REVISIONS

SYMBOL	DESCRIPTION	DATE	APPROVAL
A	Spec. Revised Per Revision Notice A078	1/19/96	[illegible]

SHEET REVISION STATUS

SH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
REV	A	--	--	--	A	A	A	A	--	--	--	--	--	--	--					
SH	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
REV																				

ORIGINATOR: T. J. Perry/Unisys	**DATE** 6/12/95	**FSC:** 5905
APPROVED: S. E. Archer-Davies/Unisys	6/12/95	Resistors, "Matched-Pair", Low TC, Precision, Radial-Lead (Caddock Type TK)
CODE 311 APPROVAL: P. J. Jones/GSFC	6/13/95	
CODE 311 SUPERVISORY APPROVAL: G. P. Kramer, Jr./GSFC	6/13/95	
ADDITIONAL APPROVAL: J. M. Lohr/GSFC	6/13/95	**S-311-P-796**

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

CAGE CODE: 25306

1. SCOPE

1.1 Scope. This specification covers the procurement requirements for "matched-pair", low TC, precision radial-lead resistors. These resistors are intended for use in GSFC space system electronic circuits with precision ratio tracking requirements.

1.2 Goddard part number. Parts procured in complete compliance with the requirements of this specification shall be identified by a Goddard part number of the following form.

G311P796	-633	-01
Goddard Designator	Style (See 1.3)	Dash Number (See 1.4)

1.3 Style. The style shall be identified by the three digits following the first dash and specifies resistors of a type and size listed in Figure 1 and Table I.

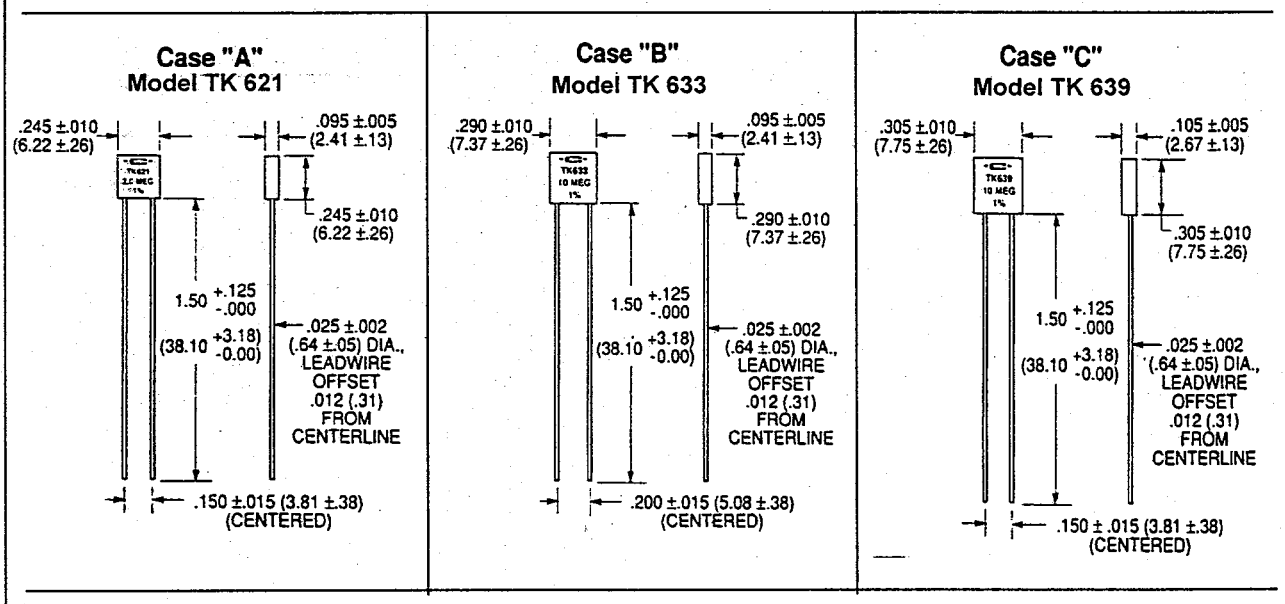

Figure 1. - Resistor outline drawings (see Table I).

1.4 Temperature characteristic. The dash number uniquely identifies a pair of matched resistors with the characteristics specified in Table II.

Table I. - Styles.

Style 1/, 2/	Power Rating @ 125°C (watts)	Maximum Working Voltage (volts)	Dielectric Strength (volts)	Dimensions (reference Figure 1) [inches (mm)]
621	Limited By Maximum Working Voltage	200	300	Ref. Case "A" Drawing
633		300	400	Ref. Case "B" Drawing
639		300	400	Ref. Case "C" Drawing

1/ Style number corresponds to manufacturer's model number.
2/ Low inductance construction.

Table II. - Dash numbers and characteristics.

Dash No.	Resistance Values		Resistance Tolerance	Resistance Ratio	Temperature Characteristic	Tracking
	Resistor A	Resistor B				
-01	3.3 MΩ	3.3 MΩ	± 0.1%	1.0000 ± 0.0005	± 5 ppm/°C 1/	≤ 1 ppm /°C

1/ -20 to +60°C, referenced to +25°C.

1.5 Performance characteristics. The performance of resistors procured to this specification shall be as specified in Table III.

2. APPLICABLE DOCUMENTS

2.1 Documents. The following documents, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

MIL-I-45208 Inspection Systems Requirements

MIL-R-39032 Resistors, Packaging of

QQ-S-571 Solder; Tin Alloy, Tin-Lead Alloy, and Lead Alloy

STANDARDS

MIL-STD-202 Test Methods for Electronic and Electrical Component Parts

MIL-STD-1285 Marking of Electrical and Electronic Parts

OTHER PUBLICATIONS

ASTM E595 Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment, Standard Test Method for

2.2 Order of precedence. In the event of any conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence. However, nothing in this text shall supersede applicable laws and regulations unless a specific exemption has been obtained.

Table III. - Performance characteristics.

Test	All Styles	
Thermal Shock (see 3.5)	ΔR	±0.10%
Dielectric Withstanding Voltage (see 3.6)	ΔR	±0.05%
Insulation Resistance (see 3.7)	10,000MΩ (minimum)	
Overload/Overvoltage (see 3.8)	ΔR	±0.20%
Load Life (see 3.9)	ΔR	±0.20%
Shock (see 3.11)	ΔR	±0.05%
Vibration Strength (see 3.12)	ΔR	±0.05%
Terminal Strength (see 3.14)	ΔR	±0.02%
Resistance to Soldering Heat (see 3.15)	ΔR	±0.05%
Moisture Resistance (see 3.16)	ΔR	±0.10%
Low Temperature Operation (see 3.17)	ΔR	±0.05%

2.3 Copies of documents. Copies of federal and military documents can be obtained from the Standardization Document Order Desk, 700 Robbins Avenue, Building #4-Section D, Philadelphia, PA 19111-5094. Copies of ASTM publications are available from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

3. REQUIREMENTS

3.1 Qualification. Resistors furnished to this specification shall be a product which has been granted qualification approval by NASA/GSFC. Qualification approval shall be based on the following criteria.

3.1.1 Design and source approval. Prior to qualification, the manufacturer's facility shall be subjected to survey at the option of GSFC, by the Office of Flight Assurance, GSFC. Compliance with MIL-I-45208 is required. In addition, the history and detailed engineering of the specific resistor design will be reviewed, as will the documented manufacturing and quality control procedures. Only those sources approved in the design and source approval phase shall be eligible for qualification or award of contract under this specification. Source approval and design approval do not constitute part qualification or an equivalent thereof.

3.1.2 Part qualification. Resistor product granted qualification shall be that which has passed the qualification inspection requirement of this specification. This requirement may be satisfied by passing the qualification inspection (see 4.4).

3.2 Materials.

3.2.1 Materials. Materials shall be as specified herein. However, when a definite material is not specified, a material shall be used which will enable the resistors to meet the performance requirement of this specification. Acceptance or approval of any constituent material shall not be construed as a guaranty of the acceptance of finished product.

3.2.2 Thermal outgassing. Materials must meet outgassing requirements of 1.0% total mass loss (TML) maximum and 0.1% collected volatile condensable materials (CVCM) maximum when tested in accordance with 4.6.17.

3.3 Design and construction. Resistors shall be of the design, construction and dimensions depicted in Figure 1.

3.3.1 Terminal leads. Terminal leads shall consist of oxygen-free, solid copper conductors covered with a hot solder finish (Type Sn, 60/40 or 63/37 per QQ-S-571) to meet the solderability requirement (see 4.6.16).

3.3.2 Insulation. Resistors shall be covered with a molded encapsulant to provide suitable protection to the resistor body.

3.3.3 Resistance material. The metal oxide shall be uniformly deposited and free of blisters, thin spots, discolorations or any other types of anomalies likely to cause chips, pits, or voids when parts are laser trimmed.

3.3.4 Power rating. These resistors are voltage-limited. See paragraph 3.3.5.

3.3.5 Voltage rating. Resistors shall have a rated direct current (dc) continuous working voltage, or an approximate sine wave root-mean-square (rms) continuous working voltage, at commercial line frequency, of 200 volts for Style 621 and 300 volts for Styles 633 and 639. In no case shall the continuous working voltage exceed these values.

3.4 DC resistance. When resistors are tested as specified in 4.6.2, the dc resistance shall be within the specified tolerance of the nominal resistance.

3.4.1 Resistance Ratio. Resistors shall meet the resistance ratio requirements in Table II when tested in accordance with 4.6.2.

3.5 Thermal shock. When resistors are tested as specified in 4.6.3, there shall be no evidence of mechanical damage, and the change in resistance shall not exceed the performance requirement in Table III.

3.6 Dielectric withstanding voltage. When resistors are tested as specified in 4.6.4, there shall be no evidence of flashover, arcing, insulation breakdown, or any type of mechanical damage. The change in resistance shall not exceed the performance requirement in Table III.

3.7 Insulation resistance. When resistors are tested as specified in 4.6.5, the insulation resistance shall meet the performance requirement in Table III.

3.8 Overload/overvoltage. When resistors are tested as specified in 4.6.6, there shall be no evidence of mechanical damage, and the change in resistance shall not exceed the performance requirement in Table III.

3.9 Load life. When resistors are tested as specified in 4.6.7, there shall be no evidence of mechanical damage, and the change in resistance shall not exceed the performance requirement in Table III.

3.10 Resistance temperature characteristic. When resistors are tested as specified in 4.6.8, the resistance temperature characteristic shall meet the requirement in Table II.

3.10.1 Tracking. Resistors shall meet the tracking requirement in Table II when tested in accordance with 4.6.8.

3.11 Shock. When resistors are tested as specified in 4.6.9, there shall be no evidence of mechanical damage, and the change in resistance shall not exceed the performance requirement in Table III.

3.12 Vibration. When resistors are tested as specified in 4.6.10, there shall be no evidence of mechanical damage, and the change in resistance shall not exceed the performance requirement in Table III.

3.13 Resistance to solvents. When resistors are tested as specified in 4.6.11, there shall be no evidence of mechanical damage, and the marking shall remain legible.

3.14 Terminal strength. When resistors are tested as specified in 4.6.12, there shall be no evidence of mechanical damage, and the change in resistance shall not exceed the performance requirement in Table III.

3.15 Resistance to soldering heat. When resistors are tested as specified in 4.6.13, there shall be no evidence of mechanical damage, and the change in resistance shall not exceed the performance requirement in Table III.

3.16 Moisture resistance. When resistors are tested as specified in 4.6.14, there shall be no evidence of mechanical damage, and the change in resistance shall not exceed the performance requirement in Table III. In addition, the dielectric withstanding voltage shall be as specified in 3.6, and the insulation resistance shall be 100 MΩ, minimum.

3.17 Low temperature operation. When resistors are tested as specified in 4.6.15, there shall be no evidence of mechanical damage, and the change in resistance shall not exceed the performance requirement in Table III.

3.18 Solderability. When resistors are tested as specified in 4.6.16, the criteria for wire-lead terminal evaluation that are contained in the referenced test method shall be met.

3.19 Marking. Each resistor shall be marked with the Goddard part number, manufacturer's name or symbol (optional), and date code. Date code shall be in accordance with MIL-STD-1285. The location and number of lines shall be at the discretion of the manufacturer. The following is an example of the complete marking:

Caddock	- Manufacturer's name or symbol (optional)
G311P796	- Goddard designator
633-01	- Style, characteristic, resistance value and tolerance
9535	- Date code

3.19.1 Date code. The date code shall be the date of the final assembly operation for the production lot, which for purposes of this specification, is the same as the inspection lot (4.5.2). The common manufacturing record shall include the same date code as that placed on parts covered by the record. When the physical size of the resistor precludes the marking of all of the above information, the Goddard designator may be abbreviated to P796. However, the complete part number must be marked on the shipping container.

3.20 Workmanship. Resistors shall be processed in such a manner to be uniform in quality when inspected in accordance with 4.6.1. Resistors shall also be free of any defects affecting life, serviceability or performance.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. The manufacturer is responsible for the performance of all inspection requirements, as specified herein, using his own or any other suitable facility acceptable to Goddard Space Flight Center. Upon receipt of product, Goddard reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to verify conformance to prescribed requirements.

4.2 Classification of inspection. Inspection requirements specified herein are classified as follows:

a. Qualification Inspection (see 4.4)
b. Quality Conformance Inspection (see 4.5).

4.3 Inspection conditions. Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL-STD-202.

4.4 Qualification inspection (see 4.2). Qualification inspection shall be performed by the manufacturer on sample units produced with equipment, processes and procedures normally used in production. At the option of the qualifying activity, data from an established reliability program subjecting same or similar parts to equivalent or more stringent testing may be submitted for part or all of the qualification requirements.

4.4.1 Sample. The number of sample units comprising a sample of resistors submitted for qualification inspection shall be 75.

4.4.2 Sample selection. Sample units submitted for qualification shall consist of 25 high and 25 low resistance values. The high and low values submitted will determine the range of resistance values qualified. Qualification of resistors to a given tolerance also qualifies all higher tolerances.

4.4.3 Test routine. Sample units shall be subjected to the qualification inspection specified in Table IV in the order shown. All sample units will be subjected to the inspections of Group 1. The samples shall then be subdivided as specified in Table IV and subjected to the inspections of Groups 2 through 7.

4.4.4 Failures. Failures in excess of those allowed in Table IV shall be cause for refusal to grant qualification.

4.4.5 Inspection report. Qualification test data and the qualification test samples shall be submitted to the following activity:

NASA/GSFC
Greenbelt, MD 20771
Attn: QPLD Administrator
Code 311

4.5 Quality conformance inspection (see 4.2). Quality Conformance Inspection (QCI) shall be performed on all product furnished to this specification.

4.5.1 Inspection of product for delivery. Inspection of product for delivery shall consist of the Group A inspection per Table V and the Group B inspection in Table VI.

4.5.2 Inspection lot. An inspection lot shall consist of all resistor product of the same style and temperature characteristic, manufactured at essentially the same time under the same manufacturing process conditions and identified by a common date code (see 3.19.1).

4.5.3 Group A inspection. Group A inspection shall consist of the examinations and tests specified in Table V and shall be performed in the order shown.

4.5.3.1 Subgroup 1 tests. Subgroup 1 tests shall be performed on 100 percent of the product supplied under this specification. Resistors that are out of resistance tolerance, or which experience a change in resistance greater than that permitted for the tests of this subgroup, shall be removed from the inspection lot. Only lots having not more than 3 percent rejects or one resistor, whichever is greater, that are rejected due to exceeding the specified resistance change limit as a result of subgroup 1 tests, shall be supplied to this specification.

4.5.3.2 Subgroup 2 tests. Subgroup 2 inspections shall be performed on resistors passing subgroup 1 inspections. The number of samples inspected shall be as specified in Table V. In the event of one or more failures, the lot shall be rejected.

4.5.3.3 Lot rejections. Rejected lots shall be segregated from new lots and those lots passing the subgroup 2 inspection. The rejected lot shall be 100 percent inspected for those quality characteristics found defective in the sample, and any defects found shall be removed from the lot. After reinspection, another random sample of the size specified in Table V shall be selected. In the event one or more failures are found in this second sample, the lot shall be rejected and shall not be supplied to this specification.

4.5.4 Group B inspection. Group B inspection shall consist of the examinations and tests specified in Table VI and shall be performed in the order shown.

Table IV. - Qualification inspection.

Inspection	Requirement Paragraph	Method Paragraph	Number of Sample Units	Number of Defects Allowed 1/
Group 1				
Visual and mechanical	3.2.1, 3.3, 3.3.1, 3.19, 3.19.1, 3.20	4.6.1	All samples	0
Thermal Shock	3.5	4.6.3		
Overload/Overvoltage	3.8	4.6.6		
DC Resistance	3.4	4.6.2		
Group 2				
Resistance Temp. Characteristic	3.10	4.6.8		
Low Temperature Operation	3.17	4.6.15	10 2/	1
Terminal Strength	3.14	4.6.12		
Group 3				
Dielectric Withstanding Voltage	3.6	4.6.4		
Insulation Resistance	3.7	4.6.5	10 2/	1
Resistance to Soldering Heat	3.15	4.6.13		
Moisture Resistance	3.16	4.6.14		
Group 4				
Load Life	3.9	4.6.7	10 2/	1
Group 5				
Shock	3.11	4.6.9	10 2/	
Vibration	3.12	4.6.10		
Group 6				
Solderability	3.18	4.6.16	8 Units	1
Resistance to Solvents	3.13	4.6.11	Any Value	
Group 7				
Thermal Outgassing	3.2.2	4.6.17	2 Any Value	0

1/ The aggregate total shall not exceed 2 defective units for the qualification samples.
2/ Sample selection of 5 high and 5 low resistance values as specified in 4.4.2.

Table V. - Group A inspection.

Inspection	Requirement Paragraph	Method Paragraph	Sample Size
Subgroup 1			
Serialization	1/		
Overload/Overvoltage	3.8	4.6.6	
DC Resistance	3.4	4.6.2	100% inspection
Thermal Shock	3.5	4.6.3	
Resistance Temperature Characteristic	3.10	4.6.8	
Tracking	3.10.1	2/	
Resistance Ratio	3.4.1	3/	
Subgroup 2			100% visual
Visual and Mechanical	3.2.1, 3.3, 3.3.1, 3.19 3.19.1 3.20	4.6.1	3 mechanical

1/ Resistors shall be serialized in a manner that can be easily recognized by the user and maintains the integrity of the matched pair.
2/ Data from resistance temperature characteristic are used to ensure tracking required by paragraph 3.10.1
3/ Data from final dc resistance are used to ensure resistance ratio per paragraph 3.4.1.

Table VI. - Group B inspection.

Inspection	Requirement Paragraph	Method Paragraph	Sample Size
Dielectric Withstanding Voltage	3.6	4.6.4	13
Insulation Resistance	3.7	4.6.5	

4.5.4.1 Sample size. A random sample, of the size specified in Table VI, shall be selected. If one or more defects are found, the lot shall be rescreened and defects removed. Another sample of the same size shall be selected. If one or more defects are found in the second sample, the lot shall be rejected and shall not be supplied to this specification.

4.5.4.2 Disposition of sample units. Sample units which have been subjected to Group B inspection may be delivered to this specification provided the resistors are within resistance tolerance and meet requirements for visual and mechanical inspection.

4.5.5 Inspection record. The manufacturer shall be required to maintain a record of all QCI inspection results (see 4.5.6).

4.5.6 Retention of qualification. As a basis for retention of qualification, the manufacturer shall be requested to furnish a summary of QCI inspection results annually. The test summary shall be submitted to the activity specified in 4.4.5.

4.6 Methods of inspection.

4.6.1 Visual and mechanical inspection (see 3.2.1, 3.3, 3.3.1, 3.19, 3.19.1, and 3.20). Resistors shall be examined to verify that materials, design, construction, physical dimensions, marking and workmanship are in accordance with the applicable requirements.

4.6.2 DC resistance (see 3.4). Resistors shall be tested in accordance with Method 303 of MIL-STD-202. The applicable test voltage shall not exceed 100 vdc.

4.6.3 Thermal shock (see 3.5). Resistors shall be tested in accordance with Method 107 of MIL-STD-202 at Test Condition B.

4.6.4 Dielectric withstanding voltage (see 3.6). Resistors shall be tested in accordance with Method 301 of MIL-STD-202. The applicable test voltage shall be as Specified in Table I. The test voltage shall be applied between a conductive foil at circuit ground, that is wrapped around the resistor body, and the lead wires electrically shorted together.

4.6.5 Insulation resistance (see 3.7). Resistors shall be tested in accordance with Method 302 of MIL-STD-202 at Test Condition A.

4.6.6 Overload/overvoltage (see 3.8). Resistors shall be subjected to 1.5 times rated power (see 3.3.4) with applied voltage not to exceed maximum rated working voltage (see 3.3.5) for 5 seconds.

4.6.7 Load life (see 3.9). Resistors may be mounted in any position in a chamber at a controlled test ambient temperature of +125°C (±2°C). The load applied shall be the maximum rated power (see 3.3.4) not to exceed maximum working voltage (see 3.3.5) for a continuous duration of 2000 hours. DC resistance shall be measured and recorded prior to the beginning of the life test and at 100, 250, 500, 1000 and 2000 hours. The change in resistance at any interval shall not exceed the requirement in Table III.

4.6.8 Resistance temperature characteristic (see 3.10). Resistors shall be tested in accordance with Method 304 of MIL-STD-202 except as modified herein. The first series of standard test temperatures shall be 25°C and -20°C; the second series shall be 25°C and 60°C.

4.6.9 Shock (see 3.11). Resistors shall be tested in accordance with Method 213 of MIL-STD-202 at Test Condition I.

4.6.10 Vibration (see 3.12). Resistors shall be tested in accordance with Method 204 of MIL-STD-202 at Test Condition D.

4.6.11 Resistance to solvents (see 3.13). Resistors shall be tested in accordance with Method 215 of MIL-STD-202.

4.6.12 Terminal strength (see 3.14). Resistors shall be tested in accordance with Method 211 of MIL-STD-202 at Test Conditions A and D except as follows: the applicable applied force for Test Condition A shall be 2.5 pounds.

4.6.13 Resistance to soldering heat (see 3.15). Resistors shall be tested in accordance with Method 210 of MIL-STD-202 at Test Condition A without the use of any flux.

4.6.14 Moisture resistance (see 3.16). Resistors shall be tested in accordance with Method 106 of MIL-STD-202. The following details and exceptions shall apply:

a. Polarization and loading voltage are not applicable.

b. Final measurements shall consist of dc resistance, dielectric withstanding voltage per 4.6.4, and insulation resistance per 4.6.5.

c. The dc resistance measurement shall be used as the initial measurement for the dielectric withstanding voltage test.

4.6.15 Low temperature operation (see 3.17).

4.6.15.1 DC resistance. DC resistance shall be measured in accordance with 4.6.2.

4.6.15.2 Mounting. Resistors shall be mounted by their terminals with at least 1 inch of free air space around each resistor. The mounting fixture shall be constructed in such a fashion as to minimize the obstruction of air flow across and around resistors when placed in the cold chamber for test.

4.6.15.3 Procedure. Following the dc resistance measurement, the resistors, mounted as specified in 4.6.15.2, shall be placed in a cold chamber at room temperature. The temperature shall then be gradually decreased to -65°C, +0°, -5°C, within a period of not less than 1 and 1/2 hours. After 1 hour of stabilization at the specified temperature, the full rated continuous working voltage specified in 3.3.5 shall be applied for 45 minutes (resistors may be loaded individually or in parallel). Within 15-20 minutes after removal of the voltage, the temperature in the chamber shall gradually be increased to room temperature within a period of not more than 8 hours. The resistors shall then be removed from the chamber and maintained at a temperature of +25 ± 5°C for a period of approximately 24 hours.

4.6.15.4 Final examination. Resistors shall then be examined for evidence of mechanical damage, and the dc resistance shall be measured as specified in 4.6.2.

4.6.16 Solderability (see 3.18). Resistors shall be tested in accordance with Method 208 of MIL-STD-202.

4.6.17 Thermal outgassing (see 3.2.2). Resistors shall be tested in accordance with ASTM E595.

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-R-39032 except each pair of matched resistors may be place in a single, anti-static bag.

6. NOTES

6.1 Style numbers. Style numbers correspond to Caddock's model numbers for Type TK, low TC, precision radial-lead resistors.

6.2 Inductance considerations. Note 2/ in Table I identifies low inductance construction. For further information, consult the manufacturer's catalog or contact Caddock Electronics, Incorporated, 1717 Chicago Avenue, Riverside, CA 92507-2364.

6.3 Ordering data. Acquisition documents should specify the following:

a. Number, title, and date of this specification.
b. Goddard Part Number
c. Quantity

6.4 Qualification provisions. With respect to product requiring qualification, awards will be made only for product which have been tested and approved by GSFC before the time for opening of bids. The attention of the suppliers is called to the following requirement: manufacturers should arrange to have qualification tests made on product which they propose to offer to GSFC to become eligible for awards of contracts or orders for product covered by this specification. The manufacturer shall bear the cost of qualification inspection to this specification. Information pertaining to qualification of product may be obtained from the activity whose address is listed in 4.4.5.

6.5 NOTICE. When GSFC drawings, specifications, or other data are sent for any purpose other than in connection with a definitely related GSFC procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever. The fact that GSFC might have formulated, furnished or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any person or corporation, or conveying any right or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Custodian:

Code 311.2
Goddard Space Flight Center
Greenbelt, MD 20771