

Metal Clad Fibers for Electrical Shielding & Harness Overbraid

FOREWORD

In August 1996 AE-8D received a request from Air Force and NavAir to study and issue a report on metal clad fibers 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 these items. It will be updated as more information becomes available.

1. SCOPE:

Over the past decade several metal clad fibers and fabrics have been developed to provide aerospace vehicle designers with a conductive, lighter weight alternative to coated copper or steel for shielding and harness overbraids of electrical cables. Several of these candidates have been unable to provide the strength or thermal stability necessary for the aerospace environment. However, the aramid-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), test results when this product is 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 is still being studied but has not yet resulted in a documented aerospace adoption.

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2. REFERENCES:

Metal Clad Aramid Fibers for Aircraft/Aerospace Cable Shielding by E.W. Tokarsky et al, AEISC - October 1993

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 Thermal Stability: Metal clad aramid fibers can be rated at 200 °C based upon thermal aging tests. Oven aging at 220 °C for 7 days (168 hours) and 21 days (504 hours) for several samples shows an increase in DC resistance of 8% after 7 days and 14% after 21 days (see Figure 1). In addition, MCAF are not cold brittle materials and have been tested to -195 °C without embrittlement or change in resistance.

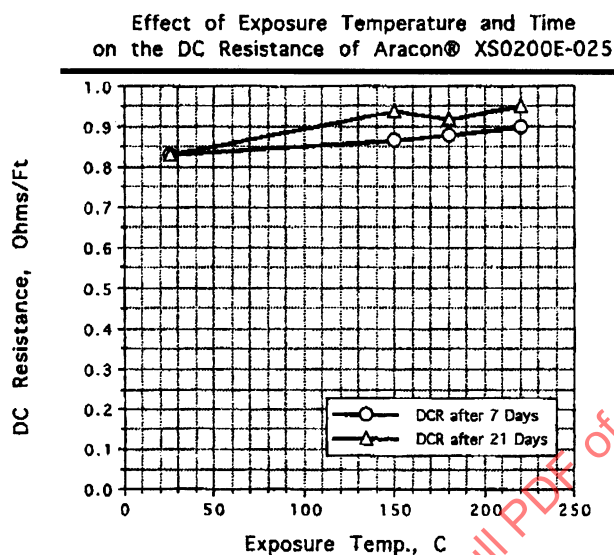


FIGURE 1

- 3.1.2 Strength: Break strength of metal clad aramid fibers (MCAF) is 310,000 to 325,000 psi versus copper at 30 to 50,000 psi or steel and some high strength copper alloys up to 100,000 psi (see Figures 2 and 3).

Base p-Aramid Fiber Properties

Nominal	
Filament Diameter	0.6 mil
Specific Gravity	1.4
Tensile Strength	425 - 525 x 10 ³ psi
Tensile Modulus	12 - 25 x 10 ⁶ psi
Elongation	3% - 4%
Decomposition Temperature	500°C

FIGURE 2

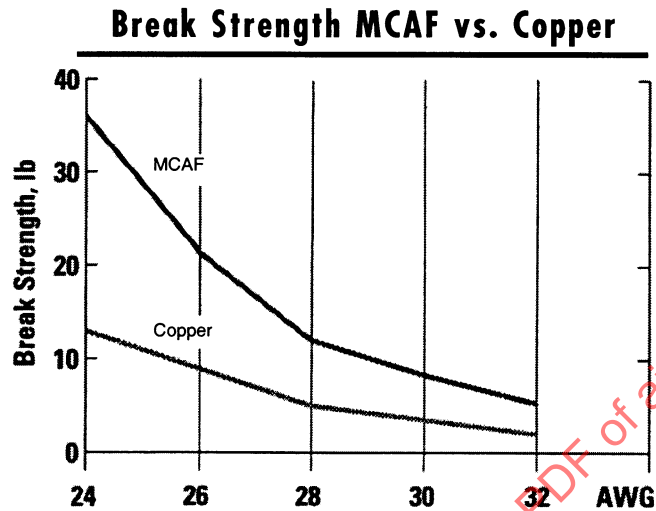


FIGURE 3

- 3.1.3 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 specific gravity of copper is 8.9 (see Figure 4). Cables made with MCAF shields have demonstrated a weight savings of 20 to 60%.

Comparison of Specific Gravities

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

FIGURE 4

- 3.1.4 Flexibility: MCAF have the inherent limpness of textiles versus the stiffness of metals such as copper and steel.

SAE AIR5464

- 3.1.5 Flex Life: Insulated MCAF wires show an improvement of 10 to 1000 X in the Boeing flex fatigue test (similar to test method 704 of AS7373) (see Figure 5).

Flex Endurance of Conductor of Metal Clad Aramid Fibers*

Per Boeing BSS7324

Cycles to Failure of Electrical Continuity

Load, lb	Control Stranded 32 AWG Cu/Ag PTFE	Silver Metal Clad Aramid Fibers			
		PTFE	PFA	PVC	TEFLON® Braid
0.5	202	22,000+	22,000+	22,000+	22,000+
1.0	50	10,000+	10,000+	10,000+	10,000+
2.0	20	1,300	3,500+	3,500+	3,500+

*Data Provided by Tensolite, Inc.

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

FIGURE 5

- 3.1.6 Conductivity: MCAF have a DC conductivity of 60 to 65% of copper, depending upon outer metal coating (silver or nickel) (see Figure 6).

Conductance vs. Strength

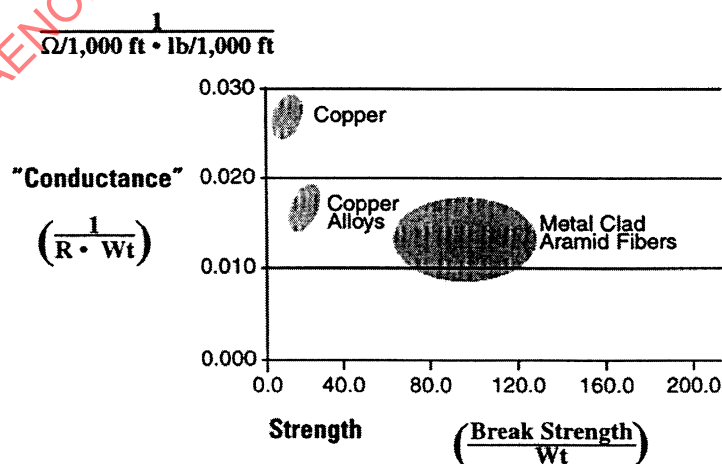


FIGURE 6

- 3.1.7 Shielding: The shielding effectiveness of cables with MCAF is better than copper based shields above 5 to 25 megahertz frequencies and has been used in cables up to 40 gigahertz. Due to lower conductivity, MCAF has lower shielding effectiveness at or near DC (see Figures 7 and 8).

Transfer Impedance vs. Frequency

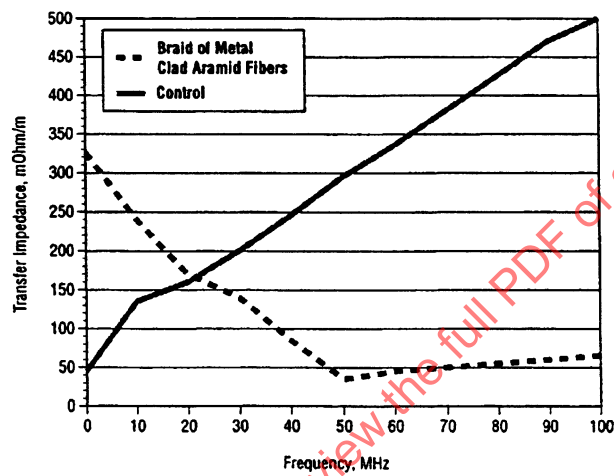


FIGURE 7

Shielding Effectiveness vs. Frequency

**RG-142 Constructions with ARACON®
Mode-Stirred Chamber Method**

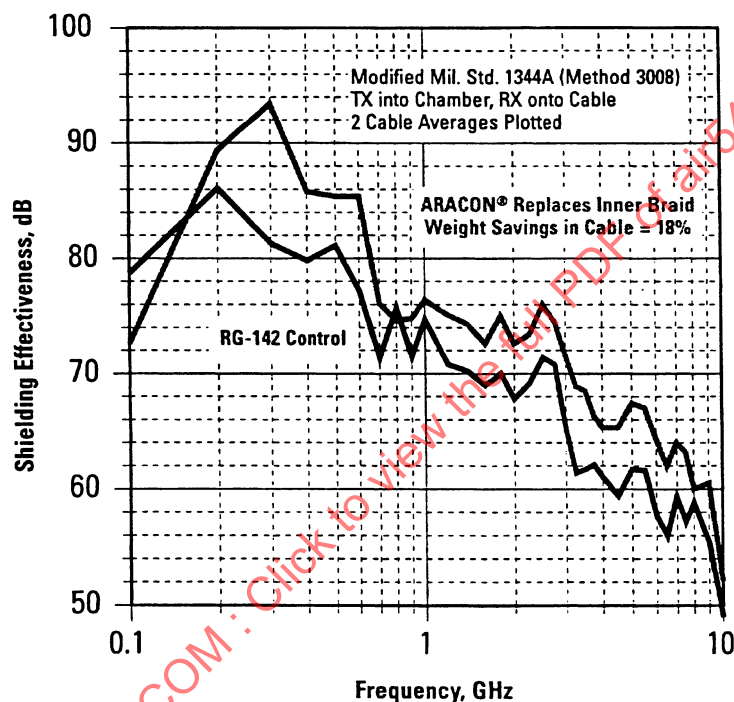


FIGURE 8

3.1.8 Other Properties:

1. MCAF are braidable on standard braiding machines used for either textiles or metals and can be mixed with metals when braiding.
2. MCAF have been successfully tested in both crimp and soldered terminations (see Figures 9 and 10). Care should be taken when terminating with MCAF to prevent fraying of the fibers. Proper cutting tools such as those used with aramid fibers will prevent fraying. (Reference: DuPont bulletin "Cutting of Kevlar®" - H.62647-3.)

Crimp Test Results with Metal Clad Aramid Fibers

Daniels Manufacturing Corporation

Yarn Sizes for Metal Clad Aramid Fibers

- 200d, 400d

Contacts

- Wire Barrel Size — 22D
- M39029/57-354
- Tri-Star Electronics

Tooling

- Tool Frame M22520/2-01
- Positioner M22529/2-06

Results

Denier	Number of Tests	Avg. Break Load (lb)	Number of Pullouts	Number Broken at Crimp	Number Broken Outside Crimp
200 ($\approx$ 32 AWG)	45	5.2	0	6	39 (87%)
400 ($\approx$ 30 AWG)	50	9.2	8	0	42 (84%)

Very high percentage of breaks outside of crimp area suggests crimp is no longer limiting failure point.

FIGURE 9

Conductor Crimped Termination Metal Clad Aramid Fibers

**Polished Cross Sections
Low and High Magnifications**

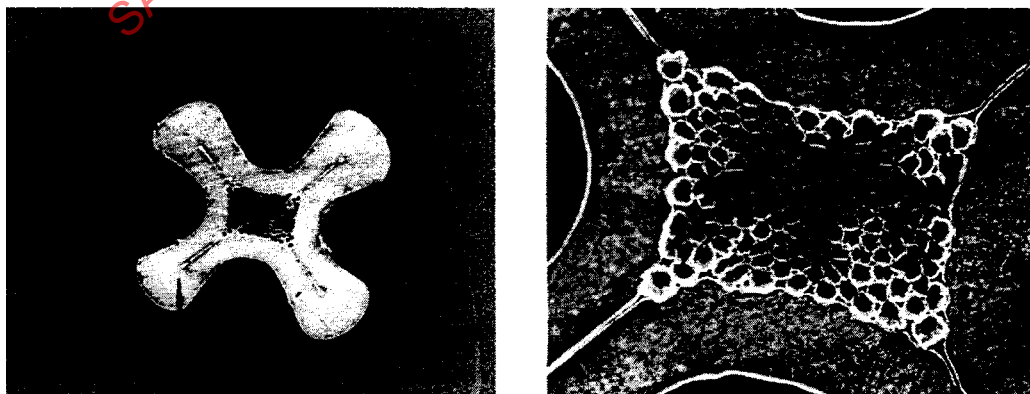


FIGURE 10