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RESISTORS, HEATERS, FLEXIBLE, SINGLE LAYER

BASED ON TYPE HFF

ESCC Detail Specification No. 4009/006

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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](#).

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: 400900601A123456

- Detail Specification Reference: 4009006
- Component Type Variant Number: 01 (as required)
- Manufacturer Specific Heater Identification: A123456 (as applicable; see Para. 1.4.3) where:
 - A: First letter of the applicable Manufacturer's name
 - 123456: A unique 6-digit number, sequentially allocated by the applicable 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	Terminal Leads (Note 1)		Resistance Range R_n (Ω)	Resistance Tolerance ($\pm$ %)	Heating Area S (cm^2) (Note 2)	Resistance Density (Ω/cm^2)	Temperature Coefficient ($10^{-6}/^\circ\text{C}$) (Note 3)	Weight Max (mg/cm^2) (Note 4)
	Wire Gauge (AWG)	Configuration						
01	18	Unjacketed Twisted Pair	$2 \leq R_n \leq 2000$	5	$3 \leq S \leq 1020$	≤ 30	± 50	50
			$1 \leq R_n \leq 2000$	10				
02	20	Unjacketed Twisted Pair	$3 \leq R_n \leq 2000$	5	$3 \leq S \leq 1020$	≤ 30	± 50	50
			$2 \leq R_n \leq 2000$	10				
03	22	Unjacketed Twisted Pair	$5 \leq R_n \leq 2000$	5	$3 \leq S \leq 1020$	≤ 30	± 50	50
			$3 \leq R_n \leq 2000$	10				
04	24	Unjacketed Twisted Pair	$7 \leq R_n \leq 2000$	5	$3 \leq S \leq 1020$	≤ 30	± 50	50
			$4 \leq R_n \leq 2000$	10				
05	26	Unjacketed Twisted Pair	$11 \leq R_n \leq 2000$	5	$3 \leq S \leq 1020$	≤ 30	± 50	50
			$6 \leq R_n \leq 2000$	10				

NOTES:

1. See Para. 1.7.3
2. See Para. 1.6.
3. Temperature coefficient is defined between $T_{\text{amb}} = +22^\circ\text{C}$ and $+60^\circ\text{C}$ and excludes the influence of the terminal leads. See Para. 2.4.2 High and Low Temperature Measurements for Resistance change limits over the full Operating Temperature range: $T_{\text{op}} = -55^\circ\text{C}$ to $+150^\circ\text{C}$.
4. The maximum weight of the heaters, excluding the weight of the terminal leads. 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 sequentially when a request for a heater is received.

Each Heater Design Drawing shall include the following information:

- (a) The heater outline and dimensions as required by Para. 1.6 Physical Dimensions and Heater Outline herein including the position and 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)
- (c) The terminal leads' ESCC Detail Specification and Component Number.
- (d) The heater electrical information as follows:
 - Resistance value R_n and tolerance 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) Pressure sensitive tape (if fitted).
- (g) Dimensions of pre-form, if required.

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	P_n	0.38	W/cm ²	Notes 1, 2, 3, 4, 5
Operating Temperature Range	T_{op}	-55 to +150	°C	T_{amb} . Notes 3, 5
Storage Temperature Range	T_{stg}	-55 to +150	°C	Note 5
Rated Voltage	U_R	$\sqrt{P_n \cdot R_n \cdot S}$	V	Notes 2, 3, 6

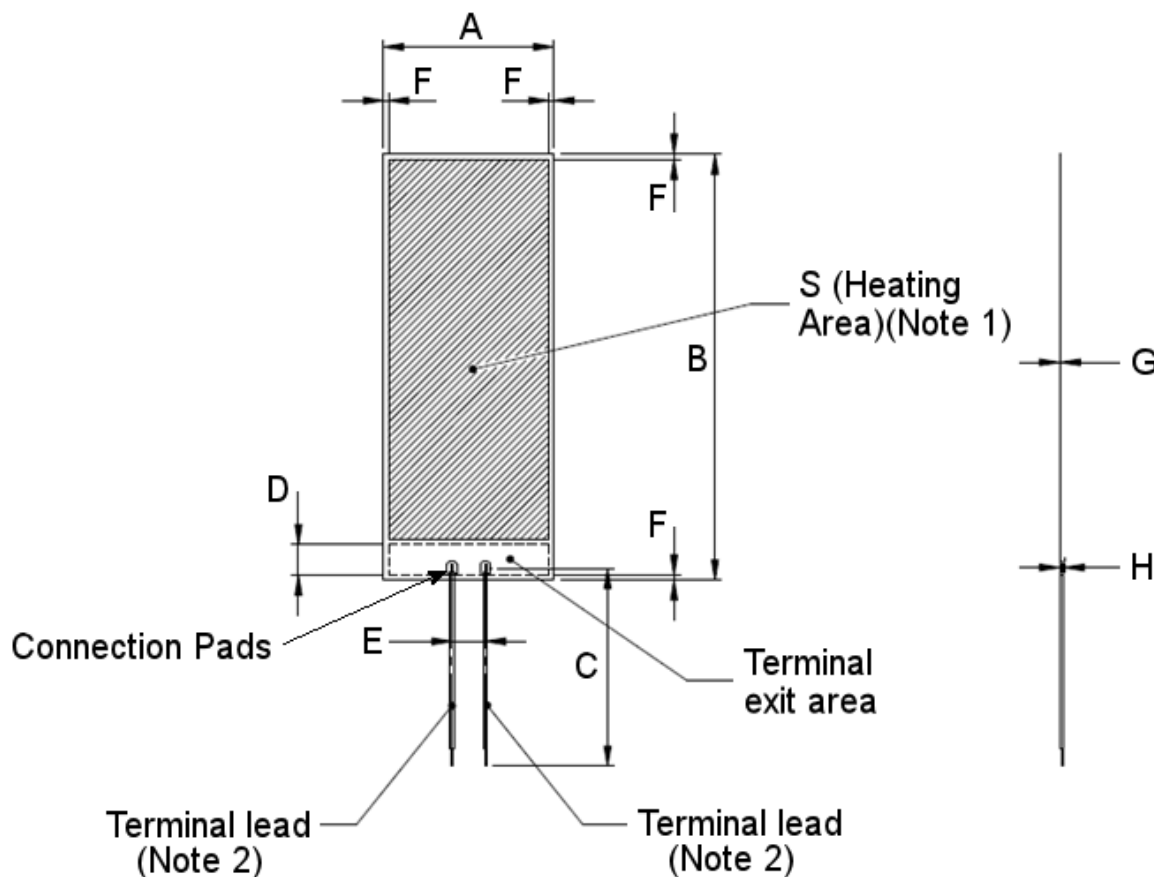
NOTES:

- With heater suspended in still air at $T_{amb} = +25^\circ\text{C}$.
- Actual rated power shall be specified in the applicable Heater Design Drawing. It shall be determined from the Heating Area (S) in cm².
- Rated Power Density shall be derated against temperature and Heating Area as follows:
 - $P_n = 0.38\text{W/cm}^2$ for $T_{amb} \leq +25^\circ\text{C}$. Derate to 0W/cm^2 at $0.00304\text{W/cm}^2/^\circ\text{C}$ for $+25^\circ\text{C} < T_{amb} \leq +150^\circ\text{C}$.
 - $P_n = 0.38\text{W/cm}^2$ for $3\text{cm}^2 \leq \text{Heating Area (S)} \leq 300\text{cm}^2$. Derate to 0.3W/cm^2 at $0.000111\text{W/cm}^2/\text{cm}^2$ for $300\text{cm}^2 < \text{Heating Area (S)} \leq 1020\text{cm}^2$.
- The following design rule shall be applied:
 - $50\% < \text{Area of Heater Resistive Element} \div \text{Heating Area (S)} < 90\%$
- When the heater temperature, T_{HTR} , exceeds $> +120^\circ\text{C}$, discolouration or darkening of the heater's protective coating (polyimide film) may occur; however, this does not affect the electrical or mechanical properties of the heater.
In order to avoid this discolouration or darkening, Rated Power Density should be derated to 76%, or lower, of the value specified in the above table. i.e. the heater temperature should be limited to $T_{HTR} \leq +120^\circ\text{C}$.
- 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 heater construction, physical dimensions and heater layout applicable to a specific heater will be specified in the Heater Design Drawing held by the Manufacturer.

EXAMPLE



Symbol	Dimensions mm		Tolerance	Remarks
	Min	Max		
A	5	265	±2mm	
B	40	385	±2mm	
C	200	-	±10mm	
D	8	30	-	
E	3	-	-	Note 3
F	0.6	-	-	Notes 4, 5
G	-	0.25	-	Note 6
H	-	4	-	Note 7

NOTES:

1. The Heating Area, S, is defined as the total area of the heater excluding the peripheral margin and the terminal exit area. The acceptable limits of S are specified in Para. 1.4.2.
2. The terminal leads' wire gauge options are specified in Para. 1.4.2. See also Para.1.7.3.
3. Terminal lead spacing shall be measured at the terminal exit area. Terminal leads may exit the terminal exit area at any angle.
4. Peripheral margin dimension.

5. Perforated holes in the peripheral margin are allowed provided that the distance between the edge of the hole and the heater resistive element or connection pad is equal to, or greater than, dimension F.
6. Heater thickness excluding connection pads, terminal wires and pressure sensitive adhesive (if fitted).
7. Thickness at the connection pads.
8. In any case, the final feasibility of a particular heater design is established according to the limiting characteristics of the materials used and the production process and shall be decided on by the Manufacturer; not all the configurations are possible.

1.7 MATERIALS AND FINISHES

1.7.1 Heater Resistive Element

The heater resistive element shall be made of Cu86Mn12Ni2.

1.7.2 Protective Coating

Heater resistive elements and terminal leads connection pads shall be completely coated with Polyimide Film/Acrylic Adhesive.

1.7.3 Terminal Leads

Terminal leads (see Para. 1.4.2) 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 soldered to the heater resistive element with Sn/Pb solder.

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) Rapid Change of Temperature: The exposures at maximum temperature shall be performed at $T_{amb} = +120 (+0, -3)^{\circ}\text{C}$.

(b) Overload: 0 failures are allowed. In the event of any failure, the lot shall be considered as failed and the Manufacturer shall act in accordance with Para. 4.3.3 of the Generic Specification.

Due to the possibility of discolouration or darkening of the heater's protective coating when operated at 1.5x rated power, the 5 samples used for Overload shall not be included in the delivery lot. Any discolouration or darkening shall not be cause for failure.

(c) High and Low Temperature Electrical Measurements: The 5 samples used for Overload shall be subjected to Burn-in with the remainder of the lot; subsequently, 3 of the 5 samples shall be used for High and Low Temperature Electrical Measurements. 0 failures are allowed.

In the event of any failure, the lot shall be considered as failed and the Manufacturer shall act in accordance with Para. 4.3.3 of the Generic Specification.

Due to the possibility of discolouration or darkening of the heater's protective coating, the 3 samples shall not be included in the delivery lot. Any discolouration or darkening shall not be cause for failure.

(d) For heaters where the Heater Design Drawing requires the application of pressure sensitive adhesive, the adhesive shall be applied at the end of Chart F3 testing after External Visual Inspection. An additional 100% External Visual Inspection shall then be performed.

2.1.1.2 *Deviations from Qualification and Periodic Tests – Chart F4*

(a) External Visual Inspection: Any discolouration or darkening of the heater's protective coating shall not be cause for failure.

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:

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

2.3 ROBUSTNESS OF TERMINATIONS

The test conditions for robustness of terminations, tested as specified in the ESCC Generic Specification, shall be as follows and apply to a single terminal lead at a time:

Wire Gauge (AWG)	18	20	22	24	26
Pull Strength (N)	57	45	36	22	13
Duration (s) minimum	5	5	5	5	5

2.4 ELECTRICAL MEASUREMENTS AT ROOM, HIGH AND LOW TEMPERATURES

The 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	Limits		Units
			Min	Max	
Resistance	R_A	ESCC No. 4009 $\pm 2\%$ Tolerance: $\pm 5\%$ Tolerance: $\pm 10\%$ Tolerance:	0.98 R_n 0.95 R_n 0.9 R_n	1.02 R_n 1.05 R_n 1.1 R_n	Ω
Insulation Resistance	R_I	ESCC No. 4009	1000	-	$M\Omega$
Voltage Proof Leakage Current	I_L	ESCC No. 4009 Test Voltage = 1000Vrms	-	6 or (1) 12	mA $\mu\text{A}/\text{cm}^2$

NOTES:

1. Whichever is greater based on the Heating Area (S).

2.4.2 High and Low Temperatures Electrical Measurements

Characteristics	Symbols	Test Method and Conditions	Limits		Units
			Min	Max	
Resistance change between $-55 (+3 -0)^{\circ}\text{C}$ and $+22 \pm 3^{\circ}\text{C}$	$\Delta R_A/R_A(L)$	ESCC No. 4009	0	-1.3	%
Resistance change between $+60 \pm 3^{\circ}\text{C}$ and $+22 \pm 3^{\circ}\text{C}$	$\Delta R_A/R_A(N)$	ESCC No. 4009	-	± 0.22	%
Resistance change between $+150 (+0 -3)^{\circ}\text{C}$ and $+22 \pm 3^{\circ}\text{C}$	$\Delta R_A/R_A(H)$	ESCC No. 4009	-	+0.5, -1.4	%

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.

The drift values (Δ) shall not be exceeded for each characteristic where specified. The corresponding absolute limit values for each characteristic shall not be exceeded.

Test Reference per ESCC No. 4009	Characteristics	Symbols	Limits		Units
			Min	Max	
Robustness of Terminations	Resistance	R_A			Ω
	Initial Measurements				
	$\pm 2\%$ Tolerance		0.98 R_n	1.02 R_n	
	$\pm 5\%$ Tolerance		0.95 R_n	1.05 R_n	
	$\pm 10\%$ Tolerance		0.9 R_n	1.1 R_n	
Final Measurements	Resistance	R_A	Record value		Ω
	Change in Resistance	$\Delta R_A/R_A$	-	± 1	%
Climatic Sequence	Resistance	R_A			Ω
	Initial Measurements				
	$\pm 2\%$ Tolerance		0.98 R_n	1.02 R_n	
	$\pm 5\%$ Tolerance		0.95 R_n	1.05 R_n	
	$\pm 10\%$ Tolerance		0.9 R_n	1.1 R_n	
Final Measurements	Resistance	R_A	Record value		Ω
	Change in Resistance	$\Delta R_A/R_A$	-	± 2	%
	Insulation Resistance	R_i	1000	-	$M\Omega$
	Voltage Proof Leakage Current (Test Voltage: 1000Vrms)	I_L	-	6 or (1) 12	mA $\mu\text{A}/\text{cm}^2$
Operating Life	Resistance	R_A			Ω
	Initial Measurements (0 hours)				
	$\pm 2\%$ Tolerance		0.98 R_n	1.02 R_n	
	$\pm 5\%$ Tolerance		0.95 R_n	1.05 R_n	
	$\pm 10\%$ Tolerance		0.9 R_n	1.1 R_n	
Intermediate Measurements (1000 hours)	Resistance	R_A	Record value		Ω
	Change in Resistance	$\Delta R_A/R_A$	-	± 3	%
Final Measurements (2000 hours)	Resistance	R_A	Record value		Ω
	Change in Resistance (related to 0 hours)	$\Delta R_A/R_A$	-	± 4	%
	Insulation Resistance	R_i	1000	-	$M\Omega$
	Voltage Proof Leakage Current (Test Voltage: 1000Vrms)	I_L	-	6 or (1) 12	mA $\mu\text{A}/\text{cm}^2$

NOTES:

1. Whichever is greater based on the Heating Area (S).

2.6 **BURN-IN CONDITIONS**

Characteristics	Symbols	Test Conditions	Units
Heater Temperature	T_{HTR}	+120 (Note 1)	°C
Power Density	P_n	0.38 (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**

Characteristics	Symbols	Test Conditions	Units
Heater Temperature	T_{HTR}	+150 (Note 1)	°C
Power Density	P_n	0.38 (Note 1)	W/cm ²

NOTES

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

APPENDIX A
AGREED DEVIATIONS FOR ISABELLENHÜTTE (D)

ITEMS AFFECTED	DESCRIPTION OF DEVIATIONS
Para. 1.4.2, Component Type Variants and Range of Components	Resistance Tolerance: a $\pm 2\%$ tolerance may be available subject to confirmation from Isabellenhütte after a positive feasibility study.
Para. 2.1.1.1, Deviations from Screening Tests - Chart F3	Rapid Change of Temperature: Mounting: Heaters may be mounted using any suitable method.
Para. 2.1.1.2, Deviations from Qualification and Periodic Tests – Chart F4	The terminal leads of component subjected to Chart F4 testing may be shortened.
	The specified period for the Endurance Subgroup shall be 24 months.
	Climatic Sequence: Low Air Pressure (Para. 8.7.5) shall not be performed.
Para. 2.2 Marking	When marking of the heater body is not possible, the marking may be performed on a Polyimide + PSA label applied to the heater leads.
	Marking of Traceability Information: The manufacturing date code may be marked using a three-digit code where: - the first digit is a letter to indicate the year of manufacture in accordance with the first digit of the two-character code for year and month in a twenty-year cycle in IEC Publication No. 60062. - the last two digits indicate the week of the year (i.e. 01 to 52) during which encapsulation or the final production process occurred. For example: U41 for week 41 of 2026