# HELICOPTER AND AIRPLANE CUSTOM SHIELDING SOLUTIONS WITH ELECTRICALLY CONDUCTIVE FABRICS IN CONJIUNCTION WITH KEVLAR OR CARBON TEXTILE IN ALTERNATIVE TO COPPER OR ALUMINUM MESH

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**Abstract**

The scope of this paper is to present our activity related to the design and manufacturing of electrically conductive textile, realized with an electro-less nickel, or other metal coating with machine line, offering for each single filament a uniform coating distribution, keeping an high component flexibility without destroying the conductive surface obtained and providing an adequate shielding protection. Implementation and test of such a process, included also some real application will be shown as far as the stability of the nickel in a salt fog condition to provide a further advantage also in comparison to similar copper treatments.

## 1. HEADLINE

One of the major problem for future development with the airplane industry is the electromagnetic shielding solution from interferences from outside or inside also .The Signals involved on the air are so wide and today is not a question to prevent low frequencies but the high frequencies from 1 GHz to 40 GHz.

We have had a possibility to have a cooperation for a project with Leonardo Helicopters (former AgustaWestland) and with the support of the REGIONE LOMBARDIA for a project involved under the name as Cash Flex where we have made a comparison with cables looms with metal mesh around a tube in composite covered with our textile electrically conductive. The scope of the activity, conducted also with the involvement of Ingegneria Dei Sistemi with (IDS) in Pisa, was to measure the shielding capacity in terms of Transfer impedance and Shielding effectiveness of shielding conducts.

In accordance with the EN 60512-23-3 was measured the transfer impedence from 100 KHz to 1 GHz . .Figure 1 show the CasFlex solution

The results in comparison with copper mesh was just a positive value where the conducts in fiber glass covered with our textile conductive have shown a good result in dB just from 10 KHz to 400 MHz but after this the fabric conductive offer a high shielding result more than copper mesh because of the holes involved on the copper mesh that cannot arrive to shield .

*Figure 1- the CasFlex solution*

Scope of the activity was to measure the shielding capacity in terms of Transfer impedance (Transfer impedance is the property of a material to attenuate the RF signal and is indicated in Ohm per meter and Shielding Effectiveness of shielded conducts is indicated on dB related to the frequencies range ). In details , the activity is focused in assessing:

- Different conductive textile
- Different construction techniques

types of shielded conducts under test are identified with the same length but different in weight in grams

as

- FARADAY HC 113,0 gr
- FARADAY GHC 107,0 gr
- FARADAY VELCRO 71,0 gr

The set up and test methodology is based on the standard EN 60512-23-3 and was performed as follow.

An external injection line is laid outside the desired sample section while inside the shielded conduct under test an inner line is used to receive and measure the amount of the injected signal provided by the unshielded external line aforementioned. From 10 KHz to 100 KHz the RF injected signal is generated with a RF generator and it is acquired with a Spectrum Analyzer (scalar measurement) from 100KHz to 1 GHz. The recording and measurement was performed with a Network Analyzer (VNA) generating and receiving the RF signal coherently, while for the DC the measurements were performed with a milliOhmeter (Figure 2). We performed several test with many different types of our electrically conductive fabrics but it was observed that only just 3 types were perfect for this application maintaining the flexibility and shielding characteristics. The sample parts involved in the test were conducts made by a layer of pre-preg with a textile fabric of FARADAY HC PN and a layer of epoxy glass fiber to offer a good mechanical property to the tube .

The comparison was performed against a conduct with the same dimension but with a mesh in copper CU029, manufactured by Henkel, to prevent lightning strike.

The textile conductive fabric made from SOLIANI EMC material and process was prepared and transferred in a Pre-Preg form by the support and collaboration with the LAMIFLEX company; competing with the HENKEL Astrostrike solution.

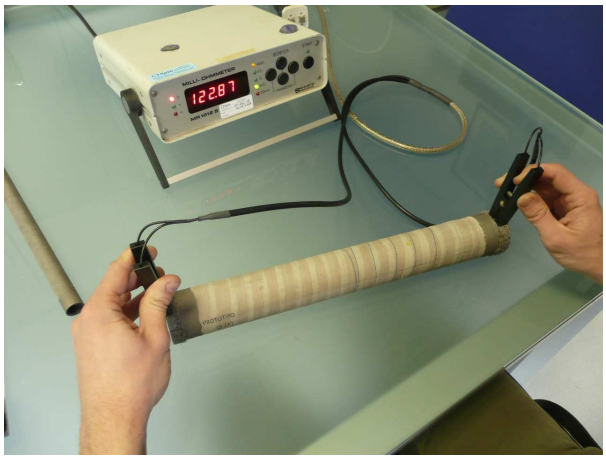

*Figure 2 - The DC measurement offer just a view in Ohm*

A very positive results was achieved with a weight reduction down to around 40% for one complete KIT of such conducts and with a significant shielding characteristics up to frequencies till 10 GHz and also with a best resistance to corrosion due to the use of nickel instead of copper in the Mesh manufacturing process.

Furthermore, several type of conduct connections were also tested to offer flexibility of solutions to join the parts while maintaining the protection characteristics: these were realized with a Felt conductive non-woven (Figure 3) or with the VELCRO conductive (Figure 4).

- FARADAY HC 0,14 ohm
- FARADAY GHC 0,07 “
- FARADAY VELCRO 0,75 “

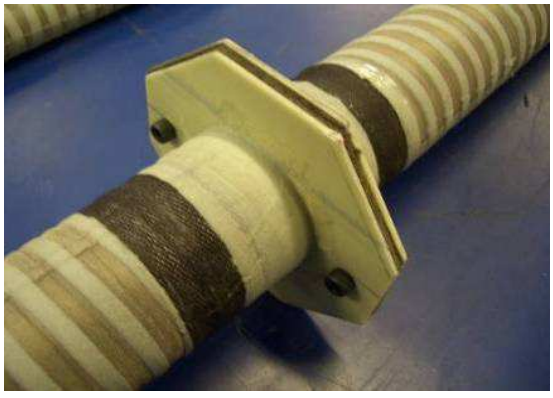

*Figure 3 - Connection with non woven felt*

*Figure 4 - Connection with Velcro conductive*

*Figure 5 - Part involved with fabric or conductive paint*

*Figure 6* - Flexible or rigid solution for cable

Test comparison for resistivity measurement were also performed.

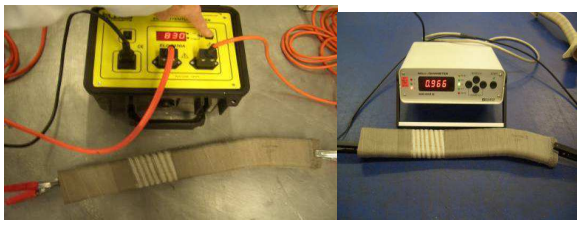

*Figure 7 - resistivity measurement*

The shielded conducts have featured a very good performance of RF shielding maintaining a very limited weight at the same time. The FARADAY GHC showed the highest shielding performance in the frequency band 10 KHz to 400 MHz (49- 66 dB mt).The test made using a Velcro electrically conductive specifically, made by us , was performed to assess the capacity of connection if required to join the parts . To increase the results in the lower frequencies band we have decided to increase the quantity of the metal fabric as layer and the test was in line with the specification requirements as:

- EN IEC 60512-23-3 connectors for electronic equipment tests measurements test 23c shielding effectiveness of connectors and accessories
- IEC 60096-4-1 radio frequency cables part 4 specification for superscreened cables section one , general requirements and test method

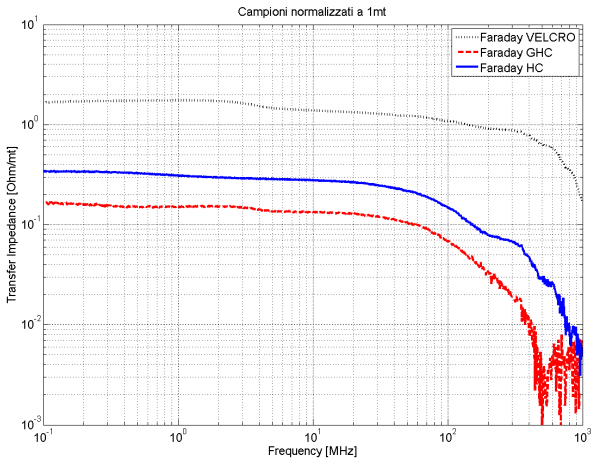


*Figure 8- Transfer Impendence from (TI ) CashFlex*

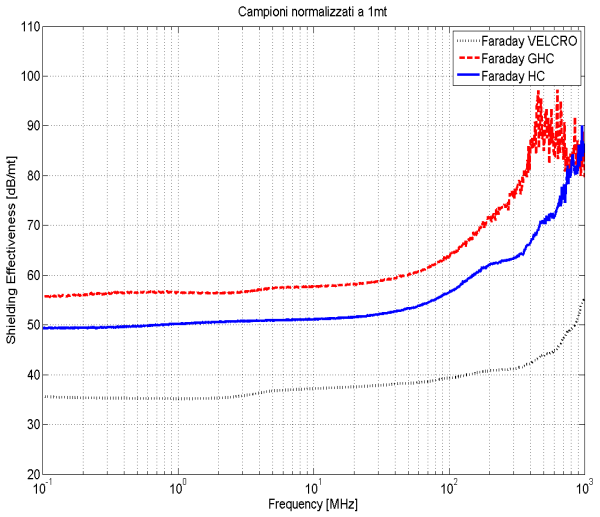


*Figure 9- Shielding Effectiveness from (TI) CashFlex*

RF shielding is not the only advantage: another important point to consider is the weight reduction that get down to the 40% less of the original solution.

Just to offer more information on the method we have put in place to achieve the results, it has been important to use two aluminum plates with connector RF on the two opposite sides of the tube in testing (and BNC) and also the use of copper tape to close all points of the discs in connection with GENERATOR RF and Spectrum Analyzer.

The test Set Up was made in conformity with a RG58 cable. All the process offered us the possibility to be involved in an interesting application to reduce weight but even more important to increase the shielding solutions offered by means of a layer of our fabric as Sonomex Nomex Metallized with Nickel. For the latter aspect it was also performed a comparison with Astrostrike where the goal was to offer a weight reduction for the same dimension using metal copper mesh: results indicated a 8% in weight reduction and 15% less in cost. SONOMEX fabric Was transferred to TEN CATE the and they applied over the carbon with thermoplastic resin TENCATE CETEX CFRT CRF 0286 003.

*Figure 10 - Fig 10 panel in thermoplastic resin with carbon and conductive fabric*

Following the solution applied with the cable looms shielding as in the CasFlex program, we performed other test to combine our conductive fabric as an attempt to substitute an aluminum sheet metal panel; the results was a panel with carbon plies and our conductive fabrics cured with a thermoplastic resin. This application offered a new possibility to achieve the weight reduction combined with shielding value in high frequency range (Figure 10). Additionally it offered a way to have and install the ready panel with a conductive surface without the need to remove resin over the copper mesh as normally done as done till now on standard composite panels. The conductive fabric could be processed with high temperature around 320 °C or lower as 150°C without any problem between the two surfaces of metal fabric and carbon.

The conductive fabric with our treatment shows a new flexibility in consideration of the general fabric involved before the metallization process. The electro-less nickel is one of our metallization process and we can cover filament as polyester,

carbon, Kevlar or Nomex with a uniform quantity of metal from 30 to 65 grams/sqmt.

In consideration of several applications, we have set up a process that could start from textile weave construction with fabric bi or tri – dimensional as warp and weft or with a range of non-woven from very light eight as 70 to 250 grams/ sqmt.

Metallization of Velcro and other solutions were involved too. Today applications adopting our conductive fabric are many, involving also big OEM as AIRBUS (Figure 11).

*Figure 11 - inside of the A400M*

The fabric was qualified as a FLEXIBLE CONDUCTIVE MATERIAL in accordance to the following references :

- EN 2743
- JAR 25 Change 25
- CS 25
- For EMI attenuation IEEE 299 Mil Std 258
- Surface Impedance A0652590 BU109
- Mass x unit area ISO 3801
- Flammability AITM 2-0002A /0004/0006/0007/
- Smoke Emission AITM 2-0007
- Tear Resistance DIN ISO 13937
- Abrasion Resistance Taber ISO 5470.1
- Temperatures from -55°C to +85°C RTCA / DO160D

Compatibility with aircraft fluids and Diesel engine exhaust fumes where tested as well.

Other customer of our technology and products are SUKOI with the Superjet 100 and also the automotive industry as Iveco Military division.

In IVECO application was interesting to cover inside the part electronic , because the JAMMER installed out side of the military vehicle was so strong the signal that was dangerous for many parts . As a first we have install inside on the cover and later was installed directly on the composite structure to prevent any damage for the world wide activity of this vehicle .

Today some other cars involved in Security Task, have decided to use also our fabric like an attempt to prevent any electromagnetic interferences over the electronic secure communication like TEMPEST and CRYPTO standard.


*Figure 12 – the* Iveco LINCE coverd with our conductive fabric

Other installation are on the Formula 1 Electric where the fabric conductive is installed inside the carbon composite battery box and on BMW i3 where we supply silicon conductive gaskets.

The High Intensity protections are today important points for radiated fields (HIRF) and lightning

threats. Electrical and Electronic equipment can be susceptible to adverse effects from electro magnetics radiation and lightning. With the increasing use of electronic system on aircrafts, coupled with the increasing use of non-metallic structure materials that are more “transparent“ to electromagnetic radiation and have also low electrical conductivity, it has been recognized for many years that HIRF and lightning protections must be enhanced to cope with the growing threat and associate risks.

In the field of products certification, EASA is also currently reliant upon raising Certification Review Item (CRIs) to introduce Special Conditions (SCs) to manage such new materials.

The approach proposed in the NPA (National Proposed Amendment) is based on the results of Electromagnetic Effect Harmonization Working Group (EEHWG). The European Aviation Safety Agency (EASA) has pose focus on it making available several references as FAR Task Number .0223

We have in our company the facility to measure and test all textile conductive materials, silicon conductive and conductive paints not only as surface resistivity but also with electromagnetic shielding solution up to 26 GHz and this offer a guaranty for our potential customer to compare our test results as to provide customized services.

*Figure 13 - test made on composite panels*

## 2. CONCLUSION

We think that we have had an interesting opportunity working for and with Leonardo Helicopter (former AgustaWestland) being involved on the first evaluation on shielding characteristics on conductive fabric and a comparison with metal mesh Astrostrike. Our treatment on fabric in combination with all type of fabrics can offer a new possibility allowing a wider involvement for future application where the frequencies are going to increase up to 40 GHz. The results that we have here presented for different application can offer a view of our flexibility, allowing us to be able to receive more and more suggestions to take care and test all the shielding performances. This can be done exploiting all the testing of devices that we have on our laboratory and also, extending the test not only on the textile electrically conductive material but including also the different parts that create the electrical connection. It has to be noted that increasing the range of the frequencies is not only sufficient to offer a surface electrically conductive but it is important ensuring the connection surface in all points of the line with:

- silicon conductive in nickel graphite
- Adhesive in Silicon conductive
- Conductive paints in nickel
- gasket in textile polyester nickel
- Non-woven felt to be pressed between the two surfaces

Regarding the thermoplastic panes is true that is not the most economic for small dimension as the tooling has a higher cost but the possibility to use the fabric conductive as a final conductive liner (as a skin) offers an economic way to ensure the surface conductive feature. This is achievable because in this condition the resin overlapped by hand cannot compromise the conductivity of the surface finishing. Furthermore the conductive skin doesn’t enter modifying all mechanical panel parameters because the fabric is installed after the process and don’t reduce or modify the originally mechanical condition of the composite

Today the final surface result is not affected by the resin application to the fabric, with no need of a further surface preparation.

Next step is the possibility to develop the fiber filament as micro fiber offering a new challenge for the metallization, being a possible solution when is required to use it in high temperature application on thermoplastic or with final application temperature up to 350°C .

For the Silicon electrically conductive in extrusion form (or moulding process to guarantee the shape in mechanical application), we have reach a good stability in salt corrosion with Nickel graphite. The same base is used for the adhesive in order to have the same connections from textile with nickel, adhesive and finally the gaskets .

The silicon gasket in flat design we manufacture from sheet and we join like a LEGO connection to reduce the cost and offer a flexibility to the customer during the product evolution like it happens in the Helicopter development.

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