SILICONES FOR AVIATION, AEROSPACE & DEFENSE

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What are avionics?

According to Wikipedia, avionics are the electronic systems used on aircraft, artificial satellites and spacecraft. In short avionics is the science of electronics when used in designing and making aircraft. The term avionics is a portmanteau of the words aviation and electronics.
Dow Silicones for aviation and aerospace

Silicones are beneficial in many applications of aircraft assembly, protection and maintenance including:

- Electronics protection
- Airframe and cabin materials
- Engine components
Electronics protection materials
Silicone benefits in electronics protection

• Performance under thermal stress/cycling
• UV, ozone, chemical, fuel and water resistance
• Dielectric strength
• Insulative properties for heat and electricity
• Non-corrosive to sensitive electronics
Mission critical electronics

DOWSIL™ Gels, encapsulants and conformal coatings are utilized in:

- Fly-by-wire
- Engine and aircraft performance sensors
- Gauges
- Connectors
- Printed circuit boards
Silicone materials in airframe, cabin and engine applications
Silicone benefits in airframe and cabin applications

- Resistance to fuels, water, oils
- Flexibility across temperature range
- Injectable, non-curing when needed
- Variable cure times, even confined
- Flowable, self leveling
- Vibration/shock dampening
- Reduced maintenance cost
- Flame retardant
- High movement capable
Cabin interior trim

DOWSIL™ RTV Sealants and adhesives and SILASTIC™ Elastomers are utilized in:

- Galley, window, lavatory seals
- Plastic trim/decorative panel seals
- ‘Reveal’ seals on windows
- Interior door seals
- Wall panel seals
- Air ducts
**Airframe: Wing/fuselage/empennage structure**

DOWSIL™ RTV Sealants and adhesives, fluorosilicone channel sealants and SILASTIC™ Elastomers are utilized in:

- Fillet/faying surface
- Fasteners/rivet cover
- Fuel tanks/lines
- Fuel filler area
- Electrical/control lines straps
- Windows and doors seals
- Insulation adhesive
Silicone benefits in engine components

- Thermal stability (-50°C up to 250°C)
- Vibration/shock dampening
- Chemical resistance to certain fuels and solvents
- Lower maintenance cost
- Helps to manage coefficient of thermal expansion (CTE) mismatches between dissimilar surfaces
Cowling, thrust reverser, turbine, propeller, engine

DOWSIL™ Abradable materials for engine seals, and gels and encapsulants for component NVH are utilized in:

- Fan tip/blade seals and protection
- Fuel/electric/vacuum line clamps
- Spline shaft lubes
- Electronics protection
- Assembly aid
- Fuel hose
Silicones for aerospace and defense
DOWSIL™ and SILASTIC™ heritage products

Elastomers

- **DOWSIL™ 732 Multi-Purpose Sealant**
- **DOWSIL™ 736 Heat Resistant Sealant**
- **DOWSIL™ 3140 RTV Coating**
- **DOWSIL™ 3145 RTV Mil-A-46146 Adhesive/Sealant**
- **DOWSIL™ 1-2577 Conformal Coating**

Rubbers

Custom HCR compounds for calendared, extruded, or molded profiles (many)

Many Mil-Specs are called out, and require regular re-certification (internal testing). A/D use typically uses more/thicker. For example, common industry use of DOWSIL™ 1-2577 Conformal Coating is 3-8 mils (2 passes). A/D is 12-20 mils.
DOWSIL™ and SILASTIC™ specialty products

Many of which have been in use since the 1960’s

General purpose tin cures

• DOWSIL™ 90-006 RF Aerospace Sealant
• DOWSIL™ 93-006 RF Sealant
• DOWSIL™ 93-076 RF Aerospace Sealant
• SILASTIC™ RTV-3110 Mold-Making Base
• SILASTIC™ RTV-3112 Mold-Making Base
• SILASTIC™ RTV-3120 Mold-Making Base

Ablatives

• DOWSIL™ 3-6077 RTV Silicone Ablative
• DOWSIL™ 93-104 Silicone Ablative
• DOWSIL™ 93-104 Fast Cure Silicone Ablative
• DOWSIL™ 90-006 RF Aerospace Sealant

Specialized silicones

• DOWSIL™ 3-6891 One-Part Silicone Rubber Abradable
• DOWSIL™ 236 Dispersion Coating
DOWSIL™ specialty products

Many of which have been in use since the 1960’s

Fluorosilicones
- DOWSIL™ 730 FS Solvent Resistant Sealant
- DOWSIL™ Q4-2817 Fluorosilicone Sealant
- DOWSIL™ 94-003 Dispersion Coating
- DOWSIL™ Q4-2805 Fluorosilicone Channel Sealant

Neutral-cure dispersions
- DOWSIL™ 94-003 Dispersion Coating
- DOWSIL™ 92-009 Dispersion Coating

Space grade
- DOWSIL™ 93-500 Space Grade Encapsulant
- DOWSIL™ 93-500 Thixotropic Encapsulant
- DOWSIL™ 6-1104 CV Sealant
- DOWSIL™ 6-1125 CV Sealant

Low temperature
- DOWSIL™ 3-6121 Low Temperature Elastomer
DOWSIL™ specialty products
General purpose tin cures – curable outside and where heat can’t be applied

**DOWSIL™ 93-006 RF Aerospace Sealant**
Moderate-temperature sealing/adhering on aircraft, submarines, ships

**DOWSIL™ 90-006 RF Aerospace Sealant**
High-temperature sealing/adhering, low end ablative, bulkhead sealing

**DOWSIL™ 93-076 RF Aerospace Sealant**
High strength adhering, low end ablative
DOWSIL™ Aerospace sealants - challenges

Shelf life, especially when opened

• Tin can react with humidity and get crusty. Use past shelf life is fairly common.

How to speed cure w/o changing product

• Use faster catalyst (-6, -2, -1/2 = working time)
• “Sprinkle” in 0.1% water
• Heat but no higher than ~ 60°C (why?)

Use as glue for pre-cured silicone sheets

• Need to keep ¼ inch thickness or tin can migrate into cured silicone and slow/stop glue cure. (Or wipe tin catalyst onto cured silicone first.) Use as glue for pre-cured silicone sheets.

Adhesion

• DOWSIL™ PR-1200 Primer
• DOWSIL™ PR-1204 Primer
Quick notes on tin catalysts...

- Because of REACH legislation in Europe, we have had to replace nearly all products containing dibutyl tin dilaurate (DBTDL) with methyl versions.

- DBTDL typically did not show significant reversion (depolymerization) until temperatures were above 150°C in oxygen-deficient environments.

- Methyl tins show reversion starting as low as 80°C.

- While DPS has been very open about this change and have informed all customers, some current or new customers may not grasp the implications. This could lead to performance differences that might be noticed in testing … or not detected/realized on fielded devices.
DOWSIL™ Abradable material
DOWSIL™ 3-6891 One-Part Silicone Rubber Abradable Sealant/Compound

Features

- Addition cure, designed to form an airtight seal in jet engine stators and rub strips
- Abradable = cuts cleanly and easily with no tears
- This is achieved by loading it with hollow glass beads
DOWSIL™ Abradable material
DOWSIL™ 3-6891 One-Part Silicone Rubber Abradable Sealant/Compound

Challenges

- Cure poisoning – standard addition cure
- Pumping/dispensing – abrasive glass, do not want to crush glass

Adhesion

- DOWSIL™ PR-1200 RTV Prime Coat
- DOWSIL™ 92-023 Primer
**DOWSIL™ Ablative materials**

Ablatives form a char when exposed to high temperatures

- **4500°C**: Solid rocket propellant
- **3500°C**: Oxy-acetylene torch
- **2500°C**: Steel melts
- **2000°C**: Flame temp of propane, wood
- **1500°C**: Silicones start to form an insulative char
- **660°C**: Aluminum melts
- **350°C**: Silicones can spontaneously combust
- **300°C**: Silicones last seconds to a few minutes
- **250°C**: Some silicones can last >1000 hrs
- **150°C**: Many silicones have a 10 year UL RTI
- **25°C**: Steel melts

You must get to +1500°C in < a few seconds or there will be nothing left to form a char.

Ablatives are NOT high-temperature stable. They have the same thermal stability as a general silicone: not even rated for high-temperature use.
**DOWSIL™ Ablative materials**

Ablatives form a char when exposed to >1500°C = burned hot

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**DOWSIL™ 93-104 Ablative Material**

**DOWSIL™ 93-104 Fast Cure RTV Ablative**

Ablative performance is about char retention, and that is about heat flux + particle counts. With solid rocket fuel, a Mach 8 sand blaster at 4500°C is created.

These materials:

- Have **super high performance** for rocket engines, direct rocket blast: addition cure with carbon fibers
- May **last 20 seconds** (that is enough), others <5 seconds with solid rocket fuel
- With liquid fuel (few particles) it may **last 30-60 seconds**, others 10 seconds.
DOWSIL™ Ablative materials

Ablatives form a char when exposed to >1500°C = burned hot

**DOWSIL™ 3-6077 RTV Silicone Ablative**
High performance; designed for concrete launch pad sealing: tin cure

**DOWSIL™ 90-006 RF Sealant**
Medium performance; most silicones have some ability based on the nature of the extending filler used in the formulation
**DOWSIL™ Fluorosilicone materials**
(Poly trifluoropropyl (methyl) siloxane)

**DOWSIL™ 730 FS Solvent Resistant Sealant**
**DOWSIL™ Q4-2817 Fluorosilicone Sealant**
**DOWSIL™ 94-003 Dispersion Coating**

**Features**

- **DOWSIL™ 730 FS Sealant:** Acetoxy, fluorosilicone version of DOWSIL™ 732 Multi-Purpose Sealant
- **DOWSIL™ Q4-2817 Sealant:** Higher-temperature stable, higher strength version of DOWSIL™ 730 FS Solvent Resistant Sealant
- **DOWSIL™ 94-003 Coating:** Oxime cure-in solvent as a coating
DOWSIL™ Fluorosilicone materials
(Poly trifluoropropyl (methyl) siloxane)

Challenges
- Will swell in ketones
  (clean up with acetone, MEK, MIBK)
- Better acid stability, but still degrades
- IPA contact can kill/slow the cure (as with any moisture cure)

Adhesion
- DOWSIL™ PR-4040 Prime Coat
- DOWSIL™ PR-1200 RTV Prime Coat

Trivia
What can happen to moisture cures if you expose them to heat before they are fully cured?
Some key temps: +65°C (methoxy cures) +140°C (titanate) +140°C (calcium carbonate)
DOWSIL™ Space grade materials
(Extremely low volatility per ASTM E595)

ASTM E-595
Hold sample 24 hours at 125°C under E-6 torr with a witness plate held at 25°C to collect volatiles.

CV Grade
Low D4-D10
Typical silicone = +2000 ppm
CV grade <500 ppm usually

Space grade
Remove up to L22
Total mass loss (TML) = <1%
Collected volatile condensable material (VCM or CVCM) = <0.1%
Typical silicone TML = 1-2%
VCM = 0.3-0.7%
DOWSIL™ Space grade materials
(Extremely low volatility per ASTM E595)

DOWSIL™ 93-500 Space Grade Encapsulant
DOWSIL™ 93-500 Thixotropic

• First and main use is to glue on cover glass for satellite solar panels
• Also used in high-end telescopes, microscopes, clean rooms

Challenges
• Standard cure poisoning
• Yellowing with heat aging = oxidized Pt

Adhesion
• DOWSIL™ 92-023 Primer
• DOWSIL™ PR-1200 Primer
DOWSIL™ Space grade materials
(Controlled volatilities)

**DOWSIL™ 6-1104 CV Sealant**
**DOWSIL™ 6-1125 CV Sealant**

- Used as general glue, sealant, patches, fixturing
- Also used in high-end telescopes, microscopes, clean rooms

**Challenges**
- Standard moisture cure speed

**Adhesion**
- **DOWSIL™ PR-1204 Primer**
DOWSIL™ Low-temperature elastomer
(Phenyl/methyl)

DOWSIL™ 3-6121 Low Temperature Elastomer

- Two-part addition cure, fairly strong
- Used as a higher-viscosity encapsulant or an adhesive (with a primer)

Challenges
- Standard addition-cure inhibition.
- Relatively low Pt level = slow to cure, easier to inhibit
- Higher viscosity captures bubbles
- Tends to have some impurities that give it a slight yellowish color

Adhesion
- DOWSIL™ PR-1200 Primer
- DOWSIL™ Q1-6132 Primer
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