PD gluing

Space qualified materials

Sources


MAPTIS
Materials And Processes Technical Information System
Home
Features
About
Register
Sign In
International Space Station
(ISS)
Welcome to the Materials and Processes Technical Information System (MAPTIS) Web Site. The goal of MAPTIS is to provide a single-point source for materials properties for NASA and NASA associated contractors and organizations. MAPTIS contains physical, mechanical and environmental properties for metallic and non-metallic materials.
NASA Official: Carole Wagner
NASA Safety Reporting System
Privacy and Legal Statements
Curator: Julia M. Reynolds
Powered by the Athena Platform
Business Hours - 6:30 am to 5:00 pm Monday - Friday, Central time, (877) 677-2123, NASA Enterprise Service Desk

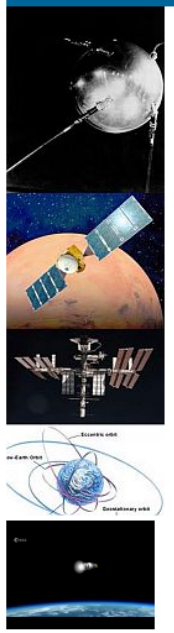
Sources


This website is for information only and these pages are no longer maintained.
esa
ESMAT
European Space Agency
Contents
Material News
News about Materials and Processes
Databases
Databases, Metallurgy reports, outgassing, SCC, bimetallic, flammability
Specifications
Specifications controlled by TEC-QT
Publications
External Publications by TEC-QT
SME
Presentations during S(mall) and M(edium) E(nterprises) Workshops
ESA Tool
Electronic Tool for Declared Material, Mechanical Part and Processes Lists
Materials Space Evaluation & Radiation Effects Section Final Presentation Day, Wednesday 28 November at Einstein
The ESA DMPL Tool has a major update. Visit the link ESA Tool
ISMSE-12, 24-28 September 2012, ESA-ESTEC, for further information on the 12th International Symposium on Materials in the Space Environment please visit our website:
http://www.congrexprojects.com/ismse12
The main mission of the ESMAT (ESTEC Materials) website is to deliver reliable test data for use on spacecraft for outgassing, stress corrosion, galvanic corrosion, flammability. It also contains the status of pcb manufacturing lines and smd verification.
The ESMAT website and its databases is controlled by the ESTEC M&P division. The Materials & Components Technology Division forms a part of the Product Assurance and Safety Department of the Directorate of Technical Support at the European Space Research and Technology Centre (ESTEC) in Noordwijk, The Netherlands.
The Division can be reached through:
Adrian Graham 0031 71 5658616
Links
ESA Home
Product assurance on the ESA website
Proceedings of the 9th ISMSE, 16-20 June 2003, Noordwijk, The Netherlands
Proceedings of the 10th ISMSE, 19-23 June 2006, Collioure, France
Proceedings of the 11th ISMSE, 15-18 September 2009, Aix en Provence, France
Proceedings of the Electronic Materials and Assembly Processes for Space (EMPS) Workshop, University of Portsmouth 2011
Future Trends in PCB Technologies for Space Applications, 22-23 October 2009, ESTEC
Local Site Search
Go

Sources

SPACEMATDB - Space Materials DataBase

About author | Covered materials | New and planned additions | Data Quality | M & P Courses | Disclaimer | **Goto DATABASE**



Materials included are:

- Bulk materials such as metals and alloys and non-metallic materials such as glasses, polymers, ceramics and composites
- Filler materials such as solder alloys
- paints, lacquers, varnishes, adhesives, lubricants and coatings
- Pottings, sealants and foams
- Films, foils, tapes, inks

Properties included are:

- Precautions
- Processing and Assembly
- Vendor information
- Experience and equivalance
- Physical properties
- Elastic properties
- Optical properties
- Electrical properties
- Thermal properties
- Environmental properties relevant for space use, such as corrosion (general, stress, bimetallic), atomic oxygen, machinebility, welding, outgassing, offgassing/toxicity, flammability, UV radiation
- Fluid compatibility
- Special recommendations and lessons learned

SPACEMATDB combines data from several sources:

- European Space Materials Database (ESMDB - not available outside ESA) at ESA/ESTEC
- The ESMAT website database section
- Metallic Materials Properties Development and Standardization (MMPDS) data and its predecessor MIL-HDBK-5
- MAPTIS (Materials and Processing Information System) at NASA
- Aluminum Association (AA)
- CDA (Copper Development Association).
- MATWEB
- NASA outgassing data
- Datasheets from manufacturers
- ASM Metals Handbook
- CRC Handbook of Chemistry and Physiscs
- Materials and Processes for Spacecraft and High Reliability Applications, by Barrie D. Dunn
- Laboratory testing at ESTEC or at ESA recognized testhouses (stress corrosion, galvanic corrosion, thermal cycling, outgassing, offgassing/toxicity, flammability, UVradiation, atomic oxygen, optical, etc)
- Published acticles by the author on atomic oxygen, stress corrosion and bimetallic corrosion
- Materials & Processes and SME Courses given by the author
- Open literature

The goal of SPACEMATDB is to provide a reliable data source for material properties for agencies and organizations present in the space community

Materials data is avalable for space applications on manned spacecraft, launchers, satellites, payloads and ground support equipment

Space qualification requirements

- Coatings and varnishes appear as electrical insulating layers, corrosion protection and mechanical protection mainly in electronic circuitry.
- Non-structural adhesives … some ensure good thermal contact and low stress concentration at the joint, but such assemblies are difficult to take apart after fabrication. Electrically conductive adhesives find a use as grounding points for conductive surfaces.
- The main danger comes from bonding agents, optical coupling agents and other assembly materials which can contaminate the optics by yielding condensable products. A contaminated optic is, in general, very difficult to clean.
- The adhesive shall be physically and chemically compatible with the component parts to be bonded.
- Adhesive bonding is in general quite sensitive to small changes in the process.

Space hazard

- Particle radiation at the level encountered in space is not harmful for adhesives, which are in any case protected by the items (adherends) they are bonding.
- UV radiation can darken optical adhesives. In this regard silicones are superior to epoxies. UV and particle radiation can both increase the outgassing rate of adhesives. UV radiation and proton fluxes are the main factors and can cause darkening and hardening of coatings and increase the outgassing rate. Insulating varnishes used in “black boxes” are not subjected to UV.
- High temperature degrades adhesives and accelerates outgassing. Silicone-type coatings and varnishes are recommended for high temperatures. When flammability is a property to be considered, silicone materials should be chosen in preference to polyurethane coatings.
- Low temperature stiffens adhesives and causes brittle bonds. Some polyurethane adhesives are still useful at very low temperatures (cryogenic). A similar effect is seen with coatings which tend to harden, shrink and crack.
- Thermal cycling leads to failure of the adhesive bond when the expansion coefficients of the adherents and adhesives are not matched and when the adhesive is not flexible enough to cope with the strain. Thick layers of rigid adhesives are prone to high stresses. Coatings and varnishes experience thermal-cycling due to shadow-sunlight passage or to variable internal heat sources caused by switching equipment on and off. Mismatch of expansion coefficients between coating and coated items gives rise to high stresses and eventually to cracks.
- Atomic oxygen (inLEO)is only applicable to adhesives exposed to ATOX (such as those on solar-cell and panel assemblies) which can be attacked. Exposed coatings are susceptible: silicones are resistant.

Prodotti consigliati

Adhesives

- Araldite AV 138,
- DC 6--1104,
- DC93500,
- Eccobond Solder 56C,
- Redux 312,
- RTV 566,
- RTV S 691,
- RTV S 695,
- Scotch Weld EC 2216,
- Solithane 113.

Coatings

- DC 93500,
- MAPSIL 213,
- RTV S 695,
- Uralene 5750.

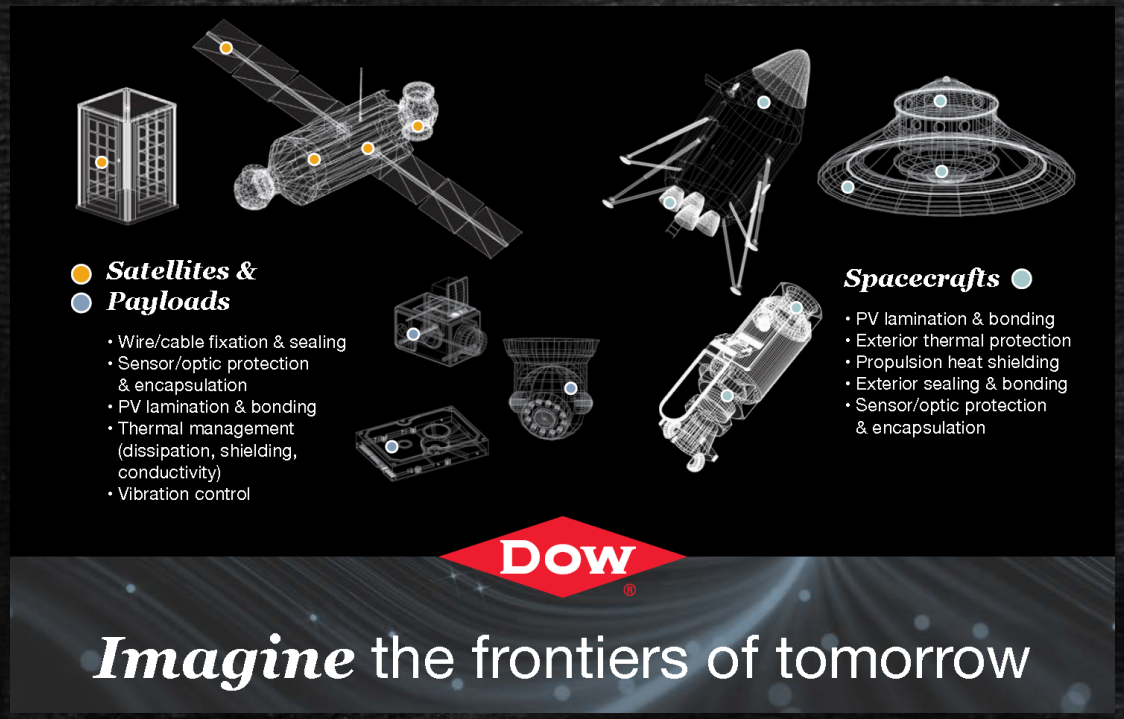
Prodotti consigliati

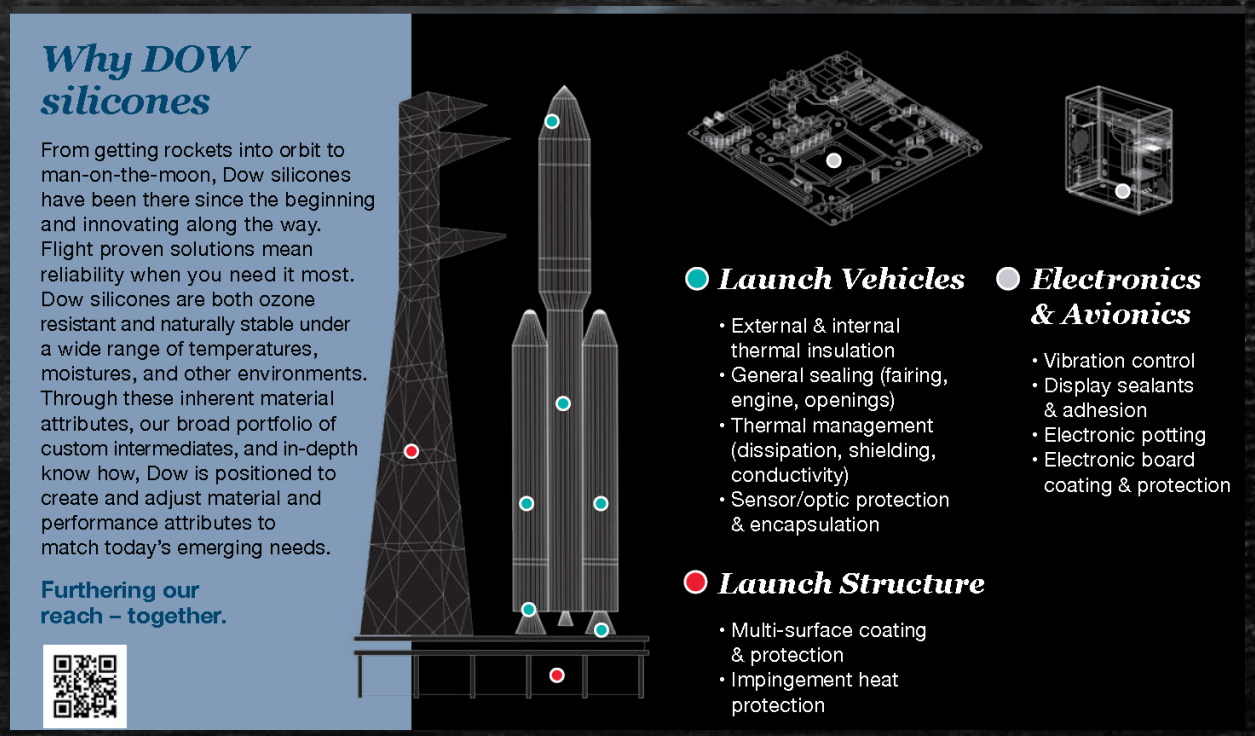
We have:

- Dow corning 732
- Dow corning 3145
- Sylgard 184
- Epotek 301

Prodotti consigliati

Dow corning has a series of products for space application





Prodotti consigliati

SILICONES ARE INHERENTLY DESIGNED FOR SPACE

By their very nature, they offer

- UV and ozone stability
- Elasticity at low temps — resist breakdown at high temps
- Solvent resistance, hydrophobicity, scratch resistance, and high light transmission
- Low toxicity, low abrasive fillers, simple mix ratios, good wet out, dielectric thermal properties
- Vibration damping, tunable modulus, excellent CTE

Their unique characteristics can be exploited in composites with filler blends to provide **electrical conductivity**

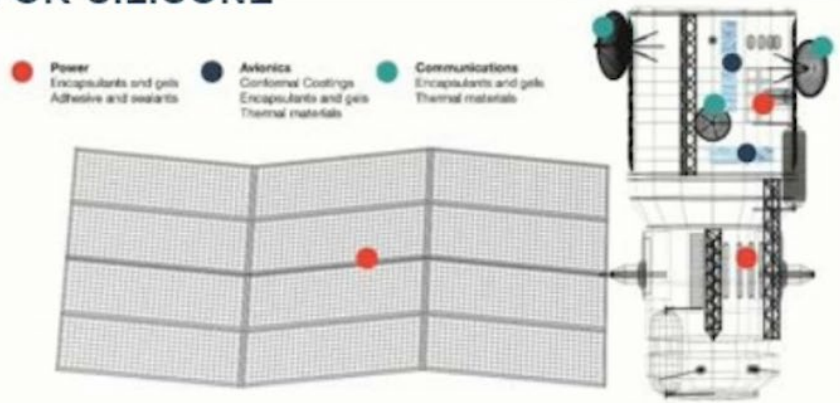
	Acrylic	PU	Epoxy	Silicone
Thermal stability	●	●	●	●
Coefficient of thermal expansion	●	●	●	●
Vibration damping	●	●	●	●
Optical stability in UV				
Stability at T_o	●	●	●	●
Following UV exposure	●	●	●	●

DOW

Prodotti consigliati

SATELLITES – APPLICATIONS FOR SILICONE

- Electronics protection
- Optical stability for sensors, lenses, solar cells
- Vibration damping and fixation
- Thermal management



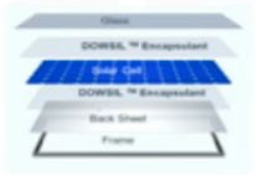
Category	Economy	Mid-line	Premium
Encapsulants and gels	• DOWSIL™ EG-1200 Gel • DOWSIL™ EG-4131 Dielectric Gel	• DOWSIL™ EI-1184 Encapsulant • SILASTIC™ Moldable Optical Silicones	• DOWSIL™ 93-500 Space Grade Encapsulant (ASTME595)
Adhesives and sealants	• DOWSIL™ 832 Multi-Surface Adhesive • DOWSIL™ 7091 Adhesive	• DOWSIL™ 3145 RTV Mil-A-46146 Adhesive	• DOWSIL™ 6-1104 CV Sealant • DOWSIL™ 6-1125 CV Sealant (ASTME595)
Thermal management	• DOWSIL™ 1-4173 Thermally Conductive Adhesive		

DOW

Prodotti consigliati

SILICONE ENCAPSULANTS FOR AEROSPACE

- Expanded product offerings aligning to orbit design needs
- Versatile curing profiles to improve process efficiency
- Pricing options to meet design specs and budget
- Best in class technical customer support
- Large-scale manufacturing capabilities



Space solar panel array assembly

Thermal aging
10,000 hrs, 150°C

Product	Heat-aged optical clarity	Mix ratio	Cure type	Working time at 25°C	Durometer Shore A	Orbit	Space heritage
DOWSIL™ EG-1200 Gel	Good	1:1	Room temp. or heat accelerated	20 min	51 Shore 00	LEO	Evaluation ongoing
DOWSIL™ EG-4131 Dielectric Gel	Good	1:1	Room temp. or heat accelerated	30 min	Low Shore 00	LEO	Evaluation ongoing
DOWSIL™ 93-500 Space Grade Encapsulant–ASTM E595 Certified	Better	10:1	Room temp. or heat accelerated	2–3 hours	43	GEO, MEO, LEO	Yes
SILASTIC™ Moldable Optical Silicone	Best	1:1	Heat cure	48 hours	50–85	MEO, LEO	New
SYLGARD™ 182 Silicone Elastomer	Best	10:1	Heat cure	8 hours	61	MEO, LEO	New
DOWSIL™ EI-1184 Encapsulant	Best	1:1	Heat cure	24 min	61	MEO, LEO	Evaluation ongoing

NASA database

Material Definition Properties:

Material Code: 61846
Designation: DOW CORNING™ 93-500
Composition: SILICONE RUBBER WITH SILOXANE CURING AGENT
Use Type: POTTING COMPOUND
Service Temp Min(F): -85
Service Temp Max(F): 392

Remarks:

Type	Seq.	Remarks
TM	1	DOW CORNING IS A REGISTERED TRADEMARK OF DOW CORNING CORPORATION

Material Specification Data:

*** No Specifications for this Entry ***

Enviromental Health and Safety (EH&S) MAPTIS Rating:

Unknown

Material Definition Properties:

Material Code: 01811
Designation: DOW CORNING™ 732 FORMERLY SILASTIC™ 732 RTV
Composition: SILICONE RUBBER
Use Type: ADHESIVE
Service Temp Min(F): -67
Service Temp Max(F): 450

Remarks:

Type	Seq.	Remarks
TM	1	DOW CORNING AND SILASTIC ARE REGISTERED TRADEMARKS OF DOW CORNING CORP

Material Specification Data:

Sequence	SpecificationName
1	MIL-A-46106B TYPE 1

Enviromental Health and Safety (EH&S) MAPTIS Rating:

Unknown

Material Definition Properties:

Material Code: 05247
Designation: DOW CORNING™ 3145 RTV
Composition: SILICONE RUBBER
Use Type: ADHESIVE
Service Temp Min(F): -58
Service Temp Max(F): 392

Remarks:

Type	Seq.	Remarks
TM	1	DOW CORNING IS A REGISTERED TRADEMARK OF DOW CORNING CORPORATION

Material Specification Data:

Sequence	SpecificationName
1	MB0120-097
2	MIL-A-46146B TYPE 3
3	MIL-A-46146B
4	MIL-R-47211 NOT FOR DESIGN

Enviromental Health and Safety (EH&S) MAPTIS Rating:

Unknown

Flammability: similar among the 3 products, e.g. 93-500

Rating criteria per NHB-8060.1C/NASA-STD-6001:
A = Materials with sample measurements/test conditions recommended in NASA-STD-6001, a burn length <= 6 in. (15 cm) and no ignition of K-10 paper. Standard test is 3 samples. (Can fail but not pass on less than 3.) Configuration test can be rated on 1-3 samples.
C = Materials that have a burn length > 6 in. and no ignition of K-10 paper.
X = Moderate or large drip burning; or small, moderate or large drip burning with K-10 ignition. Burn length is not a factor.
S = Special test conducted on the material.
I = Less than 3 standard samples with <= 6 in. burn and no burn drip or no ignition of K-10 paper with small drip burns.
U = Unacceptable data.

Rating criteria per NASA-STD-6001B:
A = Material in thickness and test condition specified meet NASA-STD-6001B requirements, a burn length <= 6 in. (15 cm) and no ignition of K-10 paper. Standard test is 5 samples. (Can fail but not pass on less than 5.) Configuration test can be rated on 1-5 samples.
C = Materials that have a burn length > 6 in. and no ignition of K-10 paper.
X = Moderate or large drip burning; or small, moderate or large drip burning with K-10 ignition. Burn length is not a factor.
S = Special test conducted on the material.
I = Less than 5 standard samples with <= 6 in. burn and no burn drip or no ignition of K-10 paper with small drip burns.
U = Unacceptable data.

Test Rpt. No.	Mtrl. Code	Rating	Percent Oxygen	Press. (psia)	Test No.
M101416-A	61846	A	20.9	14.7	01
M101416-B	61846	A	30	10.2	01
M105117-A	61846	A	20.9	14.7	01
W9224-A	61846	C	20.9	14.7	01

Flash fire: similar among the 3 products, e.g. 93-500

Flash Rating
A = a flash point => 400 F (204 C)
X = a flash point < 400 F (204 C)
Fire Rating
A = a fire point => 450 F (232 C)
X = a fire point < 450 F (232 C)

Test Rpt. No.	Flash Rating	Fire Rating	Percent Oxygen	Flash Pt. (F)
W9224-B	A	A	23.8	1000 1000 1000 1000

Fluid comp.: data available for 3145 and 732, results are the same, no data for 93-500

Fluid Compatibility - Non-Metals
A = material that meets the requirements of NASA-STD-6001 Test 15, 48 hrs. at 160 F (71 C), with no chemical changes.
B = materials which pass a two hour screening test. Materials require more testing before using.
X = materials which fail requirements of NASA-STD-6001.
I = materials with insufficient data.
S = materials which require special test setup.

Test Rpt. No.	Rating	Media
W11010-A	B	DINITROGEN TETROXIDE (N2O4)
W11010-B	B	HYDRAZINE (N2H4)
W11010-C	B	MONOMETHYLHYDRAZINE (MMH)
W11010-D	B	DINITROGEN TETROXIDE (N2O4)
W11010-E	B	HYDRAZINE (N2H4)
W11010-F	B	MONOMETHYLHYDRAZINE (MMH)

Odor: data available for 3145 and 732, results are the same, no data for 93-500

Odor
A = material meets odor requirements of NASA-STD-6001 without special cure.
B = material meets odor requirements of NASA-STD-6001 with special cure; however, in next 527 and on, the database B rating is invalid.
X = material fails to meet odor requirements of NASA-STD-6001.

Test Rpt. No.	Rating	Oxy %	Gas Name)	Gas %	Test No.
W16991-C	A	25.9	NITROGEN	74.1	06
W4391-A	A	25.9	NITROGEN	74.1	06
W5794-C	A	25.9	NITROGEN	74.1	06
W8347-C	A	25.9	NITROGEN	74.1	06

Toxicity: similar among the 3 products, e.g. 93-500

Toxicity
Toxicity/Offgassing For a Single Article
Ratings:
Toxicity ratings are now based on maximum limit weight (MLW) calculated from the summation of toxicity, T = 0.5. Ratings show use weight of material after all cures, if applicable, are met.
K = Maximum Limit Weight => 100 lbs. (45,400 grams)
H = maximum limit weight => 50 lbs. (22, 700 grams) < 100 lbs. (45,400 grams)
A = maximum limit weight => 10 lbs. (4.540 grams) < 50 lbs. (22,700 grams)
V = maximum limit weight => 5 lbs. (2,270 grams) < 10 lbs. (5,540 grams)
X = maximum limit weight < 5 lbs. (2,270 grams)
I = materials with insufficient data.
B = data are inconclusive with variations within a batch. The worst case cure is given.
X1= special circumstances which will be noted in the Test Results Remarks. Material should be tested prior to use. Toxicity ratings are based on NASA-STD-6001.
Note: materials previously rated B indicated a special cure.
Toxicity/Offgassing For Assembled
Articles Ratings:
A = assembled articles where Toxicity Value <= 0.5
X = assembled articles where Toxicity Value > 0.5

"Max. Limit" reported in pounds (lbs) are for tested materials and the "Max. Limit" reported in units (U) are for tested assemblies/configurations.

Test Rpt. No.	ISS Rating	ISS Max. Limit	ORION Rating	ORION Max. Limit	EMU Rating	EMU Max. Limit
M107257-A	A	25.8856 (lbs)	X	3.29 (lbs)	X	0.30719196 (lbs)

Outgassing: 93500

Rating criteria per NASA-STD-6016 (4.2.3.6)
Test specification: ASTM E-595
A = TML <= 1.0 and VCM <= 0.1.
Note: if the WVR is reported, subtract the WVR value from the TML value to obtain the TML value to rate by. (i.e., TML - WVR = the official TML)
C = TML > 1.0 and <= 3.0 and VCM <= 0.1.
Note: if the WVR is reported, subtract the WVR value from the TML value to obtain the TML value to rate by (i.e., TML - WVR = the official TML)
X = Materials with TML > 3.0 and/or VCM > 0.1
I = Materials with insufficient data.
S = Special test conducted on materials.

Test Rpt. No.	Rating	Press. (torr)	Duration (hrs)	TML(%)	VCM(%)	WVR(%)
BA23	A	1.00E-6	24	.31 .31	.02 .02	.3 .3
ESA232-A	A	1.00E-6	24	.25 .25	0 0	.23 .23
ESA277-C	X	1.00E-6	24	.45 .45	.26 .26	.44 .44
ESA290	A	1.00E-6	24	.2 .2	0 0	.19 .19
ESA292-A	A	1.00E-6	24	.09 .09	.01 .01	.09 .09
ESA296365	A	1.00E-6	24	.34 .34	.01 .01	.31 .31
ESA298-A	A	1.00E-6	24	.12 .12	.01 .01	.11 .11
ESA299-C	A	1.00E-6	24	.09 .09	.02 .02	.06 .06
ESA299-D	A	1.00E-6	24	.12 .12	.01 .01	.09 .09
ESA299-E	A	1.00E-6	24	.41 .41	.08 .08	.38 .38
ESA302-C	A	1.00E-6	24	.1 .1	.01 .01	.07 .07
ESA303-B	A	1.00E-6	24	.33 .33	.02 .02	.14 .14
ESA303-D	A	1.00E-6	24	.11 .11	.01 .01	.11 .11
ESA304-B	C	1.00E-6	24	1.95 1.95	0 0	.34 .34
ESA304-D	A	1.00E-6	24	.11 .11	0 0	.11 .11
ESA308	A	1.00E-6	24	.14 .14	.01 .01	.1 .1
ESA318-D	A	1.00E-6	24	.11 .11	.03 .03	.13 .13
ESA333-C	A	1.00E-6	24	.16 .16	.01 .01	.15 .15
ESA341-A	A	1.00E-6	24	.13 .13	.01 .01	.08 .08
ESA341-B	C	1.00E-6	24	2.39 2.39	.01 .01	1.33 1.33

Outgassing: 732

Test Rpt. No.	Rating	Press. (torr)	Duration (hrs)	TML(%)	VCM(%)	WVR(%)
G21PN	X	1.00E-6	24	3.4 3.4	1.43 1.43	0 0
G3443	X	1.00E-6	24	1.22 1.22	.4 .4	0 0
SRI11819	X	1.00E-6	24	2.39 2.39	.75 .75	0 0
SRI11820	X	1.00E-6	24	1.59 1.59	.8 .8	0 0
SRI11821	X	1.00E-6	24	2.5 2.5	.84 .84	0 0
SRI11822	X	1.00E-6	24	1.76 1.76	.85 .85	0 0
SRI11823	X	1.00E-6	24	2.96 2.96	.96 .96	0 0
SRI11824	X	1.00E-6	24	1.73 1.73	.93 .93	0 0
W19509-A	X	4.00E-6	24	1.3 1.29 1.295	.42 .43 .425	.06 .06 .06
W19509-B	X	6.00E-6	24	1.11 1.1	.34 .27	.04 .04

Outgassing: 3145

Test Rpt. No.	Rating	Press. (torr)	Duration (hrs)	TML(%)	VCM(%)	WVR(%)
ESA224-A	X	1.00E-6	24	1.15 1.15	.34 .34	1.06 1.06
G0188	X	1.00E-6	24	2.18 2.18	1.08 1.08	0 0
G0191	X	1.00E-6	24	1.74 1.74	.9 .9	0 0
G10047	X	1.00E-6	24	.54 .54	.27 .27	.04 .04
G1153	X	1.00E-6	24	1.7 1.7	.6 .6	0 0
G2363	A	1.00E-6	24	.11 .11	.01 .01	0 0
G2587	X	1.00E-6	24	.66 .66	.28 .28	0 0
G26101	X	1.00E-6	24	2.24 2.24	.45 .45	.03 .03
G28621	X	1.00E-6	24	2.52 2.52	.58 .58	.11 .11
G28657	X	1.00E-6	24	2.29 2.29	.52 .52	.06 .06
G8663	X	1.00E-6	24	1.08 1.08	.51 .51	.02 .02
G9344	X	1.00E-6	24	1.12 1.12	.46 .46	.05 .05

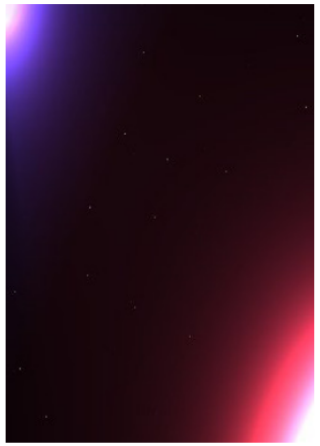
Epak Electronics

HOME ABOUT US NEWS PRODUCTS SUPPORT SPARES FAQ CONTACT SEARCH Find

NASA AND ESA QUALIFIED ADHESIVES EPOXIES AND MATERIALS AI TECHNOLOGY

Many AiT products are available to Mil Std 883D as well as NASA & ESA outgassing qualification standards. Materials can be supplied in one or two part components, syringe, in pre-formed films, sheets in various sizes and in jars.

A list of products from AIT that has years of proven success in NASA and ESA outgassing compliant adhesives for space applications.



NASA-ESA OUTGASSING QUALIFIED PRODUCTS

Test Procedures: ESA: PSS-01-792; NASA: ASTM E595-90

Test Conditions: 125°C for 24 hours @ 10-3 Pa (<10-5 Torr)

Acceptability: Total Weight Loss (TWL)<1%

Volatile Condensible Materials (VCM) <0.1%

Water Vapour Regained (WVR) NR

(Click on the Product for the TDS.)

AIT Product	%TWL	%VCM	%WVR
EG8050(Cured at 100°C @ 5 min.)	0.57	0.016	0.21
EG8050-HC(Cured at 150°C @ 5 min.)	0.84	0.070	0.64
ESP8350(Cured at 150°C @ 16 hr.)	0.08	0.010	0.01
ME7155(Cured at 150°C @ 5 min.)	0.54	0.067	Not reported
ME7158(Cured at 150°C @ 16 hr.)	0.28	0.053	Not reported
ME7158(Cured at 125°C @ 24 hr.)	0.30	0.045	Not reported
ME7158(Cured at 100°C @ 4 hr.)	0.51	0.100	Not reported
ME7159(Cured at 150°C @ 16 hr.)	0.23	0.031	Not reported
ME7159(Cured at 150°C @ 24 hr.)	0.27	0.040	Not reported
ME7159(Cured at 150°C @ 4 hr.)	0.58	0.090	Not reported
ME8456(Cured at 100°C @ 5 hr.)	0.25	0.050	0.05
TC8750(Cured at 150°C @ 30 min.)	< >0.28	0.070	0.06
TP7205(Post bonding baked at 150°C @ 30 min.)	0.78	0.080	0.08
TP7209(None)	0.38	0.080	0.28
TP7758(Post bonding baked at 150°C @ 30 min.)	0.38	0.060	0.06
TP7759(Post bonding baked at 250°C @ 0.5 sec.)	0.25	0.010	0.23

CONTACT US FOR NASA / ESA MATERIAL SELECTION Contact Us