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SANDIA REPORT

SAND91-1278 • UC-704

Unlimited Release

Printed October 1991

JT/LJT Connector Insert Material Evaluation

Volume 1—Interim Report

Johnny R. F. Baca

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
for the United States Department of Energy
under Contract DE-AC04-76DP00789

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SAND91-1278
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SAND--91-1278
DE92 002213

JT/LJT Connector Insert Material Evaluation

Volume 1—Interim Report

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Abstract

Different insert (insulator) materials are undergoing evaluation to replace the Fiberite E-3938 BE96 material currently used. Also being evaluated is the reconfiguration of the insert and metal shell-edge geometries for the purpose of reducing the alleged interference principally responsible for insert damage.

MASTER

Acknowledgments

The author thanks Rudy N. Jaramillo (2855 at the time of this publication) for the illustrations, Roger L. Kurtz (2551) and Robert R. Evans (5126) for their testing support, and the many people within the Amphenol Corporation (BCO) and ICI Fiberite Corporation for their cooperation in providing information for this study.

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JT/LJT Connector Insert Material Evaluation

Volume 1—Interim Report

Introduction

JT/LJT circular connectors have a rigid, hard dielectric insert of epoxy molding compound reinforced with long glass fibers. The insert material is a Fiberite E-3938 BE96 thermoset plastic. Pin and socket contacts in nonhermetic connectors are molded in place whereas hermetic connectors with socket contacts have an independent dielectric insert bonded to the glass header.

Forcing, twisting, jamming, and cocking of the mating halves of the connector may bend the exposed contacts, very often damage the insert, and damage the key or keyways on the connector shell.

There is a need to identify an insert material for both hermetic and nonhermetic circular connectors. The number of chipped and cracked connector inserts found in the field is significant enough to warrant a search for a replacement material. The material must be able to meet all the requirements currently in effect plus exhibit substantially improved resistance to damage such as chipping, cracking, etc. This evaluation program visits not only superior insert materials but improved connector designs as well to establish the best ingredients for surviving field-use environments. It is suspected that interference exists between the plug shell inner edge and the receptacle insert edge during separation, and that this is the principal cause of damage. Connector design improvements being considered include the redesign of edge geometries to relieve the alleged interference.

Included with this interim report are the following appendixes: Appendix A describes the materials evaluated and Appendix B the evaluation test plan; Appendix C reports on the results of the Instron bend test, Appendix D gives the results of the cable pull test, and the results of the insert test are given in Appendix E; Appendix F discusses the insert tolerance studies and Appendix G the configuration studies; a copy of the support request memo to the Organic Materials Division is presented in Appendix H, and a memo to BCO requesting estimates is given

in Appendix I; Appendix J contains the BCO material evaluation report.

A Final Report, Volume 2, will follow this Interim Report upon completion of this evaluation. The final report will identify the selected replacement insert material, explain the selection process, and summarize the test results.

Summary

The Connector Division (2551) placed a contract with Amphenol Corporation (BCO) for \$69,574 to fabricate and test 168 LJT07/LJT07H-17-26S connectors, report their findings, and identify a replacement insert material. Two smaller orders, totaling approximately \$2500, were also placed with BCO to mold and deliver 72 hermetic connector inserts of candidate materials including the current Fiberite E-3938 BE96 material. BCO is also asked to provide time and cost estimates for converting tooling and processes for three candidate materials.

We requested the ICI Fiberite Corporation to recommend a replacement for Fiberite E-3938 BE96; their recommendations have been received.

Personnel in the Organic Materials Division (2472) were asked for support in selecting an insert material. Product data sheets for the candidate materials and recommended Fiberite materials were provided.

Insert tolerance studies and configuration studies and tests were done in conjunction with the insert material studies.

Candidate Materials and ICI Fiberite Recommendations

Appendix A describes the material properties for each of the candidate materials and the ICI Fiberite Corporation recommended materials.

- Fiberite E-7459-16612 epoxy resin thermoset material. This is a proven material; it has been used in rack and panel connectors for WR use since March 1981.

- Fiberite E264H epoxy resin thermoset material, recommended by Hugh A. Kearney of BCO.
- Torlon 4203L thermoplastic material, also recommended by Hugh A. Kearney of BCO.
- Fortron 1140L4 thermoplastic, recommended by Richard W. Normann of BCO. This is a proven material used for front socket inserts in MIL-C-38999 crimp removable connectors. This material is very affordable and readily available.
- PEEK RTP2205 thermoplastic, endorsed by R. Gordon Wheeler of BCO.
- Thermoset plastics recommended by ICI Fiberite Corporation:

Fiberite E8354-19189
 Fiberite TEM 9001
 Fiberite TEM 9010
 Fiberite TEM 9025

Description of Test Sample

One way to alleviate the interference between the insert and plug shell is to "radius" the insert edge. Since this would require tooling modifications, Hugh A. Kearney of BCO suggested that a 30° bevel be ground at the insert edge.

The test sample connectors ordered through BCO included design features such as different insulator (insert) materials, 30° beveled edge and standard 90° edge inserts for edge effects studies, and aluminum (standard) and stainless-steel (hermetic) shells.

Half of the hermetic connector inserts provided by BCO had 30° beveled edges, the other half had standard 90° edges.

Test Plan

The test plan was to subject the connector samples to Instron bend tests and cable pull tests to (1) evaluate the insert materials' resistance to fracture due to interference-induced stress and impact and (2) evaluate the benefits of beveling or rounding the insert edge.

We tested the hermetic connector inserts to determine which material was most resistant to fracture at the 0.031-in.-thick contact aligning web.

Results

Damage assessment on connector and individual insert samples was made using the naked eye and 7X magnification. All connector and individual insert samples with ground 30° beveled edges were inspected under magnification for voids, inclusions,

filler material protrusions, etc. The ground surfaces in all candidate material samples exhibited only a roughness, compared to the molded surface; no other shortcomings were noted. Dave Zamora (2472) was consulted about the susceptibility of the ground surface in thermoset materials to moisture, Trichlor, alcohol, etc. Although no mold release is used with Fiberite materials, the molded surface appears to have a protective film compared to the ground surface but, nonetheless, Zamora assures us that the ground surface is no more susceptible than the molded surface. This is confirmed by the fact that molding sprues and flashing along the skirt area in rack and panel connectors are cut and ground off, leaving exposed ground surfaces.

Fiberite E-7459-16612 performed well even in the unchamfered condition. This proven material uses almost the same molding pressures as Fiberite E-3938 BE96. Four-cavity molds are currently used, and they can be used for E16612 except when molding an overly staged batch of material requiring higher pressures, which reduces capacity to three cavities. This material would require virtually no change in molding processes, procedures, or equipment. It has been molded in double-density and standard-density rack and panel connectors using size 22 contacts and size 20 contacts, respectively. The material costs about 22% more than the material currently used.

Fiberite E264H performed well even in the unchamfered condition; however, the connectors tested were in the hermetic configuration, which proved inadequate as test samples because the insert-to-glass header bond broke loose in most cases. In addition, abrasive wear is shown on the stainless-steel core pins used to create the contact cavities because of the high molding pressures required, so the use of E264H is being discouraged by BCO. Also, the standard configuration connectors using E264H could not be molded because the molded-in contacts were being damaged from the high molding pressures, and mold cavities would not fill.

The same problems and concerns experienced with Fiberite E264H apply to Torlon 4203L, except that Torlon is injection-molded by a vertical load mold. New molds and a new press would be needed. A true-blood shuttle (i.e., robotic/automated assembly line) would be required to maintain the 30-second findings (interval between injections).

Fortron 1140L4 performed the best. Under magnification, mold flash, or plastic flow caused by Instron and cable-pull testing, is visible, but the damage otherwise is nil. Fortron, an improved PPS (polyphenylene sulfide) resin, is tougher than conventional PPS, which means that it is less brittle in

thin-wall sections. Tests are underway at All-Tech to determine whether Fortron can withstand WR environments, since brittleness is a weakness in conventional PPS. The twelve test samples previously subjected to Instron or cable-pull testing will be subjected to the following test plan:

- Insulation resistance (IR)
- Dielectric withstanding voltage (DWV)
- Contact resistance (CR)
- Temperature cycle: -65°C to $+177^{\circ}\text{C}$
- Mechanical shock: 3500 g at 1 ms and 4500 g at 0.2 to 0.5 ms, both directions in all three axes
- Random vibration: 33 g rms, 10 to 2500 Hz.

Ten of the twelve test samples of the Fortron hermetic connector inserts will be subjected to a mechanical shock of 4500 g at 0.3 ms, both directions in all three axes.

BCO has not yet fabricated or tested the PEEK RTP2205 connector samples. This is a thermoplastic with good thermal, mechanical, and electrical characteristics. BCO uses carbon-filled (45% carbon fiber) PEEK in its composite connectors. R. Gordon Wheeler endorses the PEEK grade selected and suggests that PEEK is the material for the Sandia-designed product. Time and cost estimates from BCO are crucial to feasibility studies, but a reply has not yet been received.

Configuration studies and tests have demonstrated that reconfiguring the metal shells and inserts to alleviate interference may not be cost-effective, considering the magnitude of the interference in question. Results of insert tests showed that Fortron has the greatest mechanical strength, Torlon and Fiberite E264H are most severely affected by moisture and temperature changes, and Fiberite E-7459-16612 is very stable, though not exceptionally strong. Instron bend tests and cable-pull tests showed Fortron to be the superior material; it incurred no damage. Chamfered inserts of all the candidate materials tested provided good resistance to damage.

Conclusions

1. Torlon 4203L and Fiberite E264H require molding pressures so great that both the stainless-steel core pins used in molding hermetic inserts and the molded-in contacts in standard connectors are being damaged.
2. A superior insert material is required to optimize chipping resistance without altering the connector design. Reconfiguration of the insert and metal shell geometries would pro-

vide interference relief but would not eliminate the insert chipping problem.

3. Insert fracture or chipping is more likely caused by impact than by interference-induced stress (bending).
4. Test results demonstrated that a 30° bevel on the insert's outer edge reduces edge chipping by 75%.
5. Connectors with thermoplastic inserts exhibited no damage, whereas those with Fiberite (thermoset) inserts experienced some degree of damage in most cases. The best performing insert material was Fortron, a thermoplastic.
6. Materials exhibiting the greatest change due to temperature cycling and humidity were Torlon and Fiberite E264H. Fiberite E264H and E-7459-16612 exhibited equal strength after simulated environmental exposure. Fortron exhibited the greatest strength overall. PEEK inserts have not been received yet; hence, we have no test results.

Recommendations

Fortron should be considered as a serious candidate, and should be evaluated further.

Although we have not received the test samples yet, PEEK also deserves serious evaluation.

Fiberite E-7459-16612 should be the thermoset plastic most seriously considered. Test results showed a marked improvement over the currently used Fiberite E-3938 BE96. Molding pressures are nearly identical and molding processes would remain unchanged. Molds may require slight modifications because of differences in shrinkage rates. As an epoxy resin thermoset plastic, it is compatible with the Dow Corning Q3-6611 silicone adhesive (and its alternate, AF-163-2K epoxy) that BCO is proposing to use to bond epoxy inserts to glass headers in hermetic connectors.

Ken Wischmann (2472) lent his support in selecting a new insert material. Ken contacted ICI Fiberite Corporation and is supporting their recommendation to use Fiberite E-8354-19189 or Fiberite TEM-9001.

Of the four thermoset materials recommended by ICI Fiberite, Fiberite TEM-9001 appears to be the most promising. Its impact and flexural strength properties are superior to Fiberite E-3938 BE96 and E-7459-16612. It can be transfer-molded at almost the identical pressures now used, and its shrinkage rate is comparable to Fiberite E-3938 BE96. The benefits described above for Fiberite E-7459-16612 also apply. Good second-choice materials are E-8354-19189 and

E-7459-16612. But both are based on 20-year-old technology, except for an improved resin matrix in E-8354-19189.

Impact and flexural strength properties should be major considerations in the material selection.

APPENDIX A

Material Description

Materials Under Evaluation

Table A-1 lists the properties (manufacturers' data) for each of the following materials:

Fiberite E-3938 BE96—a high-temperature, medium-impact glass fiber-filled thermoset plastic consisting of 30% epoxy resin and 70% 1/8-in.-long glass fibers. This medium-flow epoxy molding compound exhibits good mechanical and electrical properties with low bulk factor. It is suitable for continuous exposure to temperatures approaching 232°C (450°F).
(ICI Fiberite Corp., Winona, MN)

Fiberite E-7459-16612—a high-temperature, medium-strength glass fiber-reinforced thermoset plastic consisting of 60% epoxy resin and 40% 1/4-in.-long glass fibers. This epoxy molding compound has good electrical and strength properties and is suitable for continuous exposure to temperatures approaching 232°C (450°F). It also features good flow and fast cure properties with excellent release.
(ICI Fiberite Corp., Winona, MN)

Fiberite E264H—a high-temperature, high-strength glass fiber-reinforced thermoset plastic consisting of 40% epoxy resin and 60% 1/4-in.-long glass fibers. This epoxy molding compound is suitable where good electrical and mechanical performance is required. In addition to its high mechanical properties, this product exhibits good molding characteristics for compression and transfer molding and is suitable for continuous exposure to temperatures approaching 232°C (450°F).
(ICI Fiberite Corp., Winona, MN)

Torlon 4203L—an unreinforced thermoplastic. This polyamide-imide molding compound contains a small amount of fluorocarbon molding aid and titanium dioxide, but no other reinforcement (no more than

5% of other fillers or modifying material). It requires 72 hours of post-cure but exhibits extreme thermal and oxidative stability, exceptional solvent and radiation resistance, excellent electrical properties, and high strength and toughness. In addition, it is suitable for continuous exposure to temperatures approaching 260°C (500°F).

(Amoco Chemical Co., Alfreda, GA)

Fortron 1140L4—a polyphenylene sulfide (PPS), 40% fiber glass, low flash grade thermoplastic. Fortron is an improved PPS resin. It has a lower level of ionic impurities, which means it is a purer, more consistent product. It is tougher than conventional PPS, i.e., less brittle in thin-wall sections. A high-performance crystalline material, Fortron offers an excellent combination of good processibility and superior thermal and mechanical properties. This material is ideal for applications that require high temperature stability, toughness, chemical resistance, inherent flame resistance, and good moldability. In addition, it is suitable for continuous exposure to temperatures approaching 220°C (428°F).

(Hoechst Celanese, Chatham, NJ)

PEEK RTP2205—a polyetheretherketone, 30% fiber glass-reinforced thermoplastic. This material is a high-performance crystalline thermoplastic polymer combining the chemical and thermal properties of some thermosets and ease of processibility. PEEK was developed for high-performance stringent requirements with respect to heat resistance, flammability, products of combustion, and chemical resistance. It is suitable for processing by extrusion or injection molding and for continuous exposure to temperatures approaching 220°C (428°F).

(RTP Co., Winona, MN)

Table A-1. Molding Compounds Being Evaluated

TYPE	THERMOSET				THERMOPLASTIC			
Compound Number	Fiberite E-3938 BF96	Fiberite E7459-16612	Fiberite E264H	Torlon 4203L	Fortron 1140L4	PEEK RTP 2205		
REINFORCEMENT	1/8" Glass Fiber	1/4" Glass Fiber	1/4" Glass Fiber	---	Glass	Glass		
GLASS FIBER, %	70	40	60	---	40	30		
RESIN SYSTEM	Epoxy	Epoxy	Epoxy	Polyamide- Imide	PPS	PEEK		
COST PER POUND	\$14.50	\$17.75	\$33.50	\$22.00	\$4.00	\$20.00		
PROCESSING CONDITIONS								
FORM	Granular	Chop. Fiber	Chop. Fiber	Granular	Granular	Granular		
COLOR	Blue	Dark Green	Tan	Natural	Black	Natural		
BULK FACTOR	2.0 - 2.5	4 - 6	6 - 8	---	---	---		
PROCESSING METHODS	Injection, Compression, or Transfer Molding	Injection, Compression, or Transfer Molding	Compression or Transfer Molding	Compression or Injection Molding, Extrusion	Injection Molding	Injection Molding, Extrusion		
Molding Temperature, °F	290-340	325-350	300-350	450	100-350	300-350		
Molding Pressure, PSI	250-500 *	400-600 *	800-1800 *	20,000-30,000	15,000-20,000	10,000-15,000		
Injection Cyl. Temp., °F	180-220	180-220	---	650-700	575-650	675-750		
Mo'd Cycle, Sec.	180	180	180	30	30	45		

(continued on next page)

Table A-1 (continued)

TYPE		THERMOSET				THERMOPLASTIC		
Compound Number		Fiberite E-3938 BE96	Fiberite E7459-16612	Fiberite E264H	Torlon 4203L	Fortron 1140L4	PEEK RTP 2205	
PHYSICAL PROPERTIES		ASTM						
Specific Gravity		D792	1.80 - 1.90	1.75 - 1.80	1.40	1.64	1.54	
Mold Shrinkage, In./In.		D955	.003 - .005	.001 - .002	---	.001 - .006	.002 - .004	
Water Absorption, %, 24HR, 23°C		D570	0.1	0.1	0.33	0.02	0.12	
%, 48HR, 50°C			0.3	0.2	---	---	---	
MECHANICAL PROPERTIES								
IZOD Impact Strength FT. LBS/In., (Notch, Side)		D256	0.3	3.6 - 5.0	14.0	2.7	2.1	
Flexural Strength, PSI		D790	15,000	23,000	39,300	34,900	42,000	
Flexural Modulus, 10 ⁶ PSI		D790	2.1	2.4	3.6	7.3	1.6	
TENSILE STRENGTH, PSI		D638	7,500	13,000	17,000	24,000	28,500	
		D1708	---	---	---	27,800	---	
TENSILE ELONGATION, %		D638	0.3 - 0.4	0.3 - 0.4	0.3 - 0.4	1.5	2.0 - 3.0	
		D1708	---	---	---	15.0	---	

(continued)

Table A-1 (continued)

TYPE		THERMOSET				THERMOPLASTIC			
Compound Number		Fiberite E-3938 BE96	Fiberite E7459-16612	Fiberite E264H	Torlon 4203L	Fortron 1140L4	PEEK RTP 2205		
ELECTRICAL PROPERTIES	ASTM								
	D149								
Dielectric Strength, Volts/Mil, ST Dry		325	380	375	580	450	400		
	SS Dry	300	---	325	---	---	---		
Dielectric Constant, 1MC, Dry, @ 1MHz		4.5	5.1	5.8	3.9	3.5	---		
	D150						---		
Dissipation Factor, 1MC, Dry, @ 1MHz		0.01	0.01	0.017	0.031	0.0011	---		
	D150						---		
Arc Resistance, Sec.		180	180	120	---	134	---		
	D495						---		
Vol. Resistivity, ohm-cm		1015	1014	1014	1016	1016	1016		
	D257								
THERMAL PROPERTIES									
Deflection Temp. @ 264 PSI, °F									
	D648	392	500	482	532	500	550		
Continuous Use Temp., No Load, °F									
	---	350 - 450	350 - 450	350 - 450	500	392 - 428	---		

(continued)

Table A-1 (concluded)

TYPE		THERMOSET				THERMOPLASTIC	
Compound Number		Fiberite E-3938 BE96	Fiberite E7459-16612	Fiberite E264H	Torlon 4203L	Fortron 1140L4	PEEK RTP 2205
OTHER PROPERTIES/ FEATURES							
Flammability	---	Flame Resistant	Flame Resistant	Flame Resistant	Flame Resistant	Flame Resistant	Flame Resistant
UL Rating	UL94	VO	---	---	VO	VO	VO
Chemical Resistance		Affected by strong acids, ketones, strong alkalies, oxidizing agents	Affected by strong acids, ketones, strong alkalies, oxidizing agents	Affected by strong acids, ketones, strong alkalies, oxidizing agents	Resists most acids, oils, fuels, greases, organic solvents, alcohol; attacked by strong alkali	There is no known solvent that dis- solves PPS at temperatures below 200°C (392°F); attacked by strong miner- al acids, strong oxidizing agents, a few organic solvents at high temp.	Resistant to acids (except 100% H2SO4, HNO3), alkalies, and to all organic solvents. Outstanding hydrolysis resistance, even above 500°F in water.

*Molding pressures used at BCO

Materials Recommended by ICI Fiberite Corporation

Table A-2 lists the properties (manufacturers' data) for each of the following materials:

Fiberite E-8354-19189—a thermoset plastic having a resin matrix much more resistant to chipping than the thermoset materials listed in Table A-1. It has a nontoughened epoxy resin but is a much improved material, although based on old technology similar to Fiberite E-3938 BE96. It also molds like Fiberite E-3938 BE96 with perhaps a molding pressure change.
(ICI Fiberite Corp., Winona, MN)

Fiberite TEM 9001—a thermoset plastic with a toughened epoxy resin and glass/mineral reinforcement. This material is superior to thermoplastics many times over, and maintains better dimensional stability. It is used in applications requiring greater toughness and strength.
(ICI Fiberite Corp., Winona, MN)

Fiberite TEM 9010—a thermoset plastic with a toughened epoxy resin and glass/mineral reinforcement. This material also is superior to thermoplastics and maintains better dimensional stability. It is replacing aluminum in many structural applications. It is ideal for applications requiring greater toughness and strength.
(ICI Fiberite Corp., Winona, MN)

Fiberite TEM 9025—a high-strength thermoset plastic with a toughened epoxy resin system and 1/2-in.-long (1/4 in. available) E-glass reinforcement. This compound offers substantial improvements in strength and toughness over other conventional glass fiber epoxy molding compounds. It is superior to thermoplastics in many cases, and maintains better dimensional stability. It should be used as a replacement in applications using Fiberite E264H.
(ICI Fiberite Corp., Winona, MN)

Table A-2. Molding Compounds Recommended by ICI Fiberite Corp.

TYPE	THERMOSET					
	Fiberite E-3938 BE96	Fiberite E-8354-19189	Fiberite TEM-9001	Fiberite TEM-9010	Fiberite TEM-9025	
REINFORCEMENT	1/8" Glass Fiber	Glass/Mineral	Glass/Mineral	Glass/Mineral	1/2" Glass Strand	
GLASS FIBER, %	70	70	70	50	60	
RESIN SYSTEM	Epoxy	Epoxy	Epoxy	Epoxy	Epoxy	
COST PER POUND	\$14.50	\$5.88	\$11.70	\$18.22	\$30.00	
PROCESSING CONDITIONS						
FORM	Granular	Granular	Granular	Granular	Chop. Fiber	
COLOR	Blue	Black	Black	Black	Natural	
BULK FACTOR	2.0 - 2.5	2.0 - 2.2	2.0 - 2.2	2.0 - 2.2	7 - 8	
PROCESSING METHODS	Injection, Compression, or Transfer Molding	Injection, Compression, or Transfer Molding	Injection, Compression, or Transfer Molding	Injection, Compression, or Transfer Molding	Compression or Transfer Molding	
Molding Temperature, °F	290-340	290-350	325-370	300-350	150-160	
Molding Pressure, PSI	250-500 *	250-4000	800-1800	20,000-30,000	15,000-20,000	
Injection Cyl. Temp., °F	180-220	180-220	180-220	180-220	180-220	
Mold Cycle, Sec.	180	180	180	180	180	

(continued on next page)

Table A-2 (continued)

TYPE		THERMOSET					
Compound Number		Fiberite E-3938 BE96	Fiberite E-8354-19189	Fiberite TEM-9001	Fiberite TEM-9010	Fiberite TEM-9025	
PHYSICAL PROPERTIES		ASTM					
Specific Gravity	D792	1.80 - 1.90	1.82 - 1.86	1.82 - 1.86	1.70 - 1.74	1.86 - 1.90	
Mold Shrinkage, In./In.	D955	.003 - .005	.0030 - .0035	.0025 - .0040	.002 - .006	.0006	
Water Absorption, %, 24HR, 23°C	D570	0.1	0.08	0.08	0.08	0.05	
%, 48HR, 50°C		0.3	0.15	0.20	0.27	0.1	
MECHANICAL PROPERTIES							
IZOD Impact Strength FT. LBS/In., (Notch, Side)	D256	0.3	0.45	0.45	1.32	32.0	
Flexural Strength, PSI	D790	15,000	18,000	28,000	20,000	60,000	
Flexural Modulus, 106 PSI	D790	2.1	2.1	2.16	1.85	3.2	
TENSILE STRENGTH, PSI	D638	7,500	10,500	18,000	14,000	30,000	
TENSILE ELONGATION, %	D638	0.3 - 0.4	0.3 - 0.4	0.90	0.75	1.0	

(continued)

Table A-2 (continued)

TYPE		THERMOSET					
Compound Number		Fiberite E-3938 BE96	Fiberite E-8354-19189	Fiberite TEM-9001	Fiberite TEM-9010	Fiberite TEM-9025	
ELECTRICAL PROPERTIES							
	ASTM						
Dielectric Strength, Volts/Mil, ST Dry		325	375	470	450	425	
	D149						
SS Dry		300	325	350	350	350	
Dielectric Constant, 1MC, Dry, @ 1MHz	D150	4.5	4.75	4.5	4.0	4.5	
Dissipation Factor, 1MC, Dry, @ 1MHz	D150	0.01	0.014	0.0012	0.009	0.01	
Arc Resistance, Sec.	D495	180	180	180	180	145	
Vol. Resistivity, ohm-cm.	D257	1015	1015	1016	1016	1016	
THERMAL PROPERTIES							
Deflection Temp. @ 264 PSI, °F	D648	392	500	482	338	482	
Continuous Use Temp., No Load, °F	---	350 - 450	350 - 450	350 - 450	300 - 400	350 - 450	

(continued)

Table A-2 (concluded)

TYPE		THERMOSET				
Compound Number		Fiberite E-3938 BE96	Fiberite E-8354-19189	Fiberite TEM-9001	Fiberite TEM-9010	Fiberite TEM-9025
OTHER PROPERTIES/ FEATURES						
Flammability	---	Flame Resistant	Flame Resistant	Flame Resistant	Flame Resistant	Flame Resistant
UL Rating	UL94	V0	---	---	---	---
Chemical Resistance		Affected by strong acids, ketones, strong alkalis, oxidizing agents	Affected by strong acids, ketones, strong alkalis, oxidizing agents	Affected by strong acids, ketones, strong alkalis, oxidizing agents	Affected by strong acids, ketones, strong alkalis, oxidizing agents	Affected by strong acids, ketones, strong alkalis, oxidizing agents

* Molding pressures used at BCO

APPENDIX B

Insert Material Evaluation Test Plan

Test Plan

Purchase Order 40-9343 requires that BCO provide the following:

168 connectors total:

- 84 hermetic connectors (SA1457-1, LJT07H-17-26S receptacle)
 - 14 with sharp-edge inserts of Fiberite E-3938 BE96
 - 14 with 30° chamfered-edge inserts of Fiberite E-3938 BE96
 - 14 with sharp-edge inserts of Fiberite E264H
 - 14 with 30° chamfered-edge inserts of Fiberite E264H
 - 14 with sharp-edge inserts of Torlon 4203L
 - 14 with 30° chamfered-edge inserts of Torlon 4203L
- 84 standard connectors (SA1442-2, LJT07-17-26S receptacle)
 - 14 with sharp-edge inserts of Fiberite E-3938 BE96
 - 14 with 30° chamfered-edge inserts of Fiberite E-3938 BE96
 - *14 with sharp-edge inserts of Fiberite E264H
 - *14 with 30° chamfered-edge inserts of Fiberite E264H
 - *14 with sharp-edge inserts of Torlon 4203L
 - *14 with 30° chamfered-edge inserts of Torlon 4203L

Molding trials with Torlon 4203L and Fiberite E264H in the standard connector configuration were unsuccessful because the high pressures required damaged the molded-in contacts.

BCO was required to perform the following tests (descriptions follow) on all of the 168 connectors, and document the results.

- Hi-Pot (DWV)
- Insulation Resistance
- Leak Check (VEECO) with data recorded

Subsequently, 72 connectors (6 from each group) were tested as follows:

- Visual examination of inserts
- Instron bend test (Figure B-1)

*Fiberite E-7459-16612 was substituted for Fiberite E264H. At BCO's recommendation, Fortron 1140L4 was substituted for Torlon 4203L.

- Hi-Pot (DWV)
- Insulation Resistance
- Leak Check (VEECO) with data recorded
- Visual examination of inserts

A report was submitted at the conclusion of these tests.

The remaining 96 connectors were delivered to the Connectors Division (2551) for testing.

Upon completion of the contract, BCO will deliver:

- The remaining 72 tested connectors
- Three mating shells for SNL testing
- A report of all findings

To date, BCO has delivered 151 connectors tested, as required, at a cost of \$30,030.89. Seventeen remain delinquent; they are:

- 8 standard connectors with sharp-edge inserts of Fortron 1140L4
- 8 standard connectors with 30° chamfered-edge inserts of Fortron 1140L4
- 1 hermetic connector with 30° chamfered-edge insert of Torlon 4203L

Purchase Order 40-9343 authorized \$69,574 for the insert material evaluation. After the remaining 17 connectors are received, enough money will be left over for continued evaluation. BCO has been requested to amend the existing purchase order by adding the following standard-configuration connectors:

- 14 with sharp-edge inserts of PEEK RTP2205
- 14 with 30° chamfered-edge inserts of PEEK RTP2205

This will increase the total required to 196 connectors: 84 to be tested by BCO and 112 to be delivered to Division 2551 for testing.

Test Description

Hi-Pot (DWV):

BCO Automatic Connector Tester F-2043

Room ambient conditions

Spec limits: no electrical breakdown or flash-over at 1500 V ac

The socket receptacles are mated to a wired, pin test harness and subjected to the DWV as follows:

- The magnitude of the test voltage is 1500 V ac.
- The voltage is applied between each contact and all other contacts and the shell tied electrically in common for a minimum of 5 s.

Insulation Resistance:

BCO Automatic Connector Tester F-2043

Room ambient conditions

Spec limits:

- 1 G Ω minimum at 500 V dc
(hermetic)
- 10 G Ω minimum at 500 Vdc
(non-hermetic)

The insulation resistance is measured on the socket receptacles by mating each to a pin test harness.

- The applied voltage for the IR measurements is 500 V dc.
- The voltage is applied to each circuit for a minimum of 5 s, and the IR is measured between each circuit and all other circuits and the shell tied electrically in common.

Leak Check:

VEECO Helium Leak Detector

Spec limits: 1×10^{-8} cm³/s for hermetic connectors

Spec limits: 1×10^{-3} cm³/s for standard connectors

Instron Bend Test: (Figure B-1)

Instron PG-1050

Room ambient conditions

Limits and conditions: 270 in.-lb load applied to front edge of insert

The test samples are subjected to a bend test using a 270 in.-lb moment. A simulated plug shell, exclusive of keys and coupling ring to permit more uniform loading against the receptacle insert, is inserted into each receptacle to a depth of 0.25 in. A 110-lb load is then applied to the plug fixture through a 2.47-in. lever arm. The load is applied to the insert, at a rate of 1 in./min, in a direction that applies stress 180° from the main keyway area of the receptacle insert.

INSTRON BEND TEST

FIGURE B1

APPENDIX C

Results of Instron Bend Test

Summary

The Connectors Division (2551) had BCO perform Instron bend tests on connectors of different insert materials and of different insert edge configurations. The Instron bend test provides a controlled and measurable way to fracture the insert. The level of insert damage sustained per connector is recorded in Table C-1 with examples of insert damage illustrated in Figure C-1. The tests were performed as described in the Insert Material Evaluation Test Plan (Appendix B).

The initial plan was to

1. Have BCO test six connectors from each group, per Statement of Work.
2. Subject the remaining connectors to humidity and temperature cycling, then have BCO Instron bend-test four from each group and subject the remaining four from each group to cable pull tests.

Exposure to humidity and temperature cycling was intended to replicate field environments.

Results

Damage ranged from no chipping to major chipping. Results of these tests also demonstrated that the 30° bevel on the insert's outer edge reduces the

amount of edge chipping that occurs. The hermetic connectors proved inadequate as test samples because the insert-to-glass header bond frequently broke loose during Instron bend tests. In cases where IR failures occurred with inserts seemingly intact after Instron testing, we speculated that the insert-to-glass header bond failed but did not separate completely. Visual damage assessment was made with both the naked eye and under 7× magnification.

Conclusion

Connectors with thermoplastic inserts exhibited no damage, whereas those with Fiberite (thermoset) inserts experienced some degree of damage in most cases. The best performing insert material was Fortron, a thermoplastic.

Although it is difficult to predict the reason damage occurred on some of the connectors, I believe that impact was the principal factor. In 90% to 95% of the cases, damage occurred in the main keyway area, which is 180° from the area being stressed. This leads me to believe that damage is occurring at the moment that the simulated plug shell slips off the receptacle shell (test sample) and bangs into the insert. The area being stressed is experiencing more interference than normal since the simulated plug shell is devoid of keys and coupling ring; yet, it is showing minimal damage.

Table C-1. Summary of Instron Bend Test Results

SAMPLE DESCRIPTION	SAMPLE #	(INITIAL) HI-POT	(INITIAL) IR	(INITIAL) VEECO	(INSTRON) VISUAL	(POST) HI-POT	(POST) IR	(POST) VEECO	NOTES
BCO# 10-551325-26S (SA1457-1 HERMETIC) BLUE FIBERITE E-3938 BE96	1	PASS	PASS	PASS	DAMAGE	PASS	PASS	PASS	3
	2	PASS	PASS	PASS	OK	PASS	PASS	PASS	1
	3	PASS	PASS	PASS	OK	PASS	PASS	PASS	1
	4	PASS	PASS	PASS	OK	PASS	PASS	PASS	1
	5	PASS	PASS	PASS	OK	PASS	PASS	PASS	1
	6	PASS	PASS	PASS	OK	PASS	PASS	PASS	1
	15	PASS	PASS	PASS	OK	PASS	FAIL	PASS	5, 1
	19	PASS	PASS	PASS	OK	PASS	FAIL	PASS	5, 1
	22	PASS	PASS	PASS	OK	PASS	FAIL	PASS	5, 1
	23	PASS	PASS	PASS	OK	PASS	PASS	PASS	5, 1
BCO #L-35754-326 (SA1457-1 HERMETIC) BLUE FIBERITE E-3938 BE96 CHAMFERED INSERT	7	PASS	PASS	PASS	DAMAGE	PASS	PASS	PASS	1, 4
	8	PASS	PASS	PASS	OK	PASS	PASS	PASS	
	9	PASS	PASS	PASS	OK	PASS	PASS	PASS	
	10	PASS	PASS	PASS	OK	PASS	PASS	PASS	2
	11	PASS	PASS	PASS	DAMAGE	PASS	PASS	PASS	2
	12	PASS	PASS	PASS	DAMAGE	PASS	PASS	PASS	5
	14	PASS	PASS	PASS	OK	PASS	FAIL	PASS	5
	17	PASS	PASS	PASS	OK	PASS	FAIL	PASS	5
	18	PASS	PASS	PASS	OK	PASS	FAIL	PASS	5
	21	PASS	PASS	PASS	OK	PASS	FAIL	PASS	5
BCO #L-35754-317 (SA1457-1 HERMETIC) TAN FIBERITE E264H	13	PASS	PASS	PASS	OK	PASS	PASS	PASS	1
	14	PASS	PASS	PASS	OK	PASS	PASS	PASS	1
	15	PASS	PASS	PASS	OK	PASS	PASS	PASS	1
	16	PASS	PASS	PASS	OK	PASS	PASS	PASS	1
	17	PASS	PASS	PASS	DAMAGE	PASS	PASS	PASS	2
	18	PASS	PASS	PASS	OK	PASS	PASS	PASS	1
	1	PASS	PASS	PASS	OK	PASS	FAIL	PASS	5, 1
	2	PASS	PASS	PASS	OK	PASS	FAIL	PASS	5, 1
	3	PASS	PASS	PASS	OK	PASS	FAIL	PASS	5, 2
	4	PASS	PASS	PASS	DAMAGE	PASS	FAIL	PASS	5, 2
					DAMAGE	PASS	PASS	PASS	

(continued on next page)

Table C-1 (continued)

SAMPLE DESCRIPTION	SAMPLE #	(INITIAL) HI-POT	(INITIAL) IR	(INITIAL) VEECO	(INSTRON) VISUAL	(POST) HI-POT	(POST) IR	(POST) VEECO	NOTES
BCO# L-35754-323 (SA1457-1 HERMETIC) TAN FIBERITE E264H CHAMFERED INSERT	19	PASS	PASS	PASS	OK	PASS	PASS	PASS	
	20	PASS	PASS	PASS	OK	PASS	PASS	PASS	
	21	PASS	PASS	PASS	OK	PASS	PASS	PASS	
	22	PASS	PASS	PASS	OK	PASS	PASS	PASS	
	23	PASS	PASS	PASS	OK	PASS	PASS	PASS	
	24	PASS	PASS	PASS	OK	PASS	PASS	PASS	
	5	PASS	PASS	PASS	OK	PASS	FAIL	PASS	5
	6	PASS	PASS	PASS	OK	PASS	PASS	PASS	5
	11	PASS	PASS	PASS	OK	PASS	PASS	PASS	5
	12	PASS	PASS	PASS	OK	PASS	PASS	PASS	5
	1	PASS	PASS	PASS	DAMAGE	PASS	PASS	PASS	3, 6
	2	PASS	PASS	PASS	DAMAGE	PASS	PASS	PASS	3, 6
BCO #10-551545-26S (SA1442-2) BROWN FIBERITE E-3938 BE96	3	PASS	PASS	PASS	DAMAGE	PASS	PASS	PASS	3, 6
	4	PASS	PASS	PASS	DAMAGE	PASS	PASS	PASS	3, 6
	5	PASS	PASS	PASS	DAMAGE	PASS	PASS	PASS	3, 6
	6	PASS	PASS	PASS	DAMAGE	PASS	PASS	PASS	3, 6
	7	PASS	PASS	PASS	DAMAGE	PASS	PASS	PASS	3, 6
	8	PASS	PASS	PASS	DAMAGE	PASS	PASS	*	5, 3, 6
	9	PASS	PASS	PASS	DAMAGE	PASS	PASS	*	5, 3, 6
	10	PASS	PASS	PASS	DAMAGE	PASS	PASS	*	5, 3, 6
								*	5, 3, 6
								*	5, 3, 6
BCO #L-35754-327 (SA1442-2) BLUE FIBERITE E-3938 BE96 CHAMFERED INSERT	7	PASS	PASS	PASS	OK	PASS	PASS	PASS	6
	8	PASS	PASS	PASS	OK	PASS	PASS	PASS	6
	9	PASS	PASS	PASS	OK	PASS	PASS	PASS	6
	10	PASS	PASS	PASS	OK	PASS	PASS	PASS	6
	11	PASS	PASS	PASS	OK	PASS	PASS	PASS	6
	12	PASS	PASS	PASS	OK	PASS	PASS	PASS	6
	13	PASS	PASS	PASS	OK	PASS	PASS	*	5, 6
	16	PASS	PASS	PASS	OK	PASS	PASS	*	5, 6
	20	PASS	PASS	PASS	OK	PASS	PASS	*	5, 6
	24	PASS	PASS	PASS	OK	PASS	PASS	*	5, 6

(continued)

Table C-1 (continued)

SAMPLE DESCRIPTION	SAMPLE #	(INITIAL) HI - POT	(INITIAL) IR	(INITIAL) VEECO	(INSTRON) VISUAL	(POST) HI - POT	(POST) IR	(POST) VEECO	NOTES
BCO# L-35754-316 (SA1457-1 HERMETIC) TORLON	14 15 17 20 22 27	PASS PASS PASS PASS PASS PASS	PASS PASS PASS PASS PASS PASS	* * * * * *	OK OK OK OK OK OK	PASS PASS PASS PASS PASS PASS	PASS PASS PASS PASS PASS PASS	* * * * * *	
BCO #L-35754-322 (SA1457-1 HERMETIC) TORLON CHAMFERED INSERT	4 5 6 10 11 12	PASS PASS PASS PASS PASS PASS	PASS PASS PASS PASS PASS PASS	* * * * * *	DAMAGE DAMAGE DAMAGE OK DAMAGE OK	PASS PASS PASS PASS PASS PASS	FAIL PASS FAIL PASS FAIL FAIL	* * * * * *	4 4 4 4
BCO #L-35754-319 (SA1442-2) GREEN FIBERITE E7459-16612	30 31 37 38 43 44	PASS PASS PASS PASS PASS PASS	PASS PASS PASS PASS PASS PASS	* * * * * *	OK OK OK OK OK DAMAGE	PASS PASS PASS PASS PASS PASS	PASS PASS PASS PASS PASS PASS	* * * * * *	1 1 1 1 1 2
BCO #L-35754-325 (SA1442-2) GREEN FIBERITE E7459-16612 CHAMFERED INSERT	48 50 53 55 56 60	PASS PASS PASS PASS PASS PASS	PASS PASS PASS PASS PASS PASS	* * * * * *	OK OK OK OK OK OK	PASS PASS PASS PASS PASS PASS	PASS PASS PASS PASS PASS PASS	* * * * * *	

(continued)

Table C-1 (concluded)

SAMPLE DESCRIPTION	SAMPLE #	(INITIAL) HI-POT	(INITIAL) IR	(INITIAL) VEECO	(INSTRON) VISUAL	(POST) HI-POT	(POST) IR	(POST) VEECO	NOTES
BCO# L-35754-318 (SA1442-2) FORTRON (PPS)	64 65 66	PASS PASS PASS	PASS PASS PASS	* * *	OK OK OK	PASS PASS PASS	PASS PASS PASS	* * *	
BCO #L-35754-324 (SA1442-2) FORTRON (PPS) CHAMFERED INSERT	67 68 69	PASS PASS PASS	PASS PASS PASS	* * *	OK OK OK	PASS PASS PASS	PASS PASS PASS	* * *	
BCO # (SA1442-2) PEEK									
BCO # (SA1442-2) PEEK CHAMFERED INSERT									

NOTES:

* BCO FAILED TO PERFORM THIS TEST.

1. VERY MINOR CHIPPING/CRACKING - BARELY NOTICEABLE (FIG. C-1A).

2. MINOR CHIPPING/CRACKING - NOTICEABLE/ACCEPTABLE (FIG. C-1B).

3. MAJOR CHIPPING/CRACKING - DAMAGE EXTENDS FROM INSERT EDGE TO AT LEAST FIRST ROW OF CONTACTS; ACCEPTABILITY IS QUESTIONABLE (FIG. C-1C).

4. INSERT/GLASS HEADER BOND FAILURE -- ESSENTIALLY A NO-TEST.

5. PRIOR TO INSTRON TEST, CONNECTORS SUBJECTED TO TEMPERATURE CYCLING FOR FIVE CYCLES FROM -55°C TO +177°C AND TEN CYCLES OF 80 - 98% RELATIVE HUMIDITY.

6. BCO INADVERTENTLY SUBJECTED CONNECTORS TO ONE TEMP. CYCLE (30 MINUTES IN FREEZER, 1 HOUR IN OVEN; TEMPS. UNKNOWN) AFTER FINAL ASSEMBLY.

ILLUSTRATIONS OF INSERT DAMAGE

FIGURE C1

APPENDIX D

Results of Cable Pull Test

Summary

Command and Control Division I (5126) performed two sets of cable pull tests, replicating field-use conditions. Each set of pull tests consisted of pulls made in four directions approximately 90° apart (Figure D-1). One set is performed by pulling at the potting boot (3-in. lever arm) and the other set at the cable itself (12 to 18 in. lever arm). The connector samples were mounted in a T1533 decoder at the J3 position. Army CT1503 PAL cables were used to perform the cable pull tests. Each connector sample was subjected to the two sets of cable pull tests above. Each pull test was a sideways disconnect pulling/yanking action, preceded by a complete mating of the connector pair, followed by disengagement of the coupling ring without separating the mated connector bodies.

The initial plan was to Instron-test four and pull-test four of each type of connector sample after subjecting them to temperature cycling and humidity tests intended to replicate field environments. The frequency of the insert-to-glass header bond failures in hermetic connectors after simulated environments prompted the discontinuance of simulated environmental exposure and subsequent cable pull testing on the remaining (Torlon, Fiberite E264H) connector samples.

The level of insert damage sustained for each connector is recorded in Table D-1.

Results

Damage results ranged from no chipping to major chipping. These tests also demonstrated that the 30° bevel on the insert outer edge reduces the amount of edge chipping that occurs. The cable pull tests show that the bevel provides a 75% reduction in chipping compared to regular connector inserts with no bevel edge. The hermetic connectors proved inadequate as test samples because the insert-to-glass header bond broke loose during cable pull tests. Visual damage assessment was made with both the naked eye and under 7× magnification.

Conclusions

Connectors with thermoplastic inserts exhibited no damage, whereas those with Fiberite (thermoset) inserts experienced some degree of damage in most cases. The best performing insert material was Fortron, a thermoplastic.

Although it is difficult to predict the reason damage occurred on some of the connectors, I believe that both impact and interference-induced stress were factors. After witnessing the test, jiggling the connector to free it, then whipping it loose, I suspect that damage was being caused by the connector's shell impacting the insert—in some cases at the point of interference and in other cases at a point opposite.

Table D-1. Summary of Cable Pull Test Results

SAMPLE DESCRIPTION	SAMPLE #	(INITIAL) HI-POT	(INITIAL) IR	(INITIAL) VEECO	(PULL TEST) VISUAL	NOTES
BCO # 10-551325-26S (SA1457-1 HERMETIC) BLUE FIBERITE E-3938 BE96	1 2 3 4	PASS PASS PASS PASS	PASS PASS PASS PASS	PASS PASS PASS PASS	DAMAGE DAMAGE DAMAGE DAMAGE	3, 4, 5 1, 4, 5 3, 4, 5 1, 4, 5
BCO #L-35754-326 (SA1457-1 HERMETIC) BLUE FIBERITE E-3938 BE96 CHAMFERED INSERT	17 18 19 20	PASS PASS PASS PASS	PASS PASS PASS PASS	PASS PASS PASS PASS	DAMAGE DAMAGE DAMAGE DAMAGE	4, 5 4, 5 4, 5 4, 5
BCO #L-35754-317 (SA1457-1 HERMETIC) TAN FIBERITE E264H	5 6 7 8	PASS PASS PASS PASS	PASS PASS PASS PASS	PASS PASS PASS PASS	DAMAGE DAMAGE DAMAGE NO TEST	3, 4, 5 1, 4, 5 3, 4, 5 5, 7
BCO #L-35754-323 (SA1457-1 HERMETIC) TAN FIBERITE E264H CHAMFERED INSERT	21 22 23 24	PASS PASS PASS PASS	PASS PASS PASS PASS	PASS PASS PASS PASS	DAMAGE DAMAGE DAMAGE DAMAGE	4, 5 4, 5 3, 4, 5 3, 4, 5
BCO #10-551545-26S (SA1442-2) BROWN FIBERITE E-3938 BE96	9 10 11 12	PASS PASS PASS PASS	PASS PASS PASS PASS	PASS PASS PASS PASS	DAMAGE DAMAGE DAMAGE NO TEST	3, 5, 6 3, 5, 6 3, 5, 6 5, 6, 8
BCO #L-35754-327 (SA1442-2) BLUE FIBERITE E-3938 BE96 CHAMFERED INSERT	13 14 15 16	PASS PASS PASS PASS	PASS PASS PASS PASS	PASS PASS PASS PASS	DAMAGE DAMAGE DAMAGE DAMAGE	3, 5, 6 3, 5, 6 3, 5, 6 3, 5, 6

(continued on next page)

Table D-1 (continued)

SAMPLE DESCRIPTION	SAMPLE #	(INITIAL) HI-POT	(INITIAL) IR	(INITIAL) VEECO	(PULL TEST) VISUAL	NOTES
BCO# L-35754-316 (SA1457-1 HERMETIC) TORLON	16 18 19 21 23 24 25 26	PASS PASS PASS PASS PASS PASS PASS PASS	PASS PASS PASS PASS PASS PASS PASS PASS	* * * * * * * *	DAMAGE DAMAGE NO TEST NO TEST NO TEST DAMAGE DAMAGE DAMAGE	4 4 7 7 7 4 4 4
BCO #L-35754-322 (SA1457-1 HERMETIC) TORLON CHAMFERED INSERT	1 2 3 7 8 9 13	PASS PASS PASS PASS PASS PASS PASS	PASS PASS PASS PASS PASS PASS PASS	* * * * * * *	DAMAGE DAMAGE NO TEST NO TEST NO TEST NO TEST NO TEST	4 4 7 7 7 7 7
BCO #L-35754-319 (SA1442-2) GREEN FIBERITE E7459-16612	28 29 32 34 35 36 39 40	PASS PASS PASS PASS PASS PASS PASS PASS	PASS PASS PASS PASS PASS PASS PASS PASS	* * * * * * * *	OK OK DAMAGE DAMAGE OK DAMAGE DAMAGE DAMAGE	1 1 3 2 1 2 2 2

(continued)

Table D-1 (continued)

SAMPLE DESCRIPTION	SAMPLE #	(INITIAL) HI-POT	(INITIAL) IR	(INITIAL) VEECO	(PULL TEST) VISUAL	NOTES
BCO# L-35754-325 (SA1442-2) GREEN FIBERITE E7459-16612 CHAMFERED INSERT	47 49 51 52 54 57 58 59	PASS PASS PASS PASS PASS PASS PASS PASS	PASS PASS PASS PASS PASS PASS PASS PASS	* * * * * * * *	DAMAGE OK OK OK OK OK OK OK	3 1 1
BCO #L-35754-318 (SA1442-2) FORTRON (PPS)	61 62 63	PASS PASS PASS	PASS PASS PASS	* * *	OK OK OK	
BCO #L-35754-324 (SA1442-2) FORTRON (PPS) CHAMFERED INSERT	70 71 72	PASS PASS PASS	PASS PASS PASS	* * *	OK OK OK	

(continued)

Table D-1 (concluded)

SAMPLE DESCRIPTION	SAMPLE #	(INITIAL) HI-POT	(INITIAL) IR	(INITIAL) VEECO	(PULL TEST) VISUAL	NOTES
BCO # (SA1442-2) PEEK						
BCO # (SA1442-2) PEEK CHAMFERED INSERT						

NOTES:

- * BCO FAILED TO PERFORM THIS TEST.
- 1. VERY MINOR CHIPPING/CRACKING - BARELY NOTICEABLE (FIG. C-1A).
- 2. MINOR CHIPPING/CRACKING - NOTICEABLE/ACCEPTABLE (FIG. C-1B).
- 3. MAJOR CHIPPING/CRACKING - DAMAGE EXTENDS FROM INSERT EDGE TO AT LEAST FIRST ROW OF CONTACTS; ACCEPTABILITY IS QUESTIONABLE (FIG. C-1C).
- 4. INSERT/GLASS HEADER BOND FAILURE -- ESSENTIALLY A NO-TEST.
- 5. PRIOR TO PULL TEST, CONNECTORS SUBJECTED TO TEMPERATURE CYCLING FOR FIVE CYCLES FROM -55°C TO +177°C AND TEN CYCLES OF 80 - 98% RELATIVE HUMIDITY.
- 6. BCO INADVERTENTLY SUBJECTED CONNECTORS TO ONE TEMP. CYCLE (30 MINUTES IN FREEZER, 1 HOUR IN OVEN; TEMPS. UNKNOWN) AFTER FINAL ASSEMBLY.
- 7. NO TEST PERFORMED BASED ON ASSUMPTION THAT INSERT/GLASS HEADER BOND WILL FAIL.
- 8. NO TEST - SAMPLE USED FOR HAND-OPERATED INSERT BEVELING TOOL EXPERIMENT BY DIV. 5126.

APPENDIX E

Results of Insert Test

Summary

Hermetic connector inserts have a history of breaking along the edges and across the contact aligning web (Figure E-1A, B). The objective was to compare the strength of six materials in the contact aligning web area. Two holes were punched out in each insert (Figure E-2A), one approximately in the center of the insert and one along the perimeter (Figure E-2C). The test was to be run at moderate speed (i.e., distinct from an impact test or a tensile test). The test was performed on the Instron using a speed of 20 mm/s nominal.

Three of six inserts for each material in both configurations (Figure E-2B) were subjected to temperature cycling for five cycles from -55°C to $+177^{\circ}\text{C}$ and ten cycles at 80% to 98% relative humidity.

Results

Test results summarized in Table E-1 show the forces required to punch out the contact aligning web. Materials exhibiting the greatest change due to temperature cycling and humidity were Torlon and Fiberite E264H. Fiberite E264H and E-7459-16612 exhibited equal strength after simulated environmental exposure. Fortron exhibited the greatest strength overall. With the exception of Fiberite E-3938 BE96, all the materials fractured and failed but held together with their filler materials. E-3938 BE96 fractured, failed, and fell off completely. PEEK inserts have not been received yet; hence, we have no test results.

BCO discourages using Torlon and Fiberite E264H. The stainless-steel core pins used to create the contact cavities exhibited wear due to the high pressures required to mold these two materials.

A

B

ILLUSTRATIONS OF BREAKAGE

FIGURE E1

Table E-1. Summary of Insert Test Results

INSERT DESCRIPTION (FORCE VALUES IN LBS)	PERIMETER HOLE				CENTER HOLE			
	SAMPLE #1	SAMPLE #2	SAMPLE #3	AVG. FORCE	SAMPLE #1	SAMPLE #2	SAMPLE #3	AVG. FORCE
FIBERITE E-3938 BE96	51.7	51.7	44.0	49.1	58.5	58.5	66.0	61.0
FIBERITE E-3938 BE96*	44.0	44.0	44.0	44.0	56.1	52.8	50.6	53.2
FIBERITE E-3938 BE96Ø	38.7	40.7	40.7	40.0	60.5	63.8	70.4	64.9
FIBERITE E-3938 BE96*Ø	40.7	46.2	45.1	44.0	52.8	56.1	50.6	53.2
FIBERITE E7459-16612	59.4	48.4	59.4	55.7	82.5	80.3	75.9	79.6
FIBERITE E7459-16612*	47.3	44.0	53.9	48.4	66.0	76.3	69.3	70.5
FIBERITE E7459-16612Ø	46.2	45.1	60.1	50.5	78.1	85.8	75.9	79.9
FIBERITE E7459-16612*Ø	40.7	51.7	53.9	48.8	63.8	77.0	69.3	70.0
FIBERITE E264H	82.5	99.0	102.3	94.6	147.4	105.6	145.2	132.7
FIBERITE E264H*	52.8	49.5	38.5	46.9	74.8	62.7	72.6	70.0
FIBERITE E264HØ	86.9	88.0	66.0	80.3	122.1	138.6	79.2	113.3
FIBERITE E264H*Ø	46.2	36.3	54.3	45.6	86.9	81.4	72.6	80.3
TORLON	80.7	89.1	90.2	86.7	113.0	114.0	108.9	112.0
TORLON*	66.0	67.1	74.8	69.3	81.4	90.2	94.6	88.7
TORLONØ	73.7	74.8	93.5	80.7	107.8	107.2	107.8	107.6
TORLON*Ø	69.3	81.4	72.6	74.4	94.6	95.7	89.1	93.1
FORTRON (PPS)	127.6	125.4	125.4	126.1	148.2	147.0	147.4	147.5
FORTRON (PPS)*	118.8	118.8	117.7	118.4	127.6	121.0	137.5	128.7
FORTRON (PPS)Ø	114.0	115.5	114.4	114.6	147.0	143.0	127.6	139.2
FORTRON (PPS)*Ø	113.3	106.7	122.1	114.0	137.5	129.8	139.7	135.7
PEEK								
PEEK*								
PEEKØ								
PEEK*Ø								

* SUBJECTED TO TEMP. CYCLE & HUMIDITY
Ø CHAMFERED EDGE

(continued)

Table E-1 (concluded)

LEGEND:

- — — Perimeter Hole
- — — Center Hole
- * Subjected to Temperature Cycle and Humidity
- Ø Chamfered Edge

APPENDIX F

Insert Tolerance Studies

Summary

As noted earlier in the Instron and Pull Test results, the simplest way to relieve any interference in the insert edge area is to chamfer or "radius" the edge itself. For experimentation purposes, the 17-26 insert arrangement was selected to serve as the benchmark since the most common connector size experiencing insert damage was the 17-shell size. The chamfer size selected was BCO's recommendation (Figure F-1A).

Test results show a definite improvement by chamfering the insert edge; however, thinning down the wall at the upper end of the contact guide hole proved to be undesirable (Figure F-1A). In addition, the chamfer used in the test experiments cannot always be used for other insert arrangements.

A tolerance study was performed for all JT/LJT insert arrangements applicable to "SA" and "MC"

connectors. The insert arrangement most vulnerable to chamfering is 15-18. In order to provide a "comfortable" 0.010 in. of material from the edge of the contact guide hole to the chamfer edge, a maximum chamfer angle of 14° is required (Figure F-1B).

A comparison of the worst-case conditions for insert arrangements 17-26 and 15-18 can be found in Figure F-1, A and B.

Without further testing, I speculate that a 14° chamfer would provide limited improvement and would not be cost-effective.

Conclusion

Based on this study, I believe a superior insert material is required to optimize chipping resistance without altering the connector design.

17-28 INSERT ARRANGEMENT
WORST CASE CONDITION

A

15-18 INSERT ARRANGEMENT
WORST CASE CONDITION

B

ILLUSTRATIONS

FIGURE F1

Summary

The reconfigured insert and metal shell-edge geometries were evaluated for the purpose of reducing the alleged interference deemed primarily responsible for insert damage.

Numerous reconfiguration combinations were tried graphically but none showed promise in eliminating the problem. The primary configurations are illustrated in Figure G-1.

The studies showed that, at the point of disengagement when insert chipping occurs, the principal areas of interference are between the bayonet pins and the coupling ring and/or the receptacles' shell and the coupling ring. However, a small amount of interference exists between the insert and plug shell.

Reconfiguration of the insert and metal shell-edge geometries would provide interference relief but would not eliminate the insert chipping problem. As mentioned earlier in the Connector Test results, chip-

ping appears to be caused by impact rather than by interference-induced stress.

The cost to reconfigure the metal shells and inserts may not be justifiable, considering the magnitude of the interference.

Test Results

Six SA1442-2 connectors with approximately 30° chamfers on the insert and shell (Figure G-2) were subjected to cable pull tests (Figure D-1). No improvement in chipping resistance was evident, lending credence to the hypothesis that chipping is principally caused by impact.

Conclusion

Based on this study, I believe that a superior insert material is required to optimize chipping resistance without altering the connector design.

APPENDIX G

Configuration Studies and Tests

PRINCIPAL CONFIGURATIONS
FIGURE G1

TEST SAMPLE ILLUSTRATION

FIGURE G2

APPENDIX H

Support Request Memo to the Organic Materials Division (without attachments)

Sandia National Laboratories

Albuquerque, New Mexico 87185

date: March 12, 1991
to: K. B. Wischmann, 7472

from: J. R. F. Baca, 2551

subject: Connector Insert Material Evaluation

This memo requests your support in selecting/recommending an insert material which will exhibit substantially improved resistance to damage such as chipping, cracking, etc. The material must continue to be able to meet all other requirements currently in effect.

The material presently used is Fiberite E3938, a thermoset plastic consisting of 30% epoxy resin and 70% one-eighth inch long glass fibers.

The candidate materials being evaluated by Division 2551 are:

1. Fiberite E7459-16612: a thermoset plastic consisting of 60% epoxy resin and 40% one-fourth inch long glass fibers.
2. Fiberite E264H: a thermoplastic consisting of 40% epoxy resin and 60% one-fourth inch long glass fibers.
3. Torlon 4203L (Amoco Chemical Co.): a polyamide-imide molding compound; unreinforced thermoplastic.
4. Fortron 1140L4 (Hoechst Celanese): a polyphenylene sulfide, 40% fiber glass, low flash grade thermoplastic.
5. PEEK RTP2205 (RTP Co.): a polyetheretherketone, 30% fiber glass reinforced thermoplastic.

Both, Fiberite E264H and Torlon 4203L require very high molding pressures, and therefore, can only be used to mold hermetic connector inserts. However, both materials exhibited abrasive wear during molding, so their use is highly discouraged by the connector manufacturer.

At my request, Fiberite Corporation recommended four thermoset materials, two in particular:

1. Fiberite E8354-19189: a thermoset plastic having a resin matrix much more resistant to chipping than the thermoset materials listed above.

March 12, 1991

2. Fiberite TEM 9001: a thermoset plastic having a toughened epoxy resin and glass/mineral reinforcement.
3. Fiberite TEM 9010: a thermoset plastic having a toughened epoxy resin and glass/mineral reinforcement.
4. Fiberite TEM 9025: a thermoset plastic having a toughened epoxy resin and one-half inch long (one-fourth inch available) E-glass reinforcement.

Fiberite Corporation's primary recommendations are Fiberite E8354-19189 and TEM 9001. The principal difference being greater chip resistance in TEM 9001 due to toughened epoxy resin.

Except for TEM 9025 these are granular products. Molding methods and processes are virtually identical to Fiberite E3938, E7459-16612, and E264H.

Fiberite highly recommends using one of these four materials in place of E3938, E7459-16612, and E264H which is 20 year old technology and has very poor batch quality control.

Product data sheets are attached for your review.

Your costs should be budgeted and charged to case number 0034.200.

JRFB:2551:vc

Copy to:

2550 D. W. Doak

2551 D. E. Carnicom

2551 M. J. Craig

7472 J. A. Sayre

2551 J. R. F. Baca

2551 Dayfile (w/o attch.)

APPENDIX I

Memo to BCO Requesting Time and Cost Estimates

Sandia National Laboratories

Albuquerque, New Mexico 87185

February 4, 1991

Amphenol Corporation
Bendix Connector Operations
40-60 Delaware Street
Sidney, NY 13838-1395

ATTN: J. B. Becker

Dear Joe:

Subject: Time and Cost Estimate for Molding New JT/LJT Insert Material

Please provide time and cost estimates for molding PEEK, FORTRON (PPS), and Fiberite E16612 inserts for SA1442-2 and SA1457-1 connectors. These two connector types will serve as benchmarks for evaluation purposes.

As per our January 24 telecon, I am requesting that you provide time and cost estimates for each of the following:

1. FIBERITE E16612.
 - Material shrinkage study
 - Transfer molds that provide a beveled edge (fig. 1B)
 - Tapered core pins (fig. 1B)
 - Establish the molding process
 - Time required to become fully operational
 - Cost per connector (SA1442-2 and SA1457-1) in quantities of 100 or more
2. FORTRON (PPS) 1140L4.
 - Vertical injection molding machine
 - Injection molds (fig. 1C)
 - Material shrinkage study
 - Tapered core pins (Fig. 1C)
 - Establish the molding process
 - Time required to become fully operational
 - Cost per connector (SA1442-2 and S1457-1) in quantities of 100 or more
3. PEEK (RTP 2205)
 - same as number two above

Sincerely,

J. R. F. Baca
Division 2551

J. B. Becker, BCO

-2-

February 4, 1991

JRFB:2551:vc

Distribution:

2550 D. W. Doak

2551 D. E. Carnicom

2551 J. R. F. Baca

FIG. 1

APPENDIX J

BCO Material Evaluation Report

ENGINEERING REPORT		REPORT NO. C1-1049	
		REPORT DATE 12/18/90	PAGE 1 of 5
Amphenol Corporation		Bendix Connector Operations	
		Sidney, New York 13838-1395	
TITLE: MATERIAL EVALUATION FOR JT/LJT INSERTS		REPORT TYPE: EVALUATION	
		PROJECT NO. (Contract) 70821K	
c: J.R.F. Baca, A. Schildkraut, J. Badolato			
<p>PURPOSE:</p> <p>To identify and insert material(s) for both hermetic and non-hermetic connectors, for the JT/LJT family, which will exhibit improved resistance to damage such as chipping, cracking, etc. The connectors must continue to meet the requirements, as defined, in Sandia National Labs specifications for the SA1457 (hermetic) and SA1442 (non-hermetic) connectors.</p>			
<p>CONCLUSIONS:</p> <ol style="list-style-type: none"> 1) Unchamfered inserts of Torlon (hermetic) and PPS (non-hermetic) appear to have provided the best resistance to damage. 2) Chamfered inserts of all materials tested except the standard (blue and brown Fiberite) provided good resistance to damage. 3) The standard materials provided better resistance to damage in the chamfered configuration than the unchamfered configuration. 4) Molding trials with Torlon and Fiberite E264H in the non-hermetic configuration were unsuccessful due to the high pressures required which damaged the molded-in contacts. 			
<p>RECOMMENDATIONS:</p> <ol style="list-style-type: none"> 1) Due to the problem of cracked/chipped inserts to socket contact inserts when used in receptacle connectors, consider the change to: <ol style="list-style-type: none"> a) restricting pin contacts to receptacle connectors b) redesign connector receptacles as hard mounting plug (plug connectors that mount in existing receptacle panels) 2) Consider an investigation of thermal plastic insert materials aimed at evaluating those with high flexural strength rather than high impact strength. 3) Consider alternative methods of molding inserts to prevent damage to molded-in contacts such as: a) a multistep process so that shorter sections of unsupported contacts are exposed to the compound flow or b) a loose assembly of contacts and insulator which is over-molded with a tough material creating solid insert. 			

RESULTS:

- 1) Due to manufacturing problems with E264H and Torlon for non-hermetic connectors, we substituted 16612 (green) and PPS (black) respectively. PPS is Fortron, 1140L4.
- 2) The PPS material which is a thermoplastic material, required modified molding techniques which had to be produced in our Materials Lab (for non-hermetic only).

Other than the standard material for the non-hermetic connectors, the molding pressures are so great as to cause the berillium copper socket to bend/break in the molds.

DETAILED REPORT:

The following connectors were manufactured: (all are LJT07 types 17-26S arrangement)

(SA1442-2) <u>Non-Hermetic</u>	Std.	Sharp Edge	14 pcs.
		Chamfered (30°) Edge	14 pcs.
	16612	Sharp	14 pcs.
		Chamfered (30°) Edge	14 pcs.
(SA1457-1) <u>Hermetic</u>	PPS	Sharp	6 pcs.
		Chamfered (30°) Edge	6 pcs.
	Std.	Sharp	14 pcs.
		Chamfered (30°) Edge	14 pcs.
	Torlon	Sharp	14 pcs.
		Chamfered (30°) Edge	13 pcs.
	E264H	Sharp	14 pcs.
		Chamfered (30°) Edge	14 pcs.
Total			151 pcs.

SEE SHEET 4 FOR BCO PART NUMBERS.

All connectors were subjected to the following tests, in order shown:

- A) 1. Dielectric Withstanding Voltage
2. Insulation Resistance
3. VEECO (leak test)
4. Visual examination of inserts after successfully passing the above six (6),
(3 pcs. in the case of PPS) of connectors were tested as follows:

DETAILED REPORT: (Cont'd)

- B) 1. Instron Bend Test (e.g. McDonnell Douglas Test) - see Figure 1
2. Dielectric Withstanding Test
3. Insulation Resistance
4. VEECO
5. Visual examination of inserts

FIGURE 1
(FOR B.I TESTS)

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Sidney, New York 13838-1395

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MATERIAL EVALUATION PROGRAM (mateval)

NO.	PART NO.	TYPE	MATERIAL	(COLOR)	DEVIATION	VISUAL RESULTS
1	10-551325-26S	HERM	STD *	(BLU/BRO)	NONE	ALL SHOWED SLIGHT MATL FLOW
2	L-35754-326	HERM	STD *	(BLU/BRO)	30 DEG CHAM	3 PCS HAD SLIGHT CRACK
3	L-35754-316	HERM	TORLON *	(YEL-TAN)	NONE	NO DAMAGE; 1 PC INSERT NOT BO
4	L-35754-322	HERM	TORLON *	(YEL-TAN)	30 DEG CHAM	ALL INSERTS TIPPED; 4 PCS FAIL
5	L-35754-317	HERM	E264H *	(TAN)	NONE	ALL SHOWED SLIGHT MATL FLOW
6	L-35754-323	HERM	E264H *	(TAN)	30 DEG CHAM	NO DAMAGE
7	10-551545-26S	SOLDER	STD *	(BLU/BRO)	NONE	ALL CRACKED
8	L-35754-327	SOLDER	STD *	(BLU/BRO)	30 DEG CHAM	1 PC HAD SLIGHT CRACK
9	L-35754-318	SOLDER	PPS *	(BLK)	NONE	NO DAMAGE
10	L-35754-324	SOLDER	PPS *	(BLK)	30 DEG CHAM	NO DAMAGE
11	L-35754-319	SOLDER	16612 *	(GRE)	NONE	3 PCS HAD SLIGHT MATL FLOW
12	L-35754-325	SOLDER	16612 *	(GRE)	30 DEG CHAM	NO DAMAGE

* MATERIAL DESCRIPTION

STD = BCD 9-7180 (BLU/BRO) FROM FIBERITE
PPS = BCD 9-8985 (BLK) FROM FORTRON
TORLON = BCD 9-7531 (YEL-TAN) FROM AMACO
E264H = BCD 9-8887 (TAN) FROM FIBERITE
16612 = BCD 9-4409 (GREEN) FROM FIBERITE

PROBLEMS/CONCERNS:

Due to the pressures required for molding E264H and Torlon (in non-hermetic only)

- a) the parts would not fill (non-fills)
- b) the BeCu sockets either bent or broke in the molds

Amphenol Corporation
Bendix Connector Operations
Sidney, New York 13838-1395

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These conditions can be seen in Polaroid photo below.

Bent Contacts and/or Non-Fills

Unless a new molding procedure or a change in contact material (one that can withstand these pressures without damage) is accomplished, thermosetting molding material other than the standard material cannot be manufactured.

Reported By: James A. Badolite
12/20/90

Approved By: R.W. Monahan
12-21-90

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