



Radio Frequency Systems

HYBRIFLEX® Coaxial Power Wire Hybrid for Junction Box INSTALLATION GUIDELINES



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Coaxial Power Wire Hybrid for Junction Box Installation Instructions

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INTRODUCTION TO HYBRIFLEX®

RFS' HYBRIFLEX hybrid feeder cabling solution combines multiple elements, including but not limited to, optical fiber, DC power, alarm wire and/or small form factor coaxial cable, in a single lightweight cable. It was developed to reduce installation complexity and cost at macro sites. HYBRIFLEX allows mobile operators deploying RRH architecture to standardize the RRH installation process. HYBRIFLEX with its combined elements all in a single jacketed cable can connect multiple RRHs with a single feeder. Standard RFS CELLFLEX® coaxial cable accessories may be used with HYBRIFLEX cable. Both pre-terminated and on-site terminated options are available. The rugged jacket facilitates easy transportation, handling, and installation.

These short instructions were written for qualified and experienced personnel. They describe, in few words, the main points that **MUST** be noted during installation, without any claim of completeness.

Any liability or warranty for results of improper or unsafe use is disclaimed!

General remarks

In principle, care must be taken to avoid all such strain that may cause permanent deformation on the cable, e.g., going below admissible bending radii, kinking, applying too high tensile stress or forcible deformation (pulling over sharp edges, over tightening of clamps, etc.).

HYBRIFLEX FEEDER CONFIGURATION

This installation guideline supports **HYBRIFLEX cable** available in multiple riser trunk configurations including 6x12 and 12x24. The trunk cable assemblies comprise of 6 AWG low inductance, coaxial DC wires, 18 AWG alarm wires and multiple pairs of single mode fiber terminated with DLC-DLC connectors.





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The use of Low Inductance Cable may allow distances upwards of ~600ft, eliminating the need to re-locate power cabinets and stay within the conventional distances supported. This application uses a combination of junction boxes with Over Voltage Protection (OVP) both top and bottom and various hybrid jumper configuration for complete installation from BBU to RRH.

HYBRIFLEX trunk cable assemblies are factory constructed specifically to suit this application, ensuring perfect junction box, with or without Over Voltage Protection (OVP), compatibility and trouble-free installation. Additional features that ease installation and ensure durability throughout service life include:

- Robust breakout design with colored/numbered optical fibers and power conductors
- Stranded construction for easy bending and maximum fiber protection
- Corrugated aluminum shield protects from crush and animal damage
- Integrated rip cords for length management
- Factory test certificate available for every cable assembly
- Smartly packaged, easy fiber end face access for pre-testing

The installation instructions here within, apply to (but not limited to) the following HYBRIFLEX families:

Generic Description	Typical Application	DC Pairs	DC Gauge mm² (AWG)	DC Type	Fiber Pairs	Fiber Conn	Model Family
6x12	Riser Box-Box	6	13.3 (6)	Coaxial LI	12	DLC-DLC	HB114-U6S12-xx-LI
12x24	Riser Box-Box	12	13.3 (6)	Coaxial LI	24	DLC-DLC	HB158-13U12S24-xx-LI
Hybrid Jumper	Box-RRH	1 or 2	Various	Red / Black Pairs	Various	Various	Various

Other Applicable Specs

- Single Mode Optical Fiber
- Aluminum Corrugated Armor
- UL Listed



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HYBRID JUMPER INSTALLATION

- In general hybrid jumpers are installed similarly to trunk line or coaxial cable. Use appropriate accessories where applicable.
- The fiber end face must be handled with care and protected during installation.
- DO NOT remove protective tubing and plastic bag until ready to connect the jumper between junction box and RRU or BBU.
- Follow the bend radius guidelines specify in the product spec sheet.
- Attach the main cable securely to the structure or equipment using hangers and/or cable ties to prevent strain on connections from movement in wind or snow/ice conditions.
- Ensure all LC optical fiber connectors are seated firmly in the junction box, RRU or in BBU equipment.
- Ensure the weatherproof boots for both fiber and power connections are seated firmly in the RRU
- All hybrid jumpers and risers are individually serialized, for immediate access to test results visit: [RFS HYBRIFLEX Performance Test Data](#)
- Power connector should be supplied with the RRU
- Red power conductor is -48V
- Black power conductor is 0V (return)
- Hybrid jumper armor and DC wire may be cut back for length adjustment. Excess fiber length must be spooled into the junction box or tray.

Helpful tip - The following are just a few examples of hybrid jumpers and riser cables for this application. Orderable lengths range from 10 to 100 ft (typically in 10ft increments) and other lengths upon request. Please check with your local RFS representative for additional product variations and options.



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HYBRID JUMPERS MODEL NUMBERING STRUCTURE

HBF058-08U1S1-xxF or -xxF1

HBF	058	-	08	U	1	S	1	-	xx	F, F1, S
Hybrid Fixed Length	Over Jacket Nom O.D.		DC Size	Unshielded	No. of DC Pair	Single Mode	No. of Fiber pair		Length in Feet	RRH OEM



Hybrid jumpers for macro application, 1x1's or 1x2's, 8AWG with 1 to 4 pair single mode optical fiber. Designed to link junction box to RRH. All jumpers come Duplex LC, some with optional FullAXS compatible connectors, depending on model ordered. All jumpers are UL-Listed, flame-retardant jacket, UV protection, suitable in both indoor and outdoor applications.

Y-Splice Jumpers

HBF058-08U1S1-xxFY

HBF	058	-	08	U	1	S	1	-	xx	FY
Hybrid Fixed Length	Over Jacket Nom O.D.		DC Size	Unshielded	No. of DC Pair	Single Mode	No. of Fiber pair		Length in Feet	RRH OEM Y- SPLICE



Y-SPLICE hybrid jumpers are designed for high-capacity dual band RRH's for macro application, 8AWG with 1 or 2 pair single mode optical fiber. They come with Duplex LC and FullAXS compatible connectors.



Coaxial Power Wire Hybrid for Junction Box Installation Instructions

HYBRIFLEX Bi-Di (Bi-Directional) Simplex Fiber Jumpers Model Structures

HBF058-08U1SS-xxF

HB	F	058	-	08	U	1	SS	2	-	xx	F, F1, S
<i>Hybrid</i>	Fixed length	Over Jacket Nom O.D.		DC Size	Unshielded	No. of DC Pair	Single Mode Simplex	No. of Fiber Strand		Length in Feet	RRH OEM

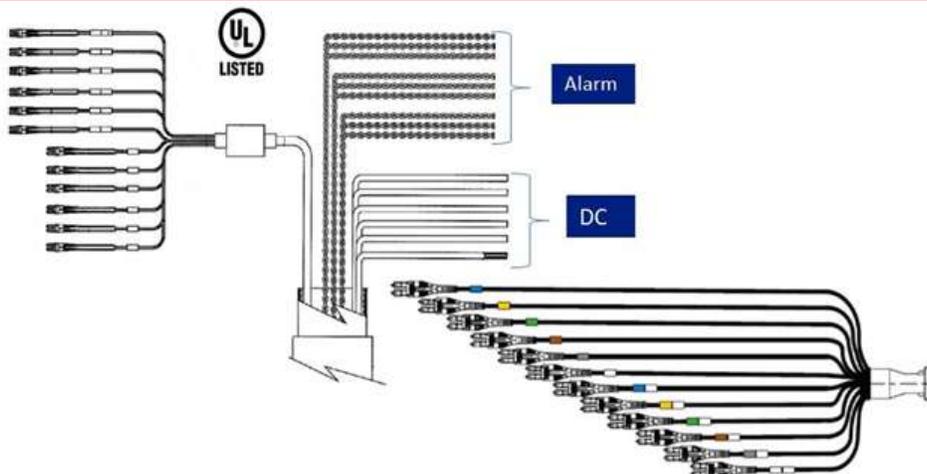


BiDi hybrid jumpers utilize 8AWG or 6AWG DC wire combined with a single mode single strand optical fiber design for transmitting and receiving on a single fiber.

RISER TRUNK LINES ASSEMBLY TERMINATION STRUCTURES/CONFIGURATION

HB114-U6S12-xx-LI (6AWG) 6X12 Low Inductance

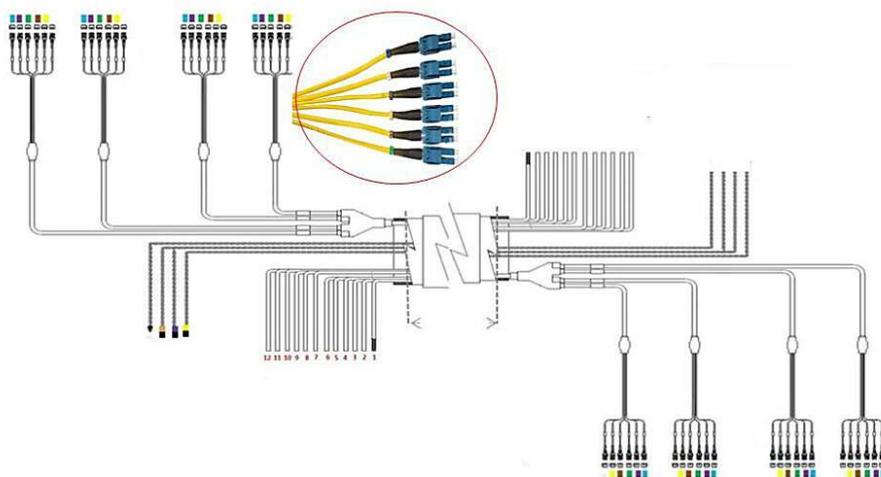
HB	114	-	U	6	S	12	-	xx	-	LI
<i>Hybrid</i>	Over Jacket Nom O.D.		Unshielded	No. of DC Pair	Single Mode	No. of Fiber pair		Length in Feet		Low Inductance



HB158-U12S24-xx-LI (6AWG) 12X24 Low Inductance

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HB	158	-	U	12	S	24	-	xx	-	LI
Hybrid	Over Jacket Nom O.D.		Unshielded	No. of DC Pair	Single Mode	No. of Fiber pair		Length in Feet		Low Inductance



Quick reference

Cable type **HB114-U6S12-xx-LI Series** **HB158-U12S24-xx-LI Series**

Cable Type	HYBRIFLEX	
Size	1-1/4"	1-5/8"
DC Conductor gauge	13.3mm ² (6AWG)	21.1mm ² (4AWG)
Number of DC Pairs	6	12
Number of fiber pairs	12	24
Armor type	Corrugated Aluminum	Corrugated aluminum
Fiber type	Single Mode	Single Mode
Fiber termination	Top: DLC; Bottom: DLC	Top: DLC; Bottom: DLC
Weight (kg/m (lb/ft))	2.5 (1.7)	4.76 (3.2)
Max over jacket diameter mm(in)	39.4 (1.55)	50.19 (1.98)
Breakout fiber length mm(in)	889 (35)	1524 (60)
Breakout power length, mm(in)	812 (32)	812 (32)
Minimum bend radius	152 (6)	254 (10)

Visit www.rfsworld.com for the most current product specifications

TRANSPORTING, SHIPPING AND HANDLING THE DRUM

Coaxial Power Wire Hybrid for Junction Box Installation Instructions

Drums must be handled carefully to avoid any damage to the drum and/or the hybrid cable.

- If the drum will be shipped unpalletized by van or truck, the drum must be secured against rolling. Pay special attention to careful loading and unloading. Do not roll the drum from high levels (load floor) of the vehicle without protective measures, e.g., roll the drum from the vehicle by using planks as a ramp. Do not drop the drum!
- If forklifts are used, on an unpalletized drum, the forks must be long enough to engage both flanges of the drum at the same time to avoid cable damage.
- If a crane is used, a special hanger is necessary to ensure vertical application of forces and thus avoiding damage of the drum flanges and the cable.
- Do not lay the drum on its side, reels must be transported and handled in their up-right position only (the cable could be deformed due to its own weight).
- Make sure that the cable end is always properly sealed and fixed as close as possible to the drum core.
- Note the recommended rotation direction of the drum, which is shown by an arrow on the drum flange (during installation/pulling of the cable the drum will be on drum stands and will then be turned in the opposite direction to unwind the cable).
- If the drum is completely protected by wooden planks, these should not be removed before the drum is placed (transported) to the final position.

HANDLING HYBRIFLEX CABLE

Upon receiving the HYBRIFLEX shipment it is highly recommended that the drum be inspected for any physical damage and all fiber connection points be tested.

Do not drag the cable over sharp edges. If it cannot be avoided to drag the cable over sharp edges, protective measures must be taken, if necessary, by positioning an additional rigging at those critical places.

To protect the cable against any damage, protective measures must be taken. This is also applicable if cables must be pulled in horizontal runs (example: using pipe rollers, wooden planks or similar).

Prevent any pinches to the DC wires, which may cause electrical spikes and short circuitry.



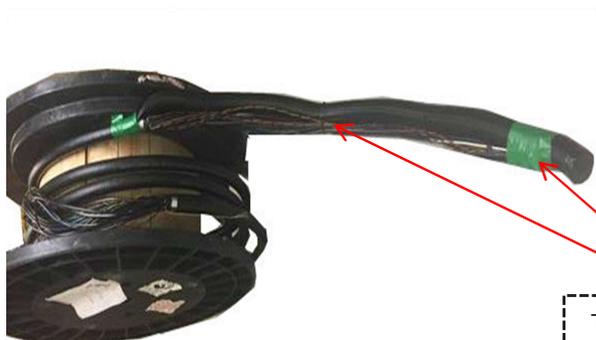
Coaxial Power Wire Hybrid for Junction Box Installation Instructions

PROTECTIVE SLEEVE REMOVAL/PACKING

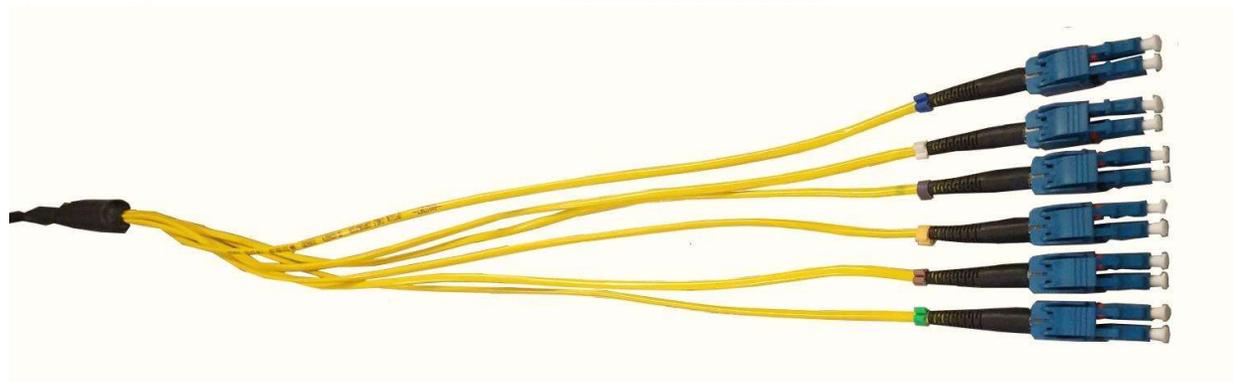
It is recommended that all assemblies are inspected and pre-tested before hanging, to do so no need to unreel the assembly. Both optical end faces are easily accessible. Use this quick instruction to unwrap and test the fiber.

Each hybrid termination is protected by a robust protective sleeve (shown below) and ESD plastic bags to prevent damage to the fiber end face.

- Use caution when removing the sleeve.
- Unwrap the packaging reel
- Remove tape and cable ties
- Slowly pull off protected sleeve
- Remove tape ESD plastic bag (only remove the section that is been work on)



Tape & Cable Ties



To repackage, simply reverse the process. Use extra caution when fitting optical termination through protective sleeve.

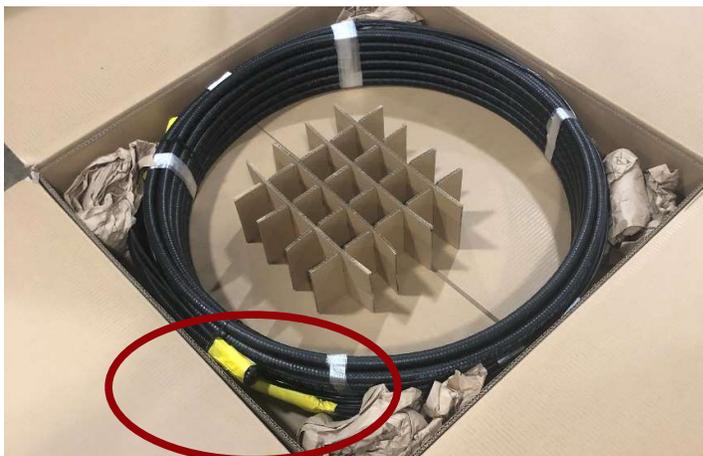
Coaxial Power Wire Hybrid for Junction Box Installation Instructions

HYBRIFLEX PACKAGED IN COIL BOXES

Some models of HYBRIFLEX may be packaged in specially designed coil boxes. General guidance still applies however below are some additional recommendations for handling HYBRIFLEX from a coil box.



Top and bottom assembly terminations will be protected and identifiable. See example below:



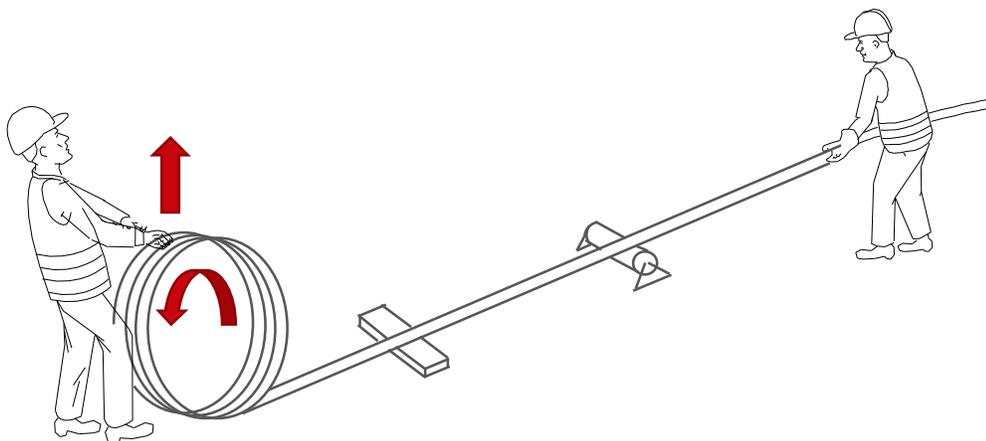
Note: Please pay attention to assembly orientation when unpacking.

Specific packaging may vary depending on assembly requirements.

- Short assembly lengths may be uncoiled and hoisted vertically directly from the coil box.
- For longer lengths, uncoiling directly from the box may induce an undesirable twist to the cable assembly.
- For longer lengths, it is recommended to unroll the HYBRIFLEX coil on the ground first, before lifting to final position.



Coaxial Power Wire Hybrid for Junction Box Installation Instructions



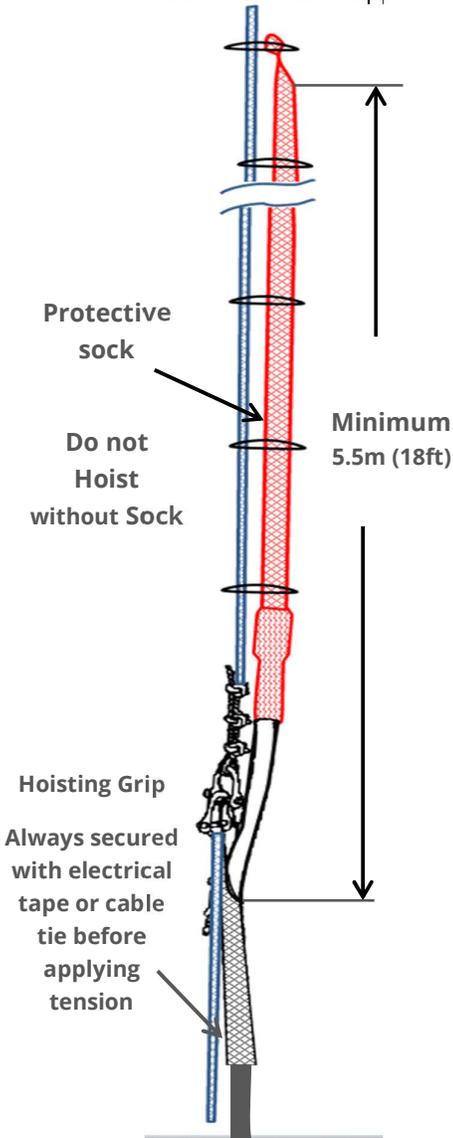
Roll out the cable ring along the ground following the cable line/route and lift the cable into the final position later. Utilize blocks, rollers or other to protect the cable. Lift up and rotate the assembly, when uncoiling.

Coaxial Power Wire Hybrid for Junction Box Installation Instructions

HOISTING/PULLING HYBRIFLEX CABLE

- **Note:** Always use caution when hoisting and pulling HYBRIFLEX.
- Do not remove the protective sleeve. If it is removed during pre-testing, re-attach securely before hoisting the cable.
- Do not attach the hoisting grip over the protective sleeve.
- Hoisting grips should be attached no less than 508mm (20in) from the breakout point.

HYBRIFLEX cables are supplied in specific lengths from the factory fully terminated with polished connectors.



Short lengths of small HYBRIFLEX can be hoisted manually, otherwise a winch is recommended. Provide a pulley high enough on the tower to enable the HYBRIFLEX line to be raised sufficiently.

Attach a hoisting grip (**do not use a closed lacing style**) using tie back rope or additional electrical tape, if needed, to prevent any stress or force to fiber and electrical wire. When using pre-installed hoisting grips, simply adjust it to the desired section of the cable and clamp it or use heavy duty tape to secure it.

General rule of thumb, 1 hoist grip for every 30.5m (100ft) of vertical run. For heavier runs, such as 1-5/8" 4AWG, double hoisting grips at each 50-60m (164-197ft) interval.

Add the hoist line to the hoisting grip or rope sling; protect the HYBRIFLEX against shackles.

Keep slack in the cable between the hoisting grips in case more than one is needed. Ensure that the slack is maintained during hoisting. Hoist the cable slowly.

Rotation of the reel must be slow to prevent buckling of the cable.

When unspooling, keep the reel secure so that it does not accidentally roll over the unprotected components.

If it is necessary to drag the cable over sharp edges of buildings or tower members, protective measures must be taken.

Careless handling can damage the cable jacket eventually causing damage to fiber end face which may render the entire HYBRIFLEX line length useless.

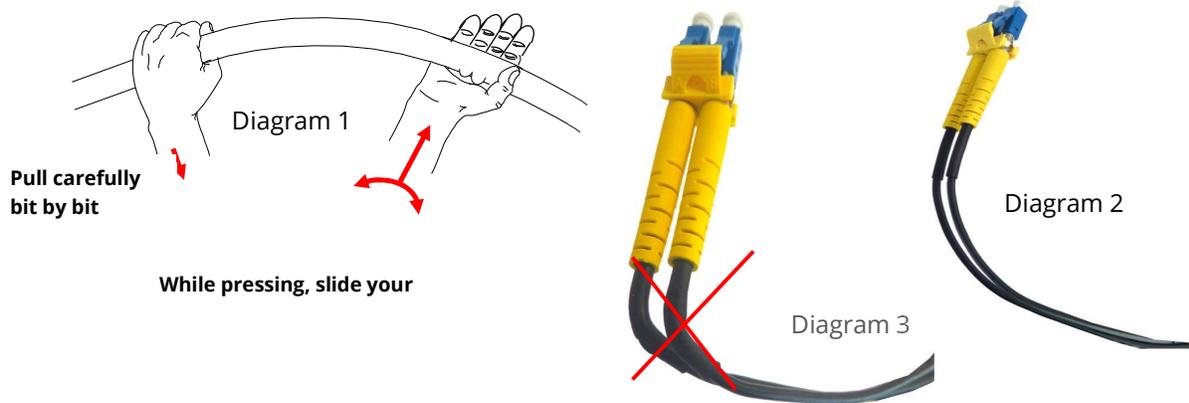
If the cable is hoisted inside the tower, feed it into the tower base and keep its top off the tower steel work. Please refer to the Monopole installation section of this document.

Caution: The protective sleeve should not be removed until installation is complete.

Coaxial Power Wire Hybrid for Junction Box Installation Instructions

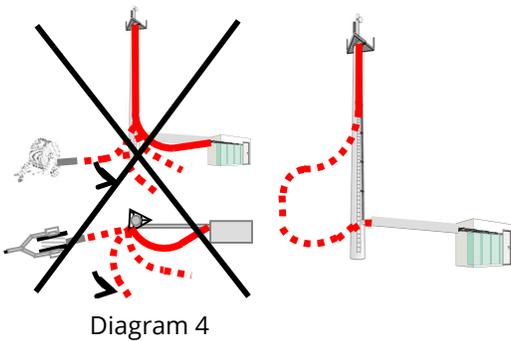
HYBRIFLEX BENDING

- The minimum-bending radius should be strictly observed. Reference product data sheets for specifications, located on RFSWORLD.com.
- HYBRIFLEX cable should be bent manually with a force applied in a distributed manner, pressing carefully while the hand slides along the cable [see diagram 1]. Avoid rapid, sharp motions.
- Avoid any tight micro bends near the fiber end face as micro bends can cause broken fiber and increase insertion loss. [See diagram 2&3].



Helpful Tip: Hybrid cables that utilize copper outer shield, are easy to bend, but must be handled carefully to avoid damage to internal elements.

- Do not twist the cable, e.g., if changing from vertical to horizontal runs [See diagram 4]
- Do not leave the Hybrid cable hanging in a long free space, e.g., during the installation under a platform. In adverse conditions, additional protective measures may have to be taken [for example see picture 1].



Protective measures: temporary fixation of the cable

As shown from side (upper) and top (lower) view, do not swing the cable horizontally creating a twist in the vertical

As shown from side view, rather form a large bow and pull and guide the cable horizontally without creating any twist

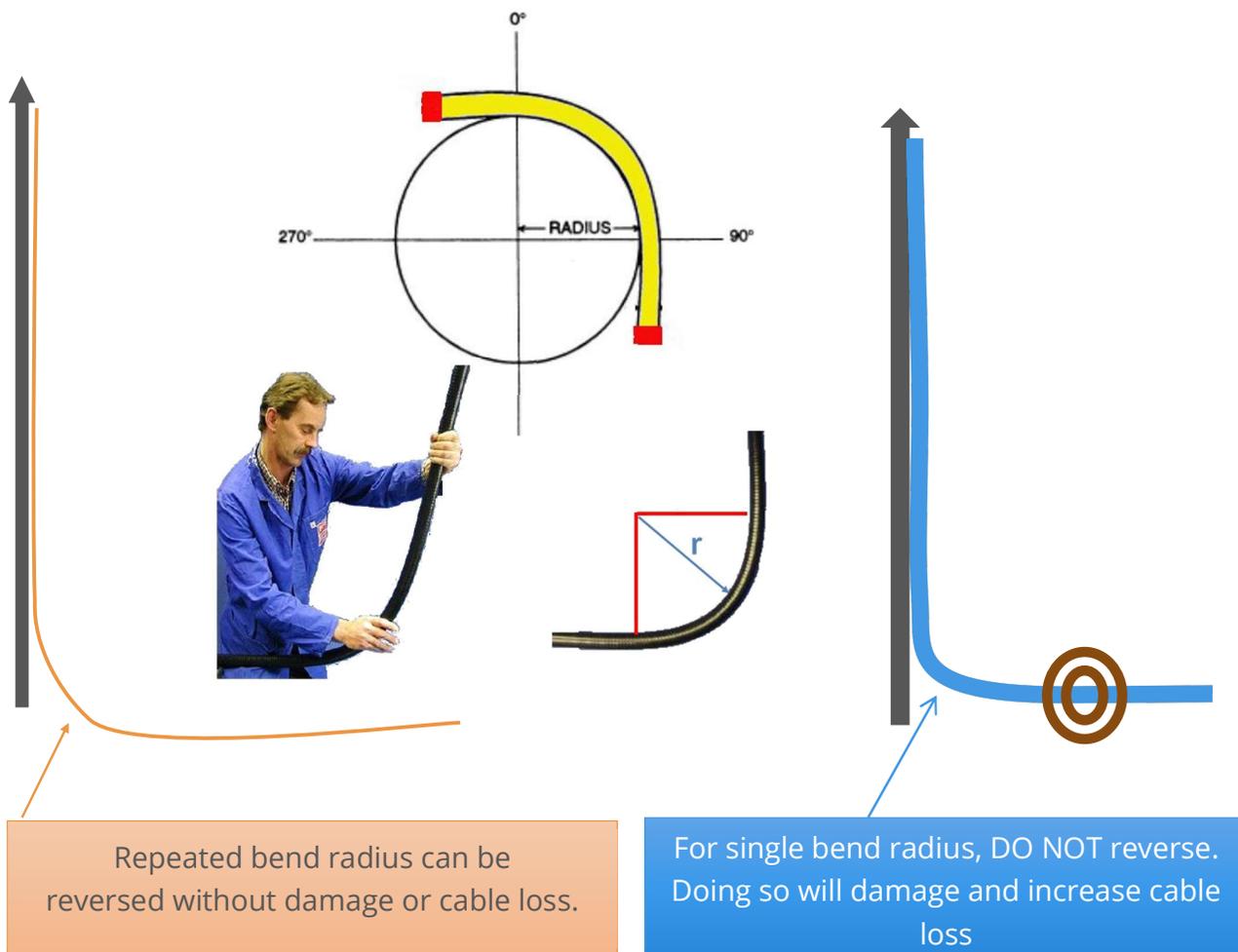
Minimum Bending Radius

- Minimum bend radius is the tightest bend an installer can bend a section of the cable without causing performance degradation and/or damage. **Refer to product data sheet for specific hybrid cable bend radius.**

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RFS specifies two types of minimum bending radius for a cable.

- Single bend – irreversible minimum bend section of the cable
- Repeated bend – reversible minimum bend section of the cable



FIXATION/MOUNTING OF THE CABLE

Crush resistance may vary for different outer materials. This should be considered when tightening the clamps (especially if these clamps have not been approved by RFS).

Several different clamps may be used. RFS recommends using the SNAP-IN type. The SNAP-IN is suitable for all fixing situations while at the same time it is a safer clamp (less chance of failure) offering many advantages.

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The recommended and maximum clamp spacing shown in table 1 must always be considered. The small spacing applies to severe site conditions (wind load, icing, etc.); whereas the greater/recommended spacing can be used for less exposed cable runs (e.g., indoor applications).

Table 1

HYBRIFLEX Size	Spacing
HB/HBF058 [5/8"]	0.7m (2.3ft)
HB/HBF078 [7/8"]	0.9m (3ft)
HB114 [1-1/4"]	1.3m (4.3ft)
HB158 [1-5/8"]	1.5m (5ft)

HYBRIFLEX SELECT TOWER ACCESSORIES AND INSTALLATION TOOLS

Helpful Tip: Accessories may be kitted with the hybrid assembly upon request. RFS recommends its accessories be used to avoid any incompatibility issues that may arise during the installation process.

Caution: Only use approved accessories and tools. RFS HYBRIFLEX does not require the use of grommets for accessory fit to outer cable jacket.

Note: Hangers are sold in kits of 10 with hardware included (multiple options available)

	Cable Size	Model Numbers	Short description
	HB058	GKFORM60-58	60-inch grounding kit
	HB078	GKFORM60-78	
	HB114	GKFORM60-114	
	HB158	GKFORM60-158	
	HB058	CLAMP-58, SNAP-58, SNAP-ST-58	Standard clamp bolt-on hanger; Snap-in hanger; Stackable snap-in hanger
	HB078	CLAMP-105, SNAP-58, SNAP-ST-78	
	HB114	CLAMP-114, SNAP-114, SNAP-ST-114	
	HB158	CLAMP-158, SNAP-158, SNAP-ST-158	
	HB058	HOIST1-58L	Hoist grip, lace up
	HB078	HOIST1-78L	
	HB114	HOIST1-114L	
	HB158	HOIST1-158L	

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	<p>Any size</p>	<p>ANGLE-UI ANGLE-CLPI</p>	<p>Universal angle adapter, snap-in or 3/8" (kit of 10) Angle member adapter kit 3/8" (SS) (Kit of 10)</p>
	<p>HB078 HB114 HB158</p>	<p>JSTRIP-78 JSTRIP-114 JSTRIP-158</p>	<p>Manual jacket stripping tool</p>

INSTALLATION OF THE GROUNDING KIT

RFS recommended that hybrid cable be grounded regardless of size. Recommended 3 kits per run up to 200ft plus 1 for every additional 200ft. Although the HYBRIFLEX jacket removal tool (HTPT's series) may be used, to avoid ripping off too much jacket the J-Strip is recommended.

To avoid any corrosion problems, the contact element of the grounding kit is tin plated copper. The tin plating allows compatibility with both aluminum and copper conductors.

Because of electrochemical potential differences between copper and aluminum do not use the grounding kits, which are designed only for copper cables!

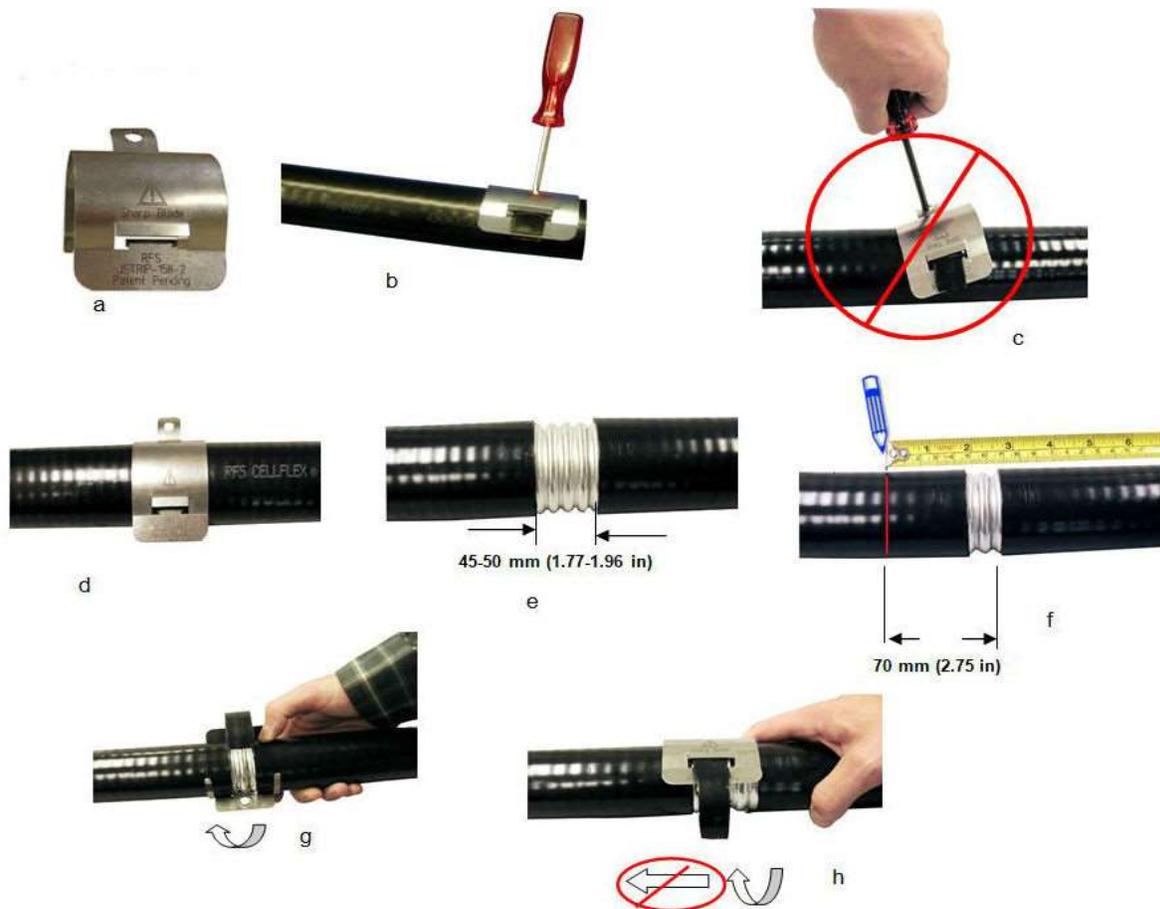


Do not used copper grounding on cable with aluminum outer.



Please follow the included installation instruction carefully. For removal of the jacket, we also strongly recommend the use of a manual jacket stripping tool, examples model JSTRIP-114-2 or JSTRIP-114 for 1-1/4" size. Check with you local RFS representative for other cable sizes.

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- Set the JSTRIP onto a straight part of cable. (a)
- Insert a screwdriver into the two support holes and begin turning, maintaining a straight line – do not push in any lateral directions and do not twist or leave the right-angle line. Continue turning by hand (the screwdriver is needed for the start only) until the jacket is cut completely around, still maintaining a straight line. (b)
- Make a mark onto the cable jacket in 70mm (2.75in) from the beginning of the first cut. That's 50mm (2.0in) which is needed for the grounding kit installation and for the part of the tool from the end of the cutting edge to the end of the tool. (f)
- Put the tool onto the cable again, whereby the cutting edge should be in the already jacket stripped area. Start again, while pushing the tool slowly in direction of the marking. The jacket will be cut in a spiral. Turn further by pushing the tool very slowly until reaching the marking. If the tool is on the mark, turn further, but now push a little bit in the reverse direction to finish the cut in straight line. (e/g)

Note: If the tool has been started to cut in a spiral, the tool will move continuously by itself in the same direction. If the marked area is reached, this movement must be stopped by pushing carefully in the opposite direction. To develop the proper technique, we recommend testing on a part of cable, which is not needed

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for the installation. If this process is not easy enough or not acceptable, a clamp (e.g., RSB-Clip) may be placed on the mark. This clamp will then stop the movement of the tool in the final position [see pictures 2-4].



Picture 2



Picture 3



Picture 4

Put the body of the grounding kit very carefully around the cable, to prevent damaging the outer conductor, and then carefully tighten the nuts.

Finally use the supplied sealing materials as described in the grounding kits installation instruction to perform a proper sealing of the complete kit.

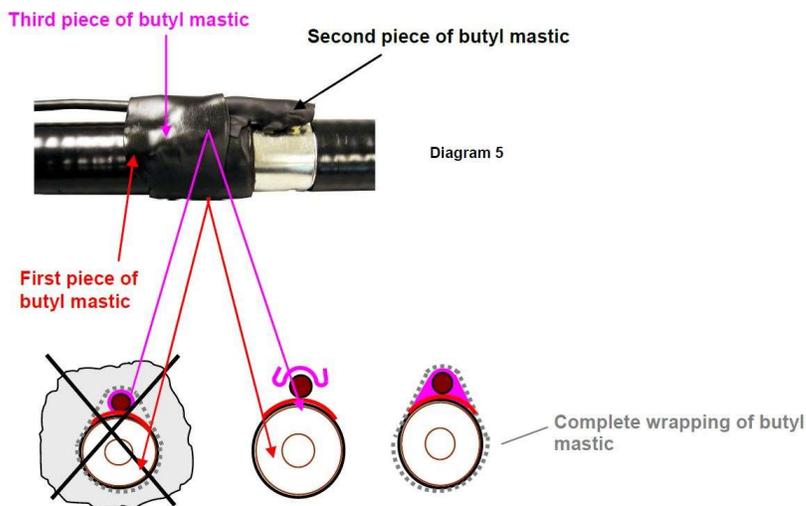


Picture 5

For example, GKFORM series, place the remaining third 50mm (2in) piece of butyl mastic carefully over the ground wire. (As shown in Diagram 5)

We recommend bending it with overlapping on both sides when placing over the ground wire. Afterwards mold it in a straight line to the coaxial cable to avoid holes where water could enter [see Diagram 5].

Special care must also be taken to form tile-like overlaps when wrapping the tape layers, i.e., start from the bottom and end at the top.





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ARMOR TRIMMING PROCEDURE FOR HYBRIFLEX CABLE

Overview: This cable is constructed with a ripcord, located right under the cable aluminum corrugation. The ripcord is designed to cut through the armor and jacket, to expose the individual fiber and power wires as necessary for the installation.

To remove the armor using the ripcord process, follow the steps below.

Safety: Use proper hand protection and safety glasses. The sharp aluminum edges and flying particles can be dangerous. This procedure should be executed with the fiber protection as received in place.

The armor cutting tools are special and unique. Regular pipe cutters from your local hardware store should **not** be used.

Although a knife can be used to remove the jacket, the jacket removal tool is strongly recommended to avoid damage to the Fiber and power wires. Also, only the referenced Mandrel should be used to remove the ripcord. Hex drives or other means should not be used.

Installation tools including the Jacket stripper tools and the armor cutting tools are available for each HYBRIFLEX cable size. This includes 5/8", 7/8", 1-1/4" and 1-5/8".

The Ripcord Mandrel is not cable size specific and comes in its own kit.

This instruction uses the 7/8" process as an example:

1. Measure and mark the length of the armor to be removed. Suggest a maximum of 4.5m (15ft) per cut, to avoid excessive ripcord accumulation into the mandrel).
2. Using the Jacket removal tool (or knife), strip 76m (3in) off the jacket.
3. Place the cutting tool over the 76m (3in) exposed aluminum armor, and then slowly turn the cutter handle clockwise until the blade is fully engaged with the aluminum armor. **Note: Armor should be cut on the high end (peak) of the corrugation, not in the valley.** Rotate cutting tool and tighten handle as needed until the aluminum armor cut.
4. Remove the electrical tape.

HYBRIFLEX 7/8" Cables have one ripcord. Approximately 152mm (6in) of the ripcord is exposed from the factory under the electrical tape.

Helpful Tip: If ripcord is not exposed or too short due to previous armor removal, stop and complete steps 1-3 above.

- 1) Locate ripcord and place a knot at the end.
- 2) Insert the mandrel into the drill tool and insert the ripcord into the mandrel slot. Start winding the ripcord around the mandrel ripping direction, at minimal speed to slice both jacket and the aluminum armor. The mandrel should be centered on the cable and in contact with the jacket surface.
- 3) After the ripcord reaches the stop collar, remove the ripcord from the mandrel by running the drill in reverse. Cut the excess ripcord leaving 6 inches exposed.
- 4) Now that the armor and jacket has been sliced, peel open the jacket, remove, and discard.

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- 5) **Caution:** Due to the sharp edges of the aluminum armor DO NOT start this step without proper gloves. Use needle nose pliers and flare open the aluminum armor ensuring that sides and bottom are flared. Peel open the aluminum armor, if need be, use shoulder to support fiber and wire during peeling.
- 6) Now that the armor is peeled off, slide the Mylar tape all the way towards the Stop Collar until it forms a small bundle. Use scissors to cut off the Mylar. Caution: Be careful not to damage the fiber or power wires.
- 7) Pull filler away from fiber and DC wire and use scissors to cut them and discard. **Caution:** Do not score the DC-wire.
- 8) Untwist fiber and DC-wires as desired and cut excess signature cord.
- 9) Continue with the installation process.

MONOPOLE CONDUIT HYBRID CABLE INSTALLATION

1. Prep and secure cable end

a) Inspect fiber termination, whereas applicable, cut all power wires below fiber fan out, and insert inside protective sleeve as recommended.



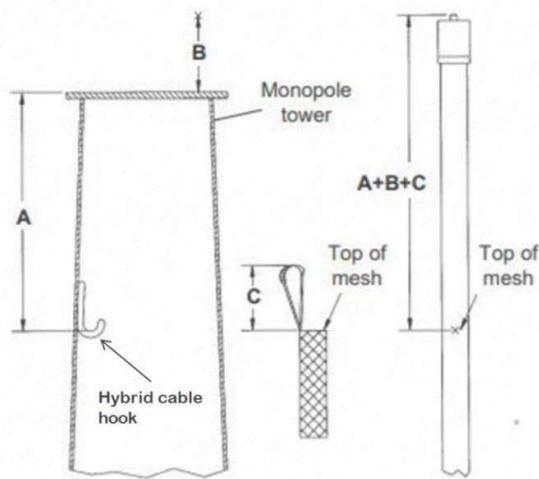
Hoisting grip fixation

Before fixing hoisting grips, make the following distance measurements before clamping or use of a lace-up style hoisting grips so that it can be hoisted to a support hook in the monopole tower:

Measure the distance from the top exit of the monopole to the interior hybrid cable support hook. (ONLY if instructions are NOT provided by the tower manufacturer.)

Measure the distance from the top mesh of the hoisting grip to the top of the cable handle.

Calculate the length of hybrid cable protruding from the top exit of the monopole. (All measurements must be made excluding the breakout)



Coaxial Power Wire Hybrid for Junction Box Installation Instructions

These three distances added together give the distance from the top of the hybrid cable breakout to the point where the top of the hoisting grip's mesh should be located after attachment. Once the location is found, the hoisting grip can then be clamped down with the support clamp.

Regardless of the calculated distance, the hoisting grips should be clamped at five feet (5') from the end of cable jacket. Do NOT attach the hoisting grip over the fiber termination protection or protection sleeve! Use a tie back rope or additional electrical tape if needed to prevent any stress or force to the fiber and protective sleeve. (Only use lace-up type hoisting grips.)

Secure pulling rope, avoid big knot, leave slack as necessary.



Hoisting cable through monopole

Feed hybrid cable top end into the tower base and keep it from hitting any tower steel work. Hoist the cable slowly and carefully, do not use excessive force as it may damage fiber termination breakout, connectors or the fiber itself.

Avoid snags when hoisting or routing hybrid cable through and around tower members and other incumbent cable that had been installed prior.

Ensure the hybrid cable weight is distributed evenly for safety and per hoisting components equipment specification.



Coaxial Power Wire Hybrid for Junction Box Installation Instructions

Due to the DC wire, hybrid cable is heavier than traditional cable; use a strong pulley at both the top and bottom of the tower to guide the hoist line. A minimum of persons is needed to properly hoist the cable assembly.

If it is necessary to install the cable over rough ground objects, protective measures must be taken.

Careless handling can damage the protective layers and potentially cause damage to fiber strands, fiber connectors or end-faces which may render the entire HYBRIFLEX line length inoperable.

Once the hybrid cable is hoisted to the appropriate height, anchor it to the support structure, starting at the top and wire the OVP box accordingly.

Ensure that enough cable is extended out from the designated top port holes to the main OVP so that cable can be bending and routed accordingly. (Most main breakout is approximately 6.5". Secure all unused terminations to prevent future damage.) Ground the hybrid cable on the top and bottom with RFS grounding kits.



Coaxial Power Wire Hybrid for Junction Box Installation Instructions

Hybrid cable into conduit

Caution: Inserting cables assembly into conduit may be difficult at times. Verify that the appropriate conduit and cable sizes specifications so that cable minimum bending radius is followed.

Hybrid cable size in minimum bending radius in 6" conduit

Cable size	Minimum bends radius
1/2"	10"
7/8"	18"
1-1/4"	22"
1-5/8"	28"

Prep cable as shown in Step 1 Monopole installation section

Once cable is prepped and secured with pulling rope, then, using a snake guide, fish rope into conduit

Feed cable slowly into conduit and start pulling (pulley may be use if space is permitted)

Cable may get harder to pull (lubricate cable, if necessary, with liquid soap or like help lubricate).



Coaxial Power Wire Hybrid for Junction Box Installation Instructions

FIBER INSPECTION

Optical Interface Connectors

The interface optical connectors are DLC to DLC.

Tools and test equipment

Use ONLY test equipment approved or recommended by the mobile network operator.

Safety Caution!

Operator should always assume fiber optic cables are live; laser radiation can cause irreversible damage or injury to the human eyes.

Optical End Face Inspection

Industry standards, as per the IEC document 61300-3-25 1.0, state that all optical fiber end faces must be inspected and cleaned before mating. Please refer to the cleaning procedure within this document if needed.

LC Connector inspection

- Inspect the LC fiber end face using the approved test equipment probe and the appropriated LC fiber tips. *If the test fails due to too much dirt, clean the end face accordingly and re-test.*

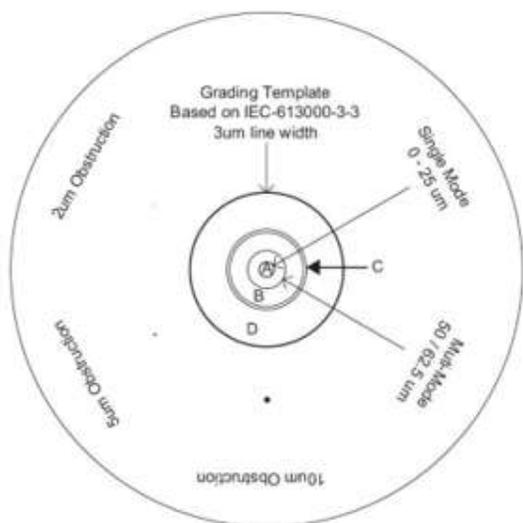
Note: For test parameters and the specific test that must be performed refer to the carrier closeout requirement.



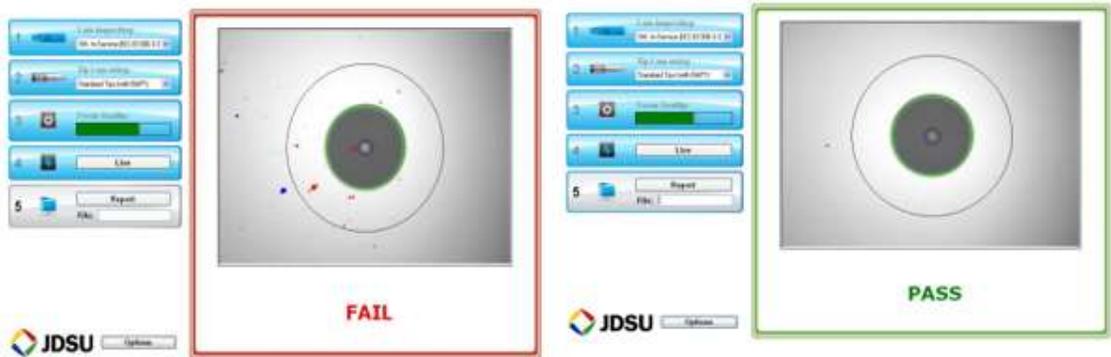
*Representative Image
– Not actual product*

Coaxial Power Wire Hybrid for Junction Box Installation Instructions

Fiber interface zones, per IEC Template 613000-3-3 (for single-mode fiber)



- A. Critical zone
- B. Cladding zone
- C. Adhesive zone
- D. Contact zone



Zone	Description	Diameter	Allowable defect diameter	Allowable size scratches
A	Core zone	25µm	None @200x	None @200x
B	Cladding zone	25-120µm	Less than 2-5µm, none > 10µm	No greater than 3µm
C	Adhesive zone	120-130µm	None >10µm	Any scratch ok
D	Contact zone	130-250µm	None > 10µm	Any scratches ok

Coaxial Power Wire Hybrid for Junction Box Installation Instructions

LC CONNECTOR INSPECTION

1. Inspect the LC fiber end-face using approved test equipment probe and the appropriate LC fiber tips. If the test fails due to too much debris, clean end-face accordingly and retest.

LC end-face inspection



Important Note: In the event of failure, clean connectors as shown below, refer to optical fiber cleaning section within this document for additional cleaning suggestions.

FIBER CLEANING INTRODUCTION

Warning: Before attempting to clean or inspect fiber optics it is strongly recommended that the technician have a good understanding of the IEC 61300-3-35 fiber optics standard procedure. This document can be obtained simply by performing an internet search for [IEC 61300-3-35](#).

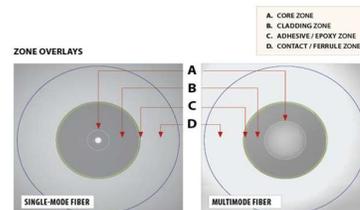
It is important that every fiber connector be inspected and cleaned prior to mating. This document describes inspection and cleaning processes for fiber optic connections. The procedures in this document describe basic inspection techniques and processes of cleaning for fiber optic cables, bulkheads, and adapters used in fiber Optics connections.

Note: This document is intended for use by service personnel, field service technicians, and hardware installers.

Inspection and Cleaning are Critical

Clean fiber optic components are a requirement for quality connections between fiber optic equipment. One of the most basic and important procedures for the maintenance of fiber optic systems is to clean the fiber optic equipment.

Any contamination in the fiber connection can cause failure of the component or failure of the whole system. Even microscopic dust particles can cause a variety of problems for optical connections. A particle that partially or completely blocks the core generates strong back reflections, which can cause instability in the laser system. Dust particles trapped between two fiber faces can scratch the glass surfaces. Even if a particle is only situated on the cladding or the edge of the end face, it can cause an air gap or misalignment between the fiber cores which significantly degrades the optical signal.





Coaxial Power Wire Hybrid for Junction Box Installation Instructions

In addition to dust, other types of contamination must also be cleaned off the end face. Such materials include:

- Oils, frequently from human hands
- Film residues, condensed from vapors in the air
- Powdery coatings, left after water or other solvents evaporate away

These contaminants can be more difficult to remove than dust particles and can also cause damage to equipment if not removed. When you clean fiber components, always complete the steps in the procedures carefully. The goal is to eliminate any dust or contamination and to provide a clean environment for the fiber optic connection. Remember that inspection, cleaning, and re-inspection are critical steps which must be done before you make any fiber-optic connection.

General Reminders and Warnings

Review these reminders and warnings before you inspect and clean your fiber-optic connections.

Reminders

- Always turn off any laser sources before you inspect fiber connectors, optical components, or bulkheads.
- Always make sure that the cable is disconnected at both ends.
- Always wear the appropriate safety glasses when required in your area.
- Always inspect the connectors or adapters before you clean.
- Always inspect and clean the connectors before you make a connection.
- Always use the connector housing to plug or unplug a fiber connector.
- Always keep a protective cap on unplugged fiber connectors.
- Always store unused protective caps in a re-sealable container to prevent the possibility of the transfer of dust to the fiber. Locate the containers near the connectors for easy access.
- Always discard used tissues and swabs properly.

Warnings

- Never look into a fiber while the system lasers are on.
- Never use alcohol or wet cleaning without a way to ensure that it does not leave residue on the end-face. It can cause damage to the equipment.
- Never clean bulkheads or receptacle devices without a way to inspect them.
- Never connect a fiber to a fiberscope while the system lasers are on.
- Never touch the end face of the fiber connectors.
- Never twist or pull forcefully on the fiber cable.
- Never reuse any tissue, swab or cleaning cassette reel.
- Never touch the clean area of a tissue, swab or cleaning fabric.
- Never touch any portion of a tissue or swab where alcohol was applied.
- Never touch the dispensing tip of an alcohol bottle.
- Never use alcohol around an open flame or spark; alcohol is very flammable.

Best Practices

- Re-sealable containers should be used to store all cleaning tools, store end caps in a separate container.

Coaxial Power Wire Hybrid for Junction Box Installation Instructions

The inside of these containers must be kept very clean, and the lid should be kept tightly closed to avoid contamination of the contents during fiber connection.

- Never allow cleaning alcohol to evaporate slowly off the ferrule as it can leave residual material on the cladding and fiber core. This is extremely difficult to clean off without another wet cleaning and usually more difficult to remove than the original contaminant. Liquid alcohol can also remain in small crevices or cavities where it might re-emerge.

General Inspection and Cleaning Procedures

This section describes the connector cleaning process. Additional sections provide more detail on specific inspection and cleaning techniques.



General Cleaning Process

Complete these steps:

1. Inspect the fiber connector, component, or bulkhead with a fiberscope.
2. If the connector is dirty, clean it with a dry, cleaning technique. Using hand tool such as "One-Click" type cleaner, etc.
3. Inspect the connector.
4. If the connector is still dirty, repeat the dry, cleaning technique.
5. Inspect the connector.
6. If the connector is still dirty, clean it with a wet cleaning technique followed immediately with a dry clean to ensure no residue is left on the end-face.



Note: Wet cleaning is not recommended for bulkheads and receptacles. Damage to equipment can occur.

7. Inspect the connector again.
 8. If the contaminate still cannot be removed, repeat the cleaning procedure until the end-face is clean.
- Note:** Never use alcohol or wet cleaning without a way to ensure that it does not leave residue on the end-face. It can cause equipment damage.

Connector Inspection Technique

This inspection technique is done with the use of fiberscopes to view the end face.

A fiberscope is a customized microscope used to inspect optical fiber components. The fiberscope should provide 200x-400x total magnification. Specific adapters are needed to properly inspect the end face of most connector types, for example: 1.25 mm, 2.5 mm

Tools

- Clean, re-sealable container for the endcaps
- Fiberscope
- Bulkhead probe



Coaxial Power Wire Hybrid for Junction Box Installation Instructions

Cleaning Techniques for Pigtails and Patch Cords

This section describes cleaning techniques for pigtails and patch cords.

Note: No known cleaning methods are 100% effective; therefore, it is imperative that inspection is included as part of the cleaning process. Improper cleaning can cause damage to the equipment.

Dry Cleaning Technique: Cartridge and Pocket Style Cleaners

This section describes dry cleaning techniques with the use of cartridge and pocket style cleaners.

Tools

- Cartridge Cleaning Tools:
- Pocket Style Cleaning Tools:

1. Make sure that the lasers are turned off before you begin the inspection.

Warning: Invisible laser radiation might be emitted from disconnected fibers or connectors. Do not stare into beams or view directly with optical instruments.

2. Remove the protective endcap and store it in a small re-sealable container.

3. Inspect the connector with a fiberscope.

4. If the connector is dirty, clean it with a cartridge or pocket cleaner.

- For cartridge cleaners, press down and hold the thumb lever. The shutter slides back and exposes a new cleaning area, then go to step 5.
- For pocket cleaners, peel back protective film for one cleaning surface, and then go to step 5.
- For manual advance cleaners, pull on the cleaning material from the bottom of the device until a new strip appears in the cleaning window, and then go to step 5.

5. Hold the Ferrule tip lightly against the cleaning area and rotate one quarter turn.

6. Pull the ferrule tip lightly down the exposed cleaning area in the direction of the arrow or from top to bottom.

Caution: Do not scrub the fiber against the fabric or clean over the same surface more than once. This can potentially contaminate or damage your connector.

7. Release the thumb lever to close the cleaning window if you use cartridge type cleaners.

8. Inspect the connector again with the fiberscope.

9. Repeat the inspection and cleaning processes, as necessary.

Caution: Throw away any used cleaning material, either cards or material cartridges, after use.

Dry Clean Technique: Lint-Free Wipes

This section describes dry cleaning techniques that use lint-free wipes.

Tools

- Lint-free wipes, preferably clean room quality

1. Make sure that the lasers are turned off before you begin the inspection.



Coaxial Power Wire Hybrid for Junction Box Installation Instructions

Warning: Invisible laser radiation might be emitted from disconnected fibers or connectors. Do not stare into beams or view directly with optical instruments.

2. Remove the protective endcap and store it in a small re-sealable container.
3. Fold the wipe into a square about 4 to 8 layers thick.
4. Inspect the connector with a fiberscope.

If the connector is dirty, clean it with a lint-free wipe.

Caution: Be careful not to contaminate the cleaning area of the wipe with your hands or on a surface during folding.

5. Lightly wipe the ferrule tip in the central portion of the wipe with a figure 8 motion.

Caution: Do not scrub the fiber against the wipe, it can cause scratches and more contamination.

6. Repeat the figure 8 wiping action on another clean section of the wipe.
7. Properly dispose of the wipe.
8. Inspect the connector again with the fiberscope.
9. Repeat this process as necessary.

Wet Cleaning Technique: Lint-Free Wipes

If a dry, cleaning procedure does not remove the dirt from the fiber end-face, then precede the wet cleaning method.

Caution: Improper cleaning can cause damage to the equipment. The primary concern with the use of isopropyl alcohol is the ability to remove any residue completely from the connector or adapter. Residual liquid alcohol acts as a transport mechanism for loose dirt on the end face. **If** the alcohol is allowed to evaporate slowly off the ferrule, it can leave residual material on the cladding and fiber core. This is extremely difficult to clean off without another wet cleaning and usually more difficult to remove than the original contaminant. Liquid alcohol can also remain in small crevices or cavities where it can re-emerge during fiber connection.

Tools

- 99% isopropyl alcohol
- Lint-free wipes

Caution: Read the reminders and warnings before you begin this process.

1. Make sure that the lasers are turned off before you begin the inspection.

Warning: Invisible laser radiation might be emitted from disconnected fibers or connectors. Do not stare into beams or view directly with optical instruments.

2. Remove the protective endcap and store it in a small re-sealable container.
3. Inspect the connector with a fiberscope.
4. Fold the wipe into a square, about 4 to 8 layers thick.



Coaxial Power Wire Hybrid for Junction Box Installation Instructions

5. Moisten one section of the wipe with one drop of 99% alcohol. Be sure that a portion of the wipe remains dry.
6. Lightly wipe the ferrule tip in the alcohol moistened portion of the wipe with a figure 8 motion. Immediately repeat the figure 8 wiping action on the dry section of wipe to remove any residual alcohol.

Caution: Do not scrub the fiber against the wipe, doing so can cause scratches.

7. Properly dispose of the wipe. **Never reuse a wipe.**
8. Inspect the connector again with a fiberscope.
9. Repeat the process as necessary

Mobile operator specific optical testing

Note: OTDR unidirectional measurements lead to inaccuracies when fibers with different Mode Field Diameters (MFD) are connected. The inaccuracies usually are in the form of “gainers” or “exaggerated losses”. At MFD mismatched connection OTDR backscattered light is greater or smaller, depending on the direction. Specifically, the capture fraction in an optical fiber is inversely proportional to the mode-field diameter squared. Thus, when two fibers of dissimilar mode field diameter are connected, measurable differences in back reflected signal will occur that will add additional 0.1 to 0.5dB per IL connection. This is an OTDR testing issue only and does not affect cable performance and actual optical loss. To avoid this issue, OTDR testing must be done bi-directionally per FOTP-61.

Certain Mobile Operators require that all cables be tested using Loopback loss method:

- Use only mobile operator approved test equipment and loopback patch cords
- Perform only recommended tests
- Keep all cleaners, adapters and calibration items clean and free of any contamination
- Replace any old, worn adapters and test cables
- Test all individual components before mating
- Used only single-mode fiber accessories. Do not mix-match adapter or loopback devices.

Mobile Operator system insertion loss table (using power meter only to measure insertion loss)

Fiber characteristic	Single Mode
Light propagation mode	1310 and 1550 nm
IL per connector one way	0.25 dB
Reflectance	Min 50 dB
Max system fiber loss allowed	4 dB (2 dB up and 2 dB down)

Coaxial Power Wire Hybrid for Junction Box Installation Instructions

HYBRIFLEX INTO JUNCTION BOX

At the base of the junction box (with OVP) there are cable glands that provide weatherproofing for the enclosure. The following steps will show how to properly install the hybrid cable.

- Remove compression nut. **(Figure 1)**
- Remove center insert from cable gland. Slide compression nut over the cable breakout (no insert required). Be careful not to damage the fiber connectors. **(Figure 2,3)**
- Carefully feed fiber and power conductors into the OVP box (Keep ESD bag intact) and tighten the compression nut. **(Figure 4,5,6,7)**

Refer to the OVP's Manual for wiring and fiber spooling detail.



Figure 1



Figure 2



Figure 4



Figure 5



Figure 3



Figure 6



Figure 7

Torque: 44 in-lbs.

- Note: Should the process of installing cables loosen the gland, then the inner nut needs to be retightened (66 in-lb. [7.5 N-m]) to maintain the environmental seal of the enclosure.

Coaxial Power Wire Hybrid for Junction Box Installation Instructions

LOW INDUCTANCE MOLDED BOOT INSTALLATION INSTRUCTION

For Rack Mount and Tower Mount OVP's

Caution: Ensure that all DC power sources are Disconnect or disable prior to Wiring.

Installation required tools: Tape, Wire Cutter, Jacket stripping tool, termination lugs

Instruction for rack Mount

1. Strip the outer jacket 5 ½ inches back **Fig. 1**
2. Twist the outer copper strands together **fig. 2**
3. Cut the non-insulated copper wire to 2 ½" **Fig. 3**
4. Strip the jacket off the insulated conductor 9/16 of an inch **Fig. 4**
5. Insert both wires into the splitter connector **Fig. 5**
6. Install and stake wires into rack mount unit using blade lugs, **Fig. 6.**
7. Repeat process for all 6 wires.

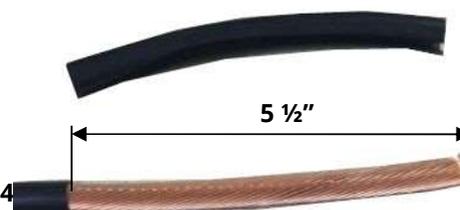


Figure 1

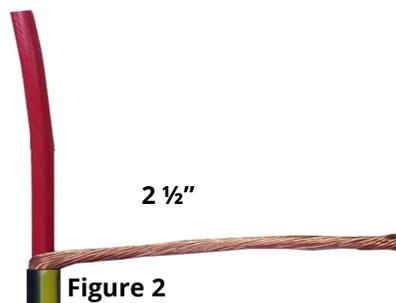


Figure 2



Figure 3



Figure 4



Figure 5

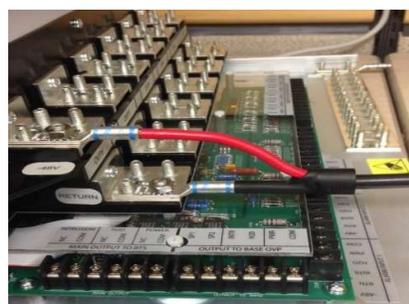


Figure 6

Coaxial Power Wire Hybrid for Junction Box Installation Instructions

Tower/Box Mount Installation to OVP in Junction Box

- 1) Strip the outer jacket 3.0 inches back **Fig. 1**
- 2) Twist the outer copper strands together **Fig. 2**
- 3) Strip the jacket off the red insulated conductor 1/2 of an inch **Fig. 3**
- 4) Insert Low Inductance wire into splitter insulator **Fig 4**
- 5) Feed the Low inductance wires into the junction box and connect to the power connectors.
- 6) Connect wires according to the mobile network operator's established color guide. Recommended starting with lower bottom left OVP of the box (OVP). **Fig. 5, 5a**
- 7) END

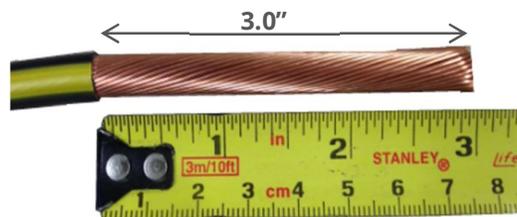


Figure 1



Figure 2



Figure 3



Figure 4

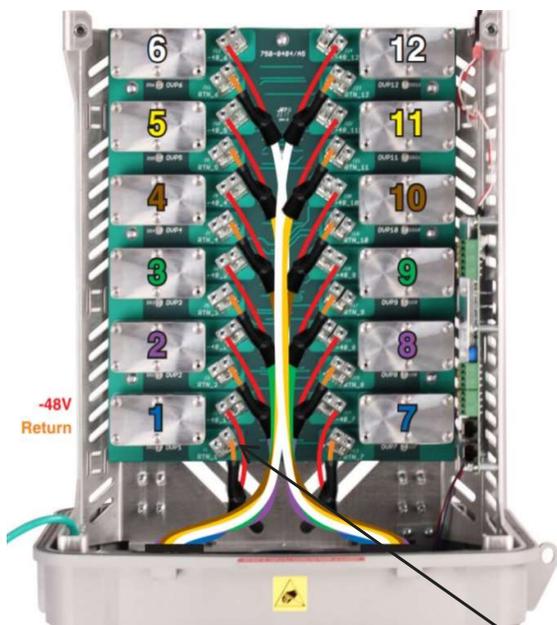


Figure 5, 12 OVP's



Figure 5a, 6 OVP's

Start Here

Coaxial Power Wire Hybrid for Junction Box Installation Instructions

FULLAXS COMPATIBLE CONNECTOR INSTALLATION

Use the following instruction to properly install/attach the FullAXS compatible connector. Failure to follow these procedures entirely may cause damage to the Fiber or Connector. For factory pre-installed assembly, skip to step 4a:

1



Carefully feed compression nut over fiber jumper connector and slide onto jacketing. Do not twist or bend the LC connector or fiber. Excessive force or bending may break the fiber or connector components.

2



Feed the fiber connector into the sleeve until the Connector comes out. **Caution: do not apply too much force as doing so can cause damage to the fiber and gland spring fingers.**

3



Wrap the rubber split grommet around the jacketing and **VERY CAREFULLY** push it **UNDER** the clamping fingers until the grommet is flush with the finger ends. **Caution: it will be necessary to gently lift the fingers.**

Coaxial Power Wire Hybrid for Junction Box Installation Instructions

4



Engage the compression nut thread to the body 3-4 revolutions to keep the grommet in place but do not tighten fully to allow for adjustment during RRU connection.

a: Remove protective dust cap (top), disengage the compression nut (bottom), adjust the jumper to proper length

5



Slide FullAXS compatible gland body down jacketing to allow access to the fiber end connector. Do not pull the fiber end connector through the sleeve or damage may occur.

6



Remove the fiber dust caps from fiber end face and seat into the RRH SPF card slot until you hear a click. Do not twist fiber end face or kink the fiber during installation.

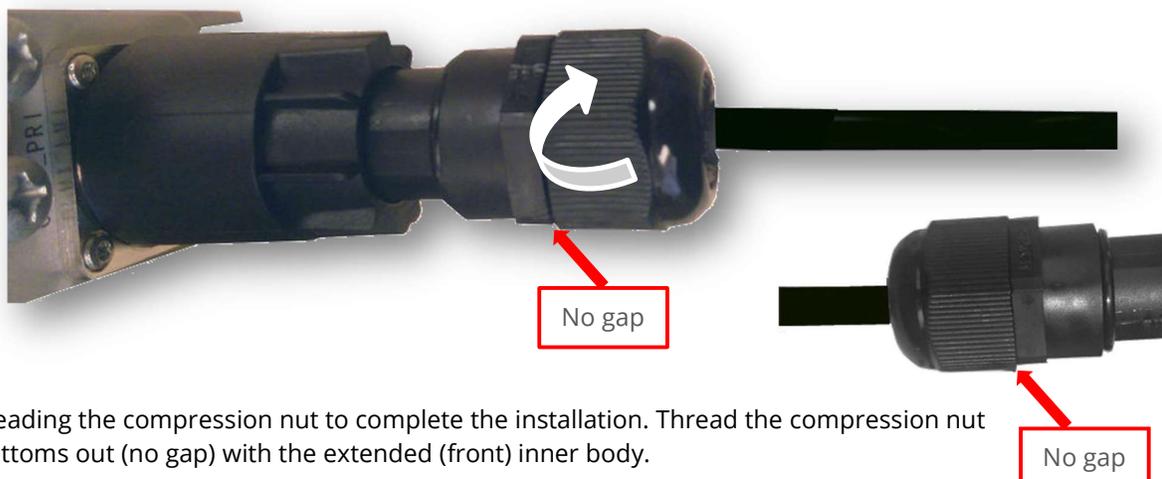
7



Slide the FullAXS compatible sleeve up to the RRH. Turn top nut clockwise to secure to RRH bulkhead connector.

Coaxial Power Wire Hybrid for Junction Box Installation Instructions

8



Reverse steps 8 to 1 to remove sleeve for maintenance. Once the Nut is tight, spring fingers are compressed tightly. To remove or adjust jumper fiber the grommet must be push from the front using a small bladed, long-shaft screwdriver



Caution: Do not insert the screwdriver blindly.

Coaxial Power Wire Hybrid for Junction Box Installation Instructions

HYBRIFLEX BULKHEAD CONNECTOR FITTING INSTALLATION

The bulkhead fitting kit is designed to be used with HYBRIFLEX cable, to secure the riser trunk line to the equipment cabinet. No additional boot is required. The bulkhead fitting forms a mechanical and water-tight connection providing ground continuity (for metal types) between the cable's armor and the metal enclosure used. These HYBRIFLEX connectors are UL listed for ordinary wet location use in accordance with UL Standard 514B. Prepare the junction box per bulkhead fitting size. Refer to the specific fitting instruction sheet (attached to the cable) for the punch-hole dimension and torque specifications.

Tools Required for Installation:

- Tape
- Ruler
- Open ended wrench (specific to the bulkhead fitting size)
- Sharp knife to remove the jacket
- Ripcord removal kit

Note: HYBRIFLEX cable bulkhead fitting kit may be optionally shipped hand tightened on all trunk cable.



Figure 1

Metal Bulkhead Fitting

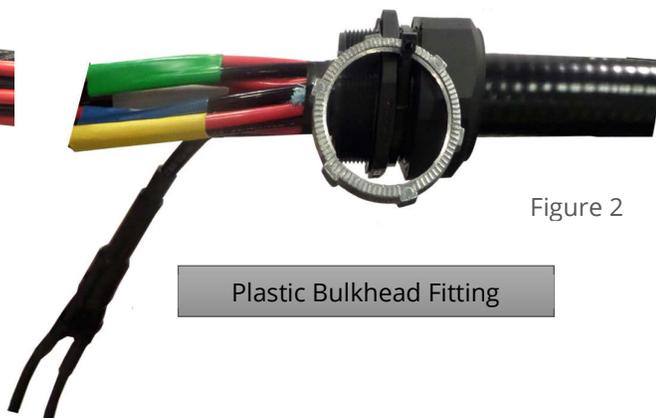


Figure 2

Plastic Bulkhead Fitting

Note: If additional breakout length is needed, loosen the bulkhead and slide it down over jacket. Refer to the ripcord removal process in this document. Once the ripcord removal is completed, prep the end of the cable using a knife and remove 2.6 inches of the jacket to expose the outer copper armor.

Coaxial Power Wire Hybrid for Junction Box Installation Instructions

Instruction steps:

1. Remove the connector from the package and inspect it to ensure there are no missing pieces or damage. DO NOT DISASSEMBLE OR TIGHTEN THREAD (Figure 1).
2. Prep the cable by removing 2.6 inches of the jacket using RFS jacket stripping tool or knife to expose the aluminum outer armor (Figure 8).
3. Carefully feed ESD taped bag with fiber terminations into the connector and slide over DC power.
 - Caution:** When sliding bulkhead over fiber splitter fan-out (Figure 3 and 4).
4. Feed cable assembly until the aluminum armor reaches the center stop of the bulkhead. Hold the intermediate body (with open ended wrench) and tighten the back-nut using the appropriate torque wrench and specific torque. See torque table
5. Tighten the front-end body and front end to the specific torque see torque table. Cut and remove the excess blue filler and clear Mylar, flush with the connector face (see figure 9 and 10).
 - a. 5a) For 6AWG assembly, tighten body sealing nut, at this point.
6. Connector is now installed on the cable assembly. It is ready to be mounted into the cabinet (See figure 10).
7. To assemble the HYBRIFLEX cable into the cabinet, loosen fitting, unwrap the locknut and adjust bulkhead as needed.
8. Carefully insert the fiber and DC wires into the cabinet punch hole, then slowly guide the HYBRIFLEX connector (and reducer if applicable) into the fitting hole. Note: Be careful not to cut any wires.
9. Slide capture locknut until it reaches the reducer thread and secured to the cabinet; a flat screwdriver may be used for additional tightening (see Figure 11).



Figure 3



Figure 4



Figure 5



Figure 6

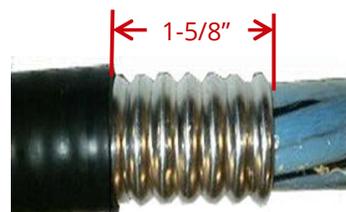


Figure 7

Coaxial Power Wire Hybrid for Junction Box Installation Instructions



Figure 8



Figure 9



Figure 10



(Plastic fitting)



(Metal fitting)

Figure 11



Coaxial Power Wire Hybrid for Junction Box Installation Instructions

TRADEMARKS

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DOCUMENT CONTROL

Document Number: 603400201500

Rev	Completed By	Approved By	Release Date	ECO#	Comments/Changes
A	E. Redvil	M. Gauvin	16 July 2019	RFS19277	Released version
B	M. Gauvin	M. Gauvin	14 July 2021	RFS21103	Added FullAXS compatible connector instructions
C	M. Gauvin	M. Gauvin	3Feb2022	RFS22020	Added coil box, updated template

About RFS

Radio Frequency Systems (RFS) delivers the end-to-end RF solutions and expert services needed to evolve wireless and broadcast networks today and tomorrow. Our cables, connectors, antenna systems and RF conditioning products are based on more than 120 years of experience delivering cutting-edge RF solutions and industry firsts. As a result, our solutions are recognized globally for their innovation, superior performance and unmatched quality.

As an ISO-compliant company with global operations, we bring our customers world-class engineering and manufacturing skills backed with comprehensive local support services. Our customers know they can rely on our expertise and commitment to excellence from initial design to final delivery and beyond — whether they're looking to support 5G, deploy small cells, empower smart cities or improve indoor coverage in the most challenging locations.

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