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NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
PATUXENT RIVER, MARYLAND



TEST REPORT

NAWCADPAX/TR-2018/254

EVALUATION OF OPTIMIZED SHIELD TERMINATION DEVICE (Trident Spring Band ISOTDS1 through 4)

by

Oliviu Muja

26 November 2018

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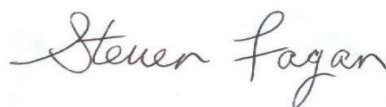
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EVALUATION OF OPTIMIZED SHIELD TERMINATION DEVICE
(Trident Spring Band ISOTDS1 through 4)

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Oliviu Muja

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26 Nov 2018

STEVEN FAGAN / AIR-4.4.5 / DATE

NAVAIR 4.4.5 Senior Engineer

Power and Energy Division

SUMMARY

NAVAIR (4.4.5.3) Wiring Systems has evaluated a new configuration of Electrical Wiring and Interconnect System (EWIS) Electromagnetic Interference shield termination device (ISOTDS1 through 4). Current termination steel bands (M85049/128) are cumbersome, take too much time to install, require multiple specialized tools to install, and verify installation. The M85049/128 bands can only be used once, are costly, and must be removed in pieces which may cause foreign object damage. This effort tested the new spring band configuration on typical EWIS installations, using the Society of Engineers (SAE) published test methods employed to evaluate and qualify the existing M85049/128 shield termination devices. Supplemental tests were also performed beyond the minimum SAE specification requirements. The new configuration ISOTDS1 through 4 trident spring band was found to meet or exceed performance requirements of the existing M85049/128. It provided a quick installation and removal, required no special tools and was shown to be reusable. Tests performed included: fit, vibration, elevated temperature life cycle, electrical conductivity, braid retention/tensile strength, and suitability.

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INTRODUCTION

1. For over three decades, wire harnesses have used steel bands for electromagnetic interference (EMI) shield terminations employed in various aerospace applications. The first program to employ the current configuration shield termination was the B-1B Lancer starting in 1984. The typical metallic shield is made up of woven tin, nickel, or silver plated stranded copper wrapped around the wires in the bundle. The EMI shield usually requires 90% optical coverage to ensure that the effects of EMI will not adversely affect the wires inside the wire bundle (A-A-59569 braid wire). The designer of the Electrical Wiring and Interconnect System (EWIS) for that application determines the requirement based on the intended mission, environment, or purpose of the air vehicle (MIL-STD-461, MIL-STD-464).
2. Current shield termination devices (M85049/128 steel bands), Figure 1, are cumbersome, take too much time to install, require several specialized tools to install, and to verify installation (SAE AS81306™). The installation process requires the maintainer to have specialized training and experience for optimum performance. The bands can only be used once, are costly, and must be removed in pieces which may cause foreign object damage (FOD). This process is logistically challenging and negatively affects deployment capability and footprint as a dedicated toolkit and spare, consumable steel bands are required.



Figure 1: M85049/88 Accessory with A-A-59569 Shield Terminated using M85049/128 Band

3. The purpose of this study is to examine the performance of the new trident spring band configuration (ISOTDS1 through 4), Figure 2, on typical aerospace installations (e.g., M85049/82 through /90 connector accessory), shown in Figure 3. The test methods employed are the same as the ones used to evaluate/test the existing shield termination devices. Both critical and supplementary tests were performed, with the full complement of first article or qualification testing to be performed once proven/passing performance results are evaluated. This test effort/evaluation focused on: corrosion characteristics, vibration, tensile strength of the shield termination, life cycle/elevated temperature, followed by the electrical bond/conductivity performance.



Figure 2: Optimized Spring Band Sample (e.g., ISOTDS1) and in the Coiled Configuration



Figure 3: Optimized Spring Band Installed on a Typical EWIS Connector Accessory (M85049/82)

4. Note that the legacy/older ISOHS150NF2509-5S design was not tested as part of this effort as it was evaluated in prior NAVAIR QPL Project: 50-06-001, NAWCADPAX/TR-2013 04.

TESTS PERFORMED

CONFIGURATION/FIT

This test method was used to measure the capability of the optimized spring band devices to fit on legacy EWIS shield termination accessories (SAE AS85049/82™ through 90 and splice /93). Measured spring band device to ensure fit on accessory banding platform that can be opened and fit on all shell sizes from 9 to 28 and 8 through 61 for various accessory size configurations. A physical measurement was made on the parts available (ISOTDS1-4 bands and M85049/82-10-W03, size 18 and 28; small, medium, and large). The remaining size connector accessories were deemed correctly sized and compatible by analysis, based on manufacturer's component specifications. The current SAE AS85049/82 thru /90™ which specify these connector accessories do not define the width of the banding platform (Figure 4). Physical measurements showed that various manufacturers employ a .37 in. wide banding platform to accommodate the current M85049/128 steel band which is .25 +/- .01 in. wide (Figure 1).

5. Measurements, fit test and analysis, showed that the four size (ISOTDS1-4) bands fit on standard M85049/82 through 90 shell sizes and cable entry configurations as they are 0.31 in. wide while the typical banding platform on accessories is 0.37 in. wide. See Table 1, dimension "N".



Figure 4: Typical Banding Platform Width Measured on an M85049 Accessory (N-dimension)

Table 1: Spring Band Part Number, Material, and Size

P/N ISOTDS1-4	Material	Size	
		P Diameter <u>1</u> / (±.030 in.)	N Width <u>1</u> / (±.030 in.)
-1	Stainless Steel in accordance with ASTM A666	.35	.31
-2		.63	
-3		.92	
-4		1.09	

1/ See Figure 5.

PIN location is optional, but shall be visible in the coiled as-supplied condition.
Temporary assigned part number (PIN) convention shown as military “MS” convention.

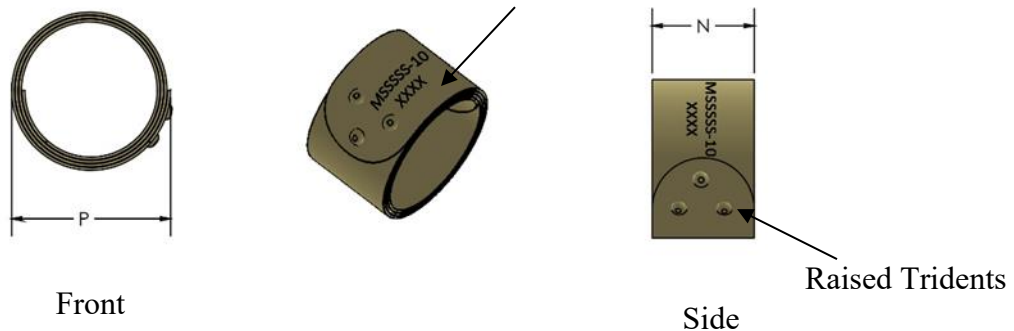


Figure 5: Trident Spring Band Dimensions (e.g., ISOTDS1-4)

CORROSION

6. This test method was used to measure the capability of the device to prevent degradation due to corrosion. The 500-hr salt fog test per EIA 364-26 is the aerospace standard test showing the typical performance requirement for EWIS applications (SAE AS50881F™). Corrosion performance criteria are determined per SAE AIR4789™. Results showed that when installed on a typical EWIS application (e.g., M85049/88), using a typical accessory and metallic shield, it met the corrosion performance requirements. Sample assembly is shown after salt accumulation was cleaned off. The test was performed at the NAVAIR Materials 4.3 facility. Follow on tests per GMW14872 Cyclic Corrosion Testing for over 1,000 hr showed no corrosion accumulation or degradation on the spring band itself (see Figure 6).

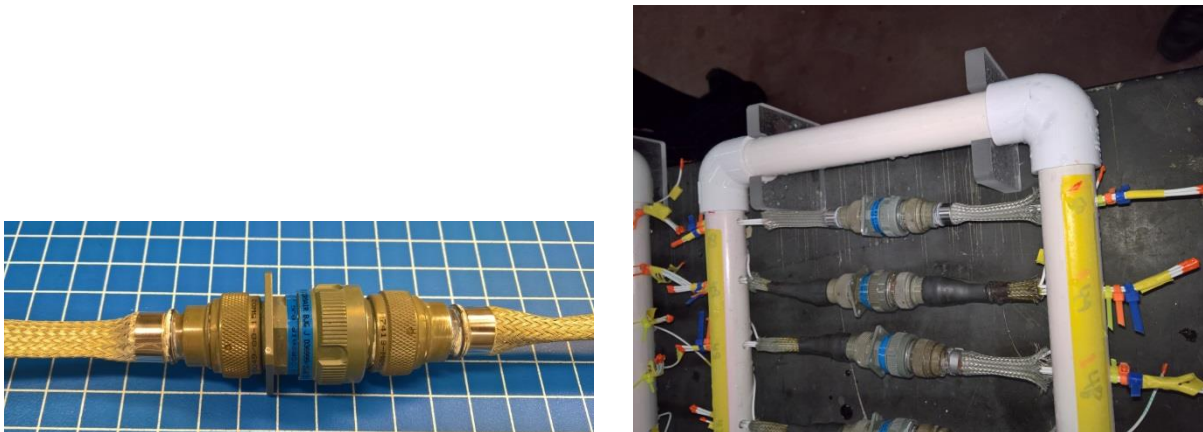


Figure 6: Corrosion Test Performance

VIBRATION

7. This test was used to simulate the harshest vibration exposure for 8 hr in two separate tests and directions. It is the same test levied on connectors, onto which the accessories cited in the SAE AS85049/128™ are required to be mounted (M85049/82-10*03, M85049/82-18*03, and M85049/82-28*03). The test verifies the mechanical integrity of the shield termination connection. The procedure followed SAE AS89049™ with applicable sections listed below:

SAE AS85049D™

3.5.4 Vibration

8. “When tested as specified in 4.6.5, connector accessories shall not be damaged, nor shall there be any loosening of parts during vibration. Connector accessories that provide termination features for individual or overall EMI/RFI shielding shall be measured for electrical conductivity before and after vibration for initial qualification only (see 3.5.2).”

3.5.4.1 Vibration (Self-Locking Only)

9. “When tested as specified in 4.6.5.4, connector accessories shall not be damaged, nor shall there be any loosening of parts during vibration. The coupling torque shall be within +20/-10 in.-lb. of the initial value after vibration. Connector accessories that provide termination features for individual or overall EMI/RFI shielding shall be measured for electrical conductivity before and after vibration for initial qualification only (see 3.5.2).”

4.6.5 Vibration

10. “A counterpart receptacle connector shall be mounted on a suitable fixture, which in turn shall be attached to the vibration table. The fully wired counterpart connector or approved modification to fixturing and connector accessory shall be engaged with the receptacle by normal locking means. Refer to AIR6151 for the connector to connector and connector to accessory recommended torque values. No safety wire shall be used. The sensing device shall monitor vibration at a point on or near the receptacle connector.”

4.6.5.2 Random Vibration - Medium Duty (see 3.5.4)

11. “The connector accessory shall then be subjected to EIA 364-28, condition VI, test condition letter I. The duration of the test shall be 8 hr in the longitudinal direction and 8 hr in the perpendicular direction.”

12. SAE AS85049/128E™ requires M85049/82 on size 8, 18, and 28; wire opening 03, self-locking configuration; W-Cadmium plated accessory; on 90% coverage tin plated A-A-59569 copper shield. Note that the /82 only fits on SAE AS50151 connectors; thus the corresponding vibration test profile was employed.

13. The vibration test was performed at the NAVAIR 4.4.6.2 vibration test lab; documented in test report NAWCAD TR 2018-003. The test articles in the configurations described were evaluated for performance in the vibration environment per Figure 7. The setup is shown in Figure 8. The test articles were exposed to 8 hr of vibration in the longitudinal and lateral axes (16 hr total) and exhibited no damage.

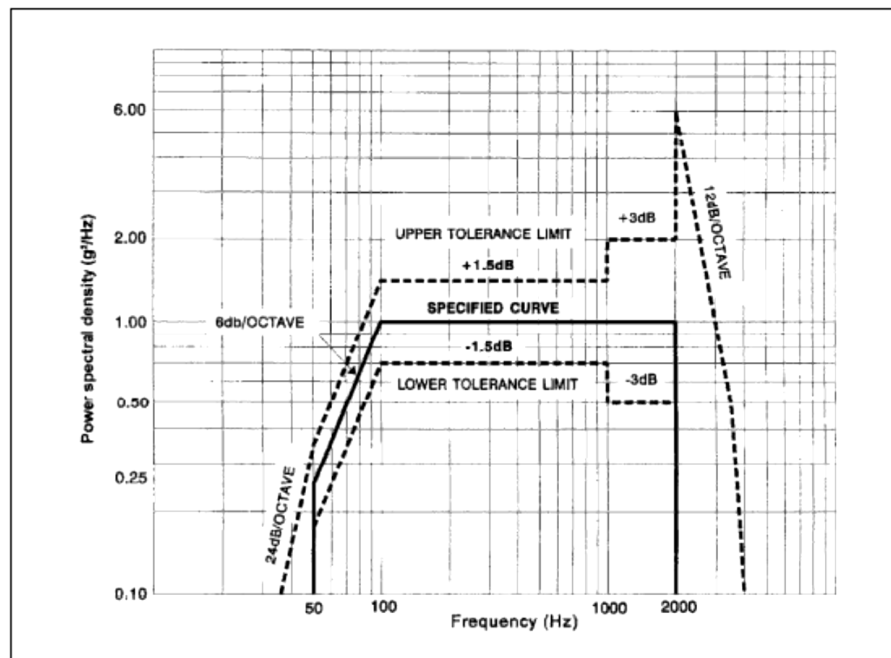


Figure 5 - Test condition VI, random vibration test-curve envelope (see table 3).

Table 3 - Values for test-condition VI ¹⁾

Test condition letter	Power spectral density, g ² /Hz	Overall rms g
A	0.02	6.21
B	0.04	8.78
C	0.06	10.76
D	0.1	13.89
E	0.2	19.64
F	0.3	24.06
G	0.4	27.78
H	0.6	34.02
I	Superseded by Test condition letter J	
J	1.0	43.92
K	1.5	53.79

Figure 7: Vibration Profile Definition per EIA 364-28

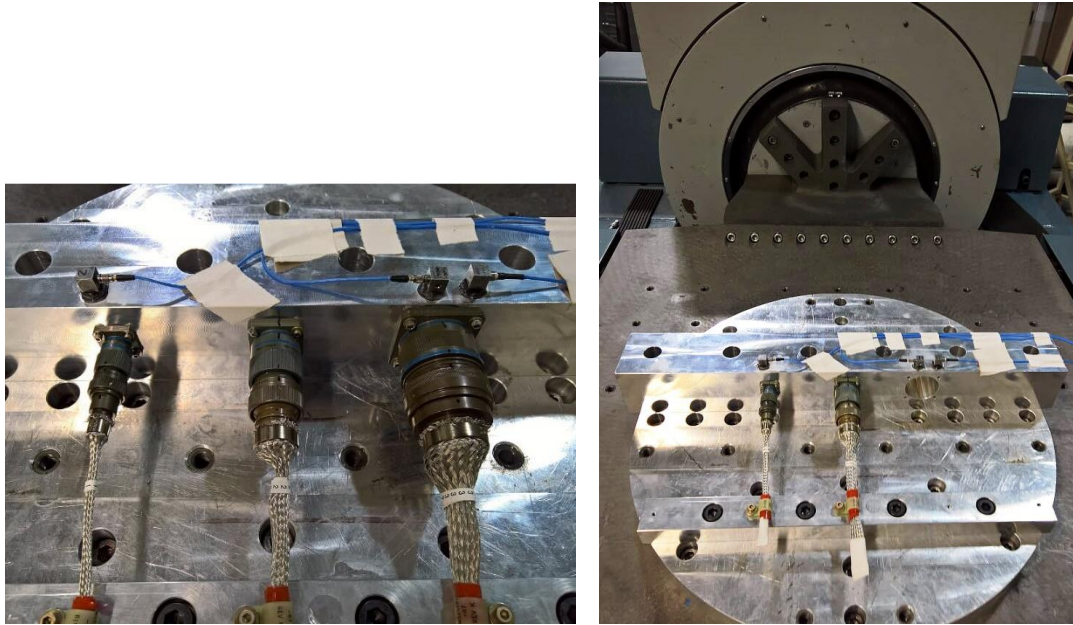


Figure 8: Vibration Test Setup

BRAID RETENTION/TENSILE STRENGTH

14. This test method was used to measure the mechanical tensile strength of the joint/connection of the metallic shield (e.g., A-A-59569) to the EWIS connector accessory (e.g., M85049/82) using the spring band (e.g., ISOTDS1) as a retention device (Figure 9). The requirement and test method stem from SAE AS85049/128F™ paragraphs 2 and 2a:

“2. BAND TERMINATION TEST (CONFIGURATION 2 AND 4 ONLY): FOR EACH DASH NUMBER TO BE QUALIFIED, PERFORM THE FOLLOWING TESTS ON TWO BAND SPECIMENS FOR EACH ACCESSORY SHELL SIZE FOR A TOTAL OF SIX SPECIMENS. A 6-IN. BRAID SHALL BE CLAMPED BY EACH SPECIMEN TO THE ACCESSORY. THE BRAID SHALL BE TIN COATED COPPER IN ACCORDANCE WITH A-A-59569 WITH A 90% COVERAGE. TWO SPECIMENS EACH SHALL BE CLAMPED TO AN M85049/82-10*03, M85049/82-18*03, AND M85049/82-28*03 ACCESSORY RESPECTIVELY. THE BAND SHALL BE ASSEMBLED TO THE ACCESSORY WITH THE APPLICABLE BAND INSTALLATION TOOL IN ACCORDANCE WITH TABLE 2.

a. BRAID RETENTION: WITH ACCESSORY SUITABLY ASSEMBLED WITH BRAID, PULL THE BRAID AT A RATE OF 1 IN. PER MINUTE TO A FORCE OF 100 LBS MINIMUM FOR BRAID .50 IN. AND UNDER AND 150 LBS MINIMUM FOR BRAID OVER .50 IN. THE BRAID SHALL NOT PULL OUT. BAND SLIPPAGE SHALL NOT EXCEED .025 IN. WHEN MEASURED FROM A FIXED POINT ON THE ADAPTER. BRAID BREAKAGE DUE TO TENSILE LOAD WILL NOT BE VIEWED AS A FAILURE.”

15. The tensile test was performed at the NAVAIR 4.3.4.1 mechanical test laboratory; documented in test report NAWCADPAX/TR-2018/01. The test articles were built per SAE AS85049/128™ legacy steel band test requirements in the configurations described. Test adapter fixtures were designed and manufactured to interface with the tensile tester and maintain a linear force application throughout the test. The suitable sized spring bands, which fit on the size 10, 18, and 28 accessories, were tested and compared to similar setups using the legacy M85049/128 steel band. The braid retention/tensile tests were performed as per AS85049/128F™; paragraph 2a requirements cited above. All tested devices met or exceeded the tensile strength performance requirements of the specification. When tested to failure and beyond the minimum requirements of 100 lb. (.5-in. wide shield) and 150 lb. (wider than .5-in. wide shield), the results showed that the performance exceeded the requirement (on average) by 45% for shell size 10, by 110% for size 18, and by 107% for size 28.

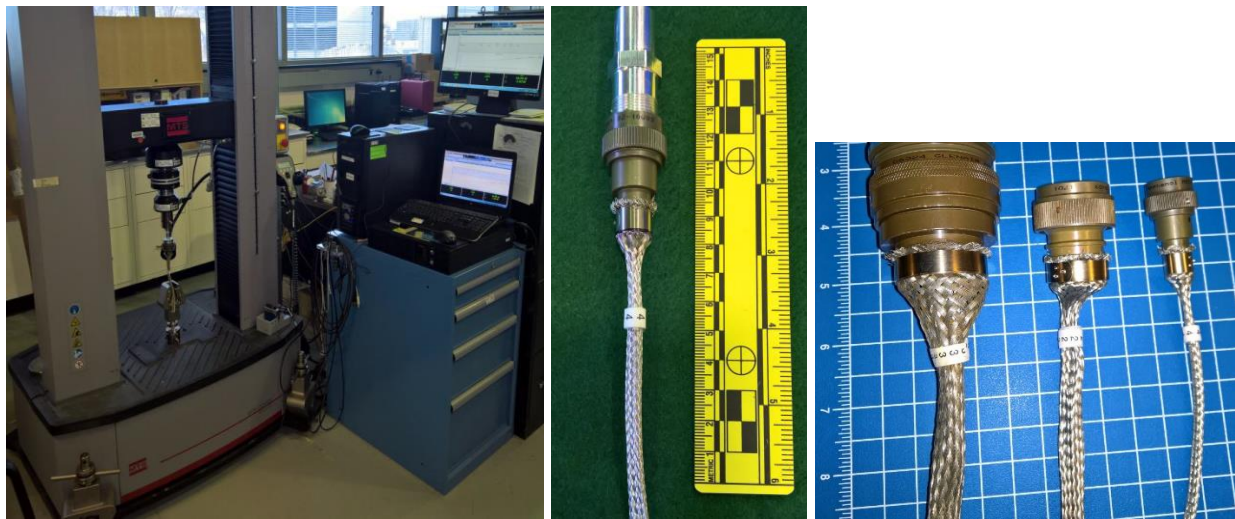


Figure 9: Braid Retention Test Setup and Sample Fixture using the Spring Band on M85049/82 EWIS Accessory

THERMAL AGING/LIFE CYCLE TEST AT ELEVATED TEMPERATURE

16. This test method was to be used to measure the electrical conductivity properties of the joint/connection of the metallic shield (e.g., A-A-59569) to the EWIS connector accessory (e.g., M85049/82) using the spring band (e.g., ISOTDS1) as a retention device after exposure to elevated temperature. The 168-hr exposure (one week) to elevated temperature of 150°C simulates a suitable level of service life degradation. The requirement and test method stem from SAE AS85049/128F™ paragraphs 2 and 2b:

“THERMAL AGING: THERMALLY EXPOSE THE ACCESSORY TO 150°C FOR 168 HR FOLLOWED BY AN ELECTRICAL RESISTANCE MEASUREMENT AT ROOM TEMPERATURE. THE APPLIED CURRENT SHALL BE 100 mA \pm 10 mA AT A MAXIMUM OF 1.50 VDC. THE MEASUREMENT SHALL BE TAKEN FROM A POINT ON THE BRAID, WITHIN 1.0 IN. \pm .00 IN. \pm .50 IN. BEYOND THE END OF THE ADAPTER, AND A POINT ON THE ADAPTER AT THE OPPOSITE SIDE OF THE BAND. THE ELECTRICAL RESISTANCE SHALL NOT EXCEED 1.0 m Ω .

17. The thermal exposure and electrical measurements were performed at an approved, independent laboratory, DNB Engineering, Inc. in Fullerton, CA (CAGE: 63242). See detailed report TR045358-1 and Figure 10.



Figure 10: Thermal Exposure Test and Samples and Setup

ELECTRICAL BOND/CONDUCTIVITY

18. This test method is to be used to measure the electrical conductivity properties of the joint/connection of the metallic shield (e.g., A-A-59569) to the EWIS connector accessory (e.g., M85049/82) using the spring band (e.g., ISOTDS1) as a retention device after exposure to elevated temperature. The conductivity is measured on the assemblies before and after heat exposure and not may not exceed 1 m Ω . The requirement and test method stem from SAE AS85049/128F™ paragraphs 2 and 2b:

“THERMAL AGING: THERMALLY EXPOSE THE ACCESSORY TO 150°C FOR 168 HR FOLLOWED BY AN ELECTRICAL RESISTANCE MEASUREMENT AT ROOM TEMPERATURE. THE APPLIED CURRENT SHALL BE 100 mA \pm 10 mA AT A MAXIMUM OF 1.50 VDC. THE MEASUREMENT SHALL BE TAKEN FROM A POINT ON THE BRAID, WITHIN 1.0 IN. \pm .00 IN. \pm .50 IN. BEYOND THE END OF THE ADAPTER, AND A POINT ON THE ADAPTER AT THE OPPOSITE SIDE OF THE BAND. THE ELECTRICAL RESISTANCE SHALL NOT EXCEED 1.0 m Ω .

19. The thermal exposure and electrical measurements were performed at an approved, independent laboratory, DNB Engineering, Inc. in Fullerton, CA (CAGE: 63242). See detailed report TR045358-1. Three of each designated shell sizes and configurations (10, 18, and 28) were tested per requirement before and after heat exposure (Figure 11). The resistance values of all tested samples passed under the 1.0 m Ω limit. Before heat exposure, the samples ranged from .01 m Ω to .88 m Ω . After/post heat exposure, the resistance ranged from .081 m Ω to .58 m Ω . Test passed for all requirements of test samples.

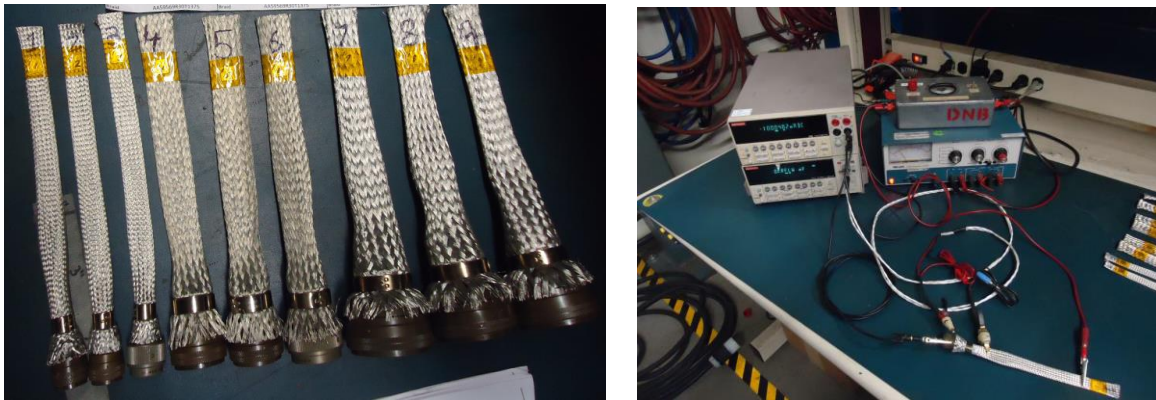
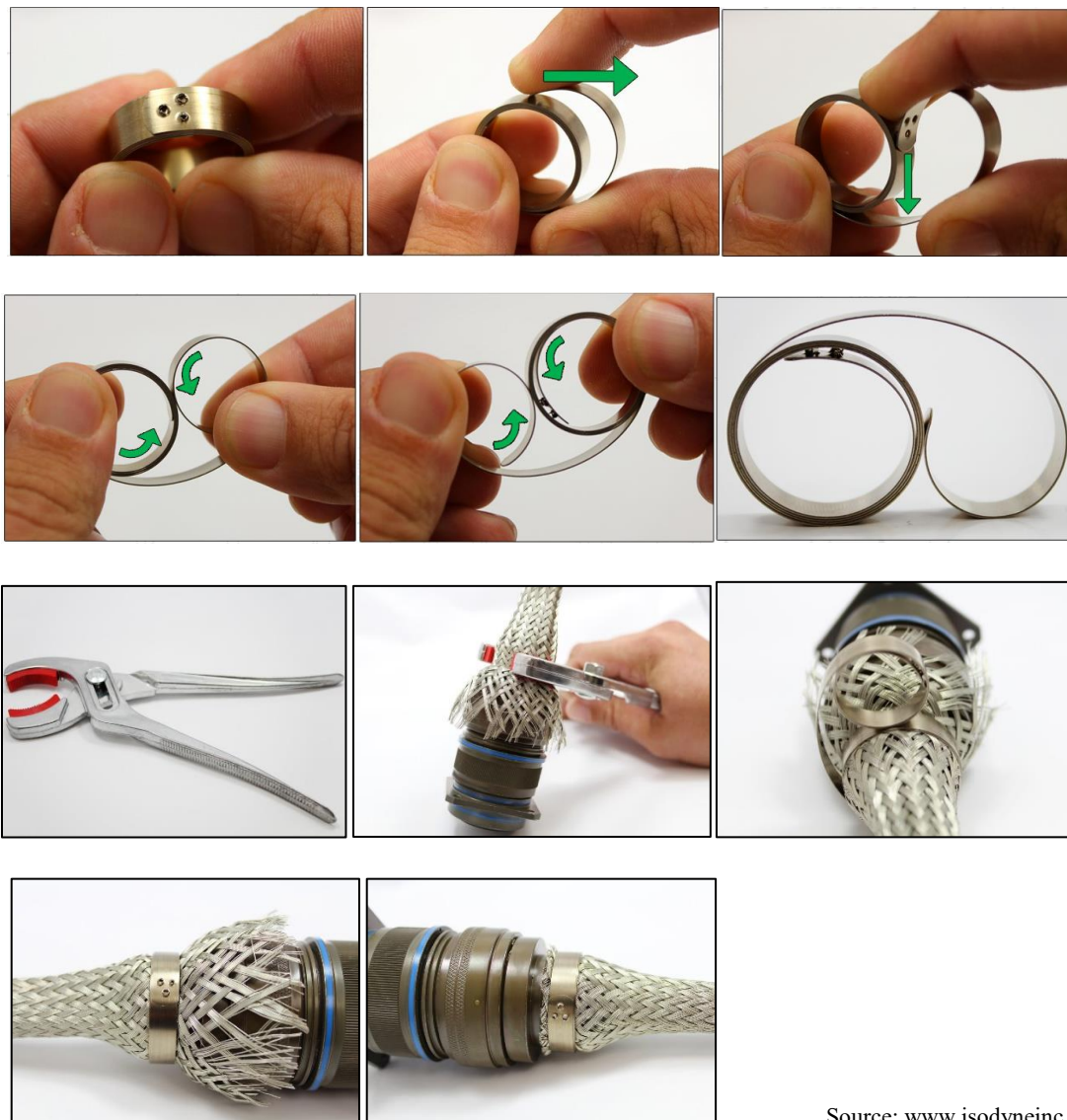


Figure 11: Thermal Exposure and Conductivity Test Samples and the Conductivity Test Setup

SUITABILITY

20. This test focused on the ability of an average, trained maintainer's ability to install and remove the device using available tools and processes available. As part of this test, the installation and removal procedure was developed and verified. This process identified that the electrical and mechanical performance of the spring bands could be improved by first cleaning the accessory banding platform with Isopropyl Alcohol (TT-I-735) and by forming the shield to the accessory banding platform using standard connector installation pliers (Cannon part number AT508K or equivalent). The procedure graphics, shown in Figure 12, are intended for addition to both the military specification (Section 6 Notes) and in the NA 01-1A-505-1, WP 024 00 maintenance manual. Suitable information and cautions were incorporated in the procedures, to ensure safe installation, with provisions for securing the spring band during the removal process to prevent FOD. The reusability aspect of the ISOTDS1 through 4 spring bands installed on typical M85049/88 was verified as ten consecutive installations and removals were performed. The last installation was similar, from the first to the tenth. It should be noted that the ten-installation

requirement was formalized as a standard test requirement for first article certification testing in the military specification. The specification is currently undergoing required Government-Industry review before publication. Publication of the MIL-DTL specification and five associated detail sheets are anticipated by Spring 2019.



Source: www.isodyneinc.com

Figure 12: Installation Method and Details

FLIGHT TESTING

21. Analysis performed compared the legacy design of spring bands P/N ISOAS150XX (without the trident features) to the ISOTDSX (with a trident design) and found that application, design, and materials are all similar. One application difference is that the legacy spring bands ISOAS150XX are employed with a commercial connector accessory design similar to the military

one. The two spring band designs are thus deemed as functionally similar. The ISOAS150XX have been in service operationally, and flying at home station and deployed locations, both land and at sea, on MH-53E and CH-53E heavy-lift aircraft for over 5 years. They have also been in service on Army aircraft with no reported spring band failures. Joint Deficiency Reporting System (jdrs.mil) research shows that there have been no reports of failure of the spring bands. Thus flight test requirement is waived based on serviceability and performance data accrued thus far. Note that they have also been in service on: H-60, V-22, H-1Z, MC, EC and C-130H, B-52, RC and KC-135, A-10, H-64, CP-140, E-4B, E-6B, F-22, FA-18, QF-16, P-3C and K, NASA "SOFIA", satellite, and several Army ground vehicles.

CONCLUSIONS

22. Evaluation and testing of the trident spring band (ISOTDS1 through 4) showed that the device meets or exceeds the qualification performance requirements of the currently employed EMI shield termination steel band (M85049/128-X).
23. This effort tested the new spring band configuration on typical EWIS installations, using the Society of Engineers (SAE) published test methods employed to evaluate and qualify the existing M85049/128-X shield termination devices. Supplemental tests were also performed beyond the minimum SAE specification requirements as a means to better understand the device capabilities.
24. The current termination steel bands (M85049/128-X) are cumbersome, take too much time to install, require multiple specialized tools to install, and to verify integrity of the installation. The M85049/128-X bands can only be used once, are costly, and must be removed in pieces which may cause FOD.
25. The new configuration ISOTDS1 through 4 trident spring band design provided a means for quick installation and removal, required no special tools, and was shown to be reusable. Tests performed included: fit, vibration, elevated temperature life cycle, electrical conductivity, braid retention/tensile strength, and suitability.

RECOMMENDATIONS

26. The trident spring band is intended for employment as an EWIS device for termination of EMI metallic shield braid over wiring harnesses. In this capacity, recommend that the configuration ISOTDS1 through 4 trident spring band, as manufactured by this, SAE or like military designation, be:

- a. Defined in a military specification, thus assuring: standardization, qualification/first article testing, marking and performance, followed by stocking and availability for end users from multiple manufacturing sources.
- b. Employed in new and current platform designs and applications for sustainment and maintenance of aerospace EWIS.
- c. Published in the joint service wiring maintenance manual (NA 01-1A-505-1, WP 011 02) for use as a suitable substitute of all configurations and sizes of the existing M85049/128-X steel bands. Acceptance criteria for continued reuse shall be added to the manual.
- d. If overall cost reduction is realized, bands and no special tools required for installation, additional changes may be proposed. More clearly, when an M85049/128 steel band is removed during maintenance, it should be replaced with a suitable sized ISOTDS1 through 4 trident spring band. Then, eventually, the acquisition of all tools required for the installation, removal, calibration, and verification of M85049/128 steel bands can be discontinued. These tools include all similar, or equivalent to: AS81306/1-X and /2-X, DBSRO3, MB1306,74005, 74003, 600-058, 900-061, DBS-1100, DBS-1200, G691, DBS-CG2, and 4DBS-BR1.

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For the referenced reports (see Bibliography), contact the cognizant organization through approved methods.

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DISTRIBUTION:

Mike Freed, m.freed@isodyneinc.com
George Benton, gbenton@isodyneinc.com
Ed E. Taylor, edwin.taylor@navy.mil
William E Bassett, william.bassett@navy.mil
Steven Fagan, steven.fagan@navy.mil
Oliviu Muja, oliviu.muja@navy.mil

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