SOLITHANE® 113 A VERSATILE LIQUID URETHANE PREPOLYMER

DESCRIPTION

SOLITHANE 113 resin is an extremely versatile liquid urethane prepolymer which can be cured with a variety of polyol and/or amine curing agents. Processing temperatures can range from 80°F to 300°f (27°C to 149°C) permitting low temperature, non-exothermic cure systems for temperature-sensitive parts. Depending upon the selection and amount of curative employed, the cured compounds can display hardness ranging from 15 shore a to 80 shore D.

APPLICATIONS

The processing versatility of SOLITHANE 113 resin permits it to be cast into intricate, void-free shapes for a variety of applications. Although cure temperatures as high as 300°F (149°C) are generally recommended for rapid mold turnover, longer cure cycles at lower temperatures can be utilized for potting temperature sensitive parts or sophisticated electric hardware. The outstanding electrical properties inherent in every product derived from SOLITHANE 113 resin designate it as an ideal prepolymer for electric potting, encapsulation and conformal coating applications. Protective coatings formulated from SOLITHANE 113 resin can be applied by spraying, dipping or brushing techniques to metallic and non-metallic surfaces.

In addition, SOLITHANE 113 resin can be used for photo-elastic stress analysis. Cured compounds, when placed under stress, rotate the plane of polarized light along the principal stress axis. By bonding films of SOLITHANE 113 resin to complex objects, or by molding prototype parts from this urethane rubber, the strain areas can be observed visually (using polarized light as an analyzer) when the object is placed under stress. Several publication described characterization of SOLITHANE 113 resin compounds for photo-elastic stress analysis.

1. "The Mechanical and Optical Characteristics of SOLITHANE 113 Resin and Investigation of Optical Lag in Photoviscoelastic Analysis", California Institute of Technology, Technical Report No. WLTR-64-15;
2. "Make Strain Visible", Product Engineering, November 8, 1965, pp. 98-101;
3. "New Method to Determine Restrained-Shrinkage Stresses in Propellant-Grain Models", A.J. Durelli and V.J. Parks, Prof. And Asst. Prof., respectively, Catholic University of America, Washington, DC;
4. "Some Low-modulus Birefringent Resins", A. San Miguel and E.N. Duran, Senior Research Engineer and Assistant Engineer, respectively, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California.

PREPOLYMER PROPERTIES	
Appearance	Pale Yellow Liquid
Isocyanate (NCO)%	10.6 + 0.2
Average Viscosity, poise **@80°F (27°C)** **@140°F (60°C)** **@212°F (100°C)**	 200 –300 10 – 20 2 – 3
Average Specific Gravity	1.073
Flash Point (ASTM D97-66)	430°F (221°C)
Storage Stability	3 months after shipping date

PHYSICAL PROPERTIES

The physical properties of cured SOLITHANE 113 resin compounds are controlled by the type and amount of curative or combination of curing agents used. Two typical curing agents are C113-300 supplied by Chemtura Chemical and TIPA (triisopropanolamine)*. By varying the quantity of C113-300, materials within a hardness range of 15 Shore A to 60 Shore A can be formed. Blending C113-300 curing agent with TIPA in varying proportions, makes it possible to produce cured compounds within the 40 Shore A to 75 Shore D hardness range. (Refer to Table IV for properties obtained with SOLITHANE compounds cured with C113-300 curing agent and/or TIPA).

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All cured compounds of SOLITHANE 113 resin exhibit excellent electrical properties throughout the broad range of hardness values. (Typical electrical properties of cured compounds listed in Table IV are shown in Table V).

The chemical resistance of two compounds taken from Table I, which represent opposite extremes in the range of hardness, indicates an excellent resistance to water, oils, dilute acids and bases. (Refer to Table VI).

Cured SOLITHANE 113 Resin compounds also show exceptional hydrolytic stability (as indicated in Table VII).

For special applications such as potting, coating and encapsulation of electronic circuits in rocket guidance systems, SOLITHANE 113 resin compounds provide superior resistance to ultra-high vacuum environments. (Table VII shows typical out-gassing data for cured SOLITHANE resin compounds.

* McKesson Chemical Company-Division of G. Mann & Co.

PROCESSING

Processing Temperatures

Although SOLITHANE 113 resin is pourable at 80°F (27°C), heating the prepolymer will make it easier to handle. (The effect of temperature on the viscosity of SOLITHANE 113 is shown in Figure II).

Curing agent C113-300, a clear liquid polyol, will cure SOLITHANE 113 resin at room temperature 80°F (27°C) without any noticeable exotherm. This system is most practical when potting temperature-sensitive parts. Curing agent TIPA, a low melting solid, will cure SOLITHANE 113 resin either alone or in varying proportions with C113-300 curing agent. Melting TIPA (m.p. 137°F [58°C]) prior to its addition to SOLITHANE 113 resin alleviates “lumping” in the cure. When blends of TIPA and C113-300 curing agent are heated together in the proportions recommended in Table IV, a very stable, clear homogeneous mixture is obtained. Separation of these mixtures will not occur, even when stored at low temperatures.

SOLITHANE 113 resin can be cured at temperatures as high as 300°F (149°C), when rapid mold turnover is desired. (The effect of different cure temperatures on two formulations from Table IV is shown in Table I).

MIXING AND DEGASSING

SOLITHANE 113 resin can be processed by the "hand batch" technique or with automatic mixing and metering machines. The prepolymer can be adequately mixed at 80°F (27°C) with C113-300 curing agent and/or TIPA. As the amount of C113-300 curing agent is increased, the initial mix viscosity is decreased (as shown in Figure III). Effective degassing of these compositions is dependent upon the percentage of C113-300 curing agent used, the total amount of material being degassed, and the efficiency of the vacuum system.

When processing at higher temperatures, degassing of the mix is faster and easier, and can be further improved by taking the following steps:

1. Preheat SOLITHANE 113 urethane prepolymer to processing temperature.
2. Degas the prepolymer at a vacuum less than 10mm Hg.
3. Return prepolymer to processing temperature.
4. Heat the curing agent and maintain in the molten state.
5. Combine prepolymer and curing agent, blend thoroughly.
6. Degas the blended material and release vacuum slowly when bubble formation is minimal.
7. Pour the blend into a properly released mold that has been preheated to curing temperature.
8. Cure the cast in a circulating hot air oven.

ADDITIVES

Plasticizers

The low temperature properties of SOLITHANE 113 resin compounds are improved by the addition of plasticizers. A variety of plasticizers, (listed in Table II), can be used effectively up to 20 parts per 100 of prepolymer. Heat aging plasticized compounds 70 hours at 212°F (100°C) produces insignificant changes in physical properties.

Rohm & Haas TP-90B plasticizer effectively extends low temperature properties, and additionally incorporates fungus resistance into cured SOLITHANE 113 resin compounds.

Accelerators

The effect of a typical organo-metallic compound on formulation No. 1 from Table IV is shown below:

Formrez Sul-4*	Pot Life, 80°F (27°C)
None	180 minutes
0.120	90 – 120 minutes
0.135	50 minutes
0.500	15 minutes

* WITCO

Colorants

SOLITHANE 113 resin compounds can be formulated with pigment dispersions designed for polyester resins. The translucence, opacity and intensity of color are based on the amount of color paste used. The effect of color paste concentration on the physical properties of formulation No. 1 from Table IV is shown in Table IX.

CURING

Cure Systems

As indicated in Table I, the physical properties of the cured compound depend upon the type and amount of curing agent used, either alone or in combination with other curatives. An increase in the amount of C113-300 curing agent:

- Lowers initial mix viscosity of system
- Increases pot life
- Lowers durometer hardness
- Lowers stress-strain properties
- Increases low-temperature properties

An increase in the amount of TIPA:

- Decreases pot life, cure time
- Increases durometer hardness
- Increases stress-strain properties*

*When used in blends with C113-300 curing agent.

Alternate cure systems by polyfunctional curing agents containing active hydrogens are also possible, (but not discussed in this bulletin). However, the use of the above cure system minimizes the number of curatives necessary to formulate different applications.

The rate of cure for three formulations from Table IV, expressed as the change in viscosity at 15 minute intervals at 140°F (80°C) is illustrated in Figure IV.

POST CURE

Optimum properties are generally reached after 7 days at 80°F (27°C) (R.T.). SOLITHANE 113 resin compounds are relatively unaffected by additional heating at temperatures up to 250°F (121°C). However, signs of instability become evident in some formulations after three weeks exposure to 300°F (149°C). The effect on the physical properties of cured SOLITHANE 113 compounds exposed to various temperatures is shown in Table III.

BONDING

SOLITHANE 113 resin compounds adhere to most substrates without the use of a primer. Some substrates can be simply treated with a solvent wipe or light abrading with sandpaper. However, bonding surfaces should be clean and free of oily films.

If a primer is used, the manufacturer's recommendations should be followed. Some bonding agents used effectively with SOLITHANE 113 resin compounds are *Chemlok 218. **Thixon XAB-1153, and Conap's 1146C.

*Lord Chemical Company
**Rohm & Haas

RELEASING AGENTS

Mold used for casting SOLITHANE 113 resin compounds should be clean and lubricated properly for easy removal of the finished product. A variety of release agents are commercially available and the manufacturer's recommendations should be followed. Some release agents used effectively with SOLITHANE resins are Exxit II, Korach 1711 (both aerosols) from Dexter and DC-7 or DC-20 mold release (wipe-on or brush-off release agents from Dow Corning Corporation.

STORAGE AND HANDLING

SOLITHANE 113 resin can be handled conveniently at 140°F (60°C). This temperature is sufficient to reduce viscosity for easy pouring without fear of thermal molecular degradation or undue chain extension of the prepolymers.

SOLITHANE 113 resin is available in 1 gallon or 5 gallon containers. Generally, compounders will "break down" these quantities into smaller units to minimize undue exposure of the entire batch to heat or atmospheric humidity. Flushing the container with nitrogen, prior to resealing, will inhibit "skinning" of the prepolymer.

To eliminate unnecessary thickening of the resin at elevated temperatures, refer to Figure I.

SAFETY (Toxicity)

Toluene diisocyanate (TDI) and, to a lesser degree, urethane prepolymers are irritating substances in liquid or vapor forms. They produce irritation if contact is made with skin or eyes and they may cause burns if not immediately removed.

Inhalation of the vapors may be injurious to the lungs, and the vapor may make breathing difficult. In some cases, the vapor can cause respiratory distress, even at extremely low concentrations. Therefore care in handling and good housekeeping practices are recommended.

SAFETY PRECAUTIONS

Ventilation

Good ventilation is essential in rooms or areas where diisocyanate containing materials are handled. Hood type ventilation units are installed over processing equipment or (where this is not possible) effective mechanical ventilation of the entire area should be provided.

Air Analyzers

Calibrated equipment for detecting diisocyanate containing vapors is commercially available.

SAFETY EQUIPMENT

Personal Protection

Properly designed emergency showers and eye baths should always be available in convenient locations employees should always be available inconvenient locations should be advised of their location and instructed in their use.

TDI urethane prepolymers are not serious industrial hazards if workers are adequately informed and supervised in the proper means of handling these materials.

Personal Hygiene

Clean work clothing and clean working areas help prevent contamination.

Eye Protection

Safety glasses or chemical safety goggles should be worn.

Respiratory Protection

A suitable air mask, gas mask, or some breathing apparatus should be worn by employees exposed to high levels of vapor concentration.

Body, Hand Protection

Appropriate clothing (e.g. long sleeved shirts) and rubber gloves should be worn where there is danger of skin contamination. Protective hand creams are also available. Contaminated clothing should be removed and laundered before re-use.

Skin Contact

The polymer should be removed from the skin by wiping (clean cloth or disposable paper towels), followed by washing with soap and water, or with rubbing alcohol. SOLITHANE 113 resin is not a primary irritant, but a physician should be consulted if a rash or irritation develops.

Eye Contact

Wash eyes immediately with large amounts of water for at least 15 minutes. **TREATMENT BY A PHYSICIAN SHOULD FOLLOW IMMEDIATLEY!**

Inhalation of Vapor

A person showing symptoms of isocyanate fume irritation, (such as respiratory distress, sever coughing) should be removed promptly from the contaminated are and administered oxygen by a trained person. Artificial respiration should be applied immediately if breathing stops. **A PHYSICIAN SHOULD BE CALLED IMMEDIATELY!**

Additional Information

For more detailed information about safe handling and use of TDI and isocyanate containing materials, refer to the "Chemical Safety Data Sheet SD-73" from the Manufacturing Chemists Association, Inc.

TEST METHODS All test methods are ASTM methods, unless otherwise specified.	
Hardness, Shore A/D	D-2240-75
Stress-Strain	D-412-68
(Tensile testing of Vulcanized rubber) **Stress Strain** **Impact Resistance**	 D-636-72 MIL-C-16923G (Oct. 1972)
Volume & Surface Resistivity	D-257-75a
Dielectric Constant & Dissipation Factor	D-150-74
Dielectric Strength	D-149-75

TABLE I **TYPICAL ALTERNATE CURE CYCLES**		
Formulation	1	17
SOLTIHANE 113 resin, pbw	100	100
C113-300	73	—
TIPA	—	15
Cured at 75°F (23°C)		
Set Time	min.	20 min.
Tack-Free Time	150 min.	40 min.
Cure Time	180 min.	15 hrs.
Shore Hardness	40A	60D

Cured at 200°F (93°C)		
Set Time	50 min.	12 min.
Tack-Free Time	min.	20 min.
Cure Time	120 min.	120 min.
Shore Hardness	40A	60D
Cured at 250°F (121°C)		
Set Time	12 min.	7 min.
Tack-Free Time	15 min.	10 min.
Cure Time	90 min.	60 min.
Shore Hardness	53A	66D

* 12 – 16 hours
(1) Time required to demold
(2) After Cure Time

TABLE II

Plasticizers for SOLITHANE 113 Resins

Control Formula compound No. 1
(see Table I)

Original Physical Properties						
Plasticizer	**Parts**	**Tensile psi, (kg/cm²)**	**Elongation %**	**Shore A Hardness**	**Die C Tear Pli(kg/cm) °F°C**	**L.T. Torsional (G10,000) Modulus**
Control	none	400 (28)	100	60	15 (2.7)	+3 (-16)
TP-90B Plasticizer	5 10 20	330(23) 290 (20) 235 (17)	95 80 60	60 58 56	19 (3.4) 19 (3.4) 17 (3.0)	-6 (-21) -15 (-26) -33 (-36)
Di-Octyl Sebacate	5 10 20	450 (32) 325 (23) 225 (16)	130 95 60	58 56 54	25 (4.5) 22 (3.9) 16 (2.8)	0 (-18) -20 (-29) -30 (-34)
Tri-Octyl Phosphate	5 10 20	340 (24) 260 (13) 195 (14)	95 80 55	57 55 52	24 (4.3) 19 (3.4) 16 (2.8)	.2 (-19) -12 (-24) ——

TABLE III

Heat Resistance of SOLITHANE 113 Resin Compounds

Physical Properties

(After 28 days at temperature indicated)

Original Physical Properties								
Temperature	**100% Modulus psi (kg/cm²)**		**Elongation, %**		**Shore Hardness**		**Tensile psi (kg/cm²)**	
Formulation No.	1	17	1	17	1	17	1	17
80°F (27°C)	—	—	80	5	66A	79D	375 (26)	3060 (215)
158°F (70°C)	430 (30)	—	105	5	68A	77D	470(33)	3450 (242)
212°F (100°C)	450 (31)	—	105	5	67A	75D	460 (32)	3760 (264)
250°F (121°C)	460 (32)	—	105	20	65A	72D	525 (37)	4010 (282)
300°F (149°C)	525 (37)	—	160	100	65A	25D	675 (47)	2165 (152)

TABLE IV (1-9)

Compounds of SOLITHANE 113 resin with C113-300 Curing Agent & TIPA

Original Physical Properties									
Formulation, pbw	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Solithane 113 Resin	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
C113-300	73.0	80.0	90.0	100.0	110.0	120.0	150.0	65.5	58.0
TIPA	—	—	—	—	—	—	—	—1.5	—3.0
Working Properties @ 80°F (27°C)									
Pot Life, hours	3	6	6	6.5	6.5	6.5	8	3.5	3.6
Set Time, hours	overnight	overnight	overnight	overnight	overnight	48	overnight	overnight	8
Tack Free time, days	4	3	3	4	4	4	4	4	3
Properties after 1 hour at 300°F (149°C) Shore Hardness After:									
1 day @ 80°F (27°C)	55A	53A	52A	49A	44A	35A	16A	40A	55A
3 days @ 80°F (27°C)	57A	54A	51A	48A	43A	35A	—	55A	58A
5 days @ 80°F (27°C)	58A	—	—	—	43A	35A	—	55A	58A
7 days @ 80°F (27°C)	60A	54A	51A	47A	43A	36A	15A	62A	64A

Properties after 1 hour at 300°F (149°C) and 7 days at 80°F (27°C) Stress Stain Properties:									
Tensile Srength, psi(kg/cm2)	400 (28)	340 (24)	280 (2)	245 (17)	140 (10)	160 (11)	70 (5)	460 (32)	(32)
Elongation	100	95	85	95	75	110	145	115	125
100% Modulus, psi(kg/cms2)	58A	—	—	—	43A	35A	—	55A	58A
7 days @ 80°F (27°C)	350 (25)	—	—	—	—	155 (11)	50 (4)	395 (28)	425 (32)

TABLE IV (1-9 cont'd)

Compounds of SOLITHANE 113 resin with C113-300 Curing Agent & TIPA

Properties after 1 hour at 300°F (149°C) and 7 days at 80°F (27°C) Stress Stain Properties:									
Formulation, pbw	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Properties after 1 hour at 300°F (149°C) and 7 days at 80°F (27°C) Tear Properties:									
Tear Strength, DieC pli (kg/cm)	10 (1.8)	18 (32)	15 (2.7)	15 (2.7)	10 (1.8)	0	0	20 (3.6)	20
Bashore Resilience Rebound %	4	7	6	10	10	15	10	3	6
Taber Abrasion: Abrasion Index	70	65	45	45	40	70	150	85	105

TABLE IV (10-17)
Compounds of SOLITHANE 113 resin with C113-300 Curing Agent & TIPA

Formulation, pbw	10	11	12	13	14	15	16	17
Solithane 113 Resin	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
C113-300	51.0	44.0	36.5	29.0	21.5	14.7	7.3	15.0
TIPA	4.5	6.0	7.5	9.0	10.5	11.8	13.2	15.0
Working Properties@ 80°F (27°C)								
Pot Life, hours	1.8	1.7	1	0.5	0.5	0.4	0.5	0.3
Set Time, hours	7	4.5	6	6.5	3.2	1	1.8	1
Tack Free time, days	2	3	3	3	2	2	overnight	overnight
Properties after 1 hour at 300°F (149°C)								
1 day @ 80°F (27°C)	55A	68A	70A	72A	40D	49D	65D	75D
3 days @ 80°F (27°C)	60A	68A	72A	78A	52D	41D	68D	75D
5 days @ 80°F (27°C)	61A	70A	78A	85A	56D	47D	69D	80D
7 days @ 80°F (27°C)	66A	70A	80A	87A	58D	60D	70D	80D
Properties after 1 hr at 300°F (149°C) and 7 days @ 80°F (27°C) Stress Strain Properties:								
Tensile, psi (kg/cm²)	770 (54)	1310 (92)	2100(148)	2750(193)	2890(203)	3200(225)	3480(295)	2530(178)
Elongation %	130	150	120	120	95	60	50	20
100% Modulus, psi(kg/cm²)	475(33)	670(147)	1140(80)	2335(164)	—	—	—	—

TABLE IV (10-17cont'd)

Compounds of SOLITHANE 113 resin with C113-300 Curing Agent & TIPA

Formulation, pbw	10	11	12	13	14	15	16	17
Properties after 1 hr at 300°F (149°C) and 7 days @ 80°F (27°C)								
Tensile, psi (kg/cm²)	770 (54)	1310 (92)	2100(148)	2750(193)	2890(203)	3200(225)	3480(295)	2530(178)
Elongation %	130	150	120	120	95	60	50	20
100% Modulus, psi(kg/cm²)	475(33)	670(147)	1140(80)	2335(164)	—	—	—	—
Tear Properties:								
Tear Strength, DieC pli(kg/cm)	45 (8.0)	65(11.6)	110(19.6)	175(31.3)	310(55.4)	450(80.4)	445(79.5)	425(79.5)
Bashore Resilience Rebound %	25	20	25	35	40	40	40	30
Falling Ball impact: Impact Strength, ft-lbs. (kg/cm)	>107.4 >14.9	>107.4 >14.9	>107.4 >14.9	>107.4 >14.9	107.4 >14.9	107.4 >14.9	82.1 12.1	95 13.1
Taber Abrasion:								
Abrasion Index	120	130	120	175	165	165	195	150

TABLE V
ELECTRICAL PROPERTIES OF SOLITHANE 113 RESIN COMPOUNDS

Samples cured 2 hrs. at 300°F (149°C) + 7 Days at 75°F (23°C)

Formulation No. (Refers to Table IV)	1	6	12	15
Hardness Shore A or D	60A	35A	80A	60D
Vol. Resistivity, ohm-cm 80°F (27°C) 185°F (85°C)	2.5×101^{4} 7.2×10^{12}	7.0×10^{12} 5.0×10^{10}	2.7×10^{14} 2.7×10^{12}	3.6×10^{14} 2.4×10^{13}
Surface Resistivity ohm 80°F (27°C) 185°F (85°C)	1.5×10^{15} 1.5×101^{5}	1.5×10^{15} 1.5×10^{15}	1.5×10^{15} 1.5×10^{15}	1.5×10^{15} 1.5×10^{15}
Dielectric Constant, 1kc 80°F (27°C) 185°F (85°C)	4.2 4.8	5.0 4.8	3.6 5.1	2.8 4.5
Dissipation Factor, 1kc 80°F (27°C) 185°F (85°C)	0.162 0.006	0.091 0.079	0.056 0.028	0.014 0.120
Dielectric Constant, @ 80°F (27°C)				
50kc	3.6	3.8	3.5	2.8
100kc	3.5	3.8	3.5	2.8
500kc	3.4	3.4	3.5	2.8
2mc	3.2	3.3	3.4	2.8
10mc	3.0	3.2	3.4	2.8
Dialectric Strength, Volts/mil, 80°F (27°C) 75 Mill Sheet				
Short Time	378	512	440	340
Step/Step	324	473	347	334

TABLE V
Resistance of SOLITHANE 113 Resin Compounds
To Common Chemicals and Solvents

FORMULATION NO.	1		17	
(Refer to Table I) Fluid Tested:	% Vol.	% Wt.	% Vol.	% Wt.
Acetone 1 Day 30 Days	Specimens Cracked			
Toluene 1 Day 30 Days	Specimens Cracked			
Ethyl Acetate 1 Day 30 Days	Specimens Cracked			
Ethyl Acetate 1 Day 30 Days	6.6 6.3	18.3 16.0	1.0 6.7	10.8 18.2
Water 1 Day 30 Days	0 0	0.23 0.18	0 -0.7	0.25 0.33
Sodium Hydroxide, 10% 1 Day 30 Days	0 —	0.24 0.04	0 —	0.30 0.16
Hydrochloric Acid, 10% 1 Day 30 Days	0 30	0.30 0.16	-0.7 0	0.23 0.27
Sulfuric Acid, 10% 1 Day 30 Days	0 0	0.31 0.15	0 -0.7	0.31 0.28
SR-6 Ref. Fuel 1 Day 30 Days	23.6 —	66.9 —	9.3 13.7	26.0 38.6
ASTM Fuel No. 1 1 Day 30 Days	5.6 6.7	11.0 14.9	0 0	0.50 3.2

*At room temperature by immersion

TABLE VII
Effect of Boiling Water on Physical Properties
Of SOLITHANE 113 Resin Compound

FORMULATION NO. (Refer to Table I)	1		17	
Conditions:	7 days/75°F (23°C) Control	7 days/H2O 212°F(100°C)	7 days/75°F (23°C) Control	7 days/ H2O @212°F(100°C)
Physical Properties				
Modulus, psi @100% (kg/cm2)	270 (19)	270 (19)	610 (45)	530 (37)
Tensile, psi (kg/cm2)	320 (22)	420 (30)	1840 (129)	1700 (120)
Elongation, %	120	130	170	175
Shore A	55	55	80	78

TABLE VIII
Typical Outgassing Data

FORMULATION NO. (Refer to Table I)	pbw
SOLITHANE 113 Resin	100
C113-300 cure agent	74
Temperature	Weight loss (at 10 x 177mmHg)
R.T.	(0.136%)
140°F (60°C)	(0.199%) Entirely Water
180°F (82°C)	(0.260%)
248°F (120°C)	(1.39%)

TABLE IX

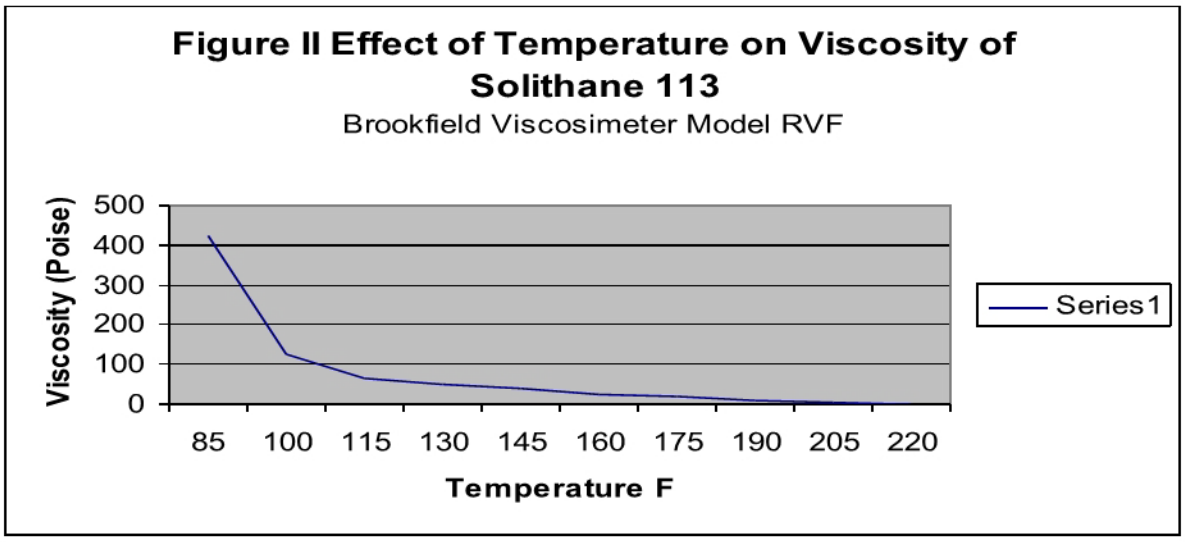
FORMULATION:	
SOLITHANE 113 Resin	100 pbw
C113-300 cure agent	73.5
Claremont Leaf Green Paste #4060-Cro-1	(As indicated)

Paste Concentration, pbw	**Hardness, Shore A** psi (kg/cm2) Samples cured 2 hrs at 300°F(149°C) + 7 days at 73°F(23°C)	**Tensile Strength**	**Elongation, %**
0.0	59	370 (26.0)	96
0.5	59	395 (27.8)	98
1.0	60	385 (27.1)	96
2.0	60	375 (26.4)	97
5.0	60	406 (28.5)	103
10.0	61	429 (30.2)	99
15.0	61	412 (29.0)	98

Brookfield Viscosimeter, Model
RVF Spindles No. 3

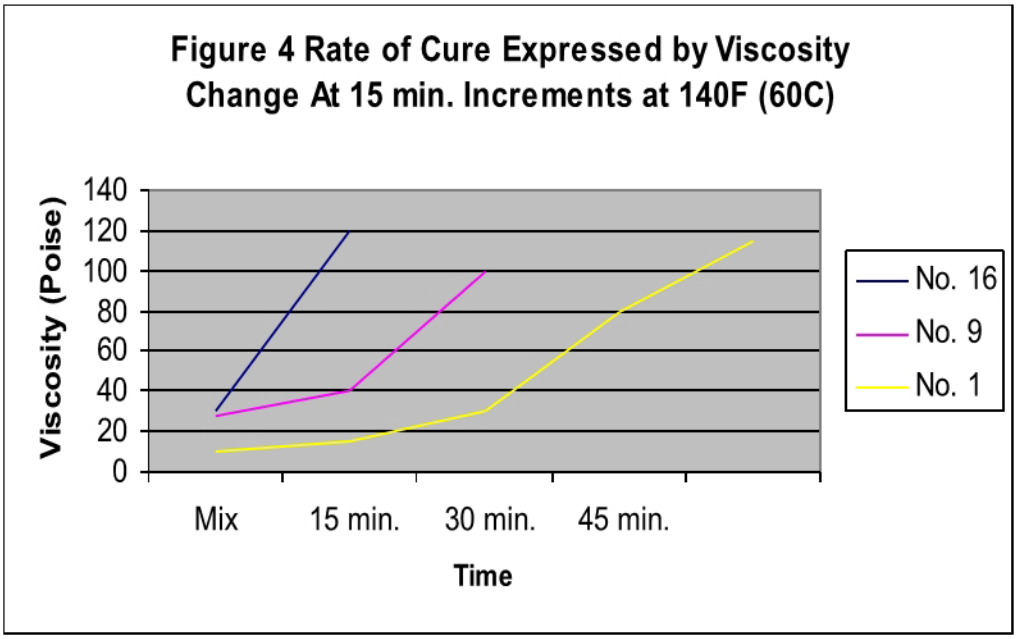
SOLITHANE 113 resin may be stored under the usual warehouse conditions. Repeated freezing and thawing does not affect the performance of the polymer. No noticeable changes in its stability under ambient conditions have been experienced to date.

FIGURE II
Effect of Temperature on Viscosity
SOLITHANE



Brookfield Viscosimeter
Model RVF

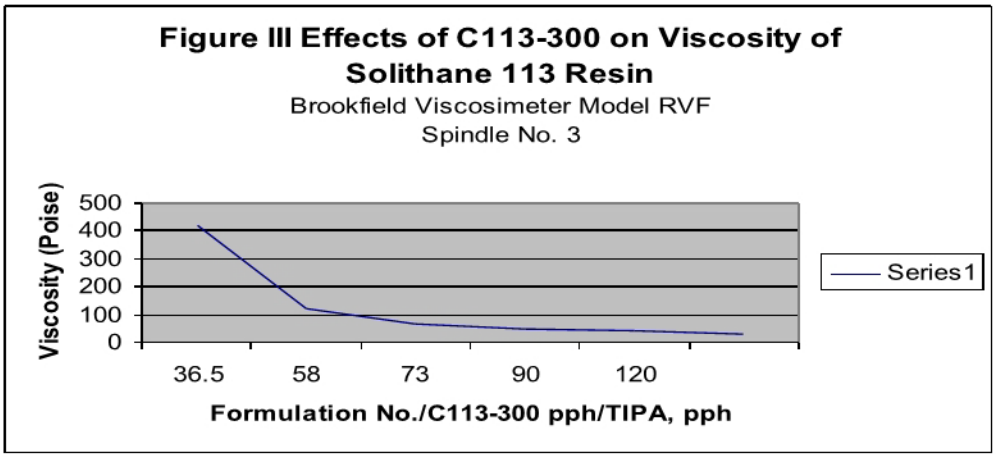
FIGURE III
Effect of C-113-300 on Viscosity
of SOLITHANE 113



Brookfield Viscosimeter
Model RVF
80°F (27°C)

FIGURE IV
Rate of Cure Expressed by Viscosity Change
@15 minute Increments at 140°F (60°C)

APPARENT MODULUS OF RIGIDITY OF SOLITHANE 113 RESIN



Purpose

To determine G, the apparent modulus of rigidity of **SOLITHANE 113** resin when formulated according to formula 1 in the Technical Bulletin.

Conclusion

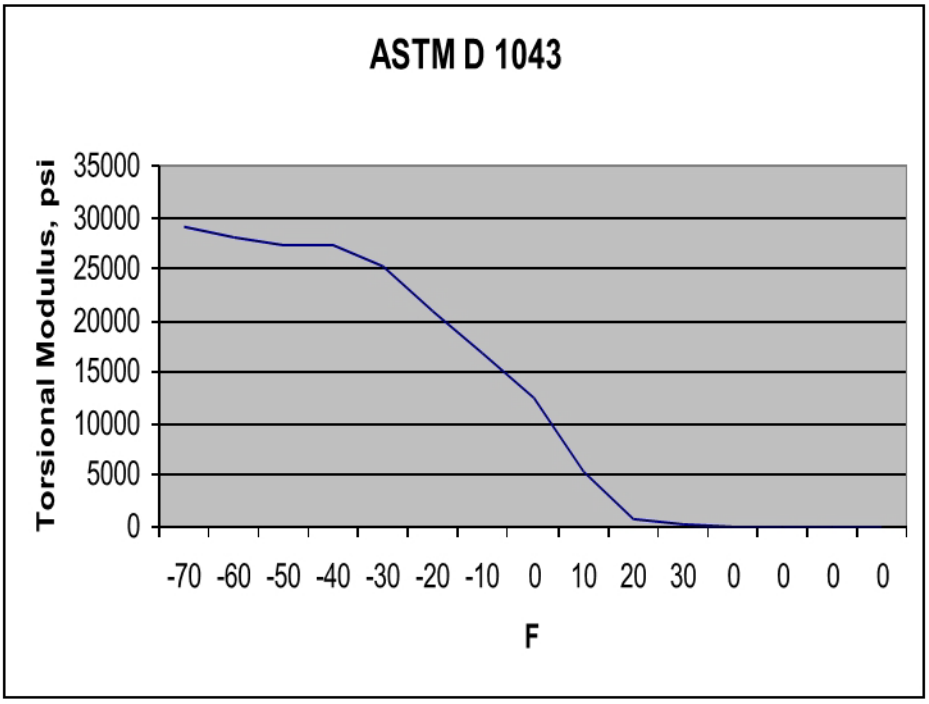
SOLITHANE 113 resin exhibits a typical curve of rigidity vs. temperature when the values are plotted. The values show that the material is essentially rigid from -40°F (-40°C) down. The value, 10,000 psi, is reached at about +3°F (-16°C).

Procedure

The tests were run accordingly to ASTM D 1043 except as modified by the Morton Thiokol apparatus. Calculations are according to D 1043.

Typical G Values for SOLITHANE 113 Resin- Formula 1
G= Apparent Modulus of Rigidity
Method: ASTM D 1043

°F	°C	G
+71	(+21.7)	78
+60	(+15.6)	74
+50	(+10)	81
+40	(+4.44)	86
+30	(-1.11)	220
+20	(-6.67)	778
+10	(-12.1)	5241
0	(-17.8)	12500
-5	(-20.5)	15556
-10	(-23.3)	16977
-20	(-28.9)	20857
-30	(-34.4)	25333
-40	(-40)	27222
-50	(-45.6)	27222
-60	(-51.1)	28000



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Listed below are data on SOLITHANE 113 resin (100 parts) when cured with C113-300 curing agent (73 parts). Such data may be helpful in aerospace applications.

1. Coefficient of Lineal Expansion
   7 x 10-5 inches/inch/degree F (from -65°F to +160°F)
2. Specific Heat
   0.44 calories/°C/gram
3. Thermal Conductivity
   5.0 x 10-4 calories/second/sq.cm/°C/cm
4. Ionising Radiation Resistance
   10 million RAD
5. Brittle Point
   +6.2°F (-14°C)

SOLITHANE 113

Property	Specification Limits	Test Method
Isocyanate, % by wt.	10.4 to 10.8	ZS1078B
Viscosity @ 25°C, poises	200 – 300	ZM1109B
Specific Gravity, 25/25°C	1.065 to 1.085	ZM1041D

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Original Issue: 1/28/65
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C113-300

Property	Specification Limits	Test Method
Acid Number (mg KOH/g)	0.80 maximum	ZS1066A
Hydroxyl Number (mg KOH/g)	160 - 167	ZS1104
Moisture, % by wt.	0.02 maximum	ZS1007D
Specific Gravity @ 24°C	0.957 – 0.961	ZM1041D
Refractive Index, n D @ 25°C	1.4765 – 1.4780	ZS1101B

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A.14.10. Solithane 113/C 113-300 (100/73 pbw)

PRODUCT

Type	Two-part, soft, transparent, potting, conformal coating, bonding agent.	
Chemical Composition	Polyurethane.	
Manufacturer	Uniroyal Chemical Company Inc.	Tel: +1 704 864-3411
	(Crompton Corporation)	Fax: +1 704 864-4079
	214 West Ruby Avenue,	Email: bob_marionneaux@cromptoncorp.com
	Gastonia NC 28053, USA	www.cromptoncorp.com
(Previously)	Thiokol Chemical Corp. Trenton, NJ, USA	

EXPERIENCE & AVAILABILITY

Development Status	Commercial Product
Cost Range	Low
Lot Reproducibility	Excellent
Space Experience	Extensive

GENERAL PROPERTIES (Physical, Mechanical, Thermal, Electrical, Optical)

Nature	Typical Value	Remarks
Specific Gravity	1.073	
Viscosity	20 000 cps	@ 27°C
Pot Life	3 hours	@ 27°C
Hardness	55 to 60	
Tensile Strength	2.85 MPa	Manufacturer's Data
Glass Transition Temperature	-10°C	Thermal expansion measurement
Dielectric Constant	4.2	@ 27°C, 1kHz
Dissipation Factor	0.162	@ 27°C, 1kHz
Dielectric Strength	14.9 kV/mm	@ 27°C
Volume Resistivity	2.5×10^{12} Ω m	@ 27°C
Thermal Expansion Coefficient	126×10^{-6} °C $^{-1}$	-55°C to -15°C
	238×10^{-6} °C $^{-1}$	0°C to 70°C

PROPERTIES RELEVANT TO SPACE USE

Nature	Typical Value	Type of Test
Temperature Range	-60°C to 120°C max.	Long Term
Outgassing	TML = 0.37%, RML =0.21%, CVCM = 0.01%	ECSS-Q-70-02
Thermal Cycling	Pass	ECSS-Q-70-04
Ionising Radiation	10 Mrad	Manufacturer's Data
Oxygen Index	24.7	ECSS-Q-70-21
Flammability	Fail (21% O_2)	NASA NHB 8060-1B

SPECIAL RECOMMENDATIONS

- Recommended cures: 7 days at room temperature, or 24 hours at 70°C.
- Compositions other than the one detailed here are possible. Large amounts of experimental data on them exists and is available on demand.
- Not resistant to solar UV radiation.
- Owing to flammability risk, not to be used as a conformal coating in manned spacecraft unless a fire-resistant overcoating is used. It's acceptability as an adhesive will depend on the configuration.
- Possible use as a screw-locking compound.
- Possible use as an ink with suitable addition of pigments and solvents.
- Possible use as a conductive coating when filled with silver powder.
- Flammability highly dependent on coating thickness. Configuration flammability tests required.