Enabling digital evolution

Truck roll elimination
Cost savings at your fingertips

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Situation today

- Coaxial fly-leads and all RF cable interconnects need to achieve greater shielding effectiveness due to 4G LTE services operating within the CATV spectrum 700MHz to 862MHz.
- Research has shown that the shielding effectiveness needs to be 105dB (ClassA++)
- Service reliability is more important now than ever before.
  - Competition just waiting to step-in
  - Customers rely on quality broadband, and have a choice of providers.
  - 4G becoming more and more a threat
  - Overall QOS is paramount (Video/ Voice/Data)

Situation today

Are Cable Operators making progress ?

- YES
  - Better installation practices
  - Improved training and skill sets
  - Improved awareness of RF issues
  - Improved test equipment
  - Improved installation equipment and tools.

All the above have reduced truck-rolls and improved overall QOS

Situation today

Has this solved all the problems ?

NO

- Truck-rolls still a problem
- Intermittent faults resulting in:
  - CPE being replaced and sent for testing coming back with “No Fault Found”
  - Huge amount of F connectors being replaced
  - Slow broadband
  - Picture pixilation/blocking
  - Replacing in-home passive equipment
  - Adding expensive in-home active RF amplifiers

SEEM FAMILIAR?

Teleste Research has identified the following:-

1. It is impossible to produce a Class A++ RF flylead that can remain Class A++ for more than a few weeks/months using current connectors, as produced today. This includes:
   - Compression type F connectors
   - Crimp type F connectors
   - Current Drop Cable

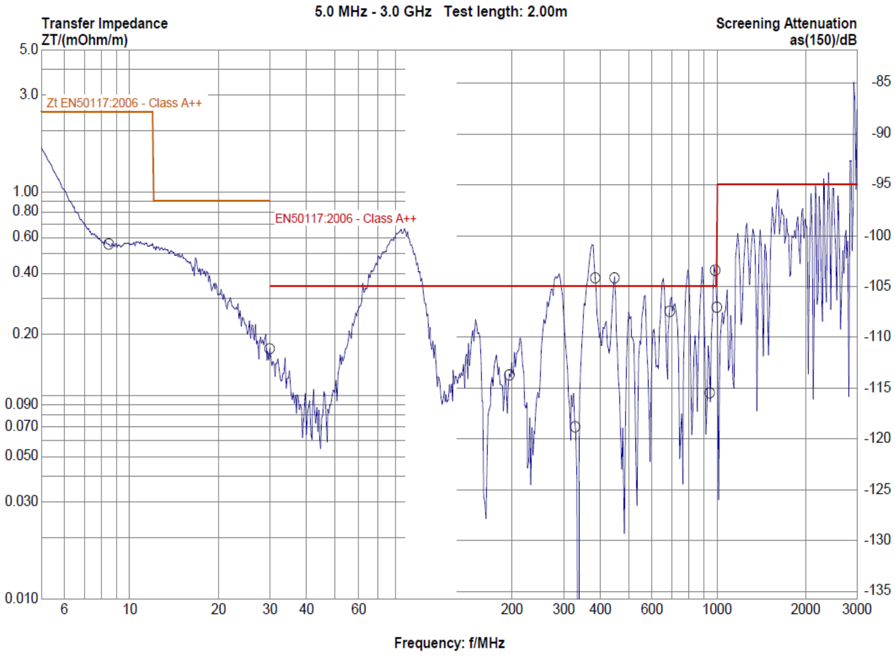
2. Current connector/cable interface is a catastrophic point of failure causing:
   - CPD (intermittent fault reports)
   - Degradation in signal C/N
   - Total RF signal failure over time

Problem 1
(Class A++ RF flyleads)

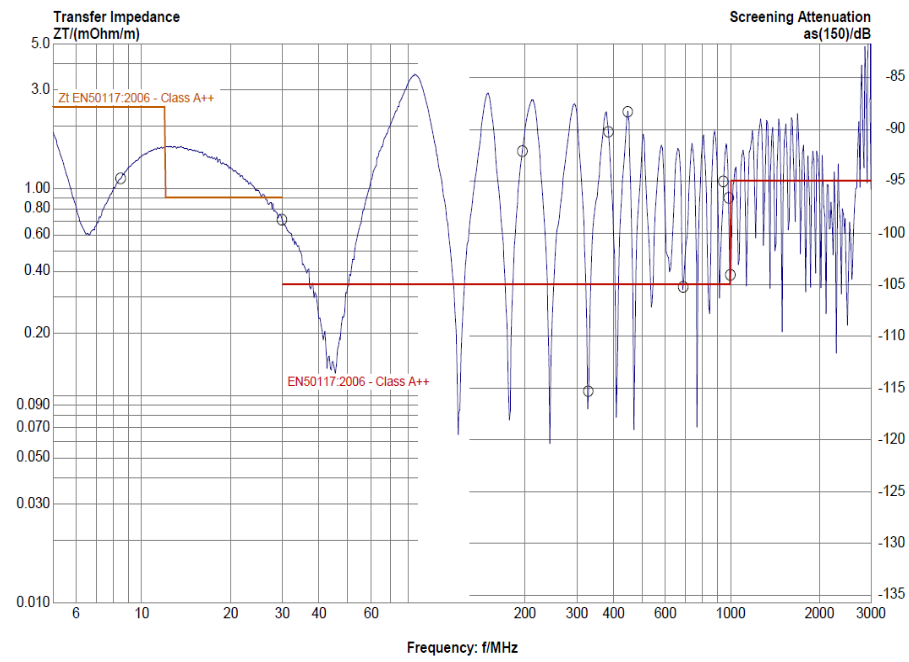
Aluminium braided cable with NiSn Plated F connectors.

Coupling Transfer Function Test Results

F Male to Standard F Male Connectors
Tested November 2014



Same Cable and Connectors
Tested April 2015

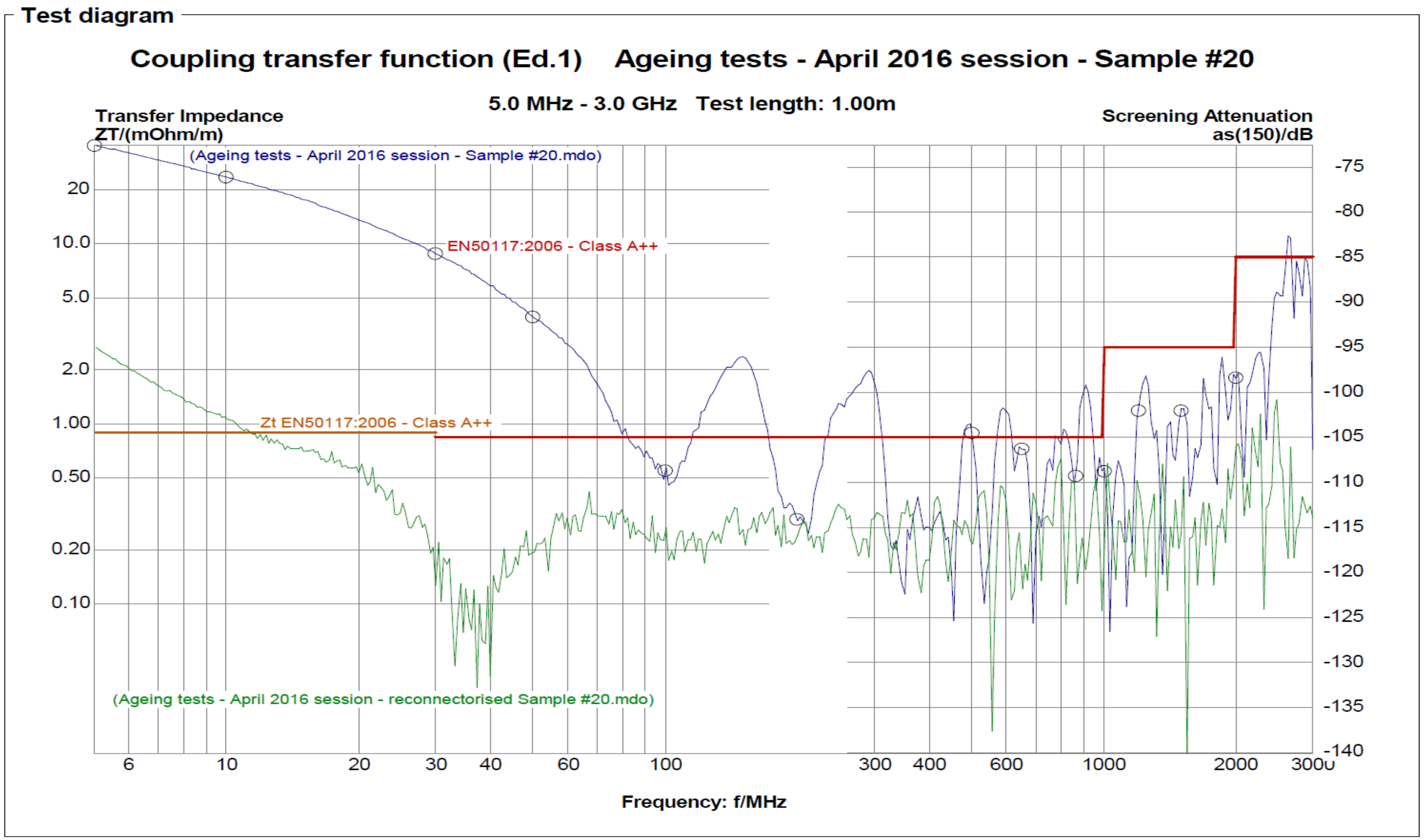


Problem 1
(Class A++ RF flyleads)

Coupling Transfer Function Test Results

Copper braided cable with NiSn Plated F connectors.

One Month old Flylead tested then new connectors fitted



Test Document: Ageing tests - April 2016 session - Sample #20.mdo

TWO KEY ISSUES IDENTIFIED:

1) **RFI Screening**
   - Coaxial cable RFI screening starts to degrade within a month of connectorisation.
   - **Resulting in potential LTE interference, Ingress and Egress issues**

2) **Transfer Impedance degradation (Source of CPD)**
   - Metal-to-Metal contact resistance between coaxial cable and RF connector starts to degrade within one month to the point where the ground connection over time will totally fail.
   - **Resulting in potential CPD (Intermittent faults within the home and cable interconnect components).**
     This in turn results in CPE equipment change outs with "No Fault Found" reported back from screen and clean process.

Teleste research has concluded the issues relate to two phenomenon:

1. **Cable PVC Jacket/Cable Braiding Creep**
   - Resulting in loss of metal-to-metal contact resistance between cable braiding and RF connector over time.

2. **Galvanic Reaction between Cable braiding and RF connector**
   - Resulting in loss of metal-to-metal contact between cable braiding and RF connector and also producing serious dissimilar metal reaction, resulting in CPD (Common Path Distortion issues over time), with eventual total loss of grounding, thus total RF signal failure.

1. Cable PVC Jacket/ Braiding Creep

- Material creep (sometimes called cold flow) is defined as a solid material moving slowly or deformed permanently under the influence of mechanical stresses.
  It occurs as a result of long-term exposure to high levels of stress that are still below the yield strength of the actual material.

- Copper and Unalloyed Aluminium cable braiding both exhibit material CREEP.

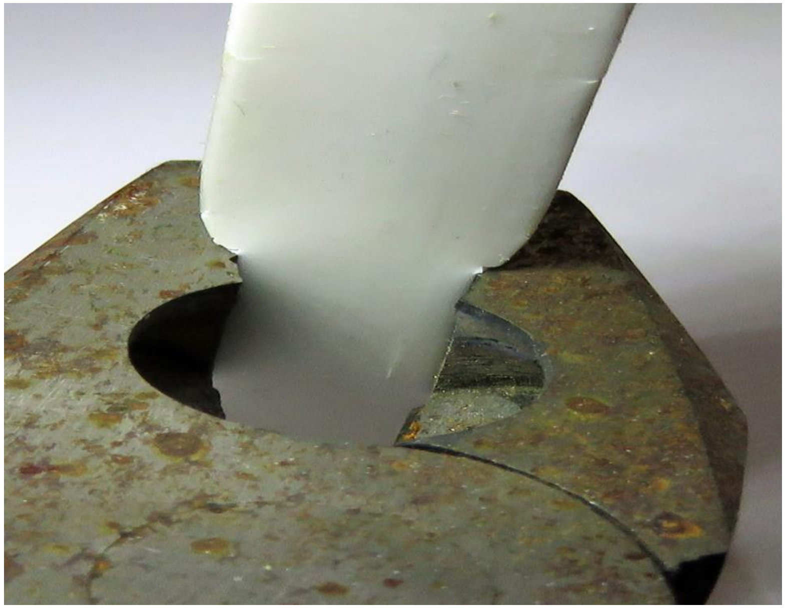
- Copper and Unalloyed Aluminium will creep under the slightest force, and its contact force will gradually decrease over time.

- PVC polymers exhibit the same issue and are very unstable in joint/pressure applications.

- In current coaxial cable/connector scenarios, we have the cable PVC jacket polymers and cable braiding in series with the main joint compression.

- PVC Polymers have large temperature expansion rates and will creep over time until the joint pressure contact is eventually reduced to almost zero.

1. Cable PVC Jacket/ Braiding Creep

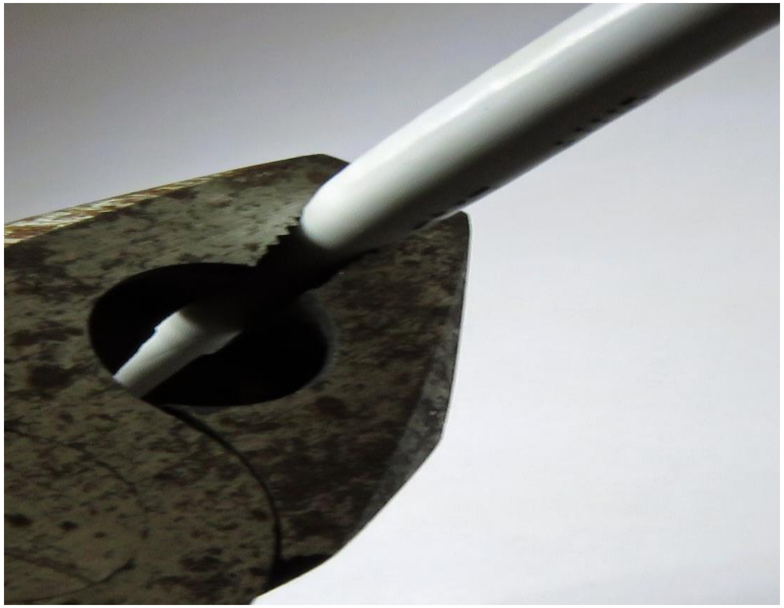


Pencil Rubber under high pressure

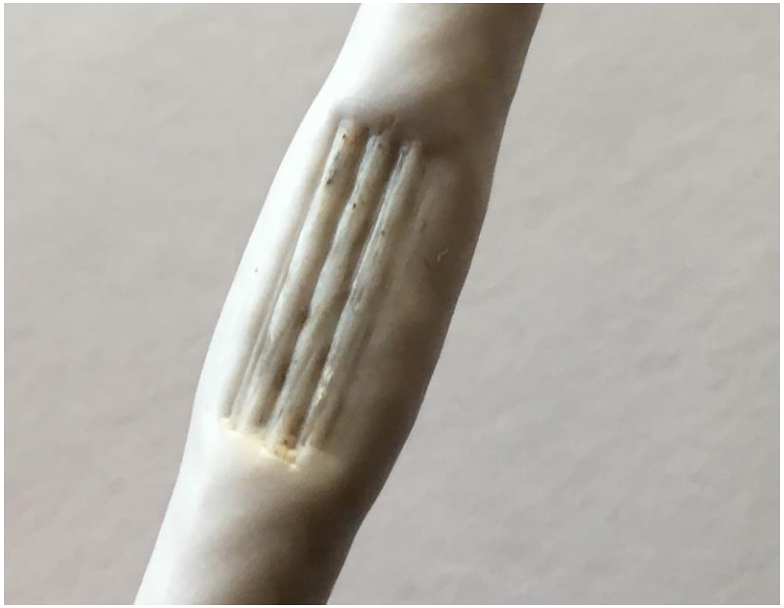
Pencil Rubber after pressure released

- The rubber has a hard shore hardness which will maintain pressure force
- High elongation break %
- Hi Tensile strength Mpa (Newton per square meter force)

1. Cable PVC Jacket/ Braiding Creep



PVC coax cable under high pressure



PVC cable after pressure released

- The pressure force exceeded the PVC polymer tensile strength
- The pressure force exceeded the elongation break % for PVC polymers
- Very poor Tensile strength Mpa (Newton per square meter force)

1. Cable PVC Jacket/Cable Braiding Creep

There are three key stages to Creep:

- Primary: Initially the strain rate is relatively high, but slows with increasing time due to work hardening. The strain rate eventually reaches a minimum and becomes near constant due to the balance between work hardening and annealing (Thermal Softening).

- Secondary: The substantial growing stage, also known as steady creep. This is very dependant on the creep mechanism and is characterised as “Creep Strain Rate.

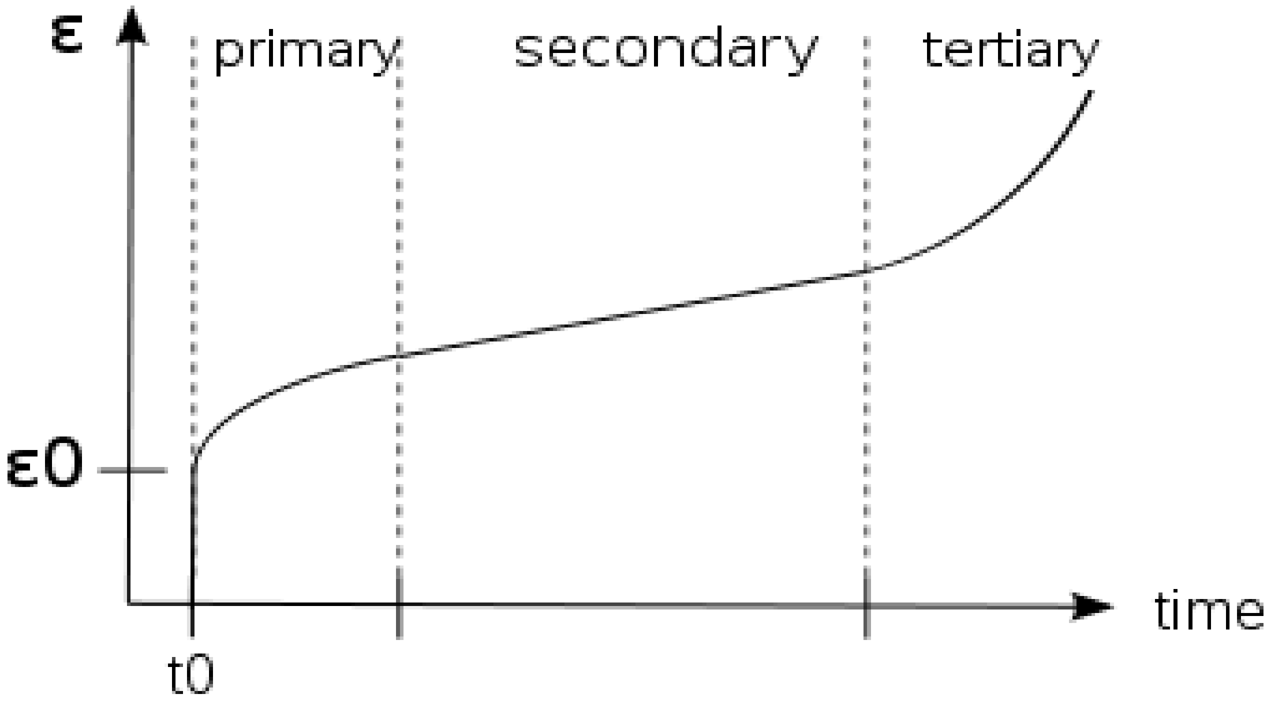
- Tertiary: Here the strain rate exponentially increases with stress due to the necking phenomena. Fractures always occur at this stage.

Summary:

In the case of the degradation in metal-to-metal contact resistance of the cable/connector, it is the Primary and Secondary stages of creep that are most applicable, although the Tertiary creep may also apply over a long period where exposure to extreme temperatures occur.

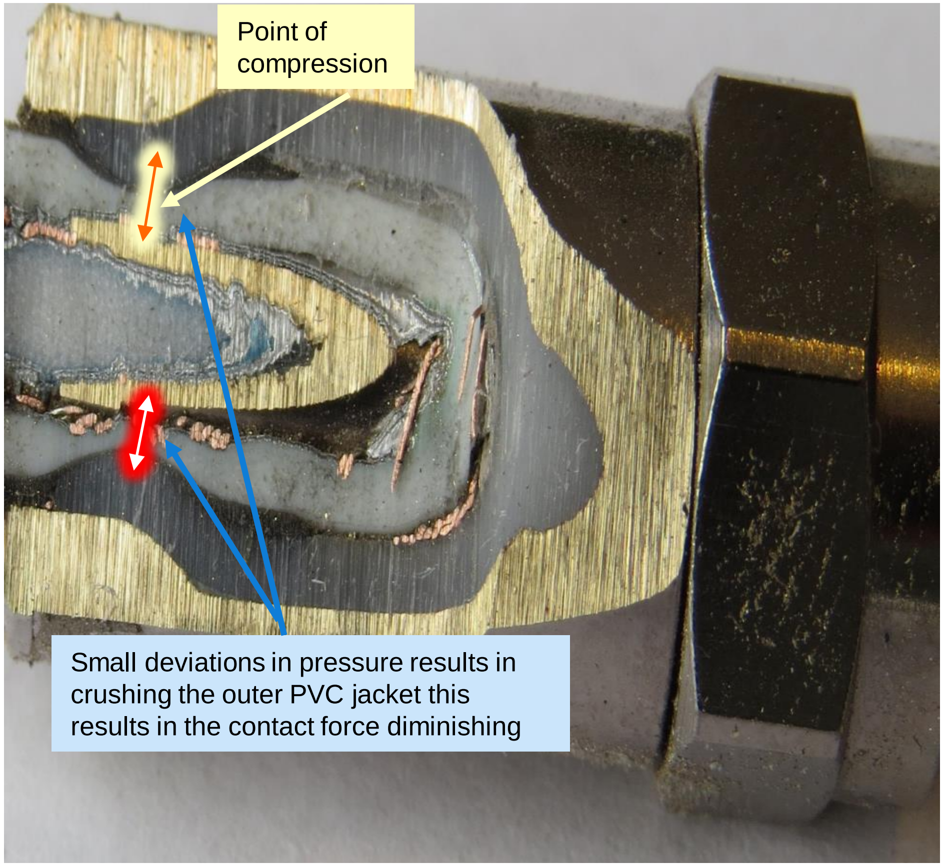
1. Cable PVC Jacket/Aluminium Braiding Creep

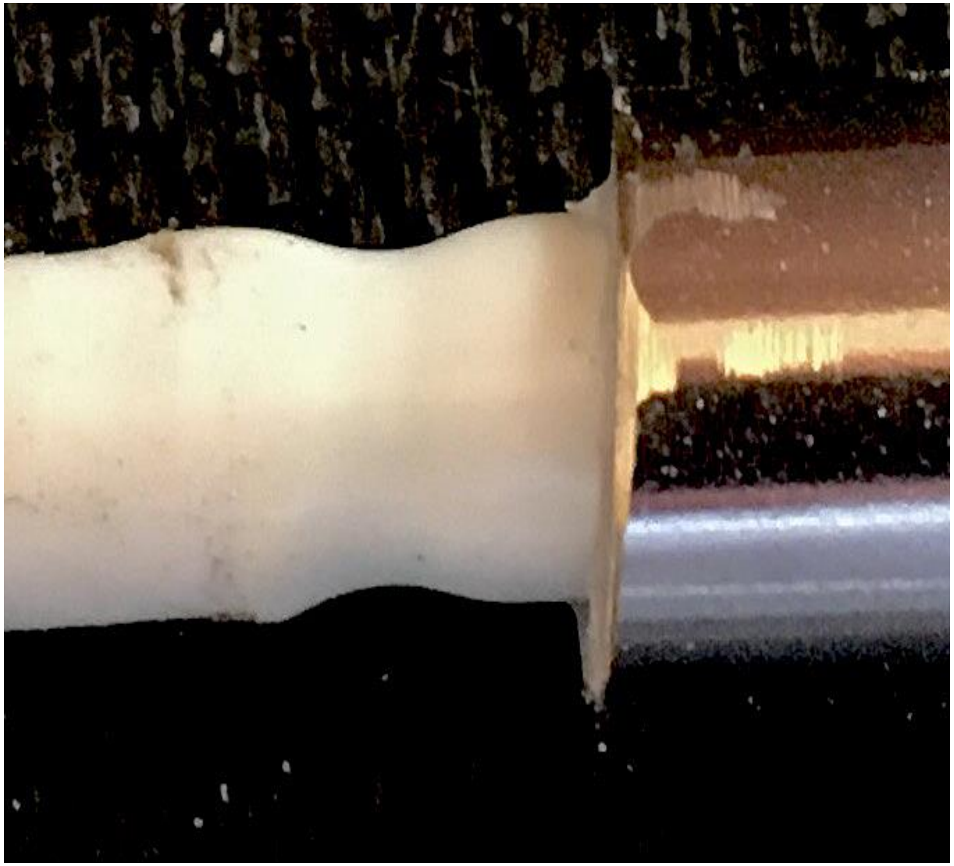
Example of the three key stages to Material Creep.



1. Cable PVC Jacket/Braiding Creep

Typical Compression Connector



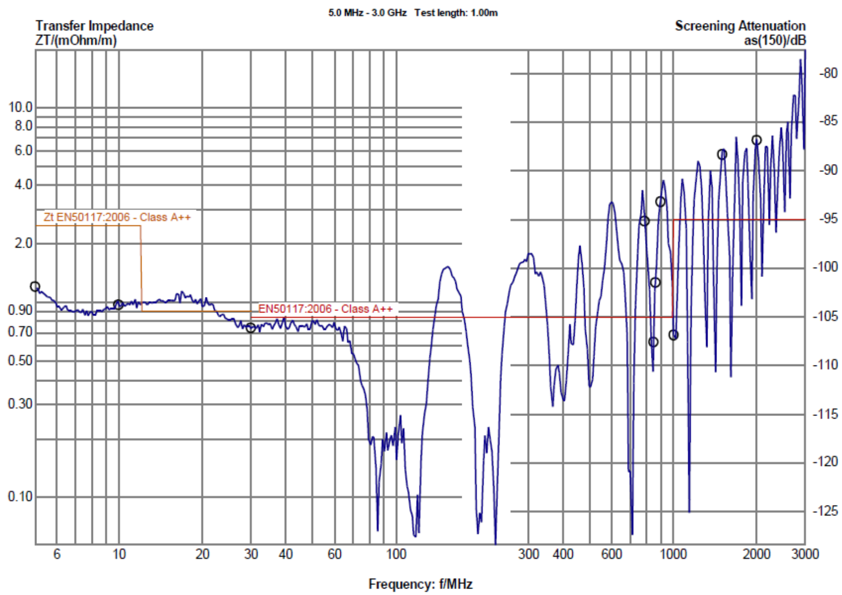


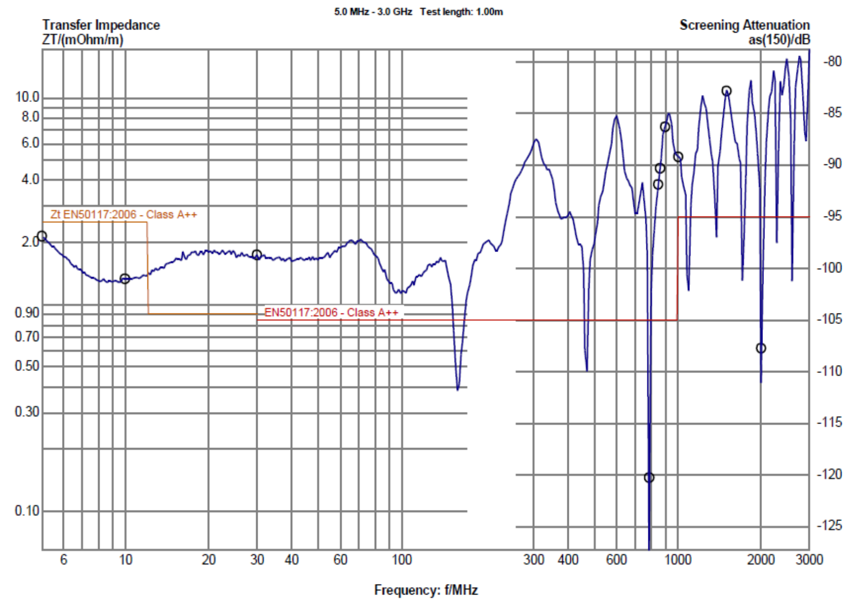
1. Cable PVC Jacket/Braiding Creep

Typical Crimp Connector

1. Cable PVC Jacket/Aluminium Braiding Creep

Example of PVC Material Creep. (Copper Braid with F male push-fit connectors)



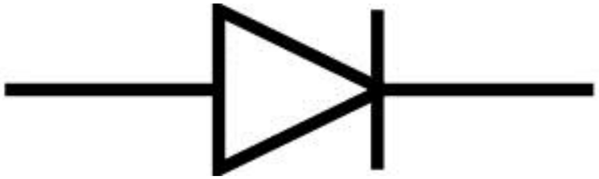


Cable assembly tested immediately

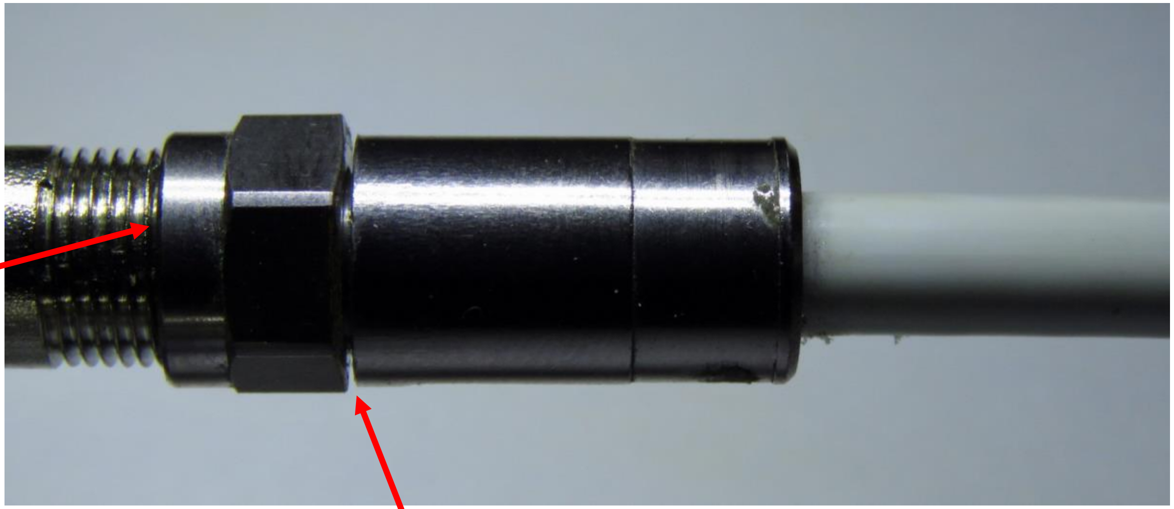
Cable assembly tested after 5 day temperature ageing test all connectors sealed. **(Creep Stage)**

TELESTE

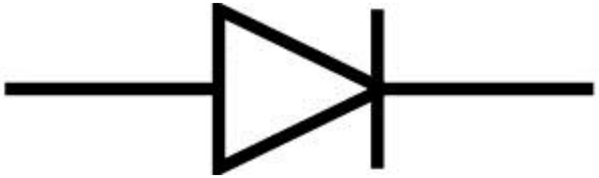
2. Galvanic Reaction (CPD Industry Research)



Air/Moisture = Corrosion = Diode effect

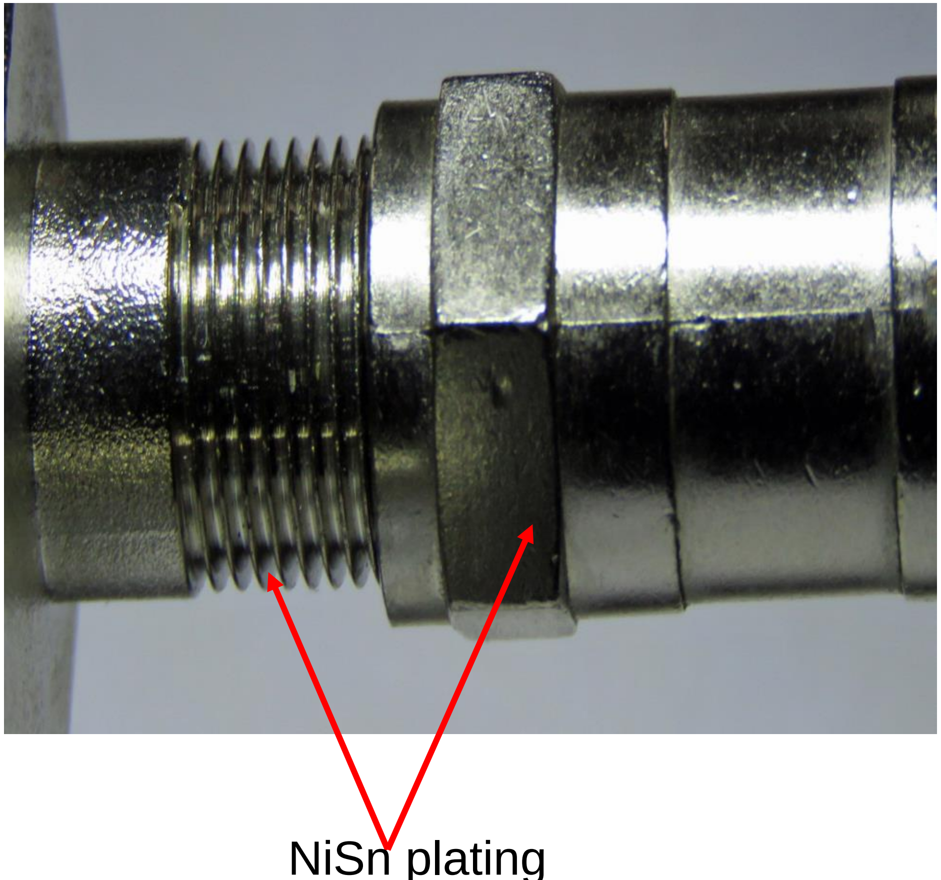


Air/Moisture = Corrosion = Diode effect



2. Galvanic Reaction (CPD Industry Research)

- **The industry conclusion for optimum connector plating material (male and female) is NiSn**



2. Galvanic Reaction (CPD Industry Research)

NiSn Plating

"That's one small step for connectors, one giant leap for CPD“

Or Is It?

- ✓ **The galvanic compatibility of the grounding metal-to-metal contact is key**
- ✓ **NiSn on the connector mating parts is proven to reduce Galvanic mismatch and reduce CPD**

QUESTION to the audience:

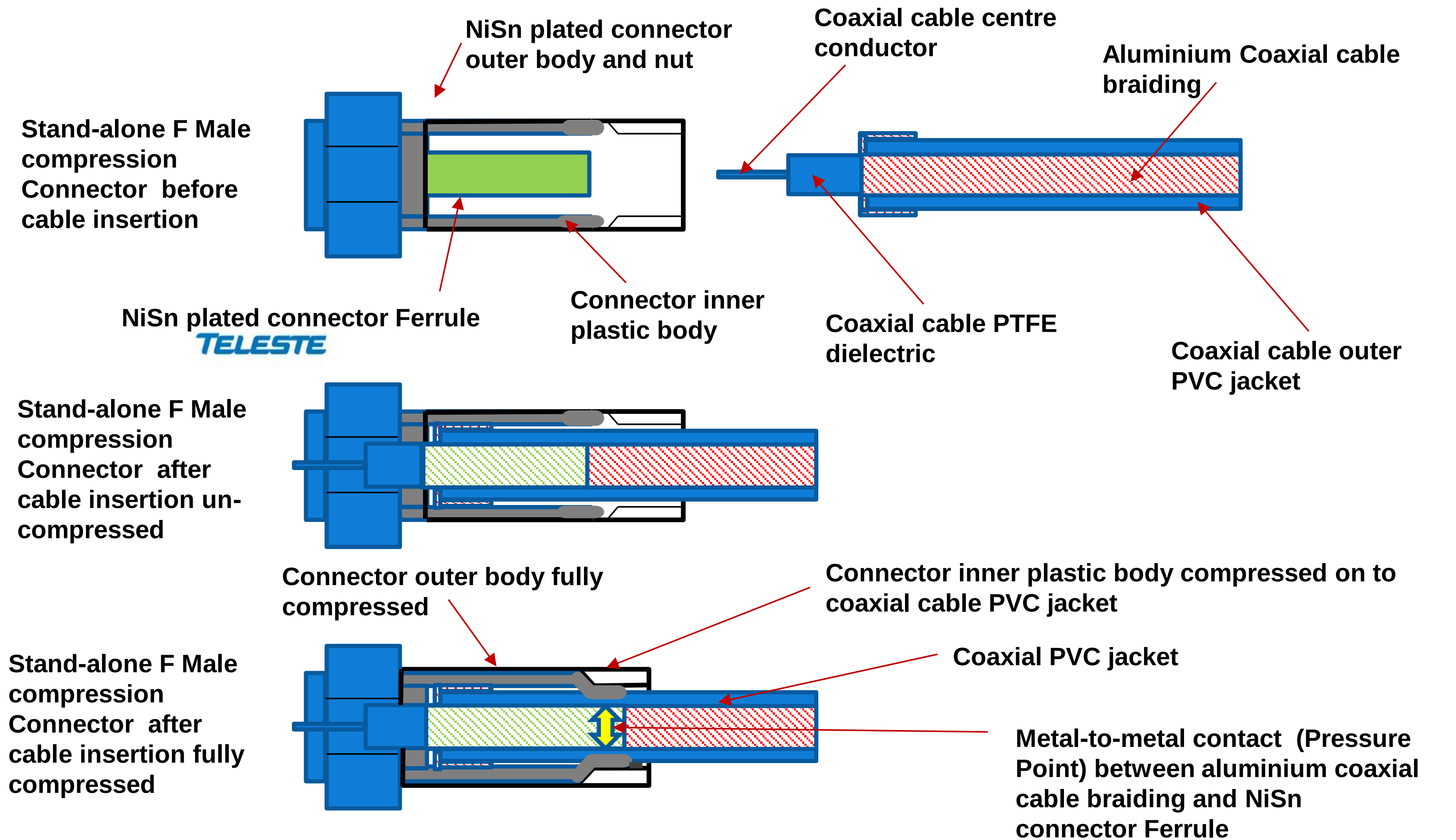
What would be the worst possible metallic material for galvanic compatibility?

2. Galvanic Reaction (The Demon exposed)

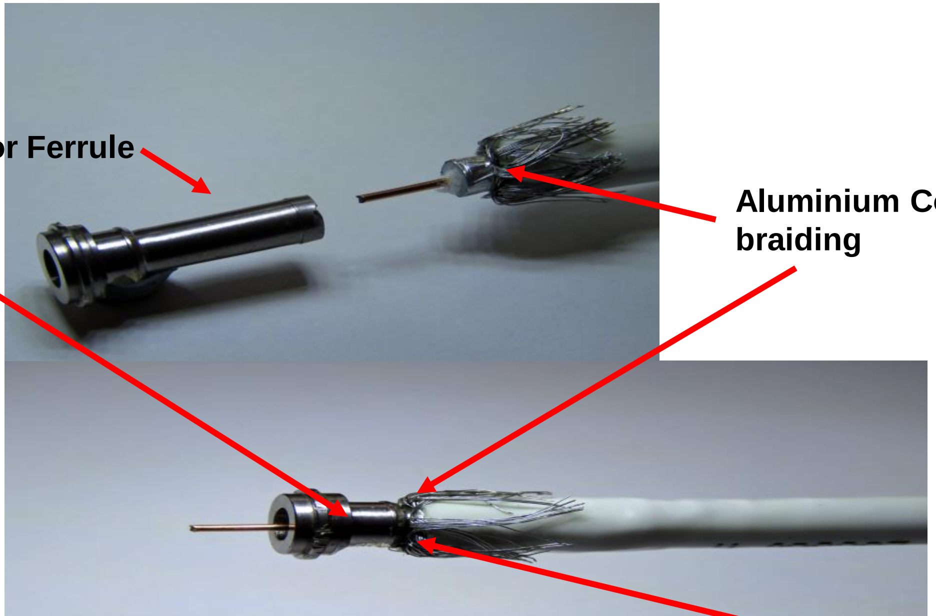
UN-ALLOYED ALUMINIUM

MUCH OF THE CATV INDUSTRY CHANGED FROM COPPER BRAIDED CABLE TO ALUMINIUM AGAINST ALL THE RESEARCH RECOMMENDATIONS

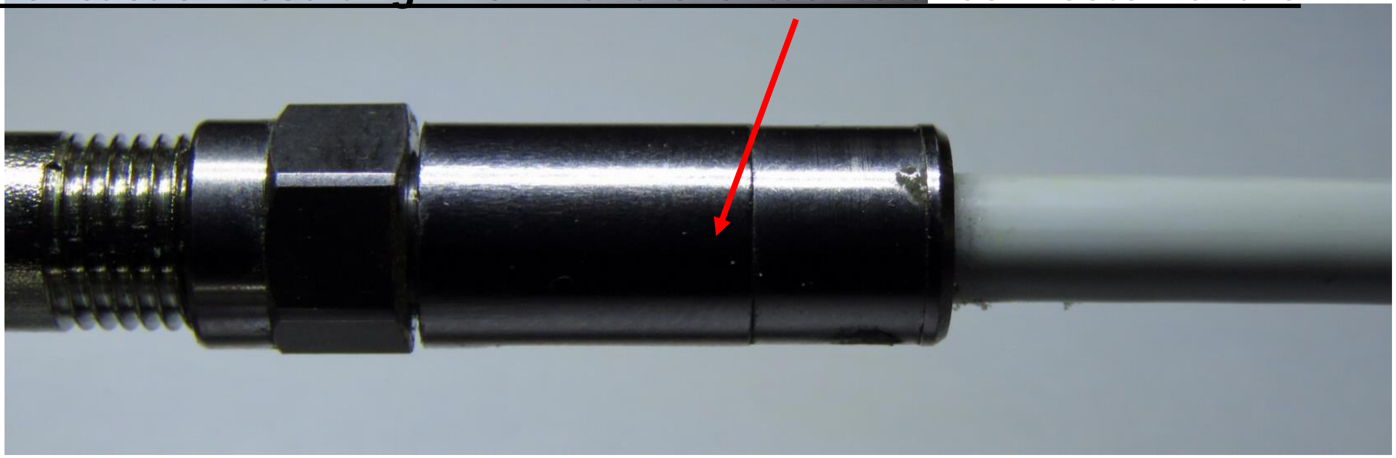
Example of current F Male Compression Connector and Coaxial Cable Assembly



2. Galvanic Reaction between Aluminium Cable Braiding and NiSn/Ni plated RF connector



Catastrophic galvanic reaction resulting in CPD and eventual total connector failure



2. Galvanic Reaction between Aluminium Cable Braiding and NiSn/Ni plating on RF connector

- Unalloyed Aluminium itself is extremely volatile when exposed to air or moisture. It will immediately start to oxidise. Oxidisation comes in two parts and has two key issues with pressure type contacts:-
  - The first relates to poor surface conductivity due to an insulating layer A1203 (Known as Sapphire) forming and constantly growing on the surface area when exposed to air. **This layer is an excellent insulator, <u>exactly what you do not need in a connector cable contact point!</u>**

  - The second relates to another oxidisation layer called Hydroxide, which is again an excellent insulator and will form in the presence of any air or moisture at the contact joint

  - Note, coaxial cable expands and contacts over temperature and will suck air through the connector once the connector torque reduces, which again is due to metal creep (Cold Flow)

2. Galvanic Reaction between Aluminium Cable Braiding and NiSn/Ni plating on RF connector

- Galvanic reaction between dissimilar metals is the most serious issue. Based on the Galvanic periodic chart, which shows the voltage potentials between metals, based on subtracting their anodic indices, it is recommended that the Galvanic potential should be as follows:
  - Normal environment, e.g. Warehouse Storage or non-temperature controlled environments **≤ 250mV**
  - Controlled environment, controlling temperature and humidity **≤ 500mV**
  - Harsh environments such as high humidity and salt air/moisture **≤150mV**

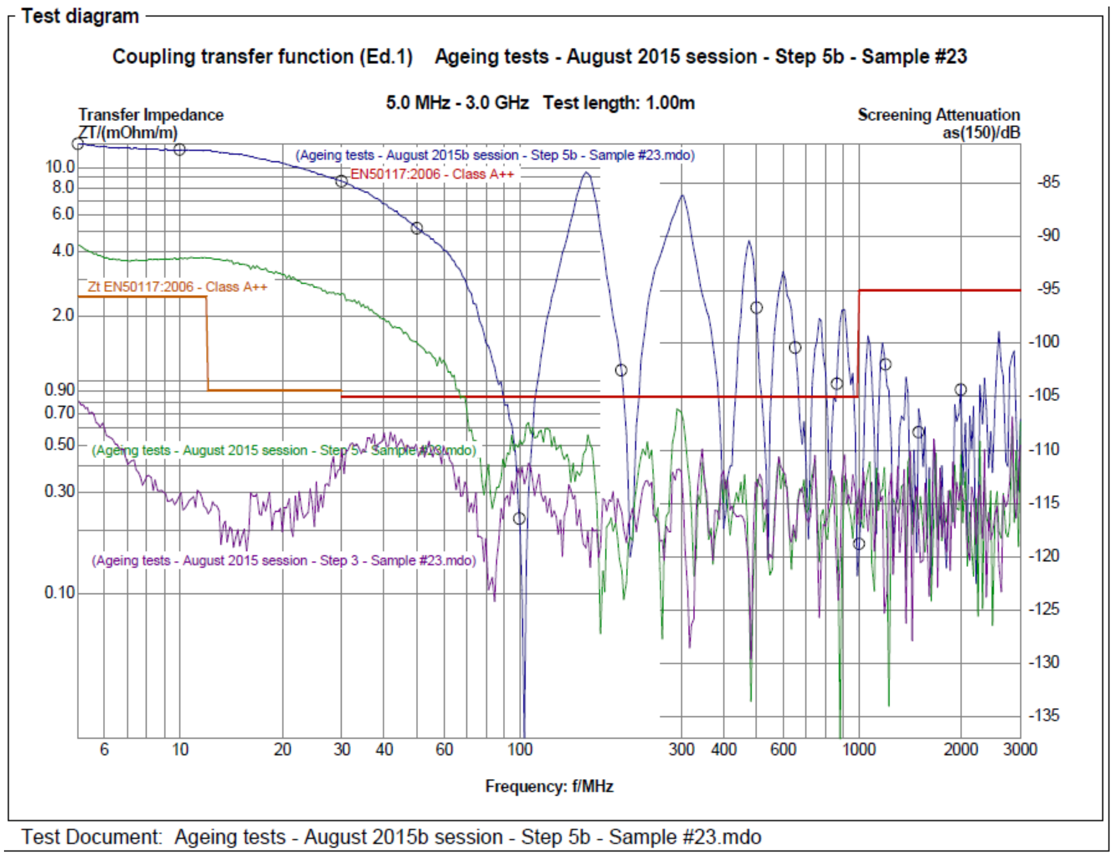
- **Aluminium and Nickel = 660mV**

As can be seen, Aluminium and Nickel have a serious Galvanic issue

ALUMINIUM CABLE WITH NiSn PLATED F CONNECTORS

- Cable assembly tested immediately
- Cable assembly tested after 5 day temperature ageing test all connectors sealed. **(Creep Stage)**
- Cable assembly tested 4 weeks after ageing test. Cable left in packaging bag in store room all connectors open (**Galvanic reaction**)

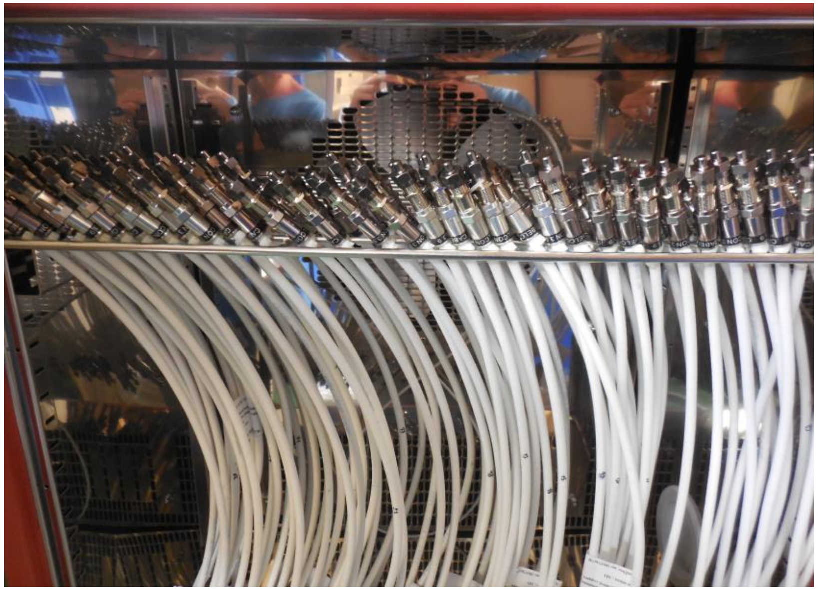
Coupling Transfer Function Test Results



RESEARCH KEY OBJECTIVES

- Gain a full understanding of the effects of metal-metal contact between cable and connector and its relationship with transfer impedance and RFI screening

84 cable/connector samples of various combinations prepared for testing



Teleste's research conclusion:

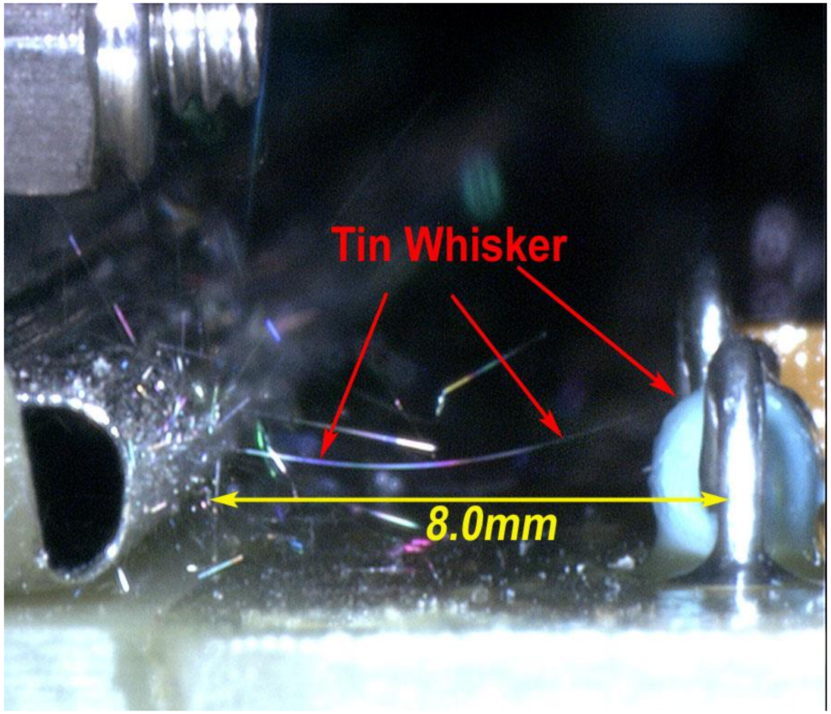
- The nearest usable metals for contact with Unalloyed Aluminium are:
    - First is Gold
    - Second is Cadmium
    - Third is Tin with a galvanic anode voltage indices of 290mV

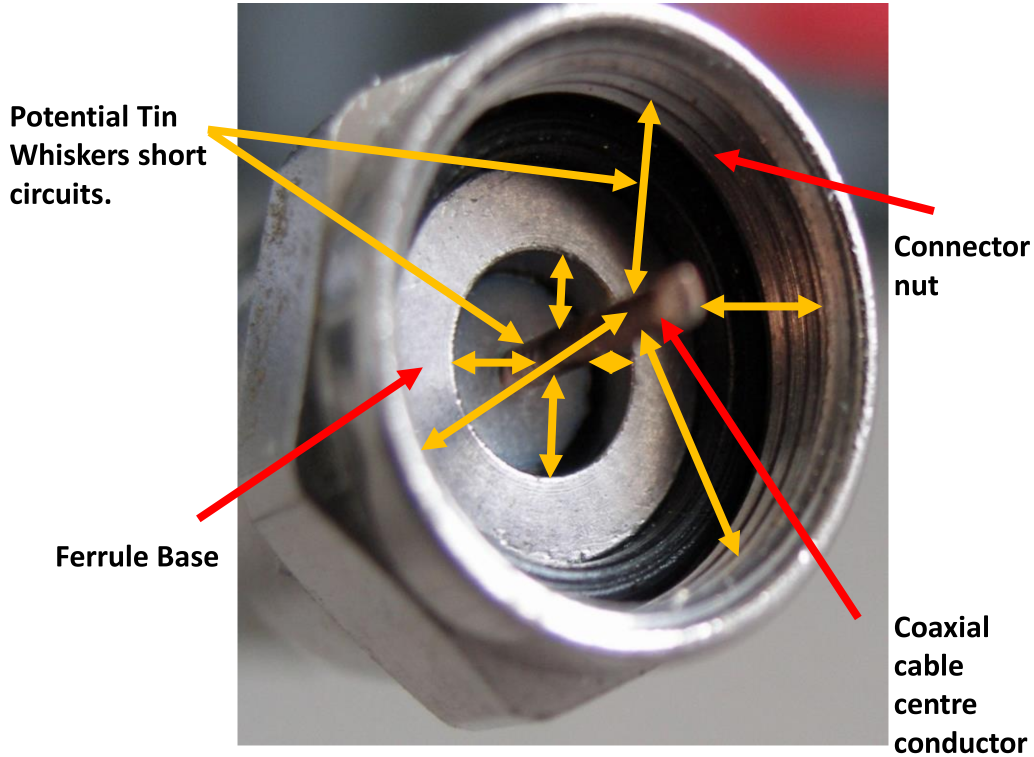
- Maintaining a constant **uniform** metal-to-metal contact force between the Aluminium cable braiding and the RF connector ferrule is essential in order to prevent the Unalloyed Aluminium from oxidising, and thus increasing the contact resistance, which will have an adverse effect on both RFI screening and transfer impedance of the cable/connector assembly.

- Minimising the Galvanic reaction between the Aluminium cable braiding and connector ferrule is essential to prevent further corrosion/oxidisation and also keep the potential diode effect of the metal-to-metal contact producing CPD and ultimately total loss of RF signal.

TIN WHISKERS PHENOMENA

As can be seen below, the Tin whisker growth is significant and these small metallic whiskers will cause electrical short circuit issues, which would be the case if Tin plating was used for a complete coaxial F connector, mainly in the nut area and ferrule base where the whiskers could short the outer body to the coaxial cable centre conductor. Hence, the innovation body is Tin plated and the base NiSn plated avoiding the issue.



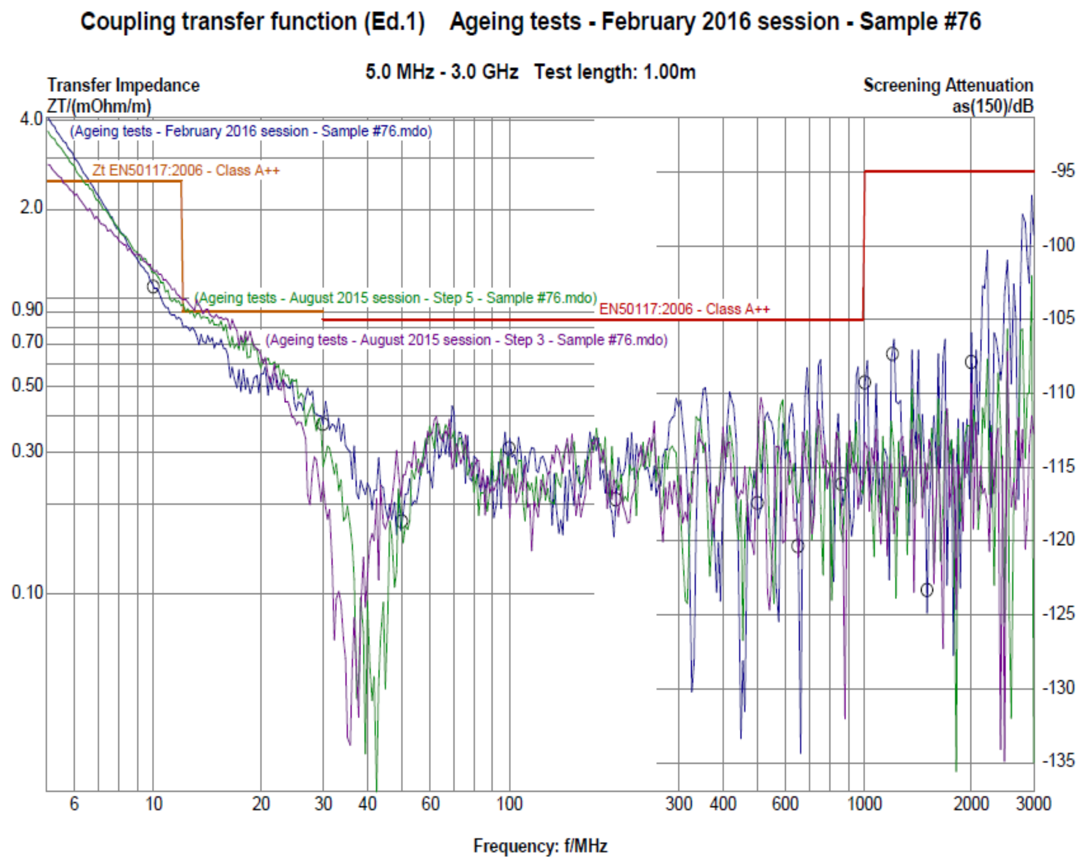


IDEAL OUTCOME STILL UNDER RESEARCH

Coupling Transfer Function Test Results

ALUMINIUM CABLE WITH NiSn PLATED F CONNECTORS

- Cable assembly tested immediately
- Cable assembly tested after 5 day temperature ageing test connectors sealed. **(Creep Stage)**
- Cable assembly tested 24 weeks after ageing test. Cable left in packaging bag in store room all connectors open (**Galvanic Reaction**)



Thank You