Corrosion is a natural and inevitable process. It cannot be eliminated, but it can be managed and controlled with the right products.

<table>
<thead>
<tr>
<th>Thomas &amp; Betts Solution Sets</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Corrosion &amp; Harsh Environment Protection</strong></td>
</tr>
<tr>
<td><strong>Grounding &amp; Bonding</strong></td>
</tr>
<tr>
<td><strong>Power Quality, Efficiency &amp; Reliability</strong></td>
</tr>
<tr>
<td><strong>Safety &amp; Contamination</strong></td>
</tr>
<tr>
<td><strong>Continuous Operation &amp; Sustainability</strong></td>
</tr>
<tr>
<td><strong>Hazardous Location Protection</strong></td>
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<tr>
<td><strong>SKU Reduction</strong></td>
</tr>
<tr>
<td><strong>Total Project Cost Reduction</strong></td>
</tr>
<tr>
<td><strong>Liquid Ingress Protection</strong></td>
</tr>
<tr>
<td><strong>Extreme Temperature Protection</strong></td>
</tr>
<tr>
<td><strong>Services &amp; Training</strong></td>
</tr>
</tbody>
</table>
Corrosion Is Eating Away at Your Bottom Line

The direct effects of corrosion costs U.S. industry and government $276 billion annually, according to a study commissioned by the U.S. Federal Highway Administration (FHWA).* This figure reflects only the direct costs of corrosion, such as the expense of repairing a bridge that has become structurally deficient due to steel corrosion or the cost of treated drinking water lost from a corrosion-induced leak in a municipal water pipeline. It doesn’t begin to take into account the indirect costs of corrosion, such as the cost of labor related to corrosion-management activities or the loss of revenue due to disruption in product supply. The FHWA study conservatively estimated this as equal to the direct costs.

Corrosion is a natural, inevitable process. It cannot be eliminated, but it can be managed and controlled. The FHWA study estimates that the implementation of optimum corrosion management practices could save as much as 25–30% of annual cost of corrosion in the U.S.

**Extrapolated Corrosion Cost: $276 Billion, 3.1% of GDP**

* The “Corrosion Costs and Preventive Strategies in the United States” study (Publication No. FHWA-RD-01-156), released in 2002, was commissioned and funded by the U.S. Federal Highway Administration (DOT), Y. Paul Virmani, project manager; conducted by Gerhardus H. Koch, Michiel P.H. Brongers and Neil G. Thompson of CC Technologies Laboratories, Inc., of Dublin, Ohio, in association with J.H. Payer, Ph.D. of Case Western Reserve University, Cleveland, Ohio; and sponsored by NACE International of Houston, Texas.
Causes of Corrosion

Corrosion is the deterioration of metal caused by a chemical reaction to its surrounding environment. In most cases this means electrochemical oxidation of metals in reaction with an oxidant such as oxygen. Corrosion can be accelerated by the presence of dust, moisture, high relative humidity, high temperatures, salt, acids, solvents and chemicals. How quickly corrosion occurs depends not only on the environment, but also on the specific type of metal. Cast iron, for example, rapidly oxidizes and forms red rust if left in its raw state, simply from exposure to the air, so it requires some form of protective finish. Other metals, such as stainless steel, have an inherently higher resistance to corrosion without the need for special coating.

What Corrosion Looks Like

When we think of corrosion, red rust that forms on iron or steel typically comes to mind, but corrosion may also appear in other forms, depending on the metal. White rust is corrosion of the zinc that is typically used as a protective coating over iron or steel. The natural green patina on the Statue of Liberty and on copper roofs is also a form of corrosion.
The Effects of Corrosion on the Electrical System

Corrosion in electrical systems typically represents only a fraction of the direct costs for many industries, but it yields a disproportionately large share of the indirect costs. Corrosion in electrical contacts creates high resistance and unreliable connections, which lead to poor power quality. In production and manufacturing, where downtime can be very costly, failure of a relatively inexpensive electrical component that leads to loss of power and control to production equipment can quickly add up to thousands of dollars in lost productivity. In aircraft, corrosion that causes electrical system failure can result in loss of life.

Electrical systems, therefore, are a prime area in which an upfront investment in corrosion protection returns significant cost savings, as well as increased safety and other benefits, over the long term. This means selecting electrical conduit, fittings, support systems and accessories in corrosion-resistant materials appropriate for the environment in which they’ll be installed.

Corrosion Protection of Electrical Conduit Systems

Corrosion Protection Options

<table>
<thead>
<tr>
<th>CHEMICAL CATEGORY</th>
<th>CHEMICAL EXAMPLES</th>
<th>PVC</th>
<th>URETHANE</th>
<th>304 STAINLESS STEEL</th>
<th>316 STAINLESS STEEL</th>
<th>POLY CARBONATE</th>
<th>CAST IRON</th>
<th>BRASS</th>
<th>ALUMINUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solvents (excluding alcohols and aliphatic)</td>
<td>Acetone, toluene, ketones, etc.</td>
<td>NR</td>
<td>NR</td>
<td>L</td>
<td>L</td>
<td>NR</td>
<td>L</td>
<td>L</td>
<td>L</td>
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<tr>
<td>Fuels</td>
<td>Jet fuel (alcohol based and aliphatic solvent based)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Plating Solutions</td>
<td>Chrome, nickel, copper, brass, gold, zinc, etc.</td>
<td>L</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Salts and Alkaline Materials</td>
<td>Caustic soda, caustic potash, alkaline cleaners, etc.</td>
<td>L</td>
<td>F</td>
<td>L</td>
<td>L</td>
<td>F</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
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<tr>
<td>Mild Acids</td>
<td>Low-concentration hydrochloric, sulfuric, fruit acids, glycolic, citric, etc.</td>
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<td>S</td>
<td>L</td>
<td>L</td>
<td>S</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
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<tr>
<td>Strong or High-Purity Acids</td>
<td>Nitric, hydrofluoric, etc.</td>
<td>S</td>
<td>S</td>
<td>F</td>
<td>F</td>
<td>S</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Oxidizing Agents</td>
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<td>L</td>
<td>L</td>
<td>S</td>
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Chemical Compatibility Legend

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<th>SUITABILITY DESCRIPTION</th>
<th>Compatibility Rating</th>
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<tr>
<td>Rated for all Fumes, Splash &amp; Liquid</td>
<td>L</td>
</tr>
<tr>
<td>Rated only for Fumes &amp; Splash</td>
<td>S</td>
</tr>
<tr>
<td>Rated for Fumes only</td>
<td>F</td>
</tr>
<tr>
<td>Not Recommended</td>
<td>NR</td>
</tr>
</tbody>
</table>

The chart above provides a general guide for the end user to choose the most suitable material for corrosion protection. Compatibility with chemical environment should be thoroughly evaluated for each installation.

Galvanic Corrosion

Galvanic corrosion results from contact between electrochemically dissimilar metals. If you connect bare copper and aluminum — two metals commonly used for electrical wiring and connectors — the aluminum, being the less noble and more anodic of the two metals, will be attacked by galvanic corrosion. However, connectors for code construction are typically tin plated, which prevents galvanic corrosion, and tin-plated aluminum connectors that are UL® Listed as dual-rated may be used safely on either aluminum or copper conductors.

The white rust that forms on galvanized steel is also an example of galvanic corrosion. The more anodic and less noble zinc applied over steel during galvanizing is intended to act as a sacrificial layer to protect the steel underneath. White rust is evidence that the zinc coating is serving its purpose; the appearance of red rust indicates corrosion of the steel.
Delivering value through system solutions based on engineering innovation.

Our Value Commitment

Thomas & Betts is committed to helping you meet the challenges of corrosion prevention with electrical solutions, services and systems that deliver value. These include:

T&B Engineered solutions — Our products are designed to perform dependably under conditions such as constant moisture, harsh chemicals, extreme temperatures, high-pressure washdown, ultraviolet exposure, hazardous areas, high-vibration equipment and continuous operation.

Tested reliability — Our products are rigorously tested for use in harsh environments, with proven results in thousands of installations.

Expert support — Thomas & Betts trained sales representatives and technical services experts are available at every stage of a project, from planning and site preparation through construction and MRO.

Training and certification — Thomas & Betts conducts training programs on specific products and systems and works closely with accredited electrical industry associations. Contact us for details.

Product availability — Our industry-leading distributor network assures you of reliable and on-time delivery. This global electrical product support system ensures that our solutions are available when and where you need them.

Product Platforms

For over a century, Thomas & Betts has provided customers with electrical system solutions to help protect their people and assets, while meeting applicable codes, lowering installed costs and providing overall value.

Wire and Cable Management — Thomas & Betts invented the Ty-Rap® Cable Ties in 1958 and continues to lead the industry in innovative wire and cable management solutions. For harsh and corrosive environments, we offer Ty-Rap® Cable Ties in coated and uncoated stainless steel as well as polypropylene and fluoropolymer materials.

Cable Protection Systems — Electrical systems exist in harsh and corrosive environments, extreme temperatures and hazardous locations. Thomas & Betts has engineered, tested and certified raceway solutions for all types of wires, cables and cords, offering long life and safe, reliable, maintenance-free performance, regardless of environmental conditions.

Power Connection and Control — Advanced electronic and electrical systems require signals and controls to be extremely accurate, consistent and reliable. Our power connection and control system solutions make this expectation a reality for your low-, medium- and high-voltage electrical system needs.

Safety Technology — Thomas & Betts is a worldwide leader in lightning and surge protection, hazardous location lighting, emergency lighting and supporting central battery systems. We use state-of-the-art technologies to design our electrical system solutions so they meet global safety and reliability standards.
Thomas & Betts has the products you need for demanding applications in harsh and highly corrosive environments.
Corrosion-Resistant Materials

Stainless Steel

Stainless steel is the household name for metal alloys containing at least 10.5% chromium and more than 50% iron. It provides one of the most hygienic surfaces, because it is very easy to clean and its surface has no pores or cracks to harbor bacteria and other impurities. It resists corrosion, withstands high temperatures and is easily maintained.

Type 304 stainless steel contains primarily iron, chromium and nickel. Sometimes referred to as marine-grade, Type 316 stainless steel is similar in formula to Type 304, but molybdenum is added to strengthen the stainless steel against surface pitting and other deterioration.

For electrical conduit systems, stainless steel offers performance that’s hard to match, combining high corrosion and chemical resistance with strength, durability, ease of installation and low maintenance. Generally speaking, when compared to using standard galvanized steel conduit in corrosive environments, stainless steel offers three to five times the lifespan for Type 304 and four to eight times the lifespan for Type 316.

PVC-Coated Metals

One method to improve the corrosion resistance of standard galvanized steel or iron, as well as aluminum, is to coat the metal in PVC (polyvinyl chloride). Numerous industry standards, including UL6, ANSI C80.1 and NEMA RN-1, cover the manufacture and testing of PVC-coated conduit systems. Compliance with these standards, combined with installation by a contractor experienced with the special requirements of working with PVC-coated conduit, helps to ensure a quality system that will withstand corrosive environments. In general, PVC-coated metal provides strong resistance to most chemicals and will typically last nearly twice as long as standard galvanized steel conduit in corrosive environments.

Non-Metallic Materials

One way to avoid corrosion is to eliminate the use of metal. While complete elimination of metal is usually not practical in real-world applications, there are plenty of alternative materials for electrical raceway system components and accessories. These include PVC, polycarbonate, nylon, fiberglass and others. PVC conduit and fittings provide excellent protection when wiring systems need to be embedded in concrete, for example.

Because different non-metallic material properties and characteristics vary so widely, you should always check the specifications of any material you’re considering for compatibility with the environment in which you’re planning to use it. In addition, most non-metallic materials have limitations for maximum operating temperature that must be taken into consideration to avoid softening or melting of components in high heat areas.
Aluminum

Aluminum provides the advantages of high strength-to-weight ratio, superior resistance to certain corrosive environments and ease of installation. Aluminum typically weighs about 50% less than steel and requires no maintenance after installation. It offers excellent resistance to solvents and fuels, but is not recommended for exposure to other types of chemicals, including salt, bleach, acid or chlorine.

In general, standard copper-free aluminum alloys such as A360 cannot be relied upon to provide any appreciably longer lifespan than galvanized cast iron or steel in most corrosive environments. However, certain specialty aluminum alloys have been developed to provide a higher degree of corrosion protection. These include the Thomas & Betts CorroStall® aluminum alloy, which offers excellent corrosion resistance as cast, without the need for protective coating, and up to 300% longer life.

Other Options

In addition to PVC coating, other protective finishes and coatings have been developed to give galvanized cast iron or steel superior protection against corrosion.

One example is the Thomas & Betts BlueKote® finish for cast iron alloy conduit bodies. The BlueKote® finish starts with the electro-zinc plating with chromate finish that most ferrous conduit bodies feature, but then adds a baked-on layer of powder-coated epoxy, followed by another baked-on layer of epoxy paint. Last, the signature BlueKote® finish is applied to and baked on the interior of the conduit body.

As another example, the Thomas & Betts Galv-Krom® finish for Kindorf® Modular Metal Framing is a gold trivalent finish applied over electro-galvanized steel to provide superior corrosion resistance as compared to industry-standard pre-galvanized G90 steel strut. The trivalent Galv-Krom® finish is OSHA and RoHS (Restriction of Hazardous Substances) compliant.
# Harsh Chemicals Used

## Chemical Resistance Performance Rating

<table>
<thead>
<tr>
<th>A</th>
<th>Best</th>
<th>B</th>
<th>Better</th>
<th>C</th>
<th>Good</th>
<th>D</th>
<th>Poor</th>
</tr>
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</table>

## Overall Chemical Resistance

<table>
<thead>
<tr>
<th>Material</th>
<th>Phosphoric Acid (Crude)</th>
<th>Phosphoric Acid (&gt;40%)</th>
<th>Sodium Hydroxide (50%)</th>
<th>Sodium Carbonate</th>
<th>Sodium Metasilicate</th>
<th>Sodium Silicate</th>
<th>Hydrogen Peroxide (30%)</th>
<th>Acetic Acid (20%)</th>
<th>Sulfuric Acid</th>
<th>Chlorine (gas)</th>
<th>Fruit Juice</th>
<th>Chlorine, Anhydrous Acid</th>
<th>Chlorine Water</th>
<th>CLOROX® Bleach</th>
</tr>
</thead>
<tbody>
<tr>
<td>316 Stainless</td>
<td>A</td>
<td>B</td>
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<td>B</td>
<td>B</td>
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<td>A</td>
<td>C</td>
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<td>C</td>
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</tbody>
</table>
Materials Comparison

Food and beverage processing plants consume over 370,000 tons of stainless steel each year. You can achieve savings up to 33% through careful selection of appropriate materials for your specific application.

<table>
<thead>
<tr>
<th>Material</th>
<th>316 Stainless</th>
<th>304 Stainless</th>
<th>Aluminum</th>
<th>Brass</th>
<th>Cast Iron</th>
<th>PVC</th>
<th>PVC Coated</th>
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<td>Ocal® PVC-Coated Conduit</td>
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<td>Hazlux® Lighting Fixtures</td>
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<td>T&amp;B® Fittings Type 316 Stainless Steel Form 8 Conduit Bodies</td>
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<td>DuraGard® Pin-and-Sleeve Connectors</td>
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Stainless Steel Solutions

T&B® Fittings

Type 316 Stainless Steel
Form 8 Conduit Bodies

- Marine-grade Type 316 stainless steel construction in rugged Form 8 design for the harshest environments
- Available in shapes LB, T, TB and the versatile new LU® Universal Conduit Elbow
- Ship complete with covers, gaskets and screws
- Hub sizes from 1/8" to 2"
- UL® Listed and CSA Certified

T&B® Cable Tray

Type 316 Stainless Steel
Cable Tray

- Ladder, ventilated and solid trough designs
- Full range of classes and associated loading capacities
- Complete selection of fittings and covers

Stainless Steel Solutions

Type 316 Stainless Steel
Form 8 Conduit Bodies

- Marine-grade Type 316 stainless steel construction in rugged Form 8 design for the harshest environments
- Available in shapes LB, T, TB and the versatile new LU® Universal Conduit Elbow
- Ship complete with covers, gaskets and screws
- Hub sizes from 1/8" to 2"
- UL® Listed and CSA Certified

T&B® Fittings

Stainless Steel Solutions

- High flexibility and high fatigue life
- Operating temperatures up to 660°F in static applications and 480°F in moving applications
- Also available in stainless steel overbraid style for EMI screening and in versions designed for use in hazardous locations

Ty-Rap®

Stainless Steel
Cable Ties

- Uncoated Type 302/304 and Type 316 stainless steel
- Also available in polyester-coated Type 316 stainless steel
- Secure, heavy-duty ball locking mechanism
**OCAL-BLUE® Conduit**

- Hot-dipped galvanized steel or aluminum conduit
- Hot-dipped galvanized threads (steel conduit only)
- Nominal 2 mils blue urethane coating on interior
- Minimum 40 mils PVC coating on exterior

**OCAL-BLUE® Double-Coated STAR TECK EXTREME® Fittings**

- Aluminum fittings for jacketed metal-clad and teck cables
- Nominal 2 mils blue urethane coating on both interior and exterior
- Nominal 40 mils PVC coating bonded to exterior
- For use in ordinary and hazardous locations

**OCAL-BLUE® Double-Coated GUA Series Conduit Boxes**

- Ductile iron bodies with O-ring gasketed cast aluminum covers
- Nominal 2 mils blue urethane coating on both interior and exterior
- Nominal 40 mils PVC coating bonded to exterior
- For use in hazardous locations

**OCAL-BLUE® Standard- and Large-Radius Elbows**

- Fabricated from Ocal® PVC-coated conduit
- Factory bent to save time and wasted materials
- Standard radius 30°, 45°, 60° and 90° and large-radius 90° available for immediate shipment
- Special radius and other angles available upon request

**OCAL-BLUE® Double-Coated UL® Listed Type 4X Form B Conduit Bodies**

- UL® Listed Type 4X and NEMA 4X rating for excellent protection against washdown, moisture, rain, ice or snow
- Cast iron bodies and covers coated inside and out with 2 mils blue urethane, then exterior coated with minimum 40 mils PVC in gray (standard), blue, white or custom colors
- Ship complete with cover with integral O-ring seal and stainless steel encapsulated screws
- Available in all popular shapes in hub sizes from ½” to 2”

**PVC-Coated Strut, Straps and Clamps**

- Steel strut with nominal 15 mils PVC coating
- Full line of PVC-coated beam clamps, pipe straps, conduit hangers and threaded rod also available

**PVC-Coated Liquidtight Conduit Connectors**

- Genuine T&B® liquidtight conduit fittings — straight, 45° and 90°
- Nominal 40 mils PVC coating bonded to exterior
- Pressure-sealing sleeves protect connections

**OCAL-BLUE® Standard-and Large-Radius Elbows**

- Genuine T&B® liquidtight conduit fittings — straight, 45° and 90°
- Nominal 40 mils PVC coating bonded to exterior
- Pressure-sealing sleeves protect connections
Non-Metallic Solutions

PMA®
High-Performance Flexible Nylon Conduit Systems

• Wide selection of flexible polyamide conduit provides excellent flexing and fatigue life in extreme operating temperature ranges
• Excellent resistance to highly corrosive chemicals
• Complete line of easy-to-install straight and angled fittings
• IP66, IP68 and IP69K liquid ingress protection

T&B® Fittings
Non-Metallic Conduit and Fittings

• Type A PVC flexible conduit and chemical-resistant, non-burning thermoplastic fittings
• XTRA FLEX® PVC Liquidtight Type B conduit and Bullet® non-metallic liquidtight fittings
• Variety of other non-metallic conduit and cord fittings available

Kindorf®
Non-Metallic Modular Framing Channel and Accessories

• Rugged polyester and vinylester construction
• 1 1/2" x 1 1/2" channel dimension reduces installation costs and waste
• Full range of non-metallic fittings, pipe clamps and hardware

Ty-Rap®
Cable Ties for Harsh Environments

• Weather-, UV- and chemical-resistant polypropylene (black)
• Flame-retardant, low-smoke density, UL94V-0 fluoropolymer (maroon)
• Radiation-resistant, UL94V-0 fluoropolymer (aqua)

Russellstoll®
DuraGard® Waterproof Pin-and-Sleeve Connections

• Not just watertight, but waterproof, mated or unmated
• Tested to 1,000 psi for washdown applications
• Full line of 20A to 60A connectors, plugs and receptacles in UL94V-0, corrosion-resistant thermoplastic housings
T&B Cable Tray

- Ladder, ventilated and solid trough designs
- Full range of classes and associated loading capacities
- Complete selection of fittings and covers

Aluminum & Other Solutions

T&B Fittings

CorroStall® Aluminum Conduit Boxes

- Special copper-free aluminum alloy provides superior corrosion resistance compared to standard copper-free aluminum
- Designed and tested to withstand prolonged exposure to corrosive agents and extreme temperatures
- Available in single- and double-gang sizes with a variety of outlet configurations

T&B Fittings

Galv-Krom® and Aluminum Modular Framing Channel and Accessories

- Galv-Krom® gold trivalent finish provides superior corrosion protection over electro-galvanized steel
- Also available in 6063 extruded aluminum
- Full range of fittings and accessories available in both Galv-Krom® finish and aluminum

Sta-Kon®

Corrosion-Resistant Nickel-Plated Wire Terminals

- High-performance solderless crimp terminals
- Complete line of ring and fork terminals, splices and disconnects
- Vinyl-insulated, nylon-insulated and non-insulated styles
- Variety of corrosion-resistant finishes and materials

T&B Fittings

BlueKote® Conduit Bodies

- Triple-layer protection over ferrous conduit body — including two layers of epoxy coating — stops corrosion in its tracks
- BlueKote® internal surface coating provides an additional layer of corrosion protection and reduces force required to pull wires

T&B Fittings

Ranger® Series Aluminum Liquidtight Cord Connectors

- Available in straight or 90° designs
- Designed to accept a wide range of cables, offering nine fittings that cover cord ranges from .125” through .950”
- Slotted design gland nut to accommodate securing in tight spaces

T&B Fittings

Hazcote® Corrosion-Resistant Lighting Fixtures

- Enclosed, gasketed and sealed fixtures for adverse, wet and marine locations
- Cast aluminum housing with Hazcote® corrosion-resistant Kynar® coating
- Polymeric and powder-coated aluminum styles also available
- Fixtures available for both ordinary and hazardous locations

T&B Fittings

Hazcote® Corrosion-Resistant Universal Conduit Elbow

- Available in Forms 7 and 8 in all popular conduit body shapes and sizes — plus the new LU® Universal Conduit Elbow
- Your choice of iron or stainless steel covers
Visit the T&B world of electrical product solutions

Visit our web site for more information about Thomas & Betts solutions and our newest products. For a user-friendly catalog and competitive part number search, application and technical support and other useful information, go to:

www.tnb.com

Industry codes and specifications

All Thomas & Betts products meet or exceed applicable industry specifications or codes which are detailed in the appropriate T&B product literature.

Online CAD library

Thomas & Betts offers free download of two- and three-dimensional CAD models of many of its products in more than 90 native CAD formats at: www.tnb.com/cadlibrary

American Recovery and Reinvestment Act (ARRA)

Get certification letters for compliant products online at:

www.tnb.com/ARRA

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