INTERNATIONAL SPACE STATION WIRE PROGRAM

Todd May
NASA Lyndon B. Johnson Space Center
Houston, Texas

Agenda

- **Introduction**
- **Hardware Provider Wire Systems**
- **Current Wire Insulation Issues**
  - Silicone Wire Contamination
  - Tefzel Cold Temperature Flexibility
  - Russian Polyimide Wire Insulation
- **Conclusion**

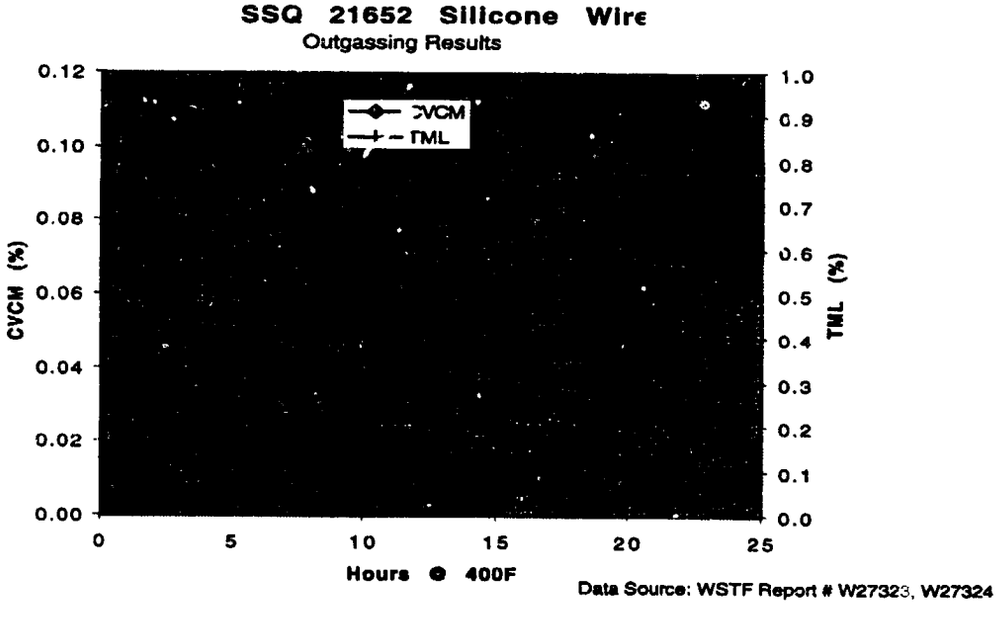
Hardware Provider Wire Systems

	TFE (Teflon)	ETFE (Tefzel)	Silicone	Polyimide (Kapton)	Teflon/ Kapton/ Teflon (TKT)
PG-1 McDonnell Douglas	I	E	E		
PG-2 Rocketdyne		E	E		
PG-3 Boeing Defense & Space Group	I, E	E	E		
Italian Space Agency (ASI)	I, E				I, E
European Space Agency (ESA)	I, E				
Japanese Space Agency (NASDA)	I	E	E		
Canadian Space Agency (CSA)	E	E	E		E
Russian Space Agency (RSA)	I, E			I, E	

I=Internal, E= External

ISS Wire Insulation Issues

- **Silicone wire contamination**
  - **McDonnell Douglas baselined silicone wire for truss power applications because of its flexibility**
  - **Wire passes JSC-SP-R-0022 (ASTM E 595) thermal vacuum stability testing requirements**
    - At elevated cure (24 hr. @400F)
    - TML = .123
    - CVCM =.018
  - **Due to large usage (1X10^6 cm^2.) material significantly fails integated outgassing deposition rate requirements (MOLFLUX)**
    - Required Rate <= 1X10^{-14} g/cm^2/s
    - Calculated Rate = 2X10^{-11} g/cm^2/s
  - **PG-1 has developed Project Directive #130 to limit use of silicone wire for ISS applications**
  - **Current plan is to use Tefzel wire with spliced silicone pigtails**
    - Splicing design under evaluation
    - ISS Program requirements for splicing being established



Data Source: WSTF Report # W27323, W27324

ISS Wire Insulation Issues (cont.)

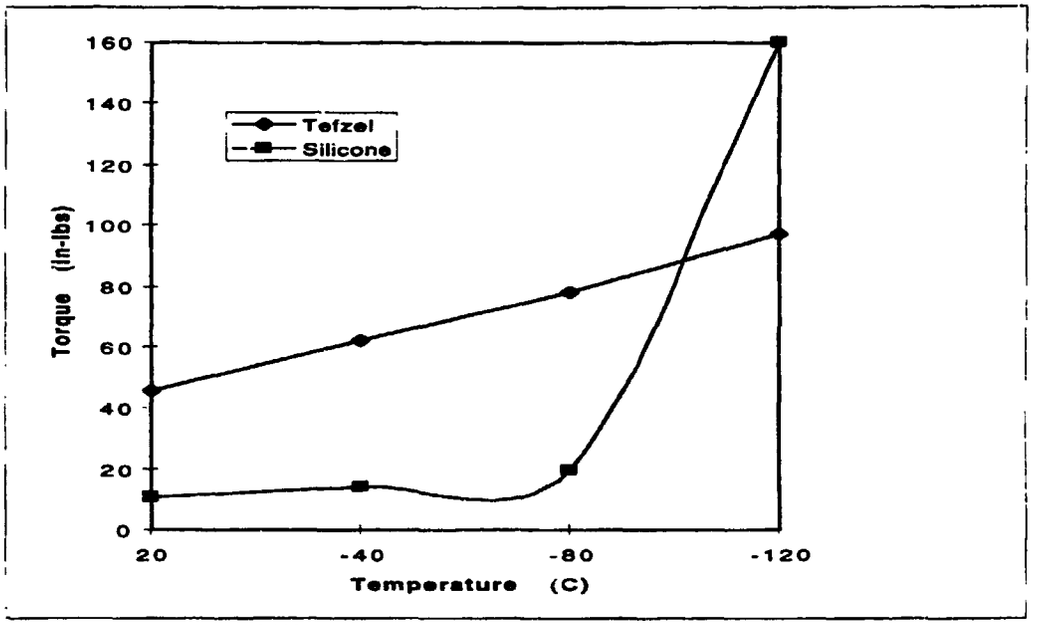
	Silicone	Silicone (baked)	Tefzel	Silicone (wrapped)
Measured 25C dep. rate (g/cm2sec)	6.0E-10	8.0E-11	8.0E-12	3.0E-13
@ measurement time (hr.)	10	77	110	87
View factor to QCM	.6	.6	.6	.6
Outgassing rate (g/cm2sec)	1.0E-9	1.3E-10	1.3E-11	5.0E-13
Total cable area assumed (cm2)	1.1E6	1.1E6	1.1E6	1.1E6
Avg. dep. on ATCS radiator (g/cm2sec)	9.0E-12	1.2E-12	1.2E-13	4.5E-15
Dep. on attached payload (g/cm2sec)	2.0E-11	2.6E-12	2.6E-13	1E-14

Source: JSC/ES5/M. Pedley

- **Tefzel cold temperature flexibility**
  - **Tefzel known to have less flexibility than silicone wire at room temperature, however silicone has Tg at approx -110C**
  - **Recent thermal vacuum tests revealed that at very cold temperatures (-100F), astronauts could not manipulate test wire harnesses**
    - "Freezes" in cooling/conditioning position
    - No "memory" when heated back to room temperature
  - **McDonnell Douglas parametric studies**
  - **More parametric studies planned (function of temperature)**
  - **STS 72 flight experiment planned**
    - 9 configurations of silicone and Tefzel wire
    - -60F to -80F

ISS Wire Insulation Issues (cont.)

Power Cable Cold Bend Tests



Maximum Torque to bend 180 degrees
(Single 1/0 wire, 11" moment)

Tefzel EVA Handling Tests

Harness Contents:	Total dia.	-120C	-100C	-75C	-50C	-25C	0C	25C
2ea. @ 4ga. 1ea. @ 8ga.	0.681	*	*	*	*	*	*	*
7ea. @ 8ga.	0.907	*	*	*	*	*	*	*
4ea. @ 4ga. 2ea. @ 8ga.	0.994						*	*
2ea. @1/0ga. 1ea. @ 4ga.	1.090							
4ea. @1/0ga.	1.374							

Shaded : Unnacceptable
Unshaded: Acceptable
*** : Operation could be performed with one hand**
Source: MDSSC Technical Report #9500837

ISS Wire Insulation Issues (cont.)

- Russians revealed February 1995 that they intend extensive use of polyimide wire
- Russian polyimide wire testing at WSTF for arc-tracking
  - Standard NHB 8060.1 Test 18
    - 200V AC
  - Nonstandard testing (DC)
    - 5 to 120V, 9 to 300A
- Russian comments to NHB 8060.1 Test Methods
  - Why AC for DC systems?
  - Wire cutting technique
  - Arc initiation method (induced failure)
- Russian circuit protection philosophy
  - Physical separation of +/- wires
  - Floating ground
  - Quick-blow fuses
- Russian wire characteristics
  - 48 Extruded layers (1.5 μm ea.)
  - Small gages only (<= 20 gauge)

SSQ Status

Spec. Number	Title	Insulation Materials	Remarks
SSQ 21652	Wire and Cable, Electric, Silicone-Insulated, Nickel Coated Cu or Cu Alloy, General Specification for	Silicone	
SSQ 21653	Cable, Coaxial, Twinaxial, and Triaxial, Flexible and Semirigid, General Specification for	Teflon (TFE) Teflon (FEP)	
SSQ 21654	Cable, Single Fiber, Multimode, Space Quality, General Specification for	Fiber Optic	
SSQ 21655	Cable, Electrical, MIL-STD-1553 Data Bus, Space Quality, General Specification for	Teflon (TFE) Teflon (FEP)	
SSQ 21656	Wire and Cable, Electric, Fluoropolymer-Insulated, Nickel Coated Cu or Cu Alloy, General Specification for	Teflon (TFE) Teflon (FEP) Tefzel (ETFE)	

Conclusion

- ISS is a complex program with hardware developed and managed by many countries and 100s of contractors
- Most of the obvious wire insulation issues are known by contractors and have been precluded by proper selection
- New issues will continue to arise as Program progresses
- We'll keep charging the windmills until they are all defeated