Engineers guide to structural steel savings with B-Line series cable ladder system
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Lower total install cost solution through reduction of structural steel supports

Eaton provides solutions that de-risk by design and drive value to our end customers. With Eaton's B-Line series cable ladder, Eaton provides support recommendations that meet and exceed NEMA VE-2 requirements. These methods have been applied across the globe on multiple applications and projects, and have saved customers millions of dollars on structural steel.

This brochure provides an overview of Eaton's recommendations for structural steel supports when utilizing Eaton's B-Line series cable ladder, fittings and splice plates. For additional information, and online resources and tools, visit Eaton.com/SSS.

Cable ladder best practice

To maximize cost savings on any cable ladder project, it is essential that:

- Electrical and structural engineers and contractors communicate effectively
- Support plans and layouts are discussed early on within the project life cycle (FEED - Front End Engineering Design) to ensure proper support placement, minimize construction complexity, and reduce budget spend

Support location best practice

<table>
<thead>
<tr>
<th>Support Location</th>
<th>System Stress and Deflection</th>
</tr>
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<tr>
<td>¼ Span</td>
<td>-Minimum</td>
</tr>
<tr>
<td>Mid-Span</td>
<td>-Maximum</td>
</tr>
<tr>
<td>Over Support</td>
<td></td>
</tr>
</tbody>
</table>

**1/4 Span** - The method of placing supports at 1/4 span away from a splice plate location on continuous runs.

- Recommended installation method by NEMA VE 2 and Eaton's B-Line series
- Up to 50% deflection reduction over simple beam or mid span installations
- Eliminates hold down clamp and splice hardware interference issues during thermal expansion and contraction
- See Fig. 1A and Fig. 1B for visual stress comparison

**Mid-Span** - The method of placing supports at 1/2 span away from a splice plate location on continuous runs.

- Excessive system deflection and stress experienced compared to 1/4 span support methodology
- Requires additional supports to account for proper thermal expansion and contraction
- Splice plate performance becomes more influential on deflection
- See Fig. 2A and Fig. 2B for visual stress comparison

**Simple Beam (Over Support)** - The method of placing supports directly under the splice plate locations on continuous runs.

- Maximum system deflection and stress experienced
- Leads to possible installation issues not allowing for proper thermal expansion and contraction
- See Fig. 3A and Fig. 3B for visual stress comparison
NEMA vs IEC Standards
National Electrical Manufacturer Association vs. International Electrotechnical Commission. NEMA & IEC both provide technical requirements regarding the construction, testing, and performance of metallic cable tray systems. However, testing methods differ drastically, showing different performance results. Choosing a manufacturer with proven success with both standards, such as Eaton’s B-Line Division, is crucial to help ensure proper system design.

- IEC has 5 continuous span testing methods where NEMA has only 1 simple beam test method
- IEC test methods are deflection based while NEMA tests to destruction
- Splice plates are included within IEC test methods and not for NEMA
- IEC does not detail support recommendations, the IEC standard refers back to NEMA VE 2
- IEC requires 3rd party witness verification (such as DNV) while NEMA tests to destruction

Choosing a manufacturer with proven success with both standards, such as Eaton’s B-Line Division, is crucial to help ensure proper system design.

Understanding Electrical Continuity
The National Electric Code (NEC) Article 392 states that a cable tray system can be utilized as an EGC (equipment grounding conductor) per the limitations of table 392.60(A).

- Only mechanically discontinuous locations (i.e. expansion splice plates & gaps) need bonding jumpers (required on both side rails)
- Indoor cable tray runs (when temperature controlled) do not require expansion joints, and therefore, bonding jumpers are not required to maintain electrical continuity
- Please see Fig. (4): Cable Ladder Amperage
- Cable tray and ladder systems are tested per UL, CSA, and/or IEC standards

Understanding Thermal Expansion
- Understanding where and how often to allow for thermal expansion and contraction is an essential measure to the longevity of a cable tray system
- Reduced system performance or failure is often due to improper system design NOT allowing for adequate thermal expansion and contraction

For SI units: one square inch=645 square millimeters.

* Total cross-sectional area of both side rails for ladder or trough cable trays; or the minimum cross-sectional area of metal in channel cable trays or cable trays of one-piece construction.

** Steel cable trays shall not be used as equipment grounding conductors for circuits with ground-fault protection above 600 amperes. Aluminum cable trays shall not be used as equipment grounding conductors for circuits with ground-fault protection above 2000 amperes.
Evolution of Project Savings

Eaton’s B-Line series engineered cable ladder solutions are leading the way for lower total installed cost.*

As the cost of structural steel continues to increase, the impact of reducing the quantity of supports on a project can offset the cost of the cable ladder system all together.

*All support details will meet and exceed NEMA VE-2 requirements.
Overview / Introduction

Eaton’s B-Line series metallic cable ladder systems are engineered to provide superior strength to weight ratio while providing the lowest total installed cost of any cable management system in the industry today. This is achieved through continuous innovation, market and customer based knowledge.

To achieve the lowest total installed cost, Eaton’s engineers developed an innovative means to significantly reduce the number of structural steel supports needed in cable ladder installations, without diminishing the load carrying capacity of the system.

In addition, extensive laboratory testing has enabled the Eaton B-Line series cable ladder to exceed the National Electrical Manufacturer’s Association (NEMA) VE-2 support recommendations for cable ladder installations.

The NEMA recommendations are created by active cable ladder manufacturers in North America, and are intended to provide a basic installation guideline for all cable ladder systems.

However, individual manufacturers can provide recommendations for their systems that exceed the basic guidelines outlined by NEMA VE-2 (section 3.5.1).

Utilizing Longer Straight Section Spans

NEMA VE-2, (section 3.4.1) defines an allowable straight section support span as the following: “straight section support span should not exceed the straight section length.”

Therefore, to eliminate supports, one option is to increase the length of cable ladder.

For example, transitioning from 10ft (3m) spans to 20ft (6m) spans reduces supports by 50%.

To create even more savings, Eaton offers B-Line series cable ladder systems that are capable of 30ft (9m) and 40ft (12m) support spans; dramatically reducing the overall quantity of structural supports needed on a job site.

The B-Line series cable ladder features a highly engineered I-beam rail, which maximizes the strength to weight ratio of the system, and allows for longer span capability.
The breadth of materials and sizes enables Eaton to offer the ideal B-Line series solution to meet a variety of customer applications and load criteria. (Refer to Structural Steel Savings (SSS-17) technical reference for support design considerations.)

B-Line series aluminum cable ladder can range up to 40ft (12m) in length while steel can range up to 24ft (7.3m). This difference in length is due to the strength to weight ratio of aluminum.

**Fitting Support Location Recommendations**

When it comes to installing supports, cable tray fittings are one of the biggest challenges. Eaton's B-Line series cable ladder is engineered to provide flexibility in selecting the proper support locations for fittings.

Eaton's industry-leading 3in (75mm) or 4in (100mm) tangents help maximize the strength and load carrying capacity of splice plates at fitting locations which allows for a reduction in support requirements.

In fact, NEMA documentation does not require the testing of fitting locations altogether. However, Eaton has conducted extensive testing on its B-Line series cable ladder to provide several alternative options for supporting horizontal bends, tees, crosses, and vertical bends as compared to the NEMA VE-2 section 3.5.1 recommendations.

NEMA VE-2 (section 3.5.1) states, "Recommended support locations follow, unless otherwise recommended by the manufacturer." (Refer to Structural Steel Savings (SSS-17) technical reference for support design considerations.) Supports are not limited to structural steel, but can be defined as strut channel and angle iron. The same recommendations apply to these supports as well.

**Vertical Adjustable Supports Locations**

For changes in elevation, with intermediate angles, and for cables not requiring a large radius, vertical adjustable splice plates are often the best solution.

NEMA VE-2 (section 3.4.3) states that a support is required within 2ft (600mm) on both sides of every vertical adjustable splice plate regardless of series or span.

Eaton has conducted extensive testing to prove that pairing B-Line series cable ladder and vertical splice plate, installers can forego transitional supports up to half span for steel, stainless steel, and aluminum cable ladder systems (2-5 and metric cable ladder series). This allows a 20ft (6m) ladder to span 10ft (3m) unsupported between adjustable splice plates.

Similarly, cable ladder series are designed for 30ft (9m) spans and can be unsupported up to 15ft (4.5m) between vertical adjustable splice plates and up to 20ft (6m) unsupported spans can be utilized with 40ft (12m) ladders.

Refer to Structural Steel Savings (SSS-17) technical reference for support design considerations. The vertical adjustable splice plate is an unparalleled "Eaton B-Line series only solution," and is applicable for both NEMA and IEC industrial style cable ladders.

**Thermal Expansion Support Location**

Designing and accounting for proper thermal expansion and contraction is key to the longevity of a cable ladder installation.

As NEMA VE-2 details in section 3.4.1, “it is ideal to lay out the system so that splice joints fall between the support and the quarter point.”

It is important to note that placing expansion splice plates directly on top of supports does not comply with NEMA VE-2 section 3.4.2, and is therefore not recommended.

Conversely, Eaton's patented B-Line series heavy duty expansion splice plate eliminates the need to install additional supports within 2ft (600 mm) on each side of the expansion location when placed at the quarter point of a support span.

Similar to the fitting supports detailed above, the performance of Eaton's highly engineered B-Line series heavy duty expansion splice plate complies with and exceeds NEMA VE-2 recommendations as detailed in section 3.4.2.

This equates to the elimination of 2 supports every 65ft (20m) with the typical 20ft (6m) aluminum ladder with a 100°F temperature differential.

**Conclusion**

In conclusion, Eaton is committed to supplying its customers with innovative solutions that will result in the lowest total installed cost.

The most significant cost driver of cable ladder installations is the cost of the supports, whether it is an industrial or commercial application.

Depending on the complexity and location of the project, supports can range anywhere from $500 to over $15,000 each.

By incorporating Eaton's support recommendations with straight sections, fittings, vertical adjustable splice plates, and heavy duty expansion splice plates, B-Line series cable ladder solutions can help eliminate substantial costs in both labor and support materials on any given project.

Please feel free to contact your local Eaton B-Line series cable ladder representative to address any additional questions regarding this information or for assistance in optimizing your support layout.

For more information, visit Eaton.com/sss
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

Vertical Inside / Outside Bend

Support Recommendation

Option 1

“½ Span”

36" (900mm) bend radius max.

½ Span
[10' (3m) max]

If less than or equal to 10' (3m) max.
no intermediate support is required

Support anywhere under fitting or splice plate

Note: Depicted support member acts as dual support for both straight section and fitting when located underneath the splice plate.

*Note: Support profile may be placed at any location underneath splice plate.
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

**Vertical Inside / Outside Bend Support Recommendation**

**Option 2**

“Dual Support”

If less than or equal to ½ span [10' (3m) max.] no intermediate support is required.

Note: Depicted support member acts as dual support for both straight section and fitting when located underneath the splice plate.

*Note: Support profile may be placed at any location underneath splice plate.

I-Beam support method

*Strut support method
Vertical Inside / Outside Bend Support Recommendation
Option 3
“Dual Support”

Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

36” (900mm) bend radius max.

½ Span [10’ (3m) max] from upper fitting

½ Span [10’ (3m) max] from lower fitting

Note: Intermediate supports intervals not to exceed 10’ (3m) on extended vertical drops

Note: Depicted support member acts as dual support for both straight section and fitting when located underneath the splice plate.

*I-Beam support method

*Strut support method

*NEMA Recommendation

Note: Depicted support member acts as dual support for both straight section and fitting when located underneath the splice plate.

*Note: Support profile may be placed at any location underneath splice plate.
Vertical Inside / Outside Bend Support Recommendation
Option 4  “Floating”

Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

Note: Intermediate supports intervals not to exceed 10’ (3m) on extended vertical drops
Horizontal Bend Support Recommendation
Option 1
“½ Span”

Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

NEMA Recommendation

12” - 36” [300-900mm] bend radius.
If larger use NEMA VE-2

½ span or 10’ (3m) max

I-Beam support method

Strut support method

Isometric view
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

**Aluminum**
12" - 24" [300-600mm] bend radius.

**Steel**
12" - 36" [300-900mm] bend radius.

Note: Depicted support member acts as dual support for both straight section and fitting when located underneath the splice plate.

*I-Beam support method*

*Strut support method*
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

**Horizontal Tee Support Recommendation**

**Option 1**

“½ Span”

Support under fitting (2 places typ.)

- ½ span or 10’ (3m) max.
- 12”-36” [300-900mm] bend radius.
  - if larger use NEMA VE-2.

**I-Beam support method**

**Strut support method**

---

**NEMA Recommendation**

At least one additional support should be placed under each side rail at the horizontal tee.

[Center support not required on 12” radial fitting.]
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

**I-Beam support method**

*Strut support method*

**NOTE:** Depicted support member acts as dual support for both straight section and fitting when located underneath the splice plate.

12"-36" Bend Radius. [300-900mm]
If Larger Use NEMA VE-2.
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

**NEMA Recommendation**

**Horizontal Tee Support Recommendation**

**Option 3**

“½ Span / Dual Support”

Support profile may be placed at any location underneath splice plate.

*Note: Depicted support member acts as dual support for both straight section and fitting when located underneath the splice plate.

Full span

½ Span or 10’ (3m) max.

12”-36” [300-900mm] Bend radius. If larger use NEMA VE-2.

I-Beam support method

*Strut support method

Isometric view
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

**Aluminum**  
12" - 24" [300-600mm] bend radius.

**Steel**  
12" - 36" [300-900mm] bend radius.

I-Beam support method  
Strut support method  
Isometric view
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

Horizontal Cross Support Recommendation
Option 1
“½ Span”

NEMA Recommendation

Isometric view

Horizontal Cross
Support Recommendation
Option 1
“½ Span”
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

12" - 36" [300-900mm] bend radius if larger use NEMA VE-2.

½ Span or 10' (3m) max

½ Span or 10' (3m) max

Full span

Full span

*Note: Support profile may be placed at any location underneath splice plate.

I-Beam support method

*Strut support method

Isometric view

NEMA Recommendation

Horizontal Cross Support Recommendation

Option 2

“½ Span / Dual Support”
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

*Note: Support profile may be placed at any location underneath splice plate.

**Horizontal Cross Support Recommendation**

**Option 3**

**“Dual Support”**

NEMA Recommendation

I-Beam support method

*Strut support method*

Isometric view

Plan view

12" - 36" [300-900mm] bend radius

If larger use NEMA VE-2.

Note: Depicted support member acts as dual support for both straight section and fitting when located underneath the splice plate.
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

**Aluminum**
- 12" - 24" [300-600mm] bend radius.
- 2' (600mm) Max.

**Steel**
- 12" - 36" [300-900mm] bend radius.
- 2' (600mm) Max.

*Note: Fitting support profile may be placed at any location underneath reducer or splice plate.*
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

Reducer Fitting Support Recommendation
Standard Option 1
“½ Span”

Supports should be located within 24” (600mm) of each fitting extremity.

Note: Fitting support profile may be placed at any location underneath reducer or splice plate.
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.
Support recommendations apply to B-Line series 2-5 steel and aluminum cable ladder, HDL series, and SDL series steel cable ladder products.

<table>
<thead>
<tr>
<th>Material</th>
<th>Cable Ladder Series</th>
<th>Maximum Unsupported Span</th>
<th>Load Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel and Stainless Steel</td>
<td>Series (2-5) [HPL, SDL, HDL]</td>
<td>10 ft. (3m)</td>
<td>100 lb./ft. (150 kg/m)</td>
</tr>
<tr>
<td>Aluminum</td>
<td>Series (2-4)</td>
<td>10 ft. (3m)</td>
<td>100 lb./ft. (150 kg/m)</td>
</tr>
<tr>
<td>Aluminum</td>
<td>H4 (6&quot; - 150mm height)</td>
<td>10 ft. (3m)</td>
<td>167 lb./ft. (248 kg/m)</td>
</tr>
<tr>
<td>Aluminum</td>
<td>H4 (7&quot; - 175mm height)</td>
<td>10 ft. (3m)</td>
<td>149 lb./ft. (222 kg/m)</td>
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<tr>
<td>Aluminum</td>
<td>Series (5)</td>
<td>15 ft. (4.6m)</td>
<td>100 lb./ft. (150 kg/m)</td>
</tr>
<tr>
<td>Aluminum</td>
<td>S8A</td>
<td>20 ft. (6.1m)</td>
<td>100 lb./ft. (150 kg/m)</td>
</tr>
</tbody>
</table>
**Case Study**

Due to Eaton’s B-Line series cable ladder solutions, engineers across the globe have experienced significant support savings on various commercial, industrial, oil and gas, and other cable management projects. This has yielded significant savings for our customers, and they are speaking up.

> “This is going to save our company a lot of money, especially on lump sum, turn-key projects,” stated a Lead Electrical Engineer, at a major EPC Firm.

> “This solution gives my team the flexibility on site to place supports, and not increase project risk,” said Project Contractor Foreman.

So, how much can you really save? Let’s take a look at a case study based on a typical bill of materials for a liquified natural gas (LNG) terminal facility and its cable management requirements.*

**LNG Facility - $1.1M Total Bill of Materials**

<table>
<thead>
<tr>
<th>Length of Cable Ladder System</th>
<th>Horizontal Bends</th>
<th>Horizontal Tees</th>
<th>Horizontal Crosses</th>
<th>Reducers</th>
<th>Vertical Inside/Vertical Outside</th>
<th>Vertical Adjustable Splice Plates</th>
<th>Temperature Differential</th>
</tr>
</thead>
<tbody>
<tr>
<td>25,000ft (7620m)</td>
<td>225</td>
<td>130</td>
<td>25</td>
<td>40</td>
<td>208</td>
<td>28</td>
<td>100°F (38°C)</td>
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</tbody>
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**#1 Longer Span Savings**

<table>
<thead>
<tr>
<th>Cable ladder series</th>
<th>Support Span</th>
<th>Cable Ladder Material Cost</th>
<th>Supports Required</th>
<th>Support Cost ($100)</th>
<th>Support Cost ($1000)</th>
<th>Support Cost ($5000)</th>
<th>Longer Span Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>24A</td>
<td>10ft (3m)</td>
<td>$500,000</td>
<td>2500</td>
<td>$1,187,500</td>
<td>$3,437,500</td>
<td>$13,437,500</td>
<td>$343,750 - $6,468,750</td>
</tr>
<tr>
<td>46A</td>
<td>20ft (6m)</td>
<td>$750,000</td>
<td>1250</td>
<td>$593,750</td>
<td>$1,718,750</td>
<td>$5,718,750</td>
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</tbody>
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**#2 Fitting Support Savings**

<table>
<thead>
<tr>
<th>Installation Method</th>
<th>Supports Required</th>
<th>Support Cost ($100)</th>
<th>Support Cost ($1000)</th>
<th>Support Cost ($5000)</th>
<th>Fitting Support Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEMA</td>
<td>2,832</td>
<td>$1,247,640</td>
<td>$3,688,440</td>
<td>$14,536,440</td>
<td>$528,120 - $10,553,920</td>
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<tr>
<td>B-Line “Floating Fitting”</td>
<td>1,644</td>
<td>$719,520</td>
<td>$2,127,120</td>
<td>$8,383,120</td>
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<tr>
<td>B-Line “1/2 span / Dual Support”</td>
<td>783</td>
<td>$341,820</td>
<td>$1,010,520</td>
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**#3 Vertical Adjustable Support Savings**

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<thead>
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<th>Installation Method</th>
<th>Supports Required</th>
<th>Support Cost ($100)</th>
<th>Support Cost ($1000)</th>
<th>Support Cost ($5000)</th>
<th>Vertical Adjustable Support Savings</th>
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<tr>
<td>NEMA</td>
<td>112</td>
<td>$12,040</td>
<td>$112,840</td>
<td>$560,840</td>
<td>$5,600 - $280,000</td>
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<td>B-Line</td>
<td>56</td>
<td>$6,440</td>
<td>$56,840</td>
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**#4 Expansion Splice Locations**

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<tr>
<th>Installation Method</th>
<th>Supports Required</th>
<th>Support Cost ($100)</th>
<th>Support Cost ($1000)</th>
<th>Support Cost ($5000)</th>
<th>HD Expansion Splice Support Savings</th>
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<tr>
<td>Standard Expansion Splice</td>
<td>416</td>
<td>$214,108</td>
<td>$588,208</td>
<td>$2,250,875</td>
<td>$214,108 - $2,250,875</td>
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<tr>
<td>HD Expansion Splice</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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</tbody>
</table>

**Total Project Savings ($USD)**

$1,091,578 - $19,553,545

*Based on 2017 standard bill of materials for this type of project, and its representative cost savings potential.

By incorporating any or all of Eaton’s B-Line series cable ladder support recommendations, customers often realize support savings greater than the full cable ladder cost, resulting in a lower total installed cost solution. To learn more, visit at Eaton.com/SSS.
Additional Resources
For additional information, visit Eaton.com/SSS.

Catalog

Specification Templates

Technical Submittals

White Paper

Cable tray systems

**Video**

**Savings Calculator**

**Technical Guide**

For more information or to schedule a technical presentation conducted by B-Line personnel, please visit Eaton.com/SSS.

By email contact **blinetechnicalsupport@eaton.com** to answer any questions you may have on subject matter, and/or call: 1-800-851-7415 > 2 > and ask for technical support.
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U.S. Customer Service Center is staffed Monday through Friday from 7 a.m. to 5 p.m. Central Standard Time.

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