



DUPONT™ VESPEL® S FAMILY

MACHINING GUIDE FOR VESPEL® PARTS AND SHAPES

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Production Options to Meet Your Needs for Quality, High-Performance Parts

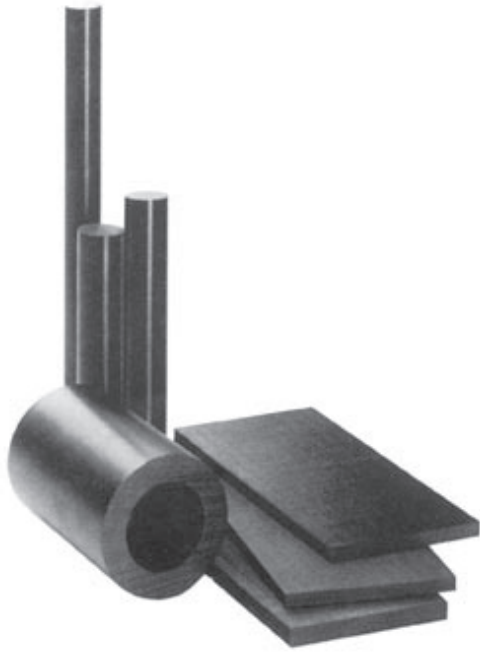


Tough, yet compliant DuPont™ Vespel® parts consistently perform in a range of physical environments that cause common materials to fail. Where trouble-free operation is key to commercial success, DuPont™ Vespel® parts can help keep your product running reliably.

DuPont™ Vespel® polyimide shapes are made by DuPont from high-performance SP and SCP polyimide resins, and are available as rods, tubes, plaques, rings, discs and/or bars. This information is designed to help you obtain the best possible results in machining DuPont™ Vespel® parts from these shapes.*

Parts machined from DuPont™ Vespel® shapes are ideal for prototype, low volume or complex geometry parts. Keep in mind, though, that if you need more than 500 parts at a time, they can often be manufactured more cost effectively by DuPont using our “direct-forming” process. For more information on direct-formed DuPont™ Vespel® parts, contact DuPont™ Vespel®.

*For other S products like SMP, ST, SF, and SMR, please contact DuPont.



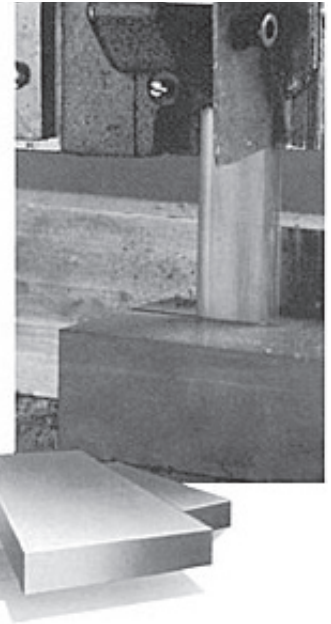
DuPont™ Vespel® shapes are relatively easy to machine because of their inherent mechanical strength, stiffness and dimensional stability at machining temperatures. In addition, they can be machined with standard metalworking equipment to produce parts to tolerances once considered too close for plastic materials. In most cases, the techniques used in machining metals are directly applicable.

Suggested Tooling

- **Tungsten Carbide Alloy Tooling.**
- **Diamond tooling suggested for large volume runs. High speed steels are not recommended.**

Special Considerations

- **Overheating** — Material may retain heat while machining. Do not allow the material to get so hot that it is uncomfortable to grasp with your bare hands. If overheating occurs, sharpen the tool and/or reduce the feed rate.
- **Light Work** — Use tools that work well with brass.
- **Tool Chatter** — Tools should have a 0° to 5° positive back rake angle and 0° to 5° back rake angle to reduce the possibility of tool chatter.
- **Special Sizes** — Large diameter (≥ 2.5 inches or 64 mm) or thin wall (≤ 0.125 inches or 3.2 mm) DuPont™ Vespel® parts have been successfully machined to close tolerances. To maintain dimensional stability, the part can be rough-machined to within 0.015–0.020 inch (0.4–0.5 mm) of finished size, then equilibrated to 70 °F (294 °K) and 50% relative humidity before final machining.



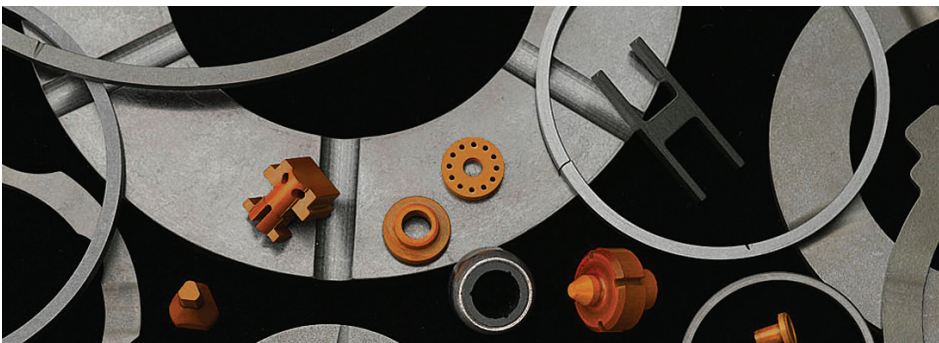
Sawing rectangular stock

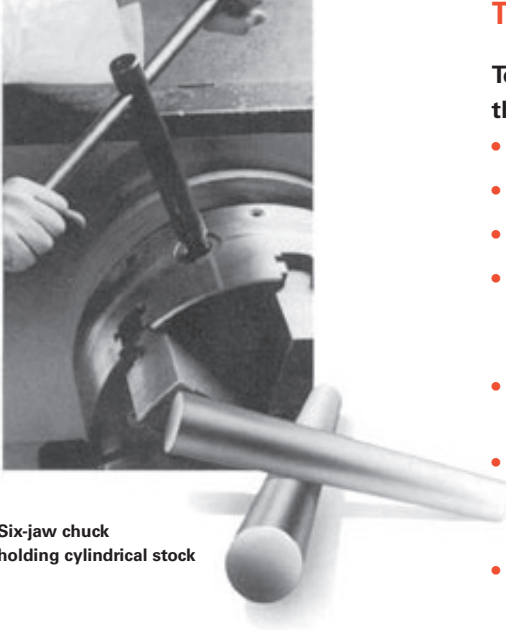
Sawing

DuPont™ Vespel® shapes cut easily with band saws. Follow these suggestions for best results.

Band Sawing:

- Sections of DuPont™ Vespel® material five inches thick can be cut on a vertical or horizontal band saw without coolant, using a sharp 10 teeth per inch blade with standard set.
- Finer blades can be used for cutting thinner sections.
- Use special alloy blades for most filled compositions.





Six-jaw chuck holding cylindrical stock

Turning

To produce good machining finishes on turned DuPont™ Vespel® parts, follow these suggestions:

- Turn using standard lathe, chucker or screw machine techniques.
- Use carbide-tipped or diamond tipped tools for work requiring close tolerances.
- Chip-breaker designed tools work well.
- Keep tool cutting edges sharp, with a nose radius of 0.003–0.008 inch (0.08–0.2 mm). Ensure sharpness by examining the cutting edge under 10× magnification, and hone the edge and nose radius with an 800-grit diamond hand hone if necessary.
- Speeds in the range of those used in the machining of brass are suggested. Stock speed can be varied over a wide range with good results.
- A coolant, preferably an aqueous-based solvent coolant, may be used to minimize thermal effects and maintain dimensional stability; however, cold air blast is generally preferred.
- Chattering could indicate a dull cutting tool or tool is extended too far from holder.

Table 1: Lathe Operating Conditions

	Cross Feed per Revolution	
	Inches	Millimeters
Rough Turning and Facing	0.010–0.020	0.25–0.51
Finish Turning and Facing	0.001–0.005	0.025–0.13
Rough Boring	0.010–0.020	0.25–0.51
Finish Boring	0.001–0.003	0.025–0.076
Parting	0.003–0.008	0.076–0.20

Holding

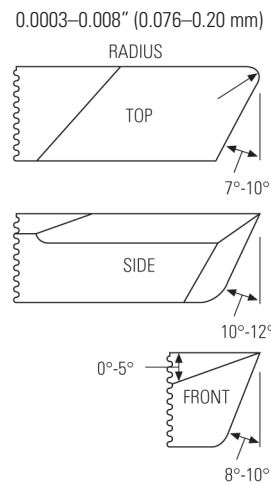
The main precaution in holding DuPont™ Vespel® shapes for machining is to prevent any deflection caused by the holding fixture, collet or chuck. Pneumatic or hydraulic chucking is recommended.

Unlike metal, plastics (including DuPont™ Vespel®) will deform if held too tightly.

Reliable Holding Methods:

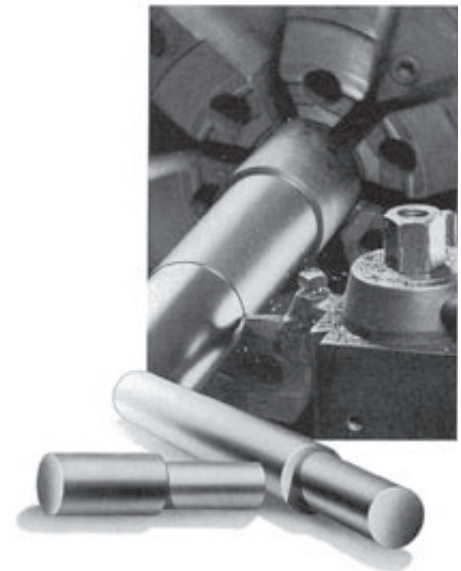
- **O.D. or I.D. Collet** — This is the most reliable holding device with sufficient pressure to ensure a good hold. Clamping force should be just enough to avoid deformation of the Vespel®.
- **Chuck** — Six-jaw type is suggested to distribute the holding force.

Figure 1: Lathe Tool

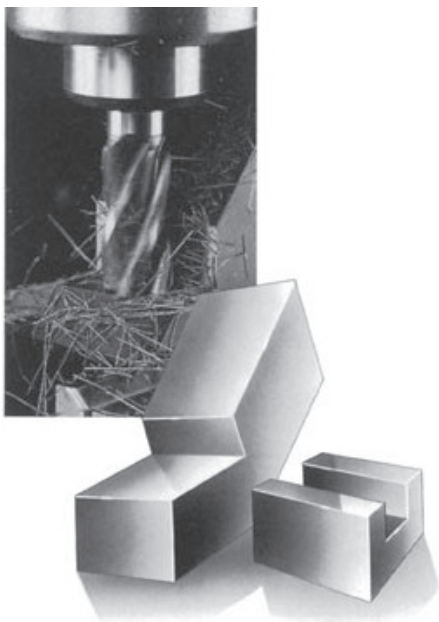


Lathe tool 0.075–0.20 mm

Note: Tool must be very sharp for good finish.



Turning cylindrical stock in a lathe



Groove Cutting with a Milling Machine

Milling

In general, milling operations which are used on metals may be used on DuPont™ Vespel® shapes. Exercise the same precautions regarding heat build-up, care in holding, sharpness of tools, avoiding dust inhalation, etc.

Avoid edge chipping by:

- Backing up edges with some other materials, like excess Vespel® material, other plastics or even wood, but not metal.
- Climb milling.
- Slowing cross feed to no more than 2 inches per minute when breaking through an edge.
- Using fly cutters whenever possible, as they work especially well.

Avoiding Chipout

To drill thin cross sections without chipout, follow these suggestions:

Use a drill with a 5° end relief or end mill. Feed automatically, if possible, or ease off feed pressure at breakthrough. Cutting speeds of 40–50 feet per minute should produce acceptable results.

Table 2: Milling

	Rough inch/rev (mm/rev)	Finish inch/rev (mm/rev)
Cross Feed	0.010 (0.25)	0.002 (0.05)
Down Feed	0.010 (0.25)	0.002 (0.05)
Depth of Cut	Up to 0.250 (6.4)	Up to 0.020 (0.51)

Drilling

DuPont™ Vespel® shapes are more elastic and some grades have a higher coefficient of thermal expansion than metal; because of this, they have a greater likelihood of seizing than metal. Depending on your application, the following drills and drill modifications can reduce the possibility of seizing.

- **Standard twist drill** — May be used to drill shallow holes (up to about one-half of the drill diameter in depth). Drilling holes deeper than one-half the drill diameter increases the risk of seizing.
- **Modified drill** — Differs from the standard twist drill in several ways:

Diameter is reduced along the full length of the drill body except for the leading 0.125 inch (3.2 mm) behind the lands.

Lip clearance is increased to 25–30° (versus standard 12–15°).

On drills, 1 inch (25 mm) diameter and larger, the thickness of the standard drill web could be reduced.

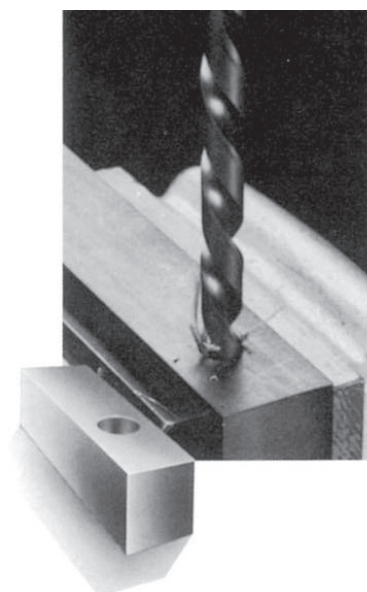
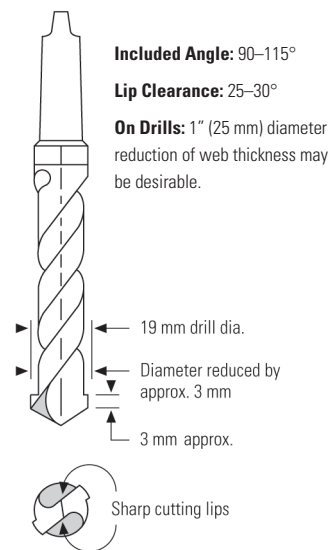
Use rates normally employed in cutting mild steels so that holes cut have good surface finishes.

- **Spade drills** — Give good surface finishes and reduced chipping when drill breaks through to other side.

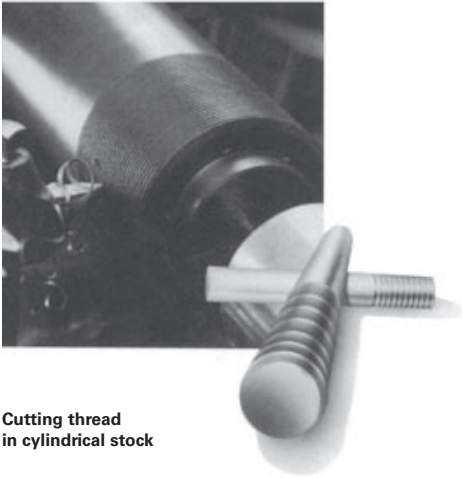
Close Tolerances

Deep blind holes are difficult to manufacture to close tolerances. Rough drill and bore whenever possible. Gun drills may be used with high pressure coolant to help remove chip buildup.

Figure 2: Modified Drill for Vespel® Shapes



Drill press operation



Cutting thread in cylindrical stock

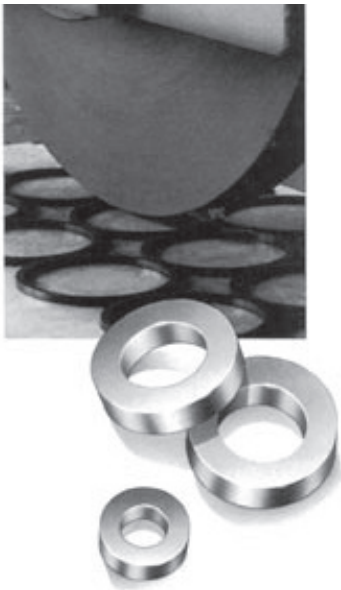
Threading

DuPont™ Vespel® shapes can be threaded using standard metal-cutting taps. The metal should not be allowed to heat to a point where thermal expansion will cause binding of the tap. Threads should be chased using a single point carbide tool and 30° compound feed whenever possible. The depth of feed should not exceed 0.005 inch (0.13 mm) on first pass and gradual reduction to 0.002 inch (0.05 mm) per pass until complete. Although this procedure will add additional cycle times to individual part production, it assures good thread quality results.

diamond dressed as for finish grinding of steel. To avoid material loading on the wheel, periodically check wheel for residual loading and clean as needed.

DuPont™ Vespel® rods and small tubes can be prepared for chucker and screw machine stock by centerless grinding. Standard setups used for steel with plenty of coolant flow are usually adequate. For double disk grinding, ultrasonic cleaning may be needed depending on cleanliness requirements of the final part.

Caution: Do not allow material to get hotter than is comfortable to handle with bare hands.



Grinding DuPont™ Vespel® rings

Grinding

DuPont™ Vespel® shapes can be ground to close tolerances on surface, double disc or centerless grinders at a table surface speed of approximately 80 feet per minute (24 meters per minute) for rough cuts and about half the speed for finish grinding on surface grinders. A 12-inch diameter ISO-22917:2004 grinding wheel (Aluminum Oxide, 46 grit, H8 Hardness, Vitriified) works well at surface speeds of 3,000–4,000 feet per minute (900–1200 meters per minute). The wheel should be

Table 3: Operating Conditions—Grinding

	Rough	Finish
Table Surface Speed	80 ft/min (24 m/min)	40 ft/min (12.2 m/min)
Transverse Feed	0.060 inch (1.5 mm)	0.005–0.060 inch (0.13–1.5 mm)
Down Feed	0.100–0.015 inch (2.5–0.38 mm)	0.001–0.0005 inch (0.025–0.013 mm)
Wheel Surface Speed	3000–4000 ft/min (915–1219 m/min)	3000–4000 ft/min (914–1219 m/min)

Buffing and Polishing

DuPont™ Vespel® parts can be polished to a high gloss with conventional muslin wheels. No special precautions are necessary beyond those normally practiced in this operation.

Deburring

Burrs can be removed using the same methods used on metal parts. DuPont™ Vespel® parts may also be tumbled in vibratory or rotating deburring equipment, along with abrasive media, tumbling detergent and water. Thin walls or pointed surfaces with angles less than 90° may experience chipping if tumbled. Hand deburring may be required. Another option for lapping is a diamond lapping block with 320 grit. Parts should be rinsed after tumbling to insure removal of detergent.

Lapping

To avoid impregnating DuPont™ Vespel® shapes with diamond or aluminum oxide compounds, follow these lapping suggestions for flat, highly polished surfaces:

- Use a wet or dry abrasive paper (such as 600 grit Norton Tufbak® Durite®) where the grit will be contained.
- Use a granite surface plate or equivalent to maintain flatness.
- Light machine oil can be used as a vehicle.
- Final lapping with crocus cloth will result in a finer finish.
- Additional surface polish can be obtained by lapping the DuPont™ Vespel® shapes on Kraft or tablet paper.

Measuring Parts

Although the same tools used to measure metal parts can be used to measure DuPont™ Vespel® parts, techniques differ because of the possibilities of greater deflection of plastic parts under the stress applied during measurement.

Parts should be measured in accordance with ASME Y14.5 for non-rigid materials. Parts should be conditioned in accordance with ASTM D618-08, in which test specimens are allowed to remain at a standard laboratory atmosphere for a minimum of 40 hours ($73.4^{\circ} \pm 3.6^{\circ}\text{F}$ with a relative humidity of $50\% \pm 5\%$). Tight tolerances may require parts to be machined and measured in a controlled environment.

Micrometer

When measuring the exterior diameter of a ring, do not use the micrometer in the usual fashion (twisting the barrel until it feels snug or until the ratchet slips) as this may actually deform the part, causing an incorrect reading. Instead, set the micrometer at the minimum reading of the tolerance and try passing the part through the gap, using the micrometer as a “no go” gauge. Use the same procedure for the upper tolerance limit, using the micrometer as a “go” gauge. The part should pass through without any pressure applied. To minimize distortion of thin-walled cross sections, a correctly-sized plug gauge may be inserted into the part. A non-contact method such as a Coordinate Measurement Machine (CMM) is also recommended with proper restraint if needed.

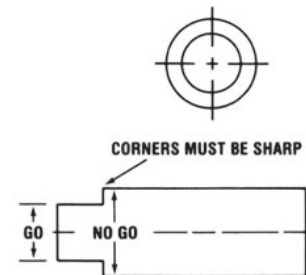
Plug Gauge

When measuring hole sizes with a plug gauge, avoid forcing the plug into the hole, as it is entirely possible to force a plug gauge into a hole as much as 0.004 inch (0.10 mm) under the plug gauge size, depending on the part design. Generally, plug gauges are better than micrometers because of the deformation the micrometers may cause.



Measuring parts

Figure 4: “Go–No Go” Gauge



Waterjet/Laser Cutting

Waterjet and laserjet cutting can be performed on Vespel® but is recommended only when rough cutting is needed. Assume material is similar to a soft metal (aluminum or brass) when setting your equipment.

Engineering Controls to Minimize Exposure to Nuisance Dust from Machining

Wet machining is the preferred method since the liquid both cools the parts and reduces dust generation. Aqueous-based coolants are preferred. Organic-based cutting fluids may degrade the in-use performance of the product and should not be used. Clean parts after cutting or before use. As with any wet machining technique, mist collection systems should be used. If parts require cleaning after dry machining, rinse with deionized water. If parts require cleaning after wet machining, remove cutting fluids with soap and water. Machining conditions are correct when no smoke is generated during machining. Do not allow the material to get so hot that it is uncomfortable to grasp in your bare hands. Ensure adequate ventilation. Use only in area provided with appropriate exhaust ventilation. Any process that has the potential to generate dust should be

performed using engineering controls, such as isolation, enclosures, local exhaust ventilation, wetting with coolant, or dust collection systems, to control airborne fibers and dusts below applicable limits. Avoid significant deposits of material which may become airborne and form combustible dust clouds.

Safety Precautions for Machining DuPont™ Vespel® SP-211 and SP-221 Parts*

DuPont™ Vespel® SP-211 and SP-221 parts and shapes contain PTFE. Because PTFE particles can become airborne during machining operations, the precautions below should be observed. Review safety data sheets or article information sheets first.

- Avoid generating excessive heat during machining. The thermal decomposition vapors of fluorinated plastics may cause polymer fume fever with flu-like symptoms in humans, especially when smoking contaminated tobacco.

Symptoms usually appear after several hours and resolve within 1 to 2 days. Repeated episodes of polymer fume fever may result in persistent lung effects. Polymer may extensively decompose if severely overheated or burned. Inhalation of fluorinated decomposition products may cause lung irritation and pulmonary oedema. Symptoms may be delayed for several hours. Symptoms may be severe or life-threatening.

- Do not sand SP-211 or SP-221 without adequate ventilation equipment.
- Keep materials for smoking, such as cigarettes and pipes, out of the immediate machining area, as airborne particles of PTFE may contaminate them.
- Avoid inhaling dust. Dust containing PTFE particles may cause respiratory tract irritation.
- Wash hands thoroughly before smoking or eating.

*Refer to the Safety Data Sheet (SDS) or Article Information Sheet (AIS) for other Vespel® products.

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(05/09) VPE-A40006-00-A0814 Previous # K-22000