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


ESCC Detail Specification No. 4009/002

(Follow-up Specification for ESCC Detail Specification No. 4009/001)

**ISSUE 2
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DCR No.	CHANGE DESCRIPTION
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1. GENERAL
1.1 SCOPE

This specification details the ratings, physical and electrical characteristics, test and inspection data for Single and Double Layer Flexible Heater Resistors, insulated and coated by polyimide. It shall be read in conjunction with ESCC Generic Specification No. 4009, the requirements of which are supplemented herein.

1.2 TYPE VARIANTS AND RANGE OF COMPONENTS

Variants of the basic type heaters and the range of components covered by this specification are given in Table 1(a).

1.3 MAXIMUM RATINGS

The maximum ratings, which shall not be exceeded at any time during use or storage, applicable to the heaters specified herein, are scheduled in Table 1(b).

1.4 PARAMETER DERATING INFORMATION

The parameter derating information applicable to the heaters specified herein is given in Figure 1.

1.5 PHYSICAL DIMENSIONS

The general physical dimension requirements are given in Figure 2.

Heater design drawings 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 Specific Heater Identification number 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 Figure 2.
- (b) The ESCC Component Number.
- (c) The Specific Heater Identification.
- (d) The terminal lead ESCC Component Number.
- (e) The heater electrical information as follows:
 - Resistance value and tolerance by circuit at $T_{amb} = +22 \pm 3 \text{ }^\circ\text{C}$.
 - Maximum power dissipation in still air at $T_{amb} = +25^\circ\text{C}$.
- (f) Track width and spacing with tolerances.
- (g) Cover material (if fitted).
- (h) Pressure sensitive tape (if fitted).
- (i) Dimension of pre-form, if required.

1.6 FUNCTIONAL DIAGRAM

The functional diagram for the heaters specified herein is shown in Figure 3.

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, for Resistors, Heaters, Flexible.
- (b) ESCC Generic Specification No. 3901, for Wire and Cable, 600V Electrical, Low Frequency.
- (c) MIL-P-46112, Plastic Sheet and Strip, Polyimide.
- (d) ESA PSS-01-702, a Thermal Vacuum Test for the Screening of Space Materials.



TABLE 1(a) - TYPE VARIANTS AND RANGE OF COMPONENTS

(1) VARIANT (Note 1)	TERMINAL LEAD		(4) RESISTANCE RANGE (Ω)	(5) TOLERANCE MIN./MAX. (\pm %)	(6) HEATER AREA (cm ²)	(7) RESISTANCE DENSITY (Ω /cm ²)	(8) TEMPERATURE COEFFICIENT (10 ⁻⁶ /°C)
	(2) AWG	(3) CONFIGURATION (Note 2)					
01, 25	20	Straight	1.0	2.0	1.6	0.1	175
02, 26	22	Sraight					
03, 27	24	Straight					
04, 28	26	Straight					
05, 29	28	Straight		3.0			
06, 30	30	Straight					
07, 31	20	U.T.P.					
08, 32	22	U.T.P.					
09, 33	24	U.T.P.	to	5.0	to	to	
10, 34	26	U.T.P.					
11, 35	28	U.T.P.					
12, 36	30	U.T.P.					
13, 37	20	J.T.P.					
14, 38	22	J.T.P.					
15, 39	24	J.T.P.					
16, 40	26	J.T.P.					
17, 41	28	J.T.P.					
18, 42	30	J.T.P.					
19, 43	20	S.T.P.					
20, 44	22	S.T.P.					
21, 45	24	S.T.P.					
22, 46	26	S.T.P.					
23, 47	28	S.T.P.		and			
24, 48	30	S.T.P.	5000	10	1300	200	

NOTES

- Variants 01 to 24 are single layer heaters.
Variants 25 to 48 are double layer heaters.
- U.T.P. = Unjacketed Twisted Pair, J.T.P. = Jacketed Twisted Pair, S.T.P. = Shielded Twisted Pair.

TABLE 1(b) - MAXIMUM RATINGS

No.	CHARACTERISTICS	SYMBOL	LIMITS		UNIT	REMARKS
			MIN.	MAX.		
1	Rated Dissipation	P _n	-	0.54	W/cm ²	At T _{amb} = +25°C Note 1 Figure 1
2	Operating Temperature Range	T _{op}	-65	+200	°C	T _{amb}
3	Storage Temperature Range	T _{stg}	-65	+200	°C	
4	Rated Voltage	U _R	-	$\sqrt{P_n \cdot R_n \cdot s}$	V	Note 2

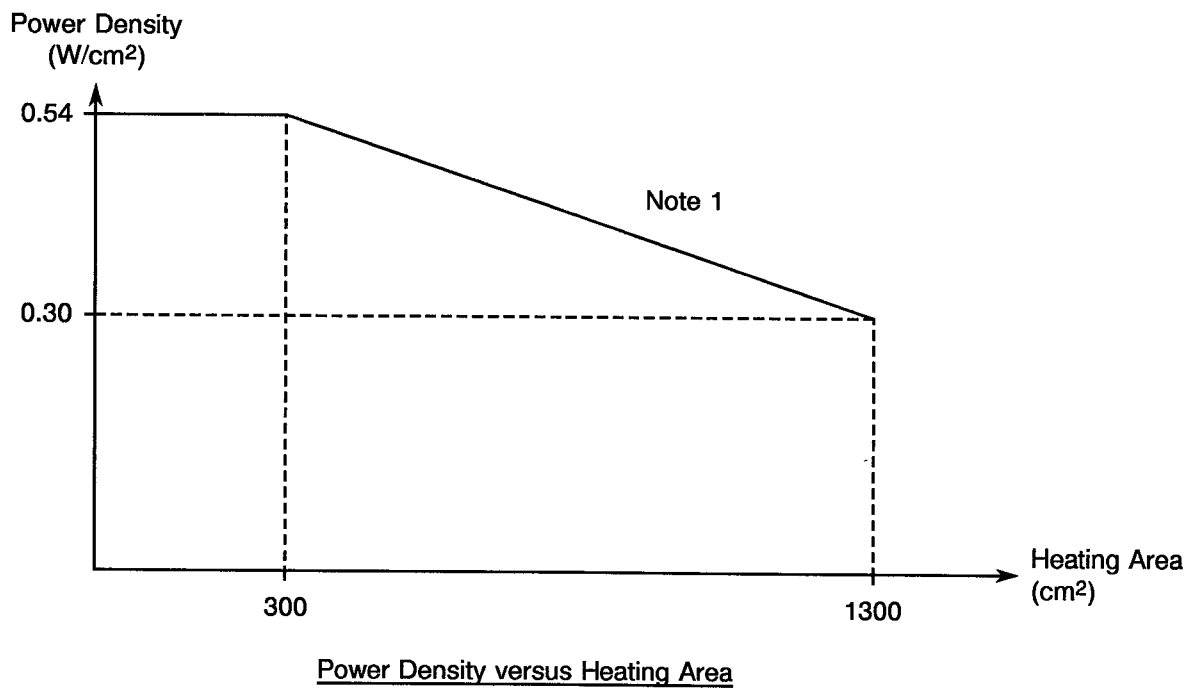
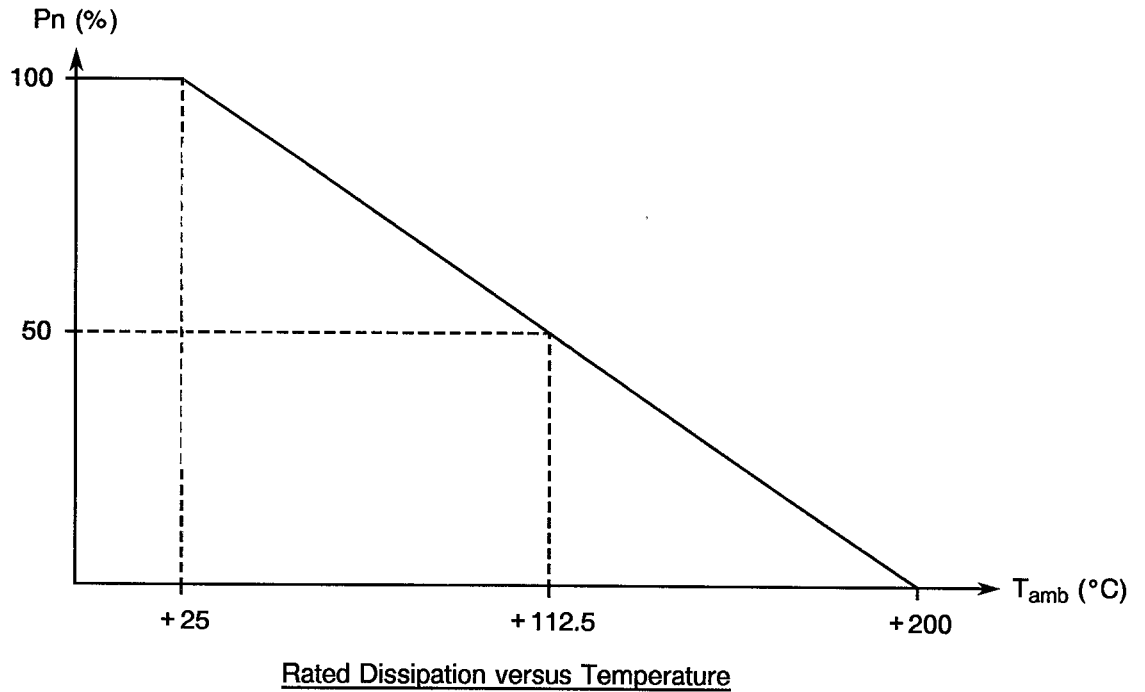
NOTES

1. Suspended in still air. The rating should be determined over the effective heating area of the device. The following design feature shall be observed:-

$$\frac{\text{Area of Resistive Element}}{\text{Heating Area}} = 50 \pm 10 \%$$

2. Where s = heating area in cm². R_n is the nominal resistance.

FIGURE 1 - PARAMETER DERATING INFORMATION

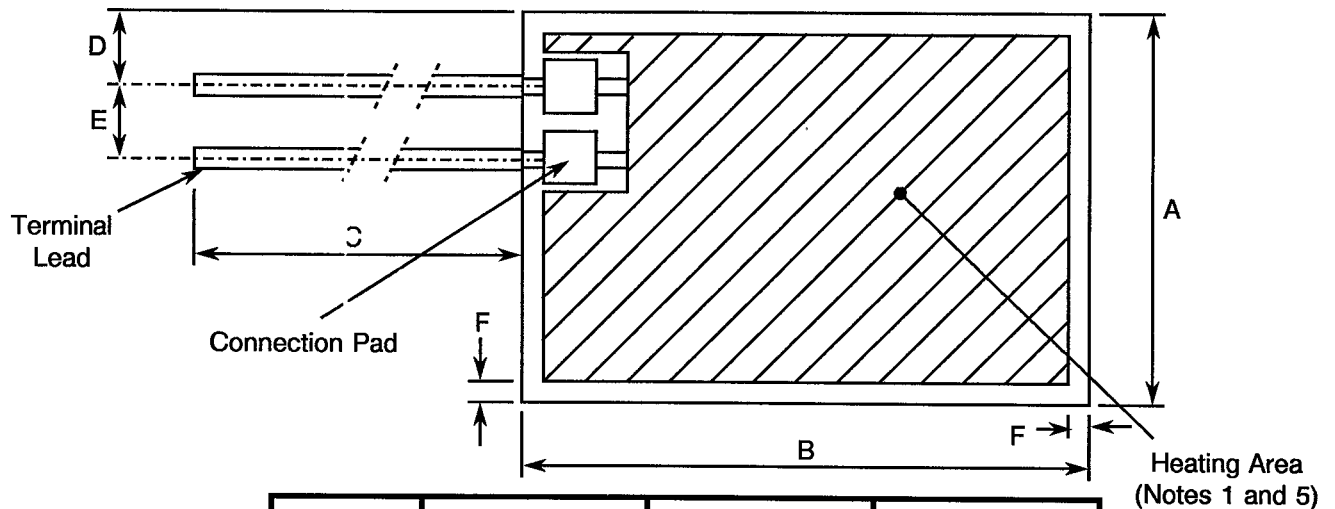


NOTES

1. Derating 0.00024 W/cm² /cm².

FIGURE 2 - PHYSICAL DIMENSIONS

GENERAL REQUIREMENTS

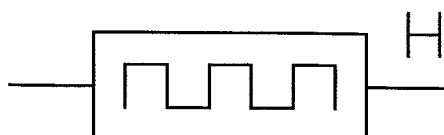



SYMBOL	MILLIMETRES		TOLERANCES (\pm mm)	REMARKS
	MIN.	MAX.		
A	6.0	590	0.5	Note 1
B	8.0	600	0.5	Note 1
C	300	-	Note 2	-
D	2.0	-	Note 3	Note 4
E	2.0	-	Note 3	Note 4
F	0.4	-	-	Note 5

NOTES

- See Table 1(a) for minimum and maximum heater area (AxB).
Heater thickness:
 - 0.2mm maximum for single layer heater,
 - 0.3mm maximum for double layer heater,
 except over connection pad area.
- The tolerance shall be $\pm 10\%$ on the required dimension.
- The tolerance shall be $\pm 0.5\text{mm}$ on the required dimension.
- The terminal leads may be located on any side of the heater; there may be more than 2 terminal leads in the case of multiple resistor and double layer heaters.
- Margin dimension of the finished product.
- Perforated holes in the heating area are allowed provided that the margin (distance between periphery of hole and track) is equal to, or greater than, dimension F.

FIGURE 3 - FUNCTIONAL DIAGRAM



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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.

4. REQUIREMENTS

4.1 GENERAL

The complete requirements for procurement of the heaters specified herein are stated in this specification and ESCC Generic Specification No. 4009 for Foil Heaters. Deviations from the Generic Specification, applicable to this specification only, are listed in Para. 4.2.

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

4.2 DEVIATIONS FROM GENERIC SPECIFICATION

4.2.1 Deviations from Special In-process Controls

None.

4.2.2 Deviations from Final Production Tests (Chart II)

None.

4.2.3 Deviations from Burn-in and Electrical Measurements (Chart III)

- (a) Para. 9.3, Radiographic Inspection is not applicable.
- (b) For deliverable heaters which have a requirement that they be submitted to cover and/or pressure sensitive tape application specified in the specific heater design drawing, the following additional steps shall be performed:-
 - (i) Immediately following Para. 9.5.3 Electrical Measurements at High and Low Temperatures, an External Visual Inspection in accordance with Para. 9.6 of the Generic Specification shall be performed.
 - (ii) On successful completion of the inspection above, the cover and/or pressure sensitive tape application shall be made.
- (c) For heaters which already have a backing foil applied at the beginning of the process, the deviation to 4.2.3(b) does not apply.
- (d) When required by the Customer in the specific heater design drawing, pre-forming of heaters shall take place at the end of Chart III after LAT3 has been performed. The pre-forming operation shall be performed at a temperature not exceeding the heater maximum temperature and shall be followed by a visual examination to check for any damage.

4.2.4 Deviations from Qualification Tests (Chart IV)

None.

4.2.5 Deviations from Lot Acceptance Tests (Chart V)

None.



4.3 MECHANICAL REQUIREMENTS

4.3.1 Dimension Check

The dimensions of the heaters specified herein shall be verified in accordance with the requirements set out in Para. 9.4 of ESCC Generic Specification No. 4009 and shall conform to those shown in the specific heater design drawings.

4.3.2 Weight

The maximum weight of the heaters specified herein shall be 50mg/cm² for single layer and 75 mg/cm² for double layer heaters (without leads). The weight of the terminal leads shall be computed using the applicable wire Detail Specification.

4.3.3 Robustness of Terminations

The requirements and test conditions for robustness of terminations are specified in Section 9 of ESCC Generic Specification No. 4009. The test conditions shall be as follows and apply to a single terminal lead.

Wire Gauge (AWG)	20	22	24	26	28	30
Force (Newtons)	45	36	22	13	9.0	4.5
Duration (seconds) (min.)	5.0	5.0	5.0	5.0	5.0	5.0

4.4 MATERIALS AND FINISHES

The materials and finishes shall be as specified herein. Where a definite material is not specified, a material which will enable the heaters specified herein to meet the performance requirements of this specification shall be used. Acceptance or approval of any constituent material does not guarantee acceptance of the finished product.

4.4.1 Element

The heater element shall be made of nickel/chromium/iron alloy (76/16/8, Inconel) flexible.

4.4.2 Protective Coating

Heaters shall be completely coated, including connections of the terminal leads with a Polyimide Polymer/FEP in accordance with MIL-P-46112, Type II, Grade A. This material shall also meet the outgassing requirements of ESA PSS-01-702.

4.4.3 Leads

The terminal leads shall be made of multistrand silver plated copper, in accordance with ESCC Generic Specification No. 3901. The wire gauge shall be as specified in Table 1(a). The terminal leads shall be electrically welded to the heater element.

4.5 MARKING

4.5.1 General

The marking of all components delivered to this specification shall be in accordance with the requirements of ESCC Basic Specification No. 21700 and the following paragraphs. When the component is too small to accommodate all of the marking specified, as much as space permits shall be marked and the marking information, in full, shall accompany the component in its primary package.

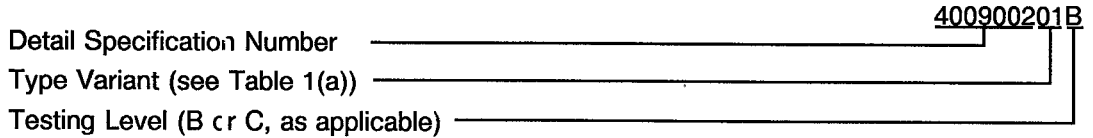
The information to be marked and the order of precedence, shall be as follows:-

- (a) Characteristics (Specific Heater Identification).

- (b) Traceability Information.
- (c) The ESCC Component Number.

4.5.2 The ESCC Component Number

The ESCC Component Number shall be constituted and marked as follows:-



4.5.3 Characteristics

The characteristic to be marked is the Specific Heater Identification which shall consist of a letter and a 4 digit number.

This identification shall be allocated by the Manufacturer (see Para. 1.5) and shall consist of the following:

- Letter : First letter of the heater Manufacturer's name.
- 4 digit number : Sequentially allocated by each individual Manufacturer.

4.5.4 Traceability Information

Traceability information shall be marked in accordance with the requirements of ESCC Basic Specification No. 21700.

4.6 ELECTRICAL MEASUREMENTS

4.6.1 Electrical Measurements at Room Temperature

The parameters to be measured at room temperature are scheduled in Table 2. The measurements shall be performed at $T_{amb} = +22 \pm 3 \text{ }^\circ\text{C}$.

4.6.2 Electrical Measurements at High and Low Temperatures

The parameters to be measured on a sample basis at high and low temperatures are scheduled in Table 3.

4.6.3 Circuits for Electrical Measurements (Figure 4)

Not applicable.

4.7 BURN-IN TESTS

4.7.1 Parameter Drift Values

The parameter drift values applicable to burn-in are specified in Table 4 of this specification. Measurements shall be performed at $T_{amb} = +22 \pm 3 \text{ }^\circ\text{C}$. The parameter drift values applicable to the scheduled parameters shall not be exceeded. In addition to these drift value requirements, the appropriate limit value specified for a given parameter in Table 2 shall not be exceeded.

4.7.2 Conditions for Burn-in

The requirements for burn-in are specified in Sections 7 and 9 of ESCC Generic Specification No. 4009. The conditions for burn-in shall be as specified in Table 5.

After 168(+24-0) hours, the heaters shall be allowed to cool under normal atmospheric conditions for a minimum of 4 hours. They shall then be visually examined. There shall be no evidence of damage and the marking shall be legible.

TABLE 2 - ELECTRICAL MEASUREMENTS AT ROOM TEMPERATURE

No.	CHARACTERISTIC	SYMBOL	SPEC. AND/OR TEST METHOD	TEST CONDITIONS	TOLERANCE (±%)	LIMITS		UNIT
						MIN.	MAX.	
1	Resistance	R _A	ESCC Gen. Spec. No. 4009	Para. 9.5.1.1	2.0	0.98 R _n	1.02 R _n	Ω
					3.0	0.97 R _n	1.03 R _n	
					5.0	0.95 R _n	1.05 R _n	
					10	0.90 R _n	1.10 R _n	
2	Insulation Resistance	R _i	ESCC Gen. Spec. No. 4009	Para. 9.5.1.2	-	1000	-	MΩ
3	Voltage Proof Leakage Current	I _L	ESCC Gen. Spec. No. 4009	Para. 9.5.1.3 500Vrms	-	-	2.0	mA

TABLE 3 - ELECTRICAL MEASUREMENTS AT HIGH AND LOW TEMPERATURES

No.	CHARACTERISTIC	SYMBOL	SPEC. AND/OR TEST METHOD	TEST CONDITIONS (NOTE 1)	LIMITS		UNIT
					MIN.	MAX.	
1	Resistance change between -65(+3-0)°C and +22±3°C	$\frac{\Delta R}{R}$	ESCC Gen. Spec. No. 4009	Para. 9.5.1.1	-1.57	-	%
2	Resistance change between +200(+0-3)°C and +22±3°C	$\frac{\Delta R}{R}$	ESCC Gen. Spec. No. 4009	Para. 9.5.1.1	-	+3.17	%

NOTES

1. Sampling Level II, AQL = 0.65%.

FIGURE 4 - CIRCUIT FOR ELECTRICAL MEASUREMENTS

Not applicable.

TABLE 4 - PARAMETER DRIFT VALUES

CHARACTERISTIC	SYMBOL	SPEC. AND/OR TEST METHOD	TEST CONDITIONS	CHANGE LIMIT (Δ)	UNIT
Resistance Change	$\frac{\Delta R}{R}$	As per Table 2	As per Table 2	± 1.0	%

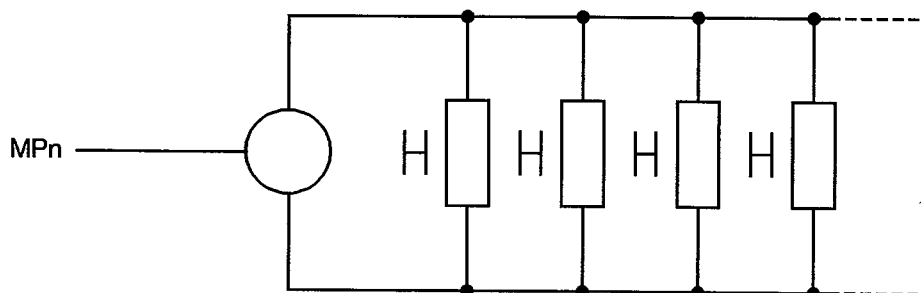
TABLE 5 - CONDITIONS FOR BURN-IN AND OPERATING LIFE TESTS

No.	CHARACTERISTIC	SYMBOL	CONDITION	UNIT
1	Heater Temperature for Burn-in and Operating Life Test	T_{HTR}	+200 (1)	$^{\circ}C$
2	Power Dissipation	P_n	0.54 (1)	W/cm ²

NOTES


1. See ESCC Generic Specification No. 4009, Para. 9.15.1(c).

FIGURE 5 - CIRCUIT FOR BURN-IN AND OPERATING LIFE TESTS



NOTES

1. M = number of Heaters.

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4.7.3 Electrical Circuits for Burn-in

The circuit for use in performing the burn-in is shown in Figure 5.

4.8 ENVIRONMENTAL AND ENDURANCE TESTS (CHARTS IV AND V OF ESCC GENERIC SPECIFICATION No. 4009)

4.8.1 Measurements and Inspections on Completion of Environmental Tests

The parameters to be measured and inspections to be performed on completion of environmental tests are scheduled in Table 6. Unless otherwise stated, the measurements shall be performed at $T_{amb} = +22 \pm 3 \text{ }^\circ\text{C}$.

4.8.2 Measurements and Inspections at Intermediate Points during Endurance Tests

The parameters to be measured and inspections to be performed at intermediate points during endurance tests are scheduled in Table 6. Unless otherwise stated, the measurements shall be performed at $T_{amt} = +22 \pm 3 \text{ }^\circ\text{C}$.

4.8.3 Measurements and Inspections on Completion of Endurance Tests

The parameters to be measured and inspections to be performed on completion of endurance tests are scheduled in Table 6. Unless otherwise stated, the measurements shall be performed at $T_{amb} = +22 \pm 3 \text{ }^\circ\text{C}$.

4.8.4 Conditions for Operating Life Test (Part of Endurance Testing)

The requirements for operating life testing are specified in Section 9 of ESCC Generic Specification No. 4009. The conditions for operating life testing shall be as specified in Table 5 of this specification.

4.8.5 Electrical Circuits for Operating Life Test

The electrical circuit for use in performing the operating life test is shown in Figure 5.

4.8.6 Conditions for High Temperature Storage Test (Part of Endurance Testing)


The requirements for the high temperature storage test are specified in Section 9 of ESCC Generic Specification No. 4009. The conditions for high temperature storage shall be $T_{amb} = +200 (+0-5) \text{ }^\circ\text{C}$.

TABLE 6 - MEASUREMENTS AND INSPECTIONS ON COMPLETION OF ENVIRONMENTAL TESTS AND AT INTERMEDIATE POINTS AND ON COMPLETION OF ENDURANCE TESTING

No.	ESCC GENERIC SPECIFICATION No. 4009		MEASUREMENTS AND INSPECTIONS		SYMBOL	LIMITS		UNIT
	ENVIRONMENTAL AND ENDURANCE TESTS (1)	TEST METHOD AND CONDITIONS	IDENTIFICATION	CONDITIONS		MIN.	MAX.	
01	Overload	Para. 9.1	Initial Measurements Resistance Final Measurements Resistance Change	Table 2 Item 1 After between 1 and 2 hrs Table 2 Item 1	R $\Delta R/R$	Table 2 Item 1 -1.0	1.0	Ω %
02	Permanence of Marking	Para. 9.2	Visual Examination	-	-	-	-	-
03	Electrical Measurements at Room Temperature	Para. 9.5.4	Electrical Measurements	Table 2	-	Table 2		-
04	External Visual Inspection	Para. 9.6	External Visual Inspection	Gen. 4009, Para. 9.6	-	-	-	-
05	Temperature Coefficient	Para. 9.7 Procedure 1	Temperature Coefficient	Gen. 4009, Para. 9.7	TC	-	175	$10^{-6}/^{\circ}\text{C}$
06	High Temperature Storage	Para. 9.8 (Change Limits Relate to 0 hr Measurement)	Initial Measurements Resistance Final Measurements Resistance Change Insulation Resistance Voltage Proof	Table 2 Item 1 After between 1 and 2 hrs Table 2 Item 1 Table 2 Item 2 Table 2 Item 3	R $\Delta R/R$ Ri VP	Table 2 Item 1 -2.0 1000 500	2.0 - -	Ω % M Ω Vrms
07	Solderability	Para. 9.9	Visual Examination	Gen. 4009, Para. 9.9.2	-	-	-	-
08	Robustness of Terminations	Paras. 9.10 and 4.3.3 of this spec.	Initial Measurements Resistance Final Measurements Resistance Change	Table 2 Item 1 Table 2 Item 1	R $\Delta R/R$	Table 2 Item 1 -1.0	1.0	Ω %
09	Rapid Change of Temperature	Para. 9.12	Initial Measurements Resistance Final Measurements Resistance Change	Table 2 Item 1 After between 1 and 2 hrs Table 2 Item 1	R $\Delta R/R$	Table 2 Item 1 -1.4	1.4	Ω %
10	Low Temperature Operation	Para. 9.13	Initial Measurements Resistance Final Measurements Resistance Change Insulation Resistance Voltage Proof	Table 2 Item 1 After 24 hrs Table 2 Item 1 Table 2 Item 2 Table 2 Item 3	R $\Delta R/R$ Ri VP	Table 2 Item 1 -1.4 1000 500	1.4 - -	Ω % M Ω Vrms
11	Climatic Sequence	Para. 9.14	Initial Measurements Resistance Final Measurements Resistance Change Insulation Resistance Voltage Proof	Table 2 Item 1 After between 1 and 2 hrs Table 2 Item 1 Table 2 Item 2 Table 2 Item 3	R $\Delta R/R$ Ri VP	Table 2 Item 1 -2.0 1000 500	2.0 - -	Ω % M Ω Vrms
12	Operating Life Test	Para. 9.15 (Change Limits Relate to 0 hr Measurement)	Initial Measurements Resistance Intermediate Measurements Resistance Change Final Measurements Resistance Change Insulation Resistance Voltage Proof Final Measurements Resistance Change Insulation Resistance Voltage Proof	Table 2 Item 1 Chart IV After between 1 and 2 hrs Table 2 Item 1 Chart IV After between 1 and 2 hrs Table 2 Item 1 Table 2 Item 2 Table 2 Item 3 Chart V After between 1 and 2 hrs Table 2 Item 1 Table 2 Item 2 Table 2 Item 3	R $\Delta R/R$ $\Delta R/R$ Ri VP $\Delta R/R$ Ri VP	Table 2 Item 1 -1.4 -2.0 1000 500 -1.4 1000 500	1.4 2.0 - - 1.4 - -	Ω % % M Ω Vrms % M Ω Vrms

NOTES

1. The tests in this table refer to either Chart IV or V and shall be used as applicable.

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APPENDIX 'A'

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AGREED DEVIATIONS FOR RICA (I)

ITEMS AFFECTED	DESCRIPTION OF DEVIATIONS
Para. 4.2.3	For deliverable heaters: Where the cover is applied during the heater lamination process, the deviations specified in Para. 4.2.3, Item (b) of this specification are not applicable.