VESPEL®

FOR PERFORMANCE THAT PAYS

YOUR GUIDE TO MACHINING VESPEL® POLYIMIDE PARTS

DUPONT®

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

Tough, yet compliant 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, VESPEL parts can help keep your product running reliably.

VESPEL shapes are made by DuPont from high-performance SP polyimide resins, and are available as rods, tubes, plaques, rings, discs and bars. This brochure is designed to help you obtain the best possible results in machining VESPEL parts from these shapes.

Parts machined from 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 VESPEL parts from DuPont, contact your local VESPEL sales engineer or write:

DuPont Company,
VESPEL Parts Marketing Section,
Wilmington, DE 19898;
telephone toll free:
800-222-VESP.

General Machining Procedures

Suggested Tooling

■ ***Carbide Tooling:*** C-2 grade

■ ***Kennametal K-11, Carbaloy 895*** or equivalent: When tool life is particularly important.

■ ***High Speed Steel:*** For short runs on multiple-point tools such as end-mills, countersinks and reamers.

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 case, the techniques used in machining metals are directly applicable.

Special Considerations

■ ***Overheating:*** Do not allow the material to get so hot that it is uncomfortable to grasp with your bare hands. If overheating occurs, resharpen the tool and/or reduce the feed rate.

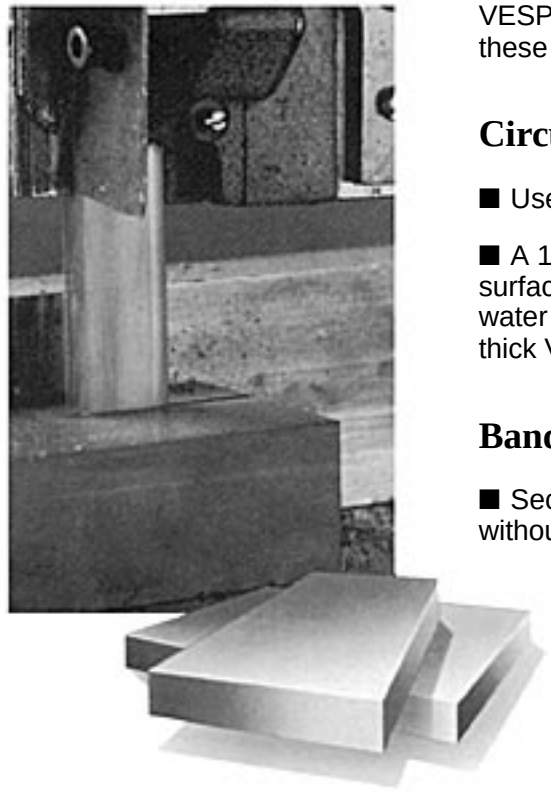
■ ***Light Work:*** Use tools that work well with brass.

■ ***Tool Chatter:*** Tools should have a 0° to 5° positive side rake angle and 0° back rake angle to reduce the possibility of tool chatter.

■ ***Special Sizes:*** Large diameter ($2^1/_2$″ or 64 mm) or thin wall ($^1/_8$″ or 3.2 mm) VESPEL parts have been successfully machined to close tolerances. To maintain dimensional stability, the part can be rough-machined to within 0.015″ to 0.020″ (0.4–0.5 mm) of finished size, then equilibrated to 70°F (294°K) and 50% relative humidity before final machining.

Sawing

Sawing rectangular stock



VESPEL shapes cut easily with either circular or band saws. Follow these suggestions for best results:

Circular Sawing

■ Use a sharp blade without “set”.

■ A 10-inch diameter saw with 8–12 teeth per inch operating at a surface speed of 6,000–8,000 ft./min. (1830–2440 m./min.) with water as a coolant has been successfully used to cut three-inch thick VESPEL stock.

Band Sawing

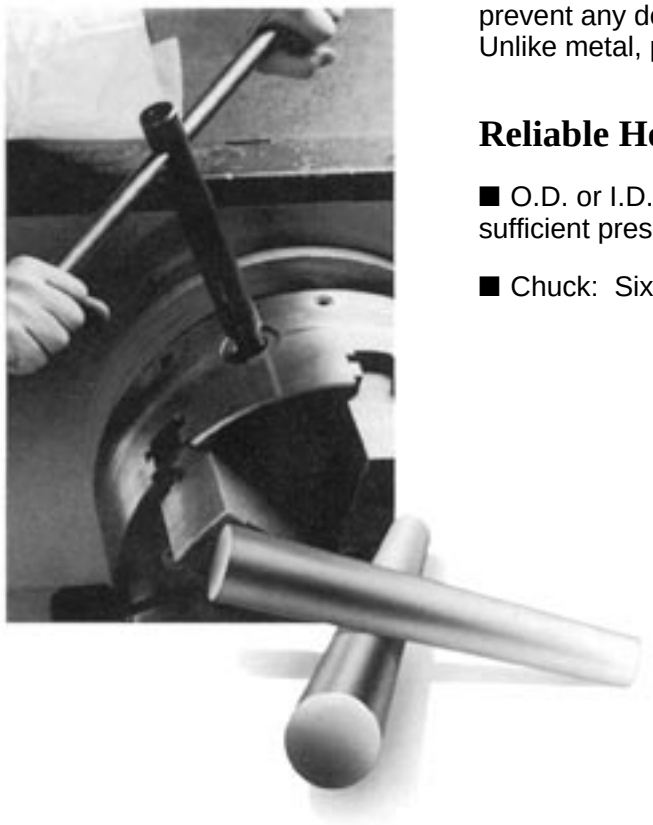
■ Sections of VESPEL five inches thick can be cut on a band saw without coolant, using a sharp 10 teeth/inch blade with standard set.

■ Finer blades can be used for cutting thinner sections.

■ Use special alloy blades for most filled compositions.

Holding

Six-jaw chuck holding cylindrical stock



The main precaution in holding VESPEL shapes for machining is to prevent any deflection caused by the holding fixture, collet or chuck. Unlike metal, plastics, including VESPEL, will deform if held too tightly.

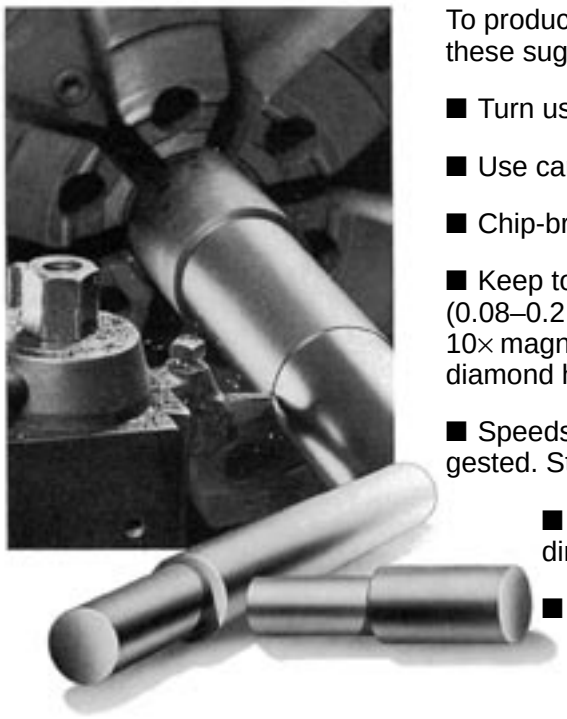
Reliable Holding Methods

■ O.D. or I.D. Collet: This is the most reliable holding device with sufficient pressure to ensure a good hold.

■ Chuck: Six-jaw type is suggested to distribute the holding force.

Turning

Turning cylindrical stock in a lathe



To produce good machining finishes on turned VESPEL® pieces, follow these suggestions:

■ Turn using standard lathe, chucker or screw machine techniques.

■ Use carbide-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″ to 0.008″ (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.

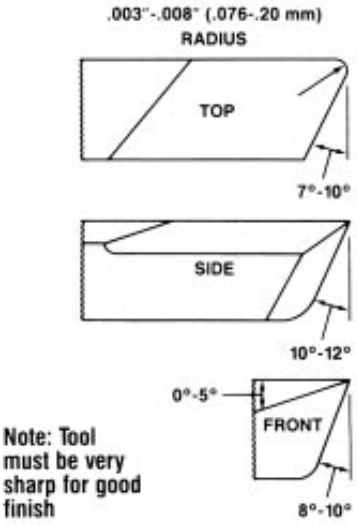
■ A coolant may be used to minimize thermal effects and maintain dimensional stability.

■ Chattering could indicate a dull cutting tool.

TABLE I
Lathe Operating Conditions

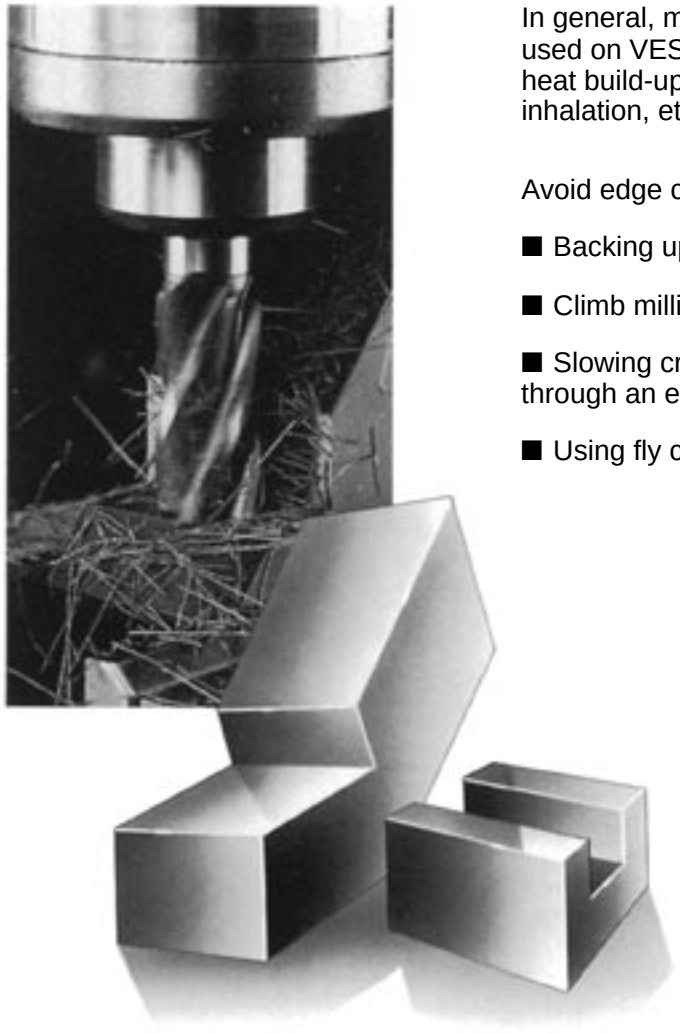
	Cross Feed Per Revolution	
	Inches	Millimeters
Rough Turning and Facing	0.010–0.020	0.25–0.51
Finish Turning and Facing	0.001–0.005	0.025–0.13
Rough Boring	0.010–0.020	0.25–0.51
Finish Boring	0.001–0.003	0.025–0.076
Parting	0.003–0.008	0.076–0.20

FIGURE I
Lathe Tool



Milling

Groove Cutting with a Milling Machine



In general, milling operations which are used on metals may be used on 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 material.
- Climb milling.
- Slowing cross feed to no more than 2″ per minute when breaking through an edge.
- Using fly cutters whenever possible, as they work especially well.

TABLE II
Milling

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

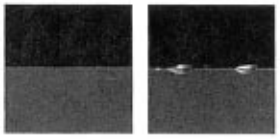
Avoiding Chipout

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.

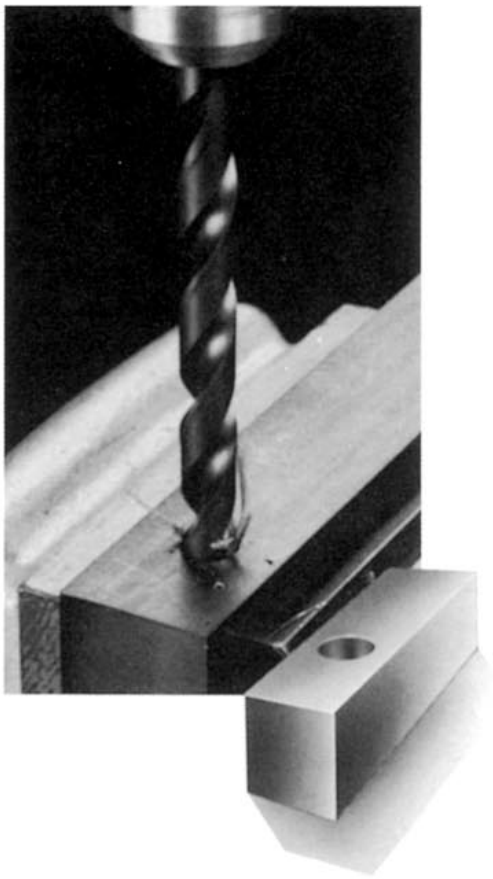
Cutting speeds of 40–50 feet per minute should produce acceptable results.



Clean Edge Edge Chipping

Drilling

Drill press operation



VESPEL® parts are more elastic and 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 $^1/_8$″ (3.2 mm) behind the lands.

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

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

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

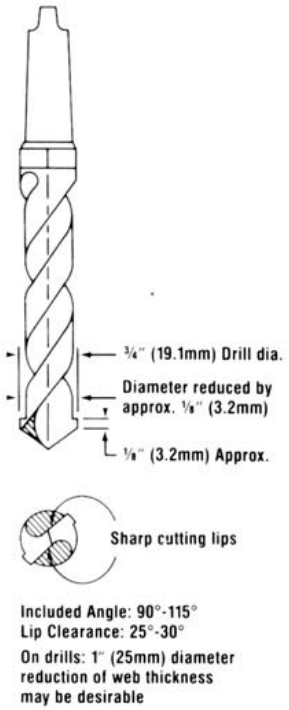
■ *Spade drills*

Give good surface finishes and reduced chipping when drill breaks through to other side.

Close Tolerances

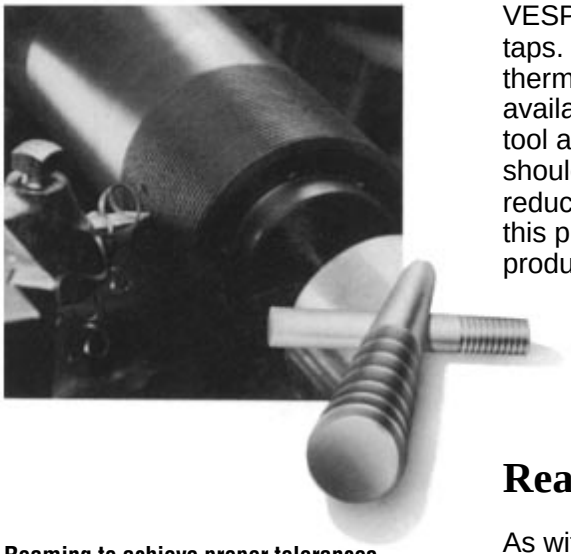
Deep blind holes are difficult to manufacture to close tolerances. Rough drill and bore whenever possible. Gun drills may be used with high pressure coolant to help remove chip buildup.

FIGURE 2
Modified Drill For VESPEL Shapes



Threading

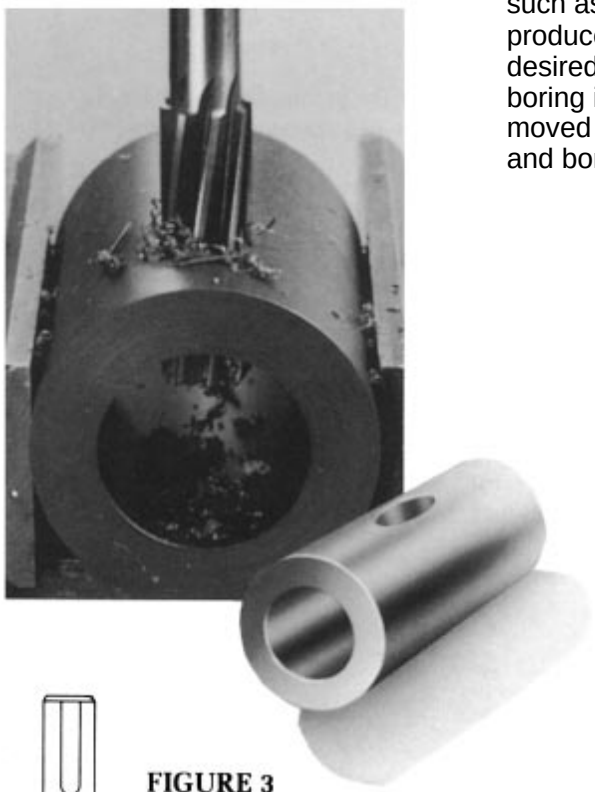
Cutting thread in cylindrical stock



VESPEL shapes can be threaded using standard metal-cutting taps. Take care to keep material from heating to a point where thermal expansion will cause binding of the tap. If facilities are available, 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″ (0.13mm) on first pass and gradual reduction to 0.002″ (0.05mm) per pass until complete. Although this procedure will add additional cycle times to individual part production it assures good thread quality results.

Reaming

Reaming to achieve proper tolerances



As with drilling, reaming VESPEL shapes requires a modified tool, such as the one shown in Figure 3, to avoid seizing. Reaming may produce a tapered hole 0.001–0.002″ (0.025–0.005mm) larger than desired because of temperature buildup. For closer tolerances, boring is better. At least 0.015″ (0.4mm) should be left to be removed in the boring operation. Deep on-size holes can be reamed and bored with techniques normally employed in cutting mild steels.

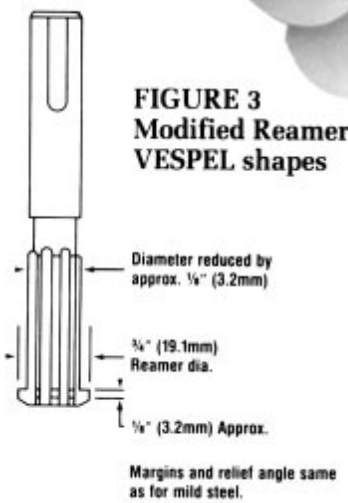


FIGURE 3
Modified Reamer For VESPEL shapes

Grinding VESPEL rings

Grinding

VESPEL® shapes can be ground to close tolerances on surface, double disc or centerless grinders at a table surface speed of approximately 80 ft./min. (24 m./min.) for rough cuts and about half that for finish grinding on surface grinders. A 12″ diameter 32A46-H8VG wheel works well at surface speeds of 3,000–4,000 ft./min. (900–1200 m./min.). The wheel should be diamond dressed as for finish grinding of steel.

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.

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

Buffing and Polishing

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. VESPEL parts may also be tumbled in vibratory or rotating deburring equipment, along with abrasive media, tumbling detergent and water.

TABLE III
Operating Conditions—Grinding

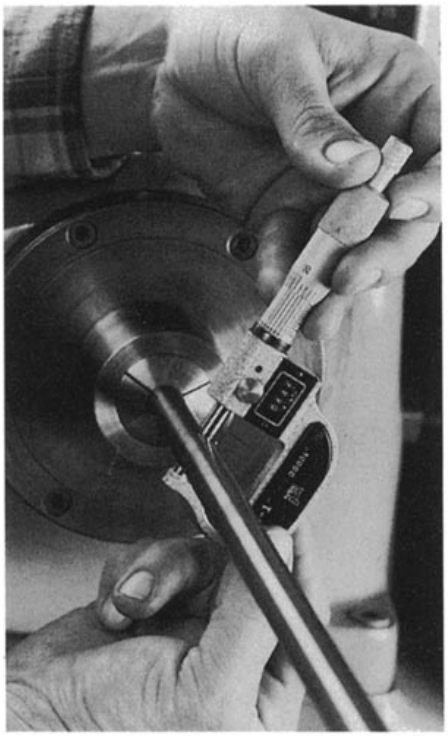
	Rough	Finish
Table Surface Speed	80 ft/min (24 m/min)	40 ft/min (12.2 m/min)
Transverse Feed	0.060″ (1.5mm)	0.005″–0.060″ (0.13–1.5mm)
Down Feed	0.100″–0.015″ (2.5–.38mm)	0.001″–0.0005″ (0.025–0.013mm)
Wheel Surface Speed	3000–4000 ft/min (915–1219 m/min)	3000–4000 ft/min (914–1219 m/min)

Lapping

To avoid impregnating 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 VESPEL shapes on Kraft or tablet paper.

Measuring Parts

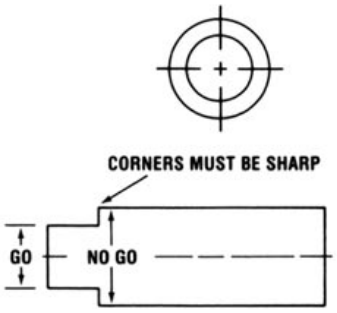


Although the same tools used to measure metal parts can be used to measure VESPEL parts, techniques differ because of the possibilities of greater deflection of plastic parts under the stress applied during measurement. Parts should be conditioned in accordance with ASTMD616, Procedure AA, in which test specimens are allowed to remain at a standard laboratory atmosphere for a minimum of 40 hours (73.4° ± 3.6°F with a relative humidity of 50% ± 5%).

Micrometer

When measuring the O.D. 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. Rather, 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 I.D. plug may be inserted into the part.

FIGURE 4
"Go" — "No Go" Gauge



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″ (0.10mm) under the plug gauge size, depending on the part design. Generally, plug gauges are better than hole micrometers because of the deformation the micrometers may cause. Air gauges work well for measuring internal diameters.

Safety Precautions for Machining TEFLON® Filled SP-211 and SP-221

VESPEL parts and shapes made from SP-211 and SP-221 resins contain 10% and 15% TEFLON PTFE resin by weight, respectively. Because PTFE particles can become airborne during machining operations, the following precautions should be observed.

■ When machining or cutting, use coolant—preferably cutting oil or water soluble coolant oil. 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, and wash hands thoroughly before smoking or eating.

More information on the benefits and properties
of VESPEL® parts is available in these brochures:
"Introduction to VESPEL Parts"
(E-61486)
"Summary of Typical Properties"
(H-15724-1)
"VESPEL Shapes: Machining Stock of SP Polyimide"
(E-61482-1)

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