NASA-STD-8739.11 Tutorial
Section H1
Heaters

Prepared by Joe Rosol, GSFC Code 561/Genesis Engineering

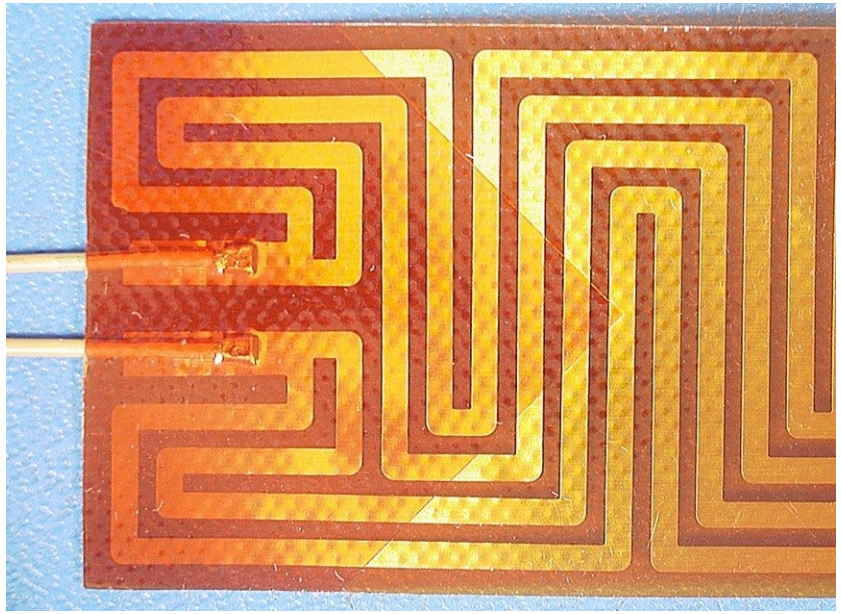
August 11, 2025

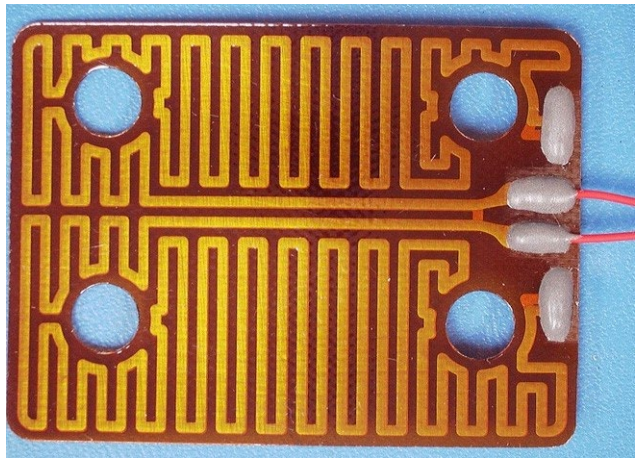
Acronyms

AWG	American Wire Gauge
°C	Degrees Celsius
COTS	Commercial Off The Shelf
ETW	Electronics Technology Workshop
FEP	Fluoroethylene Propylene
GSFC	Goddard Space Flight Center
H1	Heater Section Designator in the Screening Document
IN	Inch
LAT	Lot Acceptance Test
MIL-STD	Military Standard
NASA-STD	National Aeronautics and Space Administration Standard
SCD	Source Control Drawing
W	Watts

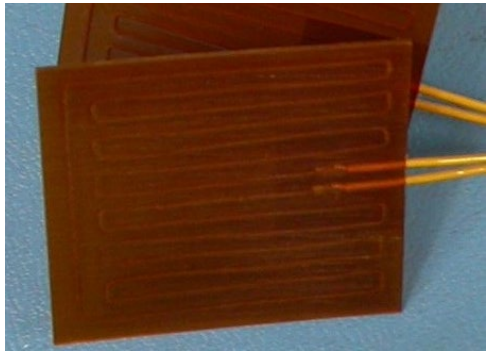
Heater Description

- Resistive conductors encased in flexible dielectric films. They are designed to transfer the most heat to its mounting surface without damaging the heater assembly. Conductor types: etched foil, flat or helical, embedded wire coil.







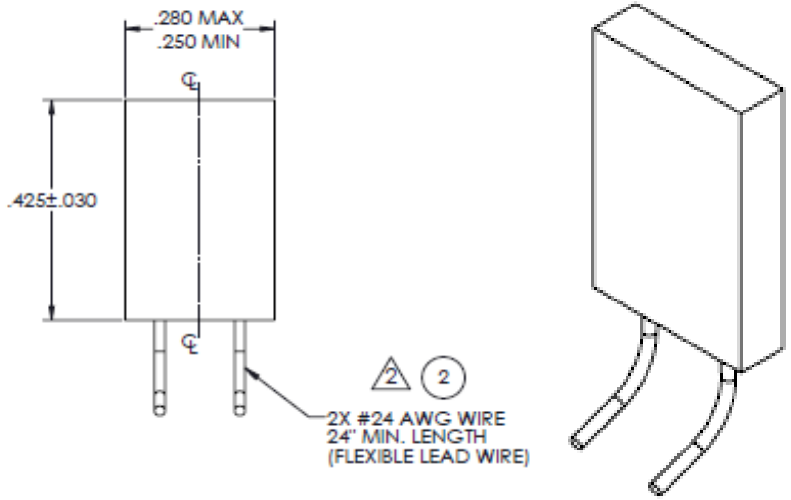




All Graphics By Code 561

Heater Exception

- Resistance wires in potted metal housings are not covered in Section H1. Due to their higher heat density, these parts may be handled as resistors with a non-intended specific application. Screening and lot acceptance test protocols should be determined by a Parts Control Board accordingly, to demonstrate reliable operation in the intended application.







All Graphics By Code 561

Key Considerations

- Aluminum or metallic foil adhering to the top surface of heater is not recommended
- Polyimide materials are porous and will absorb moisture or a gas that may lead to voids in the polyimide layers during operation
- Mounting materials and techniques are best left to the end user. It's recommended to purchase the heaters without pressure-sensitive adhesives so processes can be closely controlled.
- New heater designs should use the new GSFC 311 specifications for screening/Lot Acceptance Test (LAT) flows. Use of the S311P079 is not recommended for newer designs. The following replacements are based on their construction techniques:
  - S311P839: Fluoroethylene Propylene (FEP) Adhesive, Operating Range: -65°C to 200°C; 3.5 W/in^2
  - S311P840: Thermosetting Acrylic Adhesive, Operating Range: -65°C to 150°C; 2.5 W/in^2
  - S311P841: All Polyimide Construction, adhesiveless, Operation Range: -65°C to 220°C; 4.5 W/in^2

Major Changes from EEE-INST-002

- The three heater types are listed separately and a fourth category covering *All Heaters*, covered by a Source Control Drawing (SCD), or considered commercial. The word “Commercial” not used in this revision.
- Four assurance levels are covered, adding (Commercial Off The Shelf) COTS
- If using an underside metallic heat spreader, derate to 75% of the maximum manufacturer rated heater power
- Under assurance Level 3 screening, the burn-in time is reduced from 48 hours to 15 minutes
- Thermal shock screening MIL-STD-202, Method 107, changed from Condition D to C (to match operational temperature ranges for the heater)

Send email to address below for questions

Joseph.L.Rosol@nasa.gov

Requirements

Table 1. HEATER REQUIREMENTS 1/

Assurance Level	Heater Type	Specification /2	Use as Is	Screening	LAT	DPA
Level 1	Polyimide-FEP Adhesive Construction	GSFC S-311-P-839 /3				X
	Polyimide-Acrylic Adhesive Construction	GSFC S-311-P-840 /3				X
	All-Polyimide (Adhesiveless) Construction	GSFC S-311-P-841				X
	All Heaters	SCD		X	X	X
Level 2	Polyimide-FEP Adhesive Construction	GSFC S-311-P-839 /3	X			
	Polyimide-Acrylic Adhesive Construction	GSFC S-311-P-840 /3	X			
	All-Polyimide (Adhesiveless) Construction	GSFC S-311-P-841	X			
	All Heaters	SCD		X	X	X
Level 3	Polyimide-FEP Adhesive Construction	GSFC S-311-P-839 /3	X			
	Polyimide-Acrylic Adhesive Construction	GSFC S-311-P-840 /3	X			
	All-Polyimide (Adhesiveless) Construction	GSFC S-311-P-841	X			
	All Heaters	SCD, Commercial /4		X		X

Notes:

1/ The character "X" designates a requirement.

2/ Most heaters for space and military applications are custom-designed for the intended application to an SCD, with construction and test requirements to the applicable GSFC specification.

DRAFT

Requirements

Table 2. HEATER SCREENING 1/ 2/

Inspection/Test	Test Methods, Conditions, and Requirements	Assurance Level		
		Level 1	Level 2	Level 3
1.Visual and Mechanical Inspection	Verify material construction, design, marking, and workmanship. Verify conformance to mechanical dimensions on a sample.	X	X	X
2. Initial Electrical Measurements	DC Resistance (DCR): MIL-STD-202, Method 303 at 25 °C ± 5 °C measured between heater leads.	X	X	
	Dielectric Withstanding Voltage: MIL-STD-202, Method 301 at 500 Vrms for 1 minute between the element and conductive plates in contact with the outer surface of the heater.			
	Insulation Resistance: MIL-STD-202, Method 302, Test Condition B at 25 °C ± 5 °C.			
3. Thermal Shock	MIL-STD-202, Method 107, Test Condition C, but not to exceed the max or min storage temperature of the detailed specification.	X	X	
4. Voltage Conditioning (Burn-In)	Heaters shall be conditioned by suspension in still air at 25 °C ± 5 °C by their terminal leads. The applied voltage shall be the voltage required to reach either the maximum operating temperature or the maximum rated power density per the detailed specification, whichever is lower. For dual element heaters, both elements shall be powered simultaneously. Cycled testing, with voltage applied in cycles of 1.5 hours "ON" and 0.5 hours "OFF," is preferred but continuous applied voltage is allowed. The "OFF" cycles are included in the total test duration time.	X 168hr	X 96hr	R 15min
5. Final Electrical Measurements	DC Resistance (DCR): MIL-STD-202, Method 303 at 25 °C ± 5 °C measured between heater leads.	X	X	X
	Dielectric Withstanding Voltage: MIL-STD-202, Method 301 at 500 Vrms for 1 minute between the element and conductive plates in contact with the outer surface of the heater.			
	Insulation Resistance: MIL-STD-202, Method 302, Test Condition B at 25 °C ± 5 °C.			
6. Percent Defective Allowable (PDA)	Verified failures from Steps 3 through 5 divided by number of units tested. Failures at initial visual inspection and initial electrical test do not count towards PDA calculation.	≤5%	≤10%	
7. Visual Inspection	Heaters shall be free of any defects affecting life, serviceability, or performance.	X	X	X

Notes:

1/ The character "X" designates a requirement. The character "R" designates a recommendation.

2/ User should refer to the nearest equivalent GSC specification listed in Table 1 for more detailed definition of testing requirements, minimum and maximum values for each parameter (pass/fail criteria), and delta criteria.

Table 3. HEATER LOT ACCEPTANCE TEST 1/ 2/

Inspection/Test	Test Methods, Conditions, and Requirements	Quantity (Accept Number)	
		Level 1	Level 2
Group 1		10(0)	5(0)
Low-Temperature Operation	The unmounted heaters shall be placed in a chamber at -65 °C or minimum operating temperature of the detailed specification, and after one-hour stabilization at this temperature, full-rated continuous power shall be applied for 45 minutes. Fifteen minutes after removal of power, the heaters shall be brought to 25 °C ± 5 °C in a period not exceeding 8 hours. DC resistance shall be measured after approximately 24 hours. The change in DCR shall not exceed ±1% and there shall be no evidence of physical damage.	X	X
Lead Pull Strength	MIL-STD-202, Method 211, Test Condition A at 3 lbs. (1.36 kg). There shall be no loosening or fracturing of the lead attachment and no delamination of the heater element. The change in DCR shall not exceed ±1%.	X	X
Group 2		10(0)	5(0)
Life	Heaters shall have full rated power applied for 1000 hours while suspended in still air at 25 °C ± 5 °C. The applied voltage shall be the voltage required to reach either the maximum operating temperature or the maximum rated power density per the detailed specification, whichever is lower. For dual element heaters, both elements shall be powered simultaneously. Cycled testing, with voltage applied in cycles of 1.5 hours "ON" and 0.5 hours "OFF", is preferred but continuous applied voltage allowed. The "OFF" cycles are included in the total test duration time. There shall be no evidence of physical damage, including blistering, delamination, or bubbles. The change in DCR shall not exceed ±1%, the insulation resistance shall not decrease, and the DWV leakage current shall not exceed 1 mA.	X	X
Group 3		2(0)	2(0)
Thermal Vacuum Outgassing 3/	All construction materials must meet outgassing requirements of 1.0% TML maximum and 0.1% CVCM maximum, when tested in accordance with ASTM-E595.	X	X

Notes:

1/ Samples selected for LAT shall have successfully completed screening tests per Table 2.

2/ Generic data may be used in lieu of testing as long as the data is obtained on parts built to the applicable GSFC specification, using the same materials and similar construction and design, and built in the same manufacturing facility within 2 years of the lot date code for the flight lot.

3/ In lieu of test, the manufacturer may submit prior outgas test data for identical or similar product that uses the same construction materials, provided the specified requirement and test method are met.

DRAFT DRAFT