



**RESISTORS, HEATER, FLEXIBLE, SINGLE AND
DOUBLE LAYER**

BASED ON TYPE FHK

ESCC Detail Specification No. 4009/003

Issue 4	June 2019
---------	-----------



LEGAL DISCLAIMER AND COPYRIGHT

European Space Agency, Copyright © 2019. All rights reserved.

The European Space Agency disclaims any liability or responsibility, to any person or entity, with respect to any loss or damage caused, or alleged to be caused, directly or indirectly by the use and application of this ESCC publication.

This publication, without the prior permission of the European Space Agency and provided that it is not used for a commercial purpose, may be:

- copied in whole, in any medium, without alteration or modification.
- copied in part, in any medium, provided that the ESCC document identification, comprising the ESCC symbol, document number and document issue, is removed.

DOCUMENTATION CHANGE NOTICE

(Refer to <https://escies.org> for ESCC DCR content)

DCR No.	CHANGE DESCRIPTION
1228	Specification upissued to incorporate changes per DCR.

TABLE OF CONTENTS

1	GENERAL	5
1.1	SCOPE	5
1.2	APPLICABLE DOCUMENTS	5
1.3	TERMS, DEFINITIONS, ABBREVIATIONS, SYMBOLS AND UNITS	5
1.4	THE ESCC COMPONENT NUMBER AND COMPONENT TYPE VARIANTS	5
1.4.1	The ESCC Component Number	5
1.4.2	Component Type Variants and Range of Components	5
1.4.3	Manufacturer Specific Heater Identification	6
1.5	MAXIMUM RATINGS	7
1.6	PHYSICAL DIMENSIONS AND HEATER OUTLINE	7
1.7	MATERIALS AND FINISHES	9
1.7.1	Heater Resistive Element	9
1.7.2	Protective Coating	9
1.7.3	Terminal Leads	9
1.7.4	Optional Materials	9
2	REQUIREMENTS	10
2.1	GENERAL	10
2.1.1	Deviations from the Generic Specification	10
2.2	MARKING	10
2.3	ROBUSTNESS OF TERMINATIONS	10
2.4	ELECTRICAL MEASUREMENTS AT ROOM, HIGH AND LOW TEMPERATURES	11
2.4.1	Room Temperature Electrical Measurements	11
2.4.2	High and Low Temperatures Electrical Measurements	11
2.5	INTERMEDIATE AND END-POINT ELECTRICAL MEASUREMENTS	12
2.6	BURN-IN CONDITIONS	13
2.7	OPERATING LIFE CONDITIONS	13
	APPENDIX A	14

1 GENERAL

1.1 SCOPE

This specification details the ratings, physical and electrical characteristics, and test and inspection data for the component type variants and/or the range of components specified below. It supplements the requirements of, and shall be read in conjunction with, the ESCC Generic Specification listed under Applicable Documents.

1.2 APPLICABLE DOCUMENTS

The following documents form part of this specification and shall be read in conjunction with it:

- (a) ESCC Generic Specification No. 4009.
- (b) ASTM-D5213: Standard Specification for Polymeric Resin Film for Electrical Insulation and Dielectric Applications.
- (c) IPC4203/1: Adhesive Coated Dielectric Films for Use as Cover Sheets for Flexible Printed Circuitry and Flexible Adhesive Bonding Films.

1.3 TERMS, DEFINITIONS, ABBREVIATIONS, SYMBOLS AND UNITS

For the purpose of this specification, the terms, definitions, abbreviations, symbols and units specified in ESCC Basic Specification No. 21300 shall apply.

1.4 THE ESCC COMPONENT NUMBER AND COMPONENT TYPE VARIANTS

1.4.1 The ESCC Component Number

The ESCC Component Number shall be constituted as follows:

Example: 400900301XYZ1234

- Detail Specification Reference: 4009003
- Component Type Variant Number: 01 (as required)
- Manufacturer Specific Heater Identification: XYZ1234 (as applicable) where:
 - A: First letter of the applicable Manufacturer's name
 - XYZ1234: A unique reference allocated by the Manufacturer to a specific heater design.

1.4.2 Component Type Variants and Range of Components

The component type variants and range of components applicable to this specification are as follows:

Variant Number	Insulation Type (Note 1)	Physical Configuration & Electrical Characteristics	Rated Power Density (W/cm ²) (Note 3)	Maximum Operating / Storage Temperature (°C) (Note 3)	Weight Max (g)
01	Polyimide Film/Acrylic Adhesive	See Note 2	0.38	+150	See Note 4
02	Polyimide Film/FEP	See Note 2	0.54	+200	See Note 4
03	Polyimide Film/FEP plus Acrylic Adhesive Patch	See Note 2	0.38	+150	See Note 4

NOTES:

1. See Para. 1.7.2.
2. Available options including the specification of the physical configuration and the electrical characteristics for a specific heater design are as follows:

Physical Configuration		Available Options
Heating Area S (cm ²)		0.26 to 1000 (see Para. 1.6)
Number of Heater Resistive Elements and Heater Layers		1 Element, Single Layer
		2 or more Elements, Single Layer
		2 Elements, Double Layer (2 elements, 1 element circulating in each layer)
		1 Element, Double Layer (1 element circulating in both layers)
Terminal Leads		Configuration
		Wire Gauge (AWG)
		Length
		Heater Backing
		Pressure Sensitive Adhesive (with Release Liner)

Electrical Characteristics	Available Options
Resistance Range (Ω)	1 to 5000
Resistance Tolerance (\pm %)	1 to 10
Resistance Density (Ω/cm^2)	0.1 to 70

Other Characteristics	Available Options
Non-Magnetic Heater Resistive Element	Not Applied
	Applied (see Para. 1.7.1)

3. See Para. 1.5.
4. The maximum weight of the heaters, excluding the weight of the terminal leads, shall be:
 - 50 mg/cm² for single layer heaters
 - 75 mg/cm² for double layer heaters
 - Add 30 mg/cm² for heater backing
 - Add 10 mg/cm² for pressure sensitive adhesive

The weight of the terminal leads shall be as specified in the applicable wire ESCC Detail Specification.

1.4.3 Manufacturer Specific Heater Identification

A Heater Design Drawing shall be produced by the Manufacturer after negotiation with the Orderer, and shall be held under configuration control by the Manufacturer who will allocate a unique Manufacturer Specific Heater Identification when a request for a heater is received.

Each Heater Design Drawing shall detail the selected options applicable to the heater design, as specified in Component Type Variants and Range of Components, and include the following information as a minimum:

- (a) The heater outline and dimensions as required by Para. 1.6 Physical Dimensions and Heater Outline herein. This shall include details for the heater layer(s) and heater resistive

- element(s), as well as specify the terminal leads' configuration and identification, plus the angle of exit of each terminal lead with respect to the heater body.
- (b) The ESCC Component Number for the heater, including the Manufacturer Specific Heater Identification (see Para. 1.4.1).
 - (c) The terminal leads' ESCC Detail Specification and ESCC Component Number.
 - (d) The heater electrical information as follows:
 - Resistance value R_n and tolerance by circuit at $T_{amb} = +22 \pm 3^\circ\text{C}$.
 - Maximum rated power in still air at $T_{amb} = +25^\circ\text{C}$.
 - (e) Track width and spacing with tolerances.
 - (f) Heater backing details (if fitted)
 - (g) Pressure sensitive adhesive details (if fitted).
 - (h) If a non-magnetic heater resistive element is specified or not (the heater resistive element material)

1.5 MAXIMUM RATINGS

The maximum ratings shall not be exceeded at any time during use or storage.

Maximum ratings shall only be exceeded during testing to the extent specified in this specification and when stipulated in Test Methods and Procedures of the ESCC Generic Specification.

Characteristics	Symbols	Maximum Ratings	Units	Remarks
Rated Power Density Variants 01, 03 Variant 02	P_n	0.38 0.54	W/cm ²	Notes 1, 2, 3, 5 Notes 1, 2, 4, 5
Rated Voltage	U_R	$\sqrt{(P_n \cdot R_n \cdot S)}$	V	Notes 2, 6
Operating Temperature Range Variants 01, 03 Variant 02	T_{op}	-65 to +150 -65 to +200	°C	T_{amb} Note 3 Note 4
Storage Temperature Range Variants 01, 03 Variant 02	T_{stg}	-65 to +150 -65 to +200	°C	

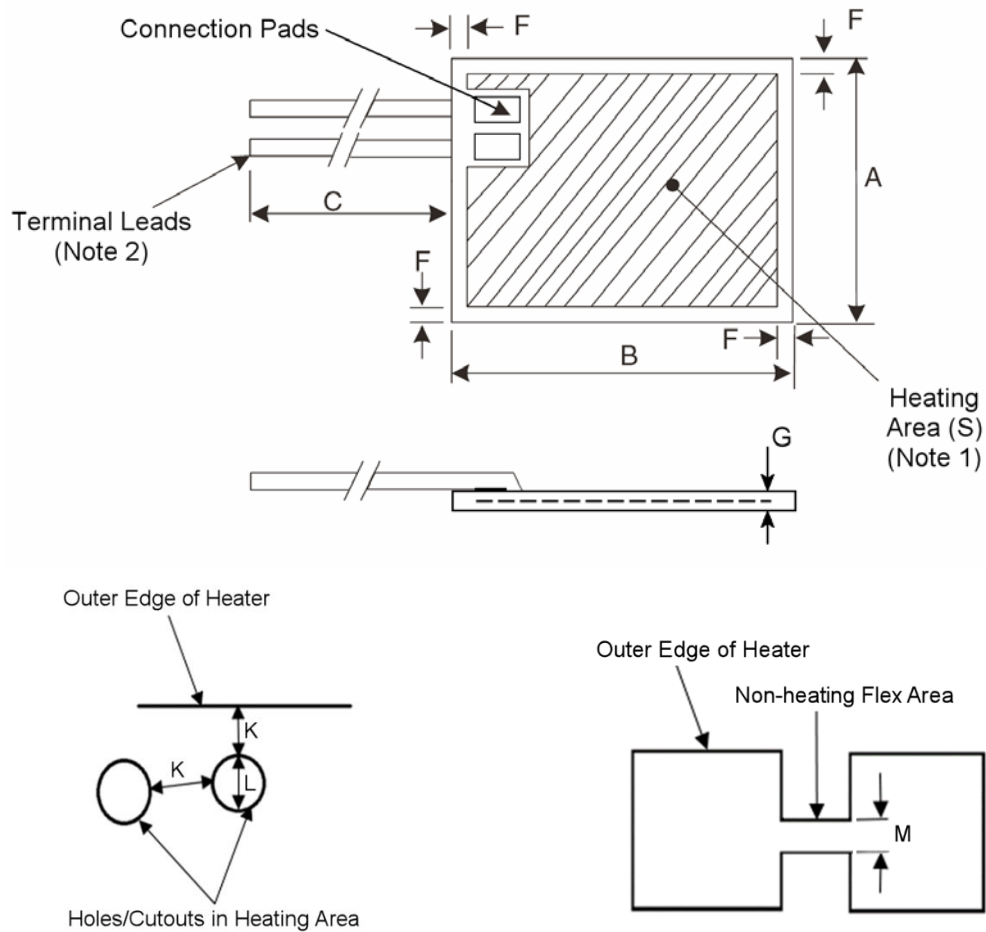
NOTES:

1. With heater suspended in still air at $T_{amb} \leq +25^\circ\text{C}$
2. Actual rated power shall be specified in the applicable Heater Design Drawing. It shall be determined from the Heating Area (S) in cm².
3. Derate to 0W/cm² at 0.00304W/cm²/°C for $+25^\circ\text{C} < T_{amb} \leq +150^\circ\text{C}$.
4. Derate to 0W/cm² at 0.00308W/cm²/°C for $+25^\circ\text{C} < T_{amb} \leq +200^\circ\text{C}$.
5. The following design rule shall be applied:
 - Area of Heater Resistive Element / Heating Area (S) = 45% to 55%
6. R_n is the nominal resistance.

1.6 PHYSICAL DIMENSIONS AND HEATER OUTLINE

The general physical dimensions and heater layout shall be as follows. The shape, layout and configuration of the heater may be customised within the limitations specified herein. The physical

dimensions and heater layout applicable to a specific heater will be specified in the Heater Design Drawing held by the Manufacturer.



Symbols	Dimensions mm		Tolerance	Remarks
	Min	Max		
A	3.8	250	As specified in the Heater Design Drawing	Note 1
B	3.8	400	As specified in the Heater Design Drawing	Note 1
C	150	-	As specified in the Heater Design Drawing	Note 2
F	0.76	-	-	Notes 3, 4
G	-	0.2	-	Notes 5, 6
	-	0.3	-	Notes 5, 6
K	3.5	-	-	Note 4
L	1	-	-	Note 4
M	3.5	-	-	Note 7

NOTES:

1. The Heating Area, S, is defined as the total area of the heater excluding the peripheral margin and the terminal leads connection pads area. The acceptable limits of S are specified in Para. 1.4.2.

2. The terminal leads' configuration, wire gauge and lead length options are specified in Para. 1.4.2.
3. Peripheral margin dimension between the outer edge of the heater and the heater resistive element.
4. Internal holes or cut-outs are allowed within the Heating Area, S, provided that the distance between the edge of any hole and the heater resistive element is equal to or greater than dimension F. Dimension K represents the distance from the edge of a hole/cut-out to the outer edge of the heater or between 2 holes/cut-outs. Dimension L represents the hole/cut-out minimum diameter.
5. The maximum limit does not apply over the terminal lead connection pad area.
6. Add 0.1mm for heater backing, if fitted. Add 0.06mm for pressure sensitive adhesive (excluding the release liner), if fitted.
7. Dimension M represents the minimum width of a non-heating flex connection (that does not contain any heater resistive element) between separate heating zones of the heater.

1.7 MATERIALS AND FINISHES

1.7.1 Heater Resistive Element

The heater resistive element shall be made of nickel/chromium/iron alloy.

When the heater is specified as non-magnetic, the heater resistive element shall be made of nickel/chromium alloy.

1.7.2 Protective Coating

Heater resistive elements and the terminal lead connection pad area shall be completely covered with insulation. The insulation type, as is specified in Para. 1.4.2 Component Type Variants and Range of Components, shall be as follows:

- Variant 01: Polyimide Film/Acrylic Adhesive: in accordance with IPC4203/1.
- Variant 02: Polyimide Film/FEP: in accordance with ASTM-D5213.
- Variant 03: Polyimide Film/FEP plus Acrylic Adhesive Patch: Heater resistive elements shall be completely covered with Polyimide Film/FEP accordance with ASTM-D5213. The terminal lead connection pad area shall be completely covered with a patch of polyimide film/acrylic adhesive in accordance with IPC4203/1.

1.7.3 Terminal Leads

Terminal leads shall be made of multi-strand silver-plated copper in accordance with ESCC Generic Specification No. 3901. The applicable Heater Design Drawing shall specify the wire ESCC Detail Specification and the wire ESCC Component Number. The wire gauge shall be as specified in Para. 1.4.2 Component Type Variants and Range of Components herein. Terminal leads shall be electrically welded to the heater resistive element.

1.7.4 Optional Materials

- (a) Heater Backing (if fitted): Al foil, 76.2µm thickness.
- (b) Pressure Sensitive Adhesive (if fitted): as specified in the PID. Pressure sensitive adhesive shall be considered as an accessory to the heater. The use of pressure sensitive adhesive may reduce the operating and storage temperature range of the heater. Pressure sensitive adhesive will have a limited shelf life.

2 REQUIREMENTS

2.1 GENERAL

The complete requirements for procurement of the components specified herein are as stated in this specification and the ESCC Generic Specification. Permitted deviations from the Generic Specification, applicable to this specification only, are listed below.

Permitted deviations from the Generic Specification and this Detail Specification, formally agreed with specific Manufacturers on the basis that the alternative requirements are equivalent to the ESCC requirement and do not affect the component's reliability, are listed in the appendices attached to this specification.

2.1.1 Deviations from the Generic Specification

2.1.1.1 *Deviations from Screening Tests - Chart F3*

- (a) For heaters where the Heater Design Drawing requires the application of pressure sensitive adhesive, the following additional steps shall be performed during Screening Tests:
- An additional 100% External Visual Inspection shall be performed after successful completion of High and Low Temperatures Electrical Measurements.
 - After successful completion of the additional External Visual Inspection the pressure sensitive adhesive shall be applied to the heater.

NOTE:

For heaters which already have heater backing applied, the additional External Visual Inspection shall not be performed.

2.2 MARKING

The marking shall be in accordance with the requirements of ESCC Basic Specification No. [21700](#) and as follows.

The information to be marked on the component or its primary package shall be:

- The ESCC qualified components symbol (for ESCC qualified components only).
- The ESCC Component Number (see Para. 1.4.1).
- Traceability information.

2.3 ROBUSTNESS OF TERMINATIONS

The test conditions for Robustness of Terminations shall be as specified in the ESCC Generic Specification and as follows and apply to a single lead at a time:

Test Condition	Wire Gauge (AWG)					
	20	22	24	26	28	30
Pull Strength (N)	45	36	22	13	9	4.5
Duration (s) minimum	5	5	5	5	5	5

2.4 ELECTRICAL MEASUREMENTS AT ROOM, HIGH AND LOW TEMPERATURES

Electrical measurements shall be performed at room, high and low temperatures.

2.4.1 Room Temperature Electrical Measurements

The measurements shall be performed at $T_{amb} = +22 \pm 3^{\circ}\text{C}$.

Characteristics	Symbols	Test Method and Conditions	Tolerance (\pm %)	Limits		Units
				Min	Max	
Resistance	R_A	ESCC No. 4009	1 to 10 (1)	$R_n - T\%$	$R_n + T\%$	Ω
Insulation Resistance	R_I	ESCC No. 4009	All	1000	-	$M\Omega$
Voltage Proof Leakage Current	I_L	ESCC No. 4009 Test Voltage = 500Vrms	All	-	1 or (2) 5	mA $\mu\text{A}/\text{cm}^2$

NOTES:

- Where T is the applicable tolerance.
- Whichever is greater based on the Heating Area (S).

2.4.2 High and Low Temperatures Electrical Measurements

Characteristics	Symbols	Test Method and Conditions (Note 1)	Limits		Units
			Min	Max	
Resistance Change between $+22 \pm 3^{\circ}\text{C}$ and $-65 (+3 -0)^{\circ}\text{C}$	$\Delta R_A/R_A(L)$	ESCC No. 4009	0	-1.57	%
Resistance Change between $+22 \pm 3^{\circ}\text{C}$ and $+150 (+0 -3)^{\circ}\text{C}$	$\Delta R_A/R_A(H)$	ESCC No. 4009 Variants 01, 03 only	0	+2.29	%
Resistance Change between $+22 \pm 3^{\circ}\text{C}$ and $+200 (+0 -3)^{\circ}\text{C}$	$\Delta R_A/R_A(H)$	ESCC No. 4009 Variant 02 only	0	+3.17	%

NOTES:

- The measurements shall be performed during Screening Tests on a sample of 3 components. In the event of any failure a 100% inspection shall be performed.

2.5 INTERMEDIATE AND END-POINT ELECTRICAL MEASUREMENTS

Unless otherwise specified, the measurements shall be performed at $T_{amb} = +22 \pm 3^{\circ}\text{C}$.

The test methods and test conditions shall be as per the corresponding test defined in Para. 2.4.1 Room Temperature Electrical Measurements.

Test Reference per ESCC No. 4009	Characteristics	Symbols	Limits		Units	
			Min	Max		
Robustness of Terminations Initial Measurements	Resistance	R_A	Note 1			
	Final Measurements	R_A	Note 1			
	Change in Resistance	$\Delta R_A/R_A$	-1	+1		%
Climatic Sequence Initial Measurements	Resistance	R_A	Note 1			
	Final Measurements	R_A	Note 1			
	Change in Resistance	$\Delta R_A/R_A$	-1	+1		%
	Insulation Resistance	R_i	Note 1			
	Voltage Proof Leakage Current	I_L	Note 1			
Operating Life Initial Measurements (0 hours)	Resistance	R_A	Note 1			
	Intermediate Measurements (1000 hours)	R_A	Note 1			
	Change in Resistance	$\Delta R_A/R_A$	-1.4	+1.4		%
	Final Measurements (2000 hours)	R_A	Note 1			
	Change in Resistance (related to 0 hours)	$\Delta R_A/R_A$	-2	+2		%
	Insulation Resistance	R_i	Note 1			
Voltage Proof Leakage Current	I_L	Note 1				

NOTES:

1. As specified in Room Temperature Electrical Measurements.

2.6 BURN-IN CONDITIONS

Characteristics	Symbols	Test Conditions	Units
Heater Temperature Variants 01, 03: Variant 02:	T_{HTR}	+150 (Note 1) +200 (Note 1)	°C
Power Density Variants 01, 03: Variant 02:	P_n	0.38 (Note 1) 0.54 (Note 1)	W/cm ²

NOTES:

1. Voltage shall be applied until either the specified heater temperature or the power density is reached.

2.7 OPERATING LIFE CONDITIONS

The conditions shall be as specified in Para. 2.6 for Burn-in.

APPENDIX A
AGREED DEVIATIONS FOR MINCO (F)

ITEMS AFFECTED	DESCRIPTION OF DEVIATIONS
Para. 2.1.1.1 Deviations from Screening Tests - Chart F3	Serialisation: A 100% serialisation, performed prior to Screening Tests with subsequent Electrical Measurements at Room, High and Low Temperatures performed read and record, is optional at the Manufacturer's discretion.
	Para. 8.2, Rapid Change of Temperature: Mounting: Heaters may be mounted using any suitable method. Test Method: As specified in MINCO instruction IP59 Programmation Chocs Thermique ESCC. Data Points: Electrical measurements during and after testing are optional at the Manufacturer's discretion.
	Para. 8.3, Overload: Data Points: Electrical measurements after testing are optional at the Manufacturer's discretion.
Para. 2.2 Marking	When marking of the heater body is not possible, the marking may be performed on a Kapton tape label applied to the heater leads.