Evolution of J-Hook Systems

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Executive Summary

This White Paper presents a short history of the J-Hook, and then details the components, installation requirements, compliance issues and environmental aspects of this unique support system for commercial, industrial and institutional cabling projects. From the original idea conceived in the early 1990s, through the first products to a complete system; and then in 2006 a re-invention of the system by ERICO®, incorporating feedback from the field as well as technological advances.

Evolution of the J-Hook Pathway Design

The principal functions of a cabling pathway are (1) guidance, (2) support and (3) containment for the cables. The most primitive and least expensive manifestation is the “painted or designated route”, originally practiced in the U.K. It is a method where one paints parallel lines on the ground (e.g., under a raised floor) and positions the cables between these limits. While the lines provide the guidance and containment, the floor serves as the support. However, this method is vulnerable to flooding and after several MACs (Moves, Adds and Changes), containment is questionable.

Additional requirements on a pathway may be increased physical protection, EMI protection, concealment, controlled access, outdoor applications, cable media separation (copper/fiber cables), etc., which raises sophistication and cost of pathway design and installation. Results are pathway systems constructed with conduits, (covered) cable trays, ladder racks, surface raceways (trunking), underfloor ducting systems and more. They may be made of steel, aluminum, fiberglass or plastic.

The majority of these systems have one thing in common: They provide continuous support for the cables, meaning every inch of the cable lies on top of a support element. Is this really necessary? Does a cable need continuous support to maintain performance?

Not everybody thought so. Several decades ago companies started to offer an alternative to cable tray for power cable installations: the cable ladder. This design provides two side rails connected by rungs. The cables are placed perpendicularly on the rungs. The rung spacing determines the support interval.

Coming from Europe to North America in the mid 1980s, wire (mesh) tray became very popular in telecommunications cabling. While still providing a continuous structure, the cable is supported by a grid of wires with spacing deemed small enough to prohibit over-bending damage. While some people claim that the cable pressure on the wire grid causes indentations in the cable sheath over time, no one has been able to verify the cause and effect relationship through testing.

One manufacturer analyzed the situation and concluded that it was time to design a system of specialty fasteners for telecommunications cabling. It considers the cable properties while creating a non-continuous pathway geometry. Primary objectives were the following:

- Multi-directional guidance of cables through attachment options.
- Ample support capacity through various fastener sizes.
- 360° containment of the cable as well as media separation through closing provisions and tree configurations.
- Bend radius limitation through patented support surface design.
- Pull force reduction through a reusable tool.

The J-Hook system, part of the CADDY® line of fixings, fasteners and supports from ERICO, was developed and introduced to the industry at the 1995 BICSI® show. With millions of J-Hooks sold and many manufacturers now offering similar designs, the success of this installation method is obvious.

Component Design and Features

J-Hook

The original J-Hook represents the side view of the letter "J" with a semi-circular bottom section. Unlike squared J-Hooks, this design defies creation of vertical cable columns with single pressure points. Instead, in a rounded profile, the upper cables nestle in gaps between and on top of lower cables and thus distribute their weight more evenly.

The slightly rounded support surface on the inside of the J-Hook continues into smooth beveled edges, providing a standard-compliant bend radius for the cables.

Plastic strips or wire forms are available for the closure of the J-Hook after installation to guarantee a 360° containment of the cables.

Common sizes range from 19 mm (3/4 in) to 100 mm (4 in) and accommodate bundles of up to 300 or more cables. The original J-Hooks were produced from spring steel. The most common material today is galvanized steel, allowing for indoor and outdoor installation. Some manufacturers supply J-Hooks made from plastic polymers.

One of the critical design elements for the CADDY® CAT LINKS system was the decision to give all J-Hook sizes the same width of 51 mm (2 in), which created a projected support surface of 54 mm (2.125 in). Based on current standard requirements, this will take care of cable diameters up to **13.5 mm (0.53 in)**. CADDY CAT LINKS is the only system on the market that will support this cable diameter in all J-hook sizes. Compare this to representative diameters of

Category 5e UTP 4-pair cable:	5.2 mm (0.21 in)
Category 6 U/UTP 4-pair cable:	5.9 mm (0.23 in)
Category 6A F/UTP 4-paircable:	7.5 mm (0.30 in)
Optical 4-fiber cable (plenum):	5.1 mm (0.20 in)
75Ω Coax cable RG59:	4.6 mm (0.18 in)
75Ω Coax cable RG6/U	6.1 mm (0.24 in)
75Ω Coax cable RG6 Quad	6.6 mm (0.26 in)

This assures sufficient head room for future multi-pair cable configurations.

One issue that comes up frequently is "Zinc Whiskering". This phenomenon describes the growing of thin whiskers on zinc-electroplated steel, which, after breaking off, can cause havoc in electrical power and communications systems. Zinc whiskers are conductive and can short-circuit or ground current-carrying conductors or termination points. Cable trays or J-Hooks could be a source for these damaging whiskers, if the support systems are electro-galvanized and not covered with a relatively thick epoxy powder coat. However, all CADDY CAT LINKS J-Hooks are hot-dip galvanized and rolled and this process will prevent the growth of zinc whiskers.

Fittings for J-Hook Attachment

Most J-Hooks have a hole at the top of the spine, which can be used for attachment to a wall or a beam, using a screw. That alone would not make J-Hooks a very universal fastener. Therefore, a host of fittings were designed to attach to ceilings, substructures, raised-floor pedestals and threaded rod. They include:

- Angle brackets with mounting holes for screws, fasteners for powder-actuated tools, and different-size threaded rod
- Hammer-on assemblies with or without 360° -rotation capabilities.
- Screw-on beam assemblies with or without 360° -rotation capabilities.
- Z Purlin assembly
- C Purlin assembly
- Strut assembly
- Rod assembly
- Flange assembly

- Underfloor assembly
- Acoustical tee bar assembly

   

Fittings for Joining Components

In the past, most of the J-Hook systems in the market relied on rivets or screws to join J-Hooks with attachment fittings. Riveted connections generally mean the joining happens in the factory and the contractor has to pre-engineer the project, so the material ordered will be correct. It is difficult and expensive for a distributor or contractor to stock all of the fastener variations in the four J-Hook sizes. Typically, there is considerable waste with this method after completion of the project. Joining assemblies with screws enables jobsite assembly but also adds a significant labor component.

CADDY CAT LINKS, the most advanced J-Hook system, has added a third option that allows flexibility in the decision-making when installing combinations at the jobsite without a significant increase in labor: the use of spring steel brackets.

We have introduced the angle brackets in the previous chapter. In addition, there is a straight bracket available. All brackets snap J-Hooks of any size and standardized attachment fittings together.

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Now the installer can optimize the size of the pathway, for example using a smaller J-Hook further away from the distributor or the main pathway. By reducing the size of the pathway, the overall installation cost is lowered.

Trees

Early challenges to the industry included how to handle more cables than one J-Hook can support and to develop options to run different cable media in separate “channels”. Manufacturers came up with solutions to mount J-Hooks onto metal profiles, like flat steel, strut or rod, either in a single-tier or a back-to-back construction, commonly called J-Hook trees.

The advantages were obvious. Instead of having all cable media placed together into one cable tray, a customer would have individual pathways for CAT5e, CAT6A, optical fiber and coax cable media and the ability to separate voice, data, CCTV, control, fire alarm, nurse call and building automation system cabling, just to name a few. Unfortunately, these trees usually have to be assembled in the factory or shop, which requires custom planning and a long lead-time.

ERICO, the developer of the CADDY CAT LINKS system had a better idea: ERICO designed a spring steel tree-mounting bracket that connects the J-Hooks vertically with each other. By simply snapping the hooks together the installer can create trees, even with different-size J-Hooks, on the job site without screws. Another advantage is that over time a J-Hook pathway may fill up to the point that an additional pathway has to be considered. If the ceiling height allows it, adding another J-Hook on the bottom of the existing one might well be the most cost-effective solution.



The attachment fitting and the structure it is attached to (e.g., the ceiling) define the load limit for any configuration. Here is an example: The CADDY CAT LINKS angle brackets and tree mounting brackets are UL® Listed for 90 kg (200 lb) each. If the ceiling can support this weight, a tree can be created of at least six 100 mm (4 in) J-Hooks loaded with category cable (see tables on cable fill capacity and weight below.)

Pulling Tool

Industry standards and best practices expect that cables be laid onto support structures like cable tray, wire tray and J-Hooks. Many contractors do just that. They stage the cable bundles on the floor below the support structure and then lift them inside.

However, we all have seen installers pulling cables in the ceiling from point A to point B, around corners and up and down level changes. Without accepting this method, standards-making bodies have required minimum bend radii for different cable media that translate into minimum bend radii for directional-change fittings in trays. Smart positioning of J-Hooks in non-continuous pathways takes care of this requirement as well.

Going one step further, some manufacturers provide tools to encourage the combination of careful cable placement and speedy pull-in.

The CADDY CAT LINKS system, for example, offers a Cable Puller that mounts temporarily with a tree-mounting bracket under every third or fourth J-Hook. The cable can be pulled in while gliding on a set of rubber rollers to reduce the pull force. After the bundle is pulled in, the installer lifts it into the J-Hook.

A fitting expression would be: The best of both worlds. After installation, the cable pullers are detached and used on the next job. Because of the rubber rollers, the cable pullers do not have a “plenum” rating. They cannot remain in plenum spaces.

Installation

Cable Media

J-Hooks are used in telecommunications for all

- Category cables (e.g., CAT3, CAT5e, CAT6, CAT6A,)
- Non-category cables (security, audio/visual)
- Optical fiber cables
- Coax cables

In addition, J-Hooks may support

- Innerduct
- Tubing
- Conduit

J-Hooks may contain branch circuits up to 600 Volts.

- Armored cable
- Metal-clad cable
- Non-metallic sheathed cable
- Power and control tray cable
- Modular metallic and non-metallic cable systems (pre-fabricated wire harnesses)

American cable and connectivity manufacturers have generally accepted J-Hooks as a proven method to support cable. An example comes to mind where a worldwide connectivity manufacturer even sells a line of J-Hooks. How can manufacturers guarantee a cable plant for 20+ years that includes doubtful cable support equipment?

Cable Fill Capacity

See below the recommended maximum cable fill

Number of Cables at a 70% fill rate

J-Hook Dia. (mm)	J-Hook Dia. (in)	Cross-Sectional Area (in^2)	Cat. 5e 4-pair UTP	Cat. 6 4-pair UTP	Cat. 6A 4-pair UTP	Optical Fiber 4 fibers	75Ω Coax RG59	75Ω Coax RG6 Quad
25	1	1.07	20	15	10	20	30	13
50	2	3.97	90	60	35	90	100	50
75	3	9.26	200	150	80	200	250	120
100	4	15.48	330	220	140	330	425	200

Pulling Tension

The maximum pulling tension for 4-pair balanced twisted pair cable shall not exceed 110 N (25 lbf) during installation. The maximum pulling tension for optical fiber cables with four or fewer fibers is 220 N (50 lbf). For multi-pair cable, manufacturer's pulling tension guidelines shall be followed. TIA^{SM}-568C-0 has recommendations in clauses 5.3 for copper cables and 5.4 for optical fiber cables

Bend Radius

The minimum bend radius for 4-pair cable shall not be less than 4 times the cable diameter during and after installation. For inside plant optical fiber cable, the minimum bend radius is 50 mm (2 in) during installation and 25 mm (1 in) after installation (no tensile load). For multi-pair cable, manufacturer's bend radius guidelines shall be followed. TIA-568C-0 has recommendations in clauses 5.3 for copper cables and 5.4 for optical fiber cables

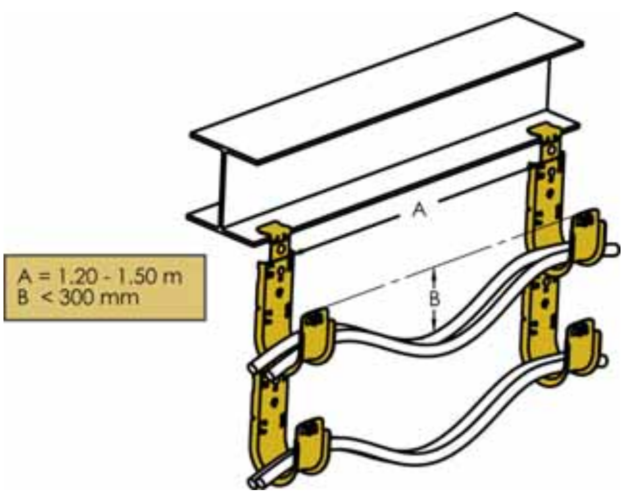
Attachment Intervals

J-Hooks for telecommunications pathways shall be spaced at 1,500 mm (5 ft) or less. Directional or level changes require closer spacing.

Some cable and connectivity manufacturers recommend in their training materials a smaller installation interval, e.g., 1,200 mm (4 ft). While our experience does not warrant a general shortening of the interval, it also does not do any harm.

It is good practice to keep the sag at a maximum of 300 mm (12 in). The sag is the vertical distance from a theoretical horizontal line between adjacent J-Hooks and the lowest point of the cables half way between two J-Hooks. Adding additional J-Hooks in between reduces the sag.

The fastening intervals of J-Hooks for branch circuits of 600 Volts or less have to comply with the relevant wiring methods in chapter 3 of the NEC® or the applicable national standards.



Weight

The tables below show the weight of a J-Hook loaded at a 70% fill rate supporting 1,500 mm (5 ft) segments of cable

J-Hook Diameter (mm)	Cat. 5e 4-pair UTP	Cat. 6 4-pair UTP	Cat. 6A 4-pair UTP	Optical Fiber 4 fibers	75Ω Coax RG59	75Ω Coax RG6 Quad
25	0.9 kg	0.9 kg	0.9 kg	0.5 kg	1.8 kg	0.9 kg
50	4.1 kg	3.4 kg	3 kg	2.5 kg	5.9 kg	3.2 kg
75	9.1 kg	8.6 kg	6.8 kg	5.5 kg	15 kg	8.2 kg
100	15 kg	12.7 kg	11.8 kg	9.1 kg	25 kg	13.2 kg

J-Hook Diameter (in)	Cat. 5e 4-pair UTP	Cat. 6 4-pair UTP	Cat. 6A 4-pair UTP	Optical Fiber 4 fibers	75Ω Coax RG59	75Ω Coax RG6 Quad
1	2 lb	2 lb	2 lb	1.2 lb	4 lb	2 lb
2	9 lb	7.5 lb	6.5 lb	5.5 lb	13 lb	7 lb
3	20 lb	19 lb	15 lb	12 lb	33 lb	18 lb
4	33 lb	28 lb	26 lb	20 lb	55 lb	29 lb

CADDY CAT LINKS J-Hooks are UL® Listed for a load of 27.3 kg (60 lb). The test pull force UL uses for this load is 81.8 kg (180 lb).

Bonding and Grounding

J-Hooks, as all non-continuous fasteners, do not need to be electrically bonded together or grounded to earth. This is only required for continuous support systems like cable tray, wire (mesh) tray and conduit installations (see 2011 NEC 250.92 (A)(1)).

Handling and Installation Time

It is a fact that J-Hook pathways can be created in less time than tray pathways. It starts with storing, transporting and preparing the cable support.

Trays usually come in sections of 0.6 m (2 ft) to 3 m (10 ft) with many pieces and parts for assembly and attachment. Transportation expenses are significant and extensive storage space at wholesaler and contractor warehouses, as well as on the job site, is required. Trays mostly require a second person to lift and mount. Adding another level to a tray is a time consuming job.

In contrast, J-Hooks come in small boxes that are easy to ship, store and move about a job site. Mounting them is a one-man job. Adding another CADDY CAT LINKS J-Hook under an existing one is virtually a "snap". And attachment fittings reduce installation time for J-Hooks.

So it is not surprising that the use of J-Hooks can yield labor savings of up to 75%.

Compliance

Code Compliance

J-Hooks have to comply with the requirements of the National Electrical Code (NEC)©, in particular with 300.11 (Securing and Supporting). When used with power cabling up to 600 Volts, they also have to comply with the provisions of the applicable wiring methods in Chapter 3 (Wiring Methods and Materials), e.g., armored cable, metal-clad cable, non-metallic sheathed cable, and the different types of conduit and tubing that can be supported by J-Hooks.

In Canada, the Canadian Electrical Code (CEC®), Part 1, has to be followed. The relevant clauses can be found in Section 12.

Standards Compliance

There are two standards sources for the evaluation of J-Hooks in North America. The Telecommunications Industry Association (TIA℠) provides the important design and installation parameters within TIA-568 and TIA-569 (in their most current editions). TIA-568 standards are concerned with the telecommunications cable media and require certain bend radii for cables, which determines the minimum bend radii for the pathways, e.g., the J-Hook.

TIA-569 standards provide requirements for telecommunications pathways and spaces, e.g., maximum attachment intervals between J-Hooks.

The other relevant standards source is the Underwriters Laboratories' UL 2239 standard "Hardware for the Support of Conduit, Tubing and Cable". The identical document is published for Canada as CSA® C22.2 No. 18.4-04. This standard provides for corrosion resistance test, pull test, etc. The tests are quite rigid, in order to achieve a high product reliability, For example, if a manufacturer wants to publish a load rating of 27 kg (60 lb) for a J-Hook, the test requires a pull force of 82 kg (180 lb), which creates a safety factor of 3. J-Hooks are anchored as non-continuous fasteners and fixings in international standards like ISO®/IEC® 18010 and national standards like EN50174 for Europe and AS/NZS 3084:2003 for Australia and New Zealand.

Third Party Agency Listings

Even though there is no requirement to do so, most J-Hook manufacturers pursue a third party listing to prove that their product complies with UL 2239. After successfully passing the applicable test, the listing mark is granted. Samples of listing marks in North America are UL, cULus® (for U.S.A. and Canada), CSA and ETL® (Intertek).

To be effective, a listing has to encompass all components of the support system, not just the J-Hook. So look for the listing mark on the attachment fittings, etc.

Additional Investigations

Over the past 15 years, tests have been performed to show how J-Hook supports may influence the transmission quality of cables. One of the original investigations was done in the laboratories of a large telecommunications company, with the intent to disprove the J-Hook system. After initial installation in intervals of 1.5 m (5 ft), as recommended by the manufacturer, the spacing was increased to 3 m (10 ft), then 7.5 m (25 ft) and finally 15 m (50 ft).
The sag is per manufacturer's recommendation max. 300 mm (12 in). In the investigation, the sag at longer support intervals was increased to more than 1,200 mm (48 in).

The NEXT (Near End Cross Talk) performance of the category 5e cables in the test setups was measured and graphed over frequencies up to 500 MHz. The study was presented to the TIA committee responsible for transmission quality standards (now TIA-TR-42.7) in 1999.

Considering all test results, even the extreme setup with 15 m (50 ft) intervals and 1,200 mm (48 in) sag, the test report came to the conclusion that J-Hooks have "*no significant effect on NEXT performance*". A follow-up investigation in the same lab in the year 2000 concluded the same for ANEXT (Alien Power Sum NEXT).

More recently, ERICO ran about 130 tests (with over 100,000 test points), evaluating the performance of Category 6 cables in J-Hooks, basket tray, ladder tray and conduit. The tests were performed at transmissions up to 10 Gb, frequencies up to 500 MHz and distances up to 90 meters. The results were presented at a BICSI Conference in September 2007 in Las Vegas.

The J-Hooks performed better than the other investigated systems. This was no surprise, when one considers that parallel run of cables, changing of the relative position of cables to each other along the pathway, bundling and distance between cables all have a considerable influence on Alien Crosstalk. Unbundling cables between J-hook supports, for example, showed a 6 dB gain.

The unique assembly of cables in J-Hooks alternates from short bundled sections inside the J-Hook to long unbundled sections between J-Hooks, where gaps among cables form and the relative position of cables constantly changes. This purposely introduced “chaos” in the cable run is much more prevalent than with other support methods and it reduces Alien Crosstalk significantly. It also promotes better heat dissipation in PoE (Power-over-Ethernet) applications.

Environmental Aspects

Recycled Material

CADDY CAT LINKS J-Hooks are manufactured using up to 80% recycled steel, and can also be recycled.

Material Savings

J-Hooks are not a continuous pathway and therefore use less material than tray systems. This example dramatically shows the material savings:

Three meters (10 ft) of pathway constructed with a 50 mm by 300 mm (2 in by 12 in) ***wire basket tray uses 6.4 kg (14 lb) of steel***. A pathway of the same length constructed with three 100 mm (4 in) ***J-Hooks uses 0.72 kg (1.6 lb) of steel***. In this case, weight savings are 88%.

Conclusion

- Advanced J-Hook systems, like CADDY CAT LINKS, not only meet but exceed the performance requirements of the industry standards for copper and optical fiber cable.
- CADDY CAT LINKS is the most flexible support system available and meets the current and future needs of copper and fiber cabling pathways.
- Compared to continuous support systems like cable tray, wire (mesh) tray and conduit, J-Hooks are more economical. Fewer logistical demands, less installation labor and reduced material spells out lower overall cost.
- The environment wins, too: J-Hooks utilize considerably less steel compared to continuous support systems, and are fully recyclable.

Author

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