding cores are used, we recommend that they are made from steel and that steel inserts are put in the cavities on rubber surfaces.
- FORTAL is suitable for making shut-offs if a 3-5° taper is made where the core enters the opposite tool half to prevent a problem of pick-up at the rubber surfaces.
- Blade ejectors lead to pick-up problems, round pins should be used and they should be nitrided. There is no need for inserts in the cavity at the ejector pin positions.
- Though there are no problems due to clamping pressure it would be better to use steel pressure plates on larger tools to prevent damage at the split line.
- It is possible to use more slender upstands in the cavities than with other aluminum alloys.
- The use of mild steel support and ejector plates will help to keep costs down.

**National Tooling and Machining Association's Mold Cavity Finish Specimen** Refined and defined — 29 different specimen finished in one block-size molded plastic reference case. Finish specimens are produced in this new guidelines book for easy reference.

**FORTAL Mold Cavity Finish Specimen.** This book presents 29 different surfaces on FORTAL that are convenient to use for producing a desired finish. A Superior FORTAL Finish Reference Guide Sheet is included with every book.

**When Ordering Please Specify:**

- Part Number (MFK-100 or MFK-200)
- Quantity



NTMA Surface Finish Reference Guide Sheet is included with each book. Detailed are 29 different surfaces produced by various finishing processes. The sheet finishes are keyed by number to matching numbers molded into the specimen book. Sheet finishes below are also represented in Superior's FORTAL Mold Cavity Specimen Book.

<b>10</b> Fine Diamond 6000 Grit (3x3 Micro Range)	<b>20</b> Med. Fine Diamond 3000 Grit (4x4 Micro Range)	<b>30</b> Med. Diamond 1500 Grit (5x5 to 7x7 Micro)	<b>130</b> Medium Buff 100 Raasper	<b>140</b> Medium Bead 140/200 Spherulite 100 P12 @ 5"	<b>150</b> Glass Bead 6 Micr. Super Abrasive #1 100 P12 @ 5"					
<b>40</b> Fine Diamond 6000 Grit (3x3 Micro Range)	<b>50</b> Fine Diamond 6000 Grit (3x3 Micro Range)	<b>60</b> Fine Diamond 6000 Grit (3x3 Micro Range)	<b>160</b> Paper Bead 60 200 Mesh Bead 50 P12 @ 5"	<b>170</b> Medium Sinter Bead 100 Mesh Bead 100 P12 @ 5"	<b>180</b> Coarse Sinter Bead 20 Mesh Maximum Circle					
<b>70</b> 600 Paper Diamond Bead 1000 Grit	<b>80</b> 600 Paper	<b>90</b> 500 Paper	<b>190</b> 500 Stone	<b>200</b> 500 Stone	<b>210</b> 100 Stone					
<b>100</b> 400 Stone	<b>110</b> Very Fine Buff Sinter Bead	<b>120</b> Fine Buff 300 20 Raasper	<b>220</b> Steel 120	<b>230</b> Steel 50-1	<b>240</b> Steel 50H	<b>250</b> Steel Sinter Coarse Diamond	<b>260</b> Steel 40000 F	<b>270</b> Steel 40000 F	<b>280</b> Steel 40000 F	<b>290</b> Steel 40000 F

Interior actual FORTAL mold cavity specimen surface finishes have been creating permitting the user to make side-by-side finish comparisons. Built for shop floor use.

## Frequently Asked Questions About FORTAL

**Q: Is FORTAL Comparable to other aluminum alloys?**

**A:** FORTAL was designed from an aircraft quality aluminum and developed for the metal working industry. The developers of FORTAL knew that in this industry, the core material is very critical because of pockets, holes and keyways that will be cut from the interior of the plate. FORTAL exceeds other brands of this alloy by having **extremely consistent** mechanical properties throughout the cross-section of the material (its the same - inside and out).

**Q: What is the hardness of FORTAL?**

**A:** The hardness of commonly used 1020 steel is approximately 143 Bhn. The hardness of FORTAL is approximately 150 Bhn. Several of our customers have registered readings of over 160 Bhn with FORTAL: **Try hitting it with at hammer!**

**Q: Do you have to use plugs/bushings in dowel or threaded holes?**

**A:** If you would use a plug/bushing in a 1020 steel plate, then you should use the same in FORTAL. FORTAL is harder.

**Q: How will the difference in “modulus of elasticity” affect my die?**

**A:** The property of springback is a function of the modulus of elasticity and refers to the extent to which metal springs back when an elastic deforming load is removed. FORTAL has a lower modulus of elasticity ( $10.3 \times 10^6$  PSI versus steel's  $30 \times 10^6$  PSI). Therefore, it will take a greater shock load without “mush-rooming” or deforming (better springback than steel).

**Q: How does FORTAL’s lineal coefficient of expansion affect my die?**

**A:** Lineal coefficient of expansion is the measure at which material expands or contracts based on temperature. FORTAL has a greater lineal coefficient of expansion than that of steel. However, since the thermal conductivity is some four times greater in FORTAL over that of steel, FORTAL will dissipate the heat (cold) calories faster and prevent the lineal expansion from occurring. Depending upon application, thermal conductivities (heat or cold dissipation) of FORTAL and steel should be considered in tooling design.

**Q: Can any lubricant be used when machining FORTAL?**

**A:** It is possible to use either cutting oils (mineral or soluble) or emulsions. Cutting oils are generally used to reduce friction during machining (drilling, milling, boring). Emulsions are preferable when it is necessary to cool down the cutting tools in pre-machining. As for emulsions, don't use products which are too alkaline (pH greater than 7), because they could damage the surface of the material. In this case, an inhibitor is to be added to the emulsion. Also, liquids containing chloride (CL) must try to be avoided. Tapping is typically done with "Tap Magic" or equivalent. When completing any machining process, a cleaning with water and a thorough drying is recommended.

**Q: What is the shear strength of FORTAL?**

**A:** Shear strength represents the ultimate failure strength of a material. The shear strength of FORTAL is 48,000 PSI (1020 steel is the same).

**Q: How are repairs performed on FORTAL?**

**A:** We do not recommend welding FORTAL. There are certain welding processes that can be performed. The common method of repair that is used is to plug or block the area of concern.

**Q: Explain "Radius on inside angle in order to eliminate the risk of cracks."**

**A:** The use of a radius in corners is just a good, basic machining practice. We can only recommend this practice, not enforce it.

**Q: How is Superior producing wear plate die sets using FORTAL?**

**A:** Since Superior is not currently recommending welding FORTAL, the manufacture of wear plate or boss die sets entails the use of screws. However, the die design is the critical factor and issues like forces, loads, block sizes, wear plate sizes and screw sizes must all be calculated.

**Q: How is Superior currently cutting FORTAL and what kind of tolerances can be expected?**

**A:** Before receiving our initial inventory of FORTAL, Superior purchased a large saw for cutting the plate. It will handle all of the sizes that we currently stock and larger. The saw is capable of cutting to the overall tolerances of our flame cutting machines (as indicated in our catalog). However, the capabilities of the saw do not include external shape-cuts or internal burn-outs. We are investigating different avenues for this requirement.

**Q: Can surface treatments be done to FORTAL?**

**A:** Typical surface treatments such as: black oxidizing, TEFLON® coating, kalon coating and color anodizing all can be done to FORTAL. Also, “hardcoat” anodizing can be done to FORTAL. Hardcoat anodizing is an electro-chemical process of converting aluminum to aluminum oxide. This process allows the production of a thicker wear and corrosion resistant coating (up to 0.004”). These hard coatings allow the use of aluminum in many design applications restricted to steel. The coating penetrates the surface as well as builds up on the parts in a one to one ratio. The anodized surface is dielectric. Hardcoating is an alternative to hard chromium plating. Wear resistance of this aluminum coating to hardened steel, and is often found to be used in molding industry.

**Q: What is the maximum temperature that FORTAL can be used at and still retain its normal properties?**

**A:** Superior recommends the working temperature of FORTAL not to surpass 140°F in order to retain its advertised properties. Serious material degradation occurs by 300°F in any form of 7075 T6, as indicated in the Machinist Handbook. Many users of 7075 T651 (QC7), will still use the alloy in excess of 200°F knowing that degradation is occurring but not to the point of complete failure, depending on the application involved. Since FORTAL is classified as 7075 T651, it can be substituted for any brand in this grade of aluminum alloy.

# FORTAL®

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