CYROLITE®
ADVANCED MEDICAL ACRYLICS

ACRYLIC ADVISOR

Technical reference guide for CYROLITE®, XT® POLYMER, CYREX® and Vu-Stat® acrylic polymers

RÖHM

ACRYLIC ADVISOR

We are traditionally innovative. Our company's founder, Dr. Otto Röhm, laid the groundwork for today's methacrylate chemicals in 1907. Since then, we have continuously expanded our technology-based strengths in the Verbund tapping into new application fields with our products. With long-term investments and targeted expansion, we drive our sustainable growth and further boost our leading market positions.

INTRODUCTION

Röhm, is a worldwide manufacturer of PMMA molding compounds. Roehm America LLC offers a range of high-performance polymers and compounds for various medical device and packaging applications.

CYROLITE® and XT® POLYMER compounds are both transparent, impact modified, BPA free PMMA-based copolymers. They both have distinctive characteristics that make them particularly successful in the medical device and packaging markets.

CYROLITE® materials are the world's leading PMMA-based copolymers specifically developed for use in the medical device and diagnostics industries. CYROLITE® PMMA acrylics and PMMA-based copolymers have been working in hospitals and labs for more than 40 years. Several CYROLITE® grades are available, offering balanced properties to meet the stringent requirements of a wide range of medical devices and diagnostics applications.

CYROLITE® MD PMMA acrylics are highly transparent materials specialized for diagnostics applications. All grades are designed to meet the most stringent UV light transmittance and optical requirements for medical diagnostic devices.

XT® POLYMER materials are PMMA-based copolymers developed for use in medical packaging and medical device industries. XT® POLYMER has been used in the medical packaging industry for more than 30 years. Multiple XT® POLYMER grades are available, offering balanced properties to meet the stringent requirements of a wide range of medical packaging and device applications.

CYREX®, an opaque acrylic-polycarbonate alloy, is a unique combination between acrylic and polycarbonate with an increased notched Izod impact strength over PC, yet it maintains the ease of processability of acrylic. It is an ideal material for medical applications which require exceptional toughness.

Vu-Stat® offers electrostatic dissipative (ESD) properties combined with an excellent balance of mechanical, thermal and flow properties. Developed for medical applications that are sensitive to static discharge, Vu-Stat® Y-20 compound retains permanent static dissipative properties even after several uses.

Roehm America offers the following product lines for the medical and packaging markets:

PMMA-based copolymers

- CYROLITE® G-20
- CYROLITE® G-20 HIFLO
- CYROLITE® GS-90
- CYROLITE® CG-97
- CYROLITE® Med 2

PMMA acrylics

- CYROLITE® MD H12
- CYROLITE® MD L40

PMMA-based copolymers

- XT® POLYMER 250
- XT® POLYMER 375

Acrylic-polycarbonate alloy

- CYREX® 200

Static dissipative acrylic compound

- Vu-Stat® Y-20

CYROLITE®
PMMA acrylics and PMMA-based copolymers

CYROLITE® grades differ in melt flow, mechanical properties, sterilizability, and in chemical resistance. Key benefits include:

- Regulatory compliance – meets requirements of the USP Class VI, ISO 10993-1 and FDA for food contact
- Safety – BPA & DEHP free
- Mechanical performance – toughness and strength
- Functionality – bondable to PVC tubing and design freedom
- Transparency – optical transparency and UV transmittance
- Sterilizability – EtO, gamma and e-beam
- Chemical resistance – lipid, blood, oncology drugs, alcohol and disinfectant wipes
- Sustainability – lightweight, easy to process, energy saving

CYROLITE®

PMMA acrylics and PMMA-based copolymers

TYPICAL APPLICATIONS

- Respiratory device components
- Blood filter housings
- IV components
- Drip chambers
- Collection and specimen vessels
- Connectors and injection ports
- Y-sites
- Needle hubs
- Luer locks
- Flow controls
- Check-valves
- Blood handling devices
- Cuvettes
- Rotors
- Well plates
- Crystallography trays

DESCRIPTION OF GRADES

CYROLITE® grades G-20, G-20 HIFLO, GS-90, CG-97, Med 2, MD H12 and MD L40:

Grade	*Description*
CYROLITE® G-20 **CYROLITE® G-20 HIFLO**	These grades are general purpose medical grade copolymers with high light transmittance and minimal haze. They have 5 times the impact resistance of unmodified acrylics and are resistant to body fluids and many chemicals. These grades bond well to PVC tubing and can also be solvent bonded, thermal bonded or ultrasonic welded. Both grades can be EtO, gamma and e-beam sterilized. CYROLITE® G-20 HIFLO has a higher melt flow that can offer easier processing, and better design freedom for complex and thin-walled parts.
CYROLITE® GS-90 **CYROLITE® CG-97**	In addition to the benefits of the CYROLITE® G-20 grade, these grades are designed specifically for enhanced stability to gamma sterilization. CYROLITE® CG-97 offers high lipid resistance. CYROLITE® GS-90 offers superior color stability after gamma sterilization. CYROLITE® GS-90 also exhibits a higher melt flow rate for intricate and thin wall parts. It is notably the clearest of the CYROLITE® copolymer grades.
CYROLITE® Med 2	In addition to the benefits of the CYROLITE® G-20 grades, CYROLITE® Med 2 offers superior resistance to lipids, blood, alcohols, disinfectant wipes and oncology drugs, while exhibiting excellent ductility.
CYROLITE® MD H12 **CYROLITE® MD L40**	CYROLITE® MD PMMA acrylic polymers are available in two grades, CYROLITE® MD H12 and CYROLITE® MD L40. They are well suited for diagnostic applications. Key benefits are: • Exceptional ultra-violet light transmittance • Superior optical clarity • Maximum flow characteristics • Excellent dimensional stability • Outstanding scratch resistance • Total cost-of-use advantage over glass CYROLITE® MD H12 offers a higher Vicat softening point. CYROLITE® MD L40 exhibits the highest melt flow for very intricate and thin wall parts.

CYROLITE®

PMMA acrylics and PMMA-based copolymers

PHYSICAL PROPERTIES

Property	ASTM Method	CYROLITE® G-20	CYROLITE® G-20 HIFLO	CYROLITE® GS-90	CYROLITE® CG-97	CYROLITE® Med 2	CYROLITE® MD H12	CYROLITE® MD L40
OPTICAL								
Light Transmission, %	D-1003	89	89	89	87	85	92	92
Haze, %	D-1003	5.0	6.0	3.0	5.0	7.0	<1	<1
Refractive Index	D-542	1.515	1.515	1.515	1.515	1.515	1.49	1.49
UV Transmittance 340 nm, %	–	–	–	–	–	–	min 87.7	min 87.7
RHEOLOGICAL								
Avg Melt Flow, g/10 min @ 230°C & 5.0 kg	D-1238	2.6	10	6.5	1.8	2.1	7.0 @ 3.8 kg	26.0 @ 3.8 kg
MECHANICAL								
Tensile Strength, psi (MPa)	D-638	6,800 (46.9)	7,000 (48.3)	6,800 (46.9)	5,270 (36.3)	5,320 (36.7)	9,500 (65.5)	8,800 (60.7)
Tensile Modulus, $x10^6$ psi (GPa)	D-638	0.32 (2.2)	0.37 (2.6)	0.32 (2.2)	0.27 (1.9)	0.25 (1.7)	0.47 (3.2)	0.47 (3.2)
Tensile Elongation @ Yield, %	D-638	4.0	3.6	3.6	3.8	3.9	4 – 6	2 – 4
Tensile Elongation @ Break, %	D-638	9.5	9.5	6.7	13.9	22	4 – 6	2 – 4
Flexural Strength, psi (MPa)	D-790	10,500 (72.4)	9,400 (64.8)	10,800 (74.5)	9,800 (67.6)	8,590 (59.2)	17,000 (117.2)	14,200 (97.9)
Flexural Modulus, $x10^6$ psi (GPa)	D-790	0.34 (2.3)	0.31 (2.1)	0.33 (2.3)	0.27 (1.8)	0.24 (1.6)	0.49 (3.4)	0.44 (3.0)
Notched Izod, ft-lb/in (J/m) on 1/4" (6.35mm) bar								
@ 23°C	D-256	1.9 (101)	1.9 (101)	2.0 (107)	2.7 (143)	2.2 (117)	0.36 (19)	0.36 (19)
@ 0°C	D-256	1.1 (59)	1.1 (59)	0.8 (43)	–	–	–	–
Compressive Strength, psi (MPa)	D-695	11,500 (79.3)	11,500 (79.3)	8,190 (56.5)	6,200 (42.8)	–	17,000 (117.2)	13,700 (94.5)
Rockwell Hardness, M scale	D-785	39	27	30	35	33	94	84
Other Properties								
DTL, °F (°C) @ 264 psi, annealed	D-648	186 (86)	186 (86)	163 (73)	158 (70)	163 (73)	201 (95)	165 (74)
Vicat Softening Point °F (°C)	D-1525	214 (101)	214 (101)	210 (99)	194 (90)	201 (94)	221 (105)	180 (82)
Specific Gravity	D-792	1.11	1.11	1.11	1.08	1.08	1.19	1.19
Water Absorption, %	D-570	0.30	0.30	0.30	0.40	0.38	0.30	0.30
Mold Shrinkage, in/in	D-955	0.004 – 0.007	0.004 – 0.007	0.004 – 0.006	0.005 – 0.007	0.005 – 0.007	0.004 – 0.006	0.003 – 0.006
Coefficient of Linear Expansion in/in/°F, 32 – 212°F (mm/mm °C, 0 – 100°C)	D-696	0.0000514 (0.0000925)	0.0000514 (0.0000925)	0.000054 (0.000095)	0.000053 (0.000095)	0.000048 (0.000086)	0.00004 (0.000072)	0.00004 (0.000072)
Flammability		UL 94 HB	UL 94 HB	UL 94 HB	UL 94 HB	UL 94 HB	UL 94 HB	UL 94 HB

CYROLITE®

PMMA acrylics and PMMA-based copolymers

PROCESSING CONDITIONS – INJECTION MOLDING

Condition	CYROLITE® G-20	CYROLITE® G-20 HIFLO	CYROLITE® GS-90	CYROLITE® CG-97	CYROLITE® Med 2	CYROLITE® MD H12	CYROLITE® MD L40
Drying Temperature, °F (3–4 hours)	175	175	160	160	160	170	160
Feed Section Temperature, °F	380 – 435	360 – 435	375 – 425	410 – 450	425 – 450	400 – 435	410 – 470
Center Section Temperature, °F	400 – 460	380 – 460	410 – 450	430 – 480	450 – 480	420 – 450	410 – 470
Front Temperature, °F	400 – 475	380 – 460	410 – 450	430 – 480	450 – 480	430 – 480	410 – 470
Nozzle Temperature, °F	400 – 475	380 – 460	410 – 450	430 – 480	450 – 480	430 – 480	410 – 470
Melt Temperature, °F	400 – 475	380 – 460	410 – 450	420 – 480	450 – 480	430 – 480	410 – 470
Mold Temperature, °F	120 – 180	120 – 180	120 – 180	120 – 180	120 – 180	90 – 175	80 – 160
Injection Pressure, psi	10,000 – 20,000	6,000 – 15,000	6,000 – 15,000	6,000 – 15,000	6,000 – 15,000	6,000 – 15,000	6,000 – 15,000
Clamp Pressure, psi			2.5 tons/in² of projected area for flow length/wall thickness <100/1 5 tons/in² of projected area for flow length/wall thickness >100/1				
Screw Speed, rpm 2:1 compression ratio 3.5:1 compression ratio	 20 – 100 20 – 70	 20 – 100 20 – 70	 75 – 150 60 – 130	 75 – 150 60 – 130	 75 – 150 60 – 130	 75 – 150 60 – 130	 75 – 150 60 – 130
Ram Speed, in/sec small gates large gates	 0.5 – 1.5 1 – 4	 0.5 – 1.5 1 – 4	 0.5 – 1.5 1 – 4	 0.5 – 1.5 1 – 4	 0.5 – 1.5 1 – 4	 0.5 – 1.5 1 – 4	 0.5 – 1.5 1 – 4
Back Pressure, psi	0 – 100	0 – 100	0 – 100	0 – 100	0 – 100	25 – 100	25 – 100

XT® POLYMER
PMMA-based copolymers

There are two different grades of XT® POLYMER varying in melt flow and in mechanical properties.
Key benefits include:

- Regulatory compliance – meets requirements of the USP Class VI, ISO 10993-1 and FDA for food contact
- Safety – BPA & DEHP free
- Mechanical performance – toughness and strength
- Functionality – bondable to PVC tubing, ultrasonic weldable
- Transparency – optical transparency, low haze
- Sterilizability – EtO
- Sustainability – lightweight

XT® POLYMER
PMMA-based copolymers

TYPICAL APPLICATIONS

- Medical packaging
- Medical tubing connectors
- Medical valves and accessories
- Breathing circuits

DESCRIPTION OF GRADES

XT® POLYMER 250 and XT® POLYMER 375 acrylic-based copolymers for injection molding, thermoforming, extrusion and blow molding applications. Both have high heat distortion temperatures, excellent bonding and welding capabilities, resistance to PVC stabilizers as well as resistance to EtO sterilization.

Grade	*Description*
XT® POLYMER 250	• 3x impact resistance of unmodified acrylics • Great light transmission properties with little haze • Good chemical resistance
XT® POLYMER 375	• 5x impact resistance of unmodified acrylics • Good light transmission properties with little haze • Better chemical resistance

XT® POLYMER
PMMA-based copolymers

PROCESSING CONDITIONS – INJECTION MOLDING

Condition	XT® POLYMER 250	XT® POLYMER 375
Drying Temperature, °F (3–4 hours)	180	180
Melt Temperature, °F	400 – 475	400 – 475
Mold Temperature, °F	120 – 170	120 – 170
Injection Pressure, psi	10,000 – 20,000	10,000 – 20,000
Clamp Pressure	2.5 tons/in² of projected area for flow length/wall thickness <100/1 5 tons/in² of projected area for flow length/wall thickness >100/1	
Screw Speed, rpm 2:1 compression ratio 3.5:1 compression ratio	 20 – 100 20 – 70	 20 – 100 20 – 70
Ram Speed, in/sec small gates large gates	 0.5-1.5 1 – 4	 0.5-1.5 1 – 4
Back Pressure, psi	0-100	0-100

XT® POLYMER
PMMA-based copolymers

RECOMMENDED DRYING CONDITIONS

Condition	
Drying Temperature, °F (3–4 hours)	180

PROCESSING CONDITIONS – EXTRUSION

Screw Diameter	3 ½ inch	4 ½ inch	6 inch
Turns of Feed – Constant Depth	4 at 0.500	4 at 0.625	7 at 0.635
Turns of Transition – Constant Taper	3	3	3
Turns of Meter Pump – Constant	6 at 0.165	5 at 0.180	4 at 0.190
Turns of Decompression – Constant Taper	1	1	1
Turns of Vent Zone – Constant Depth	4 at 0.650	4 at 0.750	3 at 0.750
Turns of Recompression – Constant Taper	2.5	2.5	2.0
Turns of 2nd Meter Pump – Constant Taper	5 at 0.300	5 at 0.325	5 at 0.335
Feed Zone, °F	350 – 400	340 – 400	280 – 320
Rear, °F	380 – 420	380 – 415	320 – 360
Rear Center, °F	380 – 425	380 – 425	360 – 420
Center, °F	390 – 430	380 – 425	400 – 440
Front Center, °F	420 – 470	420 – 460	420 – 460
Front, °F	430 – 475	420 – 460	420 – 460
Gate, °F	450 – 470	450 – 470	460
Adapter, °F	450 – 470	450 – 470	460
Die End Plates, °F	450 – 470	450 – 470	470
Die Left and Right, °F	440 – 470	445 – 460	460
Die Center, °F	440 – 470	445 – 460	460

Typical screw geometries and machine settings for sheet extrusion
(two stage screw with L/D of 24/1 assumed)

CYREX®
Acrylic-polycarbonate alloys

CYREX® offers two grades which differ in color and mechanical strength properties. Both have Izod impact strength higher than polycarbonate while maintaining the ease of processing associated with acrylic materials. CYREX® can be injection molded, extruded and thermoformed. Key benefits include:

- Regulatory compliance – meets requirements of the USP Class VI, ISO 10993-1 and FDA for food contact
- Mechanical performance – toughness, strength and heat resistance
- Functionality – bondable to PVC tubing, ultrasonic weldable
- Sterilizability – EtO, gamma and e-beam sterilizable
- Sustainability – lower processing temperatures than polycarbonate for reduced cycle times

CYREX®

Acrylic-polycarbonate alloys

TYPICAL APPLICATIONS

- Luer fittings
- Spikes
- Protection caps and covers
- Adapters
- Fittings
- Valve assemblies
- Sharp needle dispenser receptacles

DESCRIPTION OF GRADES

Grade	*Description*
CYREX® 200	Excellent resistance to alcohol and lipids, ethylene oxide, gamma and e-beam sterilizable. Exceptional impact resistance with excellent heat resistance properties. CYREX® 200 is offered in two colors: • CYREX® 200-8000 is a natural off-white opaque color • CYREX® 200-8005 is white in color

CYREX®
Acrylic-polycarbonate alloys

PHYSICAL PROPERTIES

Property	ASTM Method	CYREX® 200-8000	CYREX® 200-8005
OPTICAL			
Light Transmission, % d = 3 .2 mm %	D-1003	Opaque	Opaque
RHEOLOGICAL			
Avg Melt Flow, g/10 min @ 230°C & 3.8 kg	D-1238	3.9	3.5
MECHANICAL			
Tensile Strength, psi (MPa)	D-638	8,850 (61.0)	8,000 (55.2)
Tensile Modulus, x10⁶ psi (GPa)	D-638	0.35 (2.4)	0.32 (2.2)
Tensile Elongation @ Yield, %	D-638	4.7	4.3
Tensile Elongation @ Break, %	D-638	58	57
Flexural Strength, psi (MPa)	D-790	12,500 (86.2)	11,300 (78.9)
Flexural Modulus, x10⁶ psi (GPa)	D-790	0.35 (2.4)	0.32 (2.2)
Notched Izod, ft-lb/in (J/m) on 1/8" bar (3.2 mm)			
@ 23°C	D-256	30.0 (1600)	26.0 (1387)
@ 0°C	D-256	4.0 (213)	–
Rockwell Hardness, M scale	D-785	46	49
PHYSICAL			
DTL, °F (°C) @ 264 psi, annealed	D-648	214 (101)	214 (101)
Vicat Softening Point, °F (°C)	D-1525	277 (136)	286 (141)
Specific Gravity	D-792	1.15	1.15
Water Absorption, %	D-570	0.26	0.26
Mold Shrinkage, in/in	D-955	0.004 –0.008	0.004 – 0.008
Coefficient of Linear Thermal Expansion in/in/°F, 32-212°F (mm/mm °C, 0-100°C)	D-696	0.000052 (0.0000936)	0.000052 (0.0000936)
Flammability		UL 94 HB	UL 94 HB

CYREX®
Acrylic-polycarbonate alloys

PROCESSING CONDITIONS – INJECTION MOLDING

Condition	Suggested	Starting Point
Drying Temperature, °F (3–4 hours)	180	180
Feed Section Temperature, °F	390 – 445	410
Center Section Temperature, °F	445 – 485	450
Front Section Temperature, °F	460 – 510	480
Nozzle Temperature, °F	460 – 510	480
Melt Temperature, °F	460 – 510	480
Mold Temperature, °F	150 – 210	180
Injection Pressure, psi	8,000 – 18,000	10,000
Clamp Pressure	2.5 tons/in² of projected area for flow length/wall thickness < 100/1 5 tons/in² for projected area for flow length/wall thickness > 100/1	
Screw Speed, rpm 2:1 compression ratio 3.5:1 compression ratio	 75 – 150 60 – 130	 100 80
Ram Speed, in/sec small gates large gates	 0.5 – 1.5 1 – 4	 1 2
Back Pressure, psi	50 – 300	100

VU-STAT® Y-20

Static dissipative acrylic copolymer

Vu-Stat® key benefits include:

- Regulatory compliance – meets requirements of the USP Class VI, ISO 10993-1 and FDA for food contact
- Safety – BPA & DEHP free
- Mechanical performance – toughness
- Functionality – permanent ESD protection, excellent bonding and welding capabilities
- Transparency – optical transparency
- Sterilizability – EtO
- Sustainability – lightweight

TYPICAL APPLICATIONS

- Inhalation treatment devices
- Brachytherapy procedures
- Drug delivery devices
- Medical electronic displays and packaging

ELECTRO-STATIC DISSIPATIVE PROPERTIES

Electrical @ (73°F) 20°C/20% RH

Volume Resistivity, ohm-cm	D257-78	3.8×10^{10}
Surface Resistance, ohms/sq	D257	1.4×10^{10}
Static Decay, sec	FTM 101C (Method 406.1)	0.01

VU-STAT® Y-20

Static dissipative acrylic copolymer

PHYSICAL PROPERTIES

Property	ASTM Method	VU-STAT® Y-20
OPTICAL		
Light Transmission, %	D-1003	85
Haze, %	D-1003	7.0
Yellowness Index	D-542	-0.3
RHEOLOGICAL		
Avg Melt Flow, g/10 min @ 230°C & 5 .0 kg	D-1238	9.0
MECHANICAL		
Tensile Strength, psi (MPa)	D-638	5,700 (39.3)
Tensile Modulus, x10⁶ psi (GPa)	D-638	0.31 (2.1)
Tensile Elongation @ Yield, %	D-638	3
Tensile Elongation @ Break, %	D-638	18
Flexural Strength, psi (MPa)	D-790	8,300 (57.2)
Flexural Modulus, x10⁶ psi (GPa)	D-790	0.24 (1.7)
Notched Izod, ft-lb/in (J/m) on 1/4" (6.35mm) bar @ 23°C @ 0°C	 D-256 D-256	 1.3 (68.2) 0.5 (26.2)
Rockwell Hardness, L Scale	D-785	54
PHYSICAL		
DTL, °F (°C) @ 264 psi, annealed	D-648	194 (90)
Vicat Softening Point, °F (°C)	D-1525	217 (103)
Specific Gravity	D-792	1.13
Water Absorption, % max	D-570	0.30
Mold Shrinkage, in/in	D-955	0.004 – 0.007
Coefficient of Linear Expansion in/in/°F, 32 – 212°F (mm/mm °C, 0-100°C)	D-696	0.000053 (0.000095)

PROCESSING CONDITIONS – INJECTION MOLDING

Condition	Suggested
Drying Temperature, °F (3–4 hours)	180
Feed Section Temperature, °F	380 – 435
Center Section Temperature, °F	400 – 460
Front Section Temperature, °F	400 – 475
Nozzle Temperature, °F	400 – 475
Melt Temperature, °F	400 – 475
Mold Temperature, °F	90 – 140
Injection Pressure, psi	10,000 – 20,000
Clamp Pressure, psi	2.5 tons/in² of projected area for flow length/wall thickness < 100/1 5 tons/in² for projected area for flow length/wall thickness > 100/1
Screw Speed, rpm 2:1 compression ratio 3.5:1 compression ratio	 20 – 100 20 – 70
Ram Speed, in/sec small gates large gates	 0.5 – 1.5 1 – 4
Back Pressure, psi	0 – 100

MATERIAL CONSIDERATIONS

Material Selection

- Selecting the right acrylic-based polymer for a particular application is an extremely important part of the design process.
- The first step is to clearly define the application and the end-use performance requirements for the molded part.
- Performance requirements include: heat resistance, toughness, sterilization technique and chemical resistance.
- Match the end-use performance requirements with the properties/attributes of potential materials. A grade with the highest strength and dimensional stability under heat will result in the most durable parts, although it may be more difficult to mold.

Drying

Acrylic-based polymers are slightly hygroscopic and therefore require pre-drying in vacuum or a desiccant type dryer where the effluent air has a dew point of -20°F or lower. Moisture levels must be below 0.05% for injection molding and below 0.03% for extrusion. Problems with reduced transparency, increased haze, the appearance of surface streaks, and bubbling throughout the part can all arise due to insufficient drying. The following table lists recommended drying conditions for each material.

Recommended drying conditions

Material	Temperature	Time
CYROLITE®		
G-20	175°F	3–4 hours
G-20 HIFLO	175°F	3–4 hours
GS-90	160°F	3–4 hours
CG-97	160°F	3–4 hours
Med 2	160°F	3–4 hours
MD L40	160°F	3–4 hours
MD H12	170°F	3–4 hours
XT® POLYMER		
250	180°F	3 hours
375	180°F	3 hours
CYREX®		
200	180°F	3–4 hours
VU-STAT®		
Y-20	180°F	3–4 hours

Regrind

- Roehm's materials can all be reground and reprocessed without adversely affecting physical properties.
- The primary effect from using reground material is a shift in color.
- Use 25% regrind to 75% virgin material to minimize significant color change.
- Avoid contamination and remove all fines in the regrind process.
- Regrind may require additional drying due to the increased surface to volume ratio.

MATERIAL CONSIDERATIONS
(continued)

Purging

- In most cases the acrylic polymers in un-dried state is a sufficient purging compound.
- Commercial compounds such as ASA Clean, Dyna-Purge, and Ultimax are recommended.
- Acrylic-based polymers will discolor if left in the barrel too long (5 - 10 minutes).
- Material that is exposed to high temperatures for long periods of time (i.e. 1 hour) will decompose and develop a skin on the screw barrel and nozzle.
- Decomposition will not cause any permanent machine damage and can be removed by purging with un-dried PMMA or ground cast acrylic sheet.
- Prolonged interruptions, or when temperatures are unusually high (above 500°F), may lead to a yellowing of material in the cylinder. If yellowing occurs, purging may be required.

Material Handling

- Molding of high-quality transparent parts requires high quality handling processes to prevent contamination from external sources.
- The high surface hardness of acrylic-based polymers also means that it is abrasive in conveying systems.
- Stainless steel must be used for curved conveying lines and should be used for fixed straight conveying lines.
- Polyurethane hoses can be used for short, flexible hose runs.
- PVC should never be used as it softens and feeds particles of PVC into the conveying stream as it is abraded.
- Separators should be used to remove fines that are generated during the conveying process.

INJECTION MOLDING

Basic Design

- The mold plates should be thick enough to prevent mold deformation that can occur from high melt pressures in the cavity.
- Slide molds can be used because the relatively viscous melt scarcely penetrates the gap between the sliding members.
- Acrylic-based polymers require 2.5 tons/in^2 (352 kg/cm^2) of projected area for flow length/wall thickness (L/t) <100/1 and 5 tons/in^2 (703 kg/cm^2) for L/t >100.
- Undercuts are not recommended.
- The mold cavity should have a smooth and nonporous surface, especially important when using crystal clear polymers.
- Chrome plating is preferred for a high gloss finish and to protect against penetration of lubricants into the mold surface.
- Molds for long runs should be case hardened and highly polished.
- To maintain reasonable residence time and minimize shear degradation, the shot size should range from 40 to 60% of the barrel capacity.
- If the cylinder is too large, difficulties in processing may occur because of long residence time or because of excessive stress on the machine drive.
- The choice of using a single cavity versus a multi-cavity mold is dependent upon the capacity of the machine and the overall production economics.

Wall Thickness

- As a general rule, it is best to work with walls that are not excessively thin, 0.039 inches (1.0 mm).
- Thin wall parts are more difficult to process and often deform at temperature much lower than expected due to increased molecular orientation.
- In order to adequately fill a thin wall part, a lower molecular weight compound with a higher melt flow rate should be used.
- Roehm offers grades of materials that are better suited for thin wall applications.

Mold Temperature

- The mold temperature has a significant influence on both the processing and properties of acrylic-based polymers.
- A mold temperature control device is recommended.
- A cold mold is more difficult to fill and can lead to high cooling stresses, warping, strong orientation, and sink marks.
- A cold mold will also lead to a hazy surface appearance of parts molded from impact-modified materials.

Venting

- Acrylic-based polymers tend to generate gases during processing requiring the mold to be vented.
- Venting serves two main purposes:
  1. Allows for displacement of the air in the mold so that the polymer can fill the mold.
  2. Releases gases from the process resulting in a quality part free of dullness and poor finish.
- Use 0.0015 inches (0.0038 mm) deep vents relieved to 0.005 inches (0.127 mm) for a length of 0.25 inches (6.4 mm).
- For complex molds, vacuum venting should be considered.

INJECTION MOLDING
(continued)

Shrinkage

- Acrylic and acrylic-based parts will shrink upon cooling.
- The amount of shrinkage is dependent upon the grade of acrylic-based polymer, the processing conditions at which the part was processed, and the size and thickness of the part.
- Roehm's acrylic-based polymers have a relatively low and predictable shrinkage in the range of 0.003 in/in to 0.008 in/in, depending on the product.
- Mold design and process conditions should be taken into consideration when estimating the shrinkage.

Sprue

- The cone sprue is the simplest form of sprue.
- It connects the nozzle of the injection cylinder directly to the mold.
- It must allow good filling of the mold cavity with a low pressure drop.
- The sprue should be as short as possible with a smooth surface as flow resistance increases with sprue length.
- If the sprue is not seated directly on the mold, a cold slug well should be used opposite the sprue.
- The cold well will collect the cooler compound that emerges first from the nozzle.

Runners

- The best cross-section for a runner is full round.
- Oval and rectangular cross-sections are not recommended.
- The runners should be kept as short as possible to facilitate complete and uniform filling.

Gating

- All types of gating designs have been used successfully with Roehm's line of acrylic-based products.
- If the gate is too small, it will restrict the filling speed which in turn prevents adequate filling of the mold.
- When using a restricted gate, the diameter should not be less than 0.036 inches (0.9 mm) for articles of average weight and 0.028 inches (0.7 mm) for smaller articles with a uniform wall thickness.
- The tab gate is used in situations where the weak area around a restricted gate must be avoided. The wall of the tab should not be thicker than the wall of the part to avoid excessive cooling time.
- The fan gate is used for flat, thin moldings such as scales, covers, or rulers where one does not wish to inject on the large, flat faces.
- The umbrella gate is recommended for tubular articles.
- Submarine gating allows the molding to be automatically separated from the runner upon removal from the mold.
- Center gating was one of the first types of gates used in injection molding and is considered to be one of the best. It provides a balanced fill for the molded part which reduces stress and minimizes weld lines. Center gating requires adequate cooling around the gate area for hot runner molds.
- The position of the gate is important as it affects the strength properties of the molded part.
- The gate should be located in a position of minimum mechanical stress as the gate has a notch effect and can induce failure.

EXTRUSION

There are many steps to follow in extrusion to ensure high quality product.

1. A clean dryer, conveying line, hopper, screw, barrel, and die.
2. Maintain the proper melt temperature.
3. Use microfinished, chromed, hardened polishing rolls.
4. Dry the material adequately.

A clean screw, barrel and die will help minimize contamination problems.

It is very important to avoid contamination with other plastics as the extrusion behavior of the melt and the optical and mechanical properties of the finished extrudate can be seriously jeopardized.

- When the die temperatures are too high, a build-up will form on the die lips.
- A die lip build-up can cause lines to form on the extrudate in the machine direction. On the other hand, if the die lip is too cool, the surface will be dull. Die lip edges must be very sharp to eliminate build up.
- High quality polishing rolls are necessary to produce an excellent surface finish that is smooth and glossy.
- We recommend using microfinished, chromed, and hardened rolls to Rockwell C 50-60.
- The rolls should be equipped with accurate and independent temperature and speed controls, coupled to rubber pull rolls.
- Drying of the material is critical in extrusion. A moisture level at or below 0.03% is recommended to ensure quality parts will be produced. Failure to adequately dry the material can result in a slight reduction in transparency and surface gloss, to severe surface streaks and/or bubbles.
- When using regrind, it is important to separate fines from the regrind. Failure to do this will result in black specks as the fines degrade and form char in the barrel which will slough off into the melt stream during processing.

COEXTRUSION

- Multi-manifold/multichannel dies produce the best, easily controlled, consistent multilayer sheet structure.
- CYROLITE® grades may be used as an outer/shell cap approximately 0.003 inches (0.076 mm) thick.
- XT® POLYMER may be considered for their environmental stress craze resistance.
- The rheology (shear-viscosity) of the polymers used in the coextruded structure must be similar and determines individual grades.
- Contact Roehm's Technical Service for testing of considered polymers. A layer of regrind containing a blend of CYROLITE® and XT® POLYMER, styrene, impact styrene and polymers made from related monomers may be incorporated into the structure.

OUTDOOR USE

CYROLITE® and XT® POLYMER are not recommended for outdoor use in applications where sensitivity to ultraviolet light and color stability are important.

FINISHING AND POST TREATMENT OPTIONS

Separation of the Sprue

- It is best to remove the sprue immediately after removal from the mold.
- Thin gates are cut with scissors, heated diagonal cutting pliers, or are broken off.
- Tab gates are usually removed with a small circular saw.
- Sprues are removed with cutters. The short, residual stump may be faced on a milling machine.
- Umbrella-type gates and annular gates are usually trimmed off.

Annealing

- Annealing minimizes the effects of internal stresses caused by the molding process.
- Annealing is recommended to avoid stress crazing if the molding may contact solvents or if the part will be solvent bonded or painted.
- The optimum annealing temperature is approximately 5°C below the distortion temperature under load (DTL).
- The annealing time is dictated by the thickness of the part.
- A rough guideline is one hour of heating per millimeter of material thickness and most importantly, one hour of cooling per millimeter of material thickness.
- The cooling time and rate are very important to the annealing process. If the molded parts are cooled too quickly, stresses may increase.

Antistatic Treatment

- The attraction of dust can be reduced by surface treatment with ionized air or liquid antistatic agents.
- Moldings can be immersed in this liquid immediately after removal from the mold.

Ethyl Acetate Test for CYROLITE® MD grades

- The ethyl acetate test aids in identifying internal stresses.
- The molding is immersed in ethyl acetate for two to three minutes. It is subsequently dried and examined for cracks and crazing.
- A properly molded part or annealed part will not craze, or craze very little, and will, as a matter of experience, meet all practical requirements.
- Roehm's Technical Center can be contacted for a complete procedure.

Bonding

There are several methods for bonding Roehm's line of acrylic-based products.

- Solvent bonding uses a solvent to soften the bonding area to the point where molecular entanglement between the two surfaces will occur.
- When the solvent dissipates, the entanglement is frozen in place.

The bond strength is often as strong as the parent material.

- Common solvents used for acrylic-based polymers are methylene chloride, toluene, tetrahydrofuran, cellusolve, cyclohexanone and methyl ethyl ketone.

Adhesive bonding differs from solvent bonding in that the adhesive itself forms the bond.

- Here, the bond is only as strong as the adhesive can adhere to the plastic substrate.

Two-part epoxies, 100% solids UV curable, and cyanoacrylate adhesives are often used for acrylics.

It is important to minimize molded-in stresses when any type of bonding will be performed on a part.

- This can be achieved by following recommended processing conditions and/or annealing the part prior to bonding.
- The Tech Brief entitled "Solvent and Adhesive Bonding" gives further recommendations for this process.

REGULATORY INFORMATION

CYROLITE® and XT® POLYMER compounds comply with USP Class VI, ISO 10993-1, and FDA food contact regulations as shown. The products comply with RoHS and REACH requirements, WEEE and CONEG regulations and the European Directive 2003/11/EC restriction of pentabromodiphenyl ether, and octabromo-diphenyl ether. CYROLITE® and XT® POLYMER compounds are free of heavy metals, plasticizers/phthalates, Asbestos, PCB, PCT PCP, chlorofluorocarbons, formaldehyde, isocyanate, polyurethane, natural latex and are BPA free.

Since XT® POLYMER compounds contain acrylonitrile in their composition, they are not acceptable for beverage containers and are further regulated by 21CFR 180.2. This regulation specifies the maximum level of acrylonitrile that may be extracted from a package by a food product. We recommend that each package/application be evaluated against these requirements. Contact Roehm's Technical Center for specific details.

CYROLITE® and XT® POLYMER compounds may be used as intended in contact with food in full compliance with California Safe Drinking Water and Toxic Enforcement Act of 1986, (Proposition 65) without providing a warning to consumers.

None of these products may be considered for medical implant applications.

REGULATORY REQUIREMENTS

Roehm's products comply with the following ISO, USP and FDA regulations

Grade	FDA Food Contact (1, 2)	USP Class VI (2)	ISO 10993-1 (3)(4)
CYROLITE® G-20	Yes	Yes (2)	Yes (2)
CYROLITE® G-20 HIFLO	Yes	Yes (2)	Yes (2)
CYROLITE® GS-90	Yes	Yes (2)	Yes (2)
CYROLITE® CG-97	Yes	Yes (2)	Yes (2)
CYROLITE® Med 2	Yes	Yes (2)	Yes (2)
CYROLITE® MD L40	Yes	Yes	Yes
CYROLITE® MD H12	Yes	Yes	Yes
VU-STAT® Y20	Yes	Yes	Yes
XT® POLYMER 250	Yes	Yes (2)	Yes (2)
XT® POLYMER 375	Yes	Yes (2)	Yes (2)
CYREX® 200-8000 (5)	Yes	Not Tested	Not Tested
CYREX® 200-8005 (5)	Yes	Yes	Yes

(1) Product meets FDA food contact requirements of 21 CFR 177.1010 under Condition C (no Alcohol) and Condition D 8% alcohol, or 21 CFR 180.22.

(2) In clear and 000, 001, 301 and 3128 tints only. Other colors not tested.

(3) Indicated products have been found to be non-hemolytic, non-cytotoxic, non-pyrogenic, non-sensitizing and non-mutagenic when tested following the ISO 10993-1 Protocols.

(4) In clear and 000, 001, 301 and 3128 tints only. Other colors not tested. In CYREX® 200 8005 color only.

(5) Not BPA free.

None of these products may be considered for medical implant applications.

ADDITIONAL INFORMATION

There are several Tech Briefs available upon request from Roehm's Technical Service.

PACKAGING

All CYROLITE®, CYROLITE® MD and XT® POLYMER compounds are supplied as 1/8-inch cylindrical pellets. They are primarily packaged in 1,500-lb cartons.

TECHNICAL SUPPORT

Our Technical Support offers access to frequently asked questions, physical properties, processing conditions, regulatory compliance information, tips for troubleshooting and more. Roehm's Technical Service Center utilizes a broad range of extrusion, thermoforming, injection molding, and testing equipment for product and process evaluations. Our Technical Service Engineers are also available for on-site assistance as needed. For technical information, please go to the contact us section on the website.

Important Notice

This information and all technical and other advice are based on Roehm's present knowledge and experience. However, Roehm assumes no liability for such information or advice, including the extent to which such information or advice may relate to third party intellectual property rights. Roehm reserves the right to make any changes to information or advice at any time, without prior or subsequent notice.

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