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HIGH PERFORMANCE AEROSPACE WIRE AND CABLE FOR USE WITH SPECTRUM TECHNOLOGIES CAPRIS® UV LASER MARKING SYSTEMS

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1 Introduction

This report has been prepared to provide a general overview of aerospace wire and cable constructions suitable for use with Spectrum Technologies PLC CAPRIS® UV laser wire marking systems. It is intended to provide a useful reference but should not be taken as a substitute for a formal standards document.

UV laser wire marking technology has been developed by Spectrum Technologies PLC and British Aerospace, following its discovery at British Aerospace Sowerby Research Centre in 1987[1,2]. Today, Spectrum is the world leader in aerospace laser wire marking with over 100 CAPRIS systems installed worldwide. Ten years of experience in UV laser marking has uniquely qualified Spectrum Technologies to provide technical support for customers in selecting UV laser markable products for optimum results with our systems. Spectrum Technologies continues to work closely with wire and cable manufacturers to achieve ongoing improvements in UV laser markability.

UV laser marking has been developed specifically to provide a safe, high quality, durable identification method for use with the high performance fluoropolymer finished electrical wires and fibre optics used by the aerospace industry[3,4]. These fluoropolymer materials can generally be successfully marked in all forms including extruded polymers, thin tapes or dispersion topcoats (lacquers).

PTFE (Teflon®)	polytetrafluoroethylene - and similar materials such as PFA
FEP (Teflon)	fluorinated ethylene propylene copolymer
ETFE **XL-ETFE (Tefzel®)**	both ethylene tetrafluoroethylene copolymer (ETFE) and irradiated, crosslinked ETFE

Other polymers, including ECTFE and PVC, can also be UV laser marked. Of course, the UV laser markability of wire insulation constructions also applies to cable constructions using identical materials.

In this report, two major categories of wire are considered

- Polyimide tape primary insulation, finished with a range of tapes and topcoats
- Solid extruded fluoropolymer wires

Mark contrast measurement is often used as a measure of legibility of markings on wires[5]. Mark contrast is defined as

[(background reflectance - mark reflectance)/background reflectance] x 100 %

A perfect black mark on a perfect white background has 100% contrast, whereas the contrast of for example white on white, or black on black is 0%. On aircraft wire, mark contrasts of 60% or greater may be required by specifications and standards. Achievable contrast figures are quoted within the text for the wire types discussed. When selecting wire for UV laser marking, please check with the supplier whether their product is UV laser markable.

Please also be aware that older revisions of some wire specifications may not include UV laser marking requirements and therefore it is advisable to check the revision number of old stocks of wire before UV laser marking.

Wire types are listed by relevant standards in Appendix 1 and suppliers of aircraft wire are listed by wire type in Appendix 2. These lists may not be exhaustive, although all efforts were made to ensure correct information at the time of writing. All information given is periodically updated.

Please note:
Teflon is Du Pont's Registered Trademark for its fluoropolymer resins which include PTFE, PFA, FEP. Tefzel is Du Pont's Registered Trademark for its modified ETFE fluoropolymer resin.

2 Wire constructions for UV laser marking

2.1 UV laser markable polyimide tape-wrapped wire

UV laser markable polyimide wires are available with several outer coatings, either an outer wrapping of *PTFE tape*, or *dispersion top coated* with FEP or PTFE. PTFE tape wrapped constructions may have a temperature rating of up to 260°C whereas dispersion coatings are generally rated at 200°C. However the temperature rating of the wire will also depend on the conductor construction.

2.1.1 PTFE tape-wrapped wire

UV laser markable composite PTFE/polyimide wire constructions are widely used in Europe and North America, for both military and commercial aircraft. Good mark contrasts, of 58-65%, are achievable on current UV laser markable stock.

Relevant standards include:

Airbus DK
Boeing Commercial Airplane Group BMS13-60
Boeing Long Beach DMS2426 rev. C
MIL-W-22759/80-92
McDonnell Douglas 5MD1
Pan Avia PAN 6411, 6412, 6417
Eurofighter J61.011, JN 1026

Alternatively, wire such as Airbus DK is available with a UV laser markable dispersion top coat. This wire construction may also be known as ACT (anti-carbon tracking) wire. Certain revisions of DMS2426 are top-coated to provide a receptive surface for ink-based marking.

2.1.2 PTFE and FEP top-coated wire

Dispersion topcoated polyimide wires are used for military and commercial aircraft within Europe, and versions with very good laser markability have been available for some time. Recent improvements made possible by collaboration with Spectrum Technologies have further increased the mark contrast achievable on both FEP and PTFE topcoats to 65-70%.

These wires are similar to the older MIL-W-81381 polyimide lacquered wires discussed below in section 3. The key difference is the replacement of the old-style polyimide lacquer with a UV laser markable fluoropolymer coating (lacquer), either FEP or PTFE.

Relevant standards include Airbus CF, Pan Avia PAN 6423, Eurofighter JN1007.

2.2 Extruded wires

2.2.1 ETFE and XL-ETFE extrusions

ETFE is frequently used as a wire insulation either in its natural state or cross-linked (XL-ETFE) for improved physical properties. In general, XL-ETFE wire gives more consistent high contrast results (>70%) than non-cross linked materials. Extensive UV laser marking trials have been carried out on these wires produced by a range of suppliers. Relevant standards include

MIL-W-22759/16,17,18	non-crosslinked ETFE
MIL 22759/32-35,41-46	XL-ETFE
PAN 6843, 6844, 6845	
Eurofighter JN 1087	
Boeing Commercial Airplane Group BMS13-48	XL-ETFE
Boeing Commercial Airplane Group, Douglas Products Division BXS7008	XL-ETFE

2.2.2 PTFE extrusions

This wire construction, less frequently used in aerospace wiring, may be UV laser marked and is available from several suppliers. These wires have not yet been specified to the same high standard for laser markability as, for example, ETFE extrusions. Mark contrasts of around 50% are achievable on standard product. However Spectrum Technologies is pleased to assist with improving UV laser markability on any wire construction on request.

Relevant standards include MIL-W-22759/9-12, PAN 6429.

2.2.3 FEP extrusions

Extruded FEP wire and cable is available, rated at 150°C or 200°C, and can be UV laser marked, 70% contrast having been achieved on this wire type.

Relevant standards include PAN 6424, PAN 6425.

3 Non UV laser markable polyimide wire

Polyimide tape wrapped wire coated with a “liquid H” polyimide lacquer (MIL-W-81381) is NOT suitable for UV laser marking, but may be marked using alternative laser marking technology. This wire construction has now effectively been dropped from use on new aircraft programmes, although it may continue to be used on some programmes.

This construction has now generally been replaced by UV laser markable composite wire constructions, for example in the Boeing Commercial Airplane Group standard BMS 13-60. UV laser markable dispersion topcoated wires as discussed above in section 2.1.2 are similar in construction, apart from the topcoat, to MIL-W-81381.

4 Conclusion

In summary, within the international aerospace industry, the latest electrical wire and cable is almost universally manufactured with a fluoropolymer outer coating of PTFE, FEP, ETFE or similar, and can be successfully UV laser marked with a Spectrum Technologies CAPRIS system.

As part of Spectrum Technologies technical service to customers we are pleased to carry out laser marking trials on samples. In addition, we continue to collaborate with wire vendors and their customers to ensure correct materials specification for implementation of UV laser wire marking with Spectrum Technologies CAPRIS systems.

For further information, please contact Spectrum Technologies PLC (UK).

5 References

1 "Excimer laser printing of aircraft cables" Dr S W Williams and Dr P C Morgan, International congress on applications of lasers and electro-optics, 1989

2 "Excimer laser printing of aircraft cables", Dr S W Williams, British Aerospace PLC, SAE Aerospace Electrical Interconnect Systems Conference, Orlando FL, October 1989

3 "Developments in excimer laser wire marking technology" Dr P H Dickinson, Spectrum Technologies Ltd, SAE Aerospace Electrical Interconnect System Conference Tucson AZ, November 1991

4 "User applied markings on wires: working towards perfect legibility" C L E Higgitt and S T Lau, SAE Aerospace Electrical Interconnect System Conference Williamsburg VA, October 1997

5 prEN3838 "Requirements and tests on user-applied markings on aircraft electrical cables" April 1993

Appendix 1 Commercial aerospace electrical wire standards

STANDARD	REVISION	INSULATION TYPE	QUALIFIED SUPPLIERS
Airbus CF-U		PTFE, FEP topcoat/ polyimide	BICC Brandrex; Alcatel France; Fileca
Airbus DK-U		PTFE tape/polyimide	BICC Brandrex; Alcatel France; Fileca
BCAG BMS13-48	G	XL-ETFE	Judd Wire; Raychem
BCAG BMS13-55	C	PTFE tape	Alcatel France
BCAG BMS13-58	C	PTFE tape	Alcatel France, Thermax/CDT
BCAG BMS13-60	D	PTFE tape	Tensolite
Boeing Long Beach BXS 7008		XL-ETFE	Raychem
Boeing Long Beach DMS2426	C	PTFE tape/polyimide	Alcatel NA; Tensolite

Appendix 2 Military aerospace electrical wire standards and specifications

STANDARD	REVISION	INSULATION TYPE	QUALIFIED SUPPLIERS
MIL-W-22759/16-19		ETFE	Alcatel NA; Barcel; BICC Brandrex UK/US; Cable USA; Calmont; Dacon; Harbor Industries; Helistrand; Huber+Suhner; Intech; Specialty Cable; Rockbestos Surprenant; Thermax; Thermalcell
MIL-W-22759/32-45		XL-ETFE	Alcatel NA; BICC Brandrex US/UK; Huber+Suhner; Judd Wire; Raychem US/UK; Rockbestos Surprenant
MIL-W-22759/80-92	A	PTFE tape/ Polyimide	TBA
Def Stan 6112-33-1	Issue 2	XL-ETFE	
Def Stan 6112-33-2	Issue 2	PTFE tape/polyimide	
Def Stan 6112-33-3	Issue 2	Modified PTFE	
Def Stan 6112-33-4	Issue 2	PTFE/polyimide/PTFE	
Def Stan 6112-33-5	Issue 2	PTFE/polyimide/FEP	
PAN 6411 PAN 6412 PAN 6417		PTFE tape/polyimide	Alcatel France; BICC Brandrex UK; Raydex/CDT
PAN 6423		FEP topcoat/polyimide	Alcatel France; BICC Brandrex UK; Raydex/CDT
PAN 6424 PAN 6425		FEP extrusion	AlcatelFrance; Alcatel NA; Raydex/CDT
PAN 6429		PTFE extrusion	Alcatel France
JN1007 JN1018 JN1019 JN1026		FEP topcoat	BICC Brandrex, Alcatel France
Boeing Mesa 5MD1		PTFE tape/polyimide	Alcatel NA, Tensolite

Appendix 3 Suppliers of aerospace wire and cable - by insulation type

Insulation type	Suppliers
Polyimide/PTFE or FEP topcoat	Alcatel France; Alcatel North America; Axon; BICC Brandrex UK; Fileca; Raydex/CDT
Polyimide/PTFE tape	Alcatel France; Alcatel North America; BICC Brandrex UK; Fileca; Raydex/CDT; Tensolite; Thermax/CDT
ETFE extrusion	Alcatel NA; Barcel; BICC Brandrex UK/US; Cable USA; Calmont; Dakar; Harbour Industries; Helistrand; Huber+Suhner; Intech; Specialty Cable; Rockbestos Surprenant; Thermax; Thermalcell
XL-ETFE extrusion	Alcatel NA; BICC Brandrex US/UK; Huber+Suhner; Judd Wire; Raychem US/UK; Rockbestos Surprenant
PTFE extrusion	Alcatel France; Alcatel North America; Axon; BICC Brandrex; Harbor Industries; Tensolite; Thermax/CDT
FEP extrusion	Alcatel North America; Axon; BICC Brandrex; Fileca; Raydex/CDT; Tensolite

Appendix 4 Suppliers of aerospace wire and cable – contact details

Alcatel Cable

146 Rue Eugene Delacroix
91210 Draveil
FRANCE

Tel +33 (0) 1 69 83 78 56
Fax +33 (0) 1 69 83 78 95

Alcatel Cable North America

PO Box 909
Elm City
North Carolina
27822-0909
USA

Tel 919 236 4311
Fax 919 236 3613

Axon Cable SA

Route de Chalons
51210 Montmirail
FRANCE

Tel +33 (0) 3 26 81 22 10
Fax +33 (0) 3 26 81 28 83

Barcel Wire and Cable Corp.

2851 Alton Avenue
Irvine
California
92714-5885
USA

BICC Brand-Rex Ltd

Leigh
Lancashire
WN7 4HB
UK

Tel +44 (0) 1942 260387
Fax +44 (0) 1942 607593

BICC BrandRex Company

1600 West Main St
Willimantic
Connecticut
06226-1126
US

Tel 860 456 8000

Cable USA, Inc

2584 S. Horseshoe Drive.
Naples
Florida
33942
USA

Calmont Wire and Cable

420 East Alton Avenue
Santa Ana
California
92707
USA

Dacon Systems Inc

18270 Mt. Baldy Circle
Fountain Valley
California
92708
USA

Fileca

Route Nationale No.1
60730 Ste Genevieve
FRANCE

Tel +33 (0) 3 44 08 21 21
Fax +33 (0) 3 44 08 98 86

Harbor Industries

2075 Shelburne Road
P.O.Box 188
Shelburne
VT 05482
USA

Tel 802 985 3311
Fax 802 985 9534

Helistrand

707 E. Yanonali St
Santa Barbara
California
93103
USA

Huber+Suhner AG

Tumbelenstrausse 20
CH-8330 Pfaffikon
Switzerland

Judd Wire Inc

124 Turnpike Road
Turners Falls
MA 01376-2699
USA

Tel 413 863 4357
Fax 413 863 4367

Specialty Cable Corp

Special Cable Division
2 Tower Drive
PO Box 50
Wallingford
CT 06492
USA

Raychem Corp

300 Constitution Drive
Menlo Park
CA 94025
USA

Tel 415 361 3388
Fax 415 361 6297

Raychem Ltd

Faraday Road
Dorcan
Swindon
SN3 5HH
UK

Tel +44 (0) 1793 528171
Fax +44 (0) 1793 572516

Raydex CDT Ltd

PO Box 3
Church Street
Littleborough
Lancashire
OL15 8HG
UK

Tel +44 (0) 1706 374015
Fax +44 (0) 1706 370576

Rockbestos Surprenant Corp

172 Sterling Street
Clinton
MA 01510-1922
USA

Tel 508 365 6331
Fax 508 365 4054

Tensolite
Carlisle Corp

100 Tensolite Drive
St Augustine
FL 32092
USA

Tel 904 829 5600
Fax 904 829 3447

Thermax/CDT

Landmark Plaza
19-02 Whitestone Expressway
Whitestone
NY 11357

Tel 718 746 7800
Fax 718 746 4190

Appendix 5

Spectrum Technologies PLC
Customer sample service

We are pleased to mark samples of wire for evaluation, using CAPRIS 50, CAPRIS 60 or CAPRIS 100 UV laser markers, and ask that these guidelines are followed in sending samples for marking.

Wire gauge	8-26 awg
Wire length	approximately 3 metres/10 feet of which half will be returned and the remainder retained for our records
Wire identification	please label samples or supply in separate bags if various types of wire are to be kept separate
Marking system	please state clearly whether you have a preference for the system used - CAPRIS 50, CAPRIS 60 AND/OR CAPRIS 100
Sample legend	wires will be marked with a standard test mark unless otherwise requested. If you require a particular legend, please include details with the samples.

If possible please do not use adhesive tape on the wire. CAPRIS systems can also mark wires with an uneven surface profile such as twisted jacketed multicore wire.

We look forward to receiving your samples for marking. Should you require further assistance, please contact:

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