Presented by:

Thomas Bockstoce
Project Engineer, WW Product Development

Robert Eberly
WW Manager, Rail Connections
Thank you!

IEEE Rail Transportation Standards Committee
Overhead Contact Systems Working Group
Agenda

• Hyde Park Forum
• Grounding
• Theft Deterrent Cable Solutions
• Cable Theft Monitoring Solution
• Q & A
Electric Railway Improvement COmpany

- Founded 1903 - Cleveland, Ohio, USA
- Original customer base railway industry
- Unique products specifically for railways
- Engineered systems
- Solution provider
- Long history of superior products and service
Arc & Pressure Welded Bonds
Business in 1903

- Manufacturer and seller of electric rail bonds, railway and electric supplies

- Inspection, construction, repair and maintenance of electric street and interurban railroads, water and gas mains, water works, gas works, and power plants
Photos from the Field

“Champion” brand bonding cars circa 1910-1915
CADWELD History

1936 – First public demonstration of CADWELD Process

1939
Product installation in the field
ERC Worldwide Team
Business in 2012

ERICO is:

• Headquartered in Cleveland, OH, U.S.A.
• 1,200 employees WW
• Global Presence
  – 21 facilities
  – Over 15 countries
CADWELD

- Leading brand in the world
- Widely imitated
- Proven quality
- Engineered solution
- > 100,000,000
ERICO Electrical Market Focus Groups

ERITECH*
Grounding, Bonding, Lightning Products

ERIFLEX*,
Current Carrying Conductors, Supports and Other Non-Active Electrical Panel Components

ERICO| RAIL
Rail Electric Bonds, Grounding, Surge Protection

Facility Electrical Protection Systems
Panel Boxes for Facilities, OEMs
Railroads and Transits
ERICO CADDY and LENTON Focus Groups

CADDY* ELECTRICAL

Specialty Metal Hangers

CADDY* MECHANICAL

Metal Hangers and Support Systems

LENTON

Mechanical Couplers

Electrical and Data Com Applications

Plumbing, HVAC, Industrial, Fire Protection and Seismic Support

Concrete Reinforcement Applications
Wayside Electronics

• Use of electronics has increased steadily over the last 40 years in the railway industry worldwide
• Wayside environment is not friendly physically or electrically for electronics
Solutions Approach
What’s good enough?
Lightning Protection
Grounding - Spacing

Area of concentric shells overlap causes decrease in ground rod efficiency.
Grounding - Depth

Doubling Rod Length Reduces Resistance 40%
Comparison of Mechanical and Exothermic Connections

Molecular Bond

Mechanical Connection

Apparent Contact Surface

Actual Contact Surface

Molecular Bonds Guarantee Conductivity Across the Entire Section
Contact and Spreading Resistance ($R_s$) Portion of Connection is Zero
Comparison of Mechanical and Exothermic Connections
Copper Theft

• US Department of Energy estimates over $1 Billion in copper theft annually
Copper Thieves

Even birds are stealing copper…
Theft Prevention Methods

• Painted Conductors
• Signage
• Alternative coatings
• Encoding / marking
• Covering (PVC), etc.
• CCTV systems
• Motion detectors / lighting
• Alternative materials
• Theft monitoring systems
Theft Deterrent Products

Alternative Materials:

- Copper-Bonded steel conductors
- Copper-Bonded solid steel conductor
- Formed Copper-Bonded steel grounding down leads
- Composite cable
Copper-Bonded Steel Conductors

Construction:
• 10 mils of copper over solid steel core
• Diameters from 3/8” to 3/4”

Applications:
• Utility and Transit system grounding
• Replaces copper and copper-bonded steel wire conductors
Copper-Bonded Steel Conductors

Advantages:
• Combines the strength of steel with the conductivity and corrosion resistance of copper
• More economical and rugged than copper
• Very little scrap value

Disadvantages:
• It is harder to work with in comparison to the copper conductor
Copper-Bonded Steel Conductors
Pre-Formed Cu-Bonded Gnd Rods

Structure Ground Leads
Pre-bent Copper-bonded Rods
Pre-Formed Cu-Bonded Grnd Rods

Pre-bent Copper-bonded Rods / Fence Grounding
Field-Bent Cu-Bonded Grnd Rods
Field-Bent Cu-Bonded Grnd Rods
Field-Bent Cu-Bonded Grnd Rods
Copper-Bonded Steel Connection
Composite Conductors

• Originally developed for theft deterrent application for the rail industry (AREMA design recommendations).
• Used for rail bonding for over 40 years
• The largest size for this application is electrically equivalent to a 4/0 copper conductor

CC5A30 - 133 Tinned Copper, 24 Galvanized Steel
Fusing Ampacity = 3/0 AWG Copper Cable
Composite Conductor Features

• Copper strands are concealed by outer galvanized steel strands
• Copper strands are tinned to improve corrosion resistance
• The copper stranding increases conductivity and flexibility of the conductor
• Comes in bare or insulated option
• Has many years of proven record in successful applications at railways in the Asia, Europe, Latin America and North America
Composite Conductor Features

• Combines conductivity of copper with strength of steel
• Difficult to cut with hand tools
• The outer steel strands are magnetic which further deters thieves looking for copper
• Ideal for exposed electrical negative return and grounding leads where copper theft might occur
Composite Cable Applications

- CC5A04 (7-strand) and CC5A05 (19-strand) electrically equivalent to 4 AWG (S-1)
  - Ideal for signaling and fence grounding
- The CC5A20, 30, 40 series are electrically equivalent to 2/0, 3/0 and 4/0 AWG
  - Negative return leads
  - Structure grounding
  - Suitable for use as substation risers to connect grid to substation equipment and structures
Composite Cable Design

• Design
  – IEEE Standard 837
  – IEEE Standard 80
  – ASTM B3 and B33 Tinned Annealed Copper Wire
  – AISI 1016 – Galvanized Steel Wire

• Modeling / Verification
  – Finite Element Analysis
Composite Cable Testing

- Phase 1
  - High current testing of sizes used in rail market to determine fusing capacity
  - Used time, current and peak temperature to determine fusing equations
  - Test data used for Finite Element Analysis to design 2/0 and 4/0 equivalents
Composite Cable Testing
Composite Cable Testing

Thermal Imaging
Composite Cable Testing

• Fusing Currents / Formulas

\[ I_{\text{Fuse}} = K \times A \times \sqrt{\frac{T}{t}} \]

Where:  
\( T \) = Fusing Temperature  
\( t \) = Fusing Time (Seconds)  
\( A \) = Area (Circular Mils)  
\( K \) = Constant

\[ I_{CC5A04} = \frac{6.455}{\sqrt{t}} \]

\[ I_{CC5A05} = \frac{6.335}{\sqrt{t}} \]

\[ I_{CC5A12} = \frac{25.823}{\sqrt{t}} \]

Where:  
\( t \) = Fusing Time (seconds)  
\( I_{CC5\alpha} \) = Fusing Current (kA)
Composite Cable Testing

• Phase 2
  – Using design verified by FEA, test equivalency to 2/0 and 4/0 AWG
  – Compared $i^2t$ of composite cables to copper to confirm fusing capabilities
Composite Cable Comparison

4 AWG STR

CC5A04

CC5A05

3/0 AWG STR

CC5A30
Composite Cable

**CC5A20**
- Total DC Resistance @ 20 degrees C: 0.09755 Ohms / kFt
- Weight: 0.548 lb/ft
- OD: 0.526”
- Physical Size: 4/0 AWG

**CC5A30**
- Total DC Resistance @ 20 degrees C: 0.07594 Ohms / kFt
- Weight: 0.677 lb/ft
- OD: 0.572”
- Physical Size: 250 kcmil

**CC5A40**
- Total DC Resistance @ 20 degrees C: 0.05724 Ohms / kFt
- Weight: 0.859 lb/ft
- OD: 0.656”
- Physical Size: 350 kcmil
Composite Cable

### Cable Parts Overview

<table>
<thead>
<tr>
<th>Cable Part Number</th>
<th>Standing</th>
<th>Cross Section</th>
<th>Resistance</th>
<th>Outside Diameter of Bare Conductors</th>
<th>Fuse Capacity Excessively Fused to</th>
<th>Standard Minimum Spool Quantity</th>
<th>Net Weight</th>
<th>CADWELD® Conductor Cable Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTSA4</td>
<td>600 Amps</td>
<td>0.300 in. x 0.300 in.</td>
<td>0.030 in. 0.030 in.</td>
<td>0.065 in. 0.065 in.</td>
<td>0.125 in. 0.125 in.</td>
<td>250 ft 660 ft</td>
<td>91 lb 43 kgs</td>
<td>91</td>
</tr>
<tr>
<td>CTSA6</td>
<td>800 Amps</td>
<td>0.320 in. x 0.320 in.</td>
<td>0.055 in. 0.055 in.</td>
<td>0.145 in. 0.145 in.</td>
<td>0.225 in. 0.225 in.</td>
<td>250 ft 660 ft</td>
<td>110 lb 50 kgs</td>
<td>91</td>
</tr>
<tr>
<td>CTSA8</td>
<td>1000 Amps</td>
<td>0.340 in. x 0.340 in.</td>
<td>0.075 in. 0.075 in.</td>
<td>0.200 in. 0.200 in.</td>
<td>0.300 in. 0.300 in.</td>
<td>250 ft 660 ft</td>
<td>140 lb 63 kgs</td>
<td>91</td>
</tr>
<tr>
<td>CTSA10</td>
<td>1250 Amps</td>
<td>0.360 in. x 0.360 in.</td>
<td>0.095 in. 0.095 in.</td>
<td>0.285 in. 0.285 in.</td>
<td>0.430 in. 0.430 in.</td>
<td>250 ft 660 ft</td>
<td>200 lb 90 kgs</td>
<td>91</td>
</tr>
<tr>
<td>CTSA12</td>
<td>1600 Amps</td>
<td>0.380 in. x 0.380 in.</td>
<td>0.125 in. 0.125 in.</td>
<td>0.375 in. 0.375 in.</td>
<td>0.600 in. 0.600 in.</td>
<td>250 ft 660 ft</td>
<td>300 lb 136 kgs</td>
<td>91</td>
</tr>
</tbody>
</table>

### Connections to Theft Deterrent Composite Cable

**ERITECH® HAMMERLOCK**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Conductor Size</th>
<th>Ground Stud</th>
</tr>
</thead>
<tbody>
<tr>
<td>36H01</td>
<td>CTSA4 or CTSA6</td>
<td>Nominal 1/4&quot; Copper-bonded</td>
</tr>
<tr>
<td>36H02</td>
<td>CTSA8 or CTSA10</td>
<td>Nominal 5/16&quot; Copper-bonded</td>
</tr>
<tr>
<td>36H03</td>
<td>CTSA12 or CTSA14</td>
<td>Nominal 3/8&quot; Copper-bonded</td>
</tr>
</tbody>
</table>

**CADWELD® Connections**

<table>
<thead>
<tr>
<th>Conductor Size</th>
<th>Model</th>
<th>CADWELD® Model</th>
<th>Ground Stud or Lug</th>
<th>Welding Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTSA4 or CTSA6</td>
<td>CSG1</td>
<td>CSG1-A</td>
<td>Nominal 1/4&quot; Copper-bonded</td>
<td>151</td>
</tr>
<tr>
<td>CTSA8 or CTSA10</td>
<td>CSG1-A</td>
<td>CSG1-B</td>
<td>Nominal 5/16&quot; Copper-bonded</td>
<td>152</td>
</tr>
<tr>
<td>CTSA12 or CTSA14</td>
<td>CSG1-A</td>
<td>CSG1-C</td>
<td>Nominal 3/8&quot; Copper-bonded</td>
<td>153</td>
</tr>
</tbody>
</table>

**Weights do not include end caps.**
Cable Loss Increasing

- **Sound Transit - 2012/5**
  - 4 Miles of cable – 70,000 pounds
  - Cable alone cost >$250K
- **SEPTA**
  - One report theft >$58,000
  - Resulting equipment damage increasing
- **Minneapolis (Central Corridor)**
  - $200 of copper theft - $20K of damage
- **UK railway network for 2010/11**
  - Forced delays to more than 35,000 rail services
  - Cost Network Rail $25 million.
- **French Rail Network and National Railways for 2010**
  - Caused 5800 hours of delays
  - Estimated cost of $40 million
CTMS Background

• Deterrents exist but do not alert customer
  – are too late
  – operational delays
  – overload other cables
  – could cause health and safety implications
CTMS Project Scope

- Can sense loss of cable
- Alarm triggered upon cable theft
- Use with existing or new installations
- Existing cables unaltered
- No frequency overlays
- Independent from existing track circuits
CTMS System Components

Patent Pending
Theft Monitoring System
Questions!
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