ACTA Virtual Public Meeting
July 26, 2012

ANSI/TIA-1096-A Non-Compliance Issues (Focus on RJ45)

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Other Related Non-Compliance Issues

Sentinel Connector Systems
Bob Brennan and Dave Jeskey

How Sentinel Connector Systems Got Involved with The ACTA

- ACTA Abstract from March 6, 2008

- "Connectors continue to be a source of problems for customers. For example, connectors are reaching the marketplace without the requisite amount of gold on the connector contacts."
- "All plugs and jacks used for connection to the network, whether at the demarcation point of [sic] connected anywhere to the premises wiring must meet the mechanical requirements specified in Part 68 Subpart F - specifically the dimensions, tolerances and metallic plating requirements."
- "In the Reconsideration Order, the Commission noted that sub-standard plugs and jacks have posed a significant problem for consumers. In particular, such plugs and jacks may be difficult to interconnect and may lack the gold plating on the contact interface needed to prevent interference."

Sentinel Connector Systems

- Instrumental in Designing and Building the first RJ45 with Hardesty
- Founded Stewart Connector
- Founded Sentinel Connector
- Management- 300 + man years of experience in dealing with Modular Plugs and Jacks
- Extensive Manufacturing and Testing Capabilities
- Over the past several years, Tested and/or Analyzed over 2,000 products. Includes customer requests and Internal Market Research

- Sentinel Connector Systems is also a member of the Communication Cable and Connectivity Association (CCCA), an organization that advocates STANDARDS and COMPLIANCE dealing with all Structured Cabling products sold in the United States. All must comply with applicable fire safety codes, transmission standards … and the law.

  – Published Numerous Studies Including Non-Compliant Cables, Electrical Testing of Patch Cords, the use of Copper Clad Aluminum Conductors in Category Type Cables, Contractor Liabilities and Fraudulent and/or Counterfeit Cables.

CAVEAT EMPTOR.....NOT ALL RJ45'S ARE CREATED EQUAL

- The RJ-45 Is A Highly Engineered Interconnection System
- One of the Most Pervasive Connector Interfaces Ever …..that Crosses Many Industries and is Included in many Standards and Specifications
- When made correctly…is one of the MOST RELIABLE connector systems in the World

- THERE IS A DISTURBING TREND OF RJ45 PLUGS AND JACKS NOT MEETING THE SPECIFICATIONS PUT FORTH BY THE TIA, IEC, ISO AND OTHER STANDARDS BODIES

- Two Major Issues - Product QUALITY and PERFORMANCE
  - Sub-Standard, Non-Compliant and Counterfeit RJ45's
  - Proven RJ45 Interconnect Problems Are Affecting Signal Integrity…… Resulting in Poor Signal Transmission, Intermittencies, Shorts, Signal Loss....and now, possible Life/Safety Issues including Hot Spots and the potential for Thermal Runaway

An Eye Opener – What is the Magnitude of the Problem

RJ45 is searched for 1,200,000 times per year (more when you look at RJ45s, Source - Boostabilty)

Between 25%-30% of the Searches are Quality Related (Source – StatCounter)

Sub-Standard Material – Violates UL

Use of 94V-2 Material (cheaper) instead of 94V-0

Gold and Nickel Plating Issues

- Prior ACTA Statement regarding Gold
- Cost pressures have increased on all components, especially those with gold and precious metals involved. Many of these products are subject to offshore outsourcing and subcontractor manufacturing in the supply chain to meet these cost pressures. Unfortunately, quality standards are being compromised. As a result, there is a TICKING TIME BOMB WITH POROSITY, OXIDATION, CONDUCTIVITY, CONTACT RESISTANCE AND CORROSION that may cause complete signal transmission loss or intermittent contact (that alternates rapidly between a high and low resistance), which is the worst nightmare for anyone who has to troubleshoot network equipment.
- At current gold prices, gold represents around 60%-70% of the Cost of Plugs
- Plating Situation is getting worse

The Plating Specs

- **5.1.1 Gold Surface Layer**
  The gold surface layer in the specified contact interface area shall meet the following requirements:
  1. The material content shall be **99% pure gold minimum**.
  2. The material density shall be 17 grams/cm3 minimum.
  3. The **minimum gold thickness in the specified interface area shall be 1.2700 µm (50 µin)**
  4. The **Knoop microindention hardness value shall be between 130 and 250** when measured in accordance with ASTM E384-05a using a load force of 0.245 N (25 g).
  5. **Test specimens shall exhibit no corrosion** products having a diameter greater than 0.05 mm (0.002 in) when tested for porosity and other surface defects per EIA-364-53B.
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- **5.1.2 Nickel Barrier Layer**
  A nickel barrier layer shall be used between the gold surface layer and the base metal. It shall meet the following requirements:
  1. The material content shall be **99.5% pure nickel minimum**, and no other single component shall be more than 0.2%.
  2. The **minimum nickel thickness shall be 1.2700 µm (50 µin)**.
  3. The **nickel barrier layer shall not crack** when a contact sample is bent through a 180° angle, with the plated surface away, around a mandrel whose diameter is equal to the thickness or diameter of the contact sample.

OUR FINDINGS

OVER 50% OF ALL RJ-45 PLUGS TESTED DID NOT MEET THE MINIMUM GOLD and/or NICKEL PLATING THICKNESS REQUIREMENTS PER TIA, IEC and OTHER STANDARDS BODIES SPECIFICATIONS

Problems

The specification calls out for PURE HARD GOLD, 99.99% 24 CARAT

Seeing less than pure gold…..18 carat, 14 carat, etc.

Less than the Minimum 50 Micro-inches of Gold and/or Nickel

Gold - Seeing 30 micro-inches, 15 micro-inches, 6 micro-inches and Gold Color Only

Nickel – Seeing less than 50 micro-inches….and sometimes NO NICKEL AT ALL causing GOLD DIFFUSION

Real World Example – Cell Tower in the UK

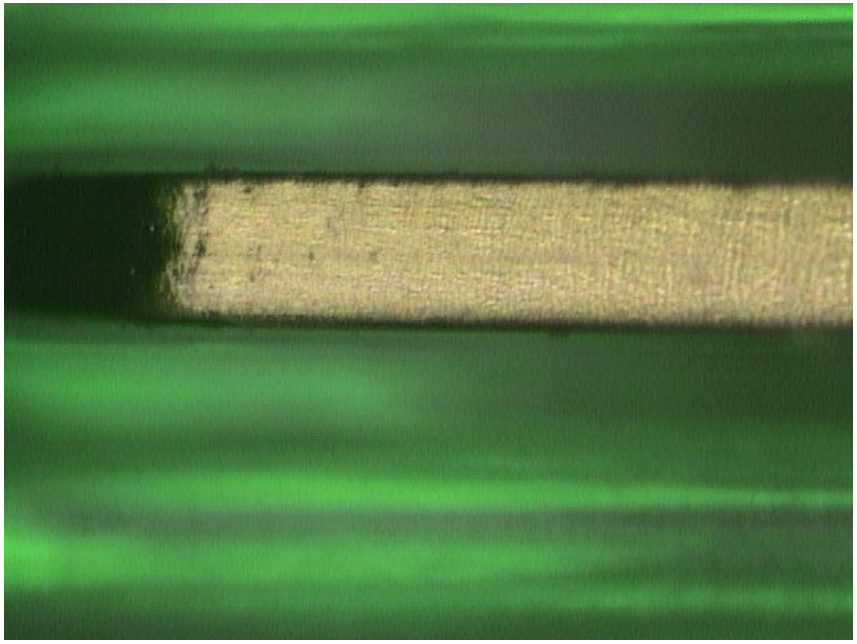
Also, seeing different plating thicknesses WITHIN THE SAME PLUG – Reflecting Poor Quality Control?

Why?

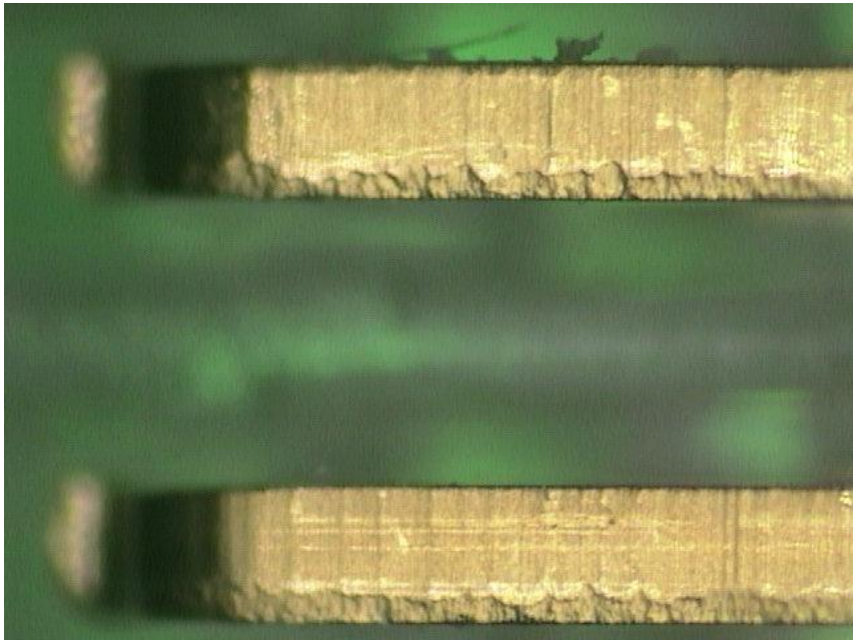
It’s obvious…..Make product cheaper

The **plug/jack contact interface shall be hard gold to hard gold** and shall have a **minimum gold thickness of 1.2700 µm (50 µin)** on each side of the interface. Alternative contact material that is compatible with hard gold and provides equivalent contact performance may be used under certain conditions. **The minimum contact force at the interface shall be 0.98 N (100 g)**. **A smooth, burr-free surface shall exist at the interface** in the area shown. **Contact surface roughness shall be 0.8128 µm (32 µin) maximum**.

Good Plating



Bad Plating



Taking a Closer Look

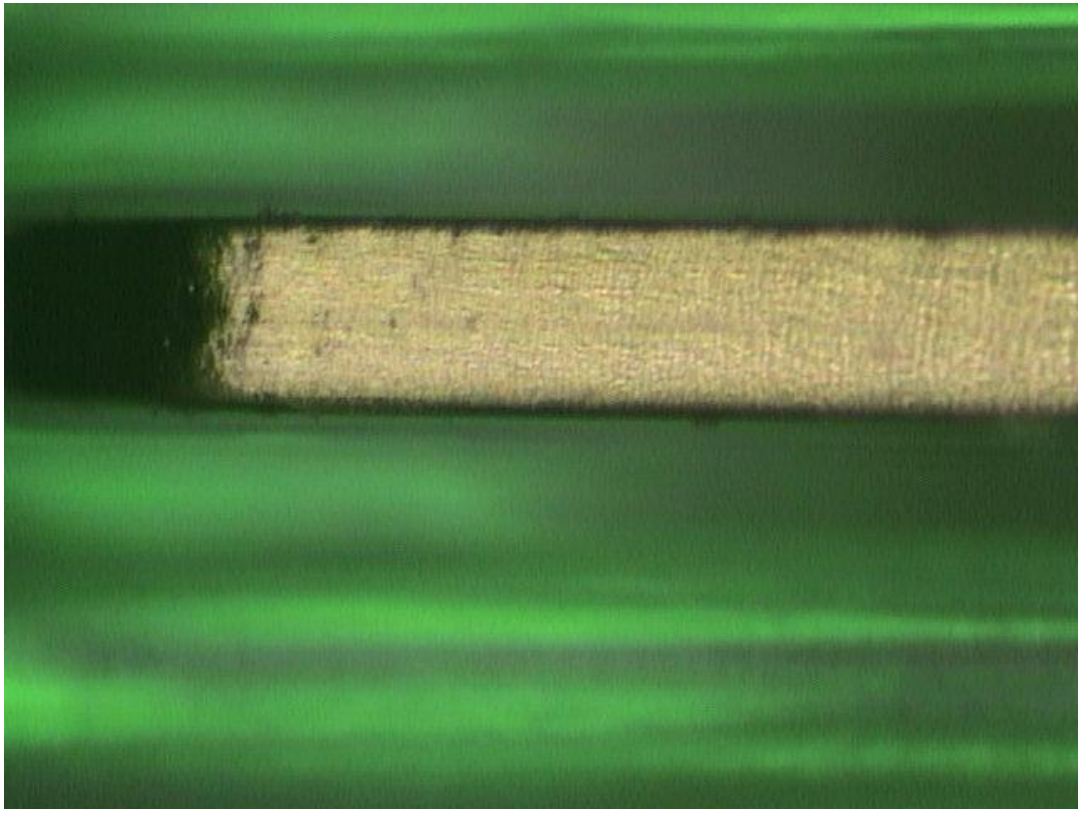
Good Plating

Electro-polished contact prior to plating process (vs wire brushing)

Creates a SMOOTH, BURR FREE SURFACE, per spec

Adherence to 24 carat gold (99.99% pure) and minimum 50 micro-inches of gold thickness

Uses 50 micro-inches of pure Nickel to provide barrier and prevent Gold Diffusion and for POROSITY considerations, important later



Taking a Closer Look

Bad Plating

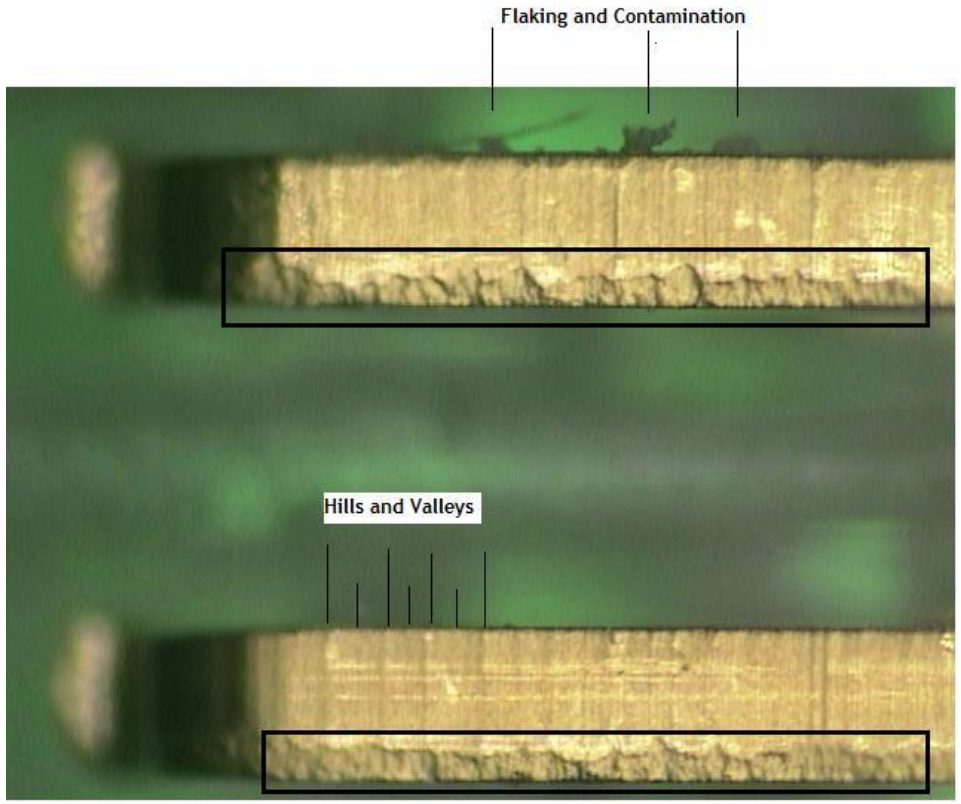
Wire Brush the Contact before plating

Causes Hills and Valleys and inconsistent plating thicknesses

Creates Ridges that will wear off (in effect, scrape) the gold off of the Jack Contact Surface

Notice Burrs and/or Rasps on stamping "BREAK". Break should be 10% clearance. In picture, it is 25%-30%. Why? Reduces tooling maintenance costs by about 50%

With this plating, you would see contact wear in as little as 10-15 insertions/de-insertions.



Other Problem Areas in Rectangles

The Plating Process

If Best Practices ARE NOT Followed

- One of the issues in the reliability of an electrical contact is the integrity of the plated surface. If there are breaks in the surface, such as pores, then corrosive elements can attack the substrate or the base material. If there are enough pores, corrosion can creep across the surface of the contact with disastrous consequences.

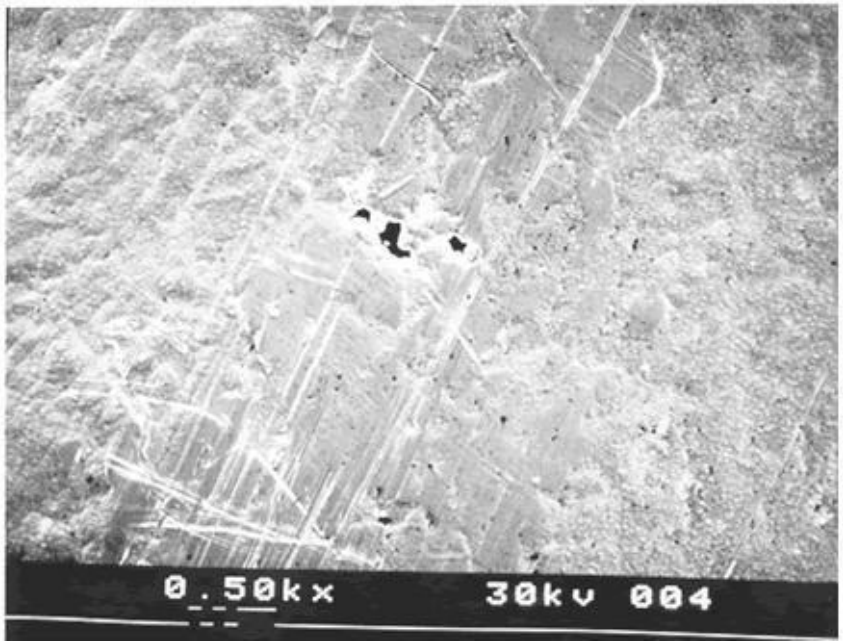
- Best Practices include……Proper Metal "Activation" (acid or caustic), Proper Cleaning and Rinsing with a Lot of Pure Water and the Use of Dedicated Plating Baths.

- In essence, NO CUTTING CORNERS

JUST WAITING TO HAPPEN

POROSITY, OXIDATION, CONDUCTIVITY, CONTACT RESISTANCE AND

CORROSION ISSUES



Contact Mating and Dimensional Issues

Several Factors are contributing to potential Signal Loss due to Improper Plug/Jack Mating

- Jack Width Being Too Wide
  - •Occurring More frequently
  - •Also see jack height issues…..too high
- Plug Tolerances
  - •Plastic where it should not be
  - •Out of Spec Dimensions
- Bad Plug Terminations
  - •Blade Depth Issues
  - •Cupping and Bowing Due to worn out tooling
- •Out of Spec Mold Drafts
  - •Internal to the Jack Creates “Play” after insertion
  - •Use of Brass (cheaper) as the base metal (instead of Phosphor Bronze) increases the resistance and affects electrical and mechanical performance

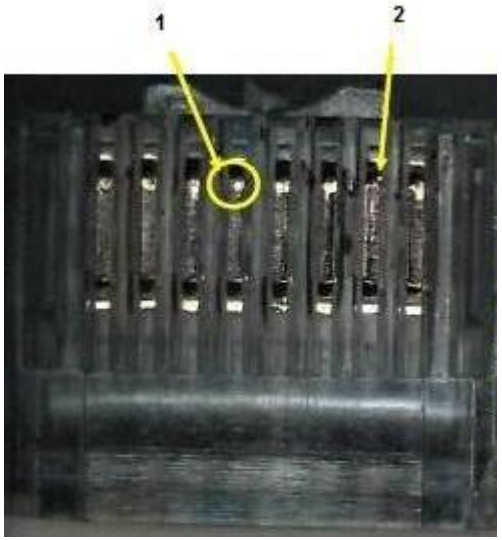
The “WIGGLE TEST”

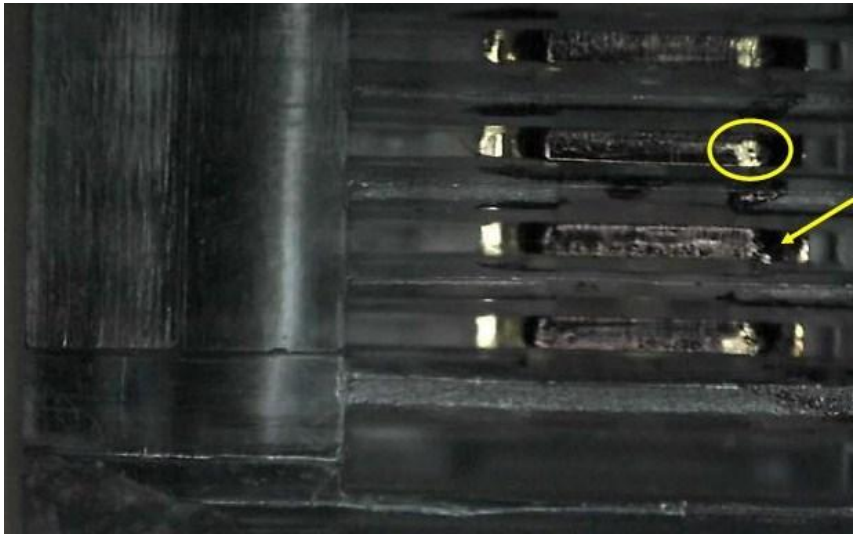
Customer Supplied Switch Sample
Air Traffic Controller Application

1 – Shows Black Die Making Contact with Jack

2 – No Contact between Plug and Jack

Close-Up View



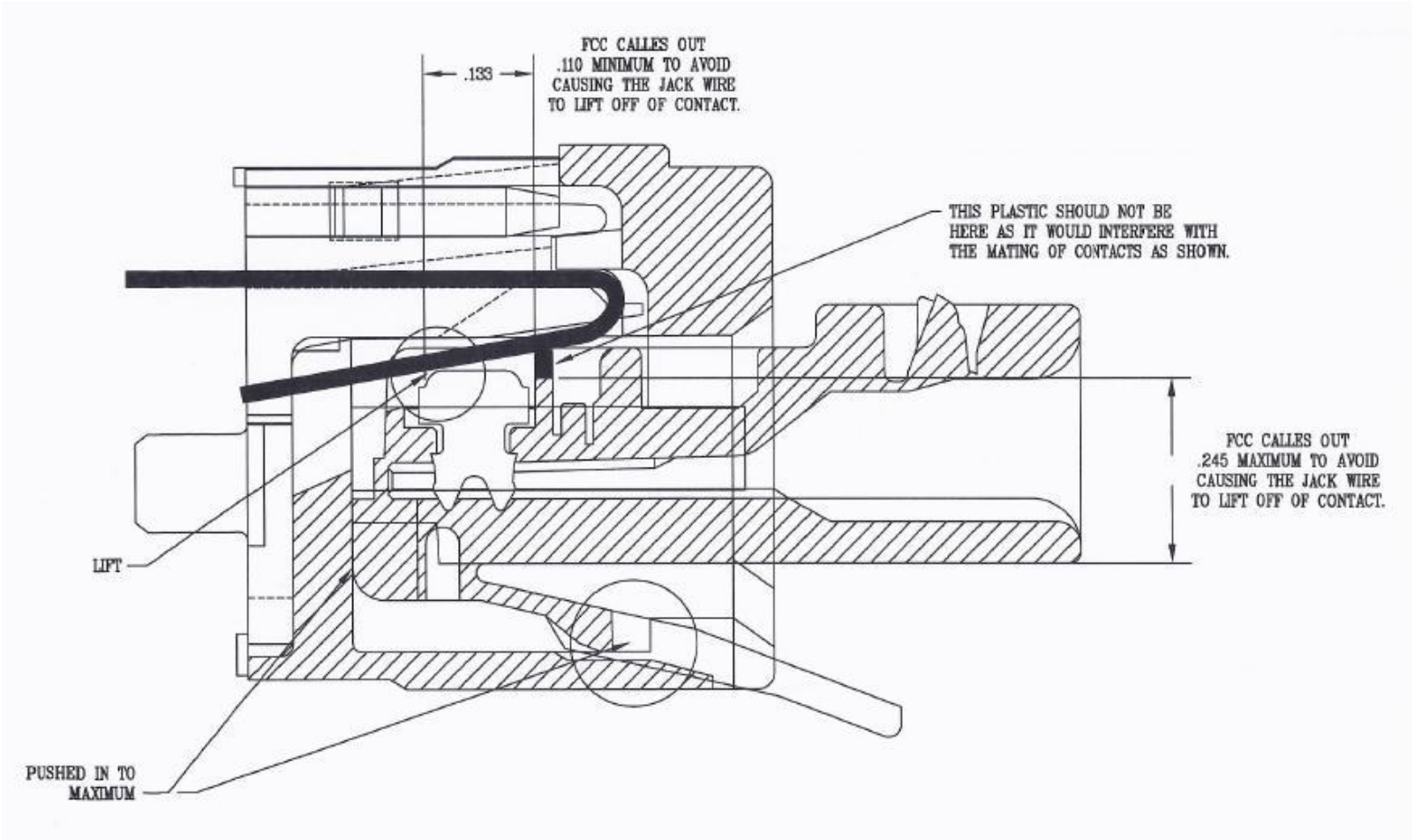


Our Analysis of the Switch

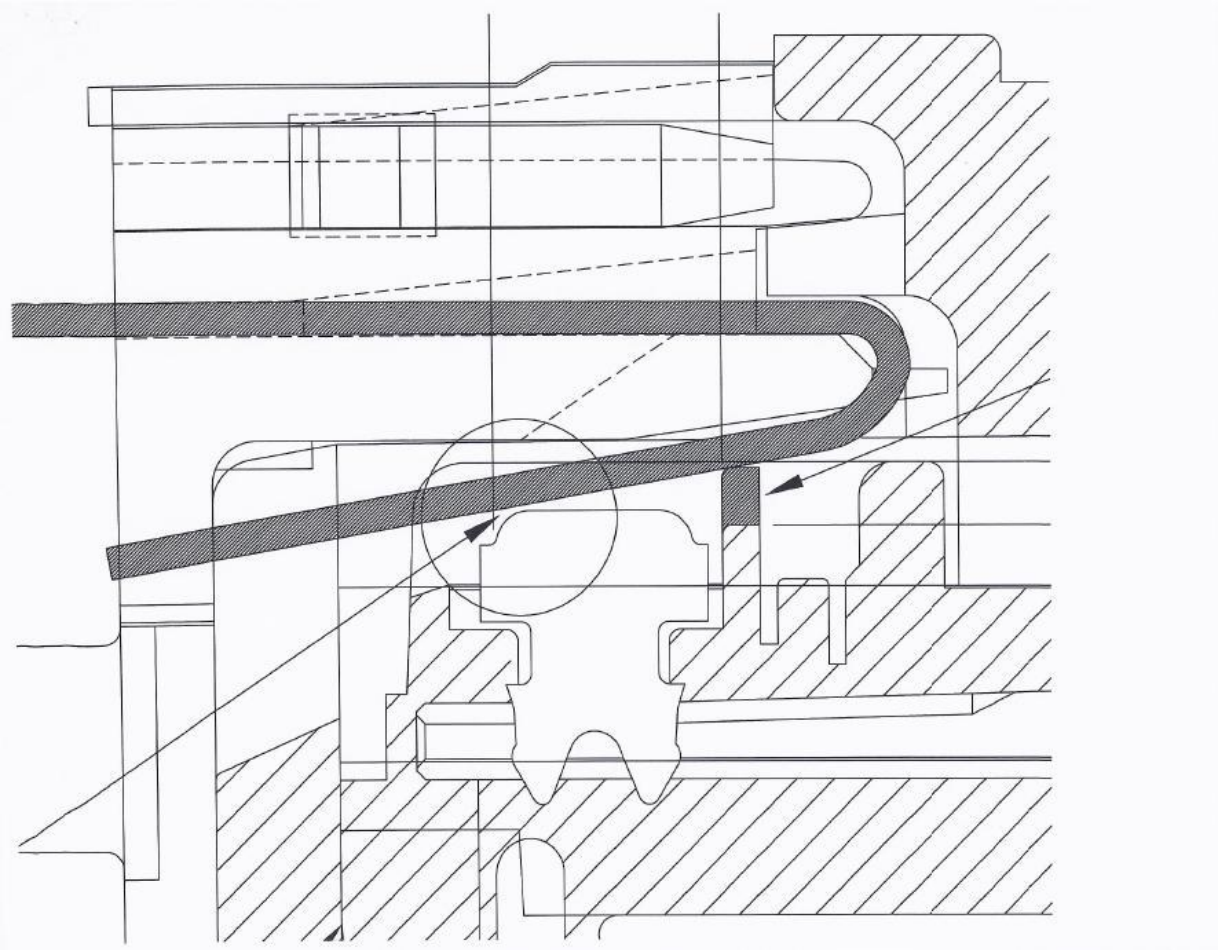
We are hearing about this more and more. Basically, the RJ45 Jack on the Switch is TOO WIDE.

This causes the plastic of the plug (between the contacts) to ‘LIFT OFF” from the jack contact resulting in Loss of Signal or Intermittencies.

Plug Plastic Out of Spec



Plug Plastic Out of Spec
Close-Up View



Bad Plug Terminations

.237” +/-.005”

Seeing More and More Blade Depth Issues

2nd Contact From Right
Taken from CI&M Article

1st Contact on the Left
Taken from The Star Report - 2011

Plug Contact (Blade) Design Issues

Some manufacturers offer a contact design for solid conductors and a different blade design for stranded conductors.

The blade for stranded conductors will pierce the insulation STRAIGHT DOWN, instead of straddling the conductors.

By specifying the wrong blade design, you can actually FRACTURE the SOLID conductor.

Improper blade design can also PUSH the conductor to one side or the other creating a HOT SPOT (important later).

CONDUCTOR BUNCHING exacerbates the situation. making plug selection CRITICAL for the cable used.

- Good Design Shows Blade “STRADDLING “ the CONDUCTOR….Forms an “S” Curve
- Can be Used with either SOLID or STRANDED Conductors

Jack Contact Design Issues (1)

Taken from ANSI/TIA Specifications

- "The **minimum contact force should be .98 N (100 grams).** Any non-gold contact material must be compatible with gold and provide equivalent contact performance."
- "The jack contact design is based upon .4572mm (.018 inch) **spring temper phosphor bronze round wire** in the modular plug blade and jack contact surface.
- "The **suggested nominal contact angle between plugs and jacks** with the plug latched into the jack. If this angle becomes **greater than 24 degrees loss of electrical contact may occur** between the plug and jack. If the nominal contact angle becomes **less than 13 degrees, interference between jack contacts and the internal plastic in the plug may occur**."

Here is what we have seen…..

Stamped and Formed Contacts not providing the necessary Tensile Strength for plug/jack mating . Only providing about 115,000 PSI instead of 145,000 psi with spring temper phosphor bronze. Stamped Beryllium Copper could meet the tensile strength, but is very costly.

Nominal Forces Not Being Met

Contact angles are sometimes out of the specified range of 13 to 24 degrees.

Jack Contact Design Issues (2)

Implications

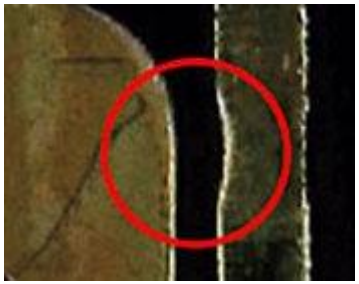
In addition to expected problems with out of spec products, you can have premature contact wear due to normal Thermal Cycling, or in applications where vibrations or micro-vibrations occur…..such as:

The Harmonic Phenomena in Data Centers

Signal Loss Due to Harmonic Vibrations of the Equipment in Data Centers

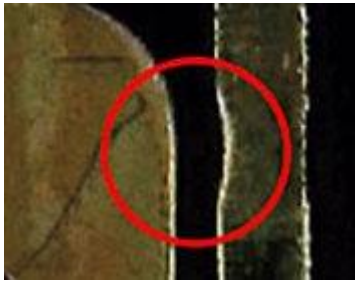
Tomography Applications (CT, CAT Scans)

The constant noise of the “THUMPING” Scan is causing perturbations and distortions in the scanned image.



Jack Contact Design Issues (3)

- You should not be seeing this type of contact wear. The plugs and jacks were designed so that the wear would occur on the PLUG SURFACE, NOT THE JACK SURFACE. Why….it is easier to replace the cord.
- This is due to the imperfections of the plating on the plug (burrs, rasps, ridges) causing the friction to rub off the plating on the jack.
- When built according to all specs, you should se an “INVERTED RESISTANCE CURVE”, whereby the plug contact surface is actually “POLISHING” the jack contact surface. You get better resistance characteristics through approximately 350-400 insertions, then the resistance begins to deteriorate.



“The Perfect Storm”

The Clouds are Forming
Putting The Pieces of Information Together

- CCCA Findings
  - Non-Compliant Cables Failing UL Burn Tests
  - Copper Clad Aluminum Conductors Found in Category Type Cables
  - Non-Compliant Fraudulent and Counterfeit Cables

  – Combine the above, with what we know about plugs and jacks…..

  – There is a potential for **THERMAL RUNAWAY**

THERMAL RUNAWAY

Something to be Aware Of

- Tablet Computer Example – Hot Spot
- Exploding Cell Phone Example from two weeks ago

- Heat does not dissipate….just keeps building up and up until a potential hazard develops.

- **Insulation Displacement Connectors (IDC) and Copper Clad Aluminum Conductors (CCA) DON'T MIX**
- **IDC + CCA =**
  - Immediate Oxidation
  - Increased Resistance and creation of a HOT SPOT
  - Bad Blade design could shift conductor to one side of the blade increasing the HOT SPOT
  - Higher the frequencies and speed, the bigger potential for problems
  - Bad plugs and jacks can cause problems

  - New PoE spec sets maximum limits at 400mA per conductor (3.2 AMPs per plug) and 48VDC to achieve higher wattages
  - Current UL Ratings are 1.5 AMPs per plug at 30VAC-42VDC

  - New HDbaseT Spec calls for similar wattages – RJ45 replacing HDMI on Smart TV's

- Something to think about.