Aluminum Conductor Rail

TransTech
POWER TRANSFER SYSTEMS

709 Augusta Arbor Way | Piedmont, SC 29673 | toll free 800.245.4552
phone 864.299.3870 | fax 864.277.7100 | email sales@transtech.com

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Executive Summary

Why are the worlds' Transit Authorities switching and using Stainless Steel Capped Aluminum Conductor Rail?

Lower Electrical Resistance

- Greater Distance Between Substations
  - In many cases a substations have been eliminated
  - Maximizes usage of regenerative braking. Longer conductor rail segments allow more trains to share regenerated power
- More available power due to lower resistance and associated power loss
- Smaller voltage drop
  - Shorter train headway

Mechanical Advantages

- All components are designed and integrated as a system providing best in class reliability and power collection performance
- Light Weight
  - Easier handling
    - Quicker installation
    - Faster repairs
- Increased shoe life due to:
  - Smoother running surface
  - Better joint tolerance

Supply flexibility

- Smaller order quantities
- Short Lead time

Green

- Less Electrical heating loss
- After cap is worn, it can be replaced

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Service History

TransTech and our sister company, Brecknell Willis, are the world leaders in aluminum conductor bar systems. We have designed, manufactured, supplied, and commissioned systems in transit systems around the world.

Our Service & Performance:

- Over **20** years installed base
- Over **1700** miles in use
- No delaminations

Location	Miles	Year
Paris	0.4	2013
LIRR	**2.1**	**2013**
Singapore	22.7	2012
Reggio Calabra	0.2	2012
Kuala Lumpur	0.9	2012
Malaysia	49.7	2012
Incheon	39.1	2011
Singapore	37.3	2011
Milan	24.9	2011
Copenhagen	22.4	2011
Taipei	24.8	2011
London	1.9	2011
TaiPei	22.1	2010
Sao Paulo	32.9	2010
Gurgaon	4.8	2010
LIRR	**6.7**	**2011**
LIRR	**7.6**	**2010**
MNR	**1.5**	**2010**
Oslo	3.9	2010
Singapore	39.1	2010
London	41	2010
Oslo	3.1	2009
Singapore	1.4	2009
London	5.6	2009
Singapore	11.2	2009
Mumbai	49.7	2009
Metro	44.1	2009
London	36	2009
MNR	**3**	**2009**
London	5	2008
Tianjin	33.6	2008
London	7.5	2008

Location	Miles	Year
London	5.9	2008
Beijing	43.5	2008
London	16.2	2008
Busan	31.7	2008
London	5	2008
London	0.7	2008
Rotterdam	0.8	2008
MNR	**3**	**2008**
Oslo	3.7	2007
Dubai	36	2007
London	4.3	2007
Berlin	0.5	2007
London	9.9	2007
London	7.5	2007
Algiers	14.9	2007
London	4.3	2007
Berlin	0.4	2006
Berlin	1.8	2006
Prague	6.8	2006
Taipei	74.6	2006
London	31.1	2006
London	3.1	2006
Singapore	5	2006
Dubai	84.5	2006
Berlin	8.1	2005
Berlin	1.8	2005
Beijing	46.6	2005
Korea	24.9	2005
Brescia	24.9	2005
MNR	**0.3**	**2005**
LIRR	**0.3**	**2005**
London	1.6	2004

Location	Miles	Year
Taiwan	77.7	2004
Berlin	19.6	2004
NYCT	**0.6**	**2004**
London	5	2003
Berlin	20.2	2003
Paris	2.2	2003
Buenos Aires	2.5	2003
Ankara	19.9	2002
Prague	5	2002
Singapore	49.7	2002
Taipei	17.4	2001
Kuala Lumpur	24.1	2001
London	17.1	2001
MNR	**6**	**2001**
Vancouver	**54.7**	**1999**
Berlin	0.1	1999
Singapore	8.4	1998
Changi Airport	5	1998
Hsintien:	17.4	1997
Taipei	28	1997
Copenhagen	19.9	1997
Izmir	17.4	1997
London	5	1997
Taipei	7.8	1996
RTSE	18.6	1996
London	16.5	1995
Naples	0.3	1995
London	55.9	1994
British Rail	1.6	1993
London	23.6	1992
London	11.2	1991
London	3.1	1990

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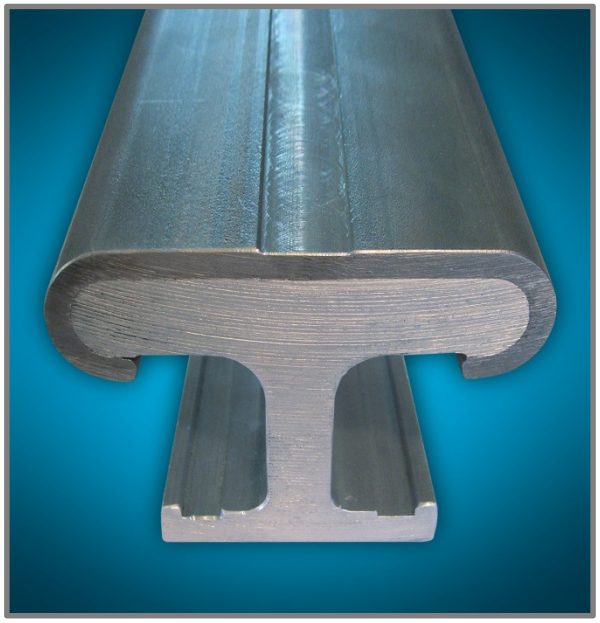
Rail Construction

Cap Construction

- The cap is constructed of two “J” shaped Stainless Steel sections welded along the seam
- When the weld cools it tightens the Cap around the aluminum and creates a best-in-class mechanical and electrical interface
- Two cap width and thicknesses are available
    - 3-5/8” wide 0.17” thick
    - 4-1/8” wide 0.25” thick
- Stainless steel grade is service proven to maximize conductivity and maximize corrosion resistance.

Aluminum

- Custom profiles can be created to meet most envelope constraints.
    - Standard profiles are available to replace; conventional150#ASCA steel rail and 84# and 85# composite rail profiles
- Due to the precise aluminum extrusion dimensions and the tightening effect of the cap;
    - The electrical resistance between cap and aluminum is extremely low
    - The high pressure / friction interface ensures no slipping between cap and aluminum during temperature fluctuations causing expansion and contraction of the rail.



Electrical Considerations

- Resistance between cap and aluminum is very low
- Aluminum provides very low resistince
    - 7L cross section 1.3 mohm/1000ft
    - No 6 cross section 2.0 mohm/1000ft
    - Custom cross sections can be supplied to meet specific requirements
- Cap is fixed continuously along the entire length (as opposed to discrete fixingng points) providing a continuous cap interface resistance with no “hot spots”

Rail Implementation

Fit and Finish

- Rail ends match with a tolorance of +/- 0.5mm, providing:
  - Excellent transitions between rails
    - No field grinding/smoothing required
    - Smooth collector shoe trasntions, resulting in improved shoe life
- Rails can be installed in any orientation (side-running, top-running, under-running)
- Rails can be installed in any direction (non directional – any end can be mounted to one another)
- Radiuses: The aluminum construction allows for easy field bending
  - > 300FT: can be field bent without special tools
  - < 300FT: can be bent by conventional rail bender or supplied form the factory prebent

Service Life & Interface

- Both Cast Iron or Carbon shoes can be used on the rail

CASE STUDY
NYCT has more than 5 years of service with our rail on their mainline with 1,300,000 cast iron shoe passes per year.
Wear measurement after 5 years << 0.1mm

- Expected life of 50-80 years on main line usage,
- Stainless Steel has 4:1 wear rate compare to ferrous steel
- Comparable to superior life expectance

Rail / Splice Joints

Purpose:

1. Mechanically join and align two pieces of Conductor Rail
2. Electrically connect two pieces of Conductor Rail

Construction/Design:

- The all aluminum splice joint minimizes weight and eliminates any dissimilar metal corrosion issues
- Wedge interface point (see below)
- Profile typically remains within the conductor rail envelope.
- Custom profiles are available to meet customer power and physical envelope (space) requirements

Installation:

- Huck Bolt fixation (preferred), this minimizes installation variances and provides a reliable, vibration proof fixation
- Grade 5 to 8 Bolt and Nut fixation capable
- All joints are coated with anti-oxidizing paste upon installation to ensure long term resistance to corrosion
- Used to interconnect all rail, expansion joins and ramps

Cross-sectional Design:

- Mechanical Considerations
  - The wedge interface ensures precise alignments of conductor rail sections, coupled with the precise cap attachment, running surfaces align with 0.5mm, providing the closest fit in the industry resulting no field grinding and increased shoe life.
- Electrical Considerations:
  - The wedge interface, provides extremely low contact resistance due to the :
    - large interface area between contact surfaces
    - The wedge's mechanical advantage increasing the contact pressure between the splice and conductor rail
    - The wedge distributes pressure along entire splice length.

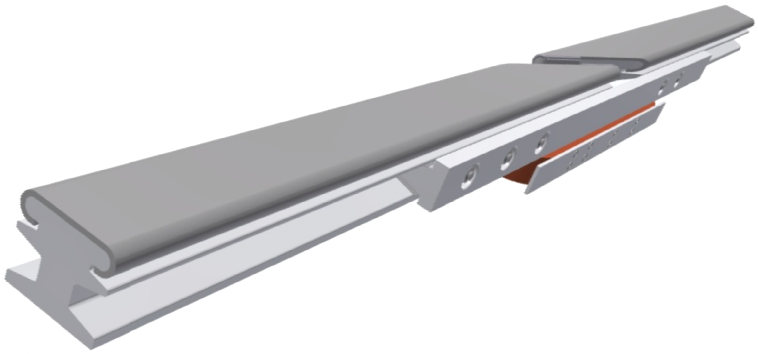
Summary:

- The combination of wedge interface, huck-bolt fixation, oxide paste application and aluminum-to-aluminum interface ensure best-in-class, long lasting, lowest resistance splice available.

Expansion Joints

Purpose:

- The Expansion Joint is used to electrically connect two rail segments while allowing for expansion and contraction of each rail segment while providing a smooth reliable transition for the collector shoe



Construction

- Assembly is constructed from 2 pieces of conductor rail, totaling approximately 6 ft long
  - Ends are square cut with standard bolt holes (to connect to next rail with a splice joint)
  - Interior joint is cut at a minor angle to create a smooth transition for contact shoe
- Two rails are free moving and connected with alignment splice which allows movement in the longitudal direction (for expansion and contraction) but inhibits any other motion, ensuring the two running surfaces have smooth transition
- Electrical connection is created using a coiled tin plated copper shunt, therefore no external cabling is required.

Details

- Compact, self supporting shunt design
- Can be designed and installed for any orientation (Side running, over running, under running)
- Reliable mechanical transition and electrical connections with low to no maintenance

Installation

- Bar is easily installed with standard splice joints
- Expansion gap is set using the marked scale on the assembly.

*** * No additional electrical connections or cabling required * ***

Electrical connections are integrated in the assembly via the coil shunt.

Service History

- Over 20 years of service history in transit authorities (environments & weather conditions) around the world.
- Over 20,000 units installed and in use.

Ramps

Purpose:

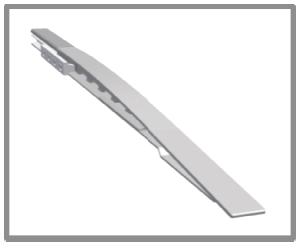
- The ramp is used to create a smooth transition for shoe engagement on and off of conductor rail segments while minimizing opportunity for collector/shoe damage.

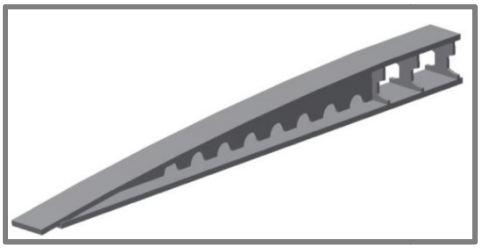
Construction

- Welded steel fabrication constructed from
  - Stainless steel running surface
  - Galvanized, mild steel support structure
- Webbed splice engagement area provides tight tolerance between running surface and splice joint engagement point.
- Light weight construction compared to cast versions

Installation

- Attached to conductor rail with standard splice joint assembly
- Minimal to No surface match grinding required due to:
  - Tight manufacturing tolerance of ramp and rail
  - Lower wear rate of conductor rail requires less transition to be made when attaching new ramp to in service rail
- Easier handling and installation due to light weight design





Design Features

- Running surface is parabolic to ensure smooth, reliable transition of shoe on and off of conductor rail
- Ramps can be provided in various lengths
  - Long ramps >4ft are typically used for high speed/main line applications
  - Short ramps <4ft are typically used for low speed /yard applications
- Stainless steel running surface holds-up well to electrical and mechanical loads
- Transitions between ramps and conductor rail is smooth, maximize shoe tracking
- Ramp running surface widths can be adjusted to accommodate multiple collector shoe designs
- Custom ramp designs available.

Insulators & Supports

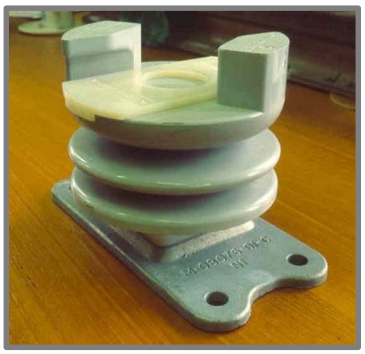
TransTech POWER TRANSFER SYSTEMS

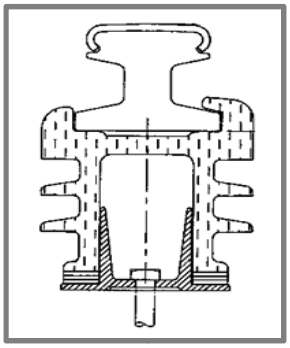
Purpose

- The insualtor is used to mechncially fix the condcutor bar in postion relative to the running rail while allowing the condcutor rail to move for expasion and contraction.
- The Insualtor is non-coductive, insulating the condoctor bar from the insulators mounting point.

Construction

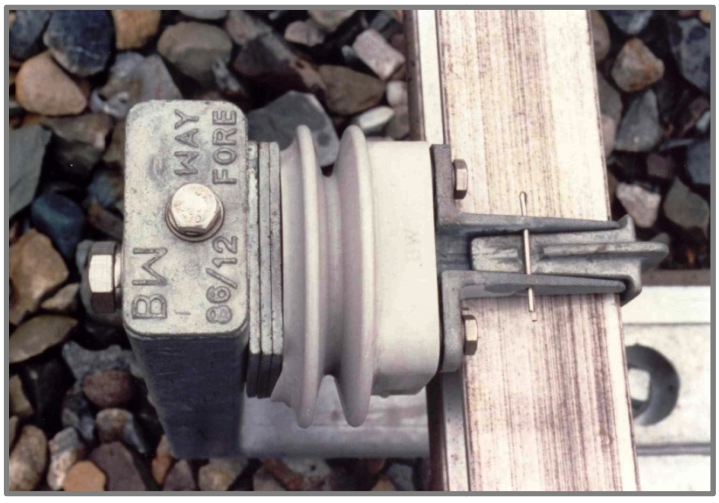
- Insualtors are constructed of railroad approved thermoset fiberglass rienforced polyseter (FRP) molded into the appropriate shape required to retain the conductor rail in position.
- Support structures are made of fabricated or cast steel and/or molded FRP assemblies





Design

- Most of TransTech's insualtors encapsulate the rail and restrict the movement of the rail realtive to the running rail. The most common designs used are the *Claw* and the *Twist-lock* desings, some benefits are:
  - Restriction of rail motion, escpecially in short circuit situations
  - Easy replacemnt without tools
  - Allows ties to move vertically without fatiguing insualtor
- Multiple configurations available for all; overruning, side running, and underrunnig applications
- Custom insutlators and support strucures can be manufactured to meet specific customer requiremnts.



Coverboard Systems

Purpose

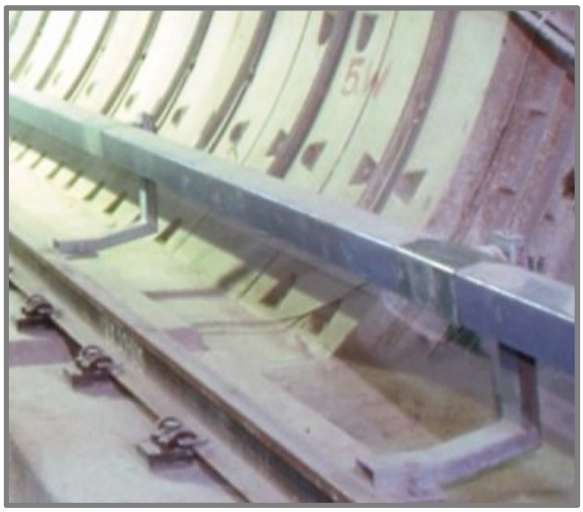
- Coverboard systems are used to restrict access to the rail and/or inhibit rain and ice from accumulating on running surface of the contact rail.

Construction

- TransTech provides various construct rail cover boars systems to meet customer space, environmental, and strength requirements.
  - Direct mount which uses FRP spacers and fiberglass reinforced coverboards
  - Coverboard Brackets:
    - Rail mounted
    - Tie mounted

Design

- These designs are durable Rail Road grade coverings designed to meet customer strength and dielectric requirements. TransTech can also custom design and manufacture coverboard systems to meet customers specific requirements



Manufacturing & Supply

Manufacturing:

- Rail and Components can be supplied from any of three manufacturing facilities

Greenville, SC, USA | Chard, England | Tain Jin, China

- American Supply is **100% Buy America Compliant**
- Each Facility has independent Supply chains
- Each facility is ISO 9001:2008 certified

Order Size & Lead Time

- Due to the construction and manufacturing method TransTech can easily accommodate smaller order quantities
- Lead times as low as 4 weeks are available on standard profiles

Markings

- All rails are marked with:
  - serialized identification number
  - manufacturer mark (TTI)
  - manufacture week/year and 100% inspections

Bending

- Rails can be factory roll formed to customer specific curve requirements
- Most bends can be made in the field without special equipment

Length

- Standard length of Rails or 39ft,
- Lengths up to 50ft can be supplied

Shipping Methods

- Rails can be shipped by various methods:
  - Dedicated, open flat bed truck
  - Rail Road Gondola
  - Special shipping can be arranged to meet customer needs

Integration

New Systems

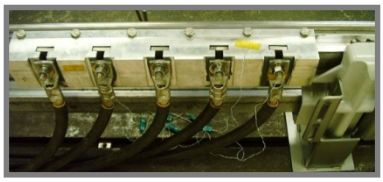
- TransTech & Brecknell Willis (Sister Company) design the entire system and all associated components
  - Component design of rail, insulators, anchors, feeders, covers, etc..
  - Detailed layout / installation drawings
- TransTech differentiates itself as the ONLY supplier of both sides of the interface, we understand the entire system providing optimal performance
  - Conductor rail system
  - Shoe gear
- Coordinate all interfaces with Track work Engineers and train builders
- Field Engineering installation support and commissioning
- Maintenance an life cycle contracts

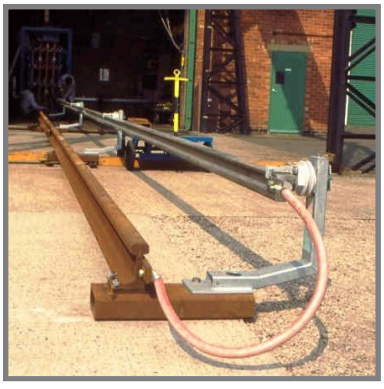
Retro Fit systems

- Specific designs of the rail profile and components can be created to easily integrate our technology into your existing systems:
  - Physical envelope constraints
  - Resistance (power) requirements
  - Integrated use of existing components such as cover board and insulators

Testing and Analysis Capabilities

- Production Tests
  - Cap resistance, overall resistance
  - Material certifications
  - Dimensional verifications (cap groove, end flatness ,etc...)
  - Weld strength destructive samplings
- Type/Qualifications Testing (including but not limited to)
  - Extreme Temperature Test
  - Mechanical loading/strength test
  - Electrical loading tests (Ampacity/heat)
  - Temperature cycle testing
  - Short Circuit Testing (Insulator Test)
- Routinely perform customer specified RAMS studies





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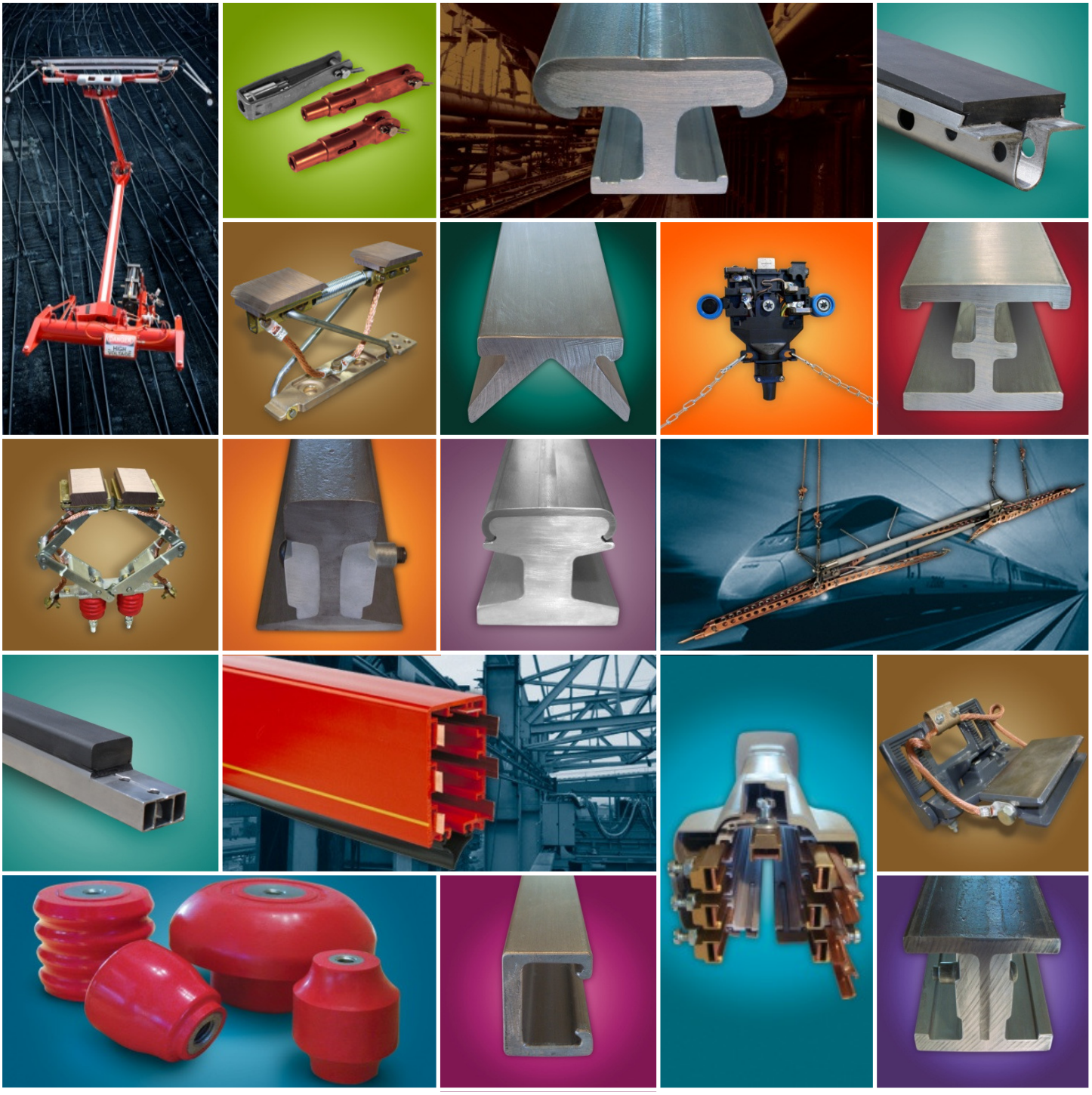

Moving Electrification Forward

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