



Direct Connection RRH HYBRIFLEX® Guidelines and Instructions



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Introduction to HYBRIFLEX®

RFS' HYBRIFLEX Remote Radio Head (RRH) hybrid feeder cabling solution combines multiple elements, including optical fiber and DC power, for RRHs in a single lightweight cable, making it the world's most innovative solution for RRH deployments. 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 combines optical fiber, power and alarm wire in a single jacketed cable and 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 (e.g. pulling over sharp edges, over tightening of clamps etc.).



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HYBRIFLEX Feeder Configuration

This installation guideline supports **HYBRIFLEX cable** available in small, medium and large riser trunk configurations, 6x12 and 6x24. The trunk cable assemblies comprise of 4, 6 or 10AWG DC wires, and twelve (12) or twenty-four (24) pairs of single mode fiber terminated with ODC-LC connector.

This application eliminates the need of junction boxes, utilizing outdoor weather tight optical fiber connection to armored, fiber only jumpers and direct DC connection to RRH from the riser trunk, for complete installation from BBU to RRH.

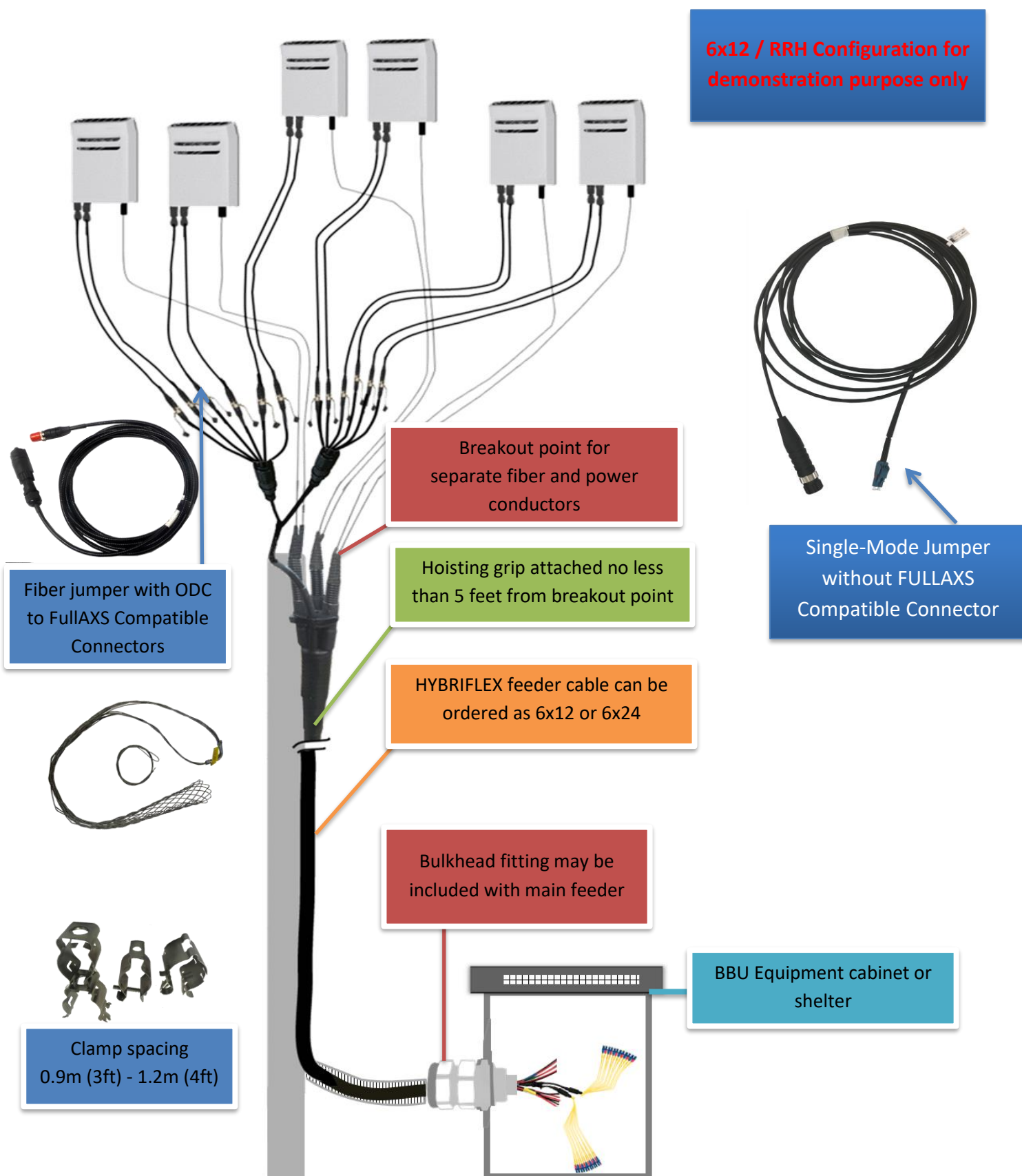
HYBRIFLEX trunk cable assemblies are factory constructed specifically to suit this application, ensuring trouble-free installation. Additional features that ease installation and ensure durability throughout service life include:

- Robust breakout design with identified 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:

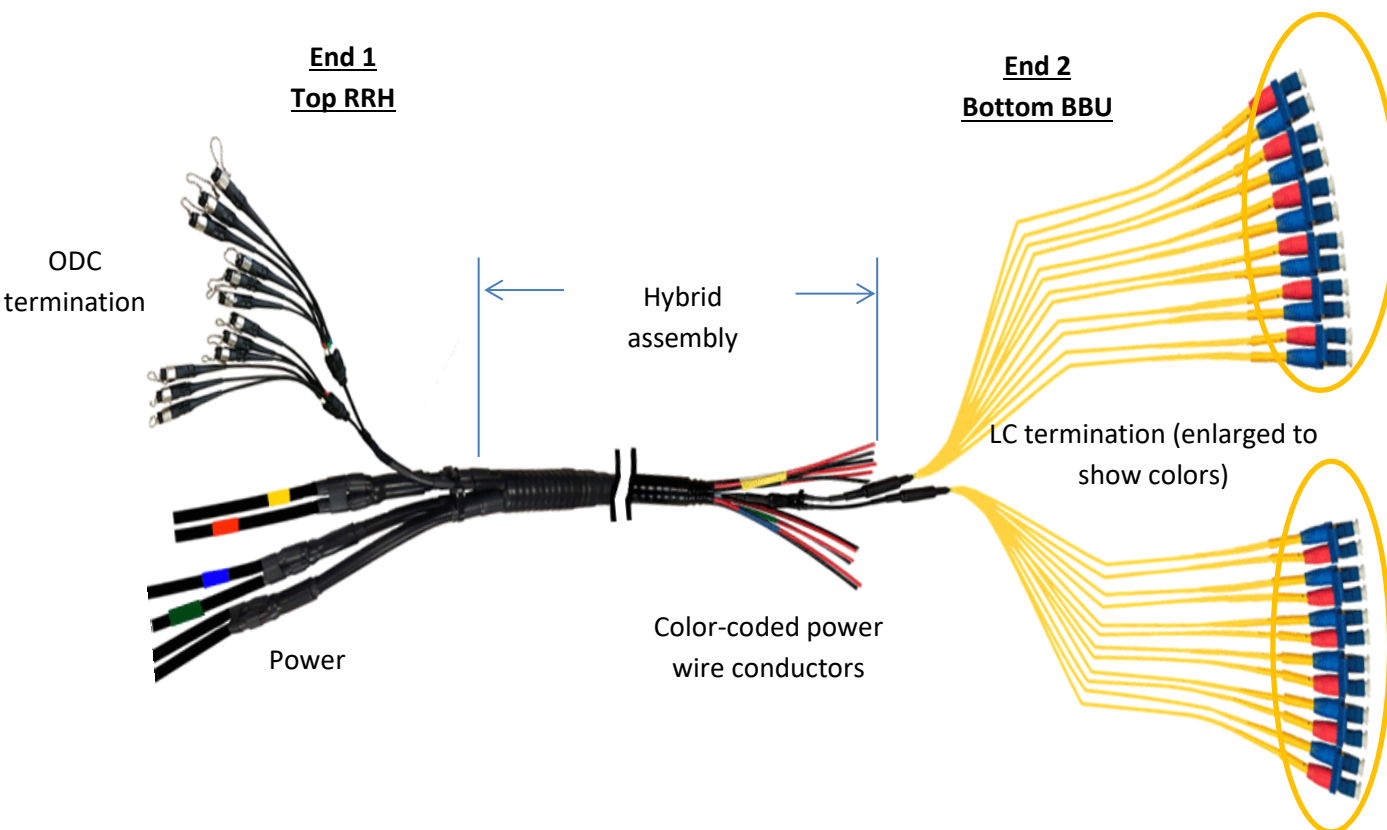
Generic Description	Type	Typical Application		DC Pairs	DC gage (AWG)	Cross Section (mm ²)		Fiber Pairs	Fiber type	Fiber Termination Top	Fiber Termination Bottom	Armor	Model Name Assembly Model Name Assembly Kit with predefined accessories
6x12	Hybrid	Riser	Riser to fiber Jumper	6	10	5.3	Jacketed, braided pairs at breakout; Unshielded individually jacketed wires in the bulk	12	SM	ODC	D-LC	Al Corrugated	HB078-05U6S12-xxM-01 HB078-05U6S12-xxM-KIT-01
6x12	Hybrid	Riser	Riser to fiber Jumper	6	6	13.4	Jacketed, braided pairs at breakout; Unshielded individually jacketed wires in the bulk	12	SM	ODC	D-LC	Al Corrugated	HB114-13U6S12-xxM-01 HB114-13U6S12-xxM-KIT-01
6x12	Hybrid	Riser	Riser to fiber Jumper	6	4	21	Jacketed, braided pairs at breakout; Unshielded individually jacketed wires in the bulk	12	SM	ODC	D-LC	Al Corrugated	HB158-21U6S12-xxM-01 HB158-21U6S12-xxM-KIT-01
6x24	Hybrid	Riser	Riser to fiber Jumper	6	4	21	Jacketed, braided pairs at breakout; Unshielded individually jacketed wires in the bulk	24	SM	ODC	D-LC	Al Corrugated	HB158-21U6S24-xxM HB158-21U6S24-xxM-KIT

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HYBRIFLEX® feeder assembly ODC (top) & LC (bottom) optical fiber connectors



Helpful tip - The following are just a few examples of hybrid riser cables kits for this application. Please check with your local RFS representative for additional product variations and options.

Hybrid riser kit model numbering structure

HB078-05U6S12-xxM-KIT-01, HB114-13U6S12-xxM-KIT-01, HB158-21U6S12-xxM-KIT-01, HB158-21U6S24-xxM-KIT

HB	078, 114, 158	05, 13, 21	U	6	S	12	xxxM	KIT
Hybrid	Over Jacket O.D.	Wire Gauge	Unshielded	No. of DC Pair	Single Mode	No. of Fiber Pair	Length in Meters	Includes Ground kit, Hoist grip

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Quick reference

Cable type

Cable brand

Conductor gauge

Number of conductors

Number of fibers

Hybrid armor type

Hybrid fiber mode

Hybrid termination

Hybrid weight (kg/m (lb/ft))

Max over jacket diameter

Breakout fiber length, top

Breakout fiber length, bottom

Breakout power length, top

Breakout power length, bottom

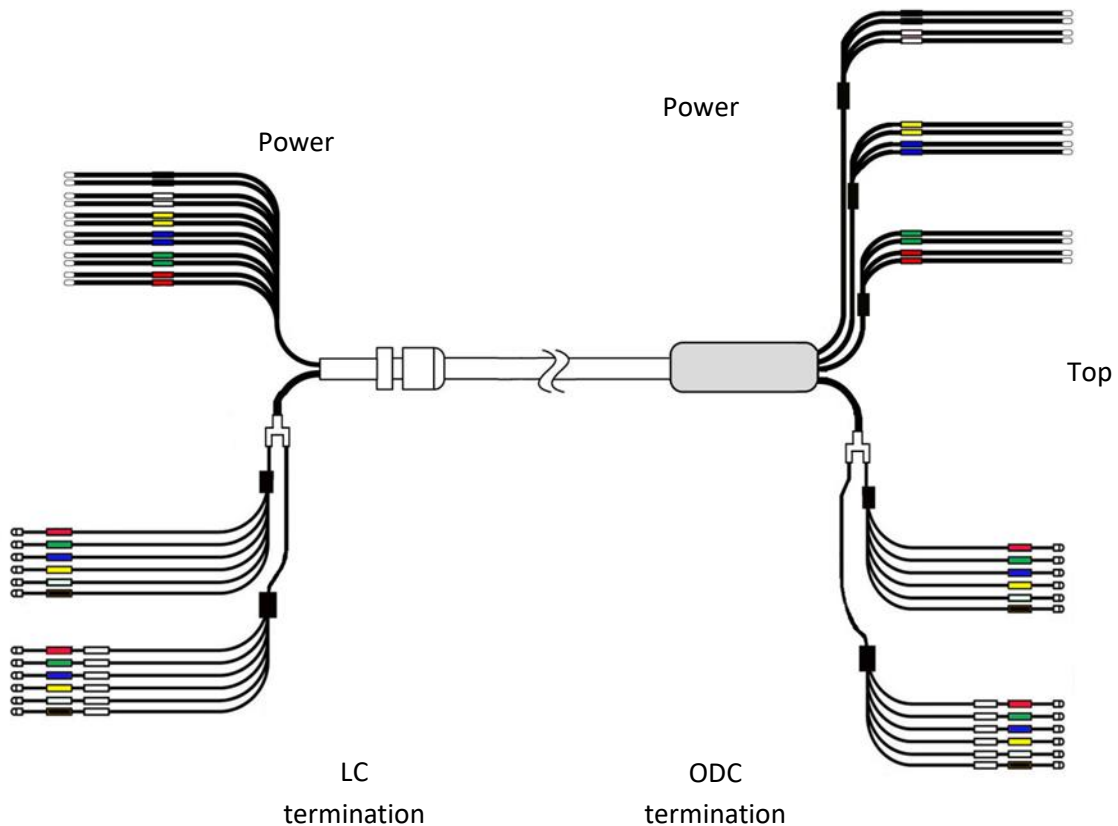
Hybrid minimum bend radius

Multi

Hybrid minimum bend radius

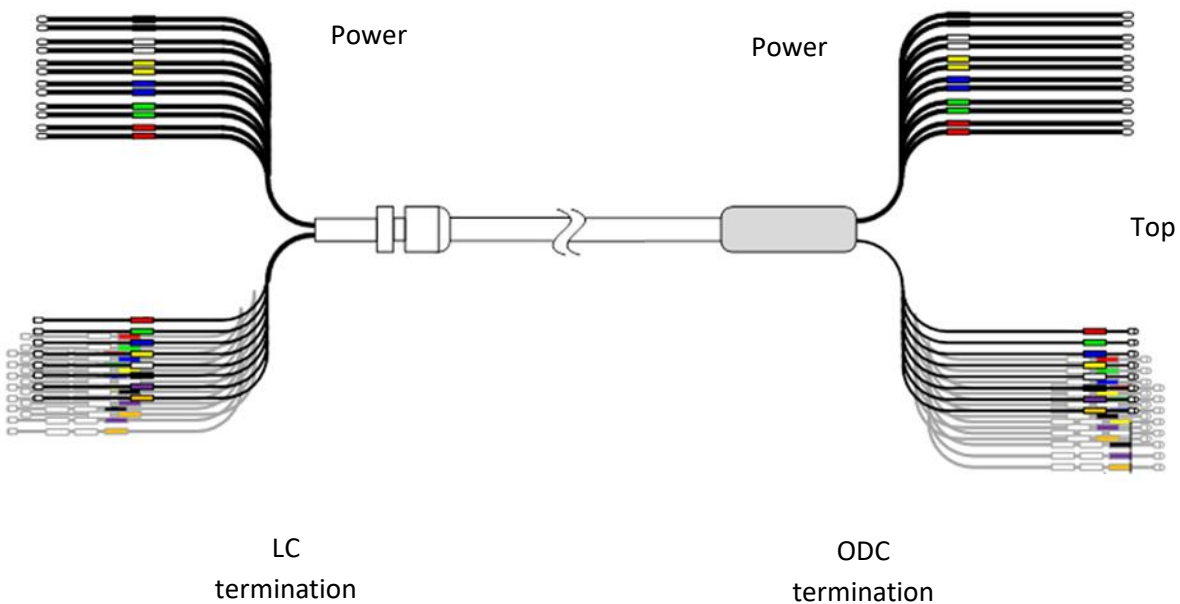
Single

	HB078-05U6S12-	HB114-13U6S12-	HB158-21U6S12-
Cable brand	HYBRIFLEX®	HYBRIFLEX®	HYBRIFLEX®
Conductor gauge	10 AWG	6 AWG	4 AWG
Number of conductors	6 pairs	6 pairs	6 pairs
Number of fibers	12 pairs	12 pairs	12 pairs
Hybrid armor type	Corrugated aluminum	Corrugated aluminum	Corrugated aluminum
Hybrid fiber mode	Single-Mode	Single-Mode	Single-Mode
Hybrid termination	Top: ODC Bottom: LC	Top: ODC Bottom: LC	Top: ODC Bottom: LC
Hybrid weight (kg/m (lb/ft))	1.03 0.7	2.24 1.51	2.8 2
Max over jacket diameter	28.6mm 1.13"	39mm 1.54"	51mm 2"
Breakout fiber length, top	0.5m 20"	0.5m 20"	0.5m 20"
Breakout fiber length, bottom	1.3m 53"	1.3m 53"	1.3m 53"
Breakout power length, top	4.0m 157"	4.0m 157"	5.0m 197"
Breakout power length, bottom	150mm 6"	150mm 6"	1.0m 39"
Hybrid minimum bend radius	254mm 10"	254mm 10"	500mm 20"
Multi			
Hybrid minimum bend radius	125mm 5"	152mm 6"	250mm 10"
Single			



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Cable type	HB158-21U6S24-
Cable brand	HYBRIFLEX®
Conductor gauge	4 AWG
Number of conductors	6 pairs
Number of fibers	24 pairs
Hybrid armor type	Corrugated aluminum
Hybrid fiber mode	Single-Mode
Hybrid termination	Top: ODC Bottom: LC
Hybrid weight (kg/m (lb/ft))	3.65 2.5
Max over jacket diameter	50.7mm 1.9"
Breakout fiber length, top	700mm 27"
Breakout fiber length, bottom	1610mm 63"
Breakout power length, top	5m 197"
Breakout power length, bottom	1m 39"
Hybrid minimum bend radius	500mm 20"
Multi	
Hybrid minimum bend radius	250mm 10"
Single	



RFS INSTALLATION GUIDELINES

Transporting, Shipping and Handling the Drum

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

- If the drum will be shipped 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, 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 can't 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 shorten circuitry.

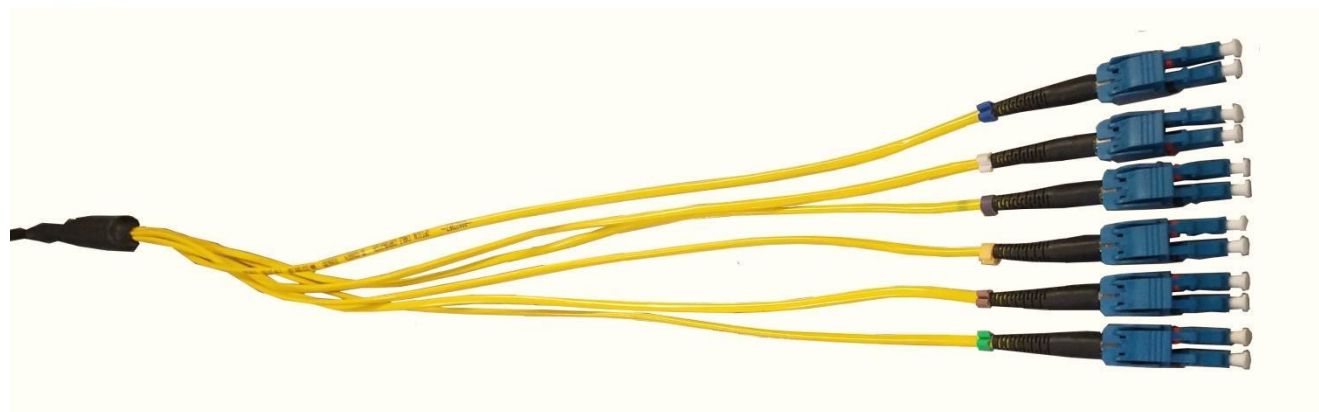
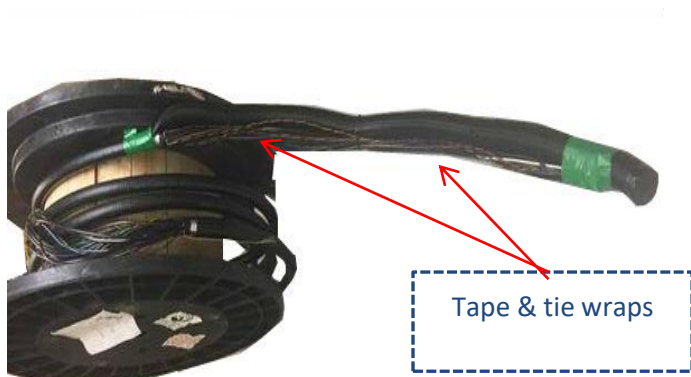
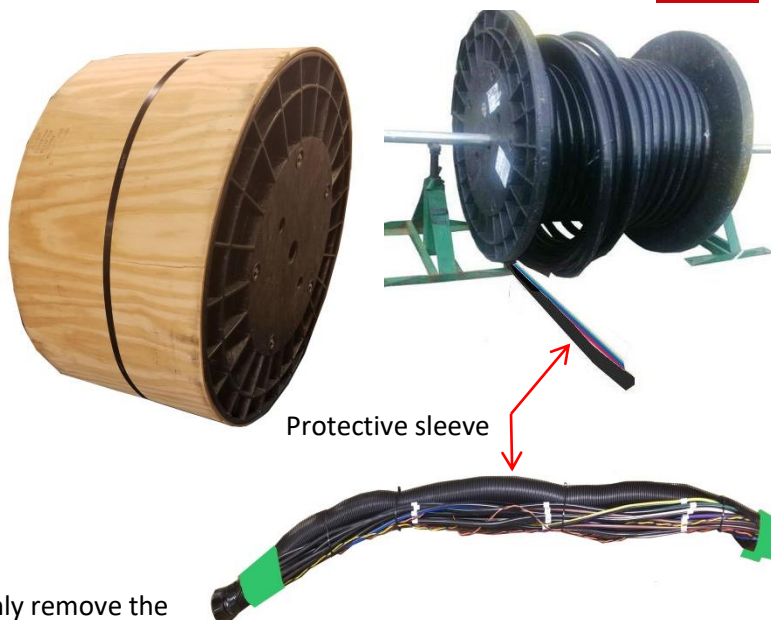


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Protective Sleeve Removal/Packing

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.

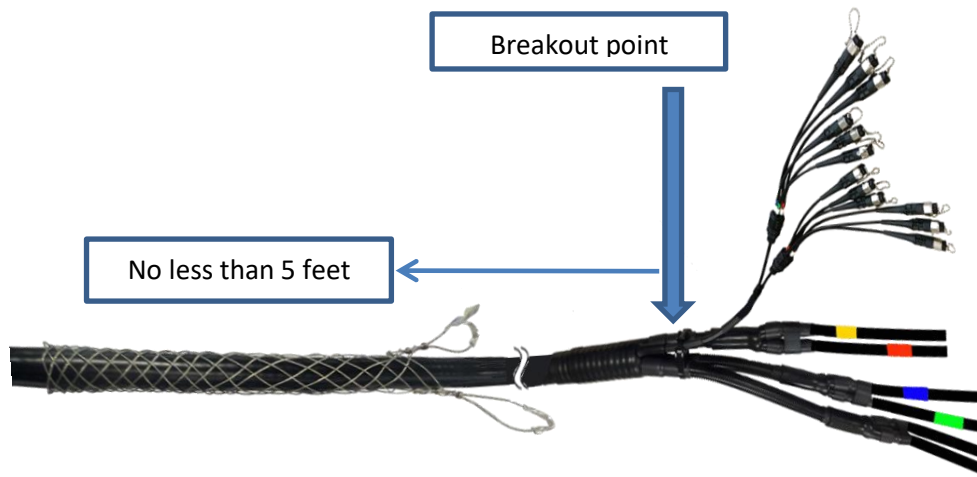
- Each hybrid termination is protected by a robust protective sleeve (as shown below) and ESD plastic bags to prevent damage to the fiber end face.
- Use caution when removing the sleeve.
- Unwrap the packaging reel
- Remove tape and tie wraps
- Slowly pull off protected sleeve
- Untapped and remove ESD plastic bag (only remove the section that is been work on)



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Hoisting/Pulling HYBRIFLEX Cable

- **Note:** when hoisting and pulling HYBRIFLEX always use caution.
- 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 sock.
- Hoisting grips should be attached no less than 5 feet from the breakout point.



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HYBRIFLEX cable is supplied in specific cut lengths with fully terminated and polished factory 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.

For every long vertical run of cable, additional hoisting grips should be attached at 50-60m intervals.

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.

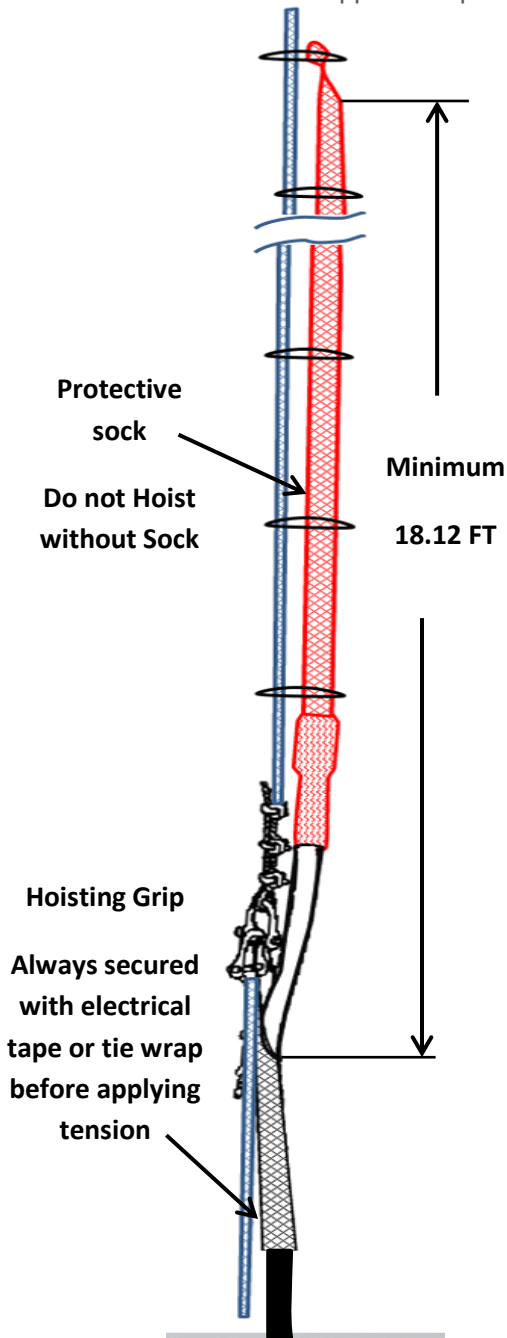
If it is necessary to drag the cable over sharp edges of buildings or tower members, protective measures must be taken.

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.

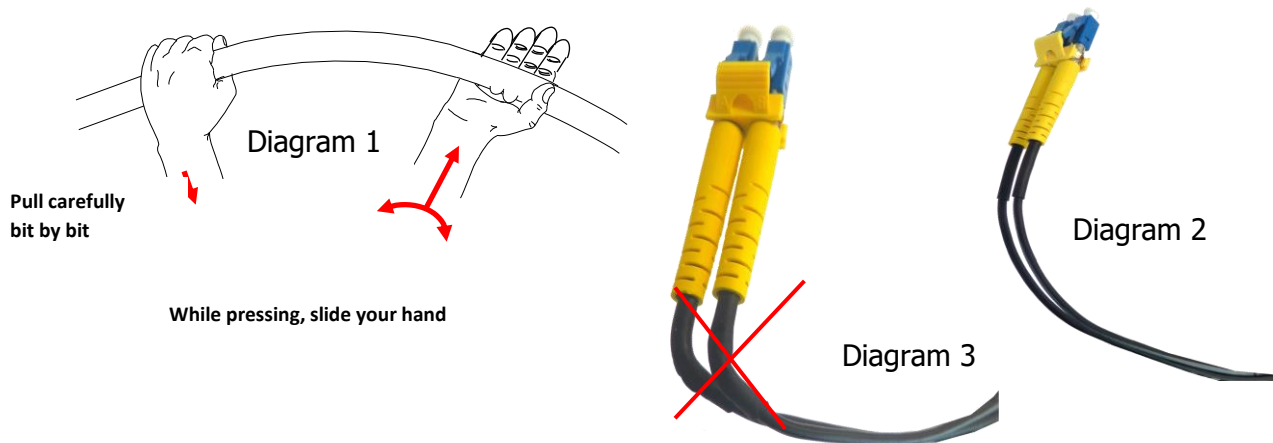
Caution! The protective sleeve should not be removed until installation is complete.

Hoisting Grips: 1 for every 100ft of vertical run. For heavier runs, such as 1-5/8" 4AWG, use 2 hoisting grips for every 200ft vertical run.



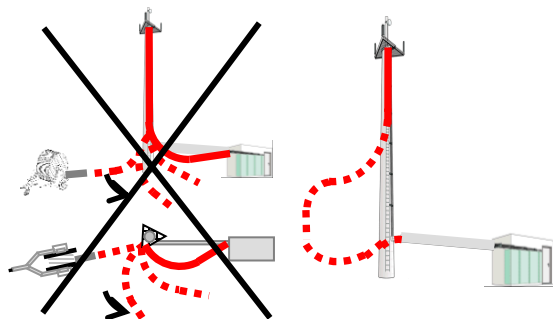
HYBRIFLEX Bending

- The minimum-bending radius should be strictly observed. [See product spec sheet]. 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 aluminum 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 run

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

RFS INSTALLATION GUIDELINES

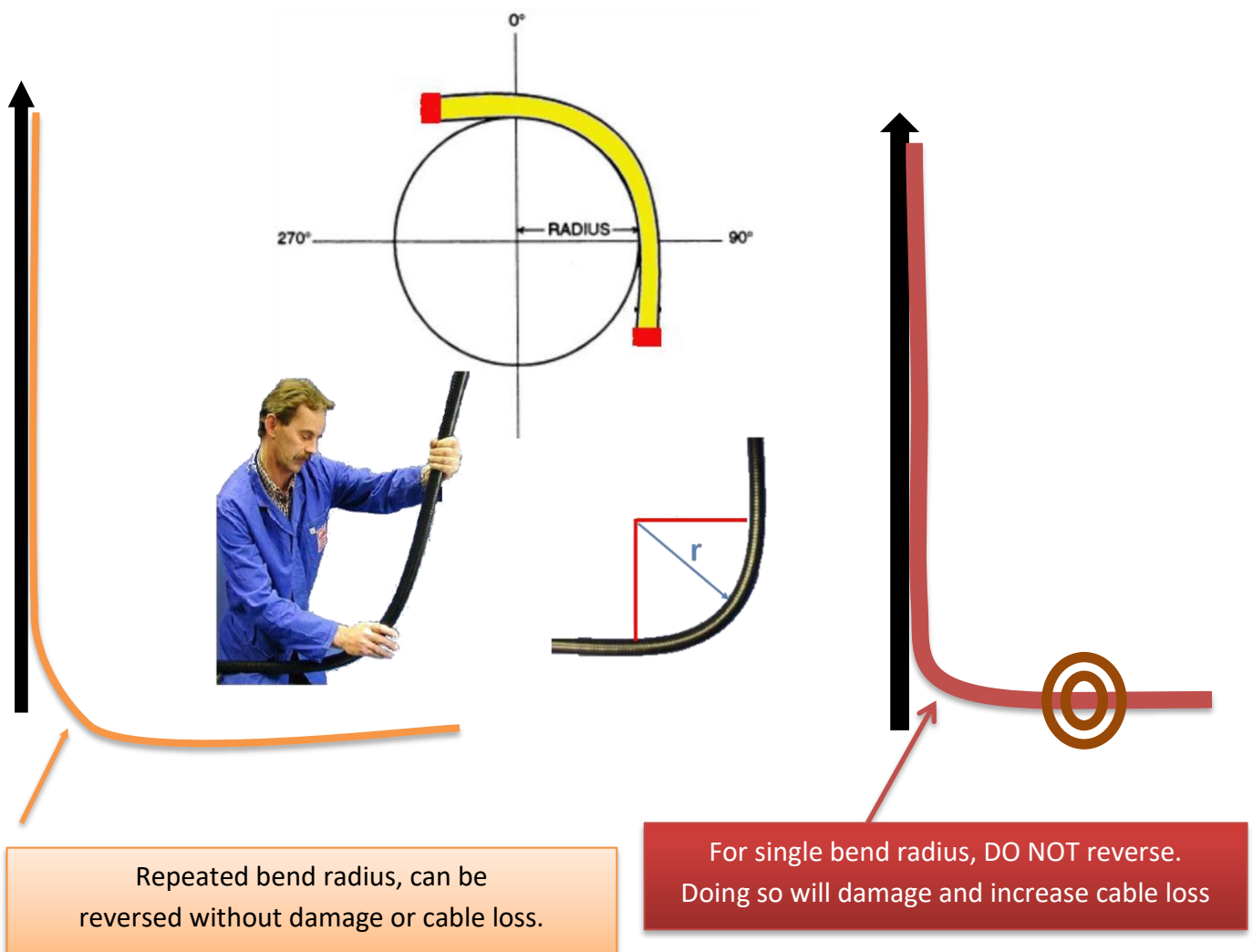
HYBRIFLEX Bending

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.**

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



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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, we recommend 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.

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
HBF058 [5/8"]	0.7m (28in)
HBF078 [7/8"]	0.9m (3ft)
HB114 [1-1/4"]	1.3m (4.25ft)
HB158 [1-5/8"]	1.5m (5ft)

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HYBRIFLEX 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. Also note: RFS HYBRIFLEX® does not require the use of grommets.

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

	Cable size	Model number	Short description
	HB058	GKFROM60-58	60-inch grounding kit
	HB078	GKFORM60-78	
	HB114	GKFORM60-114	
	HB158	GKFORM60-158	
	HB058	CLAMP-58 or SNAP-58 or SNAP-ST-58	Standard clamp bolt-on hanger; Snap-in hanger; Stackable snap-in hanger
	HB078	CLAMP-105 or SNAP-58 or SNAP-ST-78	
	HB114	CLAMP-114 or SNAP-114 or SNAP-ST-114	
	HB158	CLAMP-158 or SNAP-158 or SNAP-ST-158	
	HB058	HOIST1-58L	Hoisting grip, lace up
	HB078	HOIST1-78L	
	HB114	HOSIT1-114-L	
	HB158	HOSIT1-158L	
	Any size	ANGLE-UI ANGLE-CLPI	Universal angle adapter, snap-in or 3/8" (kit of 10) Angle member adapter kit 3/8" (SS) (Kit of 10)
	HB078	JSTRIP-78	Manual jacket stripping tool
	HB114	JSTRIP-114	
	HB158	JSTRIP-158	

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Additional installation tools

Model Number	Description
HTPT-1-058-CT	5/8" Armor cutter
HTPT-1-078-CT	7/8" Armor cutter
HTPT-1-114-158	1-1/4" Armor cutter
HTPT-1-158-CT	1-5/8" Armor cutter
HTPT-1-058	5/8" Jacket removal
HTPT-1-078	7/8" Jacket removal
HTPT-1-158	1-5/8" Jacket removal
HTPT-1-114	1-1/4" Jacket removal
HTRT-1-001-KIT	Ripcord removal kit (mandrel, stop collars)



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) can 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!

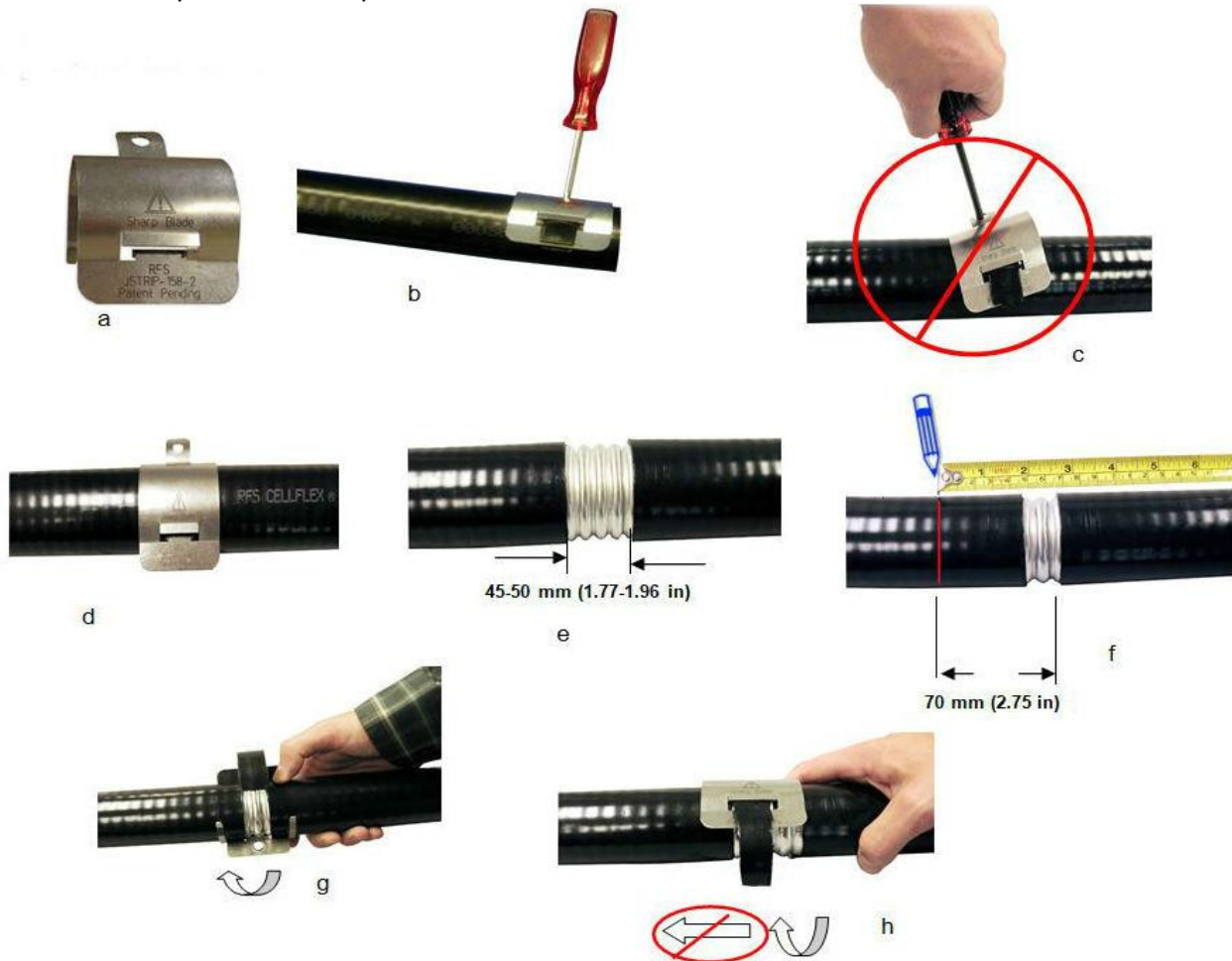


Do not used copper grounding on cable with aluminum outer.



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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.



- 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.

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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 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.

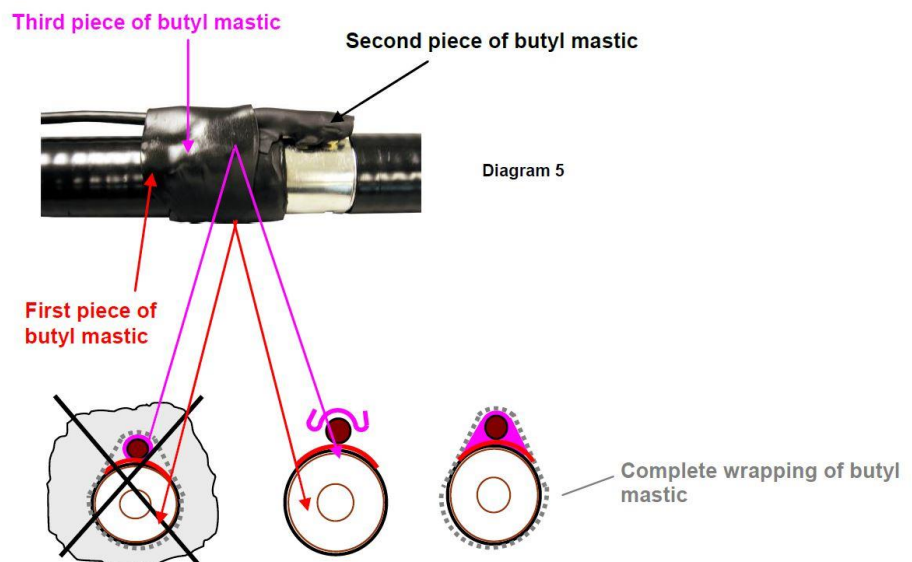
For example, GKFORM series, place the remaining third 50 mm (2") piece of butyl mastic carefully over the ground wire. (as shown in Diagram 5)



Picture 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.



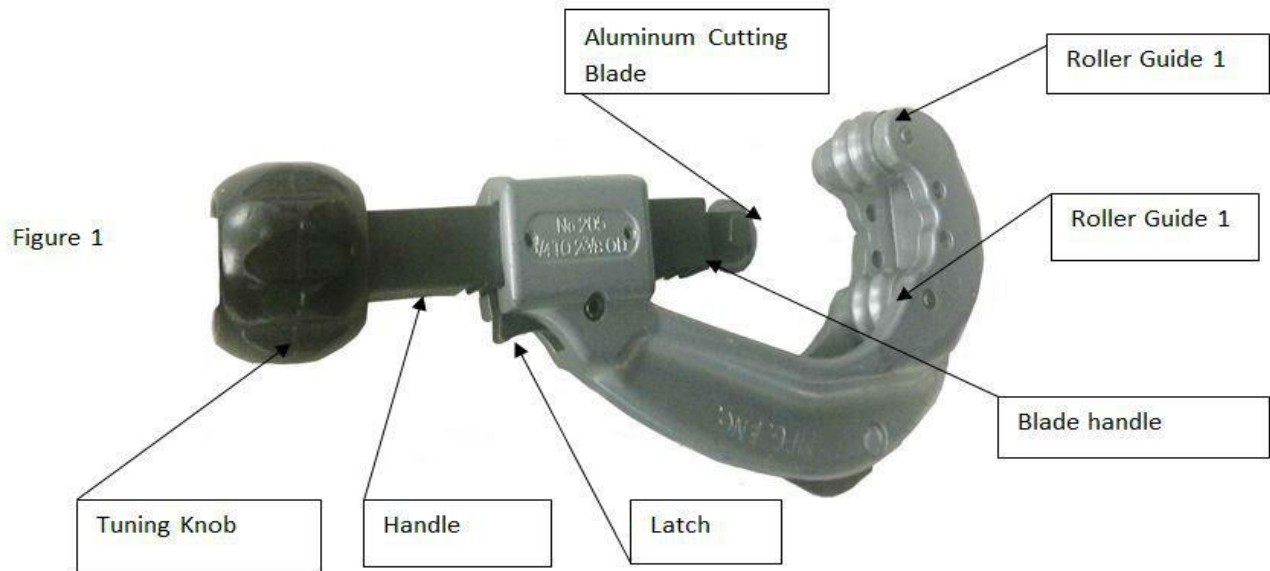
RFS INSTALLATION GUIDELINES

1-1/4 | 1-5/8 inch Armor cutting tool instruction

The following instructions can be use for 1-5/8" HYBRIFLEX cable. The cutting tool is a special design. An "off the shelf" pipe cutter from local hardware store should **not** be used. Note: *This is not a combo tool; size must be purchased as either 1-5/8" or 1-1/4"*,

To use the HTPT's cutting tool to cut the outer armor,

- 1) Using the jacket stripping tool remove the jacket off the cutting section
- 2) Turn the turning knob counter clockwise all the way until the tool is completely open (Figure 2).



Warning! Do not try to release the latch, it is locked in place. The blade can only be moved in and out by tuning the knob.

- 3) Insert the cable between roller 1 and 2 as shown in figure: 2.

- 4) Grasp cable and tool together with one hand as shown in figure: 2a

- 5) Slowly spin tool around the cable while rotating the knob continue until the aluminum armor cut through. As shown in figure: 3, 3a



Figure: 2a



Figure: 3a

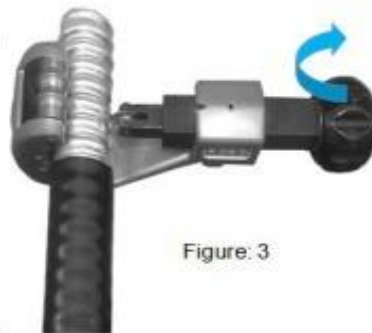
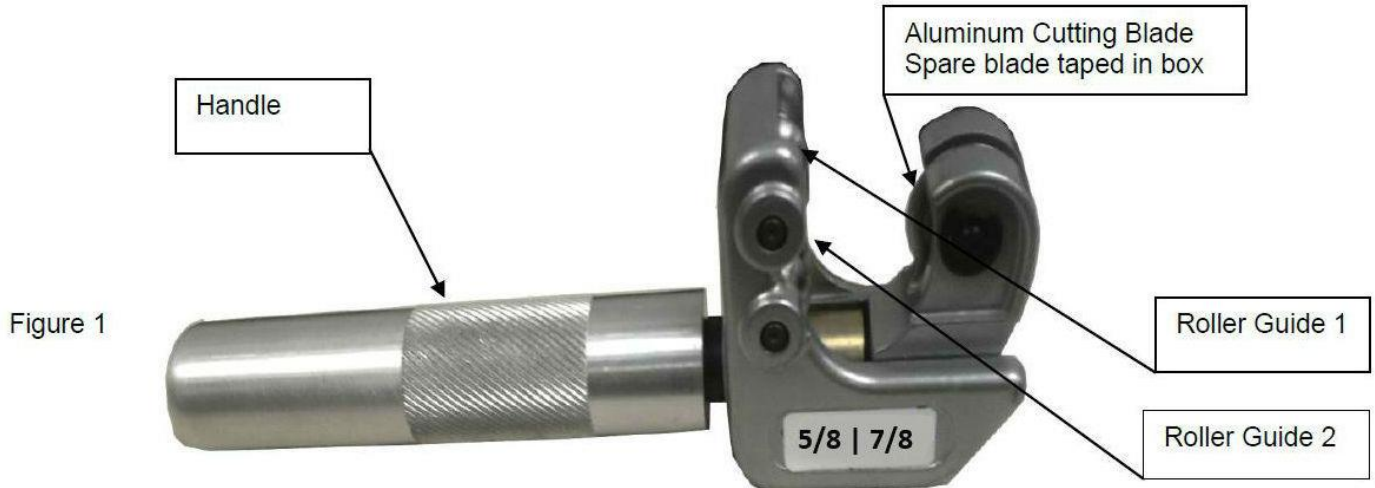


Figure: 3

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7/8 | 5/8-inch Armor cutting tool Instruction

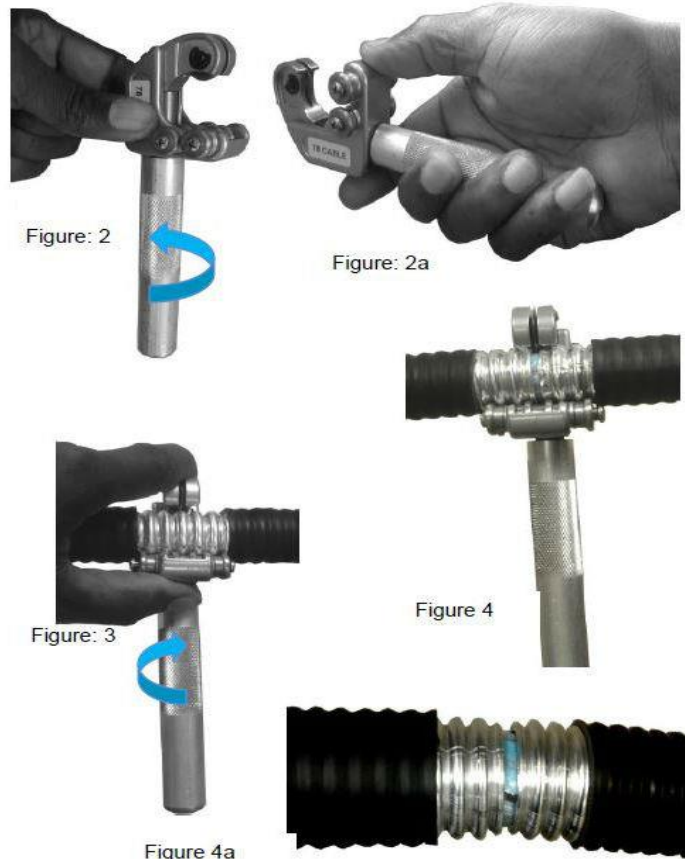
The following instructions are designed for use with the 5/8 and 7/8" HYBRIFLEX cable. This is not a combo tool, size must be purchased as either 5/8" or 7/8". The cutting tool is a special design. An "off the shelf" pipe cutter from a local hardware store should not be used.



Note: Do not unscrew the roller guide.

To use the HTPT's cutting tool to cut the outer armor,

- 1) Using the jacket stripping tool remove the jacket off the cutting section
- 2) Hold the tool body and turn the handle counter clockwise and adjust it to fit the 5/8 or 7/8" cable (Figure 2)
- 3) Grasp the handle and body of the tool together with one hand as shown in (Figure 2a) if, holding handle only the body of the tool will spin.
- 4) While holding the tool body and handle with one hand as shown on (Figure 2), insert the cable, as you grasp the tool body and cable together with the other hand as shown (Figure 3)
- 5) Turn handle clockwise until the blade engage the cable jacket. Note: Ensure that the blade is seated properly on the high end of the corrugation.
- 6) Slowly spin the tool around the cable tight handle as needed. Continue until both jacket and armor is cut through. As shown in Figure:



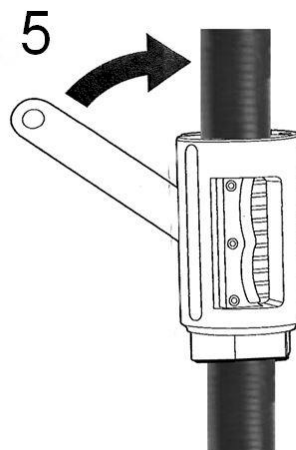
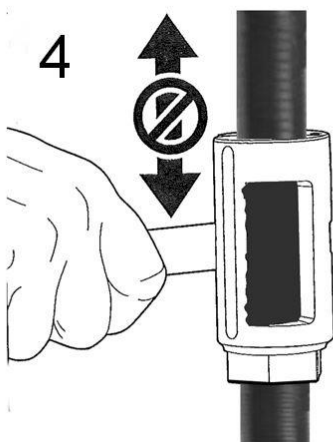
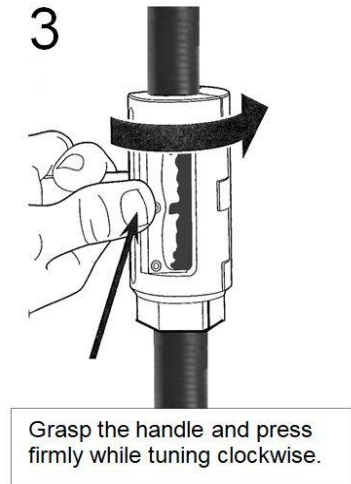
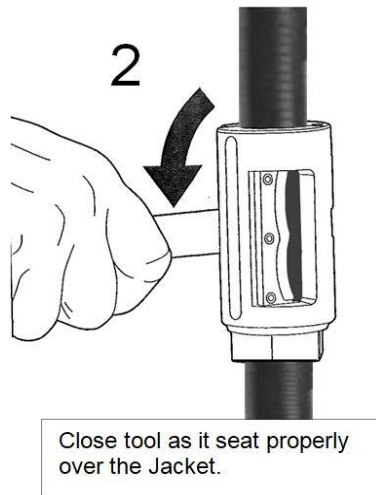
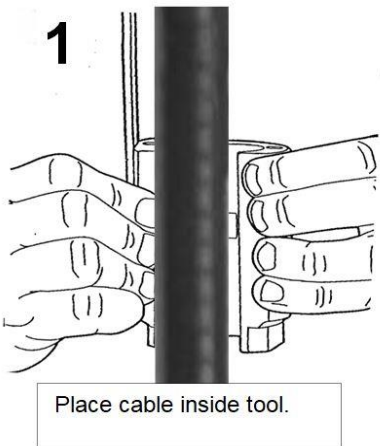
RFS INSTALLATION GUIDELINES



Hybriflex Jacket removal tool instruction

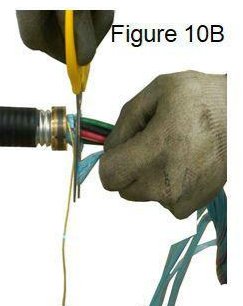
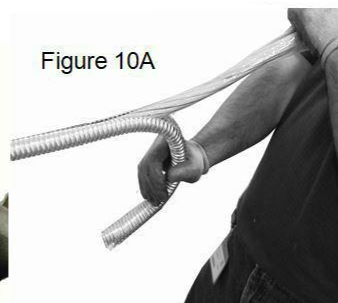
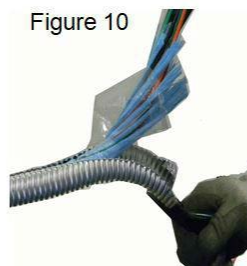
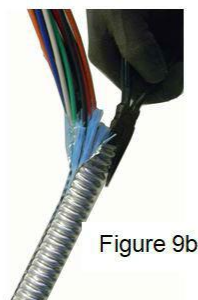
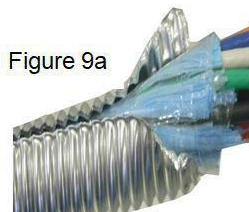
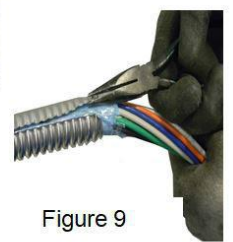
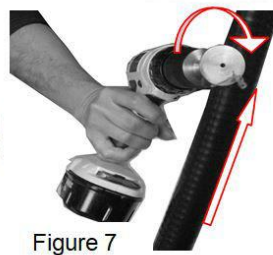
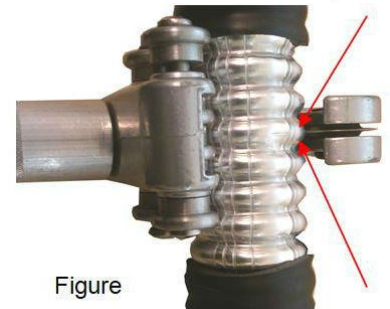
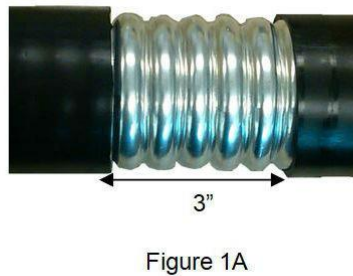
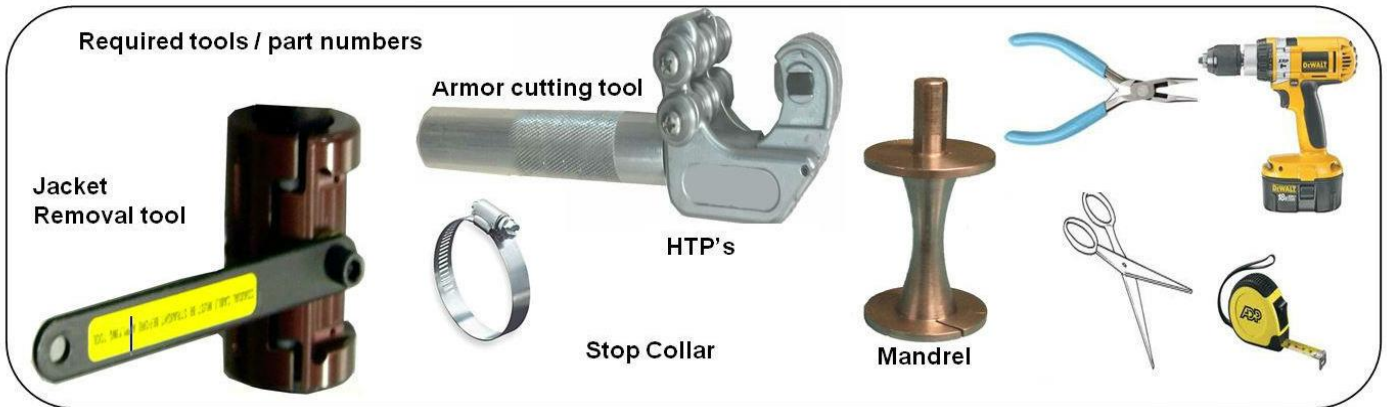


Part Number	Hybriflex size
HTPT-1-058	5/8"
HTPT-1-078	7/8"
HTPT-1-114	1-1/4"
HTPT-1-158	1-5/8"



RFS INSTALLATION GUIDELINES

[Hybriflex Armor Removal Ripcord Instruction](#) (Click here for video)





RFS INSTALLATION GUIDELINES

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.

Both the Jacket stripper tool and the armor cutting tool are available in 4 sizes, one for each HYBRIFLEX cable size. This includes 5/8", 7/8", 1-1/4" and 1-5/8".

The Ripcord Mandrel and stop collars for all size cables are included in a single kit.

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

1. Measure and mark the length of the armor to be removed. (Suggested a max. 15ft per cut, to avoid excessive ripcord accumulation into the mandrel).
2. Using the Jacket removal tool (or knife), strip 3" off the jacket as shown in Figure 1&1a.
3. Place the cutting tools (model number HTPT-1-078) over the 3" exposed aluminum armor, and then slowly turn the cutter handle clockwise until the blade is fully engaged with the aluminum armor (Figure 2). *Note: Armor should be cut on the high end (peak) of the corrugation, not in the valley (see Figure 2a).* Rotate cutting tool and tighten handle as needed until the aluminum armor cut as shown in Figure 2b.
4. Insert Stop Collar at the edge of the aluminum armor as shown in Figure 3.
5. Remove the electrical tape, shown in Figure 4

HYBRIFLEX 7/8" Cables have one ripcord. (6" 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.

6. Locate ripcord and place a knot at the end of it as shown in Figure 5.
7. Insert the mandrel into the drill tool as shown in Figure 6 and insert the ripcord into the mandrel slot (see Figure 6a) start winding the ripcord around the mandrel ripping direction (towards the stop



- collar), 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 (see Figure 7).
8. 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" exposed.
 9. Now that the armor and jacket has been sliced, peel open the jacket, remove and discard. See Figure 8.
 10. **Caution! Due to the sharp edges of the aluminum armor DO NOT start this step without proper gloves.** Use needle nose plier and flare open the aluminum armor ensuring that sides and bottom are flared as shown in Figures 9-9b. Peel open the aluminum armor as shown Figure 10, if need be use shoulder to support fiber and wires during peeling (see Figure 10a).
 11. 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.
 12. Pull filler away from fiber and DC-wire and use scissors to cut them. Pull filler towards stop collar and discard. Caution! Do not score the DC-wire (Figure 10b).
 13. Untwist fiber and DC-wires as desired and cut excess signature cord.
 14. Continue with the installation process.

RFS INSTALLATION GUIDELINES

Fiber Inspection

Optical Interface Connectors

In addition to the LC and ODC connectors on the main trunk, jumpers with ODC plug and socket connectors attach the RRH to the main trunk.

Tools and test equipment

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

Note: It is recommended that the main feeder be tested using ODC to LC test adapters and not the actual HYBRIFLEX® jumper.

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

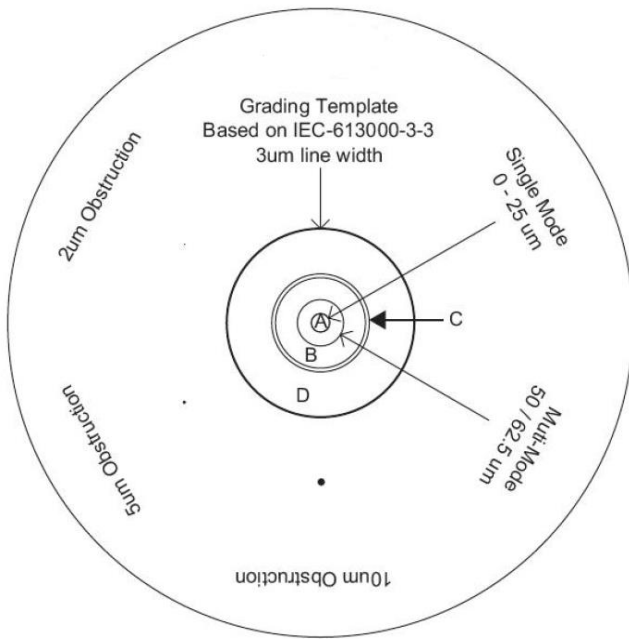
It is industry standard as per the IEC document 61300-3-25 1.0 that all optical fiber end-face are inspected and cleaned before mating. Please refer to the cleaning procedure within this document if need be.

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

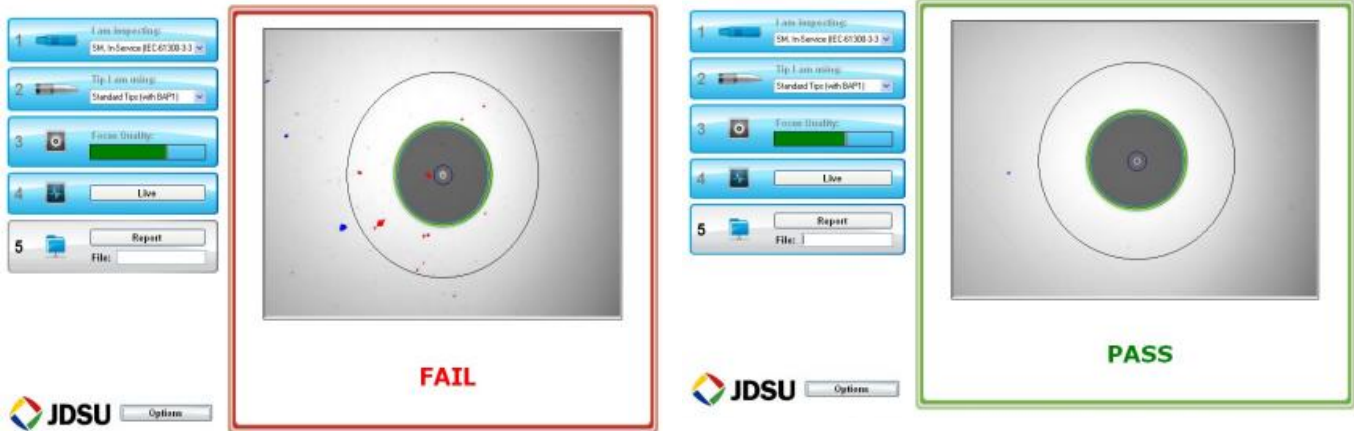


RFS INSTALLATION GUIDELINES

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

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



ODC connector inspection

2. Inspect the ODC fiber end-face using the approved test equipment probe and the appropriated ODC plug and ODC socket fiber tips. *If the test fails due to too much dirt clean end-face accordingly and re-test.*
 - a. *Unscrew the ODC cap (Caution! Protect cap against dust during the testing process).*
 - b. Insert ODC plug or socket tips into the ODC plug or socket connector as shown in figure A, B and inspect each connector (Caution! Make sure that tip is inserting fully into the connector to prevent any false image or damage).
 - c. Adjust inspection probe zoom until image can be viewed clearly.

ODC plug, Figure A



ODC socket, Figure B



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.

RFS INSTALLATION GUIDELINES

Fiber Cleaning Introduction

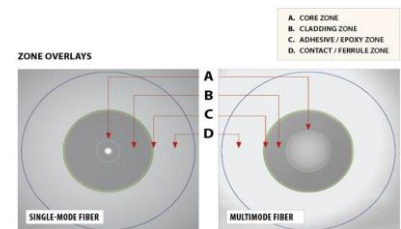
Warning: Before attempting to clean or inspect fiber optics it is strongly recommended that the technician have a good understanding of the IEC 61300-3-35 fiber optics standard procedure. This document can be obtained simply by performing an internet search for [IEC 61300-3-35](#).

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.

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.

RFS INSTALLATION GUIDELINES

- 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.

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.





RFS INSTALLATION GUIDELINES

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 end-caps
- Fiberscope
- Bulkhead probe

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 end-cap 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.



RFS INSTALLATION GUIDELINES

- 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.

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 end-cap 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. If you do it, 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.



RFS INSTALLATION GUIDELINES

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 end-cap 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.
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

RFS INSTALLATION GUIDELINES

Cleaning ODC plug and socket connector

If the ODC plug or socket end-face shows any particles or debris, clean the end-face using the following 1.25mm one click type cleaner or swab stick.



Swab stick
(Use as recommended)



One-click type cleaner
used on the appropriate tip for plug and socket



**Cleaning ODC socket using the
1.25mm one-click cleaner**



**Cleaning ODC plug using the
one-click cleaner**



Clean the ODC socket using the Swab stick, gently moisten the cleaning swab tip with an alcohol or Electro-Wash pen wet solution and gently clean each connector



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)

Field Jumpers testing

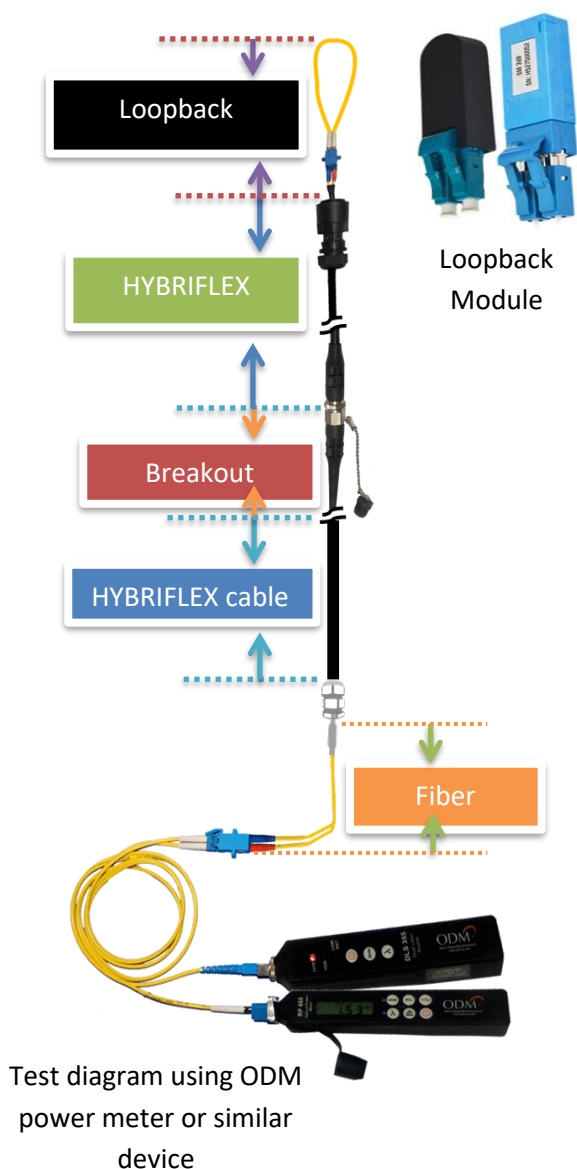
Connect the HYBRIFLEX® jumper cable to the ODC plug test lead as shown below and follow test equipment instructions. Refer to the system insertion loss table for pass/fail criteria when recording results.

Note: ODC plug and socket may be mated securely by hand, but if need be, use approved torque wrench with the applicable torque of 1 N-m to firmly secure the connection. Test equipment and reference cables should be reset prior to each measurement.

System loss measurement (sector jumper connected to main assembly)

Verify that all end-faces are clean and free of any debris. Connect loopback and test equipment as shown. Follow test equipment instructions to record test result, referring to the system insertion loss table for pass/fail criteria.

Note: When using OTDR, the longer the loopback the better the test result. RFS recommends a loopback of 30m (min) be used. Loopback modules may be used with power meters but not recommended for OTDR.



RFS INSTALLATION GUIDELINES

RFS RRH jumper with FullAXS compatible connector installation guide

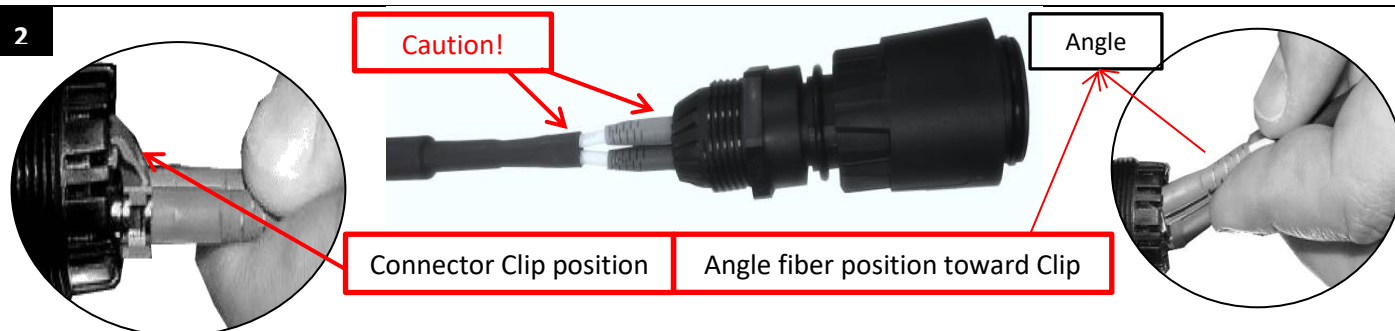
Use the following instruction to properly install/attach the FullAXS compatible connector. Failure to follow these procedures entirely may cause damage to the Fiber or Connector. For factory pre-installed assembly, skip to step 4a:

1



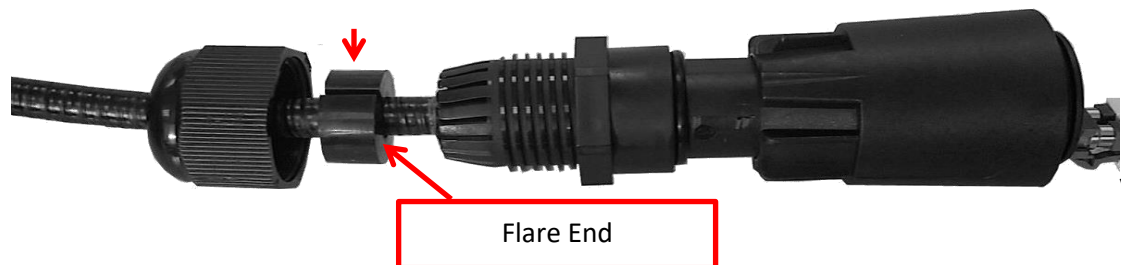
Carefully feed compression nut over fiber jumper connector and slide onto jacketing. Do not twist or bend the LC connector or fiber. Excessive force or bending may break the fiber or connector components.

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)

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.

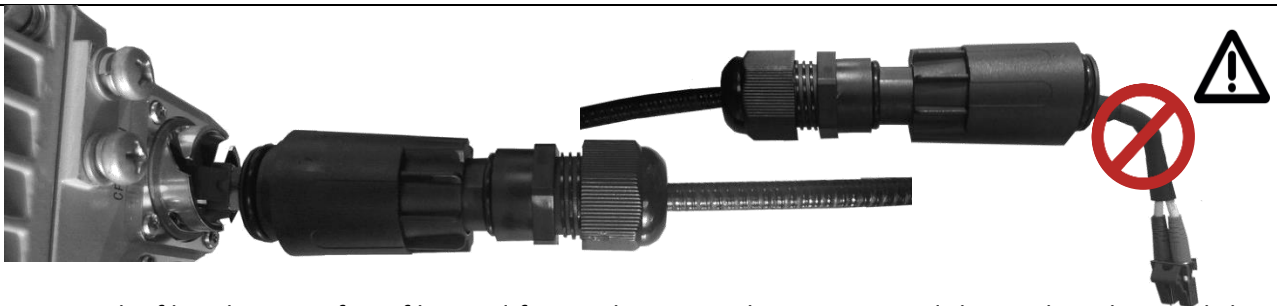
- a) Remove protective dust cap (top), disengage the compression nut (bottom), adjust the jumper to proper length

5



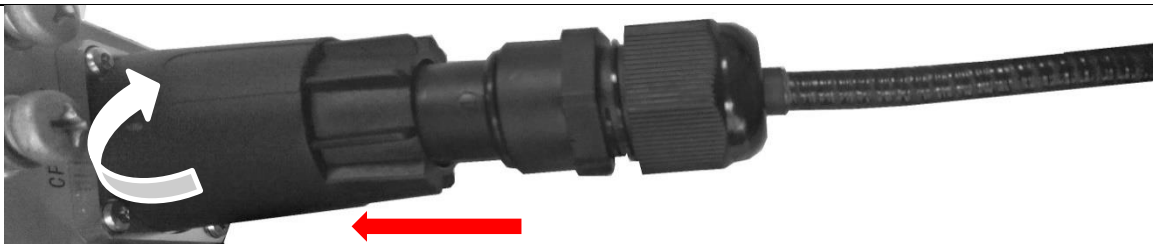
Slide FullAXS compatible gland body down jacketing to allow access to the fiber end connector. Do not pull the fiber end connector through the sleeve or damage may occur.

6



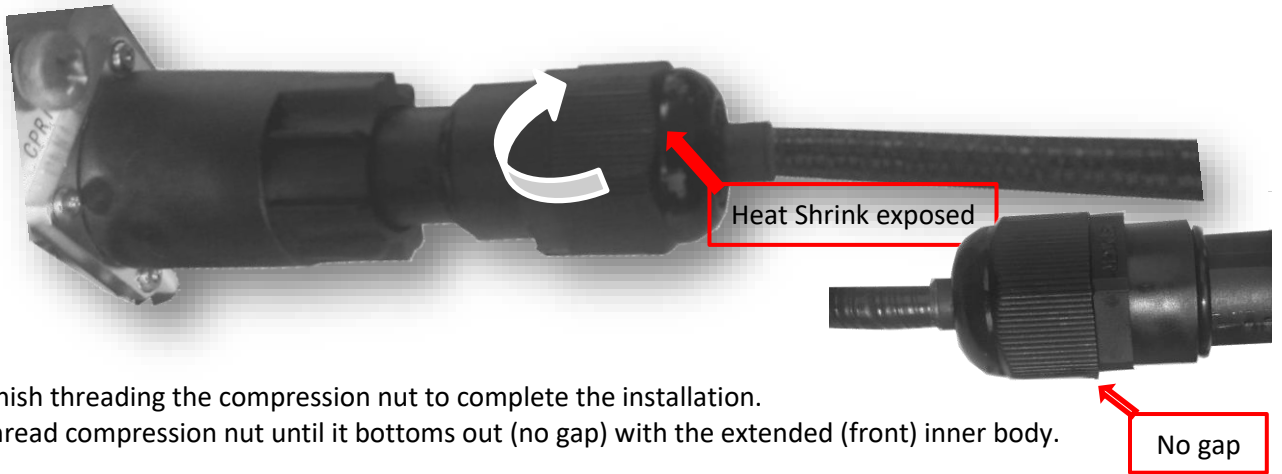
Remove the fiber dust caps from fiber end-face and seat into the RRH SPF card slot until you hear a click. Do not twist fiber end-face or kink the fiber during installation.

7



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

8



Finish threading the compression nut to complete the installation.
Thread compression nut until it bottoms out (no gap) with the extended (front) inner body.

Reverse steps 6 to 1 to remove sleeve for maintenance. Note: 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 small long-shaft screw driver



Caution! Do not insert the screw driver blindly.

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 is shipped hand tightened on all trunk cable.



Figure 1

Metal Bulkhead Fitting

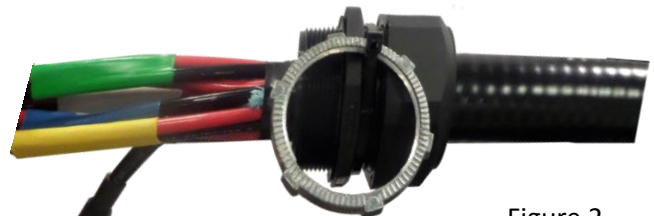


Figure 2

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.

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 time.
6. Connector is now installed on the cable assembly and 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 lock-nut 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 lock-nut until it reaches the reducer thread and secured to the cabinet; a flat screw driver may be used for additional tightening (see Figure 11).



Figure 3



Figure 4



Figure 5



Figure 6

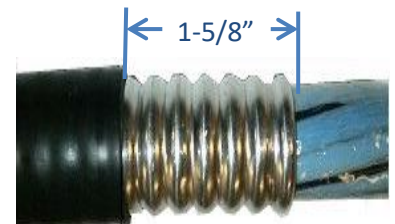


Figure 7



Figure 8



Figure 9



Figure 10



(Plastic fitting)



(Metal fitting)

Figure 11

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