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

Prepared by: ____________________
Mrs C L E Higgitt
Business Development Officer

Authorised by: ____________________
Dr P H Dickinson
Managing Director

Spectrum Technologies PLC
Bridgend, UK
Tel +44 (0)1656 655437
Fax +44 (0)1656 655920

COPYRIGHT DECLARATION
Copyright ©1999 Spectrum Technologies PLC

All rights reserved

No part of this document may be reproduced or transmitted in any form or by any means whether electronic, mechanical, photocopying recording or otherwise; nor stored in any information retrieval system of any kind; nor used for tendering or manufacturing; nor communicated to any other person, without the written permission of Spectrum Technologies PLC.

Whilst every care has been taken in preparing this document to ensure that the information therein is correct as at the date of publication, no warranties or representations are given nor implied thereby and no use is authorised in respect of this document except for the specific purposes for which it has been supplied. This document does not form part of or constitute any offer or contract with Spectrum Technologies PLC unless attached to and expressly stated to be incorporated within.

DISCLAIMER

This report is provided by Spectrum Technologies PLC (Spectrum) solely on the following basis.

The contents of this report are intended to provide general advice on the subject matter contained in it. It is for general information purposes only and should not be relied upon in isolation. It should not be regarded as a substitute for utilising your own expert knowledge and/or obtaining other specialist advice. Users of the report must satisfy themselves of the veracity of the information provided. Decisions on process parameters, materials, process, systems or other specifications are the responsibility of the relevant technical authority, for which Spectrum cannot be held responsible. This report is provided to you by Spectrum, free of charge, for these limited purposes and on this specific basis. Spectrum excludes all liability in respect of such contents to the fullest extent permitted by law.
CONTENTS

1 Introduction 4

2 Wire constructions for UV laser marking 6

3 Non UV laser markable wire 7

4 Conclusion 8

5 References 8

Appendix 1 Commercial aerospace electrical wire standards 9
Appendix 2 Military aerospace electrical wire standards 10
Appendix 3 Suppliers of aerospace wire and cable by insulation type 11
Appendix 4 Suppliers of aerospace wire and cable – contact details 12
Appendix 5 Spectrum Technologies PLC Customer sample service 16

Distribution list

Spectrum Technologies PLC

David Davies
Peter Dickinson
Eugene Creighton Griffiths
Elaine Hardy
Alan Jones
Simon Lau
Barry Lau
John Moss
Reports file

External distribution - YES
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. 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. 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 both ethylene tetrafluoroethylene copolymer (ETFE) and XL-ETFE (Tefzel®) 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. Mark contrast is defined as

\[
\frac{\text{background reflectance} - \text{mark reflectance}}{\text{background reflectance}} \times 100 \%
\]

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
- 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**

<table>
<thead>
<tr>
<th>STANDARD</th>
<th>REVISION</th>
<th>INSULATION TYPE</th>
<th>QUALIFIED SUPPLIERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airbus CF-U</td>
<td></td>
<td>PTFE, FEP topcoat/polyimide</td>
<td>BICC Brandrex; Alcatel France; Fileca</td>
</tr>
<tr>
<td>Airbus DK-U</td>
<td></td>
<td>PTFE tape/polyimide</td>
<td>BICC Brandrex; Alcatel France; Fileca</td>
</tr>
<tr>
<td>BCAG BMS13-48</td>
<td>G</td>
<td>XL-ETFE</td>
<td>Judd Wire; Raychem</td>
</tr>
<tr>
<td>BCAG BMS13-55</td>
<td>C</td>
<td>PTFE tape</td>
<td>Alcatel France</td>
</tr>
<tr>
<td>BCAG BMS13-58</td>
<td>C</td>
<td>PTFE tape</td>
<td>Alcatel France, Thermax/CDT</td>
</tr>
<tr>
<td>BCAG BMS13-60</td>
<td>D</td>
<td>PTFE tape</td>
<td>Tensolite</td>
</tr>
<tr>
<td>Boeing Long Beach BXS 7008</td>
<td></td>
<td>XL-ETFE</td>
<td>Raychem</td>
</tr>
<tr>
<td>Boeing Long Beach DMS2426</td>
<td>C</td>
<td>PTFE tape/polyimide</td>
<td>Alcatel NA; Tensolite</td>
</tr>
</tbody>
</table>
## Appendix 2  Military aerospace electrical wire standards and specifications

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

<table>
<thead>
<tr>
<th>Insulation type</th>
<th>Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyimide/PTFE or FEP topcoat</td>
<td>Alcatel France; Alcatel North America; Axon; BICC Brandrex UK; Fileca; Raydex/CDT</td>
</tr>
<tr>
<td>Polyimide/PTFE tape</td>
<td>Alcatel France; Alcatel North America; BICC Brandrex UK; Fileca; Raydex/CDT; Tensolite; Thermax/CDT</td>
</tr>
<tr>
<td>ETFE extrusion</td>
<td>Alcatel NA; Barcel; BICC Brandrex UK/US; Cable USA; Calmont; Dakar; Harbour Industries; Helistrand; Huber+Suhner; Intech; Specialty Cable; Rockbestos Surprenant; Thermax; Thermalcell</td>
</tr>
<tr>
<td>XL-ETFE extrusion</td>
<td>Alcatel NA; BICC Brandrex US/UK; Huber+Suhner; Judd Wire; Raychem US/UK; Rockbestos Surprenant</td>
</tr>
<tr>
<td>PTFE extrusion</td>
<td>Alcatel France; Alcatel North America; Axon; BICC Brandrex; Harbor Industries; Tensolite; Thermax/CDT</td>
</tr>
<tr>
<td>FEP extrusion</td>
<td>Alcatel North America; Axon; BICC Brandrex; Fileca; Raydex/CDT; Tensolite</td>
</tr>
</tbody>
</table>
### Appendix 4  Suppliers of aerospace wire and cable – contact details

<table>
<thead>
<tr>
<th>Company</th>
<th>Address Details</th>
<th>Contact Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alcatel Cable</strong></td>
<td>146 Rue Eugene Delacroix, 91210 Draveil, FRANCE</td>
<td>Tel +33 (0) 1 69 83 78 56 Fax +33 (0) 1 69 83 78 95</td>
</tr>
<tr>
<td><strong>Alcatel Cable North America</strong></td>
<td>PO Box 909, Elm City, North Carolina, USA</td>
<td>Tel 919 236 4311 Fax 919 236 3613</td>
</tr>
<tr>
<td><strong>Axon Cable SA</strong></td>
<td>Route de Chalons, 51210 Montmirail, FRANCE</td>
<td>Tel +33 (0) 3 26 81 22 10 Fax +33 (0) 3 26 81 28 83</td>
</tr>
<tr>
<td><strong>Barcel Wire and Cable Corp.</strong></td>
<td>2851 Alton Avenue, Irvine, California, USA</td>
<td></td>
</tr>
<tr>
<td><strong>BICC Brand-Rex Ltd</strong></td>
<td>Leigh, Lancashire, WN7 4HB, UK</td>
<td>Tel +44 (0) 1942 260387 Fax +44 (0) 1942 607593</td>
</tr>
<tr>
<td><strong>BICC BrandRex Company</strong></td>
<td>1600 West Main St, Willimantic, Connecticut, US</td>
<td>Tel 860 456 8000</td>
</tr>
</tbody>
</table>
**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

**Helstrand**
707 E. Yanonali St
Santa Barbara
California
93103
USA

**Huber+Suhner AG**
Tumbelenstrasse 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

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:

Spectrum Technologies
Bridgend
UK
CF31 3RT

Tel: +44 1656 655437
Fax: +44 1656 655920
Email: sales@spectrumtech.com