SPECIFICATION

108-120068

EMI Conductive Elastomers

Electrically Conductive Elastomer (ECE) articles designed for Electromagnetic Interference (EMI) shielding. There are multiple ECE materials; all are composed of an electrically conductive filler bound in either a silicone or fluorosilicone elastomer matrix. These materials are extruded or moulded to form them into a shape which can then be further fabricated to form a gasket or "seal". Under compression, ECE materials provide "grounding" and maintain a conductive pathway to facilitate dissipation of electromagnetic "noise" between the environment and the enclosure or assembly of application.

RoHS and REACH compliant.

Typical continuous operating temperature: -55°C to 160°C (-67°F to 320°F).

Please consult 9.1 Appendix 1 Material Specific Data Table at the end of this document for material specific data.

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1 SCOPE

This specification establishes the quality standard of manufactured Electrically Conductive Elastomer (ECE) materials used to manufacture Electromagnetic Interference (EMI) shield products. These products are bespoke in design and therefore, this specification adopts industry standard methods to test the materials. The performance of materials tested in accordance with this specification do not represent application-based performance.

2 REVISION HISTORY

Revision number	Change request	Date	Incorporated By
A	-	07/06/22	James Martin
A1	Added drawing references in section 6 that were previously omitted.	27/06/22	James Martin
A2	Related documents modified to include connector gasket MIL specifications. Test and inspection criteria for connector gaskets has been added. Drawing references added for connector gaskets.	27/07/22	James Martin
A3	Obsolete document references removed. Superseded document references updated.	22/08/22	James Martin
A4	Additional drawing references for D-subminiature connector gaskets and jam nut seals (standard moulded O-rings) added.	23/09/22	James Martin

3 RELATED DOCUMENTS

This specification takes precedence over documents referenced herein. Unless otherwise specified, the latest issue of referenced documents applies. The following documents form a part of this specification to the extent specified herein.

3.1 MILITARY DETAILS (MIL-DTL) & SPECIFICATIONS

MIL-DTL-83528 - General specification for gasketing material, conductive, shielding gasket, electronic, elastomer, EMI/RFI.

MIL-DTL-5015 – Detail specification, Connectors, Electrical, Circular threaded, AN type, General specification for

MIL-DTL-38999 – Detail specification, Connectors, Electrical, Circular, Miniature, High density, Quick disconnect (Bayonet, Threaded Or Breech Coupling), Environment resistant with crimp removeable contacts or hermetically sealed with fixed solderable contacts, General specification for

(Copies of MIL publications may be obtained from retailers of specifications and standards.)

3.2 AMERICAN SOCIETY FOR TESTING AND MATERIAL (ASTM)

ASTM-D395	Standard Test Methods for Rubber Property – Compression Set
ASTM- D412	Standard Test Methods for Rubber Vulcanized and Thermoplastic Elastomers - Tension
ASTM-D471	Standard Test Methods for Rubber Property-Effect of Liquids
ASTM-D575	Standard Test Methods for Rubber Properties in Compression
ASTM-D624	Standard Test Methods for Rubber and Thermoplastic Elastomers, Tear Strength of Conventional Vulcanized
ASTM-D792	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM-D991	Standard Test Methods for Rubber Property – Volume Resistivity of Electrically Conductive and Antistatic Products
ASTM-D2240	Standard Test Methods for Rubber Property – Durometer Hardness

(Copies of these documents are available online at http://www.astm.org.)

4. REQUIREMENTS

4.1 COMPOSITION AND APPEARANCE

The formed and finished components covered by this specification are conductive rubber composites. They are homogenous in colour but have a granular texture, due to the presence of the appropriate conductive filler.

The following characteristics indicate a "well cured" product and should be observed in the finished components:

a) A smooth and shiny surface finish, except for intentionally cut edges or faces of the component.
b) When lightly indented with a low pressure, the surface of the material should recover from indentation.

In addition to the specific criteria detailed above, all components should be free from, flaws, defects, discoloration and should have minimal moulding "flash".

4.2 MATERIAL SELECTION

The range of standard materials for the production of components is detailed in the table below:

TE Material Code	Material Description	Colour
SNG	Silicone Nickel Graphite	Dark Grey
SSA	Silicone Silver Aluminium	Beige
FSA	Fluorosilicone Silver Aluminium	Light Green
FNG	Fluorosilicone Nickel Graphite	Dark Green

Material selection for the required component is application specific. Therefore, please consult technical documentation carefully and if you are in need of assistance please seek advice from a customer service representative.

More detail on the performance of materials will be specified in 9.1 Appendix 1 Material Specific Data Table.

5. QUALITY ASSURANCE PROVISIONS

5.1 CLASSIFICATION OF TESTS

5.1.1 Validation Tests

Validation tests are those which are conducted periodically at our discretion to confirm that the materials manufactured perform in accordance with this specification.

5.1.2 Qualification Tests

Qualification tests are those which are performed each batch of material to confirm that the material is approved for production.

5.1.3 Acceptance Tests

Acceptance Tests are those that are performed on each batch of finished formed product to confirm that the production requirements have been met.

5.2 SAMPLE PREPARATION

Details of the sample preparation for each of the different types of tests are detailed below.

5.2.1 Validation Test Samples

Samples are prepared from a randomly selected batch of material and are moulded or cut from standard stock to meet the specified dimensions for each test method.

5.2.2 Qualification Test Samples

One sample button and one sample sheet are moulded from each and every production batch. These samples are utilized for all three standard qualification samples.

The sample button shall be moulded to a minimum thickness of 6.0mm and a minimum diameter of 25.0mm. Typical samples are 7.0-8.0mm in thickness and 25.0mm in diameter.

The sample sheet shall be moulded to a thickness of 1.6mm – 2.1mm and approximately 37mm x 37mm. This sample is then cut prior to performing the appropriate qualification test.

All qualification test samples are moulded at standard production conditions of time, temperature, and pressure to ensure that the samples are sufficiently cured. All samples are subjected to standard post-cure procedures.

5.2.3 Acceptance Test Samples

The acceptance test for extruded products are defined by the first-off inspection, periodic intermediate inspection and formal final inspection. These checks are inspection of the nominal dimensions of the profile and a visual inspection for sufficient cure of the product.

The acceptance tests for moulded sheet are 100%-dimensional inspection of sheet thickness, as well as periodic visual inspection for flaws, defects, mould faults or flash.

For finished custom moulded parts, final inspection is of the finish, cure and dimensions defined by the customer drawing.

For custom parts that are cut from sheet, such as connector gaskets, acceptance tests are defined by the first-off inspection, periodic intermediate inspection and formal final inspection. These checks are inspection of the appropriate dimensions of the part, in-line with the appropriate drawing and to the specified tolerances.

5.3 TEST PROCEDURES

All test procedures referenced from hereon are conducted at our discretion or by an approved test provider.

5.3.1 Validation Tests

5.3.1.1 Tensile Strength & Elongation (ASTM D412)

Five dumbbells shaped (Die C) samples are cut from standard moulded sheet stock of the appropriate ECE material at a nominal thickness of 2.0mm.

Figure 1: A standard sample of ECE material cut in preparation for Tensile Strength & Elongation Testing.

Each sample is measured for thickness and width at the narrowest point of the dumbbell.
The sample is then placed between the grips of a Tensile test machine and the auxiliary elongation clamps are gripped around the sample at a spacing of 20mm.
The sample is extended at a rate of 500mm/min and the resultant forces and % extension is recorded.
The mean values for the 5 samples are calculated for each parameter and reported.

5.3.1.2 Tear Strength (ASTM D624)

Five 90^{o} bent samples (Die C) are cut from standard moulded sheet stock of the appropriate ECE material at a nominal thickness of 2.0mm.

Figure 2: A standard sample of ECE material cut in preparation for Tear Strength Testing.

The thickness of each sample across the apex of the 90^{0} bend is measured and recorded.
Each sample is then placed in the grips of a Tensile test machine. The sample is stretched under a constant rate of extension of 500 mm/minute. The force results of the extension are recorded and the force at rupture (tear) through the 90^{0} bend is noted. Reported values are averaged and the Tear strength is calculated from the Force divided by the sample thickness (N/mm).

5.3.1.3 Compression Set (ASTM D395 Method B)

Six samples of material should be moulded for each test. These samples should be cylinders 13.0 ± 0.2mm in diameter & 6.0 ± 0.2mm in thickness. Sample thickness measurements are made prior to testing and the average of the measurements taken.
The samples are placed between steel plates and compressed to ≈ 25% compression.
Once under compression, the samples are placed in a fan assisted oven at 100°C ± 1°C for 72 hours.
The samples are removed after this exposure period, released from compression and allowed to cool and relax for 30 minutes.
The final thickness of each sample is recorded, and the results are averaged.

Compression set is then calculated as follows:

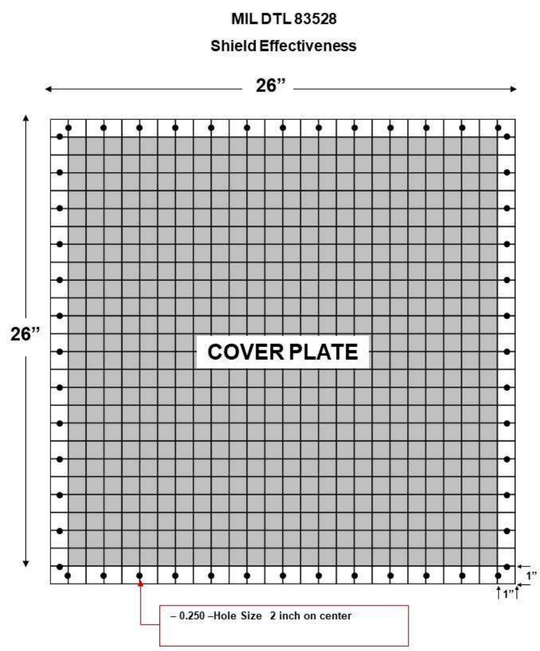
$$C_B = \left[\frac{t_0 - t_i}{t_0 - t_n}\right] \times 100$$

Where;

$$C_B = Compression\ Set\ (\%\ of\ original\ deflection)$$
$$t_0 = original\ thickness\ of\ test\ sample\ (average)$$
$$t_i = final\ thickness\ of\ test\ sample\ (average)$$
$$t_n = thickness\ of\ compression\ limiter\ used\ (actual)$$

5.3.1.4 Shielding Effectiveness 20MHz – 10GHz (MIL-DTL-83528)

Shielding effectiveness testing is performed on a gasket fabricated from the appropriate material to the following schematic:



The gasket is then placed over the flange of the shielded enclosure.
The effectiveness of the gasket to shield from EMI frequencies through the enclosure wall, is then measured and reported across the frequency range.

5.3.2 Qualification Tests

5.3.2.1 Shore A Hardness (ASTM D2240)

The previously described test button in section 5.2.2 is placed beneath the foot of a durometer with a Type C indenter.
The durometer is then placed into the material until the foot "bottoms out" on the test button and the indenter is compressed within the durometer. After 5 seconds the Shore A hardness is read from the digital display.
This measurement is repeated on the opposing side of the test button and the median value is reported.

5.3.2.2 Specific Gravity (ASTM D792)

The previously described test button from section 5.2.2 is weighed in air and water using the specific gravity densimeter. The Specific Gravity (SG) is calculated from the ratio of these 2 measurements and is displayed on the digital display.

5.3.2.3 Volume Resistivity (MIL-DTL-83528)

Using the appropriate punch, a 10mm disc is cut from the standard sheet moulding as produced in section 5.2.2.
The thickness of the disc is measured and recorded. An insulating shim at 75% of the disc thickness is selected and placed between pressure probes. The disc is then placed on the top of the pressure probes and compression is applied until the probes bottom out against the shim.
This should achieve 25% of the material. The resistance is read and recorded from a digital Ohm-meter, through a "Kelvin-resistance bridge" to reduce the uncertainty in the measurement due to the resistance of the test apparatus.
The volume resistivity is then calculated as follows:

$$\rho = R\left(\frac{A}{l}\right)$$

$$\rho = Volume\ Resistivity\ (\Omega.cm)$$
$$R = Measured\ electrical\ resistance\ (\Omega)$$
$$A = Cross\ sectional\ are\ of\ the\ test\ specimen\ (cm^2)$$
$$l = path\ length\ of\ flow\ of\ current\ through\ specimen\ (cm)$$

5.3.3 Acceptance Tests

5.3.3.1 Extruded Profiles

The product should be inspected for cure at the start of the production run.
This is done by softly indenting the product to ensure that the material recovers from indentation and does not deform under pressure.
There should also be a smooth shiny surface finish to a well cured part.
The nominal dimensions of the extruded profile should be measured using a vernier caliper and appropriately sized calibrated drill blanks. or pins.
The first off sample should be retained and used as a comparison against samples during the production run, as well as to the last-off sample.

5.3.3.2 Moulded Sheet

Each moulded sheet should be visually inspected for cure and mould faults as they are processed in production. The thickness of each sheet can be measured using a vernier caliper

5.3.3.3 Custom Moulded Parts

If a part deviates from the standard product offering, the part should be inspected to the appropriate drawing and tolerance scheme. Dimensions can be assessed using a vernier caliper where appropriate. If dimensions are difficult to interpret using standard production measurement systems, the first-off inspection should be conducted by a member of the quality team trained in the use of the non-contact measuring machine.
All custom moulded parts should still be inspected for quality of cure and finish.

5.3.3.4 Connector Gaskets

Connector gaskets should be dimensionally inspected to drawing for each of the main features (overall length, width, hole pitches and internal hole diameters).

6 DIMENSIONS

The dimensions of all parts should be in accordance with the appropriate drawings referenced below:

- C-1201-ECE-CORD
- C-1202-ECE-TUBE
- C-1210-ECE-SHEET
- C-1212-ECE-SHEET
- C-92-CONNECTOR GASKETS
- C-93-CONNECTOR GASKETS
- C-95-D-CONNECTOR GASKETS
- C-98-SERIES-JAM-NUT-SEALS
- C-99-SERIES-JAM-NUT-SEALS

6.1 Extruded Parts

Extruded parts are extruded as continuous lengths defined in Meters (MR).

Typical tolerances of extruded parts are as follows:

Nominal Dimension (mm)	Tolerance Band (mm)
0.0 – 2.0	±0.10
2.1 – 5.0	±0.15
5.1 – 9.0	±0.20

6.2 Moulded Sheet

Moulded Sheet material have standard dimensions of 150mm x 150mm or 300mm x 300mm, in various nominal thicknesses.

Typical tolerances for moulded sheet materials are as follow:

Nominal Thickness (mm)	Tolerance Band (mm)
0.0 – 2.0	±0.15
2.0 and above	±0.25
Linear Dimension (mm)	± 0.80

6.3 Custom Moulded Parts

If a requested component deviates from the standard product range, the customer drawing, dimensions, specification, and tolerances take precedence.

7 PRODUCT HANDLING

Product handling of conductive elastomers is critical to ensure that the function of the product is protected.

Conductive elastomer products should be utilised as designed, and work well in compressive force environments.
They are not suitable for stretch or strain application, as under these conditions the conductive matrix bound within the elastomer can be ruptured leaving a poor conductive pathway and therefore poor shielding material.

Protective gloves should be worn when handling ECE products to prevent damage to the surface of the components and avoid any potential contamination of the stock.

Conductive Elastomer products can be cut to further form them for end applications. It is advised that cutting process are designed so that lubricants are not required. Sharp steel blades free from any oils, grease or dirt are typically used.

8 PACKAGING & STORAGE

8.1 PACKAGING & HANDLING

ECE materials should be packaged in opaque, sulfur-free packaging that will prevent degradation of the elastomer, due to exposure to vulcanization by-products, dissimilar materials or Ultra-Violet Radiation.
The elastomer products should be free from debris, dirt, flash, grease, oils or any other fluid contaminants.
When handling or repackaging, care should be taken not to stretch the material.
Protective gloves should be worn when handling the elastomer, to prevent contamination, tarnishing of silver-containing products or skin sensitization due to the presence of Nickel.

8.2 STORAGE & SHELF-LIFE

Conductive elastomers should be stored under the following conditions:

- In original packaging
- At ambient temperature and humidity
- Isolated from corrosive materials
- Isolated from direct sunlight

Under these conditions, conductive elastomers have a shelf-life of 20 years.

9 APPENDICES

9.1 Appendix 1 Material Specific Data Table

Test Specification / Material Code	SNG	SSA	FNG	FSA
MIL-DTL-83528 Material Type	-	Type B	-	Type D
Recommended Operating Temperature Range (°C)	-55 to 160	-55 to 160	-55 to 160	-55 to 160
Specific Gravity (tolerance ± 13%) (ASTM D792)	2.000	2.000	2.200	2.000
Shore A Hardness Units (tolerance ± 7, unless otherwise stated) (ASTM D2240)	65	65	65	70
Minimum Tensile Strength (ASTM D412) (lbs/in^2 / MPa)	200 / 1.379	200 / 1.379	200 / 1.379	180 / 1.241
Minimum Elongation @ Break (%) (ASTM D412)	150	100	150	60
Maximum Compression Set (%) (ASTM D395 – 70hrs @ 100^{O}C)	25	32	25	30
Minimum Tear Strength ASTM D624 (lbf/in / N/mm)	50 / 8.756	30 / 5.254	40 / 7.005	35 / 6.1294
Maximum Volume Resistivity (as received) MIL-DTL-83528 (pressure probe method) (Ω.cm)	0.05	0.008	0.05	0.012
Minimum Shielding Effectiveness @ Specified Frequency (MIL-DTL-83528)				
20 MHz	106	108	106	106
40 MHz	105	106	105	105
60 MHz	106	109	105	107
80 MHz	114	118	110	111
100 MHz	111	109	108	106
200 MHz	116	117	114	106
400 MHz	119	123	116	117
600 MHz	112	114	106	106
800 MHz	114	120	116	120
1 GHz	118	114	108	112
2 GHz	111	101	100	106
4 GHz	100	107	104	112
6 GHz	104	105	104	97
8 GHz	110	105	106	114
10 GHz	110	102	105	112