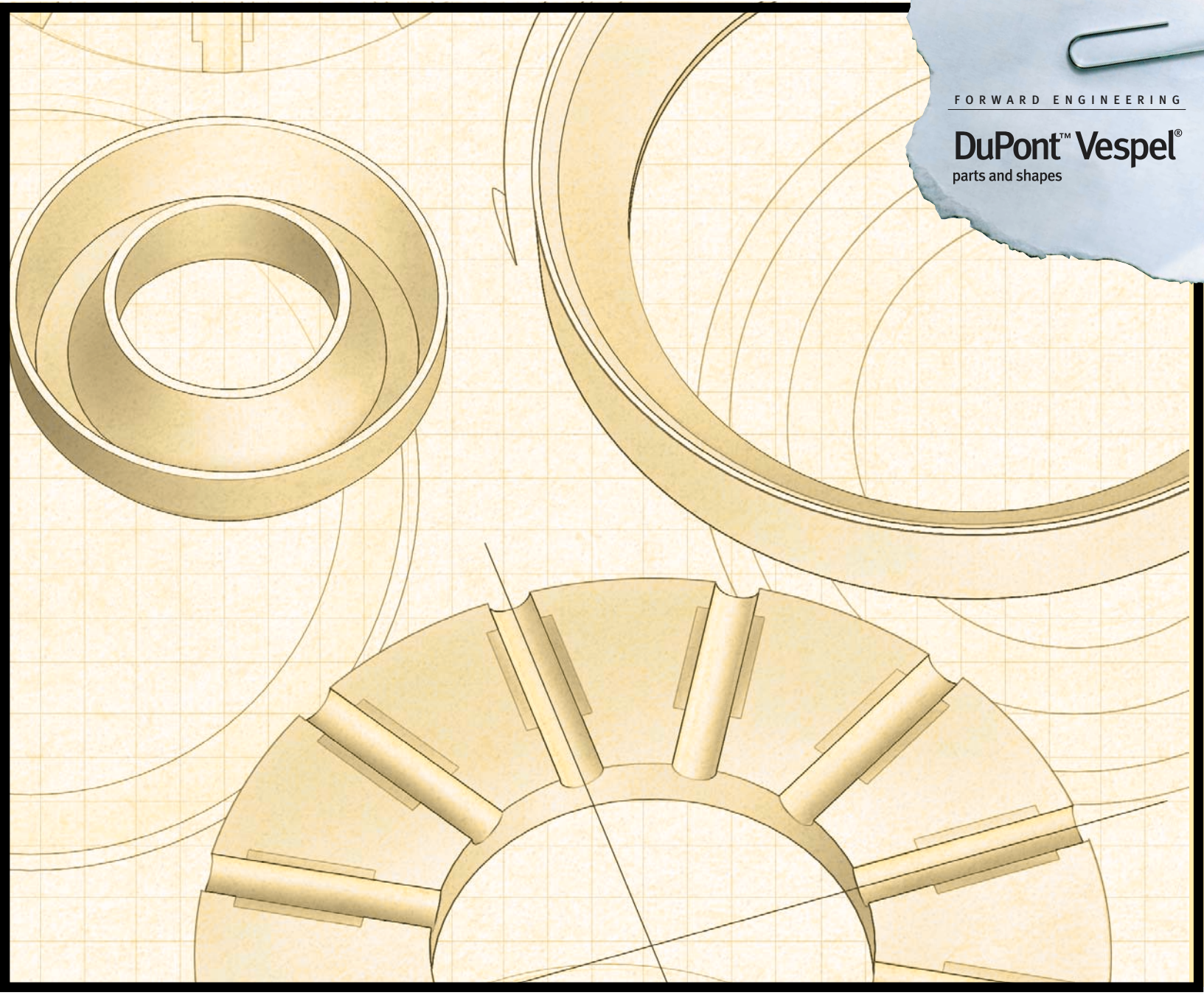

FORWARD ENGINEERING

DuPont™ Vespel®
parts and shapes

VESPEL®
CR-
6100
&
6200

FOR SUPERIOR CHEMICAL AND CREEP RESISTANCE

GENERAL MACHINING GUIDE

DUPONT
The miracles of science™

VESPEL®

CR- 6100 & 6200 FOR SUPERIOR CHEMICAL AND CREEP RESISTANCE

DuPont™ Vespel® CR chemical- and creep-resistant parts are a family of DuPont proprietary products that offers superior chemical and creep resistance, particularly at elevated temperatures. First in this family of products is a carbon fiber-reinforced fluoropolymer. Therefore, its machining characteristics are very similar to that of Teflon® products. It can be machined with standard metalworking equipment to produce tolerances once considered too close for polymer-based materials. This is possible due to the material's inherent mechanical strength, stiffness and dimensional stability at machining temperatures. In most cases, the techniques used in machining metals are directly applicable.

This document is intended to be used as a guide only. The speeds and feeds recommended for specific machining operations are given as a starting point based upon the experience of the DuPont composite parts manufacturing organization.

Special Considerations

- **PROCESSING SAFETY**

  WARNING! VAPORS CAN BE LIBERATED IF MATERIAL IS OVERHEATED, WHICH MAY BE HAZARDOUS IF INHALED.

  Before machining Vespel® CR, read the Material Safety Data Sheet. Vapors or fumes liberated from overheating, or from smoking tobacco products contaminated with machining dust, may cause flu-like symptoms (chills, fever, sore throat), commonly known as polymer fume fever. This condition may not occur until several hours after exposure and will typically pass within 36 to 48 hours. Vapors and fumes liberated during machining should be exhausted completely from the work area; avoid contamination of tobacco with machining dust.

  As in machining all fluoropolymer materials, part temperatures should be maintained below 300°C (572°F) to avoid thermal decomposition. This can be accomplished by using the following standard polymer machining guidelines:

  – Use coolant while machining or cutting, preferably a water-soluble coolant oil.
  – If no coolant is used, provide adequate ventilation.
  – 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.

- **SUGGESTED TOOLING**

  The carbon fiber reinforcement in DuPont™ Vespel® CR can increase tool wear. Therefore, carbide-tipped tools, and in cases of long machining runs, poly crystalline diamond (PCD)–tipped tools, are recommended. Also, light grinding is an acceptable method of machining contours and/or finished part dimensions.

Sawing and Drilling

Vespel® CR are easily cut and drilled. Sawing and drilling guidelines typically used for materials such as aluminum can be used for machining Vespel® CR.

When machining large part quantities, special consideration should be given to tool selection for maximized tool life and cut quality.

For cutting large quantities of material with a band saw, a 6 TPI carbide-tipped blade, with a standard saw set at 500 FPM is recommended.

For drilling large quantities of material, a carbide-tipped drill is recommended to minimize tool wear.

Holding Vespel® CR Shapes

The main precaution in holding Vespel® CR shapes for machining is to prevent any deflection caused by the holding fixture, collet or chuck. Unlike metal, polymer matrix composites will deform if held too tight.

- **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: Pie-Jaws that contact approximately 90% of the O.D. surface are recommended for uniform distribution of holding forces when machining thin-walled, tight-tolerance parts.

Turning

Vespel® CR can be machined by using standard lathe, chucker or screw techniques. To produce good machining finishes on turned Vespel® CR pieces, follow these suggestions:

- – Use PCD tools for work requiring close tolerances.
- – Tools with a 20° to 25° rake angle at the front face and a positive (0° to 5°) back rake angle will help remove machining waste.
- – Use coolant to minimize thermal effects and maintain dimensional stability.
- – Feeds and speeds used for turning aluminum can be used as a guideline for Vespel® CR.

Milling

In general, milling conditions for DuPont™ Vespel® CR are similar to those used for metals. One should exercise the same precautions previously mentioned regarding heat buildup and care in holding.

- **RECOMMENDED PRACTICES**
  - – Avoid overtightening in fixture to avert material deflection.
  - – Use 3 or 4 flute carbide-tipped end-mills or fly cutters whenever possible, as they work especially well.
  - – Cross and down feeds listed below have been demonstrated to produce good results:

	Cross feed (in./rev.)	**Down feed** (in./rev.)
Rough Machining	0.004 - 0.006	0.002 - 0.004
Finish Machining	0.003 - 0.005	0.002 - 0.004

Grinding

Close tolerance and contour machining can be achieved by grinding. A diamond dresser as used in steel finishing provides good results. Best results are obtained by removing small amounts of material using light grinding passes. Again, we recommend using plenty of coolant to avoid dimensional instability and thermal decomposition.

Typical operating conditions when using a 1/2 in. wide, 7 in. wheel are:	
Table Surface velocity	80 ft./min.
Cross feed	0.050 - .200 in./pass
Down feed	0.0005 - 0.001 in./pass
Wheel Surface Speed	3,000 - 4,000 rpm

Measuring/Inspecting Parts

Although the same tools used to measure metal parts can be used to measure Vespel® CR parts, techniques differ because the possibility of deflection is greater with polymer matrix parts under the stress applied during measurement.

- **MICROMETER**

  When measuring the O.D. of rings (especially thin-walled), 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 parts, causing an incorrect reading of the tolerance. Rather, try passing the parts through the gap, using the micrometer as a “no go” gauge. Follow 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 parts.

- **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 in. 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.

- **SURFACE FINISH**

  Inspect surface finishes using a visual reference. Measurements obtained using a surface profilometer can be erratic due to differences in hardness between polymer matrix and fiber reinforcement.

General Safety Considerations

– Please read MSDS (Material Safety Data Sheet) before machining.
– Avoid inhaling dust, and wash hands thoroughly before smoking or eating.
– Keep materials for smoking, such as cigarettes and pipes, out of the immediate machining area, as airborne particles of Teflon® may contaminate them.

Machining Tolerance Guidelines

The following table has been assembled as a quick reference guide outlining some typical machining tolerances achievable using DuPont™ Vespel® CR. This is not meant to represent the product's limitations.

Feature	Standard	Best (Small)	Best (Large)
I.D. (Ave.)	±0.005	±0.0005	±0.001
O.D. (Ave.)	±0.005	±0.0005	±0.001
Length	±0.005	±0.001	±0.001
Counterbore Diameter	±0.005	±0.001	±0.001
Filet Radius	±0.010	±0.005	±0.005
Chamfer Depth	±0.005	±0.002	±0.002
Counterbore Depth	±0.005	±0.002	±0.002
Countersink Diameter	±0.010	±0.0025	±0.0025
Concentricity	0.005	0.001	0.002
Roundness	0.010	0.001	0.003
Run-out (Face)	0.005	0.002	0.003
Squareness	0.005	0.002	0.003
Flatness	0.005	0.001	0.003
Angularity	±5°	±2°	±2°
Surf. Finish (Machined)	125 RMS/Ra	63 RMS/Ra	63 RMS/Ra
Surf. Finish (Stamped)	250 RMS/Ra	250 RMS/Ra	250 RMS/Ra
Surf. Finish (Lapped)	32 RMS/Ra	32 RMS/Ra	32 RMS/Ra

Notes: (1) All tolerances are given in inches unless otherwise noted.
(2) Small implies O.D. < 4 in., Length < 1 in., and/or Wall Thk. < 0.1 in.
(3) Surface finishes based upon comparison with visual equivalents.

For more information about DuPont™ Vespel®:

UNITED STATES
DuPont Engineering Polymers
Pencader Site
Newark, DE 19714-6100
Tel: 800-222-VESP
Fax: (302) 733-8137

EUROPE
DuPont de Nemours
(Belgium) BVBA-SPRL
Engineered Parts Center
A. Spinoystraat 6
B-2800 Mechelen
Belgium
Tel: ++32 15 441527
Fax: ++32 15 441408

ASIA-PACIFIC

Japan
DuPont K.K.
Arco Tower
8-1, Shimomeguro 1-chome
Meguro-ku, Tokyo 153-0064
Tel: 03-5434-6989
Fax: 03-5434-6982

Korea
DuPont Korea Limited
4/5 Floor, Asia Tower, #726
Yeoksam-dong, Kangnam-ku
Seoul 135-082
Tel: 02-222-5200
Fax: 02-222-5470

Taiwan/China
DuPont Taiwan Limited
13th Floor, Hung Kuo Building
167, Tun Hwa North Road
Taipei, Taiwan 105
Tel: 02-719-1999
Fax: 02-712-0460

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