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A COMPILATION OF LOW OUTGASSING POLYMERIC MATERIALS NORMALLY RECOMMENDED FOR GSFC COGNIZANT SPACECRAFT

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GSFC

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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Special Materials and Projects Office
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ABSTRACT

More than five hundred similarly tested polymer materials compiled from SRI, JPL and GSFC sources, successfully screened to meet acceptable outgassing criteria*[1], are presented in both application and alphabetical categories.

Some polymers with somewhat higher outgassing are included where they must perform a highly selective function and are the only materials available to meet special requirements.

A number of acceptable polymer materials suitable for system combinations are proposed. This material system concept can effectively increase the application scope of individual polymers listed, while still meeting outgassing criteria as a system.

*Materials are heated at 125°C for 24 hours at from 1×10^{-6} to 1×10^{-7} torr. Outgassed products are condensed on a 25°C surface and weighed. Criteria for acceptable materials must be both, less than 1 percent total outgassing and less than 0.1 percent condensables.

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CONTENTS

MATERIAL APPLICATION TABLES OUTGASSING DATA

MATERIAL APPLICATION TABLES OUTGASSING DATA (Continued)

A COMPILATION OF LOW OUTGASSING POLYMERIC MATERIALS NORMALLY RECOMMENDED FOR GSFC COGNIZANT SPACECRAFT

INTRODUCTION

The new sophisticated series of Goddard cognizant earth observing satellites together with the anticipated long lived communication, meteorological and explorer types have spawned new concepts in electro-optics instrumentation, radiant coolers and millimeter wave black boxes. These require absolute minimums of spacecraft contamination. ERTS oscillating optic elastomeric silicone dampers must be minimally outgassing. Spacecraft coolers cannot operate at design temperatures of -120°C if coated with a thickness of outgassed condensables measured in angstroms. Observations of environment sampling instrument signals, which might indicate the presence of amine, ammonia, gases, moisture, etc., require insurance that these molecular species do not emanate from the parent spacecraft. These are some of the problems which have led to an increasing need by designers, component manufacturers, contractors and spacecraft engineers for an initial acceptable first cut list of polymeric engineering materials based on low outgassing characteristics. The successfully screened materials presented in this document have been collected since JPL's early beginnings in 1964 through SRI[2] and include those resulting from recent on-going work at JPL[3] and GSFC. GSFC's strong interest in outgassing condensables arises from the observed sensitivity of spacecraft electronics, optics, instrumentation and passive thermal control surfaces, to condensable contaminants.

The compilation and application discussion will benefit designers and engineers associated with the various spacecraft technologies by accelerating both the materials review, and design acceptance process, cutting lead times and costs. In addition, the testing of questionable vendor submitted materials with their attendant agonizing delays will be minimized.

Hopefully, tomorrow's design engineer and vendor can attack their complex problems with acceptable low outgassing polymer material systems. In addition, they may be stimulated to utilize in unusual ways, the new range of physical properties inherent in the latest generation of polymer compositions. Although the low outgassing compilation will assist individual engineers in making acceptable initial polymer selections, it is still highly desirable that they continue to seek specialist guidance on hardware compatibility from a total material system environment viewpoint. This is important since there are basic properties other than outgassing which may determine the selection of a polymer system to provide optimized service.

DISCUSSION: Material Application Tables

Tables will be discussed where applicable.

Molding Compounds and Laminates for Structural Hardware (Table 1)

The group on molding materials and structural hardware includes readily available polymers and glass filled systems with individual inherent properties to fulfill a multitude of spacecraft strength and insulation requirements. In fact, epoxy boron and epoxy graphite laminate composites similar to those indicated herein, have, as demonstrated by an Air Force evaluation program,[4] exceeded both the tensile strength and modulus values of aluminum on a density basis. Graphite fiber, resin system structural components have been proposed with essentially "0" coefficient of thermal explanison, ie., the antenna dish support on ATS F.&G. Convair is proposing a graphite resin, tube-structure, optical bench for the HEAO-C, X-Ray telescope[5], that will allow a temperature tolerance of ±100°F as against aluminum's tolerance of ±1°F max. before defocusing occurs. The further versatility of various polymer systems is indicated by Vespel, Delrin, Teflon and FEP which individually or in combination with molybdenum disulphide can provide exceptionally frictionless surfaces for special situations. Vespel, Teflon and FEP are both ultraviolet and temperature resistant. The Delrin and Teflon are relatively poor in regard to particulate energy resistance; however, the Delrin has excellent dimensional stability with minimal moisture absorption. Add some glass fiber to all the above and most properties improve. These materials can provide rods, tubes, gears, housing walls, support, damping members and machined items of multidimensions and shapes. Although the polyimide Vespel has a submarginal total outgassing of 1.24%, this is primarily moisture. It may be considered for use where its excellent combination of properties, low condensables, low friction coefficient, excellent ultra violet, particulate radiation and high temperature resistance are essential to spacecraft function.

Table 1

Molding Compounds and Laminates for Structural Hardware

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. acetal/M 58 000 mol. wt. hi. visc.	Delrin-100NC10	DU	AR	AR	0.58	0.06	SRI
P. acetal/M 58.000 mol. wt. hi. visc	Delrin-150NC10	DU	AR	AR	0.56	0.06	SRI
P. acetal/M 38.000 mol. wt. med. visc.	Delrin-500NC10	DU	AR	AR	0.48	0.07	SRI
P. acetal/M 32,000 mol. wt. low visc.	Delrin-900NC10	DU	AR	AR	0.56	0.08	SRI
P. acetal/gl./M	Formafil-G80/20	FF	80 r./20 gl.	AR	0.44	0.01	GSFC
P. acetal/gl./M	KF-1006	LN	70 r./30 gl.	AR	0.28	0.02	GSFC
P. acetal/teflon/M	Delrin-AF	DU	80 Delrin/20 Teflon	AR	0.47	0.05	JPL
P. acetal/teflon/M	Fulton 404	LN	80 Delrin/20 Teflon	AR	0.52	0.01	GSFC
P. arylether/M	Arylon-T	UN	AR	AR	0.36	0.03	GSFC
P. arylether/gl./M	XF 1006	LN	70 r./30 gl.	AR	0.29	0.01	GSFC
P. arylsulphone/M	Astrel 360	MM	AR	AR	0.94	0.02	GSFC
P. boron-silica/M	Dexsil-201	OC	AR	AR	0.07	0.01	GSFC
P. buta./acrylonitrile/ gl./M	AF-1006	LN	70 r./30 gl.	AR	0.20	0.01	GSFC
P. carbonate/M intermed. mol. wt.	Lexan-100 - 111	GE	no additives	AR	0.06	0.02	SRI
P. carbonate/M intermed. mol. wt.	Lexan-100 - 112	GE	no additives	AR	0.09	0.04	SRI
P. carbonate/M intermed. mol. wt.	Lexan-101 - 111	GE	therm. stabilized	AR	0.08	0.01	SRI
P. carbonate/M intermed. mol. wt.	Lexan-103 - 112	GE	therm. + UV stabilized	AR	0.17	0.01	SRI
P. carbonate/M high mol. wt.	Lexan-130 - 111	GE	no additives	AR	0.17	0.01	SRI
P. carbonate/M high mol. wt.	Lexan-131 - 111	GE	therm. stabilized	AR	0.18	0.01	SRI
P. carbonate/M high mol. wt.	Lexan-131 - 112	GE	therm. stabilized	AR	0.17	0.01	SRI
P. carbonate/M high mol. wt.	Lexan-133 - 112	GE	therm. + UV stabilized	AR	0.20	0.01	SRI
P. carbonate/M low mol. wt.	Lexan 140 - 111	GE	no additives	AR	0.17	0.03	SRI
P. carbonate/M low mol. wt.	Lexan-141 - 111	GE	therm. stabilized	AR	0.17	0.04	SRI
P. carbonate/M low mol. wt.	Lexan-141 - 112	GE	therm. stabilized	AR	0.17	0.02	SRI
P. carbonate/M low mol. wt.	Lexan-243 - 112	GE	therm. + UV stabilized	AR	0.16	0.01	SRI
P. carbonate/S low mol. wt.	Lexan-9434-112	GE	AR	AR	0.19	0.01	GSFC
P. carbonate/gl./M	DF-1006	LN	70 r./30 gl.	AR	0.14	0.01	GSFC
P. carbonate/gl./M	Carbafil-G50/20	FF	80 r./20 gl.	AR	0.12	0.01	GSFC
P. chlorofluorocarbon/M	Kel-F 81	MM	AR	AR	0.03	0.01	SRI
DAP/gl./M	Dial-FS-4	AC	AR	24h. 150° C	0.58	0.02	SRI
DAP/gl./M	Dial-FS-10	AC	AR	24h. 150° C	0.70	0.03	SRI
DAP/gl./M	Dial-FS-40	AC	AR	24h. 150° C	1.00	0.02	SRI
DAP/gl./M	Dial-FS-80	AC	AR	AR	0.44	0.01	GSFC

Molding Compounds and Laminates for Structural Hardware (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
DAP/gl./M	Dial-52-40-40	AC	AR	AR	0.70	0.06	SRI
DAP/gl./M	Dial-52-40-40	AC	AR	24h. 150° C	0.39	0.01	SRI
DAP/gl./M	C2580-118	FM	AR	AR	0.30	0.01	GSFC
Epoxy/M	Epocast 403-S-3	FU	AR	AR	0.32	0.01	GSFC
Epoxy/M	Fiberite E3938	FB	AR	AR	0.44	0.01	GSFC
Epoxy/M	Rogers RX-611	RG	AR	AR	0.53	0.02	GSFC
Epoxy/M	Furane 403	FU	AR	AR	0.43	0.01	SRI
Epoxy/gl./min./M	Epiall 1906L	AY	AR	AR	0.39	0.06	SRI
Epoxy/gl./min./M	Epiall 1906L	AY	AR	24h. 150° C	0.16	0.03	SRI
Epoxy/gl./M	Epiall 1914	AY	AR	24h. 150° C	0.55	0.03	SRI
Epoxy/gl./M	EMC-115-B-1	PA	AR	AR	0.29	0.01	GSFC
Epoxy/iron/M	Eccosorb MF-124	EC	AR	AR	0.09	0.01	GSFC
Epoxy/metal/M	Eccosorb MF-124	EC	AR	AR	0.20	0.02	JPL
Epoxy/metal/M	Eccosorb MF500F 116	EC	AR	AR	0.30	0.04	JPL
P. ester/gl./M	WF-1006	LN	70 r./30 gl.	AR	0.19	0.01	GSFC
P. ethylene/gl./M	FF 1006	LN	70 r./30 gl.	AR	0.13	0.03	GSFC
Fluorocarbon/M	Gylon Gasket	GC	PTFE	AR	0.04	0.04	JPL
Fluorocarbon/cer./fiber/M	RT Duroid 5650	RG	PTFE	AR	0.22	0.03	JPL
Fluorocarbon/cer./fiber/M	RT Duroid 5650	RG	PTFE	AR	0.28	0.01	JPL
Fluorocarbon/gl./M	RT Duroid 5650	RG	PTFE	AR	0.22	0.02	JPL
Fluorocarbon/gl./M	RT Duroid 5650	RG	PTFE	AR	0.12	0.02	JPL
Fluorocarbon/gl./M	CT-505	CP	PTFE	AR	0.01	0.01	JPL
Fluorocarbon/mica/M	Fluorosint	AT	PTFE/mica	AR	0.09	0.03	JPL
Fluorocarbon/mica/M	Fluorosint LE 207	AT	PTFE/mica	AR	0.20	0.04	JPL
P. imide/M	Gemon 3010	GI	AR	AR	0.34	0.02	GSFC
P. imide/M	Vespel SP-1	DU	AR	AR	1.24	0.01	SRI
P. imide/gl./M	LNP XF 1004	LN	80 r./20 gl.	AR	1.06	0.01	GSFC
P. methacrylate-mod./M	Bavick II	BC	AR	AR	0.59	0.01	GSFC
P. methacrylate-mod./M	Lucerne 011-V	AY	AR	AR	0.51	0.05	GSFC
P. methacrylate/M	Plexiglas II	DU	AR	AR	0.57	0.01	GSFC
P. methacrylate/M	Plexiglas VS-100	DU	AR	AR	1.60	0.01	GSFC
Nylon-12/M	Plaskon 1980	PN	AR	AR	0.65	0.03	JPL
Nylon 6/6/gl./M	RF 1006	LN	70 r./30 gl.	AR	0.81	0.04	GSFC
Nylon 6/10/gl./M	QF-1006	LN	70 r./30 gl.	AR	0.65	0.04	GSFC

Molding Compounds and Laminates for Structural Hardware (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Nylon 11/gl./M	LNP-HF-1006	LN	70 r./30 gl.	AR	0.37	0.02	GSFC
Nylon 12/gl./M	LNP SF-1006	LN	70 r./30 gl.	AR	0.65	0.02	GSFC
P. phenylene-oxide/M	Noryl	GE	AR	AR	0.10	0.01	GSFC
P. phenylene-oxide/gl./M	Noryl-ZF-1006	GE	70 r./30 gl.	AR	0.04	0.01	GSFC
P. phenylene-oxide/gl./M	NF-1006	LN	70 r./30 gl.	AR	0.11	0.01	GSFC
P. propylene/M	Impalene	IE	AR	AR	0.30	0.05	GSFC
P. propylene/gl./M	MF-1006	LN	70 r./30 gl.	AR	0.13	0.04	GSFC
P. styrene/M			AR	AR	0.26	0.01	JPL
P. Styrene/x/M	Q 200.5	PP	AR	AR	0.09	0.01	GSFC
P. styrene/gl./M	CF-1006	LN	70 r./30 gl.	AR	0.10	0.0[illegible]	GSFC
P. styrene/gl/CrO_2/M	Styrafil/G33/20/CRO_2	FF	75 r./20 gl./5-ox	AR	0.53	0.01	GSFC
P. styrene-acrylonitrile/gl./M	Acrylaglas S/40/35	FF	65 r./35 gl.	AR	0.22	0.03	GSFC
P. styrene-acrylonitrile/gl./M	BF-1006	LN	70 r./30 gl.	A[illegible]	0.24	0.01	GSFC
P. styrene-acrylonitrile/gl./M	Acrylafil G47/20	FF	80 r./20 gl.	AR	0.23	0.01	GSFC
P. sulphone/gl./M	GF-1006	LN	70 r./30 gl.	AR	0.24	0.01	GSFC
P. sulphone/gl./M	Sulfil.G-1500/20	FF	80 r./20 gl.	AR	0.20	0.01	GSFC
P. urethane/gl./M	TF-1008	LN	60 r./40 gl.	AR	0.37	0.0[illegible]	GSFC
P. vinyl-chlor./gl./M	VF-1007	LN	65 r./35 gl.	AR	0.30	0.0[illegible]	GSFC
Epoxy/boron fil./L	Rigidite 5505	NR	AR	.5h. 93° C+ .5h. 177°C	0.46	0.0[illegible]	JPL
Epoxy/boron fil./L	Epon 828/1031	SH	25p. Epoxy+cat./ 75p. boron filament Epoxy+cat = 50p. 828 50p. { MNA-90p. BDMA-10p.	1h. 66° C 1h. 82° C 4h. 177° C	0.25	0.02	JPL
Epoxy/carbon fil./L		GY	AR	AR	0.55	0.04	GSFC
Epoxy/gl/L	Micaply G-284	MP	AR	AR	0.49	0.06	SRI
Epoxy/gl./L	Micarta 65M28 (FR-4)	WC	AR	AR	0.26	0.01	JPL
Epoxy/gl./L	Micarta H-2497	WC	AR	AR	0.18	0.01	SRI
Epoxy/gl./L	Micarta H-8457	WC	AR	AR	0.80	0.12	SRI

Molding Compounds and Laminates for Structural Hardware (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy/gl./L	Micarta H-17511	WC	AR	AR	0.44	0.04	SRI
Epoxy/gl./L	Micarta H-17690	WC	AR	AR	0.48	0.07	SRI
Epoxy/gl./L	Scotchply XP 251-S	MM	unidirectional	.5h. 149°C+4h. 177°C	0.58	0.01	JPL
Epoxy/gl./L	Scotchply 279	MM	35r./65 gl.	AR	0.96	0.06	JPL
Epoxy/gl./L	GE 101(FR-4)	EL	AR	AR	0.48	0.05	JPL
Epoxy/gl./L	K-6098	MM	AR	AR	0.01	0.01	GSFC
Epoxy/gl./L	MIT-1281627	MT	AR	AR	0.32	0.02	GSFC
Epoxy/gl./L	MIT-600	MT	AR	AR	0.54	0.03	GSFC
Epoxy/gl./pre/L	Hexcel F153	HX	AR	7h. 171°C/14 psi	0.19	.01	GSFC
Epoxy/gl./pre/L	BP-907	AY	AR	1h. 177°C	0.84	0.02	JPL
Epoxy/graph/pre/L	HY-E 1001	FB	42p. Epoxy 10836 58p. graphite 3p. BF complex	1h. 132°C 1h. 171°C	0.53	0.04	JPL
Epoxy/graph/pre/L	HY-E 1002	FB	38p. { WS-1028 or 50p.Epon 1031 / 50p.Epon 1028 } 62p. graphite 90p. NMA .45p. BDMA	1h. 82° C 4h. 177° C	0.32	0.04	JPL
P. ester/T	P-49	RD	AR	10min. 104°C	1.04	0.05	GSFC
P. ester/T	V-700075	RD	AR	10min. 93°C	0.47	0.01	GSFC
P. imide/gl./L	Pyralin 12	DU	AR	AR	0.52	0.01	GSFC
P. imide/gl./L	—	AM	AR	AR	0.77	0.01	GSFC
Phenolic/gl./L	Micarta H-5834	WC	AR	AR	0.70	0.03	SRI
Phenolic/gl./L	91 LD	SG	AR	AR	0.37	0.04	GSFC
Diphenyl-ox/gl./L	Doryl H-17511	WC	AR	AR	0.44	0.04	SRI
Diphenyl-ox/gl./L	Doryl H-17511	WC	AR	24h. 150°C	0.68	0.03	SRI
Silicone/gl./L	Micarta 20201-2	WC	AR	AR	0.16	0.04	SRI

Pottings (Table 2)

The availability of low outgassing, across the board, potting types provides ready media for the solution of the many problems encountered in space hardware development.

Cured potting hardnesses vary from the hard epoxies to the semi-rigid; include the "Solithane", urethane durometer A through D range and also the flexible silicones. Pottings are meant to protect and they will if the application is properly conceived and practiced. Many pottings involve non critical operations with selection depending on simple criteria of flexibility, electricals, exotherm, pot life, etc. However, each potting is a problem unto itself and the misinterpretation of a single condition can lead to the loss of a valuable complex piece of equipment. Pottings are easily formulated to lighter structures by utilizing glass, silica or ceramic microballoons. Adhesion of balloons to resin may be increased by surface treatment of balloons with reactive silanes.

The silicones are quality pottings and are recommended for their excellent electricals, temperature and high voltage resistance. Photo multiplier tubes should be their main target. Tube assemblies should be designed as a "total potted package." This implies that the designer must initially consider all potting operation requirements necessary to produce void free material in a vacuum environment. Potting specialists should be consulted. Design configurations aimed at potting protection with optimal, not marginal resistance to corona breakdown, should be given primary consideration. Many problems would be eliminated if these considerations were made originally. Tubes with excellent electronic characteristics can be ruined by poorly conceived and executed potting proceedures. Depotting in most cases is impossible.

Potting resins may in many instances be utilized as vehicles to make silver conductive paints for R.F. shielding or for preparing touch up black and white paints internal to the spacecraft wherever thermal control considerations are minimal, or as emergency, room temperature setting adhesives. High dielectric constant materials with K of 25 and higher or configured magnetic structures are easily formulated and designed. Energy attenuating forms can be made and these many material types readily formulated in various hardnesses.

Table 2
Pottings

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy	AV-100/HV 100	CJ	AR	7d. R.T.	0.78	0.10	GSFC
Epoxy	Bacon Ind.	BN	AR	4h. 71° C+ 16h. 100° C	0.12	0.01	GSFC
Epoxy	BSL 208	CI	AR	1h. 164° C	0.82	0.11	GSFC
Epoxy	BSL 308	CI	AR	1h. 175° C	0.49	0.10	GSFC
Epoxy	EC 1751 A/B	NM	50p./1751 A 100p./1751 B 15p./phenyl glycidyl ether	24h. R.T.	0.75	0.06	GSFC
Epoxy	Eccomold L-28	EC	AR	64h. 127° C	0.18	0.01	GSFC
Epoxy	Eccoseal 1207/20	EC	100p. 1207/1.5p. 20	4h. 71° C+ 1h. 177° C	0.27	0.01	GSFC
Epoxy/iron	Eccosorb MF 112	EC	AR	AR	0.26	0.01	GSFC
Epoxy/iron	Eccosorb MF 114	EC	AR	AR	0.22	0.01	GSFC
Epoxy	Epocast N4E-053	FU	AR	24h. R.T.+ 2h. 93° C	0.07	0.02	GSFC
Epoxy	Epon 828/A	SH	100p. 828/8p.A	3h. 95° C	0.70	0.06	SRI
Epoxy	Epon 826/Z	RO	100p. 826/20p.Z	2h. 77° C+ 2h. 135° C	0.91	0.02	JPL
Epoxy	Epon 828/Z	SH	100p. 828/20p.Z	2h. 75° C+ 2h. 135° C	0.42	0.03	SRI
Epoxy/versam.	Epon 828/140	GS	50p. 828/50p.140	24h. R.T.	0.20	0.02	GSFC
Epoxy/semi-rigid	Epon 828/871/AEP	GS	35p./828 65p./871 15.5p./AEP	12h. R.T.	0.86	0.05	GSFC
Epoxy/semi-rigid	Epon 828/871/AEP	GS	40p./828 60p./871 15.5p./AEP	18h. 65° C	0.46	0.02	GSFC
Epoxy	Epon X-24	SH	AR	10h.100° C	0.42	0.05	GSFC
Epoxy	Epotek-301 A/B	ET	20p.A/5p.B spectrally transparent	24h. R.T.	1.08	0.01	GSFC
Epoxy	HP-16-92	HA	100p. DER 332 LC/18p. HV	5h. R.T. +12h. 90°C +24h. 90°C P.C.	0.33	0.02	GSFC

Pottings (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy	Hysol C9-4188/3469	HY	10p. 4188/.75p.3469	1h. R.T. 1h. 49° C 1h. 171° C	1.01	0.08	JPL
Epoxy	Hysol C-9-4188/3469 Ferro V-780	HY	10p. 4188/.75p.3469	1h. R.T. 1h. 49° C 1h. 171° C	0.96	0.03	JPL
Epoxy	Hysol C9-5340/3426	HY	100p.5340/8.3p.3426	8h. R.T.	0.60	0.05	GSFC
Epoxy	Hysol R8-2038/ H2-3475	HY	AR	24h. R.T.	0.53	0.01	GSFC
Epoxy	Hysol XC9-G710/ H2-3561	HY	AR	AR	0.90	0.02	GSFC
Epoxy	Hysol 0151	HY	AR	24h. R.T.	0.78	0.02	GSFC
Epoxy	Maraset 655/553	MR	100p.655/20p.553	16h. 82° C	0.59	0.01	SRI
Epoxy	Maraset 655/553	MR	100p.655/20p.533	16h. 82° C+ 24h. 150° C	0.32	0.01	SRI
Epoxy	Maraset 655/555	MR	100p.655/7p.555	16h. 82° C	0.41	0.01	SRI
Epoxy	Maraset 655/555	MR	100p.655/7p.555	16h. 82° C+ 24h. 150° C	0.25	0.01	SRI
Epoxy	MPC 52	GE	AR	4h. R.T. +2h. 65° C	0.17	0.01	GSFC
Epoxy	MY 750/HY974	CI	AR	30h. 60° C	0.19	0.01	GSFC
Epoxy	MY 750/HY 974	CI	AR	.75h. 100° C	0.27	0.03	GSFC
Epoxy	R-179	RD	aliphatic epoxy	.5h. 160° C	0.81	0.03	GSFC
Epoxy	R-6005	RD	aliphatic epoxy	10 min. 160° C	0.82	0.03	GSFC
Epoxy	Scotchcast 260	MM	AR	.5h. 150° C	0.52	0.03	SRI
Epoxy	Scotchcast 281 A/B	MM	100p.A/150p.B	20h. 75° C	0.36	0.05	SRI
Epoxy	Scotchcast 282 A/B	MM	2p.A/3p.B	20h. 75° C	0.74	0.10	JPL
Epoxy	SMRD 49	GE	AR	AR	0.98	0.05	GSFC
Epoxy	Stycast 1263/31	EC	100p.1263/3p.31	16h. 107° C	0.12	0.01	SRI
Epoxy	Stycast 1269 A/B	EC	100p.A/100p.B	16h. 100° C+ 24h. 150° C	0.18	0.05	SRI
Epoxy	Stycast 2651/9	FW	AR	AR	0.23	0.01	GSFC

Pottings (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy	Stycast 2651/11	EC	AR	AR	0.14	0.01	GSFC
Epoxy	Stycast 2850 FT/9	EC	100p.2850FT/3p.9	AR	0.25	0.01	GSFC
Epoxy	Stycast 2850 FT/9	EC	100p.2850FT/3.5p.9	16h. 25° C	0.34	0.04	SRI
Epoxy	Stycast 2850GT/11	EC	100p.2850GT/4-5p.11	40h. 54° C	0.85	0.03	JPL
Epoxy	Stycast 2850GT/11	EC	AR	AR	0.33	0.02	JPL
Epoxy	Stycast 2862 A/B	EC	100p.A/100p.B	16h. 120° C 24h. 150° C	0.01	0.01	SRI
Epoxy	Stycast 2862 A/B	EC	100p.A/100p.B	16h. 120° C	0.32	0.04	SRI
Epoxy	Stycast 3050/11	EC	100p.3050/9.5p.11	16h. 77° C	0.68	0.06	SRI
Epoxy	Trucast 111/ Trucure 901	FW	100p.111/34p.901	24h. R.T.	0.36	0.01	GSFC
Epoxy	2850/24LV	EC	AR	24h. 49° C +24h. 60° C	0.73	0.10	GSFC
Epoxy/syntactic	MPC49	GE	AR	4h. R.T. + 2h. 66° C	0.52	0.01	GSFC
Epoxy/syntactic	MPC 49	GF	AR	18h. R.T. + 2h. 66° C	0.39	0.01	GSFC
Epoxy/versam	Type II Class 2.	HA	35p.DER332LC/30p.140	3h. 71°C	0.92	0.05	GSFC
P. ethylene	Stycast TPM-4	EC	AR	16h. 107° C 4h. 121° C 4h. 135° C	0.23	0.08	JPL
Silicone	77-002	DC	10p.77-002/1p.cat.	7d. R.T.	0.31	0.02	JPL
Silicone	77-002	DC	10p.77-002/1p.cat.	4h. 65° C	0.39	0.06	JPL
Silicone	93-500/cat.	DC	10p.93-500/1p.cat.	24h. R.T.	0.29	0.01	GSFC
Silicone	93-500/cat.	DC	10p.93-500/1p.cat.	7d. R.T.	0.22	0.02	JPL
Silicone	93-500/cat.	DC	10p.93-500/1p.cat.	7d. R.T.	0.16	0.01	GSFC
Silicone	E691-22E	DC	Sylgard 184 stripped of low molecular weight fraction by Dow Corning Corp.	AR	0.19	0.04	SRI
Silicone	RTV 11/T-12	GE	100p.11/2p.T-12	24h. R.T. 24h. 130° C	0.33	0.10	JPL
Silicone	RTV 566 A/B	GE	100p.A/.1p.B	24h. R.T.	0.14	0.02	GSFC
Silicone	RTV 566 A/B	GE	100p.A/.2p.B	24h. R.T.	0.25	0.03	GSFC

Pottings (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Silicone	RTV 566 A/B	GE	100p.A/.1p.B	7d. R.T.	0.07	0.04	JPL
Silicone/clear	SC-GSFC-19C	GS	12p. RTV 602 devol.+ .031p. SRC-05 cat.	G.E. prepolymer 602 heated 24h. 150° C, 10^{-6} torr. at GSFC to visc. of 2000-2200 centipoise and cooled prior to catalyzing, 7d. R.T. cure			GSFC
P. urethane	—	FM	100p. Sol. 113 51p. Sol. C-113-300 4.5p. Sol. C-113-328 10p. Eccosphere-SI	16h. 57° C	0.53	0.01	GSFC
P. urethane	—	GS	150p. Adiprene L-100 16.5p. MOCA	3h. 100° C	1.06	0.06	GSFC
P. urethane	—	GS	100p. Sol. 113 73p. Sol. C113-300 4 drops T-12	7d. R.T.	0.37	0.01	GSFC
P. urethane	—	GS	100p. Sol. 113 73p. Sol. C-113-300 6p. Cab. MS-5 4 drops T-12	7d. R.T.	0.42	0.01	GSFC
P. urethane	—	GS	100p. Sol. 113 73p. Sol. C-113-300 10.4p.Cab. MS-5 4 drops T-12	7d. R.T.	0.40	0.01	GSFC
P. urethane	—	GS	100p. Sol. 113 73p. Sol. C-113-300 7.8p.Cab MS-5 .086p. Vyac 4 drops T-12	7d. R.T.	0.37	0.01	GSFC

Pottings (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. urethane	—	GS	100p. Sol. 113 73p. Sol. C-113-300 7.8p.Cab. MS-5 .040p. Vyac	16h. 70° C	0.42	0.01	GSFC
P. urethane	—	GS	100p. Sol. 113 73p. Sol. C-113-300 10.4p.Cab. MS-5 .02p. Vyac 4 drops T-12	7d. R.T.	0.38	0.02	GSFC
P. urethane	—	GS	100p. Sol. 113 73p. Sol. C-113-300 6.9p.Cab. MS-5 .04p. Rhodamine base 4 drops T-12	7d. R.T.	0.31	0.01	GSFC
P. urethane	—	GS	100p. Sol. 113 51p. Sol. C-113-300 4.5p. Sol. C-113-328	18h. 70° C	0.34	0.01	GSFC
P. urethane	—	GS	100p. Sol. C-113 36.5p. Sol. C-113-300 7.5p. Sol. C-113-328	7d. R.T.	0.31	0.02	GSFC
P. urethane	—	GS	100p. Sol. C-113 36.5p. Sol. C-113-300 7.5p. Sol. C-113-328	20h. 70° C	0.30	0.02	GSFC
P. urethane	—	GS	100p. Sol. 113 73p. Sol. C113-300	5h. 54° C	0.51	0.09	JPL
P. urethane	—	GS	100p. Sol. 113 73p. Sol. C-113-300 87p. Al powder, MD5100	7d. R.T.	0.69	0.09	GSFC
P. urethane	Conath.RN1510	RD	AR	20 min.149° C	1.09	0.10	GSFC
P. urethane	Hysol 13-105/MOCA	HY	100p.13-105/13p.MOCA	3h. 100° + 30d. R.T.	1.09	0.08	GSFC
P. urethane	PC-22	HY	AR	8h. 66° C	0.72	0.01	GSFC

Pottings (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. urethane	PR 1527 A/B	PD	26p.A/100p.B	5d. R.T. 72h. 52° C, $1x10^{-6}$	0.92	0.10	GSFC
P. urethane	PR-1538	PR	AR	20h. 70° C	0.97	0.02	GSFC
P. urethane	RB-8-133B	AO	AR	7d. R.T.	0.75	0.01	GSFC
P. urethane	Stycast CPC-41A/B	EC	100p.A/120p.B	48h. 65° C+ 24h. 150° C	0.58	0.10	SRI
P. urethane	240-2	AB	AR	7d. R.T.	0.44	0.07	GSFC

Cellular Structures (Table 3)

In reviewing the selection of available foam systems it is apparent, since they can be easily formulated in house, that syntactic foams present no problem from the viewpoint of outgassing acceptability. Basically an inert microballoon phase embedded in an acceptable potting resin matrix with Cabosil thickener, the pre-cured material lends itself to troweling. On cure, the balloons provide a rigid unicellular structure with overall density, depending on microballoon volume, ranging from about 22 pounds/cu. ft. to possibly 40-50 lbs./cu. ft. Many acceptable epoxy, urethane or silicone resin systems listed under pottings can be used in syntactic foam production. The 3M Co. and Emerson & Cumings supply inert bubbles or microballons.

The low density pourable foams appear to present a problem since there aren't many vendors with acceptable types. Because of this situation, marginal and submarginal systems are listed. The Nopco G-302 is the recommended material; however, if some of the marginal materials are especially uniquely suited to the specific processing involved, while the G-302 presents a difficultly soluble problem, the marginal material could be used. It is important however that post cure include a moderate temperature vacuum bake out.

Table 3

Cellular Structures

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy	Stycast 1090/9	EC	100p. 1090/9p. 9	16h. 50° C	0.31	0.0[illegible]	SRI
Epoxy	Stycast 1090/11	EC	100p. 1090/12p. 11	12h. 60° C,+ 3h. 82° C	0.63	0.11	SRI
Epoxy	Stycast 1090/11	EC	100p. 1090/12p. 11	24h. 125° C	0.04	0.0[illegible]	SRI
Epoxy	Stycast 1095/11	EC	100p. 1095/12p. 11	24h. 125° C	0.50	0.11	SRI
Epoxy/syntactic	MPC 49	GE	AR	4h. R.T., 2h. 66° C	0.52	0.01	GSFC
Epoxy/syntactic	MPC 49	GE	AR	18h. R.T., 2h. 66° C	0.39	0.01	GSFC
Epoxy/syntactic	Eccobond SF-40	EC	AR	48h. R.T.	0.24	0.04	GSFC
Epoxy/syntactic	ERL-2795/HN 95-1	HA	100p. ERL-2795 2-4p. B-35A microballoons 5p. Cab. MS-5 8p. cat. HN 95-1	24h. R.T.	0.50	0.03	GSFC
Fluorocarbon	Fluorel 1062	MS	elastomer	AR	0.38	0.03	GSFC
P. urethane	Eccofoam SH	EC	7.25 lbs/ft^3	AR	1.03	0.01	SRI
P. urethane	Nopco J-106	NP	AR	AR	1.12	0.01	GSFC
P. urethane	Nopco G-302	NP	AR	AR	0.30	0.07	GSFC
P. urethane	CPR-23-2A/2B	UP	23.4p.2A/9.9p.2B	18h. R.T. + 5h. 93° C	1.04	0.01	GSFC
P. urethane	PF-3	WC	AR	AR	0.95	0.05	GSFC

Elastomers, Synthetic Rubber-Damping, Resilience, Sealing (Table 4)

A previous document[6] noted that a number of silicone elastomers were found acceptable after a 24-48 hour post cure at 400-480°F. This group has been further extended to where twenty-six company formulations have been found suitable. The Viton and fluorocarbon elastomer group have also provided excellent low outgassing materials and there are many formulations to select from, depending on company listed properties. Although acceptable Vitons have good high temperature properties, with improved compression set, they are limited to about -30°C for useful operation. The many other rubbers available are traditionally plasticized, 5-40% by weight, to make them either more easily moldable or to impart special properties. However, these low molecular weight loosely bound plasticizer molecules are readily released to the vacuum environment with resultant change in rubber properties and high condensable values. Three types of specialty rubbers have been noted. They should be used only when the mission requires the special unique property of the elastomer: i.e. butyl rubber for gas impermeability situations, butadiene-acrylonitrile formulations for oil resistance and the ethylene-propylene type elastomer in anhydrous ammonia propulsion systems. The latter was found to be the only type resistant to chemical breakdown in this severe environment. It will be noted that some recommendations in this latter group are submarginal. This should alert the engineer to design for minimal seal exposure or to design around the problem. In any event it calls for an increased effort to establish more acceptable elastomer formulations in this critical group.

Table 4

Elastomers, Synthetic Rubbers–Damping, Resilience, Sealing

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Buta/Acrylonitrile-elast.	Hycar 520-67-108-5	BF	AR	AR	0.95	0.03	SRI
Buta/Acrylonitrile-elast.	Hycar 520-67-108-6	BF	AR	AR	1.03	0.03	SRI
Butyl elast.	GSFC 218	EN	AR	AR	0.28	0.03	GSFC
Butyl elast.	Sr-634-70	ST	AR	AR	0.93	0.10	GSFC
Butyl elast.	Ex-1092	EN	AR	4h. 150° C	0.86	0.10	SRI
Ethylene/propylene elast.	E-515-8	EN	AR	AR	1.21	0.18	GSFC
Fluorocarbon elast.	JPL-10	DU	AR	AR	0.32	0.01	JPL
Fluorocarbon elast.	77-545	PS	Viton A	AR	0.24	0.03	GSFC
Fluorocarbon elast.	PLV-101	PL	AR	AR	0.82	0.02	JPL
Fluorocarbon elast.	V377-9	PS	Viton A	AR	0.33	0.01	SRI
Fluorocarbon elast.	ECD 487-90	DU	AR	AR	0.51	0.01	GSFC
Fluorocarbon elast.	L606-6	PS	Viton A	AR	0.55	0.03	JPL
Fluorocarbon elast.	PLV-1006-A	PL	AR	AR	0.52	0.02	JPL
Fluorocarbon elast.	PLV-3016-B	PL	AR	AR	0.51	0.02	JPL
Fluorocarbon elast.	4411A-776	DU	Viton A	AR	0.29	0.05	SRI
Fluorocarbon elast.	4411A-776	DU	Viton A	24h. 200° C	0.03	0.01	SRI
Fluorocarbon elast.	4411A-777	DU	Viton A	AR	0.27	0.03	SRI
Fluorocarbon elast.	4411A-777	DU	Viton A	24h. 200° C	0.01	0.01	SRI
Fluorocarbon elast.	4411A-778	DU	Viton A	AR	0.35	0.01	SRI
Fluorocarbon elast.	4411A-778	DU	Viton A	24h. 200° C	0.03	0.01	SRI
Fluorocarbon elast.	4411A-990	DU	Viton A	AR	0.54	0.03	SRI
Fluorocarbon elast.	PLV-5010-B	PL	AR	AR	0.38	0.02	JPL
Fluorocarbon elast.	PLV-8704	PL	AR	AR	0.44	0.02	JPL
Fluorocarbon elast.	PLV-30001	PL	AR	AR	0.33	0.01	JPL
Fluorocarbon elast.	Viton B	SR	AR	AR	0.46	0.01	JPL
Fluorocarbon elast.	Viton B	DU	AR	AR	0.86	0.04	GSFC
Fluorocarbon elast.	Viton C	IM	AR	AR	0.30	0.03	GSFC
Fluorosilicone elast.	L-449-6	PS	AR	AR	0.53	0.07	SRI
Fluorosilicone elast.	1056-70	PR	AR	AR	0.56	0.03	SRI
Silicone elast./Al	Lord-HD-222-22-2	LO	BTR, silicone sandwich between 0.020" aluminum	AR	0.28	0.02	GSFC
Silicone elast.	MS 20L08	MO	AR	2min. 163° C+ 2h. 249° C	0.04	0.01	GSFC

Elastomers, Synthetic Rubbers--Damping, Resilience, Sealing (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Silicone elast.	MS 30CO2	MO	AR	2mir. 163° C+ 2h. 249° C	0.07	0.05	GSFC
Silicone elast.	Silastic 35	DC	AR	5min. 116° C+ 24h. 249° C	0.14	0.06	GSFC
Silicone elast.	Silastic 75	DC	AR	10min. 171° C+ 3h. 204° C	0.31	0.10	GSFC
Silicone elast.	RR 423	RR	AR	24h. 232° C	0.11	0.02	GSFC
Silicone elast.	SE-556	GE	AR	24h. 250° C	0.10	0.01	SRI
Silicone elast.	Silastic 675	DC	AR	5 min. 116° C+ 24h. 250° C	0.41	0.05	GSFC
Silicone elast.	Silastic 916	DC	AR	5min. 116° C+24h. 249° C	0.40	0.01	GSFC
Silicone elast.	HR 2501	PS	AR	AR	0.30	0.08	GSFC
Silicone elast.	SE-3604/Varox	GE	AR	24h. 204° C	0.09	0.04	JPL
Silicone elast.	SE-3604	GE	AR	24h. 250° C	0.03	0.03	SRI
Silicone elast.	SE-3613	GE	AR	24h. 249° C	0.09	0.06	SRI
Silicone elast.	SE-3713	GE	AR	24h. 249° C	0.20	0.09	SRI
Silicone elast.	SE-3813	GE	AR	24h. 249° C	0.27	0.04	SRI
Silicone elast.	SE-4401	GE	AR	10min. 110° C+ 24h. 249° C	0.06	0.01	GSFC
Silicone elast.	SE-4404	GE	AR	10min. 110°C+24h. 249°C	0.10	0.01	GSFC
Silicone elast.	SE-4503	GE	AR	24h. 249° C	0.07	0.03	SRI
Silicone elast.	SE-4511	GE	AR	24h. 249° C	0.19	0.10	SRI
Silicone elast.	SE-5211	GE	AR	10min. 110° C 4h. 249° C	0.08	0.02	GSFC
Silicone elast.	SE-5403U	GE	AR	3h. 204° C	0.10	0.02	GSFC
Silicone elast.	Cohr-9255	CL	AR	24h. 204° C	0.18	0.06	JPL
Silicone elast.	Silastic S-9711	DC	AR	24h. 125° C	0.19	0.05	SRI
Silicone elast.	Silastic S-9711	DC	AR	AR	0.27	0.10	SRI
Sulfone elast.	P-1700	DU	AR	.25h. 343° C	0.39	0.01	JPL

Adhesives, Liquid and Film (Table 5)

The adhesives area provides many excellent low outgassing systems, some even with room temperature cures. These range from the more rigid epoxies to the low temperature flexible epoxy 828-140 versamide. Even more cold temperature resistant is the DC-C6-1104 silicone type, flexible to -65°C and nonspalling from aluminum after one minute in liquid nitrogen. The silicone however is most suitable for comparatively light loads. This light load application is also exemplified by low outgasser Dow Corning 93-500 which has been thoroughly tested and recommended for the glass cover slip adhesive on solar arrays.[7,8]

Outgassing observations on commercial tapes and their pressure sensitive adhesives indicated, that in general, acrylic adhesives were the best performers. Resultant testing of bulk acrylic adhesives with pressure sensitive capability showed that Monsanto's Gelva MP 263, which cross links after application had excellent outgassing characteristics even at room temperature cure. This adhesive might now be applied, in house, to thin annealed specialty foils of copper, lead, silver or any other small quantity film required for special characteristics at nominal temperatures, thus eliminating some of the dependence on tape manufacturers. Adhesion to FEP or Teflon would have to be examined. The availability of these various easily appliable adhesives can provide added scope or dimensions to the designers capability in creating or specifying low outgassing systems. For example, a thermal blanket might be specified, vaporized aluminum on Kapton or Mylar with separating layer of Dacron net. "hold or tie downs" would be requested in the acceptable Velcro polyester "hook and loop" system using low outgassing DC-C6-1104 silicone adhesive to adhere the loop and hook tape elements to the blanket film.

Selection of film adhesives which find application in honeycomb structures is a problem. Many are submarginal from an outgassing point of view, although having good strength characteristics. Film adhesive FM-1000 is one of our prime undesirables in this regard and should be forewarned against because it is so popular. It has excellent adhesion characteristics but is among the worst outgassers. Other marginal adhesives have been recommended not out of choice, but because there are so few acceptable types.

Table 5

Adhesives, Liquid and Film

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Acrylic/I	Gelva MP263RA	MC	AR	7d. R.T.	0.79	0.08	GSFC
Acrylic/I	Gelva MP263RA	MC	AR	24h. R.T. + 24h. 66° C	0.62	0.03	GSFC
Acrylic/I	Gelva MP784RA	MC	AR	24h. R.T. + 24h. 66° C	1.00	0.05	GSFC
Acrylic/I	PS-18	RH	acrylic cement	72h. R.T.	0.74	0.01	GSFC
Acrylic/I	Resyn 30-1215	NS	AR	16h. 66° C	0.82	0.08	JPL
Epoxy/I	Armstrong A2/A	AP	100p.A2/4p.A	.75h. 74° C+ .75h. 93° C	0.44	0.01	JPL
Epoxy/I	Armstrong A2/E	AP	100p.A2/6p.E	.75h. 93° C	0.26	0.03	SRI
Epoxy/I	Armstrong A12/A	AP	AR	2h. 85° C	0.85	0.03	SRI
Epoxy/I	Armstrong A12/A	AP	AR	2h. 85° C+ 48h. 125° C+ 1 x 10^{-5} torr	0.62	0.02	SRI
Epoxy/I	Armstrong A31A/B	AP	60p.A/40p.B	2h. 60° C	0.56	0.03	GSFC
Epoxy/I	Eccobond 51/9	EC	100p.51/7p.9	24h. R.T.	0.44	0.02	GSFC
Epoxy/I	Eccobond 51/9	EC	100p.51/7p.9	48h. 95° C+ 1 x 10^{-1} torr	0.18	0.02	GSFC
Epoxy/I	Eccobond 55/9	EC	100p.55/12p.9	16h. 65° C	0.17	0.07	SRI
Epoxy/I	Eccobond 55/9	EC	100p.55/12p.9	24h. 25° C	0.40	0.06	SRI
Epoxy/I	Eccobond 104A/B	EC	100p.A/64B	8h. 150° C	0.35	0.03	SRI
Epoxy/I	Epibond 123/952	FU	100p.123/15p.952	24h. R.T.	0.63	0.03	GSFC
Epoxy/I	Epibond 8510A/B	FU	100p.A/30p./B	5d. R.T.	0.05	0.01	GSFC
Epoxy/I	Epiphen ER 825A	BC	100p. 825A 12p Mod-7 4[illegible]p. filler [illegible]6p.825A cat.	48h. 75° C	0.84	0.01	SRI
Epoxy/I	Epiphen ER 825A	BC	100p. 825A 12p. Mod-7 40p. filler 16p. 825A cat.	48h. 25° C	1.07	0.01	SRI
Epoxy/I	Epon 815/TETA	SH	10p.815/1p. TETA	16h. 63° C	0.76	0.01	GSFC
Epoxy/I	Epon 820/TETA	SH	10p.820/1p. TETA	16h. 63° C	0.36	0.04	GSFC
Epoxy/I	Epon 820/TETA	SH	10p.820/1p. TETA	3d. R.T.	0.43	0.06	GSFC

Adhesives, Liquid and Film (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy/l	Epon 828/A	SH	100p.828/8p.A	3h. 95° C	0.70	0.06	SRI
Epoxy/l	Epon 828/TETA	SH	10p.828/1p. TETA	10h. 60-66° C	0.38	0.01	GSFC
Epoxy/l	Epon 828/TETA	SH	10p.828/1p. TETA	3d. R.T.	0.51	0.01	GSFC
Epoxy/l	Epon 828/Z	SH	100p.828/20p.Z	2h. 75° C+ 2h. 135° C	0.42	0.03	SRI
Epoxy/l	Epon 901 A/B	SH	100p.901A/11p B	.5h. 116° C	0.73	0.06	JPL
Epoxy/l	Epon 901/B3	SH	100p.901/23p.B3	1.5h. 115° C+ 1.5h. 175° C	0.19	0.01	SRI
Epoxy/l	Epon 917	SH	AR	.25h. 175° C	0.17	0.03	SRI
Epoxy/l	Epon 929	SH	AR	1h. 149° C	0.68	0.06	GSFC
Epoxy/l	Epon 931A/B	SH	100p.A/1p.B	1h. 125° C	0.13	0.01	SRI
Epoxy/l	Epon 934A/B-MoS_2	SH	100p.A/33p.B 5p.MoS_2 20mL MEK	.25h. 66° C 1h. 93° C + 24h. 125° C 1 x 10^{-2} torr	0.54	0.01	GSFC
Epoxy/l	Epon 934A/B	SH	100p.A/33p.B	16h. 52° C	0.42	0.02	JPL
Epoxy/l	Epon 934A/B	SH	100p.A/33p.B	7d. R.T.	0.28	0.01	GSFC
Epoxy/l	Epon 956A/B	SH	100p.A/58p.B	7d. R.T.	0.19	0.01	GSFC
Epoxy/l	Epon 956A/B	SH	100p.A/58p.B	2.5h. 80° C	0.38	0.01	JPL
Epoxy/l	Epotex-301A/B	ET	20p.A/5p.B spectrally transp.	24h. R.T.	1.08	0.01	GSFC
Epoxy/l	Hysol EA 956	HY	AR	R.T.	0.69	0.03	GSFC
Epoxy/versam/l	PS-269	BX	50p.828/50p.125	24h. R.T.	0.79	0.10	GSFC
Epoxy/l	Scotchweld 1838 A/B	MM	1p.A/1p.B	24h. R.T.	0.65	0.03	GSFC
Epoxy/l	Torr Seal	VA	equal lengths A, B	24h R.T.	0.84	0.01	GSFC
Epoxy/l	2850/24LV	EC	AR	24h. 49° C+ 24h. 60° C	0.73	0.10	GSFC
Epoxy/versam/l	Epon 828/140	GS	60p.828/40p.140	24h. R.T.	0.74	0.05	GSFC
Epoxy/versam/l	Epon 828/140	GS	50p.828/50p.140	24h. R.T.	0.20	0.02	GSFC
Silicone/l	C6-1104	DC	AR	7d. R.T.	0.19	0.01	GSFC
Silicone/l	93-500	DC	10p. 93-500/1p. cat	7d. R.T.	0.16	0.01	GSFC
Silicone/l	566A/B	GE	100p. A/.1pB	7d R.T.	0.07	0.04	GSFC
Epoxy/gl/F	Ablefilm 517	AT	AR	3h. 71°C	0.07	0.01	GSFC

Adhesives, Liquid and Film (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy/gl/F	FM-96U	AY	AR	1h. 175°C	0.15	0.01	SRI
Epoxy/mod/F	Hysol A9-601	HY	AR	1h. 121°C+12psi	0.37	0.03	GSFC
Epoxy/mod/F	Metlbond 328	NR	AR	1.5h. 165° C	0.12	0.10	SRI
Epoxy/mod/F	Metlbond 329	NR	AR	1.5h. 165° C	0.26	0.08	SRI
Epoxy/mod/F	Narmco 328	NR	AR	1.5h. 165° C	1.00	0.11	GSFC
Epoxy/mod/F	Narmco 329	NR	AR	1.5h. 165° C	1.21	0.05	GSFC
Epoxy/nitrile/F	FM123-5	AY	AR	1h. 121° C+12psi	0.98	0.02	GSFC
Epoxy/nitrile/F	FM-123 LVCM	AY	AR	1.5h. 116° C	1.10	0.08	JPL
Epoxy/nylon/F	FM-1000*	AY	AR	2h. 200° C	5.55	4.71	SRI
Epoxy/nylon/F	Metalbond 227	NR	AR	2-3° C/min.to 127° C, held 1h.	0.99	0.08	GSFC
Epoxy/phenolic/F	HT-424	AY	AR	.5h 65° C	0.83	0.17	SRI
Epoxy/phenolic/F	HT-424	AY	AR	2h. 165° C	0.65	0.16	SRI
Epoxy/phenolic/F	HT-424	AY	alum/fiberglas/sandwich	30h. 166° C	0.18	0.09	JPL

*Discussion example, not desirable

Insulation, Dielectrics, Circuit Boards, Tubing, Sleeving (Table 6)

There appear to be few problems associated with the selection of adequate insulation and dielectric materials. However, it should be noted that Teflon PTFE is subject to cold flow and has comparatively low particulate radiation resistance in non-radiation protected areas. This is not the case with FEP which has both good UV and particulate radiation resistance. FEP should be surface treated to provide improved adhesion to potting compounds. Silicone, either as potting or elastomer, should be one of the insulations considered for high voltage operations.

High temperature resistant silicone coated glass sleeving is often obtained with undercured outgassing formulations. Such items may be cleaned up by baking at elevated temperatures for extended periods of time. However, the designer can circumvent this problem by specifying an uncoated glass sleeving cleansed of lubricating oils and coated with DC-C6-1104. As previously indicated under "pottings", materials with varying dielectric constants can be easily fabricated.

Vinyl insulations with their high percentages of outgassing plasticizers are undesirable.

Table 6
Insulation–Sleeving Dielectrics, Circuit Boards, Tubing, Sleeving

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. acetal/I	Formex	GE	AR	AR	0.06	0.03	SRI
Fluorocarbon/I	FEP	HT	AR	AR	0.02	0.01	GSFC
Fluorocarbon/I	D-100 series	RA	Kynar solder sleeves w. polyethylene rings	AR	0.38	0.08	GSFC
Fluorocarbon/I	D-100 series	RA	Kynar sleeves without polyethylene	AR	0.44	0.08	GSFC
Fluorocarbon/olefin/I	V-44	RA	p. vinylidene fluoride irradiated, over p. alkene, irradiated	AR	0.34	0.07	GSFC
Fluorocarbon/I	33181019	BR	PTFE	AR	0.01	0.01	GSFC
Fluorocarbon/I	Permatube-1	MT	PTFE	AR	0.01	0.01	GSFC
P. ester/x/I	Polythermaleze		x-linked p. ester + p. amide-imide jacket	AR	0.28	0.01	GSFC
P. imide/I	XPI-MC-154	AY	AR	AR	1.14	0.01	GSFC
P. imide/I	Kapton T-400, 1/20	BR	AR	AR	0.51	0.10	GSFC
P. imide/I	Pyre ML	DU	AR	AR	0.07	0.02	JPL
P. imide/FEP/I	T473-1/24	BR	AR	AR	0.52	0.01	GSFC
P. olefin./I	44/0611-9	RA	AR	AR	0.21	0.07	GSFC
P. olefin/mod/I	Surlyn A	RM	AR	AR	0.28	0.03	GSFC
Silicone/elast./I	B1WP/N F 5639-L-G22	BW	high voltage silicone cable	24h. 232° C	0.03	0.01	GSFC
Silicone/elast./I	STW 0474	SU	AR	96h. 204° C	0.11	0.01	GSFC
P. urethane/I	Gripeze	PH	AR	AR	0.16	0.02	JPL
P. urethane/I	Sodereze	PH	AR	AR	0.09	0.03	GSFC
P. ester/S.T.	Mylar .004" wall	SP	AR	10min. 110° C	0.62	0.03	SRI
P. ester/S.T.	Mylar .012" wall	SP	AR	10min. 110° C	0.68	0.05	SRI
Fluorocarbon/S.T.	FEP-black	FC	AR	AR	0.03	0.01	JPL
Fluorocarbon/S.T.	FEP-clear	FC	AR	AR	0.03	0.01	JPL
Fluorocarbon/S.T.	FEP-yellow	FC	AR	AR	0.03	0.01	JPL
Fluorocarbon/S.T.	Thermofit 7-31-22	RA	p. vinylidene fluoride	1h. 150° C	0.27	0.09	SRI
Fluorocarbon/S.T.	Thermofit 7-32-16	RA	PTFE	1h. 150° C	0.01	0.01	SRI
Fluorocarbon/S.T.	Thermofit-R	RA	PTFE	1h. 150° C	0.01	0.01	SRI
Fluorocarbon/S.T.	Thermofit 7-30-09	RA	PTFE	1h. 150° C	0.01	0.01	SRI
Fluorocarbon/S.T.	Penntube II-SMT	PF	PTFE	1h. 150° C	0.01	0.01	SRI

Insulation--Sleeving Dielectrics, Circuit Boards, Tubing, Sleeving (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. olefin/S.T.	Thermofit-876	RY	AR	.25h. 125° C	0.43	0.10	GSFC
Acrylic/gl./SL	Lecton-B	BH	AR	24h. 150° C	0.09	0.09	SRI
Acrylic/gl./SL	Acrylic C-2	BH	AR	AR	0.33	0.01	SRI
Acrylic/gl./SL	Acrylic A FA1	BH	AR	24h. 150° C	0.22	0.05	SRI
Acrylic/gl./SL	Acrylic A FA1	BH	AR	AR	0.49	0.05	SRI
Silicone/gl./SL	1062-HA1	BH	AR	24h. 150° C	0.29	0.13	SRI
Fluorocarbon/D	Kynar	PT	p. vinylidene fluoride	AR	0.19	0.08	JPL
Silicone/D	K-707 (K-12)	GE	AR	AR	0.41	0.01	SRI
Silicone/D	K-707 (K-15)	GE	AR	AR	0.70	0.08	SRI
P. styrene/x/D	Q200.5	PP	AR	AR	0.09	0.01	GSFC
P. styrene/x/D	Rexolite 1422	BR	AR	AR	0.18	0.01	JPL
P. styrene/x/D	Rexolite 1422	BR	no copper	AR	0.16	0.02	GSFC
Epoxy/gl./CB	FLGF 250C 2/2AIIB	AN	CB has 2 sides copper	AR	0.12	0.01	GSFC
Epoxy/gl./CB	FLGF EG-2028FR	FL	no copper	AR	0.44	0.01	SRI
Epoxy/gl./CB	FLGF EG-2028	FL	no copper	AR	0.33	0.01	SRI
Epoxy/gl./CB	Marglass	MG	100p.Ciba MY 740 1.5p. accel. DY219 50p.cat. - HY219 glass cloth-1275 finish-P705	AR	0.93	0.01	GSFC
Epoxy/gl./CB	Micaply EG-758T	MI	no copper	AR	0.48	0.05	SRI
Epoxy/gl./CB	Micaply EG-824T	MI	no copper	AR	0.40	0.05	SRI
Epoxy/gl./CB	Micaply EG-899T	MI	no copper	AR	0.29	0.03	SRI
Epoxy/gl./CB	Micarta 65M25	WC	no copper	AR	0.43	0.01	SRI
Epoxy/gl./CB	Micarta 65M28 (FR4)	WC	copper clad	AR	0.26	0.01	JPL

Conduction (Table 7)

It is often desirable that some mode of electrical conduction other than through wires be used in special spacecraft applications. R.F. shielding and conductive adhesives demonstrate this important requirement. Shielding can be accomplished by covering insulated wires with metallic tapes. One can also protect the contents of metal boxes by using silver filled conductive compounds or gaskets at the cover/box interface. Such materials also have good thermal conductivity if this is required. In this regard they make excellent thermocouple contacts to various substrates. One technique for making conductive coatings is to first select a low viscosity potting material with good adhesion characteristics from the acceptable list. This is then blended and catalyzed with about 71-74%, by weight, flake silver, similar in properties and shape to Handy & Harmon Silflake 135. The cured material should have excellent conductivity.

Table 7

Conduction

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Acrylic/silver powder	Dupont 4922	DU	1p. r/1p. butyl acet.	.25h. 66°C + 48h. 99° C	0.61	0.01	GSFC
Acrylic/silver	E-Kote 3030	ER	conductive coating	24h. R.T., 1h. 66°C	0.76	0.06	GSFC
Alum./acrylic/silver	Eccoshield PST-C-A	EC	aluminum foil tape with silver ball filled acrylic adhesive	AR	0.26	0.09	GSFC
Cu/acrylic	X-1245	MM	copper foil with acrylic adhesive	AR	0.19	0.11	GSFC
Cu/acrylic	X-1181	MM	copper foil with acrylic adhesive	24h. 125° C	0.15	0.03	GSFC
Cu/acrylic	Mystic 7420	MY	copper foil with acrylic adhesive	AR	0.22	0 01	GSFC
Epoxy/metal	Eccobond 56C/9	EC	100p.56C/2.5p.9	16h. 50° C	0.30	0.03	SRI
Epoxy/metal	Eccobond 57C-A/B	EC	100p.A/100p.B	16h. 52° C	0.67	0.06	SRI
Epoxy/metal	Hysol K8-4238/H2-3475	HY	100p.-4238/8p.3475	24h. R.T.	0.32	0.01	GSFC
Silicone/metal	Cho Seal 1215	CH	AR	AR	0.39	0.08	GSFC
Silicone/silver powder		GE	100p.RTV11/70p.silver/ 2p.T-12	24h. R.T.+ 24h. 130° C	0.08	0.01	JPL

Tapes (Table 8)

Tapes, glass, metal, polymer or composites thereof, can be useful on spacecraft as thermal control coatings, R.F. shielding, current carriers, low friction surfaces, radiation shielding, electrical and thermal insulation. Suitable application of the above concepts have been shown to be dependent on the adhesive component of the tape. Several specialty tapes, vapor deposited gold, lead and polyimide show high outgassing. The availability and use of low outgassing adhesives applied on site to representative films would allow the designer greater freedom in the selection of processes, and in the important aspect of programming the particular time, at which the material should be applied. Such adhesives, i.e., epoxy, epoxy-versamid, acrylic, and silicone, are available to help develop such an inhouse application system capability. (See adhesives list.) Note that most of the tapes have acrylic adhesives.

Table 8

Tapes

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. ester/acrylic	5	MM	AR	AR	0.40	0.01	GSFC
P. ester/acrylic	850	MM	AR	AR	0.65	0.09	GSFC
P. ester/acrylic	X-1179	MM	AR	24h. 65° C	0.46	0.01	GSFC
P. ester/gl.	Fibre-mat 1-2539	MM	AR	AR	0.19	0.02	SRI
P. ester/acrylic	Mystic-4043	MY	AR	AR	0.68	0.02	JPL
P. ester/acrylic	Mystic 7341	MY	AR	AR	0.57	0.03	JPL
Fiberglass/acrylic	Mystic 4052	MY	AR	AR	0.59	0.02	JPL
Fiberglass/silicone	Permacel 5208	PM	AR	8h. 204° C	0.31	0.07	JPL
Fluorocarbon/acrylic	63	MM	AR	AR	0.33	0.03	GSFC
Fluorocarbon/acrylic	65	MM	AR	AR	0.29	0.08	GSFC
Fluorocarbon/silicone	CHR C-400	CI	PTFE carrier	AR	0.27	0.09	GSFC
P. imide/acrylic	Y1205	MM	AR	AR	0.73	0.10	GSFC
P. imide/acrylic	1255	MM	double coat of acrylic adhesive on p. imide	.5h. 130° C	0.93	0.07	GSFC
P. imide/acrylic	7367	MY	AR	AR	0.64	0.05	GSFC
Silicone/elast.	70	MM	AR	24h. 121°C $1x10^{-3}$ torr	0.40	0.07	GSFC
Al/p.ester/acrylic	850	MM	vaporized aluminum on Mylar	AR	0.69	0.10	GSFC
Al./p.ester/acrylic	852	MM	vaporized aluminum on Mylar	AR	0.59	0.03	GSFC
Al./p.ester/Al./acrylic	Y9360	MM	vaporized aluminum top and bottom side of Mylar	AR	0.54	0.01	GSFC
Al./p.ester/acrylic	SL-1250543	MM	vaporized aluminum on Mylar	AR	0.65	0.01	GSFC
Gold/p.imide/acrylic	Y-9184A	MM	vaporized gold on Kapton	AR	1.42	0.01	GSFC
Al./acrylic	425	MM	aluminum foil	AR	0.24	0.03	GSFC

Tapes (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Al./acrylic	Mystic 7452	MY	aluminum foil	AR	0.25	0.03	GSFC
Al./acrylic	Mystic 7453	MY	aluminum foil	AR	0.64	0.04	JPL
Al./acrylic	Y9339	MM	type 2, aluminum foil	AR	0.80	0.02	GSFC
Al./acrylic	Y9339	MM	type 3, aluminum foil	AR	0.20	0.01	GSFC
Cu/acrylic		MM	copper foil w. acrylic	24h. 125° C	0.15	0.03	GSFC
Cu/acrylic	X-1245	MM	copper foil w. acrylic	AR	0.19	0.11	GSFC
Cu/acrylic	Mystic 7420	MY	copper foil w. acrylic	AR	0.22	0.01	GSFC
Lead/acrylic	Mystic 7421*	MY	lead foil w. acrylic	AR	1.33	0.06	JPL

* Where needed for radiation resistance

Film, Lacing (Table 9)

It would appear that a simple item like acceptable lacing could be produced by many fabricators and in various types, however suitable lacing types are quite limited in availability. FEP Teflon would be desirable in a geometry or filled composition that would minimize its inherent low coefficient of friction. Polyester type lacings are useful, however most often they contain some coatings which outgas. These could be scoured or dissolved off in some instances. Irradiated polyvinylidene fluoride, high molecular weight polyethylene, polypropylene, polyvinyl fluoride should make effective aerospace lacings. None have yet made the scene.

Table 9

Film, Lacing

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. ester/F	Cronar Ortho-S-Litho-CoS7	DU	AR	AR	0.37	0.01	GSFC
P. ester/F	Mylar A	DU	AR	AR	0.40	0.10	JPL
P. ester/F	Mylar HS	DU	AR	AR	0.50	0.06	JPL
P. ester/F	Mylar 500A	DU	AR	AR	0.24	0.06	SRI
P. ester/F	Scotch Pak 8	MM	AR	AR	0.19	0.07	JPL
Fluorocarbon/F	FEP-100A	DU	AR	AR	0.06	0.06	SRI
Fluorocarbon/F	FEP-500A	DU	AR	AR	0.05	0.05	SRI
Fluorocarbon/F	FEP-500C	DU	AR	AR	0.02	0.01	SRI
Fluorocarbon/F	Ribbon Dope Thread Seal 8030-733-0055	PM	PTFE	AR	0.07	0.02	SRI
Fluorocarbon/F	Tedlar 100BG 30TR	DU	p. vinyl fluoride	AR	0.23	0.10	SRI
Fluorocarbon/F	Tedlar 100BG-30TL	DU	p. vinyl fluoride	AR	0.09	0.09	SRI
Fluorocarbon/F	Tedlar A130WH	DU	p. vinyl fluoride	AR	0.47	0.01	SRI
Fluorocarbon/F	Tedlar 150 BL 30cc black	DU	p. vinyl fluoride	AR	0.14	0.01	GSFC
P. imide/F	Kapton 200XH 667	DU	AR	AR	0.14	0.09	SRI
P. imide/FEP/F	Kapton 200XHF 929A	AP	AR	AR	0.54	0.05	SRI
P. imide/nylon/F	--	NM	thermal blanket composite	AR	0.61	0.03	GSFC
P. phenylene-ox/F	PPO-531-081 opaque	GE	AR	AR	0.09	0.02	SRI
P. phenylene-ox/F	PPO-681-111 clear	GE	AR	5h. 180° C	0.07	0.05	SRI
P. sulphone/F	P-2300	UC	AR	5h. 125° C	0.03	0.01	SRI
P. sulphone/F	P-7395-121-2	UC	AR	AR	0.09	0.02	SRI
P.-p-xylylene/F	Parylene C	UC	2 mils thick	AR	0.07	0.02	JPL
P.-p-xylylene/F	Parylene C	UC	AR	AR	0.12	0.01	SRI
P.-p-xylylene/F	Parylene N	UC	AR	AR	0.30	0.01	SRI
Al/p. ester/Dac./adhes./F	—	DU	vaporized aluminum on Mylar, over Dacron adhered to surface with adhes. 46960	AR	0.46	0.09	GSFC

Film, Lacing (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Al/p. ester/F	100M42	SU	vaporized aluminum on Mylar .002" p. vinyl fluoride .0047" aluminum foil composite	AR	0.14	0.02	GSFC
Fluorocarbon/Al/F	Tedlar 136-30WH/Al 5056 H 191			5min. 120° C	0.15	0.05	GSFC
Silver/FEP/adhes./F	—	GS	vaporized silver on FEP with Garlock 201 adhesive	AR	0.34	0.13	GSFC
P. ester/Lc	Astro-Tex	HW	AR	AR	0.58	0.07	JPL
P. ester/elast./Lc	Sturdelace 18DH	GB	Dacron/rubber	24h. 150° C	0.34	0.06	SRI
P.ester/elast./Lc	Gude-Spec18D96	GB	Dacron/rubber	24h. 150° C	0.42	0.10	SRI
Fluorocarbon/Lc	Temp-Lace H256H	GB	AR	AR	0.60	0.05	SRI
Fluorocarbon/Lc	Temp-Lace 256	GB	PTFE	AR	0.12	0.03	JPL
Fluorocarbon/Lc	Temp-Lace 256H	GB	PTFE	AR	0.64	0.10	JPL

Paints (Table 10)

Some of the formulations noted in this area are early, desperate in-house attempts at exploring the use of acceptable potting vehicles or adhesives for paints, since low outgassing paints were simply unavailable. Many commercial paints require high temperature bakeouts to even approach submarginal "total outgassing" acceptance. The problem probably results from several factors connected with the conventional use of normally desirable high boiling, low volatility solvents which are difficult to remove after paint surface case hardening. The paint vehicles explored were usually 100 percent solids, not considered sprayable, but which could be brushed out yielding glossy and flat surfaces. Application capability was a function of the initial resin-curing agent viscosity and filler content. However very little is known about the optical characteristics of these materials and so they are relegated to emergency or touch up functions. The Hughson Chemical Co. has within the past two years made available both a polyurethane black Z-306 and a white TS-1603-16. Both are sprayable systems and show acceptable outgassing after 3-4 weeks of room temperature drying without bakeout. Like many other epoxy black paints 3M's Velvet Black, 401 series is a submarginal outgasser, however it is still recommended subject to rigorous vacuum bakeout because of good radiation resistance and greatly improved spectral reflectance properties, over a wider frequency spectrum, 15-80μ than the Z-306[9]. Already, one of our staff has updated the Z-306 to near optical comparability with the Black Velvet paint series.[10] Comparative, combined ultraviolet and particulate radiation resistance have yet to be obtained. The Hughson paints are recommended in interior spacecraft situations, where spectral reflectance in the longer wavelengths is not as critical, as in the selective chopper Radiometer. The inorganic paints dependent on the silicate binders for cohesion and adherence, and designed for all around radiation stability appear destined to continue with high total outgassing, primarily water, and low condensables. They are listed primarily to indicate the present state of the art. A recent potassium titanium fluoride type shows improved total outgassing. In spite of the excessive moisture release however, some might still be most desirable for long term space exploration where resistance to radiation and elevated temperatures are important prerequisities. Hopefully the moisture would be dissipated at temperature and vacuum along the way to the experiment rendezvous.

The need still exists for easily applied, room temperature cured black and white low outgassing paints requiring no primer, having excellent low temperature adhesion, good optical characteristics, combined with ultraviolet-particulate radiation resistant properties. Some novel flexible and rigid silicone white systems with acceptable outgassing are still being developed. See FC-GSFC-14W, P764-IA[11] and Owens 650/ZrO in the paint section. If these cannot be fully evaluated soon, the answer to white paint thermal control may well be the long lived second

surface inconel backed silver mirror with very low α_s/E ratio. These metals are vacuum deposited on radiation resistant Corning 7940 glass or other higrade cerium protected, UV resistant silica. An excellently adhering moderately outgassing second surface glass mirror system with tested application techniques has been worked out in this group, and passed OAO thermal vacuum and vibration testing as a panel system. This presently includes a second surface mirror of vacuum deposited silver/inconel on glass with Dow Corning 3145 adhesive. Tests are presently underway using low outgassing Dow Corning C6-1104 adhesive on latest state of the art second surface mirrors having a gold colored protective inorganic dielectric backup against the silver. Excellent results are anticipated. Studies will also continue on the inconel backed mirrors employing Dow Corning C6-1104. The intermediate longevity type represented by second surface mirrors on FEP film may suffice in low radiation environments for comparatively short, 1 - 1.5 year, flights. FEP change due to 25-50Kev proton bombardment may present a long term problem.[12]

Table 10

Paints

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Alkyd/BF	101-C10	MM	AR	7d. 110° C	0.33	0.17	SRI
Epoxy/BF	CAT-A-LAC 463-3-8	FP	AR	24h. 120° C	1.33	0.01	GSFC
Epoxy/B	CTL-15(17038)	HA	3p.15A/1p.15B	2 coats, each air dried .25h. +.25h. 65°C + 1.75h. 121°C	0.96	0.02	GSFC
Epoxy/BF	FC-GSFC - 5B	GS	100p. 956A 58p. 956B 3.15p. Carb. 1 1.6p. Cab-MS-5	7d. R.T.	0.81	0.01	GSFC
Epoxy/BF	FC-GSFC-6B	GS	100p.956A 58p.956B 3.15p. Carb.1 1.6p. Cab-MS-5	2h. 66° C	0.49	0.01	GSFC
Epoxy/BF	FC-GSFC-7B	GS	100p.956A 58p.956B 3.15p. Carb. 1 1.6p. Syloid 620	7d. R.T.	1.02	0.01	GSFC
Epoxy/BF	FC-GSFC-11B	GS	100p.956A 58p.956B .4p. Cab.MS-5 6.32p. MoS_2 .75p. Carb.1	2h. t	0.85	0.10	GSFC
Epoxy/versam./Al	S-GSFC-20-A1	GS	60p.828 40p.140 33p.MD5100 A1 powder 133p. {toluene-50 / acetone-50}	48h. 100° C	0.77	0.07	GSFC
P. ester-epoxy/BF	401 Series	MM	6p.r./1.5p.cat.	1h. 93° C	4.49	0.23	GSFC
P. ester-epoxy/W	401-A10	MM	3p.401-A10/1p.cat.	7d. R.T.+ 24h. 121° C	3.09	0.08	GSFC
Fluorocarbon/W	Fluoroclad/W	SW	p.vinylidene fluoride in solvent	4h. R.T + .5h. 93° C +.25h. 260° C	0.67	0.05	GSFC
Silicate/BF	MSA/5	GS	Asbestos, Talc, Al_2SiO_3, Mica Carbon black, K_2SiO_3 binder	72h. R.T.	3.14	0.02	GSFC

Paints (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Silicate/BF	MSA/5	GS	asbestos, Al_2SiO_3 talc, mica, carbon black K_2SiO_3, binder	48h. 100° C	2.24	0.04	GSFC
Silicate/BF	MSA/5 ALT.	GS	asbestos, $CaSiO_3$, talc, mica, carbon black K_2SiO_3, binder	72h. R.T.	3.50	0.02	GSFC
Silicate/W	MS-74	GS	TiO_2, ZnO. Al_2O_3, K_2SiO binder	24h. R.T.	6.27	0.03	GSFC
Silicate/W	MS-74	GS	TiO_2, ZnO Al_2O_3 K_2SiO_3, binder	48h. 100° C	4.54	0.01	GSFC
Silicate/W	Z-93	GA	ZnO/K_2SiO_3 binder	7d. R.T.	2.54	0.01	GSFC
Silicone/W	C-101 GSFC-16W	GS	300p. ZnO-SP500 + lithium + potassium silicate 150p. RTV-602 100ml toluene	3h. air dry + 2h. 150° C	0.41	0.12	GSFC
Silicone/W	FC-GSFC-14W	GS	—	3.5d. R.T.	0.17	0.09	GSFC
Silicone/W	FC-GSFC-14W	GS	—	7d. R.T.+ 24h. 66° C	0.14	0.01	GSFC
Silicone/W	FC-GSFC-15W	GS	—	4d. R.T.	0.21	0.08	GSFC
Silicone/W	IITRI-S-13G	GS	dimethyl silicone, ZnO/K_2SiO_3	16h. 121° C $1x10^{-6}$ torr	0.42	0.10	GSFC
Silicone	Owens 650	GS	AR	18h. 100° C	0.51	0.02	GSFC
Silicone/W	Owens 650/ZrO	GS	60p. 650/40p. ZrO	AR	0.77	0.01	GSFC
Silicone/W	P-764-1A	GS	260p. treated ZnO 100p. devolat. 602 .25% SRC-05 based on 602 360p. toluene	7d. R.T	0.30	0.01	GSFC

Paints (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Silicone	SC-GSFC-19C	GS	12p. RTV 602 devol. .031p. SRC-05	G.E. prepolymer 602-heated 24h. 150°C, 10^{-6} torr at GSFC to a viscosity of 2000 to 2200 centipoise and cooled prior to catalyzing 7d. R.T. cure	0.35	0.02	GSFC
Silicone/B	Sicon Black 7X9055	DX	AR	24h R.T., .5h. 177° C	0.98	0.04	GSFC
P. urethane/BG		GS	100p. Sol. 113 73p. Sol. C-113-300 2.6p. Carb. 46 2 drops T-12	22h. 60° C	0.40	0.01	GSFC
P. urethane/BG		GS	100p. Sol. 113 73p. Sol. 113-300 2.6p. Carb. 46 2 drops T-12 10ml. MEK	7d. R.T.	0.51	0.02	GSFC
P. urethane/BG		GS	100p. Sol. 113 73p. Sol. C113-300 2.6p. Carb. 1 2 drops-T-12 10ml. MEK	18h. 50° C	0.41	0.04	GSFC
P. urethane/B	Chemglaze Z-306	HC	AR	30d. R.T.	0.56	0.01	GSFC
P. urethane/W	FC-GSFC-20/W	GS	100p. Sol. 113 73p. C-113-300 .26p. TiO_2 1 drop T-12	7d. R.T.	0.29	0.01	GSFC
P. urethane/W	TS-1603-16	HC	AR-w/solvent	7d. R.T.	0.61	0.02	GSFC

Paints (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. urethane/BF		GS	9ml. Chemglaze Z-306 2ml. toluene 1gm. 3M-840D microballoons thru 44 micron sieve onto 37 micron sieve	15d. R.T.	0.83	0,04	GSFC

Conformal Coatings (Table 11)

Many types of conformal coatings have been examined and it would appear that those, which are of low viscosity and 100% solids formulated, are most successful from the outgassing viewpoint. These are represented by the epoxy-versamide type, epoxies and polyurethanes. It is entirely possible that the group of previously noted low volatility silicones, GE 566, Dow Corning 93-500 or C6-1104 could also be used in high voltage specialty situations. The solution type conformal coatings, especially the epoxies, appear to lose considerable solvent during VCM testing, possibly because of previous solvent entrapment due to surface cure.

Table 11

Conformal Coatings

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy	PCA/16	EC	100p.A/2p.16	1h. 25° C+ 2h. 95° C+ 2h. 150° C	0.18	0.02	SRI
Epoxy	SMRD 100A/B	GE	57p.A/44p.B	16h. 100° C	0.46	0.04	GSFC
Epoxy	Stycast 1467/9	EC	100p.1467/7p.9	18h. R.T. + 1h. 77° C	0.14	0.01	GSFC
Epoxy/versam.	Epon 828/140	RO	70p. 828 30p. 140 1p. SR-82	1h. R.T. + 2h. 60° C	0.27	0.02	GSFC
P. ester/imide	Isomid	SC	AR	Air dry + 2 min. 204° C	0.44	0.03	GSFC
Fluorocarbon	Fluoroclad V78-VP21	SW	AR	Air dry + .5h. 93° C + 25h. 260° C	0.05	0.01	GSFC
Fluorosilicone	94-003-dispersion	DC	AR	75d. R.T.	0.18	0.01	GSFC
P. urethane	FC-GSFC-20/w	GS	100p. Sol. 113 73p. Sol. C113-300 .25p. TiO_2 1 drop T-12	7d. R.T.	0.29	0.01	GSFC
P. urethane	JPL 1002	AB	AR	4h. 75° C	0.19	0.02	SRI
P. urethane	JPL 1001	AB	AR	4h. 75° C	0.20	0.10	SRI
P. urethane		TH	100p. Sol. 113 73p. Sol. C113-300	5h. 54° C	0.51	0.09	JPL
P. urethane	—	GS	100p. Sol. 113 73p. Sol. C113-300	22h. 70° C	0.31	0.01	GSFC
P. urethane	—	GS	100p. Sol. 113 150p. Sol. C113-300	7d. R.T.	0.37	0.09	GSFC
P. urethane	—	GS	100p. Sol. 113 150p. Sol. C113-300	18h. 50° C	0.31	0.04	GSFC
P. urethane	—	SB	100p. Sol. 113 51p. Sol. C113-300 4.5p. Sol. C113-328 20.5p.B-35A gl. bubbles	16h. 28° C	0.21	0.01	GSFC

Conformal Coatings (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. urethane	RCA-A-4875	RCA	100p.1155A/70p.1155B +30p. cellosolve ac. tate	10min. R.T.+ .25h. 49° C for each of two coats + 3h. 60° C final	6.81	0.05	GSFC

Lubricants and Interfaces - Liquid Lubricants, Solid Films, Optical and Thermal Grease (Table 12)

There are few design considerations which have received the analysis and attention by aerospace technologists, as the lubricant interface between moving parts. These lubricants may be liquid or solid film. The former are generally represented by silicone oils such as F-50, purified hydrocarbon Apiezon C and refined azelate, sebacate and/or adipate esters. Apiezon L is a grease with a hydrocarbon liquid phase. A good deal of the concern with lubricating silicones even in low speed low load applications has been the high outgassing of the thin film lubricant vehicle, and in some cases non-standard quality control resulting in inconsistent properties. Each of the asterisk indicated lubricants[13] are normally considered unacceptable outgassers. However, they do have unique lubricating properties and have often been used on spacecraft in specially designed sealed systems.

New low outgassing lubricants F6-1101 a fluorosilicone and F6-1107 a chlorophenyl siloxane, both servicable from -40 to 400°F have become available from Dow Corning. Their counter parts are FS-1265 and DC-560.

The F6-1101 however, a fluorinated silicone oil shows excellent lubricity in the four ball wear test, ASTM-D-2266, when compared to either F6-1107, F-50, chlorophenyl siloxanes, or Apiezon-C hydrocarbon. Wear scar values were 0.42, 1.89, 1.23 and 0.78 millimeters respectively for the four lubricants.[14] Some GSFC evaluation of F6-1101 potential as either an improved lubricant oil or base for new greases using possibly tricresyl phosphate additive could be fruitful. Here again it becomes possible for those versed in the art to develop new specialty lubricants based on these low outgassing oils. Silicone oil creep would have to be reassessed.

Solid film lubricants are also utilized in spacecraft. These may be polymer based, epoxy or phenolic molybdenum disulphide types or the inorganic silicate molybdenum disulphide type. The latter material specified in MIL-L-81329(WP) Oct '65 was developed by personnel of the Aeronautical Materials Department.[15] Details on processing and the latest material technology can be obtained there. This is an excellent solid lubricant surface when correctly applied. It has flown on ATS satellites and is recommended in critical areas. It remains to be evaluated in outgassing tests. Teflon composites have seen satisfactory service in low load applications and usually have acceptable outgassing values. Low outgassing thermal grease used at interfaces to preserve thermal continuity is a normal development consideration for low volatility silicone oils. There are many thermally conducting filler/concentration combinations of greases or silicone pottings that can be explored and developed for maximum thermal conducitivity at interfaces. A small investment in time with such fillers as zinc, aluminum, or possibly beryllium oxides could provide materials helpful to thermal control designers.

Application of more effective low outgassing thermal greases or potting systems could lead to more exact anticipated temperatures and faster thermal equilibration of spacecraft, factors necessary to good thermal control.

Table 12

Lubricants and Interfaces-Liquid Lubricants, Solid Films, Optical and Thermal Grease

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Ester/LL*	DOA		dioctyl adipate	AR	100.00	—	GSFC
Fluorocarbon oil/LL	Krytox 143-AX	DU	fluoroalkyl polyether oil	AR	28.54	5.71	GSFC
Hydrocarbon/LL*	Apiezon-C	BD	AR	AR	31.50	—	GSFC
Hydrocarbon/LL	Apiezon-L, grease	BD	AR	AR	0.06	0.01	JPL
Silicone/TG	C6-1102	DC	AR	AR	0.05	0.02	GSFC
Silicone/G/LL	C6-1103-vac. grease	DC	AR	AR	0.17	0.01	GSFC
Silicone Oil/LL	F6-1100	DC	dimethyl siloxane	AR	0.07	0.04	GSFC
Silicone Oil/LL	F6-1101	DC	fluorosilicone	AR	0.05	0.03	GSFC
Silicone Oil/LL	F6-1105	DC	phenyl methyl siloxane	AR	0.07	0.06	GSFC
Silicone Oil/LL	F6-1107	DC	chlorophenyl siloxane	AR	0.11	0.07	GSFC
Silicone Oil/LL*	F-50, Versilube	GE	AR	AR	4.50	—	GSFC
Silicone Oil/LL*	SF-96[500 cp.]	GE	AR	AR	4.00	—	GSFC
Silicone Oil, LL*	SF-96 [50cp.]	GE	AR	AR	8.00	—	GSFC
Silicone Oil/LL	1147	GE	AR	AR	4.28	2.41	GSFC
P. acetal/teflon/M/SF	Delrin AF	DU	80 Delrin/20 Teflon	AR	0.47	0.05	JPL
P. acetal/teflon/M/SF	Fulton 404	LN	80 Delrin/20 Teflon	AR	0.52	0.01	GSFC
P. acetal/gl./SF	Formafil G80/20	FF	80 r./20 gl.	AR	0.44	0.01	GSFC
Epoxy/MoS_2/SF	Epon 934A/B-MoS_2	GS	100p. 934A/33p.B 5p.MoS_2 20ml. MEK	.25h. 66° C, 1h. 93° C + 24h. 125° C, 10^{-2} torr	0.54	0.01	GSFC
Epoxy/MoS_2/SF	FC-GSFC-11-B	GS	100p. 956A 58p. 956B 6.3p. MoS_2 .8p. Carb. 1 .4p. Cab.-MS-5	2h. 66° C	0.85	0.10	GSFC
Fluorocarbon/SF	33181019	BR	PTFE	AR	0.01	0.01	GSFC
Fluorocarbon/Dac/SF	Fairprene 80-080	DU	AR	AR	0.30	0.01	SRI
Fluorocarbon/Dac/SF	Fairprene 80-070	DU	AR	AR	0.30	0.01	SRI
Fluorocarbon/Dac/SF	Fairprene 80-060	DU	AR	AR	0.34	0.01	SRI
Fluorocarbon/gl./SF	TB5-PTFE	DU	AR	AR	0.05	0.05	JPL

*Actual lubricant weight losses when heated at 121°C and 1×10^{-4} torr for 24 hours outside the VCM test facility. These lubricants may have been used under special conditions, where outgassing effects are minimized.

Lubricants and Interfaces-Liquid Lubricants, Solid Films, Optical and Thermal Grease (continued)

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Fluorocarbon/gl./SF	RT Duroid 5870	RG	PTFE	AR	0.12	0.02	JPL
Fluorocarbon/mica/SF	Fluorosint LE 207	PC	PTFE/mica	AR	0.20	0.04	JPL
Fluorocarbon/mica/SF	Fluorosint	PC	PTFE/mica	AR	0.09	0.03	JPL
Fluorocarbon/nylon/SF	Armalon 98-101	DU	AR	AR	0.48	0.02	SRI
P. imide/SF	Vespel SP-1	DU	AR	AR	1.24	0.01	SRI
Molydisulphide/SF	Molykote, microsize	DC	AR	AR	0.55	0.01	JPL
Nylon 6/10/gl./SF	QF 1006	LN	70 r./30 gl.	AR	0.65	0.04	GSFC
Phenolic/MoS_2/SF	4306	EF	thin film	1.5h. 190° C	0.05	0.01	SRI
Silicate/MoS_2/SF	2396	EF	thin film	2h. 80° C+ 2h. 205°	0.05	0.01	SRI
Silicone/OG	DC-20-057	DC	AR	AR	0.31	0.07	JPL
Silicone/TG	Eccotherm TC-4	EC	AR	AR	0.54	0.05	GSFC
Silicone/TG	G-683	GE	AR	AR	0.62	0.07	SRI

Table 13

Textiles

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Cu/silicone/Dac	—	LH	AR	AR	0.64	0.08	GSFC
P. ester	—	RB	P. ester latex 404m 2-3 on Dacron cloth	AR	0.05	0.04	GSFC
P. ester	—	RB	p. ester latex 404m 2-3 on Dacron net	AR	0.19	0.06	GSFC
P. ester	—	RB	P. ester latex 404m 2-3 V-46-AX on Dacron thread	AR	0.45	0.09	GSFC
P. ester/HL	Velcro 100	VE	hook and loop fastener, total system	AR	0.54	0.03	GSFC
Fluorocarbon/Dac	Fairprene 80-060	DU	AR	AR	0.34	0.01	SRI
Fluorocarbon/Dac	Fairprene 80-070	DU	AR	AR	0.30	0.01	SRI
Fluorocarbon/Dac	Fairprene 80-080	DU	AR	AR	0.30	0.01	SRI
Fluorocarbon/gl.	Emfab 20-60 PTFE	AF	AR	AR	0.01	0.01	GSFC
Fluorocarbon/gl.	TB5-PTFE	MM	AR	AR	0.05	0.05	SRI
Fluorocarbon/nylon	Armalon 98-101	DU	AR	AR	0.48	0.02	SRI
Fluorocarbon/Dac	—	BX	Viton/Dacron	AR	0.86	0.09	GSFC
P. imide/gl.	Pyre M.L. Type 1	DU	AR	AR	0.50	0.01	SRI
Stainless steel	Velcro 150-46-306-1754	VE	AISI 300 series stainless-hook and loop fastener, total system	AR	0.03	0.02	GSFC

CONCLUSION

One advantage of developing this compilation is that it spotlights areas of critical material application which lack necessary and effective low outgassing systems. Conversely, it also points up the many new materials and potential material systems with the inherent possibility of doing things a better way, cutting costs, simplifying and speeding fabrication. Above all a mutual understanding by all involved, relative to the type materials desired, simplifies selection and dissipates the doubts and misunderstandings of operating without any initial material guidance.

Many spacecraft contain lightweight honeycomb sandwich structures with maximum strength characteristics provided by excessively outgassing adhesive systems. (see film adhesive section.) Where possible, one should analyze structural requirements to ascertain whether lower outgassers might be suitable. Gross adhesive outgassing as occurs with FM-1000, table 5, raises the specter of possible jeopardy to some crucial onboard experiment. The use of improved low outgassing adhesives in core structures is additionally recommended. Improved, acceptable low outgassing silicone paints are being evaluated. At the present time, however, second surface silver mirrors on radiation resistant glass or quartz probably represents the optimum thermal control system, if one considers both minimal weight penalization and minimal thermal change for moderately long term flights. Heat pipes have been shown to be very effective but costly, since configuration standardization is difficult.

There is a need for low outgassing pourable foams in various densities from 2-10 lbs./cu.ft. There are very few representative types that can be recommended. There is a need for multifunctional lubricants together with prescribed systems within which they can operate and cleanliness procedures for operational effectiveness. This entire area needs to be opened to the light of day so that there is a common ground of GSFC concepts, functional systems, and procedures within the scope of material acceptability. Perhaps the new low volatile silicone oils and lubricants will provide this impetus.

Little mention has as yet been made in this report of a previously noted important concept, pre-vacuum bakeout. All component systems incorporating "acceptable material" design should be prebaked at least 24 hours in a 10^{-6} torr vacuum at the maximum allowable temperature, i.e. 15-25°C above the

highest thermal-vacuum test level exposure for the particular spacecraft. This should be done prior to thermal-vacuum acceptance testing. Marginal systems should be vacuum baked longer, 48-72 hours. Heat sensitivity of the electronic components and coefficients of thermal expansion should be primary considerations in determining bakeout temperatures. Temperatures should not exceed prescribed electronic-component limits. The above procedure should eliminate the possibility of even the very slightest condensable deposits seen occasionally with very low outgassing materials, in our 125°C vacuum test system.

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ALPHABETICAL INDEX
OF
ACCEPTABLE POLYMERIC MATERIALS

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
p. acetal/M 58,000 mol. wt. hi. visc.	Delrin-100NC10	DU	AR	AR	0.58	0.06	SRI
P. acetal/M 58,000 mol. wt. hi. visc.	Delrin 150NC10	DU	AR	AR	0.56	0.06	SRI
P. acetal/M 38,000 mol. wt. med. visc.	Delrin-500NC10	DU	AR	AR	0.48	0.07	SRI
P. acetal/M 32,000 mol. wt. low visc.	Delrin 900NC10	LN	AR	AR	0.56	0.08	SRI
P. acetal/I	Formex	GE	AR	AR	0.06	0.03	SRI
P. acetal/gl./M	Formafil G80/20	FF	80 r./20 gl.	AR	0.44	0.01	GSFC
P. acetal/gl./M	KF 1006	LN	70 r./30 gl.	AR	0.28	0.02	GSFC
P. acetal/teflon/M/SF	Delrin AF	DU	80 Delrin/20 Teflon	AR	0.47	0.05	JPL
P. acetal/teflon/M/SF	Fulton 404	LN	80 Delrin/20 Teflon	AR	0.52	0.01	GSFC
Acrylic/A	Gelva MP263RA	MC	AR	7d. R.T.	0.79	0.08	GSFC
Acrylic/A	Gelva MP263RA	MC	AR	24h. R.T. + 24h. 66° C	0.62	0.03	GSFC
Acrylic/A	Gelva MP784RA	MC	AR	24h. R.T. + 24h. 66° C	1.00	0.05	GSFC
Acrylic/A	PS-18	RH	acrylic cement	72h. R.T.	0.74	0.01	GSFC
Acrylic/A	Resyn 30-1215	NS	AR	16h. 66° C	0.82	0.08	JPL
Acrylic/gl./SL	Acrylic C-2	BH	AR	AR	0.33	0.01	SRI
Acrylic/gl./SL	Acrylic A FA1	BH	AR	24h. 150° C	0.22	0.05	SRI
Acrylic/gl./SL	Acrylic A FA1	BH	AR	AR	0.49	0.05	SRI
Acrylic/gl./SL	Lecton--B	BH	AR	24h. 150° C	0.09	0.09	SRI
Acrylic/silver powder/CT/c	Dupont 4922	DU	1p. r /1p. butyl acetate	.25h. 66°C + 48h. 99°C	0.61	0.01	GSFC
Acrylic/silver/CT/c	E-Kote 3030	ER	AR	24 h. R.T. 1h. 66°C	0.76	0.06	GSFC
Alkyd/BF/PN	101-C10	MM	AR	7 h. 110° C	0.33	0.17	SRI
Al./acrylic/t	425	MM	aluminum foil	AR	0.24	0.03	GSFC
Al./acrylic/t	Mystic-7452	MY	aluminum foil	AR	0.25	0.03	GSFC
Al./acrylic/t	Mystic 7453	MY	aluminum foil	AR	0.64	0.04	JPL
Al./acrylic/t	Y9339	MM	type 2, aluminum foil	AR	0.80	0.02	GSFC
Al./acrylic/t	Y9339	MM	type 3, aluminum foil	AR	0.20	0.01	GSFC
Al./acrylic/silver/c	Eccoshield PST-C-A	EC	alum. foil tape with silver ball filled acrylic adhesive	AR	0.26	0.09	GSFC

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
AL/p. ester/F	100M 42	SU	vaporized aluminum on Mylar	AR	0.14	0.02	GSFC
Al./p. ester/Dac/adhes./F		DU	vaporized aluminum on Mylar, over Dacron adhered to surface with adhes. 46960	AR	0.46	0.09	GSFC
AL/p. ester/acrylic/t	850	3M,	vaporized aluminum on Mylar	AR	0.69	0.10	GSFC
Al./p. ester/acrylic/t	852	MM	vaporized aluminum on Mylar	AR	0.59	0.03	GSFC
Al./p. ester/acrylic/t	X-9460	MM	vaporized aluminum on Mylar	AR	0.83	0.04	GSFC
AL/p. ester/acrylic/t	SL-1250543	MM	vaporized aluminum on Mylar	AR	0.65	0.01	GSFC
AL/p. ester/Al/acrylic/t	Y9360	MM	vaporized aluminum on both sides of Mylar, with acrylic adhesive, superimposed on one side of aluminum	AR	0.54	0.01	GSFC
AL/p. ester/AL/acrylic/t	9460A	MM	vaporized aluminum top and bottom side of Mylar	AR	0.79	0.03	GSFC
P. arylether/M	Arylon T	UN	AR	AR	0.36	0.03	GSFC
P. arylether/gl./M	XF-1006	LN	70 r./30 gl.	AR	0.29	0.01	GSFC
P. aryl sulphone/M	Astrel 360	MM	AR	AR	0.94	0.02	GSFC
P. boron-silica/M	Dexsil-201	OC	AR	AR	0.07	0.01	GSFC
P. buta/acrylonitrile-elast.	Hycar 520-67-108-5	BF	AR	AR	0.95	0.03	SRI
P. buta/acrylonitrile-elast.	HYcar 520-67-108-6	BF	AR	AR	1.03	0.03	SRI
P. buta./acrylonitrile/gl./M	AF 1006	LN	70 r./30 gl.	AR	0.20	0.01	GSFC
Butyl elast.	GSFC 218	EN	AR	AR	0.28	0.03	GSFC
Butyl elast.	Sr-634-70	ST	AR	AR	0.93	0.10	GSFC
Butyl elast.	Ex-1092	EN	AR	4h. 150° C	0.86	0.10	SRI
P. carbonate/M intermed. mol. wt.	Lexan 100-111	GE	no additives	AR	0.06	0.02	SRI

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P.carbonate/M intermed. mol. wt.	Lexan 100-112	GE	no additives	AR	0.09	0.04	SRI
P.carbonate/M intermed. mol. wt.	Lexan 101-111	GE	therm. stabilized	AR	0.08	0.01	SRI
P.carbonate/M intermed. mol. wt.	Lexan 103-112	GE	therm. + UV stabilized	AR	0.17	0.01	SRI
P.carbonate/M high mol. wt.	Lexan 130-111	GE	no additives	AR	0.17	0.01	SRI
P.carbonate/M high mol. wt.	Lexan 131-111	GE	therm. stabilized	AR	0.18	0.01	SRI
P.carbonate/M high mol. wt.	Lexan 131-112	GE	therm. stabilized	AR	0.17	0.01	SRI
P.carbonate/M high mol. wt.	Lexan 133-112	GE	therm. + UV stabilized	AR	0.20	0.01	SRI
P.carbonate/M low mol. wt.	Lexan 140-111	GE	no additives	AR	0.17	0.03	SRI
P.carbonate/M low mol. wt.	Lexan 141-111	GE	therm. stabilized	AR	0.17	0.04	SRI
P.carbonate/M low mol. wt.	Lexan 141-112	GE	therm. stabilized	AR	0.17	0.02	SRI
P.carbonate/M low mol. wt.	Lexan 243-112	GE	therm. + UV stabilized	AR	0.16	0.01	SRI
P.carbonate/S low mol. wt.	Lexan 9434-112	GE	AR	AR	0.19	0.01	GSFC
P. carbonate/gl./M	DF-1006	LN	70 r./30 gl.	AR	0.14	0.01	GSFC
P. carbonate/gl./M	Carbafil-G50/20	FF	80 r./20 gl.	AR	0.12	0.01	GSFC
P. chlorofluorocarbon/M	Kel-F 81	MM	AR	AR	0.03	0.01	SRI
Cu/acrylic/t/c	X-1181	MM	copper foil with acrylic adhesive	24h. 125° C	0.15	0.03	GSFC
Cu/acrylic/t/c	X-1245	MM	copper foil with acrylic adhesive	AR	0.19	0.11	GSFC
Cu/acrylic/t/c	Mystic 7420	MY	copper foil with acrylic adhesive	AR	0.22	0.01	GSFC
Cu/silicone/Dac/TX		LH	AR	AR	0.64	0.08	GSFC
DAP/gl./M	Dial-FS-4	AC	AR	24h. 150° C	0.58	0.03	SRI
DAP/gl./M	Dial-FS-10	AC	AR	24h. 150° C	0.70	0.03	SRI
DAP/gl./M	Dial FS-40	AC	AR	24h. 150° C	1.00	0.02	SRI
DAP/gl./M	Dial FS-80	AC	AR	AR	0.44	0.01	GSFC
DAP/gl./M	Dial 52-40-40	AC	AR	AR	0.70	0.06	SRI
DAP/gl./M	Dial 52-40-40	AC	AR	24h. 150° C	0.30	0.01	SRI
DAP/gl./M	C2580-118	FM	AR	AR	0.30	0.01	GSFC
Diphenyl-ox/gl./L	Doryl H-17511	WC	AR	AR	0.44	0.04	SRI
Diphenyl-ox/gl./L	Doryl H-17511	WC	AR	24h. 150° C	0.68	0.03	SRI

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy/A	Armstrong A2/A	AP	100p.A2/4p.A	.75h. 74° C + .75h. 93° C	0.44	0.01	JPL
Epoxy/A	Armstrong . _/E	AP	100p.A2/6p.E	.75h. 93° C	0.26	0.03	SRI
Epoxy/A	Armstrong A12/A	AP	AR	2h. 85° C	0.85	0.03	SRI
Epoxy/A	Armstrong A12/A	AP	AR	2h. 85° C + 48h. 125° C, + $1x10^{-5}$ torr	0.62	0.02	SRI
Epoxy/A	Armstrong A31 A/B	AP	60p.A/40p.B	2h. 60° C	0.56	0.03	GSFC
Epoxy/P	AV-100/HV 100	CJ	AR	7d. R.T.	0.78	0.10	GSFC
Epoxy/P	Bacon Ind.	BN	AR	4h. 71° C + 16h. 100° C	0.12	0.01	GSFC *
Epoxy/P	BSL 208	CI	AR	1h. 164° C	0.82	0.11	GSFC
Epoxy/P	BSL 308	CI	AR	1h. 175° C	0.49	0.10	GSFC
Epoxy/BF/PN*	CAT-A-LAC 463-3-8	FP	AR	24h. 120° C	1.33	0.01	GSFC
Epoxy/A	Eccobond 51/9	EC	100p.51/7p.9	24h. R.T.	0.44	0.02	GSFC
Epoxy/A	Eccobond 51/9	EC	100p.51/7p.9	48h 95° C $1x10^{-1}$ torr	0.18	0.02	GSFC
Epoxy/A	Eccobond 55/9	EC	100p.55/12p.9	24h. 25° C	0.40	0.06	SRI
Epoxy/A	Eccobond 55/9	EC	100p.55/12p.9	16h. 65° C	0.17	0.07	SRI
Epoxy/A	Eccobond 104A/B	EC	100p.A/64B	8h. 150° C	0.35	0.03	SRI
Epoxy/P	EC 1751 A/B	MM	50p. 1751 A 100p. 1751 B 15p. phenyl glycidyl ether	24h. R.T.	0.75	0.06	GSFC
Epoxy/P	Eccomold L-28	EC	AR	64h. 127° C	0.18	0.01	GSFC
Epoxy/P	Eccoseal 1207/20	EC	100p. 1207/1.5p.20	4h. 71° C + 1h. 177° C	0.27	0.01	GSFC
Epoxy/A	Epibond 123/952	FU	100p.123/15p.952	24h. R.T.	0.63	0.03	GSFC
Epoxy/A	Epibond 8510 A/B	FU	100p.A/30p.B	5d. R.T.	0.05	0.01	GSFC
Epoxy/A	Epiphen-ER825A	BO	100p. 825A 12p. Mod-7 40p. filler 16p. 825A cat.	48h. 25° C	1.07	0.01	SRI

*Acceptable where none else will perform a required function

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy/A	Epiphen-ER 825 A	BO	100p. 825A 12p. Mod-7 40p. filler 15p. 825A cat.	48h. 75° C	0.84	0.01	SRI
Epoxy/M	Epocast 403-S-3	FU	AR	AR	0.32	0.01	GSFC
Epoxy/P	Epocast N4E-053	FU	AR	24h. R.T. + 2h. 93° C	0.07	0.02	GSFC
Epoxy/P	Epon X-24	SH	AR	10h. 100° C	0.42	0.05	GSFC
Epoxy/A	Epon 815-TETA	SH	10p. 815/1p.TETA	16h. 63° C	0.76	0.01	GSFC
Epoxy/A	Epon 820/TETA	SH	10p. 820/1p.TETA	3d. R.T.	0.43	0.06	GSFC
Epoxy/A	Epon 820/TETA	SH	10p. 820/1p.TETA	16h. 63° C	0.36	0.04	GSFC
Epoxy/P	Epon 826/Z	RO	100p. 826/20p.Z	2h. 77° C+ 2h. 135° C	0.91	0.02	JPL
Epoxy/P	Epon 828/A	SH	100p. 828/8p.A	3h. 95° C	0.70	0.06	SRI
Epoxy/A	Epon 828/TETA	SH	10p. 828/1p.TETA	3d. R.T.	0.51	0.01	GSFC
Epoxy/A	Epon 828/TETA	SH	10p. 828/1p.TETA	10h. 60-66° C	0.38	0.01	GSFC
Epoxy/P	Epon 828/Z	SH	100p. 828/20p.Z	2h. 75° C, 2h. 135° C	0.42	0.03	SRI
Epoxy/semi-rigid/P	Epon 828/871/AEP	GS	35p./828 65p./871 15.5p./AEP	12h. R.T.	0.86	0.05	GSFC
Epoxy/semi-rigid/P	Epon 828/871/AEP	GS	40p./828 60p./871 15.5p./AEP	18h. 65° C	0.46	0.02	GSFC
Epoxy/A	Epon 901 A/B	SH	100p. 901/11p.B	.5h. 116° C	0.73	0.06	JPL
Epoxy/A	Epon 901/B3	SH	100p. 901/23p.B3	1.5h. 115° C + 1.5h. 175° C	0.19	0.01	SRI
Epoxy/A	Epon 917	SH	AR	.25h. 175° C	0.17	0.03	SRI
Epoxy/A	Epon 929	SH	AR	1h. 149° C	0.68	0.06	GSFC
Epoxy/A	Epon 931A/B	SH	100p. A/1p.B	1h. 125° C	0.13	0.01	SRI
Epoxy/A	Epon 934A/B	SH	100p. A/33p.B	7d. R.T.	0.28	0.01	GSFC
Epoxy/A	Epon 934A/B	SH	100p. A/33p.B	16h. 52° C	0.42	0.02	JPL
Epoxy/A	Epon 956A/B	SH	100p. A/58p.B	7d. R.T.	0.19	0.01	GSFC

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy/A	Epon 956A/B	SH	100p. A/58p.B	2.5h. 80° C	0.38	0.01	JPL
Epoxy/A	Epotek-301A/B	ET	20p.A/5p.B spectrally transp.	24h. R.T.	1.08	0.01	GSFC
Epoxy/M	Fiberite E3938	FB	AR	AR	0.44	0.01	GSFC
Epoxy/M	Furane 403	FU	AR	AR	0.43	0.01	SRI
Epoxy/P	HP-16-92	HA	100p. DER 332LC/18p. HV	5h. R.T. + 12h. 90° C + 24h. 90° C,P.C.	0.33	0.02	GSFC
Epoxy/P	Hysol 0151	HY	AR	24h. R.T.	0.78	0.02	GSFC
Epoxy/mod./F/A	Hysol A9-601	HY	AR	1h. 121°C + 12 psi	0.37	0.03	GSFC
Epoxy/P	Hysol C9-4188/3469	HY	10p. 4188/.75p. 3469	1h. R.T.+1h. 49° C 1h. 171° C	1.01	0.08	JPL
Epoxy/P	Hysol C9-4188/3469 Ferro V-780	HY	10p. 4188/.75p. 3469	1h. R.T. + 1h. 49° C 1h. 171° C	0.96	0.03	JPL
Epoxy/P	Hysol C9-5340/3426	HY	100p. 5340/8.3p. 3426	8h. R.T.	0.60	0.05	GSFC
Epoxy/P	Hysol XC9-G71D/ H2-3561	HY	AR	AR	0.90	0.02	GSFC
Epoxy/A	Hysol EA 956	HY	AR	R.T.	0.69	0.03	GSFC
Epoxy/P	Hysol R8-2038/ H2-3475	HY	AR	24h. R.T.	0.53	0.01	GSFC
Epoxy/P	Maraset 655/553	MR	100p. 655/20p. 553	16h. 82° C	0.59	0.01	SRI
Epoxy/P	Maraset 655/553	MR	100p. 655/20p. 553	16h. 82° C + 24h. 150° C	0.32	0.01	SRI
Epoxy/P	Maraset 655/555	MR	100p. 655/7p. 555	16h. 82° C	0.41	0.01	SRI
Epoxy/P	Maraset 655/555	MR	100p. 655/7p. 555	16h. 82° C + 24h. 150° C	0.25	0.01	SRI
Epoxy/P	MPC 52	GE	AR	4h. R.T. 2h 66° C	0.17	0.01	GSFC
Epoxy/P	MY 750/HY974	CI	AR	30h. 60° C	0.19	0.01	GSFC
Epoxy/P	MY 750/HY 974	CI	AR	.75h. 100° C	0.27	0.03	GSFC

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy/CF	PCA/16	EC	100p. A/2p. 16	1h 25° C + 2h. 95° C + 2h. 150° C	0.18	0.02	SRI
Epoxy/versam/A	PS-269	BX	50p. 828/50p. 125	24h. R.T.	0.79	0.10	GSFC
Epoxy/P	R-179	RD	aliphatic-epoxy	.5h. 160°C	0.81	0.03	GSFC
Epoxy/P	R-6005	RD	aliphatic epoxy	10min. 160° C	0.82	0.03	GSFC
Epoxy/M	Rogers RX-611	RG	AR	AR	0.53	0.02	GSFC
Epoxy/P	Scotchcast 260	MM	AR	.5h. 150° C	0.52	0.03	SRI
Epoxy/P	Scotchcast 281 A/B	MM	100p. A/150p.B	20h. 75° C	0.36	0.05	SRI
Epoxy/P	Scotchcast 282 A/B	MM	2p. A/3p.B	20h. 75° C	0.74	0.10	JPL
Epoxy/A	Scotchweld 1838 A/B	MM	1p. A/1p.B	24h R.T.	0.65	0.03	GSFC
Epoxy/P	SMRD 49	GE	AR	AR	0.98	0.05	GSFC
Epoxy/CF	SMRD 100A/B	GE	57p. A/44p.B	16h. 100° C	0.46	0.04	GSFC
Epoxy/CL	Stycast 1090/9	EC	100p. 1090/9p.9	16h. 50° C	0.31	0.07	SRI
Epoxy/CL	Stycast 1090/11	EC	100p. 1090/12p. 11	12h. 60°C + 3h. 82° C	0.63	0.11	SRI
Epoxy/CL	Stycast 1090/11	EC	100p. 1090/12p. 11	24h. 125° C	0.04	0.04	SRI
Epoxy/CL	Stycast 1095/11	EC	100p. 1095/12p. 11	24h. 125° C	0.50	0.11	SRI
Epoxy/P	Stycast 1263/31	EC	100p. 1263/3p. 31	16h 107° C 24h. 150° C	0.12	0.01	SRI
Epoxy/CF	Stycast 1467/9	EC	100p. 1467/7p. 9	18h R.T. + 1h. 77° C	0.14	0.01	GSFC
Epoxy/P	Stycast 2651/9	FW	AR	AR	0.23	0.01	GSFC
Epoxy/P	Stycast 1269 A/B	EC	100p. A/100p. B	16h. 100° C + 24h. 150° C	0.18	0.05	SRI
Epoxy/P	Stycast 2651/11	EC	AR	AR	0.14	0.01	GSFC
Epoxy/P	Stycast 2850 FT/9	EC	100p. 2850FT/3p. 9	AR	0.25	0.01	GSFC
Epoxy/P	Stycast 2850 FT/9	EC	100p. 2850FT/3.5p. 9	16h. 25° C	0.34	0.04	SRI
Epoxy/P	Stycast 2850 GT/11	EC	AR	AR	0.33	0.02	JPL
Epoxy/P	Stycast 2850 GT/11	EC	100p. 2850GT/4-5p.11	40h 54° C	0.85	0.03	JPL
Epoxy/P	Stycast 2862 A/B	EC	100p. A/100p. B	16h. 120°C,	0.32	0.04	SRI
Epoxy/P	Stycast 2862 A/B	EC	100p. A/100p. B	16h. 120°C, 24h. 150°C	0.01	0.01	SRI
Epoxy/P	Stycast 3050/11	EC	100p. 3050/9.5p. 11	16h. 77° C	0.68	0.06	SRI
Epoxy/A	Torr Seal	VA	equal lengths A,B	24h. R.T.	0.84	0.01	GSFC

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy/P	Trucast 111/ Trucure 901	FW	100p. 111/34p. 901	24h. R.T.	0.36	0.01	GSFC
Epoxy/P	2850/24LV	EC	AR	24h. 49° C + 24h. 60° C	0.73	0.10	GSFC
Epoxy/B/PN	CTL-15(17038)	HA	3p. 15A/1p. 15B	2 coats, each air dried .25h. +.25h. 65°C +1.75h. 121°C	0.96	0.02	GSFC
Epoxy/BF/PN	FC-GSFC-5B	GS	100p. 956A 58p. 956B 3.15p. Carb. 1 1.6p. Cab. MS-5	7d. R.T.	0.81	0.01	GSFC
Epoxy/BF/PN	FC-GSFC-6B	GS	100p. 956A 58p. 956B 3.15p. Carb. 1 1.6p. Cab. MS-5	2h. 66° C	0.49	0.01	GSFC
Epoxy/BF/PN	FC-GSFC-7B	GS	100p. 956A 58p. 956B 3.15p. Carb. 1 1.6p. Syloid 620	7d. R.T.	1.02	0.01	GSFC
Epoxy/BF/PN/SF	FC-GSFC-11B	GS	100p. 956A 58p. 956B .4p. Cab. MS-5 6.3p. MoS_2 .8p. Carb. 1	2h. 66° C	0.85	0.10	GSFC
Epoxy/boron fil./L	Epon 828/1031	SH	25p. Epoxy+cat/ 75p. boron filament Epoxy+cat. 50p. 828 50p. { MNA-90 / BDMA-10	1h. 66° C 1h. 82° C 4h. 177° C	0.25	0.02	JPL
Epoxy/boron fil./L	Rigidite 5505	NR	AR	.5h. 93° C .5h 177° C	0.46	0.01	JPL

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy/Carbon fil./L	–	GY	AR	AR	0.55	0.04	GSFC
Epoxy/gl./F/A	Ablefilm 517	AT	AR	3h. 71° C	0.07	0.01	GSFC
Epoxy/gl./pre/L	BP-907	AY	AR	1h. 177° C	0.84	0.02	JPL
Epoxy/gl./M	EMC-115-B-1	PA	AR	AR	0.29	0.01	GSFC
Epoxy/gl./min./M	Epiall 1906L	AY	AR	AR	0.39	0.06	SRI
Epoxy/gl./min./M	Epiall 1906L	AY	AR	24h. 150° C	0.16	0.03	SRI
Epoxy/gl./M	Epiall 1914	AY	AR	24h. 150° C	0.55	0.03	SRI
Epoxy/gl./CB	FL GF/EG-2028	FL	no copper	AR	0.33	0.01	SRI
Epoxy/gl./CB	FL GF/EG 2028FR	FL	no copper	AR	0.44	0.01	SRI
Epoxy/gl./CB	FLGF 250C2/2AIIB	AN	CB has 2 sides copper	AR	0.12	0.01	GSFC
Epoxy/gl./L	GE 101(FR-4)	EL	AR	AR	0.48	0.05	JPL
Epoxy/gl./pre/L	Hexcel F 153	HX	AR	7h. 171° C 14 psi	0.19	0.01	GSFC
Epoxy/gl./L	K-6098	MM	AR	AR	0.01	0.01	GSFC
Epoxy/gl./CB	Marglass	MG	100p. Ciba MY 740 1.5p. accel. DY 219 50p. cat. HY 219 glass cloth 1275 finish P705	AR	0.93	0.01	GSFC
Epoxy/gl./CB	Micaply EG-758T	MI	no copper	AR	0.48	0.05	SRI
Epoxy/gl./CB	Micaply EG-824T	MI	no copper	AR	0.40	0.05	SRI
Epoxy/gl./CB	Micaply EG-899T	MI	no copper	AR	0.29	0.03	SRI
Epoxy/gl./L	Micaply G-284	MP	AR	AR	0.49	0.06	SRI
Epoxy/gl./CB	Micarta 65M25	WC	AR	AR	0.43	0.01	SRI
Epoxy/gl./CB	Micarta 65M28 (FR4)	WC	copper clad	AR	0.26	0.01	JPL
Epoxy/gl./L	Micarta H-2497	WC	AR	AR	0.18	0.01	SRI
Epoxy/gl./L	Micarta H-8457	WC	AR	AR	0.80	0.12	SRI
Epoxy/gl./L	Micarta H-17511	WC	AR	AR	0.44	0.04	SRI
Epoxy/gl./L	Micarta H-17690	WC	AR	AR	0.48	0.07	SRI
Epoxy/gl./L	MIT-600	MT	AR	AR	0.64	0.03	GSFC

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy/gl./L	MIT-1281627	MT	AR	AR	0.32	0.02	GSFC
Epoxy/gl./L	Scotchply XP 251-S	MM	unidirectional	.5h. 149° C + 4h. 177° C	0.58	0.01	JPL
Epoxy/gl./L	Scotchply 279	MM	35 r./65 gl.	AR	0.96	0.06	JPL
Epoxy/graph./pre./L	HY-E 1001	FB	42p. epoxy 10836 58p. graphite 3p. BF3 complex	1h. 132° C 1h. 171° C	0.53	0.04	JPL
Epoxy/graph./pre/L	HY-E 1002	FB	38p. { WS-1028 or 50p. Epon 1031 50p. Epon 1028 62p. graphite 90p. NMA .45p. BDMA	1h. 82° C 4h. 177° C	0.32	0.04	JPL
Epoxy/iron/M	Eccosorb MF 112	EC	AR	AR	0.26	0.01	GSFC
Epoxy/iron/M	Eccosorb MF114	EC	AR	AR	0.22	0.01	GSFC
Epoxy/iron/M	Eccosorb MF-124	EC	AR	AR	0.09	0.01	GSFC
Epoxy/metal/c	Eccobond 56C/9	EC	100p. 56C/2.5p. 9	16h. 50° C	0.30	0.03	SRI
Epoxy/metal/c	Eccobond 57C-A/B	EC	100p. A/100p. B	16h. 52° C	0.67	0.06	SRI
Epoxy/metal/M	Eccosorb MF-116	EC	AR	AR	0.20	0.02	JPL
Epoxy/metal/M	Eccosorb MF500F116	EC	AR	AR	0.30	0.04	JPL
Epoxy/metal/c	Hysol K8-4238/H2-3475	HY	100p.-4238/8p. 3475	24h. R.T.	0.32	0.01	GSFC
Epoxy/MoS_2/SF	Epon 934 A/B-MoS_2	GS	100p. A/33p.B 5p. MoS_2 20 ml. MEK	.25h. 66° C, 1h. 93° C + 24h. 125° C, 1 x 10^{-2} torr	0.54	0.01	GSFC
Epoxy/mod./F/A	FM-96U	AY	AR	1h. 175° C	0.15	0.01	SRI
Epoxy/mod/F/A	Metlbond-328	NR	AR	1.5h. 165° C	0.12	0.10	SRI
Epoxy/mod./F/A	Metlbond 329	NR	AR	1.5h. 165° C	0.26	0.08	SRI
Epoxy/mod/F/A	Narmco 328	NR	AR	1.5h. 165° C	1.00	0.11	GSFC
Epoxy/mod/F/A	Narmco 329	NR	AR	1.5h. 165° C	1.21	0.05	GSFC

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Epoxy/nitrile/F/A	FM-123 LVCM	AY	AR	1.5h. 116° C	1.10	0.08	JPL
Epoxy/nitrile/F/A	FM123-5	AY	AR	1h. 121° C 12 psi	0.98	0.02	GSFC
Epoxy/nylon/F/A*	FM-1000	AY	AR	2h. 200° C	5.55	4.71	SRI
Epoxy/nylon/F/A	Metalbond 227	NR	AR	2-3° C/min. to 127° C, held 1h.	0.99	0.08	GSFC
Epoxy/phenolic/F/A	HT-424	AY	AR	.5h. 65° C	0.83	0.17	SRI
Epoxy/phenolic/F/A	HT-424	AY	AR	2h. 165° C	0.65	0.16	SRI
Epoxy/phenolic/F/A	HT-424	AY	alum./fiberglass sandwich	30h. 166° C	0.18	0.09	JPL
Epoxy/syntactic/CL	Eccobond SF-40	EC	AR	48h. R.T.	0.24	0.04	GSFC
Epoxy/syntactic/CL	MPC 49	GE	AR	18h. R.T. + 2h. 66° C	0.39	0.01	GSFC
Epoxy/syntactic/CL	MPC 49	GE	AR	4h. R.T. + 2h. 66° C	0.52	0.01	GSFC
Epoxy/syntactic/CL	ERL-2795/HN 95-1	HA	100p. ERL-2795 2-4p. B-35A micro-balloons 5p. Cab. MS 8p. cat. HN 95-1	24h. R.T.	0.50	0.03	GSFC
Epoxy/versam./P	Epon 828/140	GS	50p. 828/50p. 140	24h. R.T.	0.20	0.02	GSFC
Epoxy/versam./A	Epon 828/140	GS	60p. 828/40p. 140	24h. R.T.	0.74	0.05	GSFC
Epoxy/versam./CF	Epon 828/140	RO	70p. 828 30p. 140 1p. SR-82	1h. R.T. + 2h. 60° C	0.27	0.02	GSFC
Epoxy/versam/P	Type II class 2	HA	35p. DER 332LC 30p. 140	3h. 71° C	0.92	0.05	GSFC
Epoxy/versam./Al/PN	S-GSFC-20-Al	GS	60p. 828 40p. 140 33p. MD 5100 Al powder 133p. { toluene 50p. acetone 50p.	48h. 100° C	0.77	0.07	GSFC

*Discussion example, not desirable

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. ester/Lc	Astro-Tex	HW	AR	AR	0.58	0.07	JPL
P. ester/F	Cronar Ortho-S-Litho CoS 7	DU	AR	AR	0.37	0.01	GSFC
Ester/LL*	DOA	UC	dioctyl-adipate	AR	100.00	—	GSFC
P. ester/F	Mylar A	DU	AR	AR	0.40	0.10	JPL
P. ester/F	Mylar 500A	DU	AR	AR	0.24	0.06	SRI
P. ester/F	Mylar HS	DU	AR	AR	0.50	0.06	JPL
P.ester/S.T.	Mylar .004" wall	SP	AR	10min. 110° C	0.62	0.03	SRI
P. ester/S.T.	Mylar .012" wall	SP	AR	10min. 110° C	0.68	0.05	SRI
P. ester/T	P-49	RD	AR	10min. 104° C	1.04	0.05	GSFC
P.ester/x/l	Polythermaleze	BE	x-linked p.ester + p. amide-imide jacket	AR	0.28	0.01	GSFC
P. ester/F	Scotch Pak 8	MM	AR	AR	0.15	0.06	JPL
P. ester/T	V-700075	RD	AR	10min. 93° C	0.47	0.01	GSFC
P. ester/HL/TX	Velcro 100	VE	hook and loop fastener, total system	AR	0.54	0.03	GSFC
P. ester/TX	—	RB	p. ester latex 404m 2-3 on Dacron net	AR	0.19	0.06	GSFC
P. ester/TX	—	RB	p. ester latex 404m 2-3 on Dacron cloth	AR	0.05	0.04	GSFC
P. ester/TX	—	RB	P. ester latex 404m 2-3 V-46-AX on Dacron thread	AR	0.45	0.09	GSFC
P. ester/acrylic/t	5	MM	AR	AR	0.40	0.01	GSFC
p.ester/acrylic/t	850	MM	AR	AR	0.65	0.09	GSFC
P. ester/acrylic/t	X-1179	MM	AR	24h. 65° C	0.46	0.01	GSFC
P. ester/acrylic/t	Mystic 4043	MY	AR	AR	0.68	0.02	JPL
P. ester/acrylic/t	Mystic 7341	MY	AR	AR	0.57	0.03	JPL
P. ester/elast./Lc	Sturdelace 18DH	GB	Dacron/rubber	24h. 150° C	0.34	0.06	SRI
P. ester/elast./Lc	Guide-Spec.18D96	GB	Dacron/rubber	24h. 150° C	0.42	0.10	SRI

*Actual lubricant weight losses when heated at 121°C and 1×10^{-4} torr for 24 hours outside the VCM test facility. These lubricants may have been used under special conditions, where outgassing effects are minimized.

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. ester-epoxy/BF/PN	401 Series	MM	6p. r./1.5p. cat.	1h. 93° C	4.49	0.23	GSFC
P. ester-epoxy/W/PN	401-A10	MM	3p. 401-A10/1p. cat.	7d. R.T. + 24h. 121° C	3.09	0.08	GSFC
P. ester/gl./t	Fibre-mat 1-2539	MM	AR	AR	0.19	0.02	SRI
P. ester/gl./M	WF-1006	LN	70 r./30 gl.	AR	0.19	0.01	GSFC
P. ester/imide/CF	Isomid	SC	AR	Airdry + 2min. 204° C	0.44	0.03	GSFC
P. ethylene/P	Stycast TPM-4	EC	AR	16h. 107° C 4h. 121° C 4h. 135° C 1 w. R.T.	0.23	0.08	JPL
P. ethylene/gl./M	FF 1006	LN	70r./30 gl.	AR	0.13	0.03	GSFC
Ethylene/propylene elast.	E 515-8	EN	AR	AR	1.21	0.18	GSFC
Fiberglass/acrylic/t	Mystic 4052	MY	AR	AR	0.50	0.02	JPL
Fiberglass/silicone/t	Permacel 5208	PM	AR	8h. 204° C	0.31	0.07	JPL
Fluorocarbon/I	D-100 series	RA	Kynar solder sleeves w. polyethylene rings	AR	0.38	0.08	GSFC
Fluorocarbon/I	D-100 series	RA	Kynar solder sleeves without polyethylene	AR	0.44	0.08	GSFC
Fluorocarbon/I	FEP	HT	AR	AR	0.02	0.01	GSFC
Fluorocarbon/F	TFE 120A	DU	AR	AR	0.06	0.06	SRI
Fluorocarbon/F	FEP-500A	DU	AR	AR	0.05	0.05	SRI
Fluorocarbon/F	FEP 500C	DU	AR	AR	0.02	0.01	SRI
Fluorocarbon/S.T.	FEP clear	DU	AR	AR	0.03	0.01	JPL
Fluorocarbon/S.T.	FEP-yellow	DU	AR	AR	0.03	0.01	JPL
Fluorocarbon/S.T.	FEP-black	DU	AR	AR	0.03	0.01	JPL
Fluorocarbon/W/PN	Fluoroclad/W	SW	p. vinylidene fluoride in solvent	4h. R.T. + .5h. 93° C + .25h. 260° C	0.67	0.05	GSFC
Fluorocarbon/CF	Fluoroclad V78-VP21	SW	AR	Airdry + .5h 93° C +.25h. 260° C	0.05	0.01	GSFC

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Fluorocarbon/M	Gylon Gasket	GC	PTFE	AR	0.04	0.04	JPL
Fluorocarbon oil/LL	Krytox 143-AX	DU	fluoroalkyl polyether oil	AR	28.54	5.71	GSFC
Fluorocarbon/D	Kynar	PT	p. vinylidene fluoride	AR	0.19	0.08	JPL
Fluorocarbon/S.T.	Penntube II-SMT	PF	PTFE	1h. 150° C	0.01	0.01	SRI
Fluorocarbon/I	Permatube-1	MT	PTFE	AR	0.01	0.01	GSFC
Fluorocarbon/F	Ribbon Dope Thread Seal 8030-733-0055	PM	PTFE	AR	0.07	0.02	SRI
Fluorocarbon/F	Tedlar A130WH	DU	p. vinylfluoride	AR	0.47	0.01	SRI
Fluorocarbon/F	Tedlar 100BG 30 TL	DU	p. vinylfluoride	AR	0.09	0.09	SRI
Fluorocarbon/F	Tedlar 100 BG 30 TR	DU	p. vinylfluoride	AR	0.23	0.10	SRI
Fluorocarbon/F	Tedlar 150 BL 30cc black	DU	p. vinylfluoride	AR	0.14	0.01	GSFC
Fluorocarbon/Lc	Temp-Lace 256	GB	PTFE	AR	0.12	0.03	JPL
Fluorocarbon/Lc	Temp-Lace 256H	GB	PTFE	AR	0.64	0.10	JPL
Fluorocarbon/Lc	Temp-Lace H256H	GB	AR	AR	0.60	0.05	SRI
Fluorocarbon/S.T.	Thermofit-7-30-09	RA	PTFE	1h. 150° C	0.01	0.01	SRI
Fluorocarbon/S.T.	Thermofit-7-31-22	RA	p. vinylidene fluoride	1h. 150° C	0.27	0.09	SRI
Fluorocarbon/S.T.	Thermofit 7-32-16	RA	PTFE	1h. 150° C	0.01	[illegible]	SRI
Fluorocarbon/S.T.	Thermofit R	RA	PTFE	1h 150° C	0.01	[illegible]	SRI
Fluorocarbon/I	33181019	BR	PTFE	AR	0.01	0.01	GSFC
Fluorocarbon/Al/F	Tedlar 136-30WH/Al-5056 H 191	RP	.002" p. vinyl fluoride .0047" aluminum foil composite	5min. 120° C	0.15	0.05	GSFC
Fluorocarbon/acrylic/t	63	MM	AR	AR	0.33	0.03	GSFC
Fluorocarbon/acrylic/t	65	MM	AR	AR	0.29	0.08	GSFC
Fluorocarbon/Dac/TX	–	BX	Viton/Dacron	AR	0.86	0.09	GSFC
Fluorocarbon/Dac/TX	Fairprene 80-060	DU	AR	AR	0.34	0.01	SRI
Fluorocarbon/Dac/TX	Fairprene 80-070	DU	AR	AR	0.30	0.01	SRI
Fluorocarbon/Dac/TX	Fairprene 80-080	DU	AR	AR	0.30	0.01	SRI
Fluorocarbon elast.	ECD 487-90	DU	AR	AR	0.51	0.01	GSFC
Fluorocarbon/elast./CL	Fluorel 1062	MS	elastomer	AR	0.38	0.03	GSFC
Fluorocarbon elast.	JPL-10	DU	AR	AR	0.32	0.01	JPL

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Fluorocarbon elast.	L608-6	PS	Viton A	AR	0.55	0.03	JPL
Fluorocarbon elast.	PLV-101	PL	AR	AR	0.82	0.02	JPL
Fluorocarbon elast.	PLV-1006-A	PL	AR	AR	0.52	0.02	JPL
Fluorocarbon elast.	PLV 3016-B	PL	AR	AR	0.51	0.02	JPL
Fluorocarbon elast.	PLV 5010-B	PL	AR	AR	0.38	0.02	JPL
Fluorocarbon elast.	PLV 8704	PL	AR	AR	0.44	0.02	JPL
Fluorocarbon elast.	PLV-30001	PL	AR	AR	0.33	0.01	JPL
Fluorocarbon elast.	V377-9	PS	Viton A	AR	0.33	0.01	SRI
Fluorocarbon elast.	Viton B	SR	AR	AR	0.46	0.01	JPL
Fluorocarbon elast	Viton B	DU	AR	AR	0.86	0.04	GSFC
Fluorocarbon elast.	Viton C	IM	AR	AR	0.30	0.03	GSFC
Fluorocarbon elast.	77-545	PS	Viton A	AR	0.24	0.03	GSFC
Fluorocarbon elast.	4411A-776	DU	Viton A	AR	0.29	0.05	SRI
Fluorocarbon elast.	4411A-776	DU	Viton A	24h. 200° C	0.03	0.01	SRI
Fluorocarbon elast.	4411A-777	DU	Viton A	AR	0.27	0.03	SRI
Fluorocarbon elast.	4411A-777	DU	Viton A	24h. 200° C	0 01	0 01	SRI
Fluorocarbon elast.	4411A-778	DU	Viton A	AR	0.35	0.01	SRI
Fluorocarbon elast.	4411A-778	DU	Viton A	24h. 200° C	0.03	0.01	SRI
Fluorocarbon elast.	4411A-990	DU	Viton A	AR	0.54	0 03	SRI
Fluorocarbon/gl/M	CT-505	CP	PTFE	AR	0.01	0.01	JPL
Fluorocarbon/gl.	Emfab 20-60 PTFE	AF	AR	AR	0.01	0.01	GSFC
Fluorocarbon/mica/M	Fluorosint	PC	PTFE/mica	AR	0.09	0.03	JPL
Fluorocarbon/mica/M	Fluorosint LE207	PC	PTFE/mica	AR	0.20	0.04	JPL
Fluorocarbon/cer./fiber/M	RT Duroid 5600	RG	PTFE	AR	0.22	0.03	JPL
Fluorocarbon/cer./fiber/M	RT Duroid 5650	RG	PTFE	AR	0.28	0.01	JPL
Fluorocarbon/gl./M	RT Duroid 5813	RG	PTFE	AR	0.22	0.02	JPL
Fluorocarbon/gl./M	RT Duroid 5870	RG	PTFE	AR	0.12	0.02	JPL
Fluorocarbon/gl./TX	TL5-PTFE	MM	AR	AR	0.05	0.05	SRI
Fluorocarbon/nylon/TX	Armalon 98-101	DU	AR	AR	0.48	0.02	SRI
Fluorocarbon/olefin	V-44	RA	p. vinylidene fluoride irradiated, over p. alkene, irradiated	AR	0.34	0.07	GSFC
Fluorocarbon/silicone/?	CHR C-400	CL	PTFE carrier	AR	0.27	0.09	GSFC
Fluorosilicone elast.	L-449-6	PS	AR	AR	0.53	0.07	SRI

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Fluorosilicone/CF	94-003-dispersion	DC	AR	75d. R.T.	0.18	0.01	GSFC
Fluorosilicone elast.	1050-70	PR	AR	AR	0.50	0.03	SRI
Gold/p. imide/acrylic/t	Y-9184A	MM	vaporized gold on Kaptor	AR	1.42	0.01	GSFC
Hydrocarbon/LL*	Apiezon-C	BD	AR	AR	31.50	–	GSFC
Hydrocarbon/LL	Apiezon-L, Grease	BD	AR	AR	0.06	0.01	JPL
P. imide/M	Gemon 3010	GE	AR	AR	0.34	0.02	GSFC
P. imide/F	Kapton 200XH667	DU	AR	AR	0.14	0.09	SRI
P. imide/I	Kapton T-400, 1/20	BR	AR	AR	0.51	0.10	GSFC
P. imide/I	Pyre, ML	DU	AR	AR	0.07	0.02	JPL
P. imide/M	Vespel SP-1	DU	AR	AR	1.24	0.01	SRI
P. imide/I	XPI-MC-154	AY	AR	AR	1.14	0.01	GSFC
P. imide/acrylic/t	Y1205	MM	AR	AR	0.73	0.10	GSFC
P. imide/acrylic/t	1255	MM	double coat of acrylic adhesive on p. imide	.5h. 130° C	0.93	0.07	GSFC
P. imide/acrylic/t	7367	MY		AR	0.64	0.05	GSFC
P. imide/FEP/F	Kapton 200XHF 929A	DU	AR	AR	0.54	0.05	SRI
P. imide/FEP/I	T473-1/24	BR	AR	AR	0.52	0.01	GSFC
P. imide/gl./L	–	AM	AR	AR	0.77	0.01	GSFC
P. imide/gl./M	LNP XF1004	LN	80 r./20 gl.	AR	1.06	0.01	GSFC
P. imide/gl./L	Pyralin 12	DU	AR	AR	0.52	0.01	GSFC
P. imide/gl./TX	Pyre-M.L. Type 1	DU	AR	AR	0.50	0.01	SRI
P. imide/nylon/F	–	NM	thermal blanket composite	AR	0.61	0.03	GSFC
Lead/acrylic/t	Mystic 7431	MY	Lead foil	AR	1.33	0.06	JPL
P. methacrylate/M	Plexiglas II	DU	AR	AR	0.57	0.01	GSFC
P. methacrylate/M	Plexiglas VS-100	DU	AR	AR	1.00	0.01	GSFC
P. methacrylate-mod/M	Bavick II	BC	AR	AR	0 59	0.01	GSFC
P. methacrylate-mod/M	Lucerne 011-V	AY	AR	AR	0.51	0.05	GSFC
Molydisulphide/SF	Molykote microsize	DC	AR	AR	0.55	0.01	JPL

*Actual lubricant weight losses when heated at 121°C and 1×10^{-4} torr for 24 hours outside the VCM test facility. These lubricants may have been used under special conditions, where outgassing effects are minimized.

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Nylon-12/M	Plaskon 1980	PN	AR	AR	0.65	0.03	JPL
Nylon 6/6/gl./M	RF 1006	LN	70 r./30 gl.	AR	0.81	0.04	GSFC
Nylon 6/10/gl./M	QF-100b	LN	70r./30gl.	AR	0.65	0.04	GSFC
Nylon 11/gl./M	LNP-HF-1006	LN	70 r./30 gl.	AR	0.37	0.02	GSFC
Nylon 12/gl./M	LNP-SF 1006	LN	70 r./30 gl.	AR	0.65	0.02	GSFC
P. olefin/I	44/0611-9	RA	AR	AR	0.21	0.07	GSFC
P. olefin/S.T.	Thermofit-876	RY	AR	.25h. 125° C	0.43	0.10	GSFC
P. olefin/mod/I	Surlyn A	RM	AR	AR	0.28	0.03	GSFC
Phenolic/gl./L	Micarta H-5834	WC	AR	AR	0.70	0.03	SRI
Phenolic/gl./L	91 LD	SG	AR	AR	0.37	0.04	GSFC
Phenolic/MoS_2/SF	4306	EF	thin film	1.5h 190° C	0.05	0.01	SRI
P. phenylene-ox/M	Noryl	GE	AR	AR	0.10	0.01	GSFC
P. phenylene-ox/F	PPO-531-081 opaque	GE	AR	AR	0.09	0.02	SRI
P. phenylene-ox/F	PPO-681-111 clear	GE	AR	.5h. 180° C	0.07	0.05	SRI
P. phenylene-ox/gl./M	NF-1006	LN	70 r./30 gl.	AR	0.11	0.01	GSFC
P. phenylene-ox/gl./M	Noryl-ZF-1006	GE	70 r./30 gl.	AR	0.04	0.01	GSFC
P. propylene/M	Impalene	IE	AR	AR	0.30	0.05	GSFC
P. propylene/gl./M	MF 1006	LN	70 r./30 gl.	AR	0.13	0.04	GSFC
Silicate/W/PN	C-PS7-150 GSFC/17W	GS	K_2TiF_6 + K_2SiO_3 binder	18h. 122° C	0.84	0.01	GSFC
Silicate/BF/PN	MSA/5	GS	asbestos, Al_2SiO_3 talc, mica carbon black K_2SiO_3 binder	72h. R.T.	3.14	0.02	GSFC
Silicate/BF/PN	MSA/5	GS	asbestos, Al_2SiO_3 talc, mica carbon black K_2SiO_3 binder	48h. 100° C	2.24	0.04	GSFC

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Silicate/BF/PN	MSA/5 ALT.	GS	asbestos, $CaSiO_3$ talc, mica carbon black K_2SiO_3 binder	72h. R.T.	3.50	0.02	GSFC
Silicate/W/PN	MS-74	GS	TiO_2, ZnO, Al_2O_3 K_2SiO_3 binder	24h. R.T.	6.27	0.03	GSFC
Silicate/W/PN	MS-74	GS	TiO_2, ZnO, Al_2O_3 K_2SiO_3 binder	48h. 100° C	4.54	0.01	GSFC
Silicate/W/PN	Z-93	GA	ZnO/K_2SiO_3 binder	7d. R.T.	2.54	0.01	GSFC
Silicate/MoS_2/SF	2396	EF	thin film	2h. 80° C + 2h. 205° C	0.05	0.01	SRI
Silicone/TG	C6-1102	DC	AR	AR	0.05	0.02	GSFC
Silicone/A	C6-1104	DC	AR	7d. R.T.	0.19	0.01	GSFC
Silicone/W/PN	C-101 GSFC-16W	GS	300p. ZnO-SP500 lithium + potassium silicate 150p RTV-602 100mL toluene	2h. 150° C +	0.41	0.12	GSFC
Silicone/OG	DC-20-057	DC	AR	AR	0.31	0.07	JPL
Silicone/P	E691-22E	DC	Sylgard 184 stripped of low mol. wt. fraction by Dow Corning Corp.	AR	0.19	0.04	SRI
Silicone/TG	Eccotherm TC-4	EC	AR	AR	0.54	0.05	GSFC
Silicone/W/PN	FC-GSFC-14W	GS	–	3.5d. R.T.	0.17	0.09	GSFC

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Silicone/W/PN	FC-GSFC-14W	GS	–	7d. R.T. + 24h. 66° C	0.14	0.01	GSFC
Silicone/W/PN	FC-GSFC-15W	GS	–	4d. R.T.	0.21	0.08	GSFC
Silicone/TG	G-683	GE	AR	AR	0.62	0.07	SRI
Silicone/W/PN	IITRE-S-13G	GS	dimethyl silicone ZnO/K_2SiO_3	16h. 121° C $1x10^{-6}$ torr	0.42	0.10	GSFC
Silicone	Owens 650	GS	AR	18h. 100° C	0.51	0.02	GSFC
Silicone/W/PN	Owens 650 ZrO	GS	60p. 650/40p. ZrO	AR	0.77	0.01	GSFC
Silicone/W/PN	P-764-1A	GS	260p. treated ZnO 100p. devolat. 602 .25% SRC-05 based on 602 360p. toluene	7d. R.T.	0.30	0.01	GSFC
Silicone/P	RTV 11/T-12	GE	100p. 11/2p. T-12	24h. R.T. 24h. 130° C	0.33	0.10	JPL
Silicone/P/A	RTV 566 A/B	GE	100p. A/.1p. B	7d. R.T.	0.07	0.04	JPL
Silicone/P/A	RTV 566 A/B	GE	100p. A/.1p. B	24h. R.T.	0.14	0.02	GSFC
Silicone/P/A	RTV 566 A/B	GE	100p. A/.2p. B	24h. R.T.	0.25	0.03	GSFC
Silicone/P/A	SC-GSFC-19C	GS	12p. RTV 602-devol. .031p. SRC-05	G.E. prepolymer 602-heated 24h. 150° C 10^{-6} torr at GSFC to a viscosity of 2000 to 2200 centipoise and cooled prior to catalyzing 7d. R.T. cure	0.35	0.02	GSFC
Silicone/B/PN	Sicon Black 7x9055	DX	AR	24h. R.T. .5h. 177° C	0.98	0.04	GSFC
Silicone/P	77-002	DC	10p. 77-002/1p. cat.	7d. R.T.	0.31	0.02	JPL
Silicone/P	77-002	DC	10p. 77-002/1p. cat.	4h. 65° C	0.39	0.06	JPL
Silicone/A/P	93-500/cat.	DC	10p. 93-500/1p. cat.	24h. R.T.	0.29	0.01	GSFC
Silicone/A/P	93-500/cat.	DC	10p. 93-500/1p. cat.	7d. R.T.	0.22	0.02	JPL
Silicone/A/P	93-500/cat.	DC	10p. 93-500/1p. cat.	7d. R.T.	0.16	0.01	GSFC

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Silicone elast./I	B1WP/N F 5639-L-G22	BW	high voltage silicone cable	24h. 232° C	0.03	0.01	GSFC
Silicone elast.	Cohr-9255	CL	AR	24h. 204°C	0.18	0.06	JPL
Silicone elast.	HR. 2501	PS	AR	AR	0.30	0.08	GSFC
Silicone elast.	MS 20L08	MO	AR	2 min 163°C + 2h. 249° C	0.04	0.01	GSFC
Silicone elast.	MS 30CO2	MO	AR	2 min. 163°C + 2h. 249°C	0.07	0.05	GSFC
Silicone elast.	RR 423	RR	AR	24h. 232°C	0.11	0.02	GSFC
Silicone elast.	SE-556	GE	AR	24h. 250°C	0.10	0.01	SRI
Silicone elast.	SE-3604	GE	AR	24h. 250°C	0.03	0.03	SRI
Silicone elast.	SE-3604/Varox	GE	AR	24h. 204°C	0.09	0.04	JPL
Silicone elast.	SE-3613	GE	AR	24h. 249°C	0.09	0.06	SRI
Silicone elast.	SE-3713	GE	AR	24h. 249°C	0.20	0.09	SRI
Silicone elast.	SE-3813	GE	AR	24h. 249°C	0.27	0.04	SRI
Silicone elast.	SE-4401		AR	10 min. 110°C + 24h. 249°C	0.06	0.01	GSFC
Silicone elast.	SE-4404	GE	AR	10 min. 110°C + 24h. 249°C	0.10	0.01	GSFC
Silicone elast.	SE-4503	GE	AR	24h. 249°C	0.07	0.03	SRI
Silicone elast.	SE-4511	GE	AR	24h. 249°C	0.19	0.10	SRI
Silicone elast.	SE-5211	GE	AR	10 min. 110° C + 4h. 249°C	0.08	0.02	GSFC
Silicone elast.	SE-5403U	GE	AR	3h. 204°C	0.10	0.02	GSFC
Silicone elast.	Silastic 35	DC	AR	5 min. 116°C+ 24h., 249°C	0.14	0.06	GSFC
Silicone elast.	Silastic 75	DC	AR	10 min. 171°C + 3h. 204°C	0.31	0.10	GSFC
Silicone elast.	Silastic 675	DC	AR	5 min. 116°C + 24h., 250°C	0.41	0.05	GSFC
Silicone elast.	Silastic 916	DC	AR	5 min. 116°C + 24h. 249°C	0.40	0.01	GSFC
Silicone elast.	Silastic S-9711	DC	AR	AR	0.27	0.10	SRI
Silicone elast.	Silastic S-9711	DC	AR	24h. 125°C	0.19	0.05	SRI

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
Silicone elast	STW 0474	SU	AR	96h. 204°C	0.11	0.01	GSFC
Silicone elast/t	70	MM	AR	24h. 121° C $1x10^{-3}$ torr	0.40	0.07	GSFC
Silicone elast./Al	Lord-HD-222-22-2	LO	BTR, silicone sandwich between 0.020" aluminum	AR	0.28	0.02	GSFC
Silicone/G/LL	C6-1103 vac. grease	DC	AR	AR	0.17	0.01	GSFC
Silicone oil/LL*	F-50	GE	AR	AR	4.50	-	GSFC
Silicone oil/LL	F6-1100	DC	dimethyl siloxane	AR	0.07	0.04	GSFC
Silicone oil/LL	F6-1101	DC	fluorosilicone	AR	0.05	0.03	GSFC
Silicone oil/LL	F6-1105	DC	phenyl methyl siloxane	AR	0.07	0.06	GSFC
Silicone oil/LL	F6-1107	DC	chlorophenyl siloxane	AR	0.11	0.07	GSFC
Silicone oil/LL*	SF-96 (50 cp)	GE	AR	AR	8.00	–	GSFC
Silicone oil/LL*	SF-96 (500 cp.)	GE	AR	AR	4.00	–	GSFC
Silicone oil/LL	1147	GE	AR	AR	4.28	2.41	GSFC
Silicone/D	K-707 (K~12)	GE	AR	AR	0.41	0.01	SRI
Silicone/D	K-707 (K~15)	GE	AR	AR	0.70	0.08	SRI
Silicone/gl./L	Micarta 20201-2	WC	AR	AR	0.16	0.04	SRI
Silicone/gl./SL	1062-HAI	BH	AR	24h. 150° C	0.29	0.13	SRI
Silicone/metal/c	Cho Seal 1215	CH	AR	AR	0.39	0.08	GSFC
Silicone/silver powder/c	–	GE	100p. RTV 11/70p. silver/ 2p. T-12	24h. R.T. + 24h. 130° C	0.08	0.01	JPL
Silver/FEP/adhes./F	–	GS	vaporized silver on FEP with Garlock 201 adhesive	AR	0.34	0.13	GSFC
Stainless steel/HL/TX	Velcro 150-46 306-1754	VE	AISI 300 Series stainless-hook and loop fastener total system	AR	0.03	0.02	GSFC
P. styrene/x/D	Q200.5	PP	AR	AR	0.09	0.01	GSFC
P. styrene/x/D	Rexolite 1422	BR	no copper	AR	0.16	0.02	GSFC

*Actual lubricant weight losses when heated at 121°C and 1×10^{-4} torr for 24 hours outside the VCM test facility. These lubricants may have been used under special conditions, where outgassing effects are minimized.

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. styrene/x/D	Rexolite 1422	BR	AR	AR	0.18	0.01	JPL
P. styrene/M	—		AR	AR	0.26	0.01	JPL
P. styrene/TiO_2/M	Hi-K-707-L-9	EC	p. styrene, TiO_2	AR	0.08	0.01	GSFC
P. styrene/gl./M	CF-1006	LN	70 r./30 gl.	AR	0.10	0.01	GSFC
P. styrene/gl./CrO_2/M	Styrafil/G33/20/CrO_2	FF	75 r./20 gl./5 ox.	AR	0.53	0.01	GSFC
P. styrene-acrylonitrile/gl./M	Acrylafil G47/20	FF	80 r./20 gl.	AR	0.23	0.01	GSFC
P. styrene-acrylonitrile/gl./M	Acrylaglas S40/35	FF	65 r./35 gl.	AR	0.22	0.03	GSFC
P. styrene-acrylonitrile/gl./M	BF-1006	LN	70 r./30 gl.	AR	0.24	0.01	GSFC
P. sulphone/F	P-2300	UC	AR	.5h. 125° C	0.03	0.01	SRI
P. sulphone/F	P-7395-121-2	UC	AR	AR	0.09	0.02	SRI
P. sulphone/gl./M	GF-1006	LN	70 r./30 gl.	AR	0.24	0.01	GSFC
P. sulphone/gl./M	Sulfil G-1500/20	FF	80 r./20 gl.	AR	0.20	0.01	GSFC
Sulfone elast.	P-1700	DU	AR	.25h. 343° C	0.39	0.01	JPL
P. urethane/P	—	GS	150p. Adiprene L-100 16.5p. MOCA	3h. 100° C	1.06	0.06	GSFC
P. urethane/P	—	GS	100p. Sol. 113 73p. Sol C113-300	5h. 54° C	0.51	0.09	JPL
P. urethane/CF	—	GS	100p. Sol. 113 73p. Sol. C113-300	22h. 70° C	0.31	0.01	GSFC
P. urethane/P	—	GS	100p. Sol. 113 73p. Sol. C113-300 4 drops T-12	7d. R.T.	0.37	0.01	GSFC
P. urethane/P	—	GS	100p. Sol. 113 73p. Sol. C113-300 87p. Al powder MD 5100	7d. R.T.	0.69	0.09	GSFC
P. urethane/CF	FC-GSFC-20/w	GS	100p. Sol. 113 73p. Sol. C113-300 .25p. TiO_2 1 drop T-12	7d. R.T.	0.29	0.01	GSFC
P. urethane/P	—	GS	100p. Sol.C113 36.5p. Sol. C113-300 7.5p. Sol C113-328	7d. R.T.	0.31	0.02	GSFC

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. urethane/P	—	GS	100p. Sol. C113 36.5p. Sol. C113-300 7.5p. Sol. C113-328	20h. 70° C	0.30	0.02	GSFC
P. urethane/P	—	GS	100p. Sol. C113 51p. Sol. C113-300 4.5p. Sol. C113-328	18h. 70° C	0.34	0.01	GSFC
P. urethane/P	—	EM	100p. Sol. C113 51p. Sol C113-300 4.5p. Sol. C113-328 10p. Eccosphere-SI	16h. 57° C	0.53	0.01	GSFC
P. urethane/CF	—	SB	100p. Sol. 113 51p. Sol. C113-300 4.5p. Sol. C113-328 20.5p. B-35A gl. bubbles	16h. 38° C	0.21	0.01	GSFC
P. urethane/P	—	GS	100p. Sol. 113 73p. Sol. C113-300 6p. Cab. MS-5 4 drops T-12	7d. RT	0.42	0.01	GSFC
P. urethane/P	—	GS	100p. Sol. 113 73p. Sol. C113-300 6.9p. Cab. MS-5 .04p. Rhodamine base 4 drops T-12	7d. R.T.	0.31	0.01	GSFC
P. urethane/P	—	GS	100p. Sol. C113 73p. Sol. C113-300 7.8p. Cab. MS-5 .040p. Vyac	16h. 70° C	0.42	0.01	GSFC
P. urethane/P	—	GS	100p. Sol. C113 73p. Sol. C113-300 7.8p. Cab. MS-5 .086p. Vyac 4 drops T-12	7d. R.T.	0.37	0.01	GSFC

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. urethane/P	—	GS	100p. Sol. 113 73p. Sol. C113-300 10.4p. Cab. MS-5 4 drops T-12	7d. R.T.	0.40	0.01	GSFC
P. urethane/P	—	GS	100p. Sol. C113 73p. Sol. C113-300 10.4p. Cab. MS-5 .02p. Vyac 4 drops T-12	7d. R.T.	0.38	0.02	GSFC
P. urethane/BG/PN	—	GS	100p. Sol. 113 73p. Sol. C113-300 2.6p. Carb. 1 2 drops - T-12 10 mL-MEK	18h. 50° C	0.41	0.04	GSFC
P. urethane/BG/PN	—	GS	100p. Sol. 113 73p. Sol. 113-300 2.6p. Carb. 46 2 drops T-12 10ml-MEK	7d. R.T.	0.51	0.02	GSFC
P. urethane/BG/PN	—	GS	100p. Sol. 113 73p. Sol. C113-300 2.6p. Carb. 46 2 drops T-12	22h. 60° C	0.40	0.01	GSFC
P. urethane/CF	—	GS	100p. Sol. 113 150p. Sol. C113-300	7d. R.T.	0.37	0.09	GSFC
P. urethane/CF	—	GS	100p. Sol. 113 150p. Sol. C113-300	18h. 50° C	0.31	0.04	GSFC
P. urethane/BF/PN	—	GS	9ml. Chemglaze Z-306 2ml. toluene 1gm. 3M-840D microballoons thru 44 micron sieve, onto 37 micron sieve	15d. R.T.	0.83	0.04	GSFC

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. urethane/B/PN	Chemglaze Z-306	HC	AR	30d. R.T.	0.56	0.01	GSFC
P. urethane/P	Conath. [illegible]1510	RD	AR	33h. 149° C	1.09	0.10	GSFC
P. urethane/CL	CPR-23-2A/2B	UP	23.4p. 2A/9.9p. 2B	18h. R.T. + 5h. 93° C	1.04	0.01	GSFC
P. urethane/CL	Eccofoam SH	EC	7.25lbs/ft^3	AR	1.03	0.01	SRI
P. urethane/I	Gripeze 2	PH	AR	AR	0.16	0.02	JPL
P. urethane/P	Hysol 13-105/MOCA	HY	100p. 13-105/13p. MOCA	3h. 100° C + 30d. R.T.	1.09	0.08	GSFC
P. urethane/CF	JPL 1001	AB	AR	4h. 75° C	0.20	0.10	SRI
P. urethane/CF	JPL 1002	AB	AR	4h. 75° C	0.19	0.02	SRI
P. urethane/CL	Nopco G-302	NP	AR	AR	0.30	0.07	GSFC
P. urethane/CL	Nopco J-106	NP	AR	AR	1.12	0.01	GSFC
P. urethane/P	PC-22	HY	AR	8h. 66° C	0.72	0.01	GSFC
P. urethane/CL	PF-3	WC	AR	AR	0.95	0.05	GSFC
P. urethane/P	PR 1527 A/B	PD	26p.A/100p.B	5d. R.T. 72h. 52° C 1 x 10^{-6}	0.92	0.10	GSFC
P. urethane/P	PR-1538	PR	AR	20h. 70° C	0.97	0.02	GSFC
P. urethane/P	RB-8-133B	AO	AR	7d. R.T.	0.75	0.01	GSFC
P. urethane/CT	RCA-A-4875	RC	100p. 1155A 70p. 1155B 30p. cellosolve acetate	10min. R.T + .25h. 49° C for each of 2 coats + 3h. 60° C final	0.81	0.05	GSFC
P. urethane/I	Sodereze	PH	AR	AR	0.09	0.03	GSFC
P. urethane/P	Stycast CPC-41A/B	EC	100p. A/120p.B	48h. 65° C + 24h. 150° C	0.58	0.10	SRI
P. urethane/W/PN	TS-1603-16	HC	AR w/solvent	7d R.T.	0.61	0.02	GSFC
P. urethane/gl./M	TF-1008	LN	60 r./40 gl.	AR	0.37	0.08	GSFC
P. urethane/P	240-2	AB	AR	7d. R.T.	0.44	0.07	GSFC

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P. vinyl-chlor./gl./M	VF-1007	LN	65 r./35 gl.	AR	0.30	0.05	GSFC
P. p-xylylene/F	Parylene C	UC	2 mils thick	AR	0.07	0.02	JPL
P.-p-xylylene/F	Parylene N	UC	AR	AR	0.30	0.01	SRI
P. p-xylylene/F	Parylene C	UC	AR	AR	0.12	0.01	SRI

Table 15
Addendum

Material	Mfg. Code	Co	Composition	Comments and Previous Cure History	Percent Weight Loss	Percent Condensables	Data Source
P.ester/Tx	Style 15320	SS	AR, fabric	AR	0.13	0.02	GSFC
Epoxy/A	Hysol 11-C	HY	equal lengths A&B	AR	0.64	0.01	GSFC
Epoxy/P	Dynaloy 325A/B	DY	1p.A/1p.B	24h. R.T.	0.69	0.03	GSFC
Epoxy/P	C7/activator W	CI	50p.C7/50p.W	18h. R.T.	0.36	0.02	GSFC
Epoxy/P	Epibond 1210/9615A	FU	100p. 1210/65p. 9615A	3h. 65°C	0.66	0.02	GSFC
Epoxy/alumina,FN	Bond 517	AR	insulating paint	AR	0.88	0.04	GSFC
Epoxy/gl./CB	G11-FR-4	MI	AR	AR	0.32	0.02	GSFC
Epoxy/gl./CB	FLG-65M,28-11	MM	fire retardant type-AR	AR	0.20	0.01	GSFC
Epoxy/graph./L	HMS/4617	CO	low therm. expansion, high modulus, no coating	AR	0.63	0.03	GSFC
Epoxy/graph./L	HMS/4617	CO	As above with aluminized coating microwave absorber	AR	0.55	0.02	GSFC
Epoxy/iron/P	Eccosorb MF-110	EC		AR	0.51	0.01	GSFC
Epoxy/silver/A	Eccobond 2015A/B	AD	10p.A/1p.B	2h. 66°C	0.44	0.02	GSFC
Fluorocarbon/F	XR	DU	AR	AR	0.04	0.03	GSFC
Fluorocarbon/acrylic/t	Y-9224	MM	teflon	AR	0.19	0.03	GSFC
Fluorocarbon/silicone/t	61	MM	teflon/silicone	3h.260°C	0.15	0.08	GSFC
Fluorocarbon/gl./CB	CPT G/1-62	CU	AR without copper	AR	0.03	0.02	GSFC
P.imide/CL	Skybond RI-7271-06	MC	rigid foam 6lb/ft3	AR	0.32	0.05	GSFC
P.imide/CL	Skybond-RI-7271-12	MC	rigid foam 12lbs/ft3	AR	0.42	0.02	GSFC
P.imide/graph./M	Vespel SP-22-D-1	DU	60p. imide/40p. graph.	AR	0.58	0.01	GSFC
Silicone/W/PN	S13G-C120	IT	GSFC P764 devol. GE 602 and II TRI pigment system	R.T.	0.36	0.11	GSFC

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LETTER CODE

A	adhesive	SL	sleeving
AR	as received	ST	shrink tubing
B	black	SF	solid film
BF	black flat	T	tube
BDMA	benzyl dimethyl amine	t	tape
BF_3	borontrifluoride	TG	thermal grease
buta	butadiene	TX	textile
c	conductive	w	white
Carb.	carbolac	x	cross linked
Cab.	Cabosil		
CB	circuit board		
cer	ceramic powder		
CF	conformal coat		
CL	cellular		
CT	coating		
D	dielectric		
Dac	dacron		
DAP	Diallyl phthalate polymer		
DP	damping		
fil	filament		
F	film type		
gl	glass fiber		
graph.	graphite		
G	grease		
HL	hook, loop		
I	insulation		
L	laminate		
Lc	lacing		
l	liquid		
LL	liquid lubricant		
M	molding compound or structural hardware		
min	mineral filled		
MEK	methyl ethyl ketone		
MoS_2	molybdenum, disulphide		
NMA	nadic methyl anhydride		
OG	optical grease		
p.	parts by weight		
pre	prepreg		
PN	paint		
P	potting		
r	resin		
s	sheet		

SOURCES

AB	Ablestik Adhesive Co.
AC	Allied Chemical Corp.
AD	Adhesive Engineering Co.
AF	Amflex Products Co.
AL	Alpha Electronic Wire Co.
AM	Amoco
AN	Atlantic Laminate Co.
AO	Allaco
AP	Armstrong Products Co.
AR	Aremco
AT	Abletech Co.
AY	American Cyanamid Corp.
BA	BASF Colors & Chemicals Inc.
BC	Baker Chemical Co.
BD	Biddle Co.
BE	Belden Co.
BF	B. F. Goodrich Chemical Co.
BH	Bently Harris Co.
BI	Boston Insulated Wire Co.
BN	Bacon Industries
BO	Borden Chemical Co.
BR	Brand Rex Div. American Enka Co.
BW	Boston Wire & Cable Co.
BX	Bendix Corp.
CH	Chomerics Inc.
CI	Ciba Corp.
CL	Connecticut Hard Rubber Co.
CO	Convair
CP	Coast Pro Seal Co.
CU	Custom Materials Inc.
DC	Dow Corning Corp.
DU	E. I. Dupont de Nemours Inc.
DX	Dexter Corp. - Midland Div.
DY	Dynaloy Inc.
EC	Emerson & Cuming Inc.
EF	Electrofilm Inc.
EL	Electrophy Co.
EM	EMR Co.
EN	Enjay Chemical Co.
EP	Elco Pacific Co.
ET	Epoxy Technology Inc.

FB	Fiberite Co.
FC	Fluorocarbon Co.
FF	Fiberfill Corp.
FH	Fairchild Hiller
FI	Franklin Institute
FL	Fortin Laminating Co.
FM	Food Machinery Corp.
FP	Finch Paint & Chemical Co.
FU	Furare Plastics Inc.
FW	Fenwall Co.
GA	Grumman Aircraft Co.
GB	Gudebrod Brothers Silk Co.
GC	Guylon Gasket Co.
GE	General Electric Co.
GK	Garlock Inc.
GR	Green Rubber Co.
GS	Goddard Space Flight Center
GY	Goodyear Corp.
HA	Hughes Aircraft Corp.
HC	Hughson Chemical Co.
HT	Hi-Temp. Wire Co.
HW	Hope Webbing Co.
HX	Hexcel Aerospace
HY	Hysol Corp.
IE	Imperial Eastman Ltd.
IM	Irving B. Moore Co.
IT	IITRI
LH	Lockheed Corp.
LN	Liquid Nitrogen Process Corp.
LO	Lord Mfg. Co.
MC	Monsanto Chemical Co.
MD	Microdot Corp.
MG	Marglas
MI	Mica Corp.
MM	Minn. Mining & Mfg. Co.
MO	Moxness Co.
MP	Micaply Co.
MR	Marblette Corp.
MS	Mosites Co.
MT	Mass. Inst. Tech.
MY	Mystic Tape Co.
NM	National Metallizing Co.
NP	Nopco Chemical Co.

NR	Whittaker Corp. Narmco Div.
NS	National Starch and Chemical Corp.
OC	Olin Corp.
PA	Pacific Resin & Chemical Co.
PC	Polymer Corp.
PD	Products Research Inc.
PF	Pennsylvania Fluorocarbon Co.
PH	Phelps Dodge Corp.
PL	Pelmor Labs.
PM	Permacell Corp.
PN	Plaskon Corp.
PP	Polypenco Corp.
PR	Products Research & Chemical Corp.
PS	Parker Seal Co.
RA	Rayclad Tubes Inc.
RB	Rubber Corp. of America
RC	Ram Chemicals Co.
RD	Resdell Co.
RG	Rogers Corp.
RH	Rhom & Haas Co.
RM	Rome Cable Corp.
RO	Radio Corp. of America
RP	Riegle Paper
RR	Ranthor Reiss Corp.
RY	Raychem Corp.
SB	Santa Barbara Research Center
SC	Schenectady Chemical Co.
SD	Schjeldahl Co.
SG	Space General Corp.
SH	Shell Chemical Co.
SP	Stone Paper Tube Co.
SR	Schultz Rubber Products
SS	Stem & Stern Textiles
ST	Sargent Industries, Stillman Rubber
SU	Super-Temp. Div. of Haveg Industries
SW	Sherwin Williams Paint Co.
TB	T & B Ty-Rap Co.
TH	Thiokol Chemical Co.
UC	Union Carbide Corp.
UN	Uniroyal Chemical Co.
UP	Upjohn Co.
VA	Varian Associates
VE	Velcro Co.
WC	Westinghouse Electric Corp.