## **CONDENSED**

## Mold Design And Processing Conditions

A Guide to Processing Injection Molding Grade Specialty Compounds

**SI Metric** 



web site: www.rtpcompany.com

# **Operating Conditions**



## **Standard Molding Equipment**

**Machine Type:** We recommend using a screw injection machine for molding reinforced thermoplastics. A screw injection machine improves melt homogeneity, reduces variations in the molded parts, and minimizes degradations and cold spots of the polymer melt.

**Machine Size:** The machine should be sized to use approximately 50-70% of machine barrel capacity per shot. This maintains a short barrel residence time and eliminates material degradation. The machine should have adequate clamp pressure to obtain 55-110 N/mm<sup>2</sup> of projected surface area. Generally, a reinforced material requires 50-70% higher clamping pressures than a nonreinforced polymer of the same type.

## Molding Conditions

**Drying:** Successful molding of reinforced thermoplastics requires adequate drying. Inadequate drying can cause extremely erratic molding conditions and less than perfect molded parts. Excessively wet materials outgas and can undergo a viscosity change during processing. This may cause brittleness, blisters, voids, silver streaking and poor surface finish. RTP Company materials are dried prior to packaging in moisture resistant containers. However, we recommend thoroughly drying the materials in a dehumidifying type dryer. This is important with hygroscopic materials but can also be essential for non-hygroscopic materials. Condensed surface moisture can dramatically affect high temperature molded parts. The recommended drying times are provided as guidelines; however, an actual moisture check is necessary.

**Barrel Temperature:** Typically the rear zone/zones are set 6-12° C cooler than the front zone and nozzle. Some modifications may be needed depending on part size and configuration.

**Melt Temperature:** Use the Processing Conditions Chart in this guide for recommended starting temperatures.

**Mold Temperature:** Use the Processing Conditions Chart in this guide for recommended starting temperatures. Normally, reinforced materials require higher mold temperatures than nonreinforced materials. Higher mold temperatures will achieve a smoother, more blemish-free surface by providing a resin rich skin on reinforced materials.

**Injection Pressure:** Injection pressure should be set low initially and increased to the point of filling the part just short of causing flash. Maximum pressure without flash generates optimum physical properties for your RTP Company material.

**Back Pressure:** Low back pressure (approx. 0.34 MPa) minimizes fiber breakage and property deterioration.

**Injection Speed:** Generally, the fastest possible cavity fill time is best. This minimizes glass orientation and maximizes weld line integrity

**Screw RPM:** The lowest possible rpm is recommended to minimize fiber breakage and screw recovery should be set accordingly. Slower rpm's result in a more uniform melt by minimizing shear heat buildup.

### Tips To Improve Surface Conductivity

#### **Compounds With Conductive Fillers**

The parts may look beautiful but not be functional in static dissipative applications. The following processing conditions are important to successfully molding good, conductive parts.

- 1 All resins containing carbon black should be dried.
- Slower fill rates improve surface conductivity. Fill rates less than 25.4 mm per second generally work best. Decreasing the fill speed has little effect when using subgates.
- Higher melt temperatures and slower fill speeds tend to layer the carbon black particles on the part surface. A more conductive carbon black part typically has a more mottled, dull surface.
   A glossier surface is more resin rich and usually less conductive.
- 4. Decreased packing usually increases surface conductivity. Short shots can have much higher levels (one or two magnitudes) of surface conductivity, especially if measured at the edge of the flow front where the carbon particles lay closest to the surface.
- 5. Typical molding is usually less conductive near the gate and more conductive away from the gate, (i.e. 1K 2K ohms with carbon black).
- 6. Mold temperature does not have a significant effect on conductivity.
- 7. Surface conductivity is usually independent of back pressure and screw speed.

### **Compounds With Conductive Fibers**

Conductive materials based on carbon fiber typically require opposite molding conditions from conductive fillers.

- 1. Use the base resin drying requirements for carbon fiber reinforced compounds.
- 2. Increasing the fill speed usually increases surface conductivity  $10^5$  to >10<sup>4</sup> ohms/sq. (Caution: Excess fill speeds can break up carbon fibers and reduce mechanical properties.) All corners in the flow path should have generous radii.
- With carbon fiber, high melt temperatures decrease surface resistivity (thereby increasing conductivity) because they increase the degree of packing. Short shots in carbon fiber are typically non-conductive.
- 4. A typical carbon fiber molding is more conductive near the gate.
- 5. Mold temperature does not have a significant effect on conductivity.
- 6. Back pressure and screw speed should be kept as low as possible, i.e. 0.17-0.34 MPa and 20-40 rpm respectively.

## Mold Design

This guide is a condensed version. For more comprehensive information refer to RTP Company's Comprehensive Mold Design and Processing Conditions or contact our marketing department at 507-454-6900.

### Sprue/Cold Material Trap Design

Sprues connect the nozzle of the injection molding machine to the main runner or cavity. The sprue should be as short as possible to minimize material usage and cycle time. The bushing should have a smooth, tapered internal finish that has been polished in the direction of the draw to ensure clean separation of the sprue and the bushing.



#### Ribs



### **Runner Design**

Runner systems convey the melted plastic from the sprue to the gate or part. The most efficient profile for a runner is circular (full-round). A less expensive, yet adequate, profile is a trapezoid, with tapers as shown in the diagram to ensure a good volume-to-surface area ratio. Half rounds are not recommended because of their poor perimeter to area ratio.



## Secondary runner - A runner system located between the main runner and the molded part.



### Cooling

Molds must be provided with adequate cooling to take advantage of the faster cooling rates of reinforced compounds. Poor cooling results in rising mold temperatures and longer cycle times. Inadequate heating can result in voids, shorts and poor surface finish. Cooling and heating channels should be located directly in the mold inserts and cores if mold design permits.



Ejector Pins: Should be located on the heaviest sections of the part to minimize distortion when it leaves the core They should be balanced as much as possible over the part's surface. Reinforced thermoplastic require more pins due to lower mold shrinkage and greater potential for drag during ejection.

### Venting

Proper venting of cavities is very important. Inadequate venting can result in gas burns, poor weld line strength and nonfilled parts. Too much venting can result in excessive flash and poor weld lines due to inadequate pressure buildup. Venting should primarily be located at the last point of fill and where weld line occur. Vent size depends on the viscosity of the polymer and can vary from 0.01270 mm to 0.07620 mm deep. Venting can also be used around knockout pins, moving cores and mold inserts.









### Gate Design

The gate serves as the entrance to the cavity and should be designed to permit the mold to fill easily. A cavity can have more than one gate. Gates should be small enough to ensure easy separation of the runner and the part but large enough to prevent early freeze-off of polymer flow, which can adversely affect the consistency of part dimensions. A variety of gate designs and locations are shown below:





## **Troubleshooting Guide**

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Reduce Overall Cycle Time						6								
Reduce Screw Speed		4	3							5				

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Manufacturing Locations:

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Fort Worth, TX • Indianapolis, IN

# Processing Conditions



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400POLYSTYRENE1(PS)210-24938-608222NANA500STYRENE ACRYLONITRILE1(SAN)238-27952-8282022621030.01600ACRYLONITRILE BUTADIENE STYRENE1(ABS)204-2821-66792NANA700AIGUDENSITY POLYETHYLENE(IDPC)193-2321-66792NANA800ACETAL(DVD ENSITY POLYETHYLENE(IDPC)193-2321-667923.010.15900POLYSULFONE(IPC)182-21879-10712123.230.150.15900POLYSUTYLENE TEREPHTHALATE1(PBT)238-27179-10712142.920.031000POLYBUTYLENE TEREPHTHALATE1(PET)238-271135-17714961.011.011200POLYBETHALENE TEREPHTHALATE1(PET)36-32135-17714961.040.041200POLYBETHYLENE SULFIDE(PEN)313-37714961.040.041300POLYBENYLENE SULFIDE(PEN)210-2821-69932.4NANA1400POLYETHERSULFONE1(PEN)249-2868-3932.4NANA1500POLYETHERSULFONE1(PPO)249-2861-323.41.021.61.61.021500POLYETHERSULFONE1(PEN)232-263263241.80.021.61.6 <td< td=""><td>300</td><td>POLYCARBONATEt</td><td>(PC)</td><td>288-316</td><td>82-121</td><td>121</td><td>4</td><td>-29</td><td>0.02</td></td<>	300	POLYCARBONATEt	(PC)	288-316	82-121	121	4	-29	0.02	
500STYRENE ACRYLONITRILE(SAN)238-27952-82822NANA600ACRYLONITRILE BUTADIENE STYRENE(ABS)204-23863-858221.180.10700HIGH DENSITY POLYETHYLENE(HDPE)193-23221-66792NANA700ALOW DENSITY POLYETHYLENE(LDPE)193-23221-66792NANA800ACETAL(POM)182-1879-1071212-320.15900POLYSULFONE(PSU)332-37193-1491354-290.031100POLYBUTYLENE TEREPHTHALATE1(PET)260-298135-16212144.000.011200POLYBUTYLENE TEREPHTHALATE1(PET)260-298135-16212144.000.011300POLYBHENYLENE SULFIDE(PES)307-329135-1771496NA0.041400POLYETHERSULFIDE(PES)343-377135-1771496.320.041500POLYEHENENDE1(PEN)249-28866-339321480.021600POLYENENENDEL(PEC)182-21879-1079341480.021700POLYENENENDEL(PEC)249-28866-339321480.0218004POLYENENENDEL(PEC)354-399135-17714942.990.0418005POLYENENENDENENDE1(PC/PMMA)182-2	400	POLYSTYRENE†	(PS)	210-249	38-66	82	2	NA	NA	
600ACRYLONITRILE BUTADIENE STYRENET(ABS)204-28863-85822-180.10700HIGH DENSITY POLYETHYLENE(HDPE)193-23221-66792NANA700ALOW DENSITY POLYETHYLENE(LDPE)193-23221-66792NANA800ACETAL(POM)182-21879-10712122.20.15900POLYSULFONE(PEN)323-37193-14913544.2290.031000POLYBUTYLENE TEREPHTHALATE1(PET)280-281135-10712144.290.031100POLYENTYLENE TEREPHTHALATE1(PET)260-288135-10714966.180.011200POLYENTENE SULFIDE(PES)307-329135-17714966.04.001300POLYETHENSULFONE1(PES)343-377135-17714966.04.001400POLYETHENSULFONE1(PES)343-377135-17714966.04.001500POLYESTER THERMOPLASTIC ELASTOMER1(TPE)210-2866-339322.180.011600ACRVLC(PMM)182-21879-10713944.180.021700POLYENTENENCIDE, MODIFIED(PPO)249-28866-339322.180.011800AACRVLC(PMM)182-21879-1071494.290.021800APOLYCARBONATE/ACRYLIC ALL	500	STYRENE ACRYLONITRILE†	(SAN)	238-279	52-82	82	2	NA	NA	
TOOHIGH DENSITY POLYETHYLENE(HDPE)193-23221-66792NANA700ALOW DENSITY POLYETHYLENE(LDPE)193-23221-66792NANA800ACETAL(POM)182-21879-1071212-320.15900POLYSULFONE(PSU)332-37193-1491354-220.031000POLYBUTYLENE TEREPHTHALATE†(PBT)238-27179-1071214-290.031100POLYETHYLENE TEREPHTHALATE†(PET)260-298135-1621104-4000.011200POLYUETHANE THERMOPLASTIC ELASTOMET†(TPUR)135-17714966-180.011300POLYETHERSULFODE(PES)343-377135-17714966-320.041400POLYETHERSULFONE†(PES)343-377135-17714966-320.041500POLYENTERENPHOPLASTIC ELASTOMET†(TPE)210-23821-499322-4NANA1700POLYENTERENDOLATIC ELASTOMET†(PEO)249-28866-93932-180.021800AACRYLIC(POIMA)182-21879-107934-180.021800APOLYENTEREINENDE↑(PEO)249-28866-93932.4NANA1800ACRYLICMODIFIED(PC/PMMA)182-21879-107934-180.021800APOLYENTEREINERE	600	ACRYLONITRILE BUTADIENE STYRENE†	(ABS)	204-238	63-85	82	2	-18	0.10	
700ALOW DENSITY POLYETHYLENE(LDPE)193-23221-66792NANA800ACETAL(POM)182-21879-1071212-320.15900POLYSULFONE(PSU)332-37193-1491354-320.151000POLYBUTYLENE TEREPHTHALATE1(PBT)238-27179-1071214-290.031100POLYETHYLENE TEREPHTHALATE1(PET)260-298135-1621214-400.011200POLYURETHANE TEREPHTHALATE1(PET)185-21838-601076-180.011200POLYURETHANE THERMOPLASTIC ELASTOMER1(TPUR)185-21838-601076-320.041300POLYEHERSULFONE1(PES)307-329135-1771496-320.041400POLYETHERSULFONE1(TPE)210-23821-49932-4NANA1500POLYENTER THERMOPLASTIC ELASTOMER1(TPE)210-23821-49932-4NANA1700POLYENTERNOPLASTIC ELASTOMER1(TPE)210-23821-49932-4NANA1800ACRYLICMODE1(POP)249-28866-93932-180.021800APOLYENTERIMER/CNCLIC ALLOY(PC/PMMA)238-26632-66823-4-180.021800APOLYETHERETHERKETONE1(PEL)354-399155-1771494-290.04 <t< td=""><td>700</td><td>HIGH DENSITY POLYETHYLENE</td><td>(HDPE)</td><td>193-232</td><td>21-66</td><td>79</td><td>2</td><td>NA</td><td>NA</td></t<>	700	HIGH DENSITY POLYETHYLENE	(HDPE)	193-232	21-66	79	2	NA	NA	
800         ACETAL         (POM)         182-218         79-107         121         2         -32         0.15           900         POLYSULFONE         (PSU)         332-371         93-149         135         4         -32         0.15           1000         POLYBUTYLENE TEREPHTHALATE†         (PBT)         238-271         79-107         121         4         -29         0.03           1100         POLYETHYLENE TEREPHTHALATE†         (PET)         260-298         135-162         121         4         -40         0.01           1200         POLYETHANE THERMOPLASTIC ELASTOMER†         (TPUR)         185-218         38-60         107         6         -18         0.01           1300         POLYETHERSULFONE         (PES)         307-329         135-177         149         6         -32         0.04           1400         POLYETHERSULFONE†         (PES)         343-377         135-177         149         6         -32         0.04           1500         POLYENTER THERMOPLASTIC ELASTOMER†         (TPE)         210-238         21-49         93         2-4         NA         NA           1700         POLYENTERNE OXIDE, MODIFIED         (PEN)         249-238         66-93         93	700A	LOW DENSITY POLYETHYLENE	(LDPE)	193-232	21-66	79	2	NA	NA	
900         POLYSULFONE         (PSU)         332-371         93.149         135         4         -32         0.15           1000         POLYBUTYLENE TEREPHTHALATE†         (PBT)         238-271         79.107         121         4         -29         0.03           1100         POLYETHYLENE TEREPHTHALATE†         (PET)         260-298         135-162         121         4         -40         0.01           1200         POLYURETHANE THERMOPLASTIC ELASTOMER†         (TPUR)         185-218         38-60         107         6         -18         0.01           1300         POLYENTLENE SULFIDE         (PPS)         307-329         135-177         149         6         NA         0.04           1400         POLYETHERSULFONE†         (PES)         343-377         135-177         149         6         -32         0.04           1500         POLYENTLENE OXIDE, MODIFIED         (PES)         343-377         135-177         149         6         -32         0.04           1700         POLYENTLENE OXIDE, MODIFIED         (PPO)         249-288         66-33         93         2         -18         0.02           1800A         POLYEARBONATE/ACRYLIC ALLOY         (PPMMA)         182-218         7	800	ACETAL	(POM)	182-218	79-107	121	2	-32	0.15	
1000         POLYBUTYLENE TEREPHTHALATE†         (PBT)         238-271         79-107         121         4         -29         0.03           1100         POLYETHYLENE TEREPHTHALATE†         (PET)         260-298         135-162         121         4         -40         0.01           1200         POLYURETHANE THERMOPLASTIC ELASTOMER†         (TPUR)         185-218         38-60         107         6         -18         0.01           1300         POLYPENYLENE SULFIDE         (PPS)         307-329         135-177         149         6         NA         0.04           1400         POLYETHERSULFONE†         (PES)         343-377         135-177         149         6         -32         0.04           1500         POLYESTER THERMOPLASTIC ELASTOMER†         (TPE)         210-238         21-49         93         2-4         NA         NA           1700         POLYPHENYLENE OXIDE, MODIFIED         (PPO)         249-288         66-93         93         2         -18         0.02           1800A         ACRYLIC         ALDOY         (PC/PMMA)         182-218         79-107         93         4         -18         0.02           2100         POLYEARBONATE/ACRYLIC ALLOY         (PC/PMMA)	900	POLYSULFONE	(PSU)	332-371	93-149	135	4	-32	0.15	
1100         POLYETHYLENE TEREPHTHALATE†         (PET)         260-298         135-162         121         4         -40         0.01           1200         POLYURETHANE THERMOPLASTIC ELASTOMER†         (TPUR)         185-218         38-60         107         6         -18         0.01           1300         POLYPHENYLENE SULFIDE         (PPS)         307-329         135-177         149         6         NA         0.04           1400         POLYETHERSULFONE†         (PES)         343-377         135-177         149         6         -32         0.04           1500         POLYESTER THERMOPLASTIC ELASTOMER†         (TPE)         210-238         21-49         93         2-4         NA         NA           1700         POLYENTEN OXIDE, MODIFIED         (PPO)         249-288         66-93         93         2         -18         0.02           1800A         ACRYLIC         (POLMAN)         182-218         79-107         93         4         -18         0.02           1800A         POLYEARBONATE/ACRYLIC ALLOY         (PC/PMMA)         238-266         32-66         82         3-4         -18         0.02           2100         POLYETHERIMIDE†         (PEI)         354-399         135-177<	1000	POLYBUTYLENE TEREPHTHALATE	(PBT)	238-271	79-107	121	4	-29	0.03	
1200         POLYURETHANE THERMOPLASTIC ELASTOMER†         (TPUR)         185-218         38-60         107         6         -18         0.01           1300         POLYPHENYLENE SULFIDE         (PPS)         307-329         135-177         149         6         NA         0.04           1400         POLYETHERSULFONE†         (PES)         343-377         135-177         149         6         -32         0.04           1500         POLYESTER THERMOPLASTIC ELASTOMER†         (TPE)         210-238         21-49         93         2-4         NA         NA           1700         POLYPHENYLENE OXIDE, MODIFIED         (PPO)         249-288         66-93         93         2         -18         0.10           1800         ACRYLIC         (PMMA)         182-218         79-107         93         4         -18         0.02           1800A         POLYCARBONATE/ACRYLIC ALLOY         (PC/PMMA)         238-266         32-66         82         3-4         -18         0.02           2100         POLYETHERETIMERTONE†         (PEL)         354-399         135-177         149         4         -29         0.04           2200         POLYETHERETHERKETONE†         (PEL)         354-399         163-218<	1100	POLYETHYLENE TEREPHTHALATE†	(PET)	260-298	135-162	121	4	-40	0.01	
1300         POLYPHENYLENE SULFIDE         (PPS)         307-329         135-177         149         6         NA         0.04           1400         POLYETHERSULFONE†         (PES)         343-377         135-177         149         6         -32         0.04           1500         POLYESTER THERMOPLASTIC ELASTOMER†         (TPE)         210-238         21-49         93         2-4         NA         NA           1700         POLYPHENYLENE OXIDE, MODIFIED         (PPO)         249-288         66-93         93         2         -18         0.10           1800         ACRYLIC         (PMMA)         182-218         79-107         93         4         -18         0.02           1800A         POLYCARBONATE/ACRYLIC ALLOY         (PC/PMMA)         238-266         32-66         82         3-4         -18         0.02           2100         POLYETHERIMIDE†         (PEI)         354-399         135-177         149         4         -29         0.04           2200         POLYETHERETMERKETONE†         (PEK)         349-399         163-218         149         3         -29         0.10           2300A         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         238-260         93-121	1200	POLYURETHANE THERMOPLASTIC ELASTOMER	(TPUR)	185-218	38-60	107	6	-18	0.01	
1400         POLYETHERSULFONE†         (PES)         343-377         135-177         149         6         -32         0.04           1500         POLYESTER THERMOPLASTIC ELASTOMER†         (TPE)         210-238         21-49         93         2-4         NA         NA           1700         POLYPHENYLENE OXIDE, MODIFIED         (PPO)         249-288         66-93         93         2         -18         0.10           1800         ACRYLIC         (PMMA)         182-218         79-107         93         4         -18         0.02           1800A         POLYCARBONATE/ACRYLIC ALLOY         (PC/PMMA)         238-266         32-66         82         3-4         -18         0.02           2100         POLYETHERIMIDE†         (PEI)         354-399         135-177         149         4         -29         0.04           2200         POLYETHERETHERKETONE†         (PEK)         349-399         163-218         149         3         -29         0.10           2300A         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         221-243         52-93         107         4-6         -32         0.01           2300C         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         238-260 <td< td=""><td>1300</td><td>POLYPHENYLENE SULFIDE</td><td>(PPS)</td><td>307-329</td><td>135-177</td><td>149</td><td>6</td><td>NA</td><td>0.04</td></td<>	1300	POLYPHENYLENE SULFIDE	(PPS)	307-329	135-177	149	6	NA	0.04	
1500         POLYESTER THERMOPLASTIC ELASTOMER†         (TPE)         210-238         21-49         93         2-4         NA         NA           1700         POLYPHENYLENE OXIDE, MODIFIED         (PPO)         249-288         66-93         93         2         -18         0.10           1800         ACRYLIC         (PMMA)         182-218         79-107         93         4         -18         0.02           1800A         POLYCARBONATE/ACRYLIC ALLOY         (PC/PMMA)         238-266         32-66         82         3-4         -18         0.02           2100         POLYETHERIMIDE†         (PEI)         354-399         135-177         149         4         -29         0.04           2200         POLYETHERETHERKETONE†         (PEEK)         349-399         163-218         149         3         -29         0.10           2300A         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         221-243         52-93         107         4-6         -32         0.01           2300C         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         238-260         93-121         132         4-6         -32         0.01           2500         POLYCARBONATE/ABS ALLOY†         (PC/ABS)         243-274	1400	POLYETHERSULFONE <sup>†</sup>	(PES)	343-377	135-177	149	6	-32	0.04	
1700         POLYPHENYLENE OXIDE, MODIFIED         (PPO)         249-288         66-93         93         2         -18         0.10           1800         ACRYLIC         (PMMA)         182-218         79-107         93         4         -18         0.02           1800A         POLYCARBONATE/ACRYLIC ALLOY         (PC/PMMA)         238-266         32-66         82         3-4         -18         0.02           2100         POLYETHERIMIDE†         (PEI)         354-399         135-177         149         4         -29         0.04           2200         POLYETHERETHERKETONE†         (PEEK)         349-399         163-218         149         3         -29         0.10           2300A         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         221-243         52-93         107         4-6         -32         0.01           2300C         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         238-260         93-121         132         4-6         -32         0.01           2500         POLYCARBONATE/ABS ALLOY†         (PC/ABS)         243-274         52-93         93         4         -29         0.02           2700         STYRENIC THERMOPLASTIC ELASTOMER         (TES)         182-210	1500	POLYESTER THERMOPLASTIC ELASTOMER†	(TPE)	210-238	21-49	93	2-4	NA	NA	
1800         ACRYLIC         (PMMA)         182-218         79-107         93         4         -18         0.02           1800A         POLYCARBONATE/ACRYLIC ALLOY         (PC/PMMA)         238-266         32-66         82         3-4         -18         0.02           2100         POLYEARBONATE/ACRYLIC ALLOY         (PEI)         354-399         135-177         149         4         -29         0.04           2200         POLYETHERETHERKETONE†         (PEEK)         349-399         163-218         149         3         -29         0.10           2300A         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         221-243         52-93         107         4-6         -32         0.01           2300C         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         238-260         93-121         132         4-6         -32         0.01           2300C         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         238-260         93-121         132         4-6         -32         0.01           2500         POLYCARBONATE/ABS ALLOY†         (PC/ABS)         243-274         52-93         93         4         -29         0.02           2700         STYRENIC THERMOPLASTIC ELASTOMER         TES)	1700	POLYPHENYLENE OXIDE, MODIFIED	(PPO)	249-288	66-93	93	2	-18	0.10	
1800A         POLYCARBONATE/ACRYLIC ALLOY         (PC/PMMA)         238-266         32-66         82         3-4         -18         0.02           2100         POLYETHERIMIDE†         (PEI)         354-399         135-177         149         4         -29         0.04           2200         POLYETHERETHERKETONE†         (PEEK)         349-399         163-218         149         3         -29         0.10           2300A         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         221-243         52-93         107         4-6         -32         0.01           2300C         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         238-260         93-121         132         4-6         -32         0.01           2300C         RIGID THERMOPLASTIC POLYURETHANE†         (PC/ABS)         243-274         52-93         93         4         -29         0.02           2500         POLYCARBONATE/ABS ALLOY†         (PC/ABS)         243-274         52-93         93         4         -29         0.02           2700         STYRENIC THERMOPLASTIC ELASTOMER         (TES)         182-232         16-38         79         2         NA         NA           2800         OLEFINIC THERMOPLASTIC ELASTOMER†         (TEO) </td <td>1800</td> <td>ACRYLIC</td> <td>(PMMA)</td> <td>182-218</td> <td>79-107</td> <td>93</td> <td>4</td> <td>-18</td> <td>0.02</td>	1800	ACRYLIC	(PMMA)	182-218	79-107	93	4	-18	0.02	
2100         POLYETHERIMIDE†         (PEI)         354-399         135-177         149         4         -29         0.04           2200         POLYETHERETHERKETONE†         (PEEK)         349-399         163-218         149         3         -29         0.10           2300A         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         221-243         52-93         107         4-6         -32         0.01           2300C         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         238-260         93-121         132         4-6         -32         0.01           2500         POLYCARBONATE/ABS ALLOY†         (PC/ABS)         243-274         52-93         93         4         -29         0.02           2700         STYRENIC THERMOPLASTIC ELASTOMER         (TES)         182-232         16-38         79         2         NA         NA           2800         OLEFINIC THERMOPLASTIC ELASTOMER†         (TEO)         182-210         16-66         79         2         -18         0.03	1800A	POLYCARBONATE/ACRYLIC ALLOY	(PC/PMMA)	238-266	32-66	82	3-4	-18	0.02	
2200         POLYETHERETHERKETONE†         (PEEK)         349-399         163-218         149         3         -29         0.10           2300A         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         221-243         52-93         107         4-6         -32         0.01           2300C         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         238-260         93-121         132         4-6         -32         0.01           2500         POLYCARBONATE/ABS ALLOY†         (PC/ABS)         243-274         52-93         93         4         -29         0.02           2700         STYRENIC THERMOPLASTIC ELASTOMER         (TES)         182-232         16-38         79         2         NA         NA           2800         OLEFINIC THERMOPLASTIC ELASTOMER†         (TEO)         182-210         16-66         79         2         -18         0.03	2100	POLYETHERIMIDEt	(PEI)	354-399	135-177	149	4	-29	0.04	
2300A         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         221-243         52-93         107         4-6         -32         0.01           2300C         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         238-260         93-121         132         4-6         -32         0.01           2500         POLYCARBONATE/ABS ALLOY†         (PC/ABS)         243-274         52-93         93         4         -29         0.02           2700         STYRENIC THERMOPLASTIC ELASTOMER         (TES)         182-232         16-38         79         2         NA         NA           2800         OLEFINIC THERMOPLASTIC ELASTOMER†         (TEO)         182-210         16-66         79         2         -18         0.03	2200	POLYETHERETHERKETONEt	(PEEK)	349-399	163-218	149	3	-29	0.10	
2300C         RIGID THERMOPLASTIC POLYURETHANE†         (RTPU)         238-260         93-121         132         4-6         -32         0.01           2500         POLYCARBONATE/ABS ALLOY†         (PC/ABS)         243-274         52-93         93         4         -29         0.02           2700         STYRENIC THERMOPLASTIC ELASTOMER         (TES)         182-232         16-38         79         2         NA         NA           2800         OLEFINIC THERMOPLASTIC ELASTOMER†         (TEO)         182-210         16-66         79         2         -18         0.03	2300A	RIGID THERMOPLASTIC POLYURETHANEt	(RTPU)	221-243	52-93	107	4-6	-32	0.01	
2500         POLYCARBONATE/ABS ALLOY†         (PC/ABS)         243-274         52-93         93         4         -29         0.02           2700         STYRENIC THERMOPLASTIC ELASTOMER         (TES)         182-232         16-38         79         2         NA         NA           2800         OLEFINIC THERMOPLASTIC ELASTOMER†         (TEO)         182-210         16-66         79         2         -18         0.03	2300C	RIGID THERMOPLASTIC POLYURETHANE	(RTPU)	238-260	93-121	132	4-6	-32	0.01	
2700         STYRENIC THERMOPLASTIC ELASTOMER         (TES)         182-232         16-38         79         2         NA         NA           2800         OLEFINIC THERMOPLASTIC ELASTOMER†         (TEO)         182-210         16-66         79         2         -18         0.03	2500	POLYCARBONATE/ABS ALLOY†	(PC/ABS)	243-274	52-93	93	4	-29	0.02	
2800         OLEFINIC THERMOPLASTIC ELASTOMER†         (TEO)         182-210         16-66         79         2         -18         0.03	2700	STYRENIC THERMOPLASTIC ELASTOMER	(TES)	182-232	16-38	79	2	NA	NA	
	2800	OLEFINIC THERMOPLASTIC ELASTOMER†	(TEO)	182-210	16-66	79	2	-18	0.03	
3000 POLYMETHYLPENTENE (PMP) 266-304 66-93 79 2 NA NA	3000	POLYMETHYLPENTENE	(PMP)	266-304	66-93	79	2	NA	NA	
3100 PERFLUOROALKOXY (PFA) 343-385 149-232 121 2 NA NA	3100	PERFLUOROALKOXY	(PFA)	343-385	149-232	121	2	NA	NA	
3200 ETHYLENE TETRAFLUOROETHYLENE (ETFE) 293-343 66-149 121 2 NA NA	3200	ETHYLENE TETRAFLUOROETHYLENE	(ETFE)	293-343	66-149	121	2	NA	NA	
3300 POLYVINYLIDENE FLUORIDE (PVDF) 210-288 82-104 121 2 NA NA	3300	POLYVINYLIDENE FLUORIDE	(PVDF)	210-288	82-104	121	2	NA	NA	
3400-3 LIQUID CRYSTAL POLYMER (LCP) 332-366 66-121 149 8 -29 NA	3400-3	LIQUID CRYSTAL POLYMER	(LCP)	332-366	66-121	149	8	-29	NA	
3400-4 LIQUID CRYSTAL POLYMER (LCP) 363-399 66-93 149 8 -29 NA	3400-4	LIQUID CRYSTAL POLYMER	(LCP)	363-399	66-93	149	8	-29	NA	
3500 FLUORINATED ETHYLENE-PROPYLENE (FEP) 343-385 93+ 121 2-4 NA NA	3500	FLUORINATED ETHYLENE-PROPYLENE	(FEP)	343-385	93+	121	2-4	NA	NA	
4000 POLYPHTHALAMIDE† (PPA) 302-329 135-163 79 6 -32 0.05	4000	POLYPHTHALAMIDE†	(PPA)	302-329	135-163	79	6	-32	0.05	
4000A POLYPHTHALAMIDE HOT WATER MOLDABLE (PPA) 329-343 66-163 79 6 -29 0.10	4000A	POLYPHTHALAMIDE HOT WATER MOLDABLE	(PPA)	329-343	66-163	79	6	-29	0.10	
4200 THERMOPLASTIC POLYIMIDE† (TPI) 399-416 177-232 204 6 -40 0.01	4200	THERMOPLASTIC POLYIMIDE	(TPI)	399-416	177-232	204	6	-40	0.01	
4300 POLYSULFONE/POLYCARBONATE ALLOY (PSU/PC) 282-327 66-99 121 4 -29 0.02	4300	POLYSULFONE/POLYCARBONATE ALLOY	(PSU/PC)	282-327	66-99	121	4	-29	0.02	
4400 NYLON, HIGH TEMPERATURE (NHT) 310-343 135-163 79 4 -40 0.10	4400	NYLON, HIGH TEMPERATURE	(NHT)	310-343	135-163	79	4	-40	0.10	
4500 ALIPHATIC POLYKETONE (PK) 221-260 82-149 60 4 -32 0.02	4500	ALIPHATIC POLYKETONE	(PK)	221-260	82-149	60	4	-32	0.02	
4600 SYNDIOTACTIC POLYSTYRENE (SPS) 293-327 71-149 82 2 -29 0.02	4600	SYNDIOTACTIC POLYSTYRENE	(SPS)	293-327	71-149	82	2	-29	0.02	
4700 POLYTRIMETHYLENE TEREPHTHALATE (PTT) 232-260 87-120 127 4-6 -40 0.01	4700	POLYTRIMETHYLENE TEREPHTHALATE	(PTT)	232-260	87-120	127	4-6	-40	0.01	

+Hygroscopic Materials

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## CONDENSED Mold Design And Processing Conditions

A Guide to Processing Injection Molding Grade Specialty Compounds

English/Standard

000.0-7000

5% HEIGH

2X1.D



web site: www.rtpcompany.com

# **Operating Conditions**



## **Standard Molding Equipment**

**Machine Type:** We recommend using a screw injection machine for molding reinforced thermoplastics. A screw injection machine improves melt homogeneity, reduces variations in the molded parts, and minimizes degradations and cold spots of the polymer melt.

**Machine Size:** The machine should be sized to use approximately 50-70% of machine barrel capacity per shot. This maintains a short barrel residence time and eliminates material degradation. The machine should have adequate clamp pressure to obtain 4-8 tons per square inch of projected surface area. Generally, a reinforced material requires 50-70% higher clamping pressures than a nonreinforced polymer of the same type.

## Molding Conditions

**Drying:** Successful molding of reinforced thermoplastics requires adequate drying. Inadequate drying can cause extremely erratic molding conditions and less than perfect molded parts. Excessively wet materials outgas and can undergo a viscosity change during processing. This may cause brittleness, blisters, voids, silver streaking and poor surface finish. RTP Company materials are dried prior to packaging in moisture resistant containers. However, we recommend thoroughly drying the materials in a dehumidifying type dryer. This is important with hygroscopic materials but can also be essential for non-hygroscopic materials. Condensed surface moisture can dramatically affect high temperature molded parts. The recommended drying times are provided as guidelines; however, an actual moisture check is necessary.

**Barrel Temperature:** Typically the rear zone/zones are set 10-20° F cooler than the front zone and nozzle. Some modifications may be needed depending on part size and configuration.

**Melt Temperature:** Use the Processing Conditions Chart in this guide for recommended starting temperatures.

**Mold Temperature:** Use the Processing Conditions Chart in this guide for recommended starting temperatures. Normally, reinforced materials require higher mold temperatures than nonreinforced materials. Higher mold temperatures will achieve a smoother, more blemish-free surface by providing a resin rich skin on reinforced materials.

**Injection Pressure:** Injection pressure should be set low initially and increased to the point of filling the part just short of causing flash. Maximum pressure without flash generates optimum physical properties for your RTP Company material.

**Back Pressure:** Low back pressure (approx. 50 psi) minimizes fiber breakage and property deterioration.

**Injection Speed:** Generally, the fastest possible cavity fill time is best. This minimizes glass orientation and maximizes weld line integrity.

**Screw RPM:** The lowest possible rpm is recommended to minimize fiber breakage and screw recovery should be set accordingly. Slower rpm's result in a more uniform melt by minimizing shear heat buildup.

### Tips To Improve Surface Conductivity

#### **Compounds With Conductive Fillers**

The parts may look beautiful but not be functional in static dissipative applications. The following processing conditions are important to successfully molding good, conductive parts.

- 1 All resins containing carbon black should be dried.
- Slower fill rates improve surface conductivity. Fill rates less than 1 inch per second generally work best. Decreasing the fill speed has little effect when using subgates.
- Higher melt temperatures and slower fill speeds tend to layer the carbon black particles on the part surface. A more conductive carbon black part typically has a more mottled, dull surface.
   A glossier surface is more resin rich and usually less conductive.
- 4. Decreased packing usually increases surface conductivity. Short shots can have much higher levels (one or two magnitudes) of surface conductivity, especially if measured at the edge of the flow front where the carbon particles lay closest to the surface.
- 5. Typical molding is usually less conductive near the gate and more conductive away from the gate, (i.e. 1K 2K ohms with carbon black).
- 6. Mold temperature does not have a significant effect on conductivity.
- 7. Surface conductivity is usually independent of back pressure and screw speed.

### **Compounds With Conductive Fibers**

Conductive materials based on carbon fiber typically require opposite molding conditions from conductive fillers.

- 1. Use the base resin drying requirements for carbon fiber reinforced compounds.
- 2. Increasing the fill speed usually increases surface conductivity  $10^{\circ}$  to  ${>}10^{4}$  ohms/sq. (Caution: Excess fill speeds can break up carbon fibers and reduce mechanical properties.) All corners in the flow path should have generous radii.
- 3. With carbon fiber, high melt temperatures decrease surface resistivity (thereby increasing conductivity) because they increase the degree of packing. Short shots in carbon fiber are typically non-conductive.
- 4. A typical carbon fiber molding is more conductive near the gate.
- 5. Mold temperature does not have a significant effect on conductivity.
- 6. Back pressure and screw speed should be kept as low as possible, i.e. 25-50 psi and 20-40 rpm respectively.

# Mold Design

This guide is a condensed version. For more comprehensive information refer to RTP Company's Comprehensive Mold Design and Processing Conditions or contact our marketing department at 507-454-6900.

### Sprue/Cold Material Trap Design

Sprues connect the nozzle of the injection molding machine to the main runner or cavity. The sprue should be as short as possible to minimize material usage and cycle time. The bushing should have a smooth, tapered internal finish that has been polished in the direction of the draw to ensure clean separation of the sprue and the bushing.



### Ribs



### Runner Design

Runner systems convey the melted plastic from the sprue to the gate or part. The most efficient profile for a runner is circular (full-round). A less expensive, yet adequate, profile is a trapezoid, with tapers as shown in the diagram to ensure a good volume-to-surface area ratio. Half rounds are not recommended because of their poor perimeter to area ratio.



Secondary runner - A runner system located between the main runner

Cold Material Trap

Secondary runner 0.66 x

size of main runner

and the molded part.

Main Runner

0 0 20 - 0 0 60"

radius

Plastic Resin (material)

Tool Steel

### Cooling

Molds must be provided with adequate cooling to take advantage of the faster cooling rates of reinforced compounds. Poor cooling results in rising mold temperatures and longer cycle times. Inadequate heating can result in voids, shorts and poor surface finish. Cooling and heating channels should be located directly in the mold inserts and cores if mold design permits.



Ejector Pins: Should be located on the heaviest sections of the part to minimize distortion when it leaves the core They should be balanced as much as possible over the part's surface. Reinforced thermoplastic require more pins due to lower mold shrinkage and greater potential for drag during ejection.

### Venting

Proper venting of cavities is very important. Inadequate venting can result in gas burns, poor weld line strength and nonfilled parts. Too much venting can result in excessive flash and poor weld lines due to inadequate pressure buildup. Venting should primarily be located at the last point of fill and where weld line occur. Vent size depends on the viscosity of the polymer and can vary from 0.0005" to 0.0030" deep. Venting can also be used around knockout pins, moving cores and mold inserts.



0.030" 0.0005 - 0.0030"

- 0.50" wide x 0.03" deep to exterior of mold



### Gate Design

The gate serves as the entrance to the cavity and should be designed to permit the mold to fill easily. A cavity can have more than one gate. Gates should be small enough to ensure easy separation of the runner and the part but large enough to prevent early freeze-off of polymer flow, which can adversely affect the consistency of part dimensions. A variety of gate designs and locations are shown below:



## **Troubleshooting Guide**



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Reduce Molded Stress			8											6
Reduce Overall Cycle Time						6								
Reduce Screw Speed		4	3							5				

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Manufacturing Locations:

Winona, MN South Boston, VA Dayton, NV Beaune, France



Fort Worth, TX • Indianapolis, IN

# Specialty Compounds Processing Conditions



			TEMPERATURE °F		DR	ING	DEW	MOISTURE
RTP SERIES	POLYMER TYPE	-	MELT	MOLD	TEMP (°F)	TIME (HRS)	POINT °F	CONTENT %
100	POLYPROPYLENE	(PP)	375-450	90-150	175	2	NA	NA
200	NYLON 6/6†	(PA)	530-570	150-225	175	4	0	0.20
200A	NYLON 6t	(PA)	470-535	130-200	180	2	0	0.20
200B	NYLON 6/10	(PA)	530-570	150-225	175	2	0	0.20
200C	NYLON 11	(PA)	435-550	100-150	175	4	0	0.20
200D	NYLON 6/12†	(PA)	480-545	140-200	175	4	0	0.20
200E	NYLON, AMORPHOUS	(PA)	520-570	150-210	175	4	-30	0.10
200F	NYLON 12†	(PA)	430-525	150-220	175	4	-40	0.10
200H	NYLON 6/6 IMPACT MODIFIED	(PA)	530-570	150-225	175	4	0	0.20
300	POLYCARBONATEt	(PC)	550-600	180-250	250	4	-20	0.02
400	POLYSTYRENE†	(PS)	410-480	100-150	180	2	NA	NA
500	STYRENE ACRYLONITRILE†	(SAN)	460-535	125-180	180	2	NA	NA
600	ACRYLONITRILE BUTADIENE STYRENE†	(ABS)	400-460	145-185	180	2	0	0.10
700	HIGH DENSITY POLYETHYLENE	(HDPE)	380-450	70-150	175	2	NA	NA
700A	LOW DENSITY POLYETHYLENE	(LDPE)	380-450	70-150	175	2	NA	NA
800	ACETAL	(POM)	360-425	175-225	250	2	-25	0.15
900	POLYSULFONE	(PSU)	630-700	200-300	275	4	-25	0.15
1000	POLYBUTYLENE TEREPHTHALATE†	(PBT)	460-520	175-225	250	4	-20	0.03
1100	POLYETHYLENE TEREPHTHALATE†	(PET)	500-570	275-325	250	4	-40	0.01
1200	POLYURETHANE THERMOPLASTIC ELASTOMER†	(TPUR)	365-425	100-140	225	6	0	0.01
1300	POLYPHENYLENE SULFIDE	(PPS)	585-625	275-350	300	6	NA	0.04
1400	POLYETHERSULFONE†	(PES)	650-710	275-350	300	6	-25	0.04
1500	POLYESTER THERMOPLASTIC ELASTOMER†	(TPE)	410-460	70-120	200	2-4	NA	NA
1700	POLYPHENYLENE OXIDE, MODIFIED	(PPO)	480-550	150-200	200	2	0	0.10
1800	ACRYLIC	(PMMA)	360-425	175-225	200	4	0	0.02
1800A	POLYCARBONATE/ACRYLIC ALLOY	(PC/PMMA)	460-510	90-150	180	3-4	0	0.02
2100	POLYETHERIMIDEt	(PEI)	670-750	275-350	300	4	-20	0.04
2200	POLYETHERETHERKETONEt	(PEEK)	660-750	325-425	300	3	-20	0.10
2300A	RIGID THERMOPLASTIC POLYURETHANE†	(RTPU)	430-470	125-200	225	4-6	-25	0.01
2300C	RIGID THERMOPLASTIC POLYURETHANE	(RTPU)	460-500	200-250	270	4-6	-25	0.01
2500	POLYCARBONATE/ABS ALLOY†	(PC/ABS)	470-525	125-200	200	4	-20	0.02
2700	STYRENIC THERMOPLASTIC ELASTOMER	(TES)	360-450	60-100	175	2	NA	NA
2800	OLEFINIC THERMOPLASTIC ELASTOMER†	(TEO)	360-410	60-150	175	2	0	0.03
3000	POLYMETHYLPENTENE	(PMP)	510-580	150-200	175	2	NA	NA
3100	PERFLUOROALKOXY	(PFA)	650-725	300-450	250	2	NA	NA
3200	ETHYLENE TETRAFLUOROETHYLENE	(ETFE)	560-650	150-300	250	2	NA	NA
3300	POLYVINYLIDENE FLUORIDE	(PVDF)	410-550	180-220	250	2	NA	NA
3400-3	LIQUID CRYSTAL POLYMER	(LCP)	630-690	150-250	300	8	-20	NA
3400-4	LIQUID CRYSTAL POLYMER	(LCP)	685-750	150-200	300	8	-20	NA
3500	FLUORINATED ETHYLENE PROPYLENE	(FEP)	650-725	200+	250	2-4	NA	NA
4000	POLYPHTHALAMIDE:	(PPA)	575-625	275-325	175	6	-25	0.05
4000A	POLYPHTHALAMIDE HOT WATER MOLDABLE	(PPA)	625-650	150-325	175	6	-20	0.10
4200	THERMOPLASTIC POLYIMIDE+	(TPI)	750-780	350-450	400	6	-40	0.01
4300	POLYSULFONE/POLYCARBONATE ALLOY	(PSU/PC)	540-620	150-210	250	4	-20	0.02
4400	NYLON, HIGH TEMPERATURE	(NHT)	590-650	275-325	175	4	-40	0.10
4500	ALIPHATIC POLYKETONE	(PK)	430-500	180-300	140	4	-25	0.02
4600	SYNDIOTACTIC POLYSTYRENE	(SPS)	560-620	160-300	180	2	-20	0.02
4700	POLYTRIMETHYLENE TEREPHTHALATE	(PTT)	450-500	190-250	260	4-6	-40	0.01

+Hygroscopic Materials

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