

THERMOPLASTICS FOR AIRCRAFT INTERIORS

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DEVELOPMENT OF PROCESSES AND  
TECHNIQUES FOR MOLDING THERMALLY  
STABLE, FIRE RETARDANT, LOW  
SMOKE EMITTING POLYMERIC MATERIALS

127

Contract NAS 9-15406  
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## TYPICAL MOLDING TYPES

- A. Compression Molding Materials
- B. Injection Molding Materials
- C. Thermoforming Sheet Materials

# PROGRAM SCHEDULE

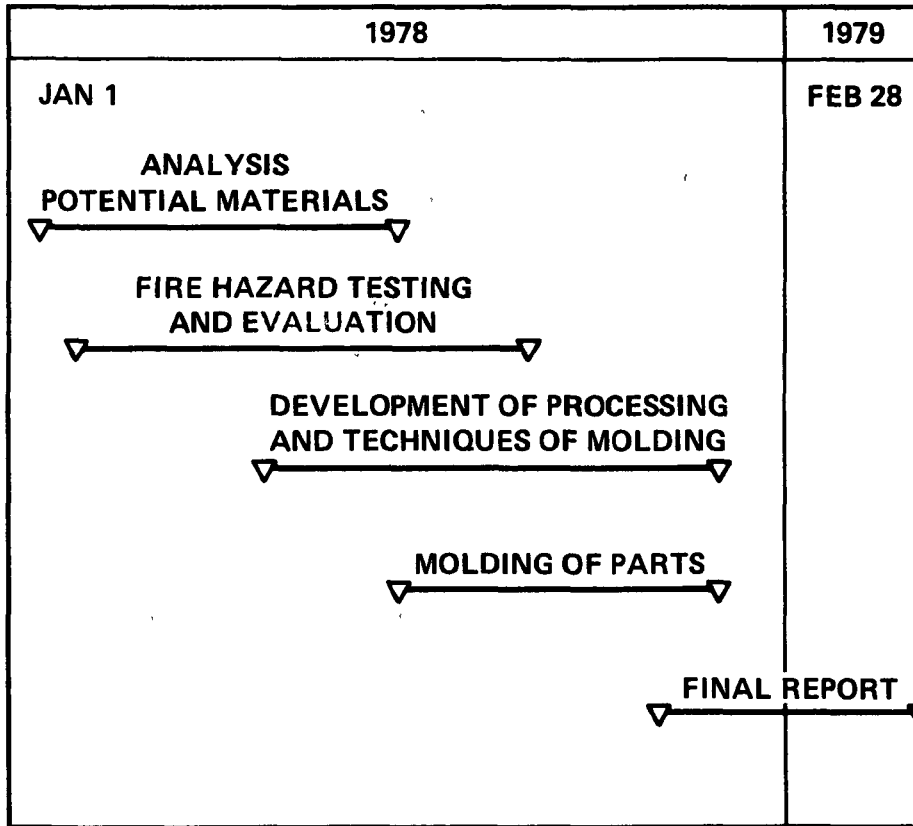


TABLE 4-1. PHYSICAL TECHNICAL PROPERTIES (Typical)

PHYSICAL PROPERTY	TYPE OF MOLDING			TEST METHOD FED. STD.-406, EXCEPT AS NOTED
	THERMOFORMED	INJECTION	COMPRESSION	
Tensile Strength psi min	6000	6000	8000	1011 Speed C
Impact Strength (notched Izod) ft lb/in of notch	3.0 min	3.0 min	3.0 min	1071
Flexural Strength psi-min	8000	8000	10,000	1031
Elongation % min at break	20	5	5	1011 Speed C
Mod of Elasticity, psi-min	300,000	300,000	300,000	1031
Specific Gravity max	1.40	1.30	1.30	5011
Heat of Deflect Temp °F min. @ 264 psi	250°F	250°F	300°F	ASTM D648
Color Fastness Fade-O-Meter	50 hr min	50 hr min	50 hr min	Fed. Std. 191 5060
Stress Cracking Resistance Solvent Test	No visible cracks	No visible cracks	No visible cracks	LAC C-22-1115 D Method 4.1.1.1
Oxygen Index (LOI) min	40	40	40	ASTM D-2863
Smoke Optical Density (DMS) max (6 minutes)	75	75	75	NBS Smoke Chamber AMINEO COT #4-5800
Thermal Stability (TGA) min	400	400	400	Thermogravimetric Analysis
Flammability Screening Test 60 sec vertical Test Method	5 sec extingh. max no drip	5 sec extingh. max no drip	5 sec extingh. max, no drip	FAA 25.853a Appendix F
Bondable Lap Shear psi min	500	500	500	1/2 in. overlap 1200-1400 psi/min.
180° Peel	8 ppi	8 ppi	8 ppi	2 in/min jaw sep.

Tentative Goals



**INDIVIDUAL  
(TYPICAL)**

	PROPERTIES	MATERIAL
GENERAL	CHEMICAL NAME TRADE NAME VENDOR FINISHED FORM RAW MATERIAL COST, \$/lb. COLORS AVAILABLE PAINT SYSTEMS ADHESIVE BONDING AVAILABILITY	POLYCARBONATE LEXAN GENERAL ELECTRIC INJECTION MOLDING 2.0 CLEAR, BLACK, COLORS ON ORDER URETHANE + PRIMER URETHANE FULL PRODUCTION
PRO- CESSING	DRYING REQUIREMENTS CURE CYCLE POST CURE CYCLE ANNEALING	YES, 4 HRS AT 100°C INJECTION TEMP., MOLD TEMP. NONE NONE
PHYSI- CAL	DENSITY, G/cc <sup>3</sup> , (\$/in. <sup>3</sup> ) WATER ABSORPTION, % IN 24 HOURS ROCKWELL HARDNESS	1.21 0.15 70 M, 1/8 R
MECHANICAL	TENSILE STRENGTH, (psi) MPa TENSILE MODULUS, (psi x 10 <sup>5</sup> ) TENSILE ELONGATION, % FLEXURAL STRENGTH, (psi) MPa FLEXURAL MODULUS, (psi) MPa COMPRESSIVE STRENGTH, (psi) MPa COMPRESSIVE MODULUS, (psi) MPa IZOD IMPACT, NOTCHED, ft-lb/in.	58.6 MPa (8500 psi) (3.25) .50 82.7 (12,000) 2070 (3.0 x 10 <sup>5</sup> ) (12,500) 87.2 (3.5 x 10 <sup>5</sup> ) 12.0
THERMAL AND FIRE SAFETY	HEAT DEFLECTION, °F (264 psi) 182°C MPa MAXIMUM SERVICE USE, (°F) °C OXYGEN INDEX FLAMMABILITY RESISTANCE FAR 12 sec-IGNITION (60-sec IGNITION) FLAME-OUT GLOW TIME BURN LENGTH cm SMOKE IGNITION D <sub>S</sub> - 6 min (D <sub>M</sub> ) TGA TOXIC GAS EMISSIONS	(270°F) (230°F) 35 GOOD PASSES 12, & 60 sec 5 0 5 DRIPS (NO FLAME) 105
SERVICEABILITY	SOLVENT RESISTANCE HUMIDITY STABILITY STRESS CRACK RESISTANCE CLEANABILITY COMMON MAINTENANCE COMMERCIAL CLEANERS WITH AMMONIA TRICHLOROETHANE ULTRA-VIOLET LIGHT RESISTANCE ABRASION RESISTANCE	POOR GOOD GOOD FAIR FAIR FAIR FAIR POOR GOOD 60 HRS FAIR
MISC.	COST OF PROCESSING/lb MATERIAL	EQUAL TO PRESENT TYPE POLYCARBONATE
REMARKS		

# INJECTION MOLDING MATERIALS

## PROPERTIES

	CHEMICAL NAME	POLYCARBONATE	POLYETHERSULFONE	POLYPHENYLSULFONE
GENERAL	TRADE NAME VENDOR FINISHED FORM RAW MATERIAL COST COLORS AVAILABLE PAINT SYSTEMS ADHESIVE BONDING AVAILABILITY	Lexan 940 General Electric Small Pellets \$2.50 Clear & All Colors PES-Urethane PES-Urethane In Production	200P ICI (USA) Small Pellets \$8.00 Transp. & All Colors Possible-Devel 7-Devel Limited Production	Radel Union Carbide Small Pellets * \$15.00 All Colors ? ? Limited Production
PROCESSING	DRYING REQUIREMENTS CURE CYCLE INJECTION TEMP °C POST CURE CYCLE °C ANNEALING °C	4 Hrs @ 100°C 300°C-R.T. None None	4 Hrs. 150°C * 350°C I.T.-170°C M.T. None Required For Larger Parts	3 Hrs 150°C 375°C I.T.-165°C M.T. None None
PHYSICAL	DENSITY, g/cc <sup>3</sup> , (lb/in <sup>3</sup> ) WATER ABSORPTION, % IN 24 HOURS ROCKWELL HARDNESS	1.21 0.15 70 M	1.37 0.43 88 M	1.27
MECHANICAL	TENSILE STRENGTH MPa (psi) TENSILE ELONGATION % FLEXURAL STRENGTH, MPa (psi) FLEXURAL MODULUS, MPa (psi) COMPRESSIVE STRENGTH, MPa (psi) IZOD IMPACT, NOTCHEN, ft-lb/in	58.6 (8500) 50 82.7(12,000) 2070(3.0x10 <sup>5</sup> ) 87.2(12,500) 12	82.7 (12,000) 8 113(16,000) <sup>5</sup> 2415(3.5x10 <sup>5</sup> ) 82.7(12,000) 1.6	71.7 (10,400) 60 85.5 (12,400) 2280 (3.3x10 <sup>5</sup> ) 12.0
THERMAL AND FIRE SAFETY	HEAT DEFLECTION, °C 1820 KPa (264 psi) MAXIMUM SERVICE USE, °C OXYGEN INDEX FLAMMABILITY RESISTANCE - ASTM F501-77 FAR 853-60 SEE VERTICAL TEST - FLAME OUT GLOW TIME BURN LENGTH SMOKE IGNITION D <sub>s</sub> -6min (D <sub>m</sub> ) TGA °C TOXIC GAS EMISSIONS	132°C(270°F) 110°C(230°F) 5 (.030) Passes 5 0 8cm (.060) 110 Very Low	203°C 175°C 37 Passes (.030) 3 0 3cm 20 440°C Fair	240°C (400°F) 290°C 39 .039) Passes 0 0 1.5 cm 5 500°C Minimal
SERVICEABILITY	SOLVENT RESISTANCE HUMIDITY STABILITY STRESS CRACK RESISTANCE CLEANABILITY Common Maintenance Commercial Cleaners With Annomia Tricacoraethane Ultra Violet Light Resistance ABRASION RESISTANCE	Poor Good Good Fair Fair Poor Good Fair	Poor Good Fair Good Fair Fair Good ?	Good Excellent Good Good Good Good ?
MISC.	COST OF PROCESSING	Equal To Present Type Polycarbonate		
REMARKS		May Be Substituted Directly In System A Impact Resistance Greatly Improved	*Impact Strength Very Low	*May Be Prohibitive But Offers Other Good Features With Respect to Fire Safety  Does Not Drip

	POLYAMIDE-IMIDE	POLYVINYLIDINE FLUORIDE	POLYIMIDE ALLOY (PPS)	POLYARYL
E-200 32 None into Small Pellets \$8 00 One Light Color ? Developmental	Torlon 4203 Amoco Chemical Small Pellets \$4 00 Dark Brown ? Epoxy Limited Production	Kynar Pennwalt Small Pellets  Black No No Limited Production	Tribolon XT-1211 Fluorocarbon Small Pellets \$12.50 Dark Brown ? Possible ? Possible Limit Small Parts	Sulfone Asteel # 360
350°C 1 T -100°C ( M.T. None None	8 Hrs at 120°C 360°C I.T.-260°C M.T. * 96 Hrs(130°C to 260°C)	None 200°C- R.T None None	2 Hrs 130°C 370°C I.T.-180°C M.T. 12 Hrs 20°C To 260°C	
1 19 0 15	1 40 0 28	180 109	1 45	
(10,000) 66  (2.9x10 <sup>5</sup> )  3 0	(27,000) 12 (30,000) (2.5x10 <sup>5</sup> ) (40,000) 2.5	(6000) 51-200  (2.0x10 <sup>5</sup> ) (8600) 5	(7000) 8 (10,500) (6.1x10 <sup>5</sup> ) (12,500) * 1.1 To 2.5	
172°C 160°C 34 (.030) Passes  80  Minimal	274°C 250°C 41 (.030) Passes 0 0 1.2 cm 10 450°C Minimal	82°C(180°F) 70°C 45 Passes 0 0 2 cm  350°C High	250°C 225°C  Passes 0 0 1 cm 3 450°C Minimal	
Fair Good ? Good Good Fair ? ?	Excellent Good Good Depends on Paints " " "	Good Good Good Depends on Paints " " "	Excellent Good Good Depends On Paint " " "	
	*Processing Costs For Stress Relief Would Be Prohibitive	High Material & Processing Costs	High Material & Processing Costs	
		*Prohibitive Weight Cost * Is not Bondable	*Low Impact Strength *Higher Density	*Too Costly To Be Considered



PRELIMINARY MATERIAL SELECTION

Compression

Injection

Thermoforming

Phenolic/Glass

Polycarbonate  
(Lexan 940)

Polycarbonate  
(Lexan EF-6000)

Modified Phenolic-  
glass

Polyphenyl Sulfone  
(Radel)

Modified Kel-F

Polyimide/glass

Aromatic Polymer

?

SESSION B: FIRE TOXICOLOGY

Session Chairman: Henry A. Leon  
Ames Research Center