



Installation *guide* for  
**HYBRIFLEX™**  
*fiber / power cables*



*Rev 3.0 - Hints and recommendations*



# General hints & recommendations for the installation of RFS HYBRIFLEX® Fiber / Power cables

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## **Introduction to Hybriflex**

RFS' HYBRIFLEX Remote Radio Head (RRH) hybrid feeder cabling solution combines optical fiber and DC power for RRHs in a single lightweight aluminum corrugated cable, making it the world's most innovative solution for RRH deployments. It was developed to reduce installation complexity and costs at Cellular sites. HYBRIFLEX combines optical fiber (multi-mode or single-mode) and power in a single corrugated cable and can connect multiple RRHs with a single feeder. Standard RFS CELLFLEX® accessories can be used with HYBRIFLEX cable.

The aluminium outer conductor provides extreme robustness while allows easy transportation (because of the light weight) and handling. Moreover this cable is easier to bend than other Optic / power solutions using a steel outer conductor.

**This new generation of hybrid cable should be handled and installed according to the same rules, instructions and regulations as typical coaxial cables.**

These short instructions were written for qualified and experienced personnel. They describe in short words the main points that have to be noted during the 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 of the corrugated outer conductor (e.g. pulling over sharp edges, over tightening of clamps etc.).

## **Transport/shipment & handling of the drum**

Drums have to be handled carefully, in order to avoid any damage to the drum and/or the cable.

- If the drum will be shipped e.g. by van or truck the drum has to 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.
- Avoid laying the drum on its side, reels must be transported and handled in their up-right position.
- 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.

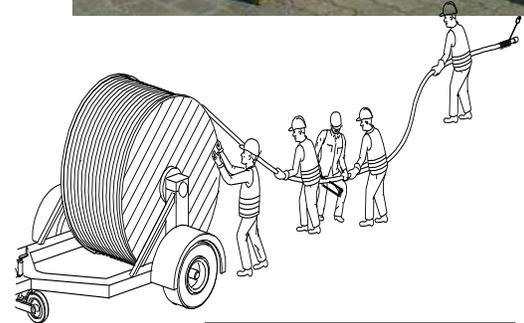


**Label fixed to the drum. Please follow the instructions.**



## Handling of 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.
- If the protective sleeve or Sock has been removed for pre-testing, replace and secure it before hosting/pulling.
- Do not drag the cable over sharp edges.
- In order to protect the cable against any damage, protective measures must be taken also applicable if, cables have to be pulled in horizontal runs. For example by using pipe rollers, wooden planks or similar.
- Prevent any pinches to the DC wires, which may cause electrical spikes and shorten circuitry.



## Hoisting/Pulling

- **Note:** when hoisting and pulling HYBRIFLEX™ always use Caution.
- Keep fibers connector's caps on at all times.
- Do not remove the protective sleeve
- Do not attach Hoisting grip over the un-armored segment
- Hoisting grips must be placed 2 inch below the breakout (exposed segment) or sealing boot to avoid damage to the fiber endface.

Hybriflex Cable is supplied in cut lengths with fiber connectors factory installed and polished.

Short lengths of small HYBRIFLEX™ can be hoisted manually, otherwise winch is recommended. Obtain a suitable Hoist grip that will adequately take the weight of the line. Provide a pulley high enough on the tower to enable the HYBRIFLEX™ line to be raised sufficiently, so a proper connection to the distribution box can be made while the HYBRIFLEX™ is still on the hoisting line.

Attach hoisting grip or a rope sling 2 inches below the un-armored segment of the fiber endface to prevent any stress or force to the un-armored segment of the HYBRIFLEX™.

Hoisting grips can be ordered base on Hybriflex size. RFS recommends open lace up – since it is used to prevent damage to fiber end face, its lacing keeps it together after being laid around the cable.

Protection sleeve





For long vertical runs of cable, additional Hoisting grips should be attached at 50 – 60m intervals.

Add the hoist line to the hoisting grip or ropes sling; protect the *HYBRIFLEX™* against shackles.

Make certain to allow slack in the cable between the hoisting grips in case more than one is used, so each one can carry weight, and ascertain that the slack is maintaining during hoisting. Hoist the cable slowly.

Rotation of the reel must be retarded to prevent buckling of the cable. If it is necessary to drag the Cable over sharp edges of buildings and tower members, protective measures must be taken.

Careless handling can cause damage to fiber endface 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.

**Caution!** Fiber endface must be protected at all times.

When unspooling keep reel secure that it does not accidentally roll over the unprotect

### Hybriflex bending

- The minimum-bending radius should be strictly observed. Check the product datasheet. *HYBRIFLEX®* cable should be bent manually with a force applied in a distributed manner (while pressing carefully the hand slides along the cable [see diagram 1]. (make sure to avoid rapid, sharp motions)
- Avoid any tight microbend near the fiber endface as microbend can cause broken fiber and increase insertion loss. [See diagram 2&3].

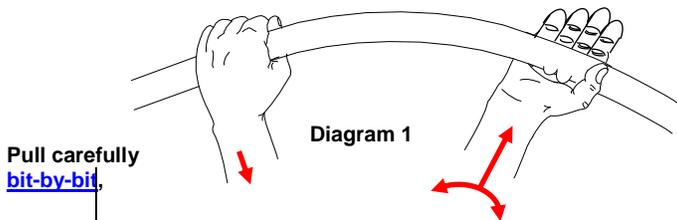
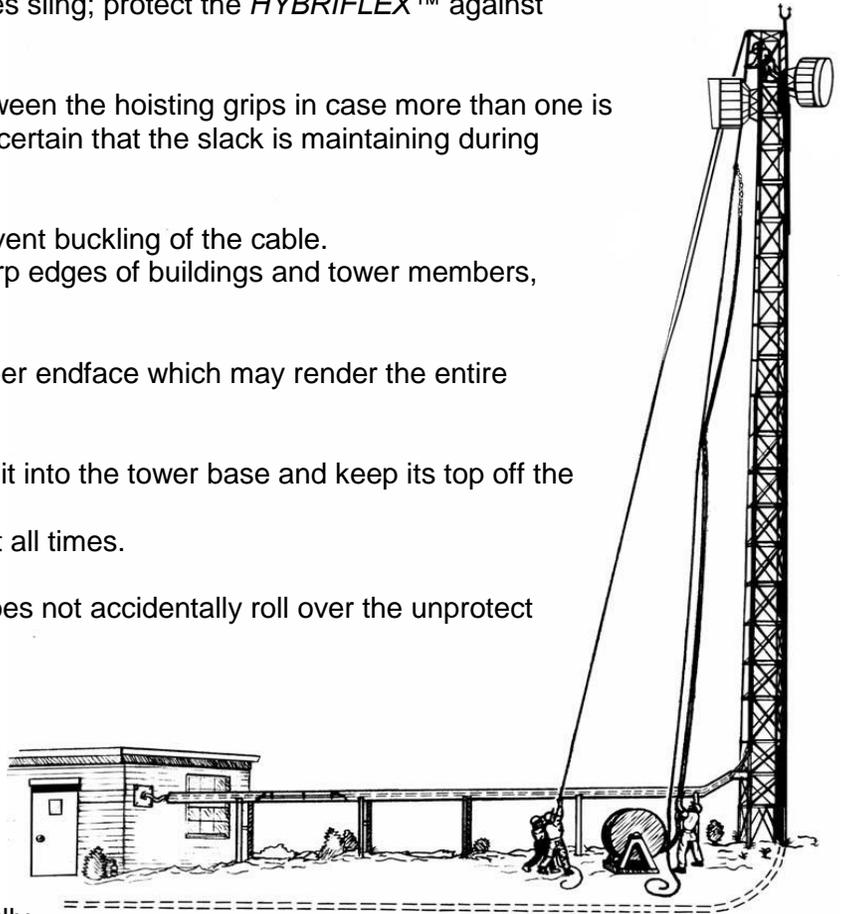


Diagram 1

Pull carefully  
bit-by-bit

While pressing, slide your hand



Diagram 2

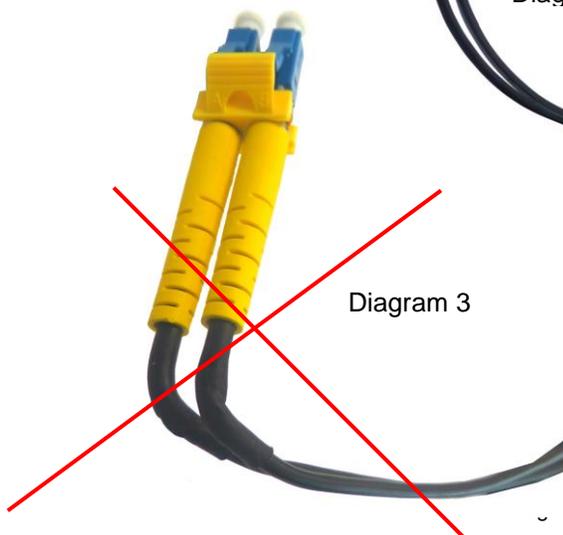
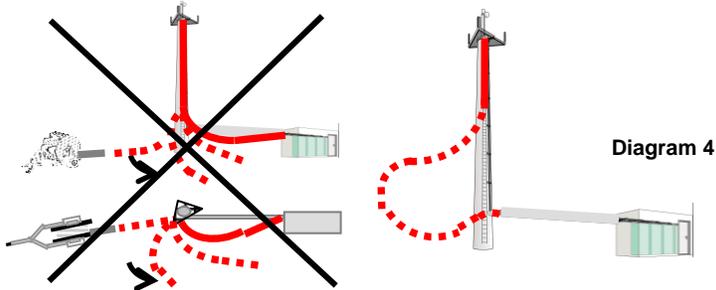


Diagram 3

**HYBRIFLEX® cable, with its Aluminum outer conductor, is easy to bend, but must be handled carefully, especially during bending.**

- Do not twist the cable, e.g. if changing from vertical to horizontal run

[See diagram 4].



- Do not leave the 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].



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

## **Fixation / Mounting of the cable**

The crush resistance of aluminum is lower than copper, this should be considered for instance if tightening the clamps (especially if these clamps have not been approved by RFS).

A number of 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 the safest (most failure proof) clamp offering a large number of exceptional advantages.

In any case the recommended and maximum clamp spacing shown in table 3 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).

If other clamps are used, the maximum torque has to be noted (lower torque than for copper cables). The maximum torque is shown in table 2.

Table 1 – Accessories for 1-1/4” size cable (check with RFS for other sizes)

Clamp type	Model Number	Information – maximum torque
Snap in Hanger	SNAP-114	Can be used without any reservation, torque limit not applicable because of snap-in fixation
Stackable Snap-In	SNAP-ST-114	Can be used without any reservation, torque limit not applicable because of snap-in fixation
Bolt-on Hanger	CLAMP-114	Tighten carefully, clamp must not be fully closed

Table 2

SCS clamp	SCS-114-L3M	0.5 Nm
SCS clamp modified	SCS-114-L3M	2-3 Nm

Table 3

HYBRIFLEX® Size	Spacing
HB058 [5/8”]	0.7m (28”)
HB078 [7/8”]	0.9m (3ft”)
HB114 [1-1/4”]	1.3m (4.25ft)
HB158 [1-5/8”]	1.5m (5ft)

## Installation of the Grounding Kit

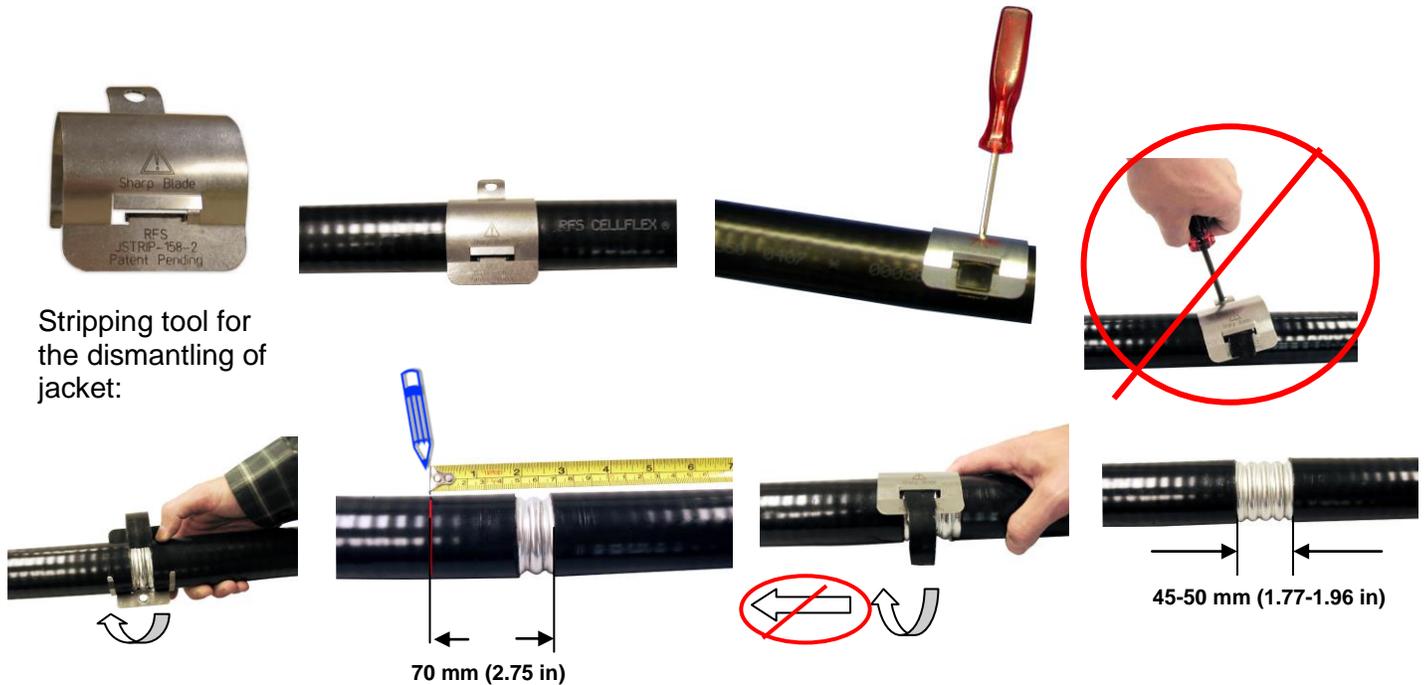
In order to avoid any corrosion problems, the contact element of the grounding kit below are tin plated copper. The tin plating allows compatibility with both aluminum and copper conductors.



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

Please follow the included installation instruction carefully.

For removal of the jacket we also strongly recommend the use of a manual jacket stripping tool, model name: JSTRIP-114-2 or JSTRIP-114 (for 1-1/4” size. Check with RFS for other cable sizes).



Stripping tool for the dismantling of jacket:

Set the JSTRIP onto a straight part of cable. 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. Make a mark onto the cable jacket in a distance of 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. 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 in order to finish the cut in straight line.

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 has to 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, in order to prevent damaging the outer conductor, and then carefully tighten the nuts.



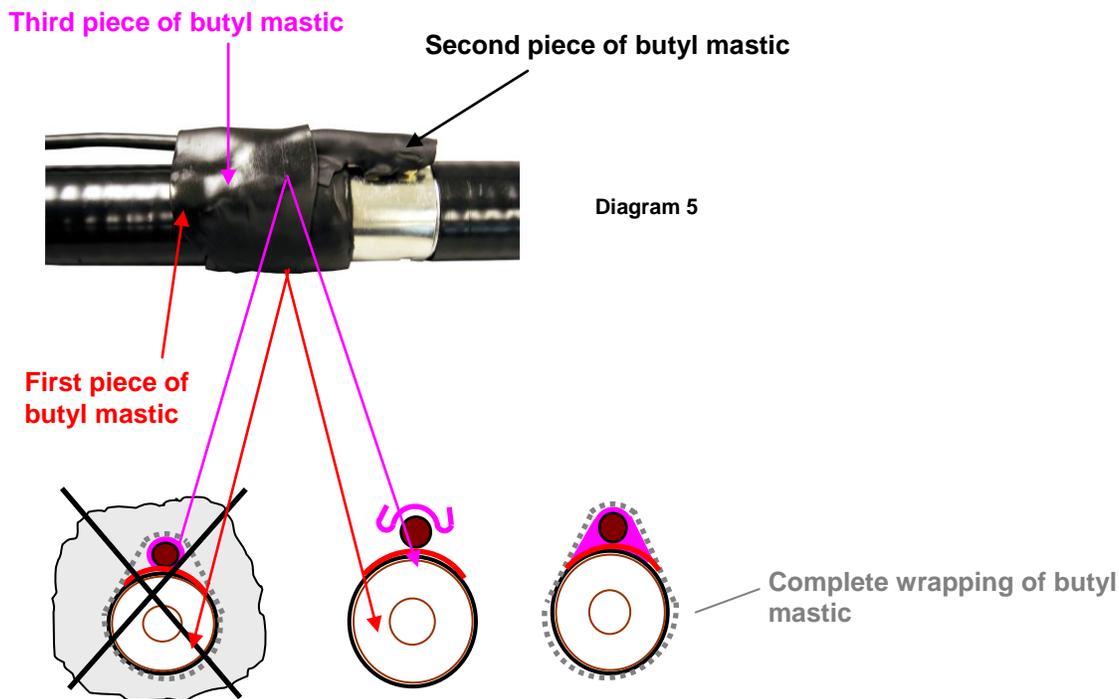
Picture 5

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

Place the remaining third 50 mm (2") 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 mould 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.





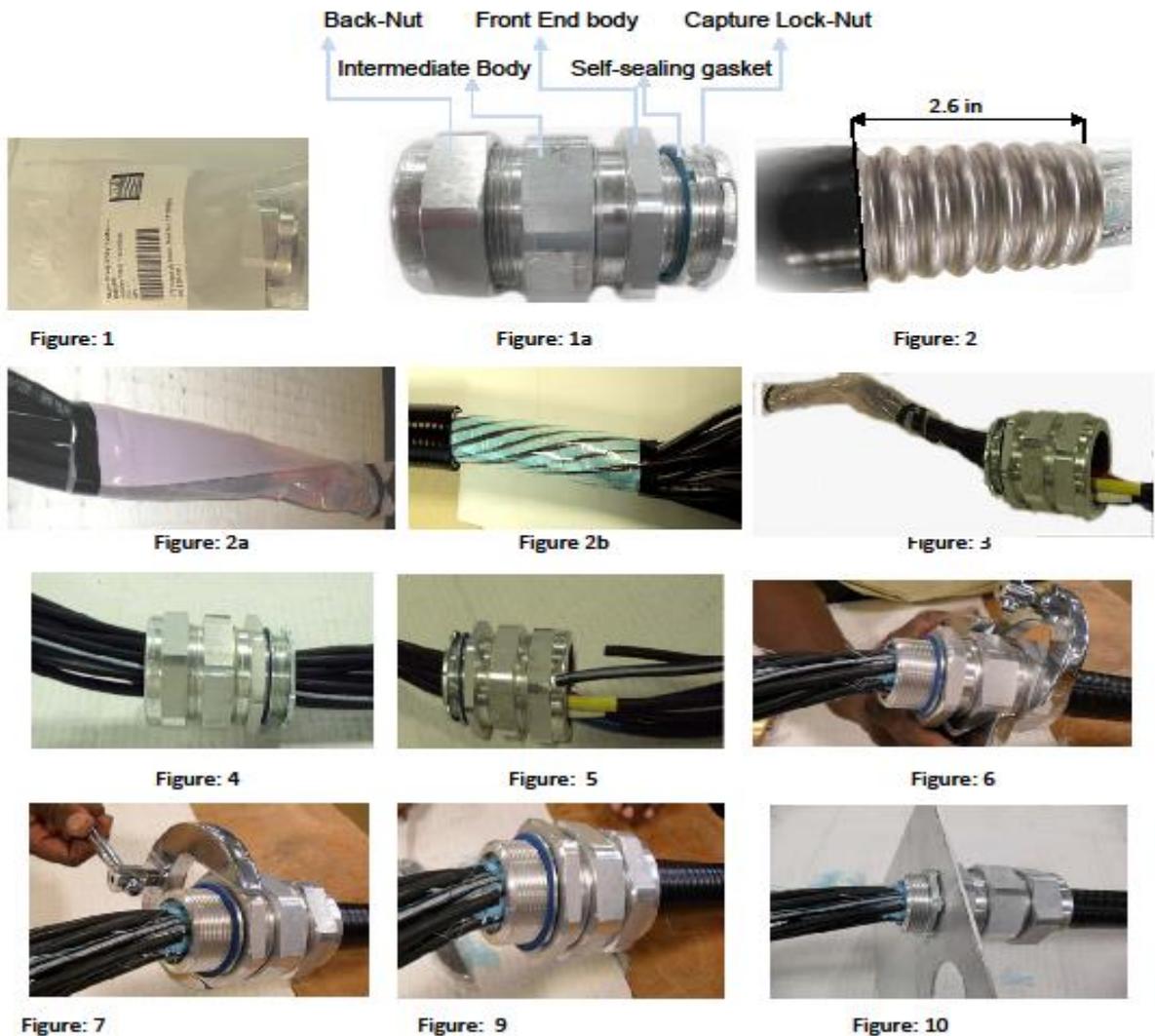
## Appendix A Hybriflex Fitting instruction

<b>RFS Hybriflex</b> <b>Connector Kit - 15894149</b>	<b>Installation instruction</b> <b>Hybriflex Fitting 1-1/4in bulkhead</b>
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This Hybriflex 15894149 Connector Kit is designed for use on RFS 114 Hybriflex to the Enclosure, Panel board or other equipment; to form a Mechanical and water tight connection, and to provide Ground Continuity between the Cables Armor and the metal enclosure in use. These Hybriflex Connectors are UL listed for ordinary wet location use in accordance with UL Standard 514B.

### Installation requires tools:

Tape, Ruler, 2-5/8" torque wrench, 2-5/8" Std. Open Ended Wrench, Jacket stripping tool, ESD Bag





**Note:** Install connector after the cable armor has been removed to the desired length. See the cable armor removal for instructions.

If additional armor removal is required, cut the compression cord and/or ripcord. Next tape the Mylar binder and blue filler to ease pressure or friction on the fiber wires during the installation of the connector.

- 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 and 1A
- 2) Prep the cable by removing 2.6" of the jacket using the jacket stripping tools or knife to expose the aluminum outer armor. Figure: 2

Separate the fibers from DC wires, firmly fold and tape the ESD bag over fiber terminations (Figure: 2a), if additional armor was removed, place a piece of tape where the Mylar binder and blue fillers begin, this way they stay intact while sliding the core into the connector.. Figure: 2b

- 3) Carefully feed ESD taped bag with Fiber terminations into the connector and through the plastic armor stop. Figure: 3 and 4.
- 4) Push the connector down 3ft away from fiber termination, then start feeding the DC wires into the connector through the plastic armor stop, one by one. Figure: 5
- 5) Once all DC wires are in place, straighten them all including fiber, then slowly slide the connector back over the aluminum outer armor while guiding fiber cable and DC wires to ensure they are not tangled together. Make sure that the aluminum armor does not go beyond the plastic armor centering stop.
- 6) Insert the cable assembly until the aluminum armor reaches the aluminum armor centering stop. Hold the intermediate body ( with open ended wrench) and tighten the Back-Nut using the 2-5/8" torque wrench to the specified torque of 58 (ft-lbs). Figure: 6
- 7) Repeat step 6, tighten the front end body to the specific torque of 83 (ft-lbs). Cut and remove the excess blue filler and clear Mylar flush with the connector face. See figure #7.
- 8) Connector is now installed on the cable and is ready to mount into the junction box.
- 9) To assemble the cable into the junction box, remove the Lock-Nut and carefully insert the fiber and DC wires into the junction box punch hole in the bottom of the box, then slowly guide the Hybriflex connector (and reducer if applicable) into the fitting hole. Note: Be careful not to cut any wires.
- 10) Slide Capture Lock-Nut until it reaches the reducer thread and secured to the box, a flat screw driver can be used for additional tightening.

**Appendix B**

**Protective sock installation where applicable**

**Step 1:**

Insert the fiber terminations into an ESD Approved bag. Fold the bag tight around the cable terminations. Using electrical tape, tape the open end. Fold one end of the tape together and leave as a "tape tab" as shown for easy removal

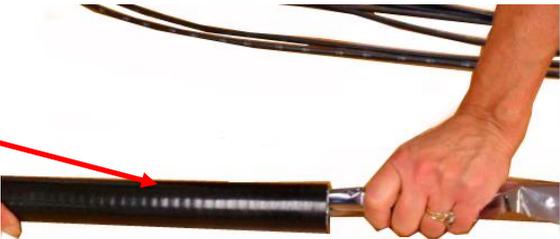


**Step 2:**

**Caution-sharp metal edges Use finger protectors or equivalent as a precaution.**



Insert the fiber terminations into the protective armor as shown.



"Fan out" power cables.

**Step 3:**

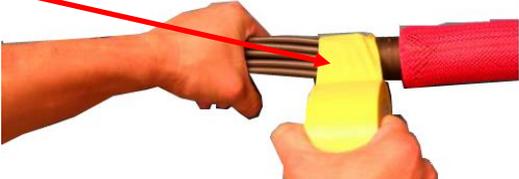
Evenly "fan out" the power cables onto the top of the armor.



Armor is underneath cables.



Tape loose ends.



**Step: 4**

While holding the power cables in place, “push” the red braided sleeving over the power cables in the direction as shown.



Continue pushing the sleeving.  
Until fully extended over the cables as shown in step 14



**Step 5:**

Place two tie wraps as shown, The top tie wrap is just below the armor.



**Step 6:**

Tighten the tie wraps and cut flush the excess tie wrap tabs



**Caution:** If the tie wrap is not cut flush, a sharp edge will be present





## Appendix C: Fiber Cleaning Introduction

**Warning:** Before attempting to clean or inspect fiber optics it is strongly recommended that technician have a good understand of the IEC 61300-3-35 fiber optics standard procedure. This document can be obtained simply by performing a google 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 fiberoptic 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 in order 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 tool, and 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.
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 in order 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 in order to view the endface. A fiberscope is a customized microscope used in order to inspect optical fiber components. The fiberscope should provide 200x-400x total magnification. Specific adapters are needed to properly inspect the endface 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 patchcords.

**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.
- 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: Throwaway 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 proceed the wet cleaning method.



**Caution:** Improper cleaning can cause damage to the equipment. The primary concern with the use of isopropyl alcohol is that it can be removed 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.

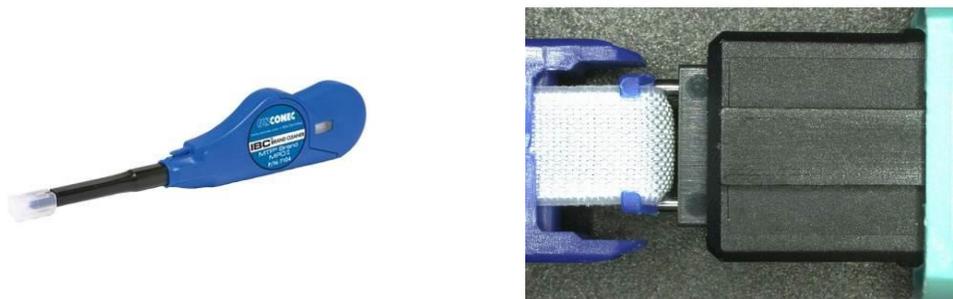
## Appendix D

### Cleaning MPO Fiber connector where applicable

**Note:** There are 3 major differences between inspecting and cleaning an MPO connector when compared to standard LC, FC or SC connectors.

1. MPO (Multiple-Fiber Push-On/Pull-off) offers a tremendous benefit in the field, since it reduces the number of connections in a ratio of 1 to 6 when compared to LC connectors. RFS utilizes IP67 rated assemblies that ensure a good and reliable outdoor fiber connectivity.
2. The MPO ferrule is flat across its entire surface as opposed to a standard connector which is conical. This means that any contaminants anywhere on the ferrule endface (and not just close to the fiber as in standard connectors) will affect the quality of the connection.
3. The male MPO connector has guide pins close to the fibers (fiber no. 1 and fiber no. 12) which make cleaning more challenging compared to an LC connector.
4. The MPO connector can be housed inside a bulkhead/adaptor which means accessing the ferrule is more challenging than an LC connector.

MPO connectors can be cleaned using the cleaning tool called MTP IBC® Cleaning Tool.



IBC™ Brand Cleaners MT series mechanical cleaning tools are designed for cleaning the fiber arrays on MT based connector systems, such as the MPO.

Steps:

- Open the dust cap lid on the MTP IBC® cleaner.
- The MTP IBC® cleaner is keyed the same as an MPO connector. Insert the cleaner tip into the adapter with the key of the cleaner matching the keyway of the adapter or directly place it on MT endface.
- Push the Outer Shell to start cleaning the connector endface. An audible “**click**” sound indicates end of cleaning process. This moves fresh cleaning material across the ferrule endface. US Conec brand is a PUSH style. The previous dial turn engagement has been changed to a pushing motion with audible click to alert the operator when the tool is fully engaged. If the cleaner is manual just wind a dial to access a new cleaning tape.

- Remove the connector from the cleaner tip. Close the dust cap lid
- Inspect the endface with a 200X microscope. If contamination (oil, moisture, lint, etc.) is visible on any of the fiber tips, repeat the cleaning. Continue until all fiber tips are clean.

Alternatively, MPO connectors can be cleaned using the cassette type MPO cleaner - it has side channels to accept male pins. The benefit of using a cassette cleaner over the MTP IBC® Cleaning Tool is that it is a more “stable” base to perform the cleaning procedure, given that one would hold the cassette with one hand in a firm grip, and have the assembly free to be cleaned using the other hand, thus avoiding the “shaking” that can happen when MTP IBC® Cleaning Tool is used.



Steps:

- Grip the cleaner, depressing the green lever of the cassette. The metal shutter on top of the cassette will open, exposing fresh cleaning material. Fresh material is exposed each time the green lever is depressed.
- Position the ferrule endface so that the fiber tips are in contact with the cleaning material as shown. Wipe the ferrule endface along the cleaning material in the direction shown on the cleaner cassette.



Correct– all 12 fibers across clean tape



Incorrect – sideways is wrong

- Release the green lever of the cassette to cover the cleaning material.
- Inspect the endface with a 200X microscope. If contamination (oil, lint, etc.) is visible on the fiber tips, repeat the cleaning. Continue until all fiber tips are clean.

NOTE: if after cleaning oily residue does not come off, repeat the process by moistening the cleaning tape with alcohol. This applies to both cleaning methods/types.

**MPO connector inspection instruction**

Using standard inspection probe remove the LC tip and replace with an MPO tip as shown.



**Figure 1 Video probe with LC tip**



**Figure 2 Video probes with MPO tip**

After changing the tips refer to fiber inspection/cleaning tips within this document and the IEC Fiber optics Standard document [IEC 61300-3-35](#) for pass/fail criteria.

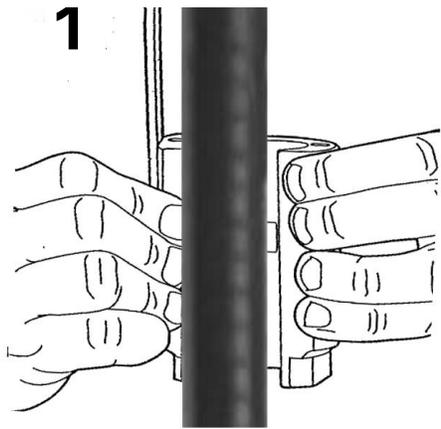


## Appendix E Hybriflex™ Jacket removal tool instruction

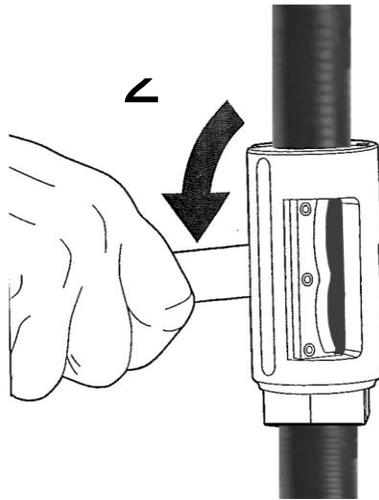


Part Number	Hybriflex™ size
HTPT-1-058	5/8"
HTPT-1-078	7/8"
HTPT-1-114	1-1/4"
HTPT-1-158	1-5/8"

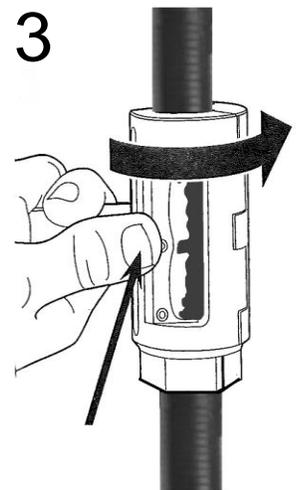
*Note: These instructions are written for qualified and experienced personal. Please study them carefully before starting any work. Any liability or responsibility for the result of improper or unsafe practices is disclaimed. Please respect valid environmental regulations for assembly and was disposal. Always make sure to use appropriate protection. Also, this user instruction is applicable for all size of Hybriflex™. Use caution when handling the jacket removal tool to avoid any accidental contact with the cutter blade.*



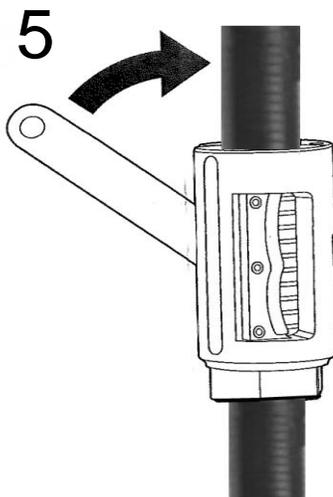
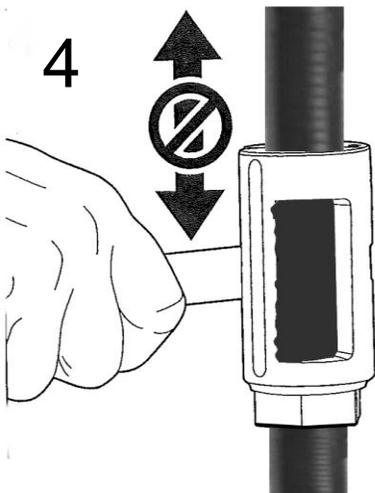
1  
Place cable inside tool.



2  
Close tool as it seat properly over the Jacket.



3  
Grasp the handle and press firmly while tuning clockwise.



## Appendix F 7/8 inch Armor cutting tool instruction

The following instructions are designed for use with the 7/8" HYBRIFLEX cable.

**Note**, the cutting tool is a special design; an 'off the shelf' pipe cutter from a local hardware store should not be used.

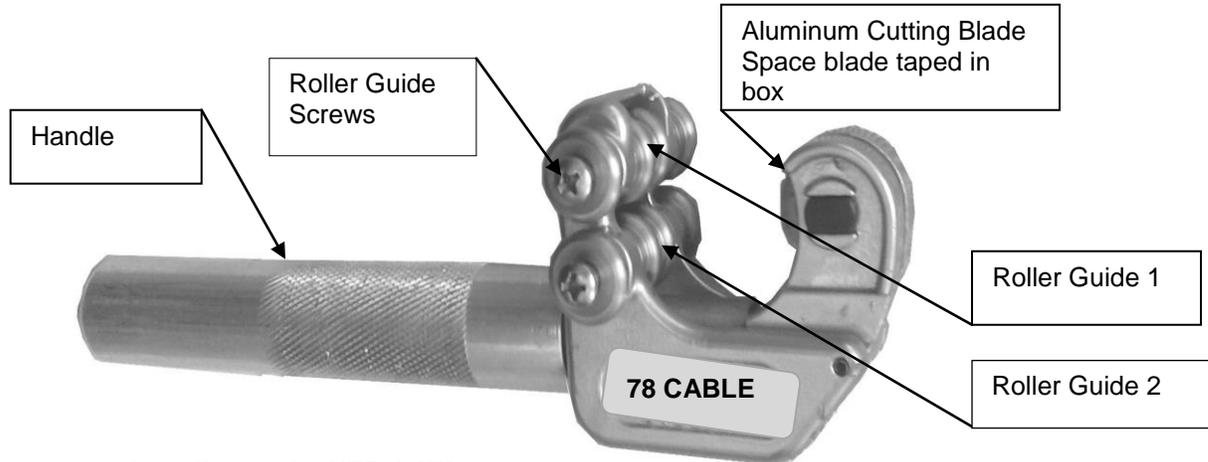


Figure 1

**Note: Do not unscrew the roller guide. HTP-1-078 is strictly design for 7/8" cable.**

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

- 1) Using the jacket removal 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 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: 4, 4a

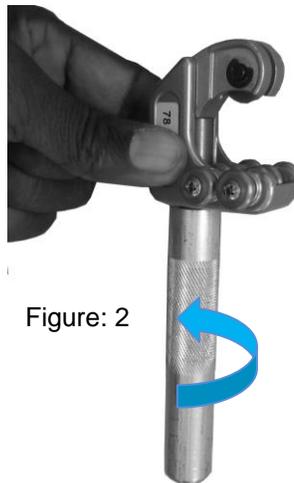


Figure: 2



Figure: 2a



Figure: 3



Figure 4



Figure 4a

*These instructions are written for qualified and experienced personal. Please study them carefully before starting any work. Any liability or responsibility for the result of improper or unsafe practices is disclaimed. Please respect valid environmental regulations for assembly and was disposal. Always make sure to use appropriate protection.*

## Appendix G 5/8 inch Armor cutting tool instruction

RADIO FREQUENCY SYSTEMS  
The Clear Choice®



The following instructions are designed for use with the 5/8" HYBRIFLEX cable.

**Note**, the cutting tool is a special design; an 'off the shelf' pipe cutter from a local hardware store should not be used.

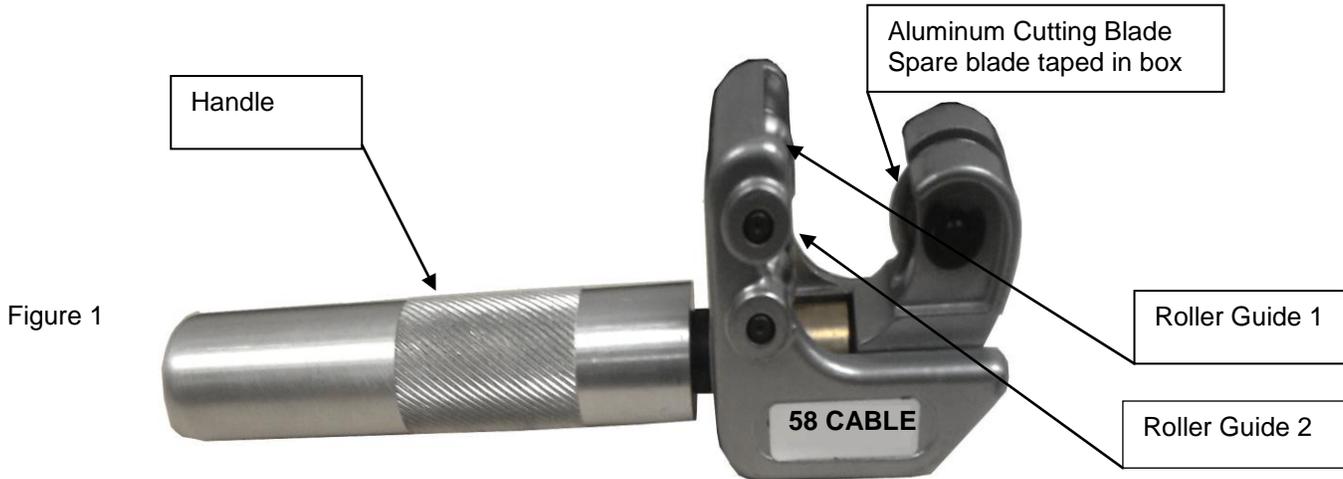


Figure 1

**Note: Do not unscrew the roller guide. HTP-1-058 is strictly design for 5/8" cable.**

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 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: 4, 4a

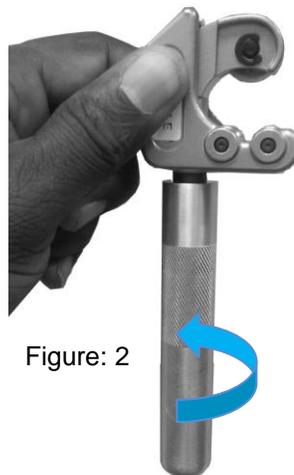


Figure: 2

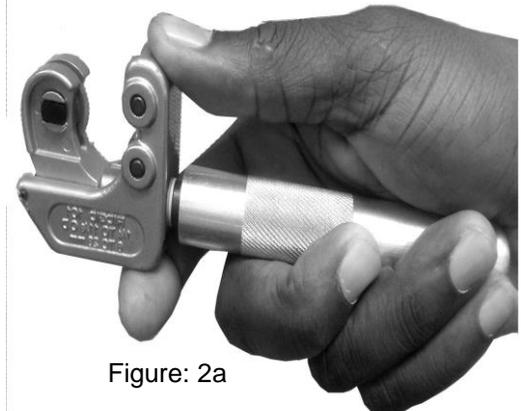


Figure: 2a

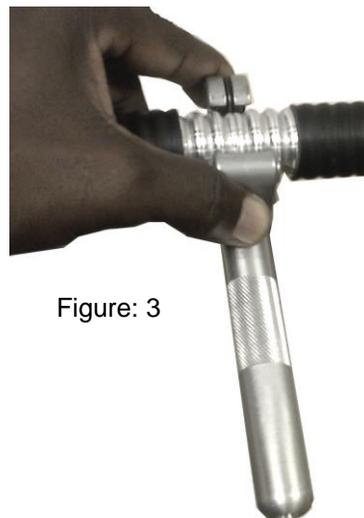


Figure: 3

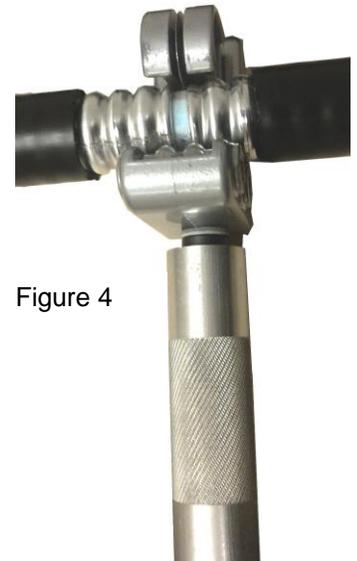


Figure 4



Figure 4a

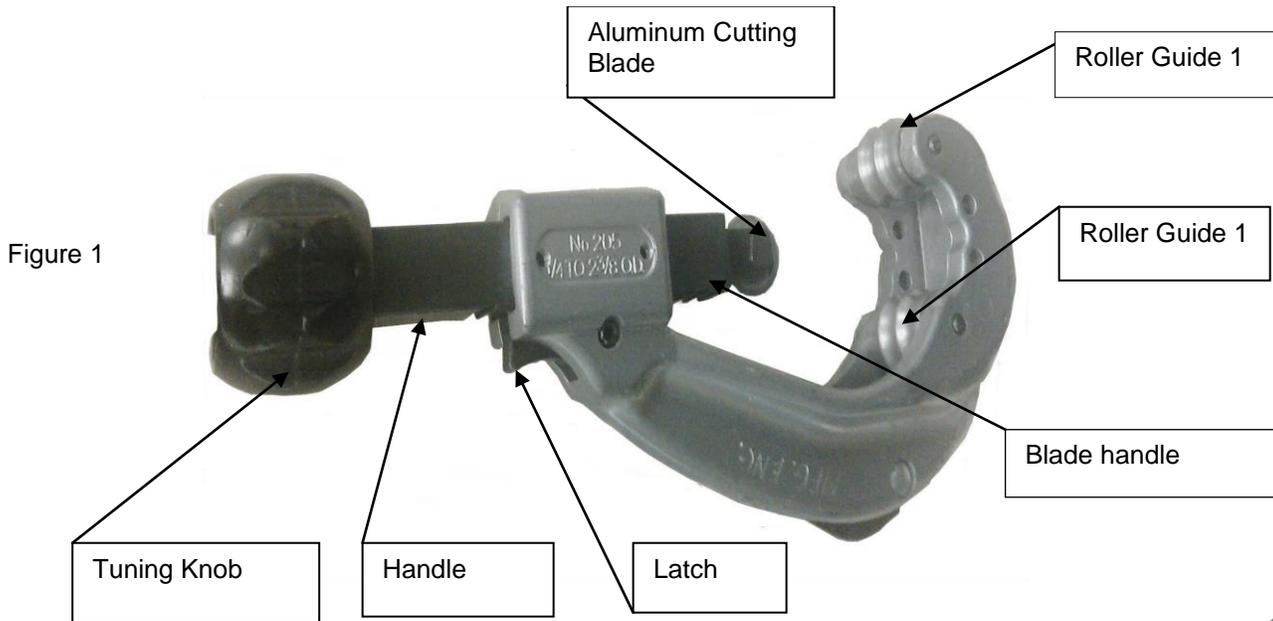
*These instructions are written for qualified and experienced personal. Please study them carefully before starting any work. Any liability or responsibility for the result of improper or unsafe practices is disclaimed. Please respect valid environmental regulations for assembly and was disposal. Always make sure to use appropriate protection.*

# Appendix H

## 1-1/4 inch Armor cutting tool



The following instructions can be use for 1-1/4" of HYBRIFLEX's cable. Note, the cutting tool are special design, an off the shelf pipe cutter from local hardware should not be use.



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 move 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

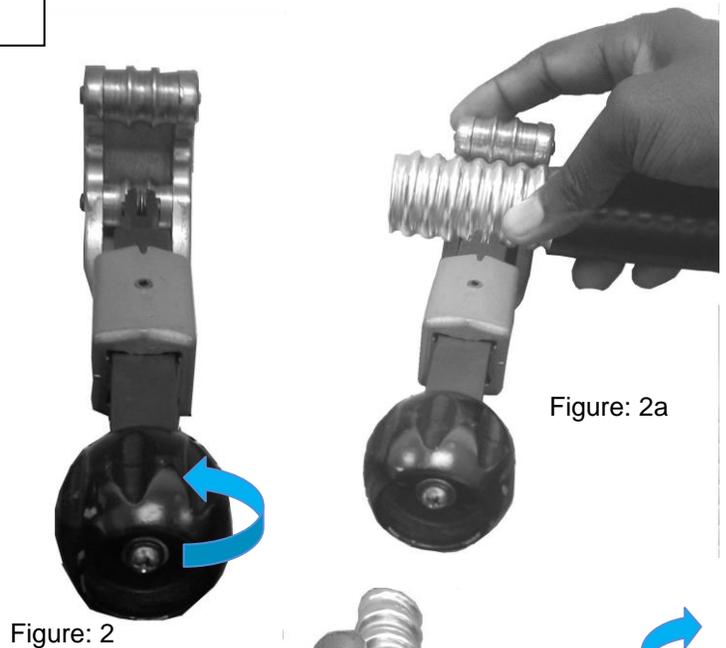


Figure: 2

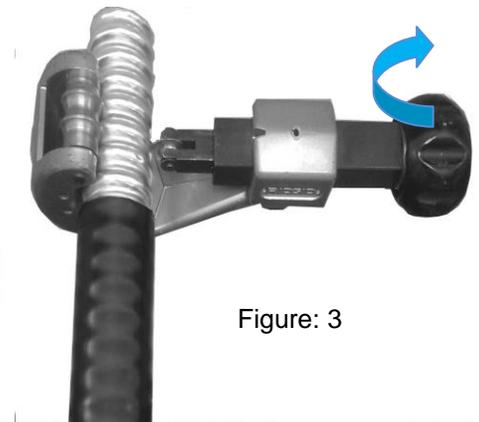


Figure: 3

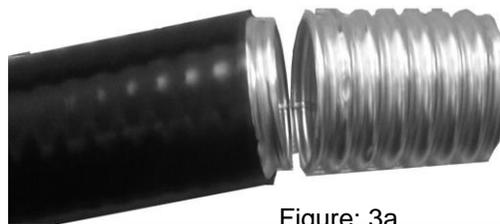


Figure: 3a

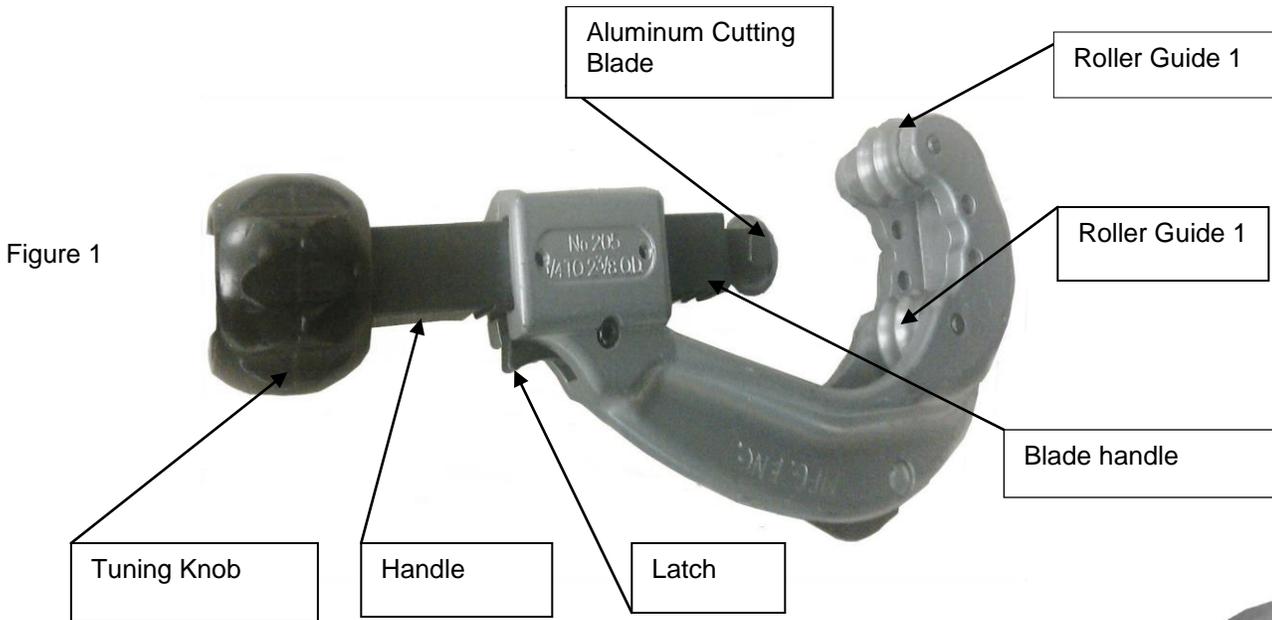
*These instructions are written for qualified and experienced personal. Please study them carefully before starting any work. Any liability or responsibility for the result of improper or unsafe practices is disclaimed. Please respect valid environmental regulations for assembly and was disposal. Always make sure to use appropriate protection.*

# Appendix I

## 1-5/8 inch Armor cutting tool instruction



The following instructions can be use for 1-5/8" HYBRIFLEX's cable. Note, the cutting tool are special design, an off the shelf pipe cutter from local hardware should not be use.



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

- 6) Using the jacket stripping tool remove the jacket off the cutting section
- 7) 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 move in and out by tuning the knob.
- 8) Insert the cable between roller 1 and 2 as shown in figure: 2.
- 9) Grasp cable and tool together with one hand as shown in figure: 2a
- 10) Slowly spin tool around the cable while rotating the knob continue until the aluminum armor cut through. As shown in figure: 3, 3a

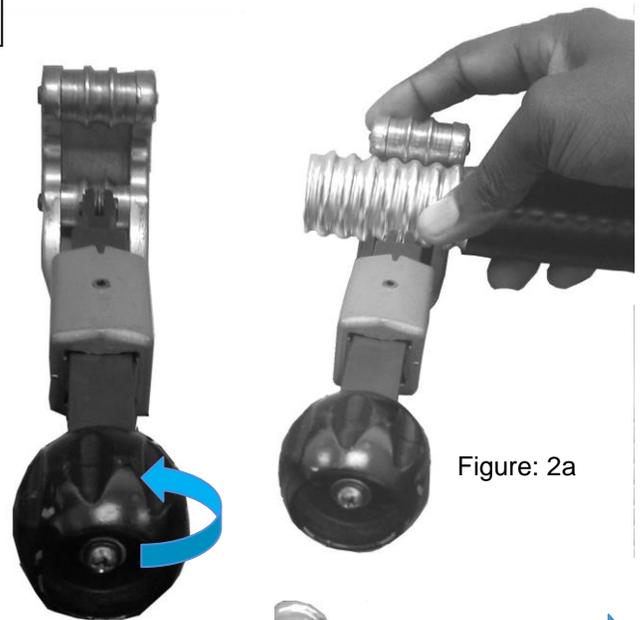


Figure: 2a

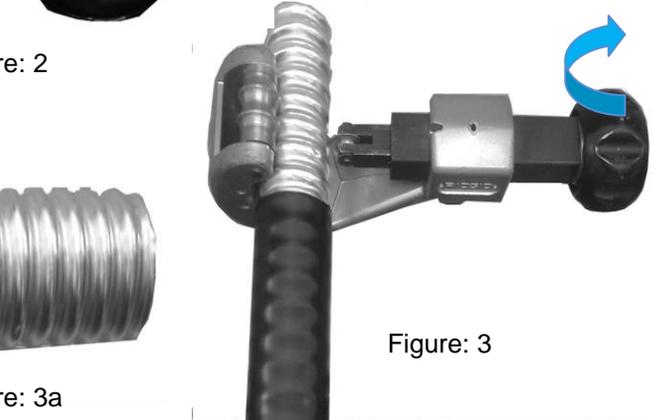


Figure: 3

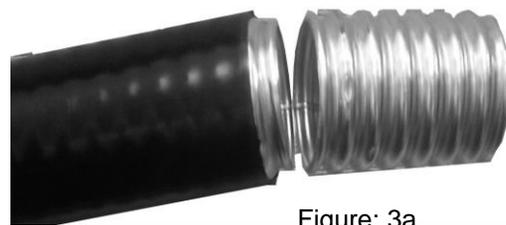


Figure: 3a

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**Appendix J**  
**Armor removal ripcord instruction**

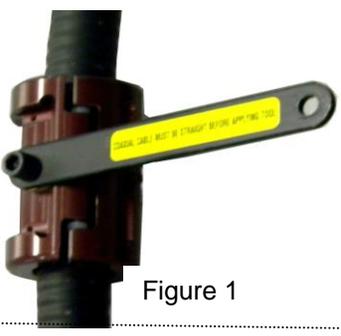
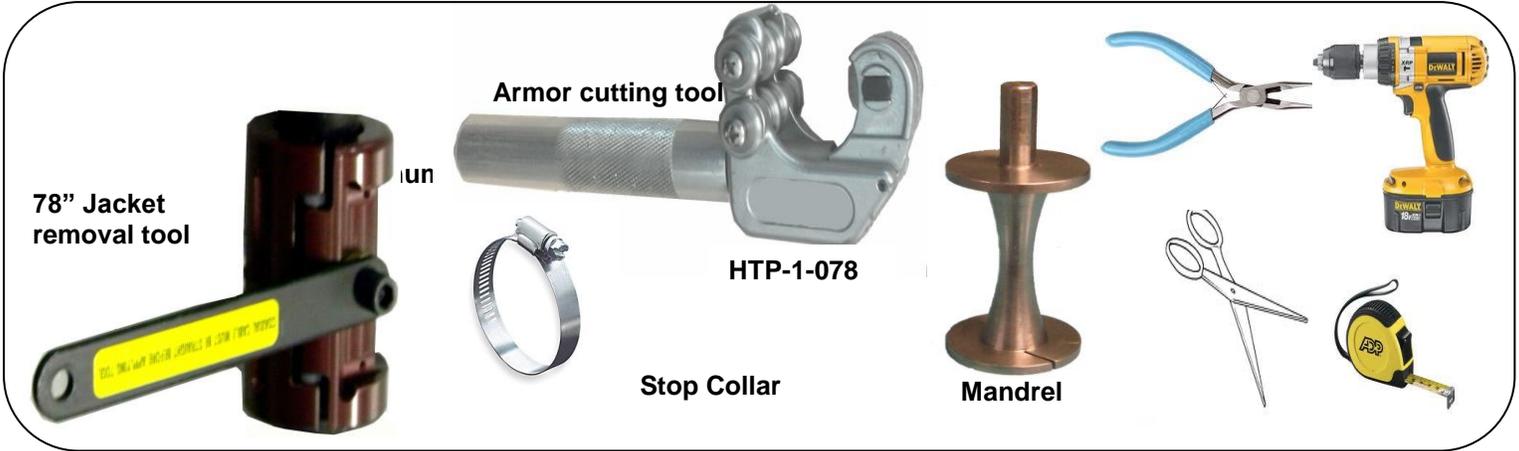


Figure 1

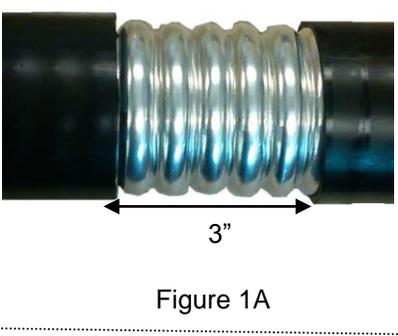


Figure 1A

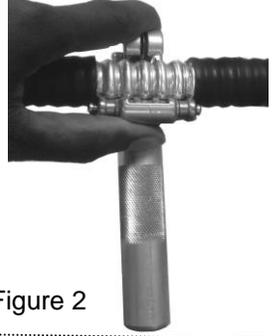
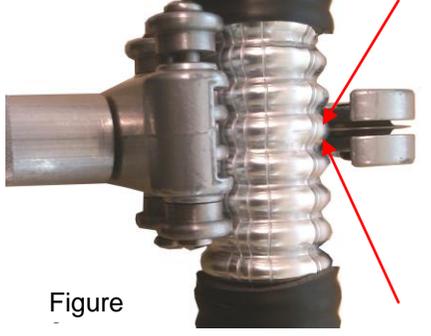


Figure 2



Figure



Figure 2b

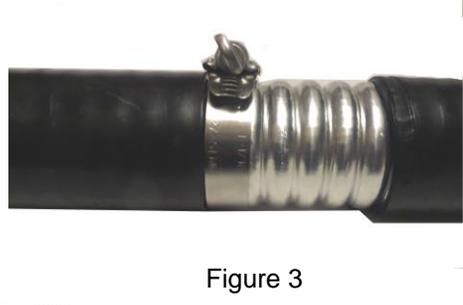


Figure 3

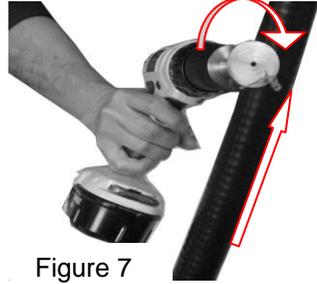
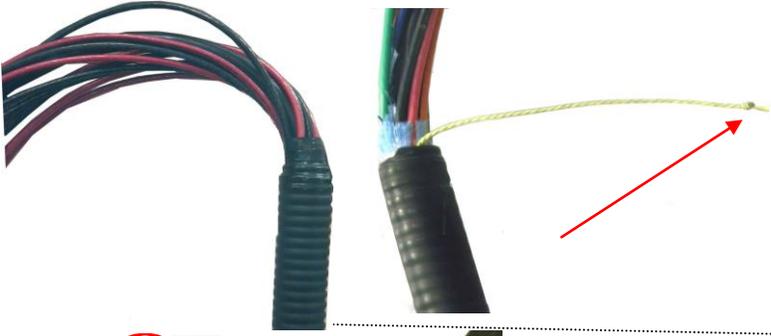


Figure 7

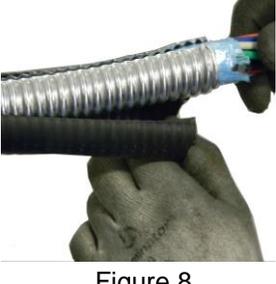


Figure 8

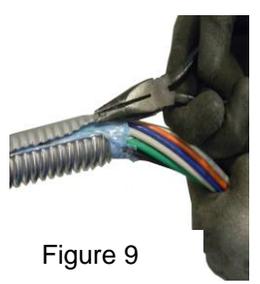


Figure 9

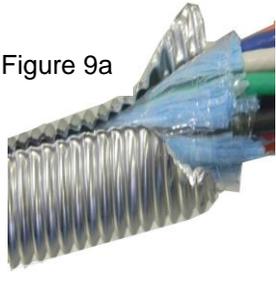


Figure 9a



Figure 9b

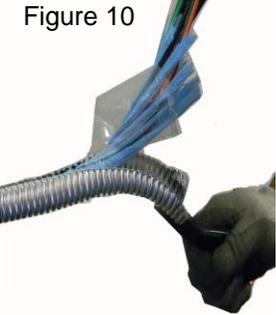


Figure 10

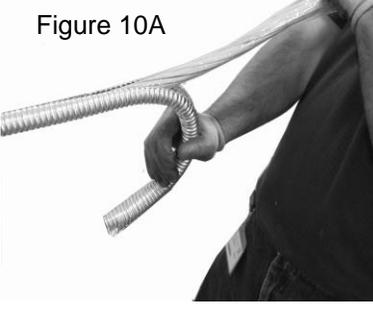


Figure 10A

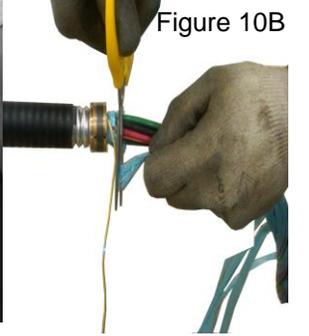


Figure 10B



### 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:** **Caution!** Use 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.

**Note:** *The armor cutting tools are special and unique, regular pipe cutters from your local hardware store (Lowe's, Home depot etc.) **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

6) **Note:** **HYBRIFLEX 7/8" Cables have one ripcord.** (6" of the ripcord is exposed from the factory under the electrical tape).

**Note:** **If ripcord is not exposed or too short due to previous Armor removal Stop and Complete steps 15-23 first.**

- 7) Locate ripcord and place a knot at the end of it as shown in Figure 5.

8) 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).

9) 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.

10) Now that the armor and jacket has been sliced, peel open the jacket, remove and discard. See Figure 8.

11) **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).

12) 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.

13) 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).

14) Untwist fiber and DC-wires as desired and cut excess signature cord.

15) Continue with the installation process.

### **Additional instruction for Non-exposed ripcord**



Figure 11



Figure 12



Figure 13



Figure 14



Figure 15

Figure 16

16) Using the jacket removal tool, strip a couple inches of the jacket as shown in Figure 11.

17) Using a metal snip make four even cuts on the aluminum armor and bend the cut edges over the aluminum armor. This step is critical to ensure the sharp aluminum edges do not scratch or damage wires during armor removal.

**Caution! Use hand protection, the sharp aluminum edges can be dangerous.** See Figure 12.

18) Cut 6 inches of the armor by positioning the cutting tool as shown in Figure 2a.

19) Repeat step 3.

20) Push the cut piece of armor in the direction of the LC connectors until it reaches the Fiber heat shrink as shown in Figure 13.

21) Now, 6 inches of ripcord (shown yellow in the picture) is accessible as shown in Figure 14. Pull it and go through steps 1-14.



22) Hold the cut piece described in step 17, pull the DC-wires one by one from it, according to Figure 16. **Do not apply excessive force when pulling DC-wire.**

23) Once all DC-wires are removed, push the cut piece back over the fiber jacket as shown in Figure 15 and use a metal snip to slice open the 6" strip or armor, and peel it off as described in step 9. Caution! Be careful not to damage the fiber jacket with the metal snip.

24) End

*These instructions are written for qualified and experienced personnel. Please study them carefully before starting any work. Any liability or responsibility for the result of improper or unsafe installation practices is disclaimed. Please respect valid environmental regulations for assembly and waste disposal. Always make sure to use appropriate personal protection!*



## Appendix K Boot sealing (where applicable)

### Required:

- Urethane Sealant Kit (supplied with cable)
- Electric Heat Gun (installer supplied)
- Dispensing Gun (installer supplied)

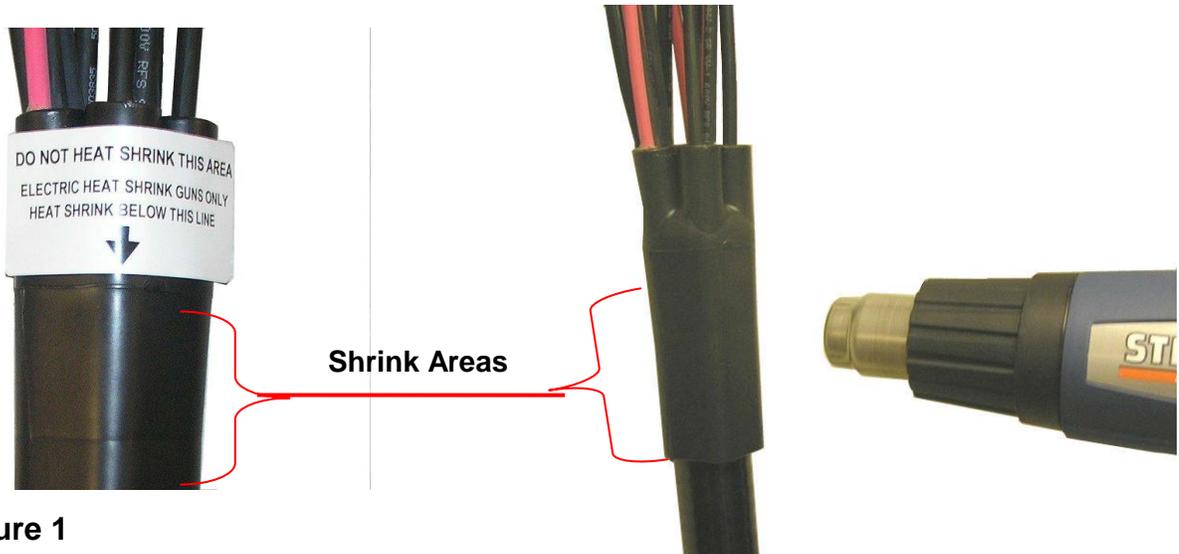


Figure 1

### Steps:

1. Shrink boot
2. Fill boot with Urethane Sealant
3. Allow sealant to cure before moving – approximately 60 minutes.
  - For best results apply at temperatures above 50 degree F.
  - Follow filling instructions carefully to insure proper weather seal.

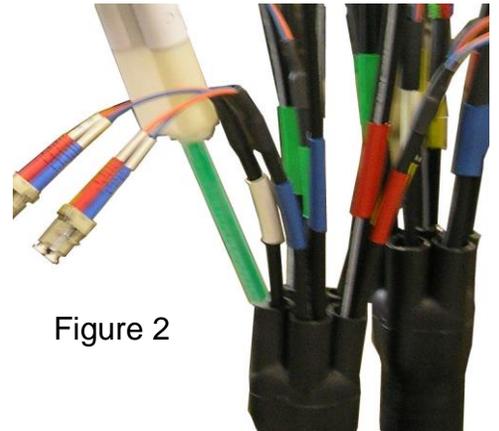


Figure 2

### 4. Shrinking the boot

a) Using an electric heat gun set to 750°F apply heat to boot area below the parting line of the fingers as indicated by the label (excessive temperature can damage the cables).

b) Continue to apply heat until boot shrinks tight to cable.

**Caution: Do not attempt to shrink the fingers or damage to fiber cables will occur.**



**5. Urethane Dispenser Instruction:**

- a) Remove tip cover from cartridge.
- b) Install static mixer.
- c) Dispense a small amount into a waste area to insure two parts are mixing.

**6. Boot Filling Instructions:**

- a) Orient boot with finger openings facing up.
- b) Dispense urethane sealant into the finger opening with the single cable only. See boot shrink figure 2
- c) Gently move the cables in all fingers during filling to allow urethane to fill around them.
- d) Continue filling only this finger until sealant reaches the top of the finger.

*Note: This should take the entire contents of one cartridge.*

- e) Let material to settle for a few minutes.

- f) Top off remaining fingers.

- g) Allow to remain undisturbed for 60 minutes before moving.



# Appendix L

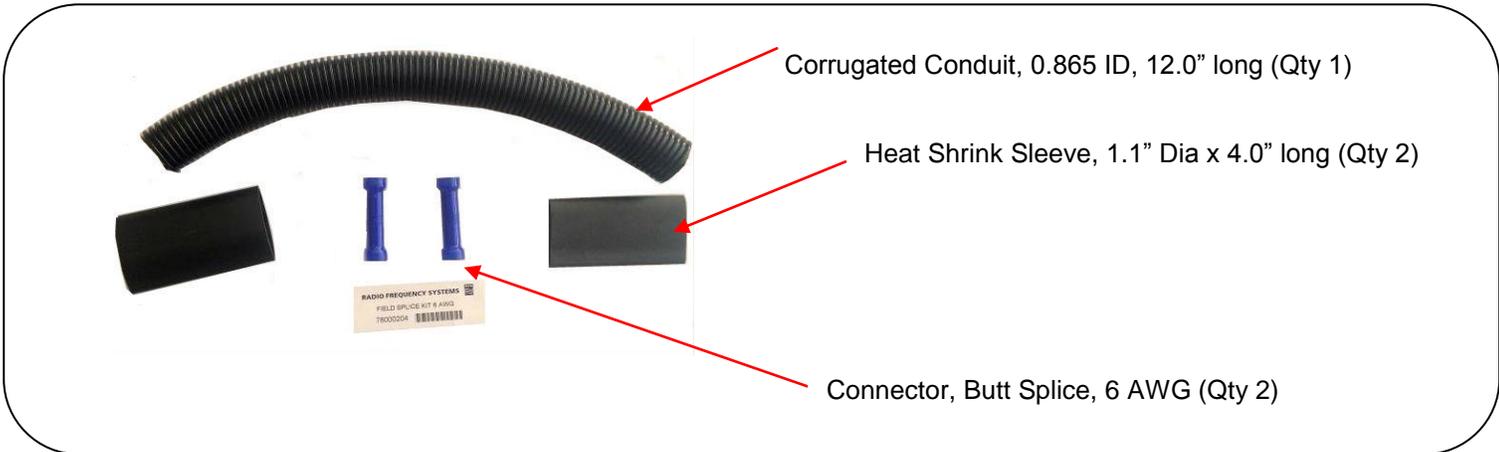
## HYBRIFLEX™ Riser / Jumper Connection Instructions

1

**Overview:** The following instructions explain how to splice the two power cables inside the corrugated tube of the jumpers and riser assemblies. This procedure applies to 4 AWG, 6 AWG and 8 AWG connections. This guide uses splice kit #6 (6 AWG) as an example. These instructions also explain how to assemble the IP-MPO fiber connectors from the jumper and riser.

**Safety:** **Caution!** Use hand protection and safety glasses when splicing power cables.

**Figure 1: Field Splice Kit Parts**



**Note:** The Field Splice Kit is provided along with every HYBRIFLEX jumper, and it does not need to be ordered separately. For replacement purposes only, use part # listed in the following table.

Splice Kit	Power Wires Size (AWG)	RFS Part #
#4	4 AWG	78000208
#6	6 AWG	78000204
#8	8 AWG	78000209



RECOMMENDED TOOLS:



Crimp Tool\*



Conduit Cutter



Heat Gun



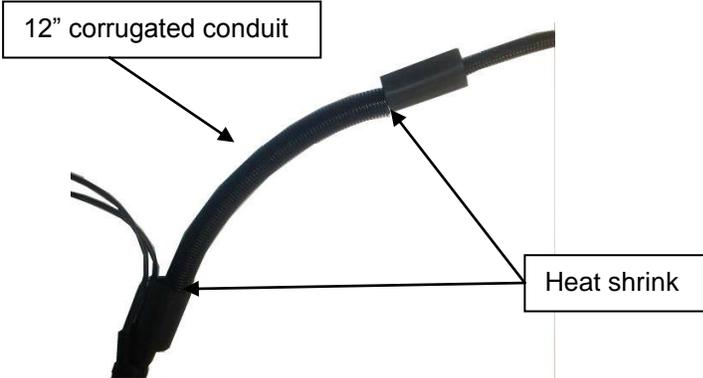
Measuring Tape

\* Thomas & Betts (T&B) model number ERG4007 needed for 6 AWG and 8 AWG. Crimp tool not needed for 4 AWG (5/32 hex screw)

Both the riser and jumper cables need to be prepared prior to DC splicing / installation.

**Jumper end preparation:**

- 1) Make sure the power wires are flush with the end of the corrugated conduit.
- 2) Slide 1<sup>st</sup> heat shrink sleeve, the 12" corrugated conduit and 2<sup>nd</sup> heat shrink sleeve over the jumper's conduit.



- 3) Measure and mark 6.0" from the end of the corrugated tube.

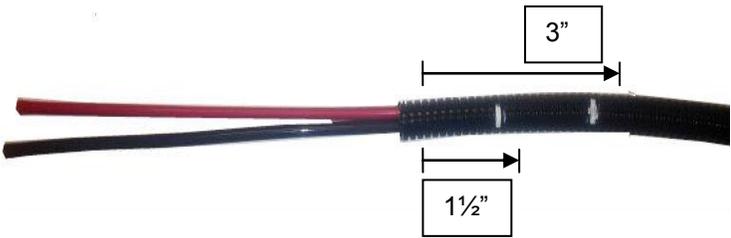




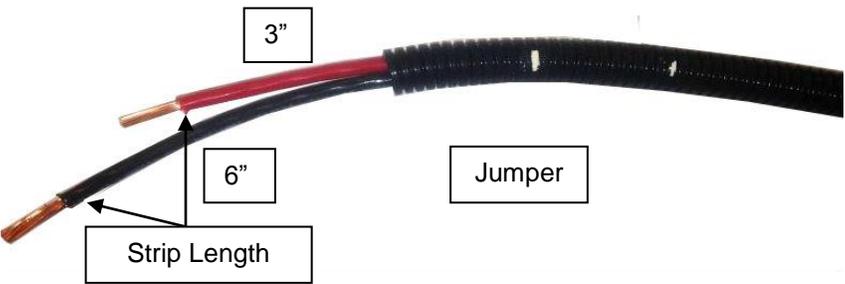
- 4) Place the blades of corrugated tubing cutter over the 6.0" mark, carefully squeeze the handles, until the blades cut through the tubing (Careful not to cut into the power cables).
- 5) Rotate the cutter 360 degrees around the tube (careful not to cut into the power cables) until the 6" piece of tubing is completely cut-off. Remove the marked length exposing the two power wires (6") and discard.



- 6) Make two marks on the corrugated tubing at 1 1/2" from the end of the tubing and another at 3.0"



- 7) Trim the red wire leaving only 3" (Do not trim the 6.0" long black wire)
- 8) Strip insulation off both ends of black and red power wires per the table below.



Wire Size	Strip length
8 AWG	17/32" (.53")
6 AWG	17/32" (.53")
4 AWG	3/4" (.75")

- 9) A) For 6 AWG and 8 AWG, attach butt splices to each stripped end of power wires and crimp using T&B crimp tool.



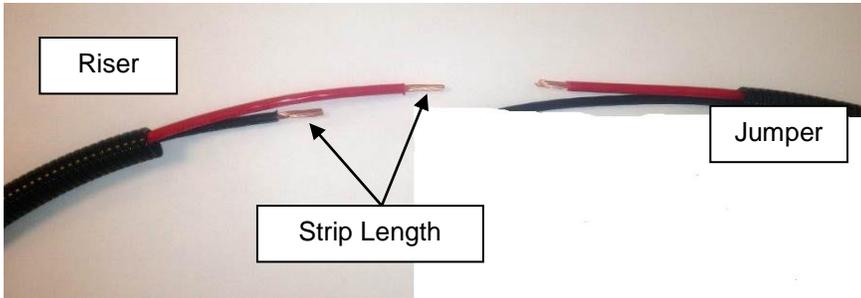
- B) For 4 AWG, attach mechanical splice to each stripped end of power wires using a 5/32 hex screwdriver.



### Riser end preparation:

- 10) Make sure the power wires are flush with the end of the corrugated tube with power wires.
- 11) Repeat steps 3 through 6 above on the riser corrugated tube.
- 12) Trim the black wire leaving only 3" (Do not trim the 6.0" long Red wire)
- 13) Strip insulation off both ends of black and red power wires per the table below.





Wire Size	Strip length
8 AWG	17/32" (.53")
6 AWG	17/32" (.53")
4 AWG	3/4" (.75")

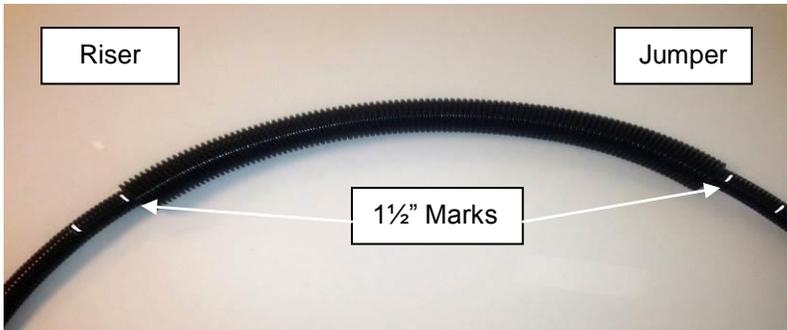
**Splicing & Weatherproofing:**

- 14) Attach butt splice already crimped to Black wire on jumper end to the Black power wire on the riser end, and do the same with the Red power wires. Crimp both ends using T&B crimp tool.

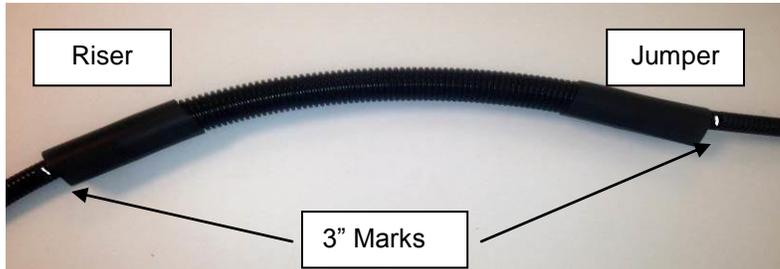


- 15) Slide the 1<sup>st</sup> heat shrink sleeve onto the riser corrugated tubing, and slide the 12" corrugated conduit over the butt-spliced power cables. Leave the other heat shrink sleeve at the jumper end.

- 16) The ends of the 12" conduit should be over the 1½" marks on both ends (jumper and riser) of the splice.



- 17) Slide the heat shrink sleeves about half-way over both ends of the 12" conduit so that the end of the sleeves will be over the 3" marks.



- 18) Using a heat gun, heat shrink both heat shrink sleeves. The final assembly should look like the picture below.



## **Procedure to Connect the HYBRIFLEX™ Fiber**

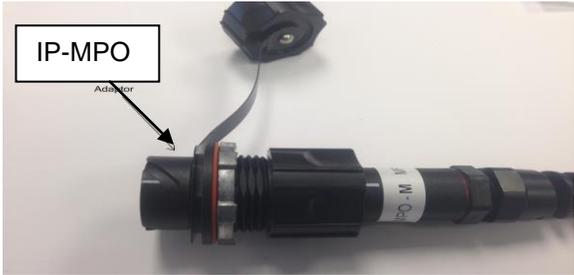
*The following instructions explain how to connect the Riser IP-MPO connector to the Jumper factory Connected IP-MPO Male connector (already connected to an adaptor). This will provide an IP68 outdoor connection to the fiber optics solution.*

*Note: Do NOT remove the protective caps on the IP-MPO connectors until it's time to install and connect the fiber. Follow inspection and cleaning procedure before making connection.*

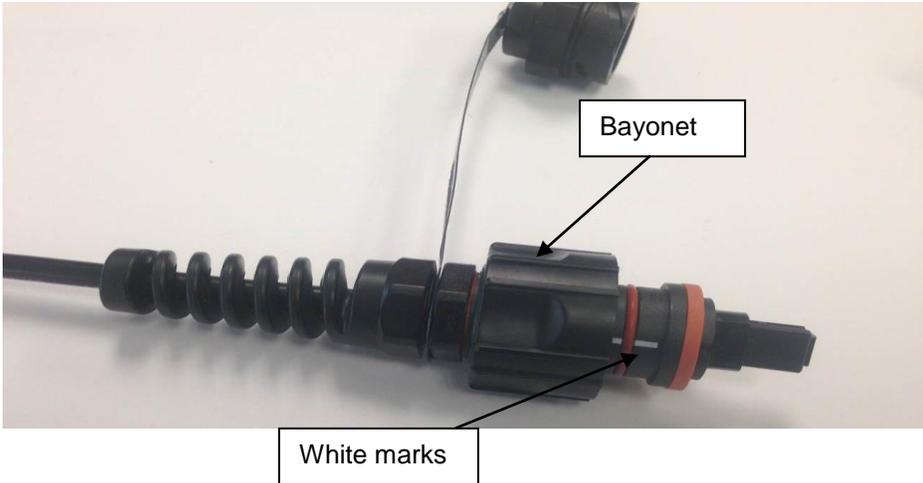
1. The jumper fiber IP-MPO male connector is factory connected with an adaptor. DO NOT disconnect the adaptor.



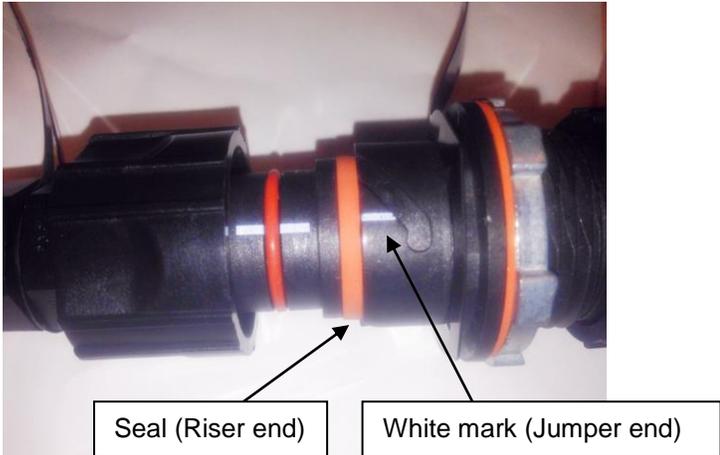
2. Remove the dust caps from the jumper IP-MPO connector.



3. Remove the dust cap from the riser IP-MPO and slide the bayonet housing back.



4. IMPORTANT!! Line up white markings on jumper and riser IP-MPO connectors and slide the riser connector to the jumper connector. Push the white mark on the jumper connector flush against the red seal on the riser connector.



5. **IMPORTANT!!** Rotate the bayonet housing clock wise until you hear a click sound (means a good connection is in place).



6. Fiber connection is complete!

## Appendix M

### HYBRIFLEX™ Jumper Enclosure Installation Instructions

**Overview:** The following instructions explain how to install the spare fiber enclosure and replace a damaged fiber with a spare fiber from inside the jumper assembly enclosure. This procedure applies to spare fiber enclosure housing the 3 spare LC fiber pairs on the 5/8" Hybriflex jumper assembly end connecting to the RRH.

**Safety:** **Caution!** Use safety glasses when replacing a fiber and installing the enclosure.

**Figure 1: Spare Fiber Enclosure Kit Parts**



**Note:** The Hybriflex jumper assembly is shipped with the enclosure. The container will house (3) spare fibers pairs (Yellow, Orange and Purple) inside it. The enclosure does not need to be ordered separately. For replacement purposes only, use part # XXXXXX

#### RECOMMENDED TOOLS:

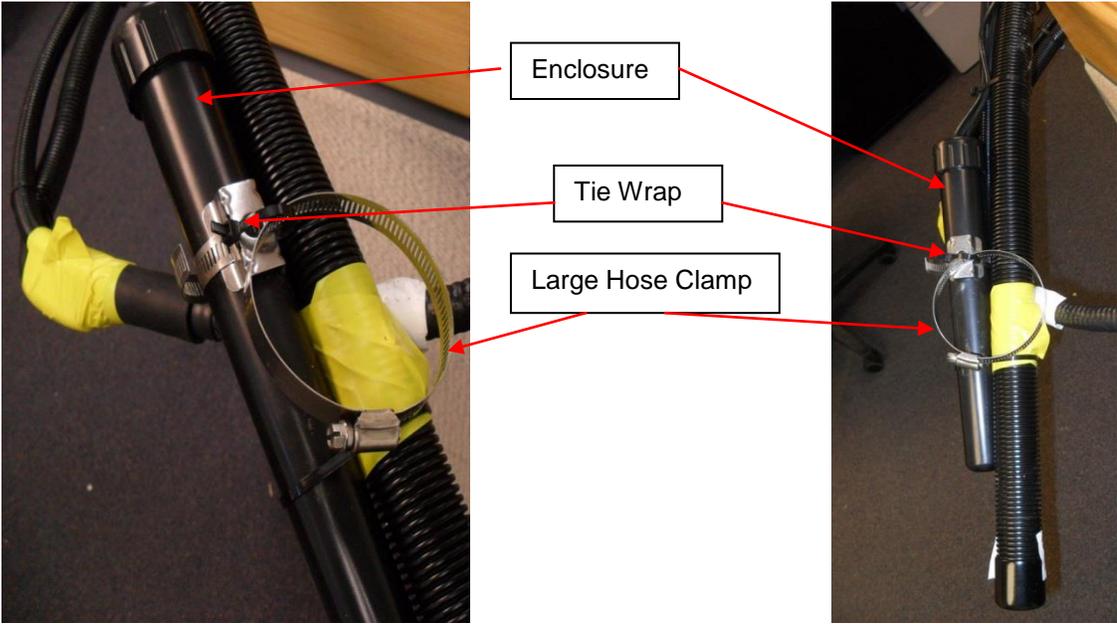


Flat head Screw driver



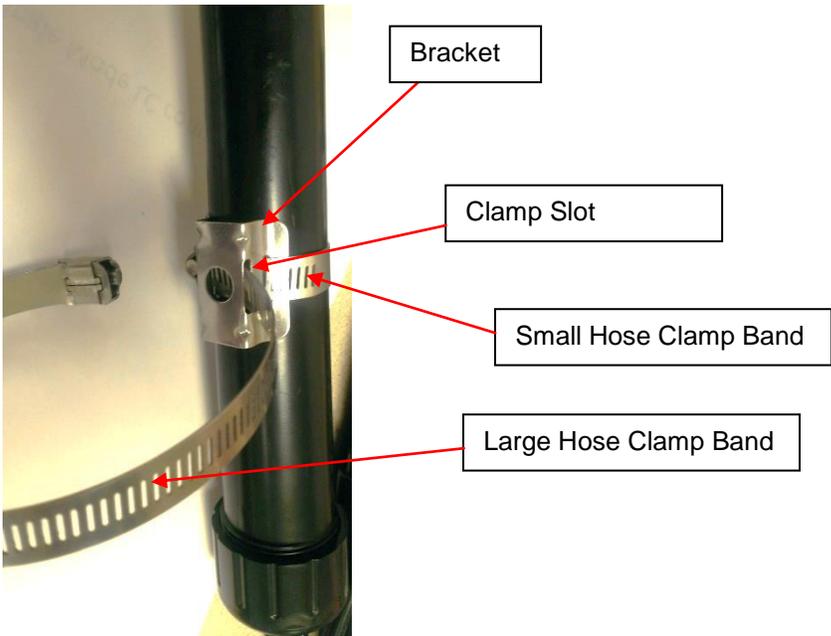
**Enclosure packing and shipping:**

- 1) Hybriflex Jumper assembly is shipped with the enclosure tie wrapped to the jumper assembly. The bracket will be attached to the enclosure with a small hose clamp. The large hose clamp will be tied to the bracket with a plastic tie wrap.



**Field Handling and Installation:**

- 2) To mount the enclosure, cut the tie wrap holding the large hose clamp and thread the band of the large hose clamp through the slots of the bracket.

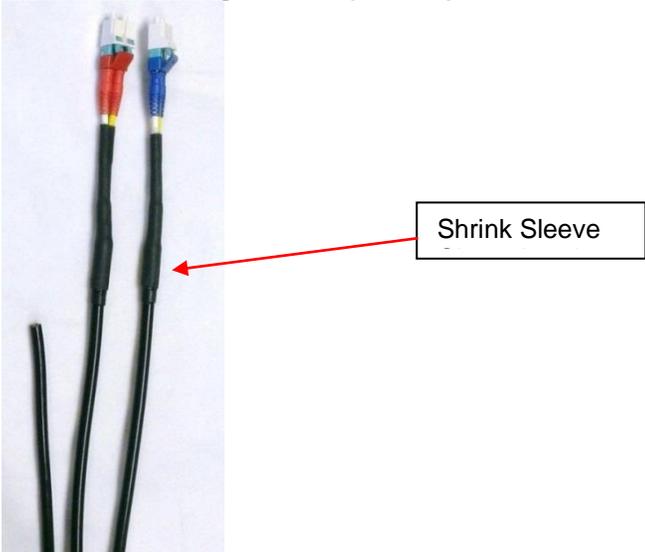




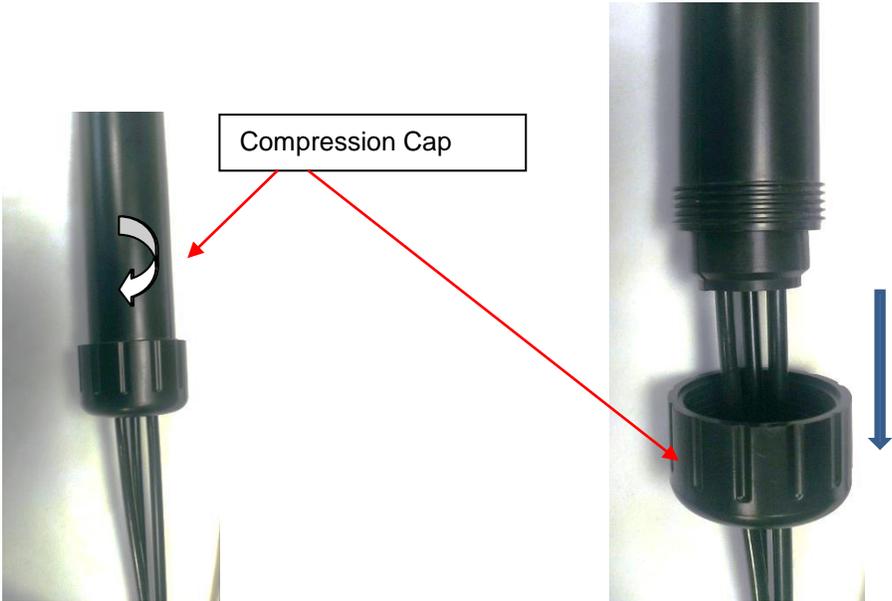
- 3) Attach the container to an appropriate surface using the large hose clamp. The enclosure can be mounted in any orientation. Tighten the large hose clamp with a flat head screw driver

**Replacing a Damaged Fiber:**

- 4) Cut the damaged fiber pair to just below the shrink sleeve.

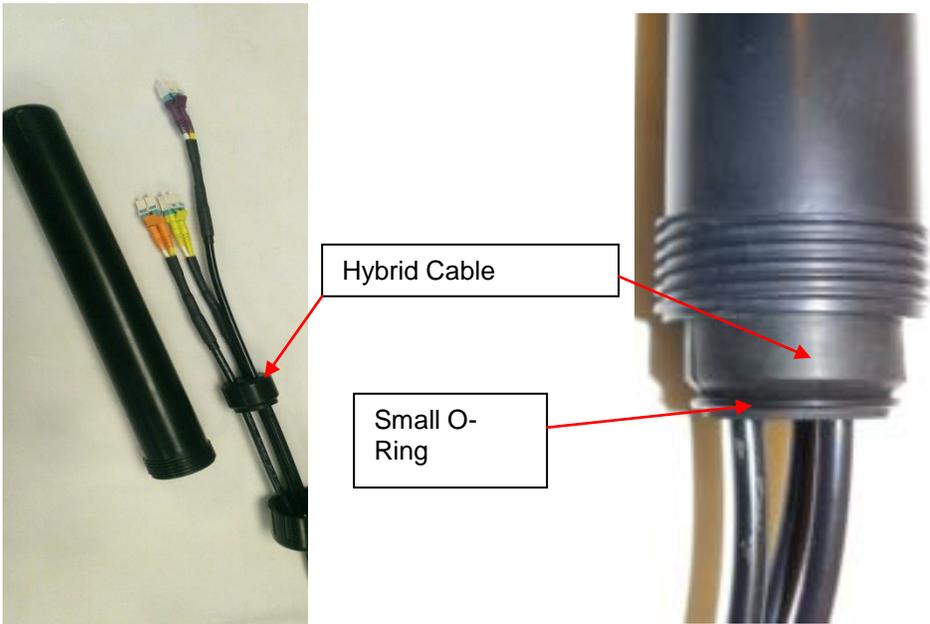


- 5) Without detaching the enclosure from its position, loosen the threaded cap by rotating it counter clockwise and remove the cap down by pulling it down.





- 6) Carefully remove the small O-Ring and the pull down the cable cushion holding the 3 LC spare pairs of fiber slowly

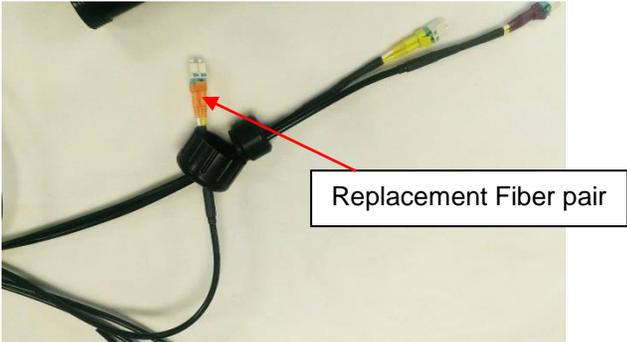


- 7) Remove one pair of fiber from the cushion by spreading the cushion on either side of the split in the cushion with your thumbs, and pushing the fiber cable out of its hole with the index finger.

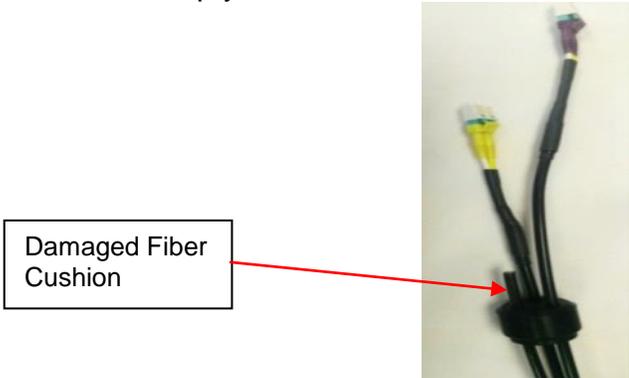




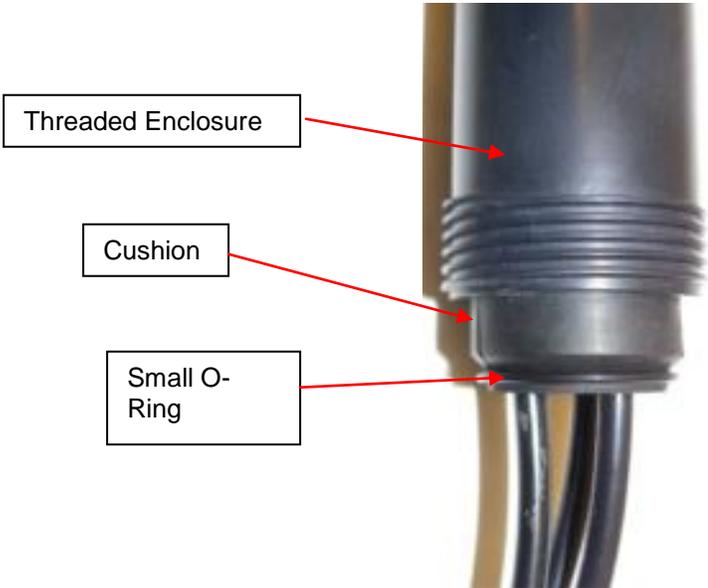
8) Carefully remove the replacement fiber out of the enclosure cap.



9) Insert the damaged fiber that was cut in step 4, through the compression cap and into the empty cushion hole.



10) Insert the two good spare fiber pairs and the damaged fiber pair, back into the enclosure tube, then press the cushion with the small O-Ring securely back into the enclosure tube all the way in until cushion cannot go any further.





- 11) Make sure the large O-Ring is inserted all the way to the bottom of the threads on the inside of the threaded cap.



- 12) Hand tighten the cap with the large O-Ring onto threads of the threaded enclosure as tight as possible, to compress the cushion and O-Rings together to assure a water-tight seal.



- 13) Fiber replacement is COMPLETE!!