



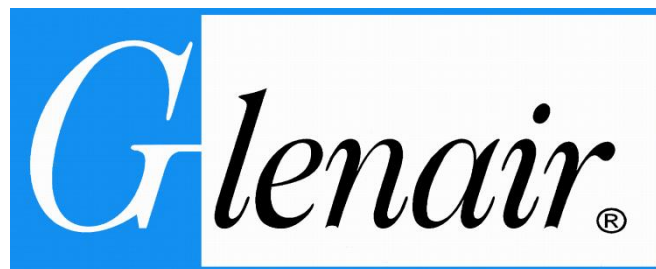
Glenair Test Report

ArmorLite Braid (103-051) Testing

GT-17-263

Version C

4/11/18



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Table 1: Report Revision History

Date	Revision	Notes
12/12/17	A	Release
12/12/17	B	Corrected number of samples referenced.
4/11/18	C	Nomenclature and label clarification.

Table 2: Test Deviations

Test	Description
N/A	N/A

1.0 Summary of Testing

All testing in this report was conducted in accordance with QTP-648 “ArmorLite Braid (103-051) Qualification”. The intent of this testing is to verify that ArmorLite yarn (960-10004) material in braid form performs sufficiently in the following tests: Vibration, Thermal Shock, Pull Strength, Salt Spray, Flex Testing, Abrasion Resistance, and Transfer Impedance.



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2.0 General Information

2.1 References

- **QTP-648:** “ArmorLite Braid (103-051) Qualification”.
- **EN 6069-406:** Aerospace series – Electrical cables, installation – Protection sleeves – Test methods – Part 406: Vibration.
- **EN 3475-511:2002:** Cables, electrical, aircraft use. Test methods Cable to Cable abrasion.
- **EN 3475-301:2002:** Cables, electrical, aircraft use. Test methods. Ohmic resistance per unit length
- **RTCA/DO-160G:** Environmental Conditions and Test Procedures for Airborne Equipment.
- **EN 6059-308:** Aerospace series – Electrical cables, installation – Protection sleeves – Test methods Part 308: Rapid Change of Temperature.
- **EN 6059-308:** Aerospace series – Electrical cables, installation – Protection sleeves – Test methods Part 308: Rapid Change of Temperature.
- **ISO 7137:** Aircraft – Environmental conditions and test procedures for airborne equipment.
- **IEC 62153-4-3:** Metallic communication cable test methods, Electromagnetic compatibility (EMC) – Surface transfer impedance—Triaxial method.
- **IEC 62153-4-4:** Metallic communication cable test methods, Electromagnetic compatibility (EMC) – Shielded screening attenuation, test method for measuring of the screening of attenuation, a_s , up to and above 3 GHz.
- **EN 6059-404:** Aerospace series – Electrical cables, installation – Protection sleeves – Test methods Part 404: Tensile Strength.
- **EN 6059-402:** Aerospace series – Electrical cables, installation – Protection sleeves – Test methods Part 402: Bending Properties.



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2.2 Test Samples

103-051

DASH NO	NOMINAL I.D. (REF.)	REF. WIRE BUNDLE RANGE NOMINAL	APPROX. GRAMS PER FT. NICKEL CLAD	APPROX. GRAMS PER FT. SILVER CLAD	APPROX. MILLIAMS PER METER
D01	.031 (.8)	.016 (.4) .047 (1.2)	.52	.53	355
D02	.082 (1.8)	.040 (1.0) .075 (1.9)	1.18	1.23	128
D04	.125 (3.2)	.083 (2.1) .140 (3.5)	1.56	1.60	108
D08	.250 (6.4)	.126 (3.2) .312 (7.9)	2.28	2.35	85
D12	.375 (9.5)	.250 (6.4) .406 (10.3)	3.00	3.10	48
D18	.500 (12.7)	.375 (9.5) .560 (14.2)	4.56	4.70	33
D20	.625 (15.8)	.500 (12.7) .700 (17.8)	4.97	5.13	32
D24	.750 (18.8)	.600 (15.2) .800 (20.3)	6.00	6.18	25
D32	1.000 (25.4)	.780 (19.8) 1.100 (27.9)	11.9	12.3	13
D40	1.250 (31.8)	.938 (23.8) 1.312 (33.3)	14.5	15.0	11.3
D48	1.500 (38.1)	1.187 (30.1) 1.580 (40.4)	17.9	18.5	9
D64	2.000 (50.8)	1.312 (33.3) 2.000 (50.8)	23.6	24.4	5
D80	2.500 (63.5)	2.000 (50.8) 2.750 (69.9)	T.B.D.	T.B.D.	T.B.D.

REV.	DESCRIPTION	DATE	APPROVED
A	RELEASED	02/18/10	T.L.
B	REVISED PER DDN 36314	04/06/10	H.P.
C	REVISED PER DDN 36627	04/30/10	T.L.
D	REVISED PER DDN 37558	12/22/10	ACH
E	REVISED PER DDN 38560	03/28/11	ACH
F	REVISED PER DDN 38865	04/14/11	T.L.
G	REVISED PER DDN 38818	04/18/11	T.L.
H	REVISED PER DDN 38868	04/28/11	T.L.
J	REVISED PER DDN 38854	05/11/11	ACH
K	REVISED PER DDN 40540	11/28/11	H.D.
L	REVISED PER DDN 41528	02/15/12	ACH
M	REVISED PER DDN 51588	02/15/14	H.P.
N	REVISED PER DDN 52311	10/02/14	DD
P	REVISED PER DDN 64365	03/13/16	J.N.
R	REVISED PER DDN 60455	08/01/18	J.N.

PART NUMBER DEVELOPMENT

EXAMPLE: 103-051-024-S

PRODUCT SERIES

BASIC NO.

4 DASH NO.

S = SILVER CLAD
OMIT FOR STANDARD

ORDER LENGTH

WIRE BUNDLE ACCOMMODATION RANGE (REF.)

NOMINAL I.D. (REF.)

NOTES:

- MARKING - LABEL INDIVIDUAL PACKAGES.
- MATERIAL - ARMORLITE[®] NICKEL CLAD/316L STAINLESS STEEL.
- ARMORLITE[®] REGISTERED TRADEMARK OF GLENAIR, INC.
- SPECIFY DASH NO. XXX FOR MACHINE BRAIDED CABLE.

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UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES:	<table border="1"> <tr> <td>DRAWN</td> <td>T. LE</td> <td>02/18/10</td> </tr> <tr> <td>CHECK</td> <td>P. CLARK</td> <td>02/18/10</td> </tr> <tr> <td>ENGR</td> <td>R. FAULKNER</td> <td>02/18/10</td> </tr> </table>	DRAWN	T. LE	02/18/10	CHECK	P. CLARK	02/18/10	ENGR	R. FAULKNER	02/18/10	<p>GLENAIR, INC.</p> <p>1251 AIR WAY - GLENDALE - CALIFORNIA 91201</p> <p>ARMORLITE[®] SPECIAL PURPOSE BRAID, LIGHT WEIGHT, STAINLESS STEEL</p>
DRAWN	T. LE	02/18/10									
CHECK	P. CLARK	02/18/10									
ENGR	R. FAULKNER	02/18/10									
<p>FRACTIONS ± 1/16</p> <p>DECIMALS ±.02</p> <p>ANGLES ± 3°</p>	<p>DATE: 02/18/10</p> <p>SCALE: N/A</p> <p>WEIGHT: N/A</p>	<p>REV. 103-051</p> <p>SHEET 1 OF 1</p>									

Figure 1: Glenair Armorlite braid drawing 103-051



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Figure 2: Flat Armorlite braid samples prepared for testing



Figure 3: Armorlite braid samples installed on cable bundles and ready for testing



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3.0 Test Sequence

Table 3: Test Group Identification

Test Group	Test Type	Specification	Sample Labels	Sample Construction
1	Vibration	DO-160G Matrix Category S Curves E and H.	201 / 202 / 203	Braid Over Cable Bundle
2	Thermal Shock	EN 6059-308.	204 / 205 / 206	Braid Over Cable Bundle
3	Pull Strength	EN 6059-404.	207 / 208 / 209	Braid Only
4	Salt Spray	DO-160G, Section 14.0, Matrix Category T.	210 / 211 / 212	Braid Only
5	Flex Testing	EN 6059-402	213 / 214 / 215	Braid Over Cable Bundle
6	Abrasion Resistance	EN 3475-511	216 / 217 / 218	Braid Over Cable Bundle
7	Transfer Impedance & Screening Attenuation	IEC 62153-4-3 IEC 62153-4-4	219 / 220 / 221	Braid Over Teflon Wrapped Coax Cable

Note: Each sample shall be 48" in length per EN 3475-301. All test samples part # 103-051-016.



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Table 4: Order of Testing

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Visual Inspection	x	x	x	x	x	x	x
Resistance Per Unit Length	x	x	x	x	x	x	
Vibration	x						
Thermal Shock		x					
Pull Strength			x				
Salt Spray				x			
Flex Testing					x		
Abrasion Testing						x	
Transfer Impedance & Screening Attenuation							x
Visual Inspection	x	x	x	x	x	x	
Resistance Per Unit Length	x	x		x	x	x	



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4.0 Tests

4.1 Vibration

4.1.1 References

- QTP-648: “ArmorLite Braid (103-051) Qualification”.
- EN 6069-406: Aerospace series – Electrical cables, installation – Protection sleeves – Test methods – Part 406: Vibration.
- RTCA/DO-160G: Environmental Conditions and Test Procedures for Airborne Equipment.

4.1.2 Test Equipment

Table 5: Vibration Test Equipment

Manufacturer	Model Number	Description
Ling	A395	Electrodynamic Shaker
Vibration Research	VR9500	4 Channel Vibration Controller
Dytran	3056D1	9.87 mV/g Accelerometer
Dytran	3056B1	10.76 mV/g Accelerometer
IET	LOM-510A	Micro-OhmMeter
Husky	39104	100 ft-lbs Torque Wrench
Starrett	S-25	25ft Tape Measure

4.1.3 Test Method and Setup

All test samples were tested in accordance with QTP-648 and DO-160G. Each of the 3 samples was tested on a single fixture and underwent 1 hour of random vibration 7.94 Grms (Category S, Curve E) in each axis and a single sweep of sinusoidal vibration (Category H, Curve P) from 10 Hz to 250 Hz at approximately 10 Hz per minute and 10 G's.

4.1.4 Test Results

All Armorlite samples were exposed to the tests defined in section 4.1.3. All samples showed no excessive wear when examined visually and no large increase in electrical resistance post vibration. All resistance measurements were performed in accordance with QTP-648 over 1 meter of flat braid. Please see electrical resistance Table below for details.



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Table 6: Vibration Testing Resistance Values

Sample Number	Initial Resistance mΩ	Final Resistance mΩ	Percent Change	PASS/FAIL (Less Than +10% Change)
201	34.75	34.51	-0.7%	PASS
202	34.74	34.47	-0.8%	PASS
203	34.87	34.81	-0.2%	PASS

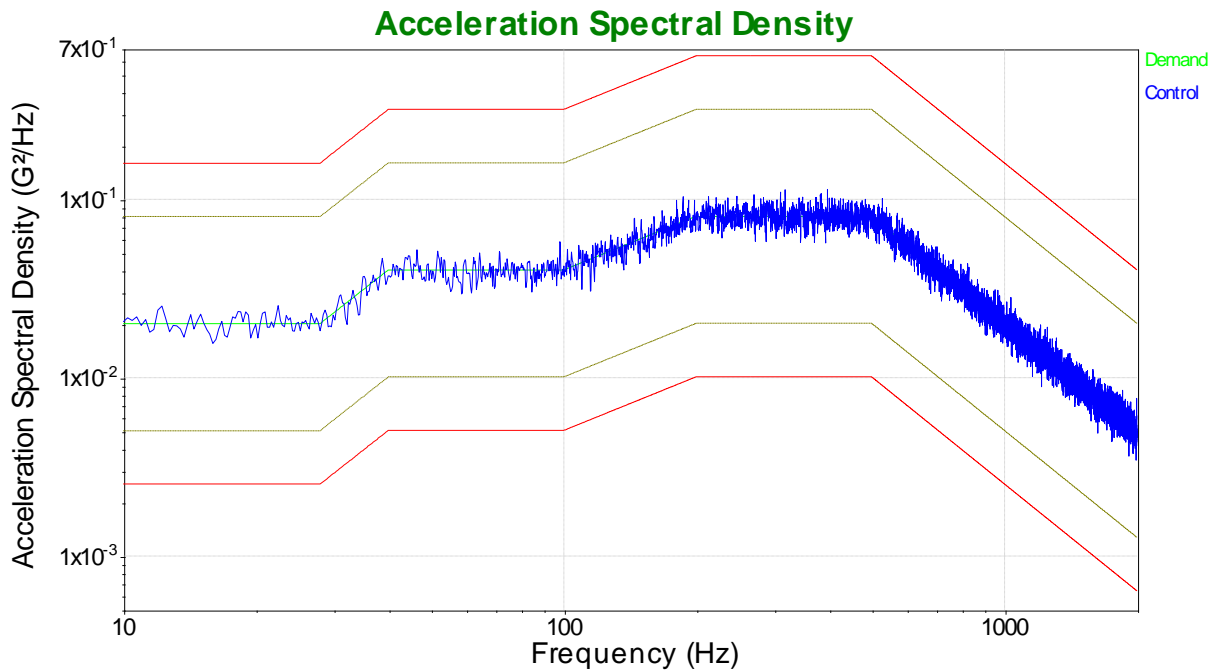


Figure 4: Random vibration profile, X-axis, sample



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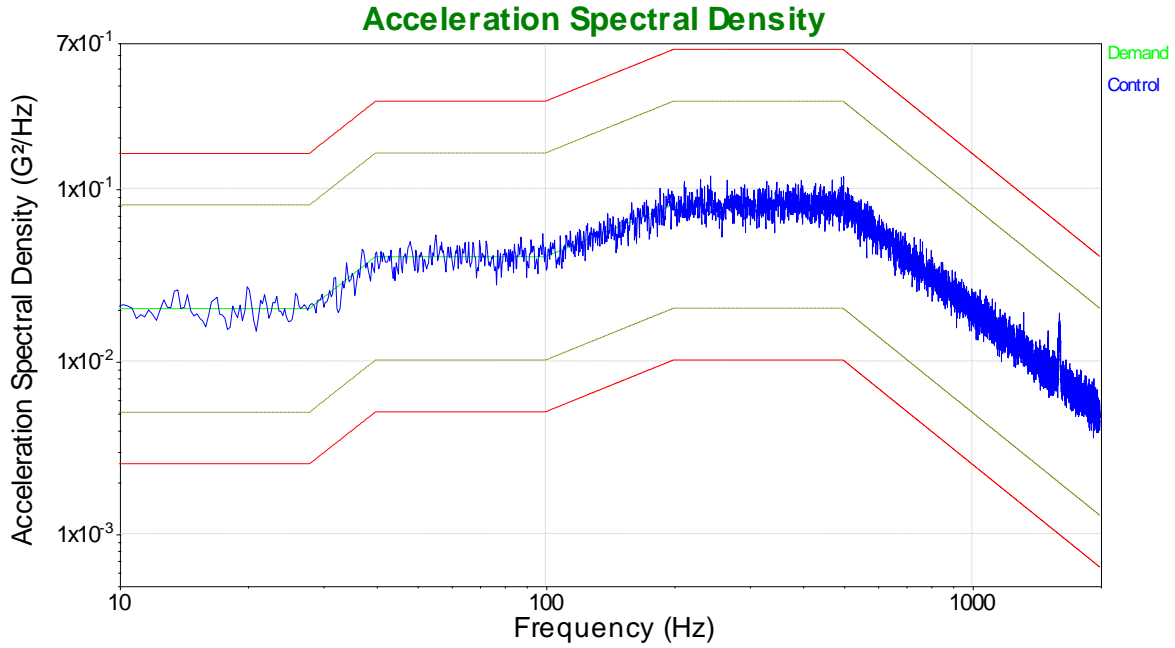


Figure 5: Random vibration profile, Y-axis, sample

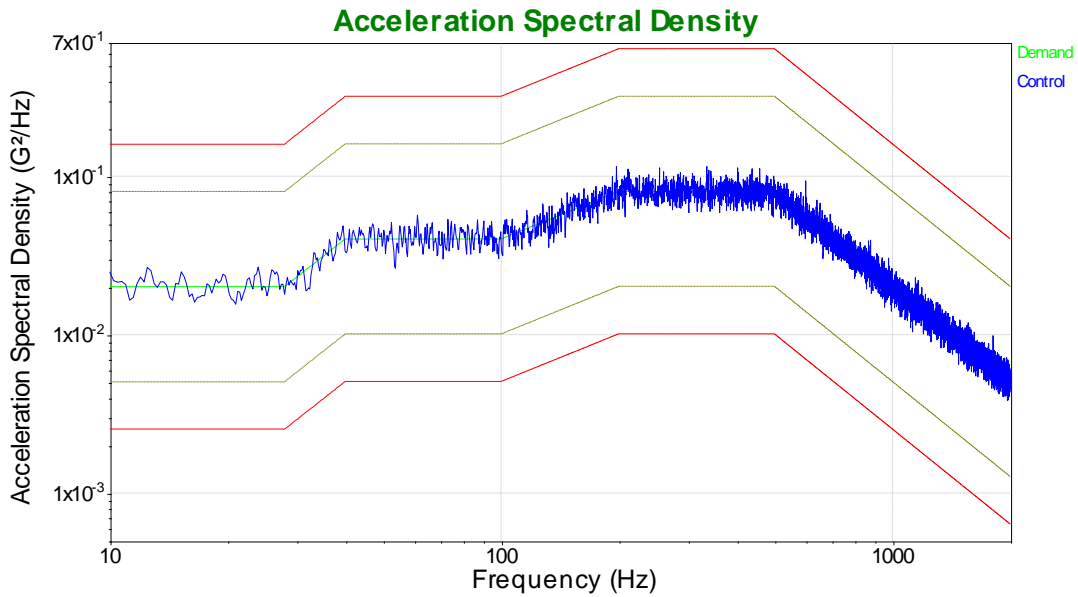


Figure 6: Random vibration profile, Z-axis, sample



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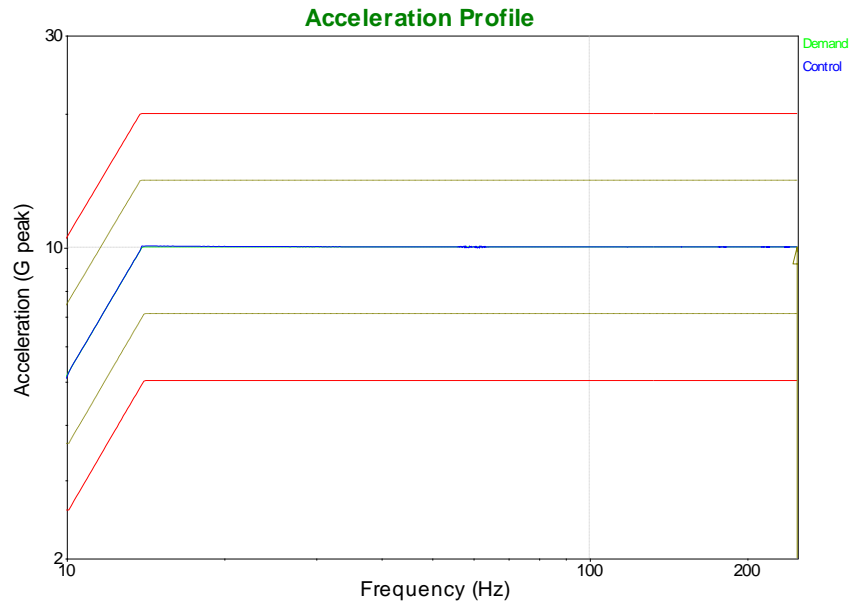


Figure 7: Sine vibration sweep, X-axis, test sample 201

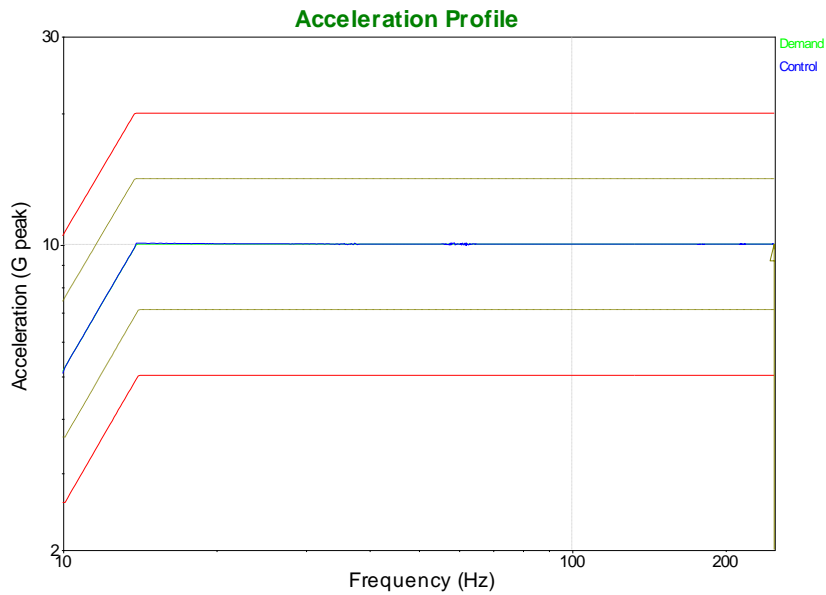


Figure 8: Sine vibration sweep, Y-axis, test sample 201



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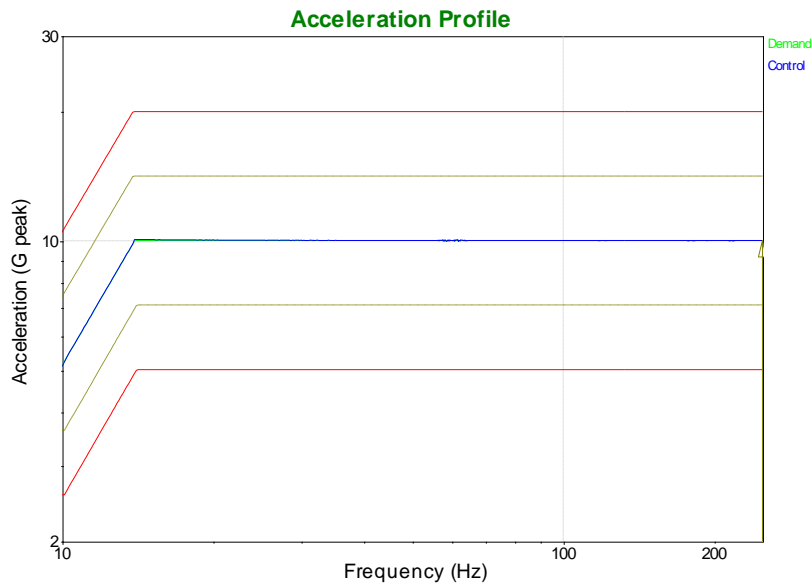


Figure 9: Sine vibration sweep, Z-axis, test sample 201

4.1.5 Deviation of Test

No test deviations were present during vibration testing.



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4.1.6 Photographs



Figure 10: Vibration Test Set up for Z-axis



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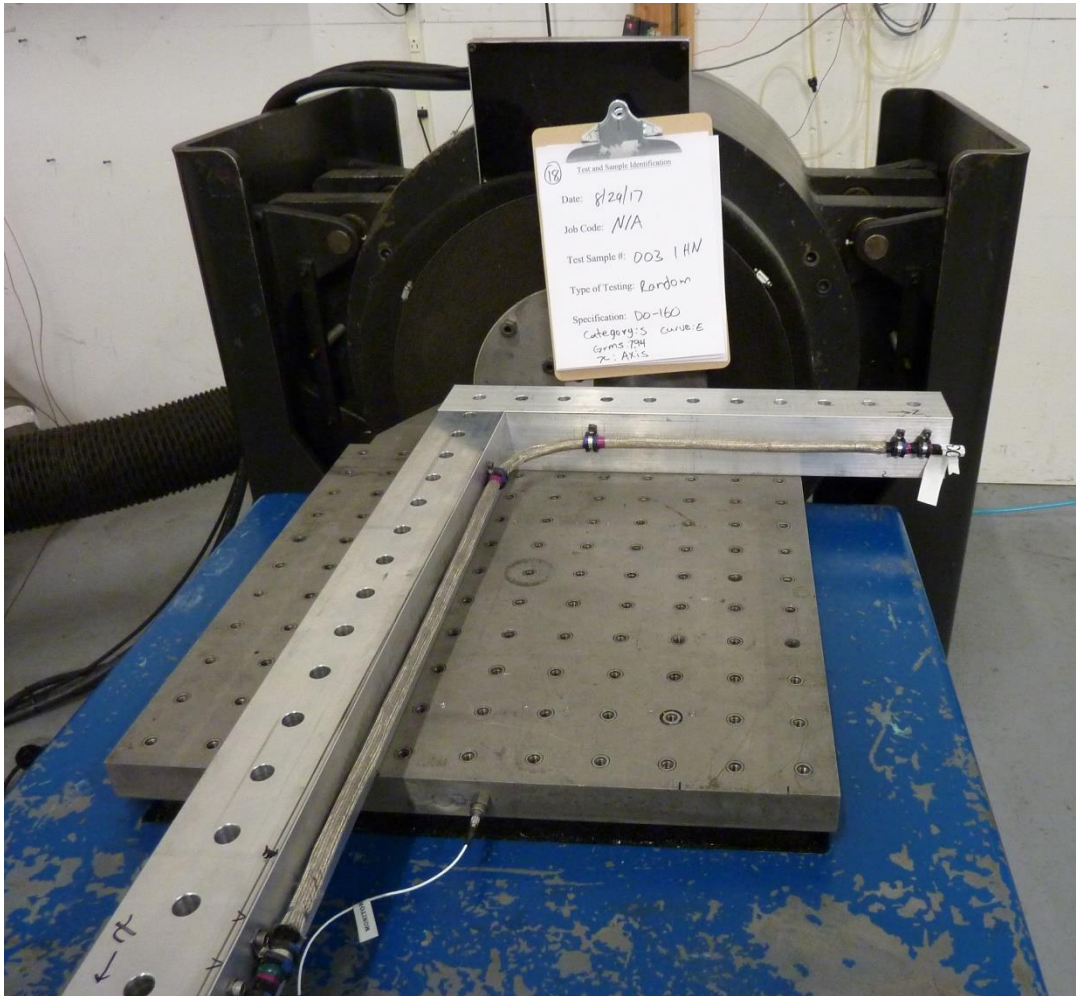


Figure 11: Vibration Test Set up for X-Axis



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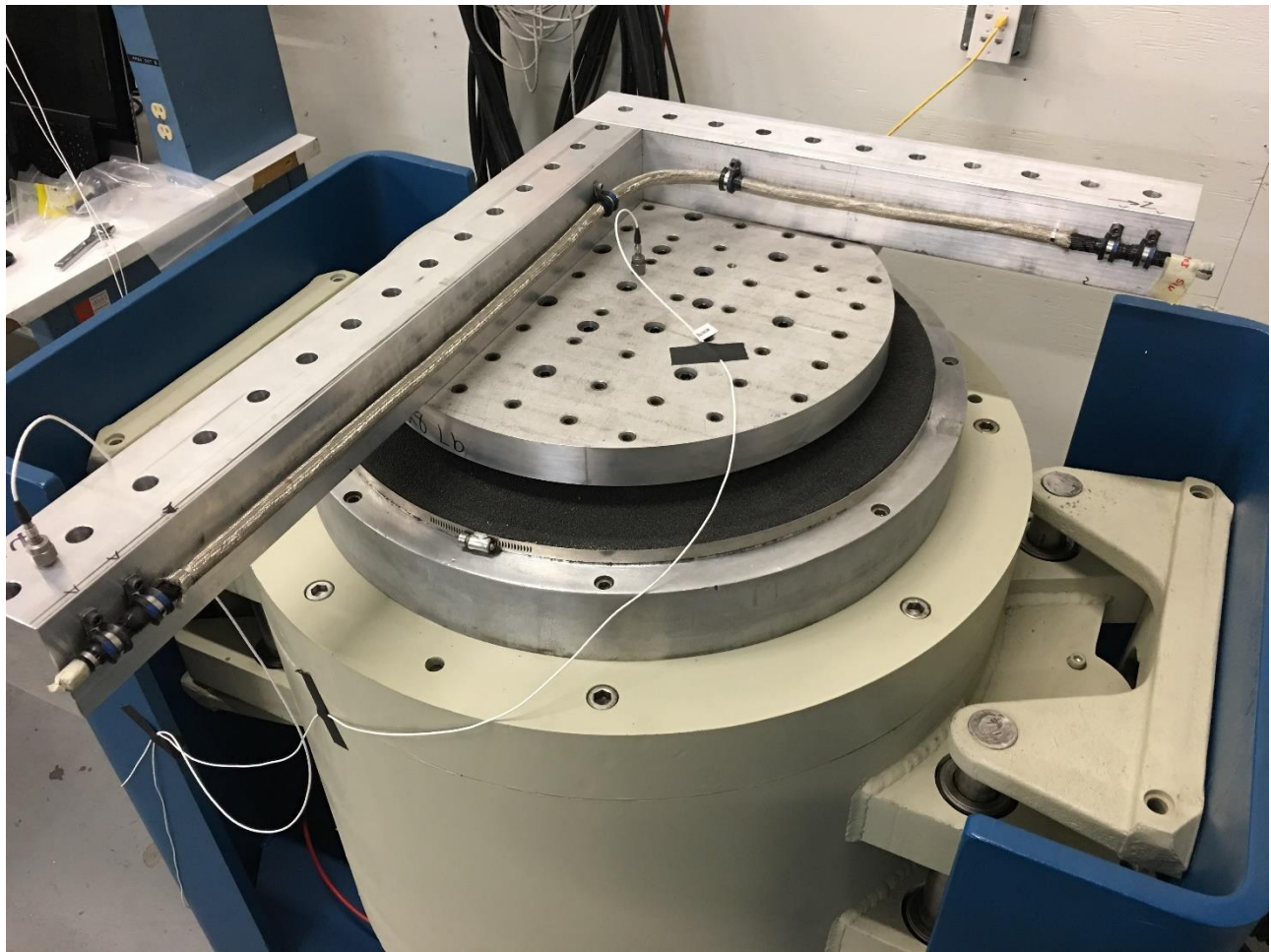


Figure 12: Vibration Test Set up for Y-Axis



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4.2 Thermal Shock

4.2.1 References

- QTP-648: “ArmorLite Braid (103-051) Qualification”.
- EN 6059-308: Aerospace series – Electrical cables, installation – Protection sleeves – Test methods Part 308: Rapid Change of Temperature.

4.2.2 Test Equipment

Table 7: Thermal Shock Equipment

Manufacturer	Model Number	Description
IET	LOM-510A	Micro-OhmMeter
Ransco	7108	Thermal Shock Chamber

4.2.3 Test Method and Setup

All test samples were tested in accordance with QTP-648 and EN 6059-308. Each of the 3 samples was tested in a thermal shock chamber with automatic shuttle. Temperature extremes were -65C to 200C, 30 minute soak at each extreme, 10 cycles. Total test time of 10 hours.

4.2.4 Test Results

All Armorlite samples were exposed to the test parameters defined in section 4.2.3. All samples showed no excessive wear when examined visually and no large increase in electrical resistance post thermal shock testing. All resistance measurements were performed in accordance with QTP-648 over 1 meter of flat braid. Please see electrical resistance table below for details.

Table 8: Thermal Shock Resistance Values

Sample Number	Initial Resistance mΩ	Final Resistance mΩ	Percent Change	PASS/FAIL (Less Than +10% Change)
204	34.91	34.03	-2.5%	PASS
205	34.87	33.97	-2.6%	PASS
206	34.88	34.14	-2.1%	PASS



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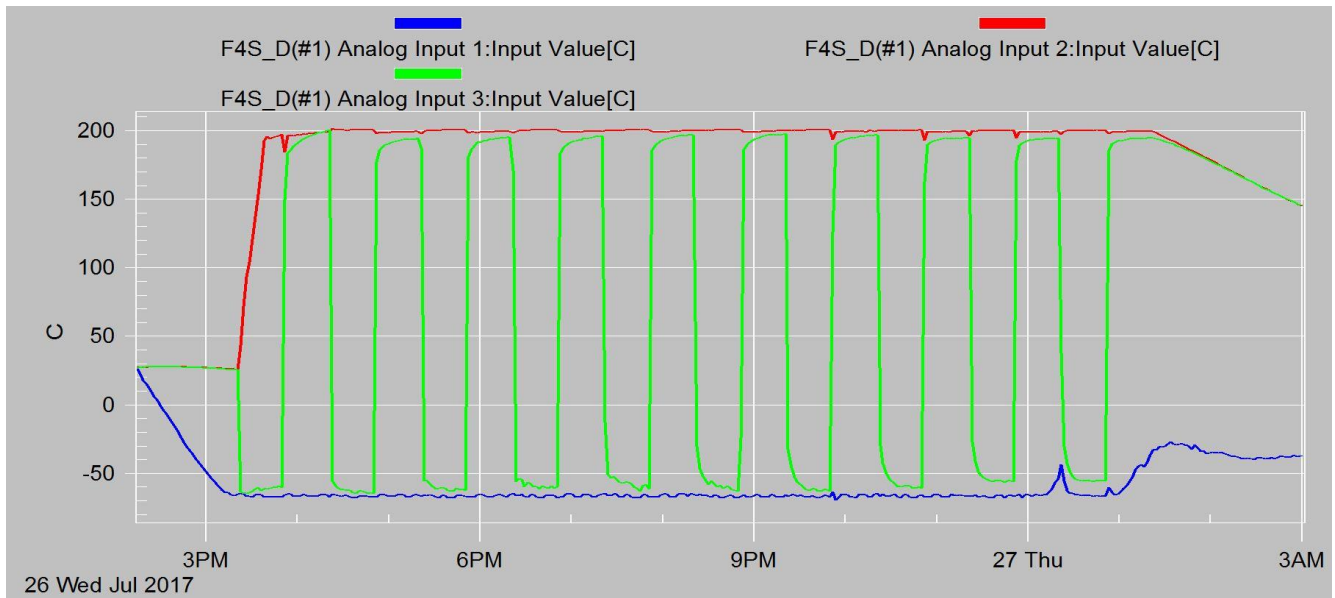


Figure 13: Thermal shock temperature profile

4.2.5 Deviation of Test

No test deviations were present during thermal shock testing.



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4.3 Pull Strength

4.3.1 References

- QTP-648: “ArmorLite Braid (103-051) Qualification”.
- EN 6059-404: Aerospace series – Electrical cables, installation – Protection sleeves – Test methods Part 404: Tensile Strength.

4.3.2 Test Equipment

Table 9: Pull Strength Equipment

Manufacturer	Model Number	Description
Omega	LC-40	Tensile Tester Load Cell

4.3.3 Test Method and Setup

All test samples were tested in accordance with QTP-648 and EN 6059-404. Each of the 3 samples was tested in an appropriate tensile tester until failure. As required, samples were mounted in mandrel/clamp fixtures to minimize localized stress concentrations at clamp points. All samples were tested at a rate of ½ inch per minute.

4.3.4 Test Results

All Armorlite samples for tensile testing were exposed to the test parameters defined in section 4.3.3. Please see data table below for ultimate break strength of each sample:

Table 10: Pull Strength Ultimate Break Strength Values

Sample #	Ultimate Break Strength	PASS/FAIL (Min. Strength of 220 lbs)
207	281 lbs	PASS
208	282 lbs	PASS
209	279 lbs	PASS



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4.3.5 Deviation of Test

No test deviations were present during pull strength testing.

4.3.6 Photographs



Figure 14: Pull Strength Sample Under Test



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4.4 Salt Spray

4.4.1 References

- QTP-648: “ArmorLite Braid (103-051) Qualification”.
- RTCA/DO-160G: Environmental Conditions and Test Procedures for Airborne Equipment.

4.4.2 Test Equipment

Table 11: Salt Spray Equipment

Manufacturer	Model Number	Description
IET	LOM-510A	Micro-OhmMeter
Harshaw/Filtrol	Model 15	Salt Fog Chamber
Eutech Instruments	pHTestr 30	pH Meter
Chase	255662	Specific Gravity Tester

4.4.3 Test Method and Setup

All test samples were tested in accordance with QTP-648 and DO-160. The initial resistance was measured on each sample over a distance of 1 meter. Samples were placed in the Salt Fog chamber for a period of 48 hours, removed for 24 hours and placed in an environmental chamber at 25C and 30% humidity, then placed back into the Salt Fog Chamber for 48 hours. As per the DO-160 specification, samples were then washed off with water at a temperature no greater than 28C.

4.4.4 Test Results

All Armorlite samples for Salt Spray were exposed to the test parameters defined in section 4.4.3. Total exposure time was 96 hours. Post exposure all samples had a light film of salt deposit. All samples were washed off with water and measured for resistance post Salt Spray exposure. Please see results below:



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Table 12: Salt Spray Resistance Values

Sample Number	Initial Resistance mΩ	Final Resistance mΩ	Percent Change	PASS/FAIL (Less Than +10% Change)
210	34.80	35.61	2.3%	PASS
211	34.86	35.44	1.7%	PASS
212	34.74	35.14	1.2%	PASS

Table 13: Salt Spray Process Data

Date	Time	Elapsed Process Time (hrs)	SG of Condensate	pH of Condensate	Total Collected Volume (ml)	Collected Volume per hour (ml)	Chamber Temp (F)
8-29-17	3 pm	24	1.035	6.92	210	2.91	95
8-30-17	3 pm	48	1.030	6.79	122	1.69	95
9-1-17	3 pm	72	1.032	6.94	200	2.77	95
9-2-17	3 pm	96	1.030	6.80	182	2.52	95

4.4.5 Deviation of Test

No test deviations were present during Salt Fog testing.



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4.4.6 Photographs



Figure 15: Placement of Samples in Salt Fog Chamber

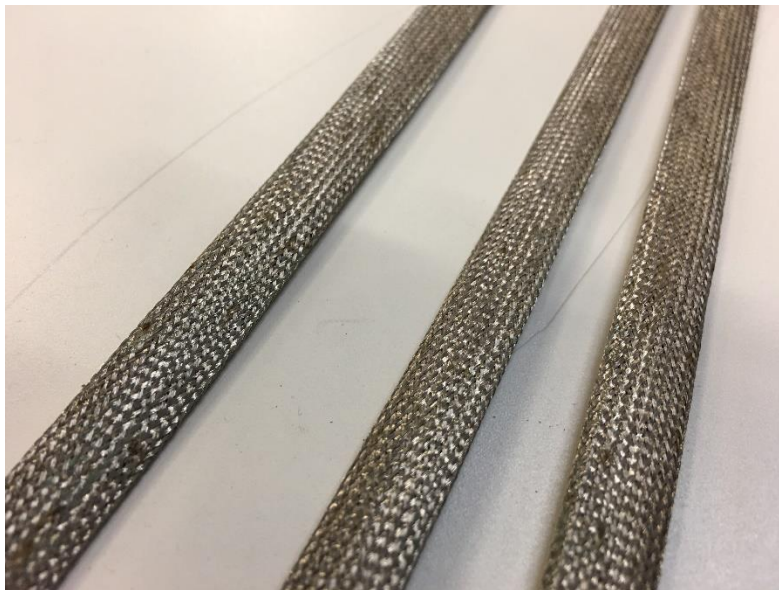


Figure 16: Samples 210, 211, and 212 (left to right) Post 96 hours of Salt Fog Exposure



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4.5 Flex Testing

4.5.1 References

- QTP-648: “ArmorLite Braid (103-051) Qualification”.
- EN 6059-402: Aerospace series – Electrical cables, installation – Protection sleeves – Test methods Part 402: Bending Properties.

4.5.2 Test Equipment

Table 14: Flex Test Equipment

Manufacturer	Model Number	Description
IET	LOM-510A	Micro-OhmMeter
Glenair	N/A	Bend/Flex Tester

4.5.3 Test Method and Setup

All test samples were tested in accordance with QTP-648 and EN 6059-402. The initial resistance was measured on each sample over a distance of 1 meter. Samples were mounted on the bend tester swing arm on one end and attached to a 2.5 lb weight on the other. Samples underwent 25,000 full 180 degree cycles, they were then removed, visually inspected, and measured for final resistance on flat braid over 1 meter.

4.5.4 Test Results

All Armorlite samples experienced some fraying and damage at the bend point of the sample. This is documented with images in section 4.5.6. There was no large increase in electrical resistance post bend testing. Please see table below for details.



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Table 15: Flex Test Resistance Values

Sample Number	Initial Resistance mΩ	Final Resistance mΩ	Percent Change	PASS/FAIL (Less Than +10% Change)
213	34.68	34.96	0.8%	PASS
214	34.68	34.87	0.5%	PASS
215	34.51	35.44	2.7%	PASS

4.5.5 Deviation of Test

No test deviations were present during bend testing.

4.5.6 Photographs

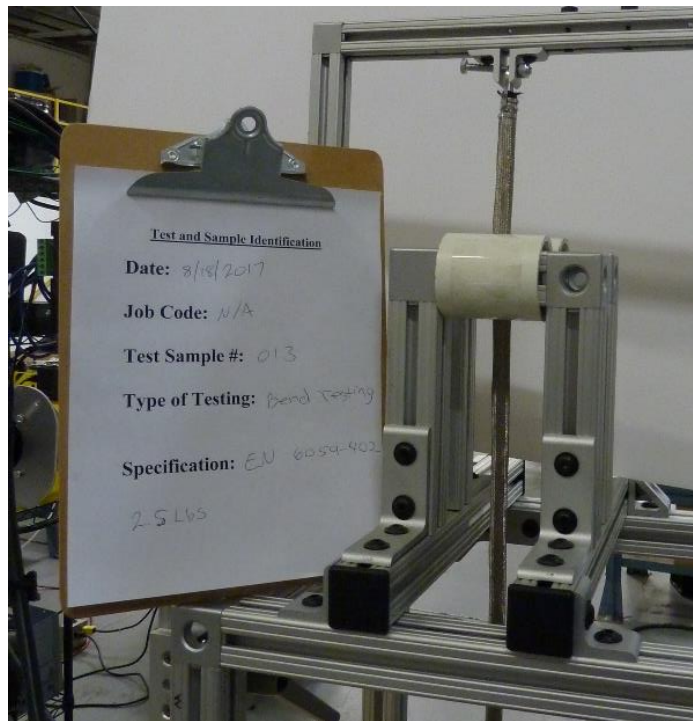


Figure 17: Flex Testing Set up



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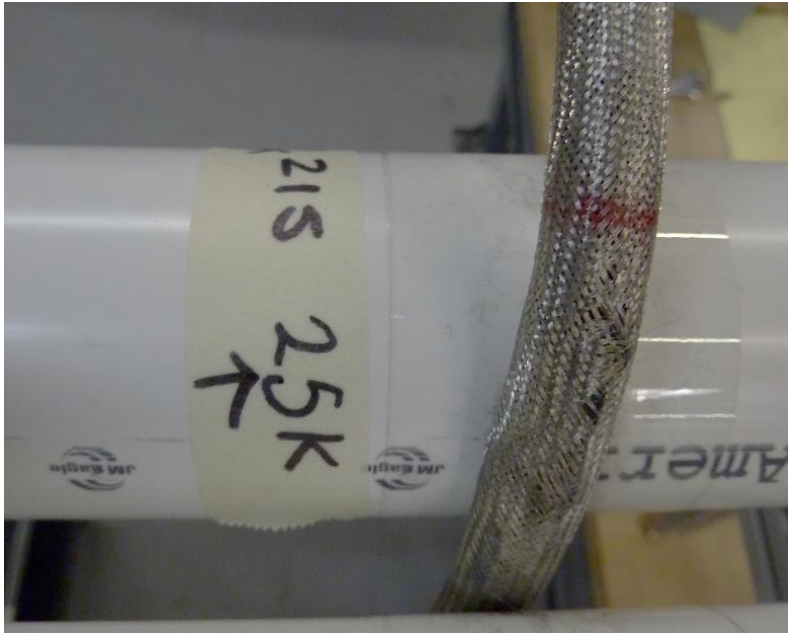


Figure 18: Sample 215 Post 25K Cycle



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4.6 Abrasion Testing

4.6.1 References

- QTP-648: “ArmorLite Braid (103-051) Qualification”.
- EN 3475-511:2002: Cables, electrical, aircraft use. Test methods Cable to Cable abrasion.

4.6.2 Test Equipment

Table 16: Abrasion Testing Equipment

Manufacturer	Model Number	Description
Ling	A395	Electrodynamic Shaker
Vibration Research	VR9500	4 Channel Vibration Controller
Dytran	3056D1	9.87 mV/g Accelerometer
Dytran	3056B1	10.76 mV/g Accelerometer
IET	LOM-510A	Micro-OhmMeter
Husky	39104	100 ft-lbs Torque Wrench
Starrett	S-25	25ft Tape Measure
Rice Lake System	11lb Hanger, 1 lb, ½ lb	Hanging WSeights

4.6.3 Test Method and Setup

All test samples were tested in accordance with QTP-648 and EN 3475-511:2002. The initial resistance was measured on each sample over a distance of 1 meter. Samples were then mounted in abrasion testing fixture and abraded for 36,000 cycles (1 hour). Every 6,000 cycles samples were inspected, and continuity was checked between the Armorlite braid and the inner conductors of the cable bundle. Once testing was complete the samples were removed and a final resistance measurement was taken over 1 meter of flat braid.



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4.6.4 Test Results

All Armorlite samples experienced some fraying and damage at the abrasion point of contact, however, no continuity between braid and inner cable conductor was ever achieved on any sample at any point. This is documented with images in section 4.6.6. There was no large increase in electrical resistance post abrasion testing. Additionally there was no damage to the jacket of wire bundle due to the Armorlite material, P/N: 103-051. Please see table below for details.

Table 17: Abrasion Testing Resistance Values

Sample Number	Initial Resistance mΩ	Final Resistance mΩ	Percent Change	PASS/FAIL (Less Than +10% Change)
216	34.41	34.91	1.5%	PASS
217	34.48	34.83	1.0%	PASS
218	34.47	34.76	0.8%	PASS

4.6.5 Deviation of Test

No test deviations were present during abrasion testing.



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4.6.6 Photographs



Figure 19: Abrasion Test Set up



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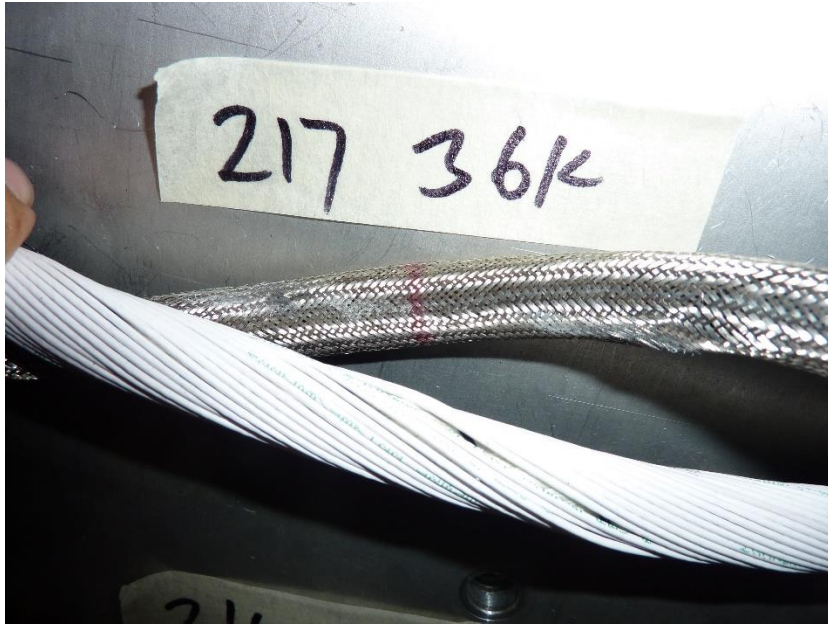


Figure 20: Sample 217 Post 36,000 Cycles of Abrasion Testing



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4.7 Transfer Impedance & Screening Attenuation

4.7.1 References

- QTP-648: “ArmorLite Braid (103-051) Qualification”.
- IEC 62153-4-3 pp. 11, 17.
- IEC 62153-4-4 pp. 7.

4.7.2 Test Equipment

Table 18: Transfer Impedance & Screening Attenuation Equipment

Manufacturer	Model Number	Description
Rohde and Schwarz	ZNB 8 Vector	Network Analyzer
Bedeia	CoMeT 90	Screening Attenuation Set Up

4.7.3 Test Method and Setup

All test samples were tested in accordance with QTP-648, IEC 62153-4-3 and IEC 62153-4-4.

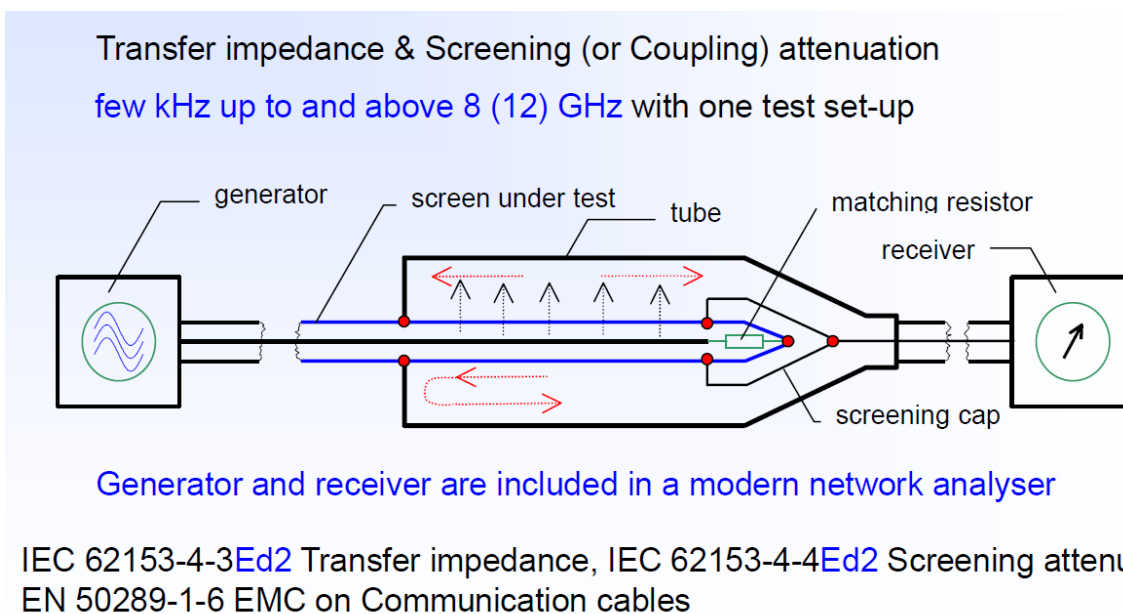


Figure 21: Transfer Impedance and Screening Attenuation Test Diagram



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4.7.4 Test Results

Please see below 5dB safety margin of Screening Attenuation for each braid over discrete frequency ranges.

Table 1: Minimum Screening Attenuation (A_s) of 103-051-016 (Per IEC 62153-4-4)	
Frequency Range	dB
0.353 GHz to 0.5 GHz	59.5 dB
0.5 GHz to 1.0 GHz	57.4 dB
1.0 GHz to 1.5 GHz	55.2 dB
1.5 GHz ~ 2.0 GHz	57.6 dB
2.0 GHz to 2.5 GHz	57.6 dB
2.5 GHz ~ 3.0 GHz	57.6 dB
3.0 GHz ~ 3.5 GHz	53.2 dB
3.5 GHz ~ 4.0 GHz	53.0 dB

Table 19: Minimum Screening Attenuation of 103-051-016 (Per IEC 62154-4-4)



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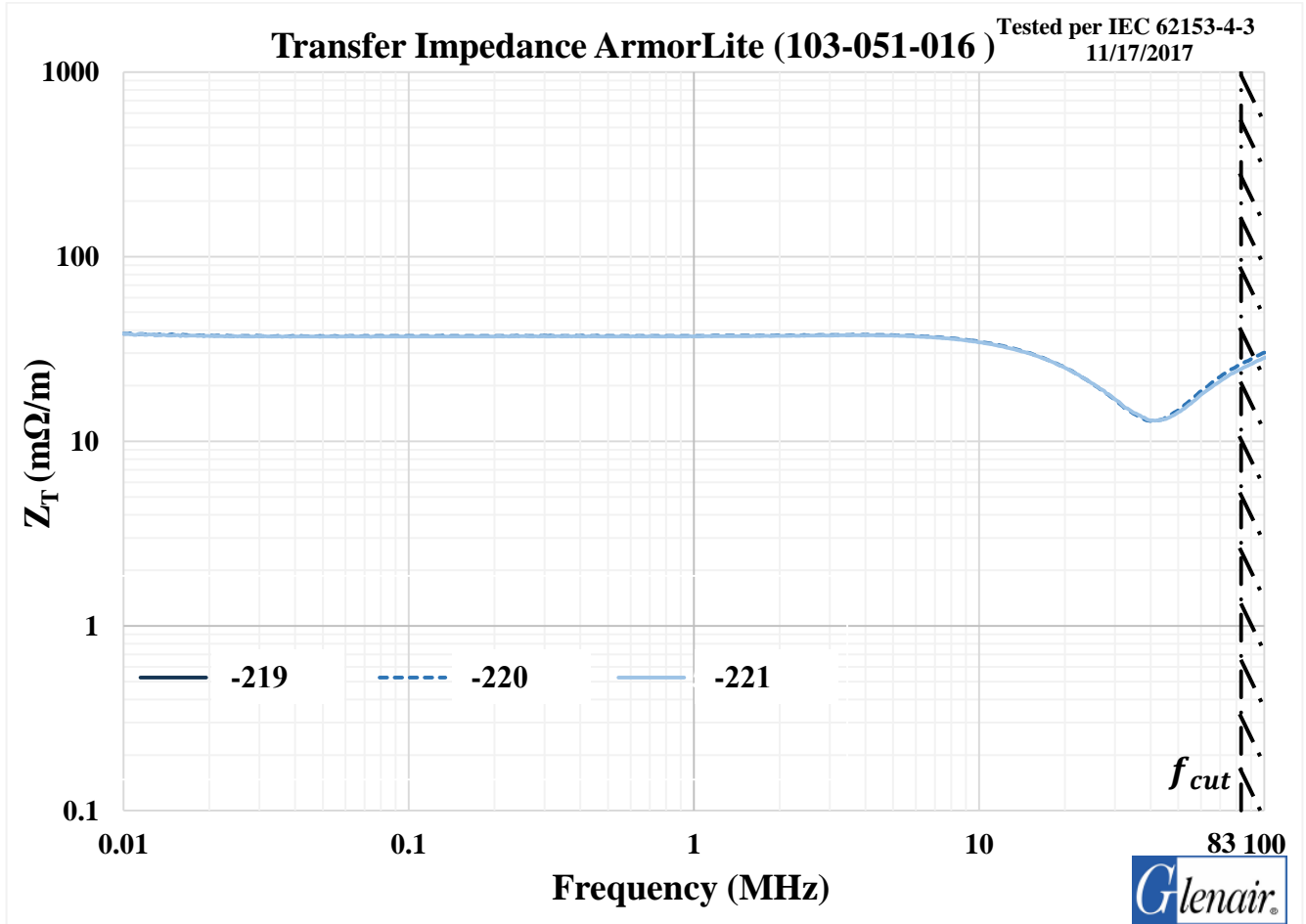


Figure 22: Transfer Impedance of Armorlite (103-051-016)



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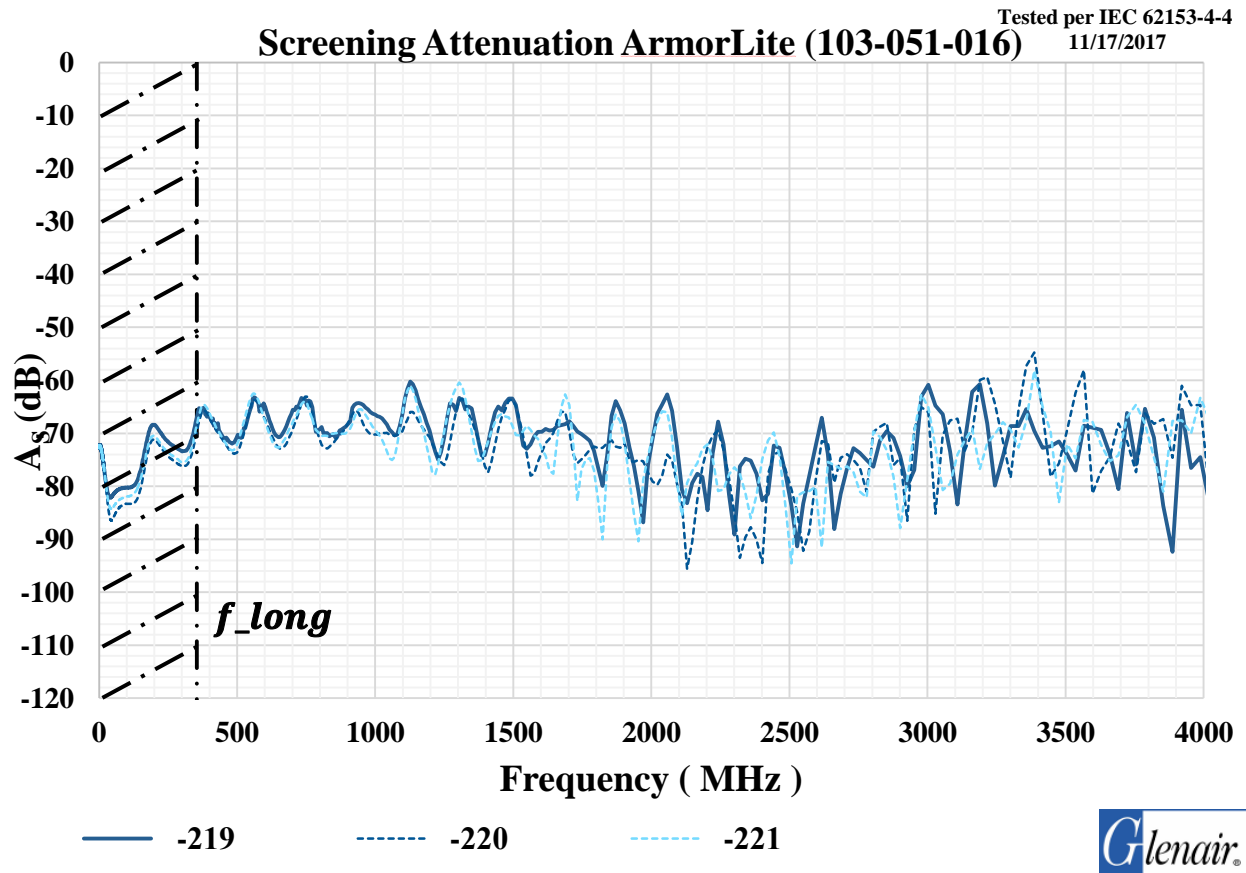


Figure 23: Screening Attenuation of Armorlite (103-051-016)



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4.7.5 Deviation of Test

No test deviations were present Transfer Impedance and Screening Attenuation testing.

4.7.6 Photographs



Figure 24: Screening Attenuation Test Setup Using bedea CoMeT 90 for 1 Meter Braid Assembly



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