



AEROSPACE INFORMATION REPORT

AIR5464™

REV. A

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Superseding AIR5464

(R) Metal Clad Fibers for Electrical Shielding and Harness Overbraid

RATIONALE

Report updated to include new information on metal clad fibers. This change includes updates to specified technical information, addition of new information, and updates to typical applications.

AIR5464A has been reaffirmed to comply with the SAE Five-Year Review policy.

FOREWORD

In August 1996 AE-8D received a request from Air Force and NAVAIR to study and issue a report on metal clad fibers (MCF) for shielding electrical cables, harness overbraids and electrical wire conductors. At the October 1996 meeting an AE-8D Task Group was formed and meetings of this Task Group have been held twice a year since then with discussions and presentations on the properties, test results and applications of these fibers by McDonnell Douglas, Glenair, DuPont, and others. This report is a compilation of that initial effort and new work conducted by Carlisle Interconnect Technologies, Syscom Advanced Materials, and others. It will be updated as more information becomes available.

1. SCOPE

Over the past two and one-half decades several metal clad fibers and fabrics have been developed to provide aerospace vehicle designers with a conductive, lighter weight alternative to coated copper, coated stainless steel and steel wire used for cable and wire shielding and harness overbraids on electrical cables. Several of these candidates have been unable to provide the strength or thermal stability necessary for the aerospace environment. However, several polymer-based products have shown remarkable resistance to the rigorous environment of aerospace vehicles.

Concurrent with these fiber developments, there have been changes in the structures of aerospace vehicles involving greater use of nonmetallic outer surfaces. This has resulted in a need for increased shielding of electrical cables which adds substantial weight to the vehicle. Thus, a lighter weight shielding material has become more critical to meet the performance requirements of the vehicle.

This report covers the properties of metal clad aramid fibers (MCAF), metal clad polybenzobisoxazole (PBO) fibers (MCPF), and metal clad liquid crystal polymer (LCP) fibers (MCLF), with test results when these products are used as a shield or harness overbraid and a listing of some of the known applications in the aerospace field. The use of these fibers as an electrical conductor in high strength tethers and other aerospace applications are new developments that show the versatility of MCF not only for weight savings, but also for applications where high strength and long flex life are required.

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2. REFERENCES

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New Developments on Metal Clad Aramid Fibers for Aerospace Wire & Cable by E.W. Tokarsky et al, AEISC - October 1995
Metal Clad Fiber for Specialty Cable Shielding and Conductor by E.W. Tokarsky et al, Wire & Cable FOCUS - September 1996

Case Histories of ARACON® Metal Clad Aramid Fibers by E.W. Tokarsky, Wire & Cable FOCUS - September 1998

Case Histories of Aerospace Wire and Cable Uses of Metal Clad Fibers in Harness Overbraids and Shielding by E.W. Tokarsky, AEISC - October 1999

3. TECHNICAL INFORMATION

3.1 Properties

3.1.1 Materials

Metal clad fibers (MCF) consist of an electro-less nickel adhesion layer, an electrolytic copper layer for conductivity, followed by an electrolytic nickel layer environmental barrier. For solderability, an optional electrolytic silver finish can be specified.

3.1.2 Metallization

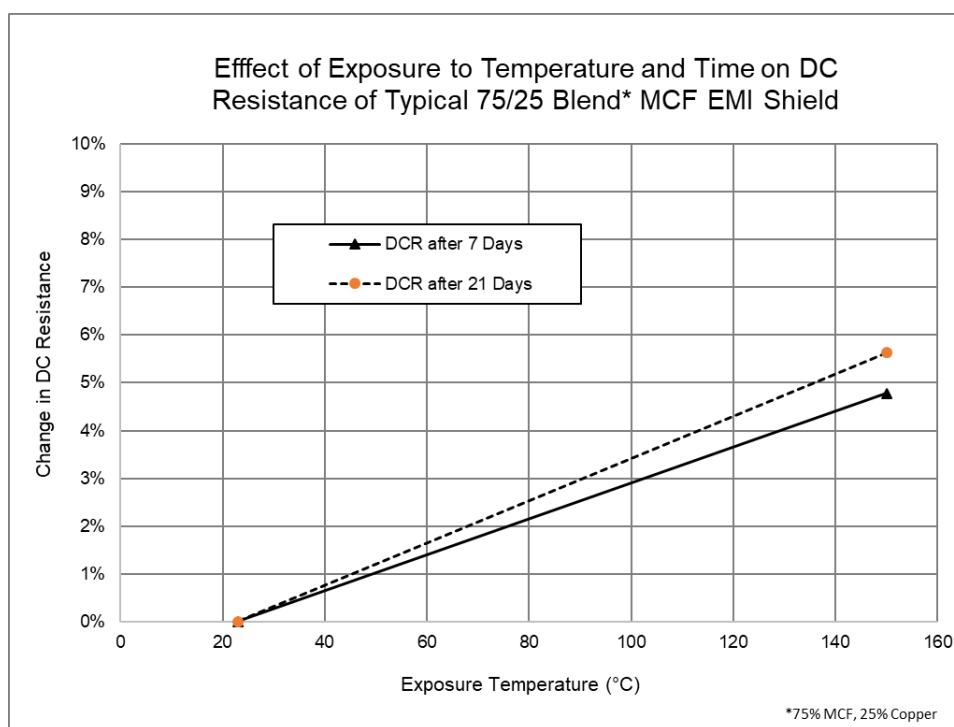
Each polymer fiber is comprised of a bundle of filaments individually metalized using a process that ensures 360 degrees metal coverage of each filament.

3.1.3 Dimensions

The large number of very fine filaments together with the tendency of the metal clad fiber yarn bundles to flatten and spread result in a cross section that is more ovalar than circular when braided or woven.

3.1.4 Thermal Stability

EMI shields made from metal clad fibers and blended with copper wire are rated at 150 °C based upon thermal aging tests. Oven aging at 150 °C for 7 days (168 hours) and 21 days (504 hours) for several samples shows an increase in DC resistance of around 5% after 7 and 21 days (see Figure 1). In addition, MCF are not cold brittle materials and have been tested to -195 °C without embrittlement or change in resistance.

**Figure 1**

3.1.5 Strength

Break strength of metal clad aramid fibers (MCAF) is 310000 to 325000 psi, while the break strengths of metal clad PBO fibers and metal clad LCP fibers are 590000 psi and 350000 psi, respectively. MCF have tensile strengths that outperform copper or steel, which have break strengths of 30000 to 50000 psi, and even exceed the performance of some high strength copper alloys or tempered steels, which have break strengths exceeding 100000 psi (see Figure 2).

Base Fiber Properties

Nominal

Material	p-Aramid Fiber	PBO Fiber	LCP Fiber
Filament Diameter (mil)	0.6	0.5	0.9
Specific Gravity	1.4	1.5	1.4
Tensile Strength (psi)	425-525 x10 ³	841 x 10 ³	435-464 x10 ³
Tensile Modulus (psi)	12-25 x 10 ⁶	26 x 10 ⁶	10-15 x10 ⁶
Elongation	3.0% - 4.0%	2.5%	2.8 - 3.3%
Decomposition Temperature	500 °C	650 °C	350 °C

Figure 2

3.1.6 Weight

The average specific gravity of MCAF is 3.1 but it can vary from 2.0 to 5.0, depending upon the metal thickness. The average specific gravity for MCPF is 3.9 and the average specific gravity for MCLF is 3.6, but they both can also vary from 2.0 to 5.0 depending upon metal thickness. The specific gravity of copper is 8.9 (see Figure 3). Cables made with MCF shields have demonstrated a weight savings of 20 to 60% and harness over braids made with MCF have demonstrated weight savings of 60 to 80%.

Comparison of Specific Gravities

Material	Specific Gravity
Copper	8.9
Nickel	8.9
Tin	7.3
Silver	10.5
Stainless Steel	8.0
Aluminum	2.7
Metal Clad Fibers	2.0 - 5.0

Figure 3

3.1.7 Flexibility

MCF have the inherent limpness of their textile cores versus the stiffness of metals such as copper and steel.

3.1.8 Flex Life

Insulated MCAF wires show an improvement of 10 to 1000X compared to copper when tested in accordance with Method 704 of AS4373 (see Figure 4).

Flex Endurance of Conductor Metal Clad Aramid Fibers

Per AS4373, Method 704

Cycles to Failure of Electrical Conductivity

Load, lb	Control Stranded 32 AWG Cu/Ag PTFE	Silver Metal Clad Aramid Fibers			
		PTFE	PFA	PVC	PTFE Braid
0.5	202	22,000+	22,000+	22,000+	22,000+
1	50	10,000+	10,000+	10,000+	10,000+
2	20	1,300	3,500+	3,500+	3,500+

Metal clad aramid fibers provide superior endurance to flexural fatigue compared to standard standard conductor of same size.

Figure 4

Figure 5 illustrates the flex life difference between a coaxial cable using MCF as the braid shield and that using silver plated copper. The cable is 0.2-inch diameter and was flexed 180 degrees for 500 cycles over a 1-inch radius mandrel. The jacket was removed after the test to allow visual examination of the braid.