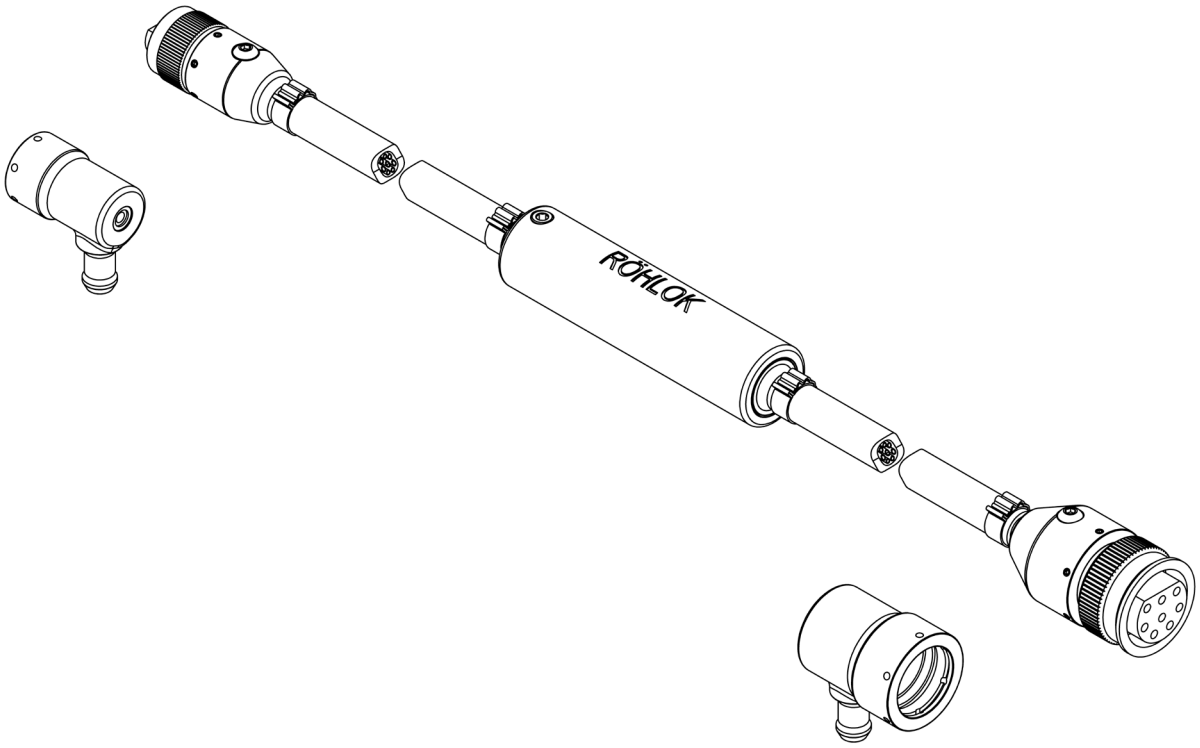
RÖHLOK

Modular Subsea Cables

TECHNICAL MANUAL
OIL-FILLED CABLE
DUAL-END



Patent information

The oil-filled cable system as described in this manual is protected by multiple international patents. Any breach of our IP by full or partial copying, modification or reverse-engineering will lead to prosecution in the courts of the relevant jurisdiction.

Disclaimer

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Draining and filling cavity with oil

To fill:

1. Assemble all parts and fasteners required, including the following tools and lubricants:
   - 1/8" hex (Allen) key
   - Oil-fill & air-bleed adaptors
   - 4 x 1mm BUNA-N70 O-rings
   - Dow-Corning 111 O-ring grease
   - Garden spray-bottle containing new, filtered, non-conductive hydraulic oil such as Shell Tellus 32
   - Oil-soak pads and/or rags & safety glasses
2. If installed, remove the 10-32 x ¼" BHCS from the two electrical connector adaptors, discarding both 4 x 1mm O-rings. Ensure both the oil-fill and air-bleed adaptors are fully assembled and have a 4 x 1mm O-ring installed on the thread of their respective oil port adaptors.
3. Place the cable assembly in a similar orientation as is shown in **Annexure 3**. In practice, it may be most convenient to place the uppermost electrical connector assembly in a vice. This will reduce the chance that spillage could occur during the filling process.
4. Install the air-bleed assembly finger tight in the upper electrical connector adaptor. Install the oil-fill assembly finger tight into the lower electrical connector adaptor. Connect a pump bottle containing new, filtered, non-conductive hydraulic oil such as Shell Tellus 32 to the -4 JIC fitting of the oil-fill adaptor.
5. Start filling the cable with oil, ensuring that all air is chased out of the void by the incoming oil. Rocking the flexible tubing and electrical connector adaptor assemblies this way and that and/or tapping them gently with a soft-face mallet will greatly assist in this process.
6. Once a column of pure oil appears in the clear tubing of the air-bleed adaptor, the cable is full. Immediately close the ¼ turn valve on the pump-bottle or spillage will occur. Bend the entire oil-filled cable assembly back and forth and roll it this way and that, ensuring that any remaining trapped air can escape to the high-point. Refill as required.
7. Locate two 10-32 x ¼" BHCS and two new 4 x 1mm O-rings. Generously lubricate the O-rings with Dow Corning 111 compound and install just under the screw head. Remove the air-bleed adaptor from the upper electrical connector adaptor and replace with a BHCS. Tighten firmly. Loosen the vice and swap the electrical connector assemblies. Remove the oil-fill adaptor and replace with the second BHCS. Tighten firmly.
8. Double check all exposed fasteners and hose clamps for tightness. The cable is now ready for use.

To drain:

1. Assemble all parts and fasteners required, including the following non-included tools and lubricants:
   - 1/8" hex (Allen) key
   - bucket or another suitable container
   - Oil-soak pads and/or rags
2. Secure one of the electrical connector assemblies in a vice and place a bucket or other container on the floor below, including oil-soak rags as appropriate.
3. Remove the BHCS from the electrical connector adaptor in the vice and replace with the air-bleed adaptor installed finger tight.
4. Seal the end of the small plastic tube of the air-bleed adaptor with your finger and remove the electrical connector assembly from the vice, inverting into the bucket. Release your finger. The second electrical connector assembly can now be raised above the first, its BHCS removed and the oil drained from the cable's cavity. **NEVER** reuse this oil, only fill with new brand-new oil of the same brand and type.

Reconfiguring pin-outs

1. Assemble all parts and fasteners required, including the following tools and lubricants:
   - 5/32" hex (Allen) keys
   - 2.4mm flat-blade screwdriver
   - 4 x 1mm Buna-N70 O-rings
   - 2-117 & 2-118 BUNA-N70 O-rings (if required)
   - Dow-Corning 111 O-ring grease
   - Oil-soak pads and/or rags
2. Take note of the existing conductor matrix (pin-outs) and record in Table 1 of **Annexure 1**.
3. Drain the cable cavity as per the **Draining and filling cavity with oil** section.
4. If still installed, remove assembly cover retaining screw using a 5/32" hex key (discard the 4 x 1mm O-ring).
5. Holding the clear outer tubing close to the hose-barb (to avoid stretching the tubing), slide the assembly cover completely off the inner frame to expose the PCB terminal blocks inside.
6. Inspect the two O-rings on the inner frame for any cuts, nicks or excessive flattening. If replacement is required, do this sometime in the next few steps when convenient.
7. Using the 2.4mm flat-blade screwdriver, release the relevant terminal clamps and reconfigure the conductors as required. Note your changes in Table 1 of **Annexure 1**.

- ***Note:*** *Depending on which conductors need swapping, and whether extra length has already been factored in for the shorter conductor during initial assembly; you may need to slightly shorten the length of the clear outer tubing by the same amount of length the shorter conductor requires. Simply remove the hose clamp, carefully trim the tubing and push it back onto the hose-barb.* ***DO NOT*** *just pull the shorter conductor tight and hope for the best, as this may lead to failure should the cable be stretched during use.*

8. Using Table 1 of **Annexure 1**, check the conductor matrix is correct using a multimeter. Check the pin to pin, and pin to case insulation using a Megger (250V) and record your readings in Table 3 of **Annexure 1**.
9. Apply another smear of Dow-Corning 111 O-ring grease to both O-rings on the inner frame and slide the assembly cover back into position. Apply a smear of Dow-Corning 111 O-ring grease to a new 4 x 1mm O-ring and install on the 10-32 x ¼" SHCS. Pass the screw through the hole in the assembly cover and install into the threaded port in the inner frame. Tighten firmly using a 5/32" hex key.
10. Fill the cable cavity as per the **Draining and filling cavity with oil** section.
11. Double check all exposed fasteners and hose clamps for tightness. The cable is now ready for use.

Replacement of electrical connector(s)

1. Assemble all parts and fasteners required, including the following tools and lubricants:
   - 1/16", 5/32" and 1/8" hex (Allen) keys
   - 2.4mm flat-blade screwdriver
   - NormaClamp® Cobra pliers *or* medium-sized flat-blade screwdriver and pair of slip-joint pliers
   - NormaClamp® Cobra 15-8 W4 (white band) hose clamps x 2
   - 4 x 1mm Buna-N70 O-rings
   - 2-017 or 2-023 BUNA-N70 O-ring (depending on Burton™ shell size)
   - 2-117 & 2-118 BUNA-N70 O-rings (if required)
   - Dow-Corning 111 O-ring grease, WD40 & Aqua Shield marine grease
   - Oil-soak pads and/or rags
2. Take note of the existing conductor matrix (pin-outs) and record in Table 1 of **Annexure 1**.
3. Drain the cable cavity as per the **Draining and filling cavity with oil** section.
4. If still installed, remove assembly cover retaining screw using a 5/32" hex key (discard the 4 x 1mm O-ring).
5. Holding the clear outer tubing close to the hose-barb (to avoid stretching the tubing), slide the assembly cover completely off the inner frame to expose the PCB terminal blocks inside.
6. Inspect the two O-rings on the inner frame for any cuts, nicks or excessive flattening. If replacement is required, do this sometime in the next few steps when convenient.
7. Using the 2.4mm flat-blade screwdriver, release the relevant terminal clamps and remove all the conductors of the loom attached to the electrical connector(s) you are replacing.
8. Using a pair of NormaClamp® Cobra pliers (or a medium flat-blade screwdriver) release the hose clamp and remove the end of the flexible tube from the termination assembly hose-barb, separating the entire flexible tube, wiring loom and electrical connector assembly from the termination assembly. Discard the hose clamp.
9. Using a pair of NormaClamp® Cobra pliers (or a medium flat-blade screwdriver) release the second hose clamp and slide the flexible tubing completely off the electrical connector adaptor and wiring loom. Discard this hose clamp also.
10. Remove the six radial set-screws in the electrical connector adaptor and set aside.
11. Remove the electrical connector from the electrical connector adaptor. It may be tight so don't give up! Rocking the electrical connector back and forth whilst pulling may assist in removal.

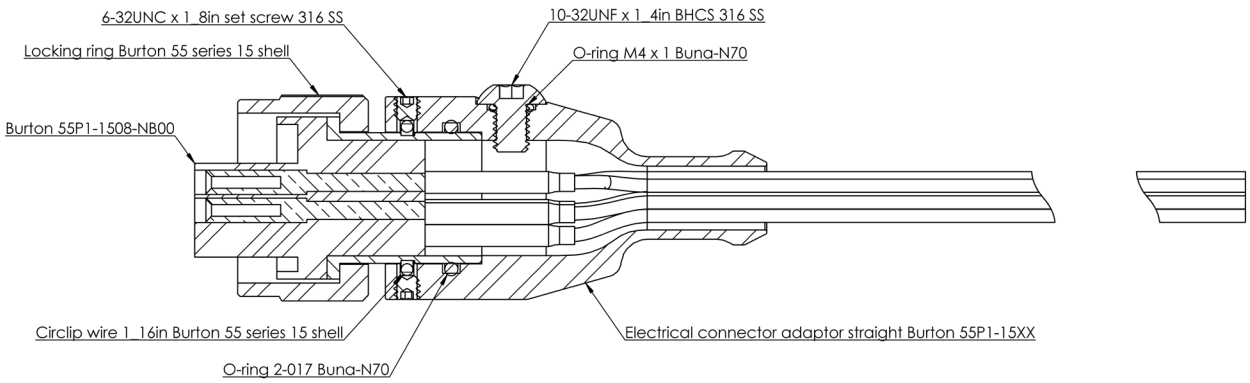
- ***Note:*** *If the electrical connector will not release, squirt a small amount of WD40 into the set-screw holes and let soak for 10 minutes before trying again.*

12. Once the electrical connector has released, remove it and its attached loom completely. Inspect the inside of the electrical connector adaptor for any gunk or corrosion paying particular attention to the wire circlip. Clean as required and regrease with Aqua Shield marine grease. Replace the O-ring with a new one that has been liberally greased with Dow Corning 111 compound. Pack the 6 set-screw holes with Aqua Shield and **loosely** install the six radial set-screws.
13. Locate a new electrical connector ensuring that its wiring loom is at least 6" (150mm) longer than the flexible tubing of the side you are repairing. Install the locking collar if required. Pass the loom through the electrical connector adaptor and seat the electrical connector firmly against the machined internal shoulder.

- ***Note:*** *If electrical connector(s) is(are) unwired, wire using 18AWG conductors with TFE or other oil-impervious insulation and MILSPEC soldering instructions at* ***Annexure 4****, ensuring the loom is at least 6" (150mm) longer than the flexible tubing. Record this dimension (C) in Table 2 of* ***Annexure 1****.*

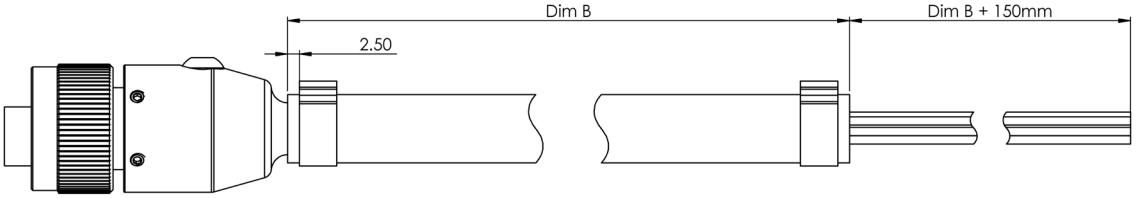
- ***Note:*** *If using a 90-degree electrical connector adaptor, ensure you note the required cable to plug orientation before seating the electrical connector into the connector adaptor. This avoids the possibility of significantly stressing the wiring loom (by twisting more than 15deg) once assembled, if the orientation is incorrect and needs to be adjusted.*

14. Tighten the six radial set-screws in two stages. Firstly, tighten until all screws are just touching the wire circlip, then, progressively tighten screws 1/8 of a turn at a time until all are tight. Loctite **IS NOT** required. Your assembly should now look as follows:



- ***Note:*** *At this point it can be useful to install a small piece of heat shrink or electrical tape to the free end of the loom keeping all wires together and make feeding the loom through the clear outer tubing easier. If the loom is longer than 6' (2m) it may be necessary to attach a 'leader' made from stout straight wire to assist pull-through.*

15. If reusing the old length of flexible tubing, inspect to ensure it is not significantly damaged and is still suitably flexible, replace if required. Slide 2 new NormaClamp® Cobra 15/8 W4 (white band) hose-clamps onto the flexible tubing, straighten the tubing and feed the wiring loom through. **A generous spray of WD40 inside of the tubing before insertion will greatly assist assembly**. Install the end of the flexible tubing snugly onto the electrical connector adaptor hose barb and using a pair of NormaClamp® Cobra pliers or (or a pair of slip-joint pliers) secure with one of the clamps, ensuring there is at least 1/8" (2.5mm) of tube protruding past the clamp. Your assembly should now look as follows:

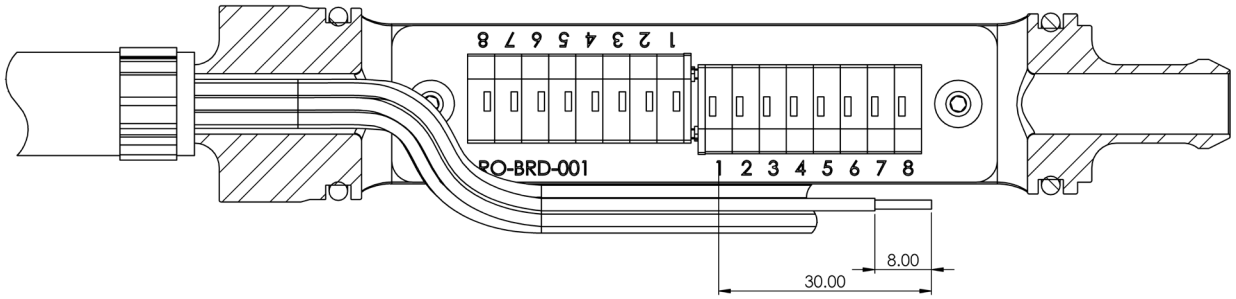


16. Pass the loom through the termination assembly cover (if applicable) and feed the loom into the termination assembly, exiting to the right of the terminal strip on the circuit board. Install the end of the flexible tubing snugly onto the termination assembly hose barb. It is advised not to install the second hose clamp until all electrical tests have been completed.

17. Ensure wires in loom are not excessively twisted around each other and give each wire of the loom a good tug to make sure they are all the same length inside the flexible tube.

18. As standard, our wiring looms are manufactured using the MILSPEC colour coding system. This can be found at **Annexure 5**. If your cable loom is not colour coded, or conductors are not otherwise marked with their connected pin designation, identify conductors' number with a multimeter and mark them now using oil-impervious heat-shrink cable markers.

19. Pull each conductor tight along its axis beside the terminal strip. Trim 1-¼" (30mm) longer than the position of the terminal clamp into which it will be connected. Remove 5/16" (8mm) of insulation and **lightly tin** the exposed conductor strands to keep them from splaying when inserting into terminal clamps.



- ***Note:*** *If the pinouts are not completely known (such as when RS232 / 485 TX and RX lines may need to be reversed), it is strongly advised that you add an extra 3/8 inch (10mm) length to the shortest conductor when terminating to allow the conductors to be swapped if required. This extra length can be easily pushed back into the flexible tubing just prior to final assembly.*

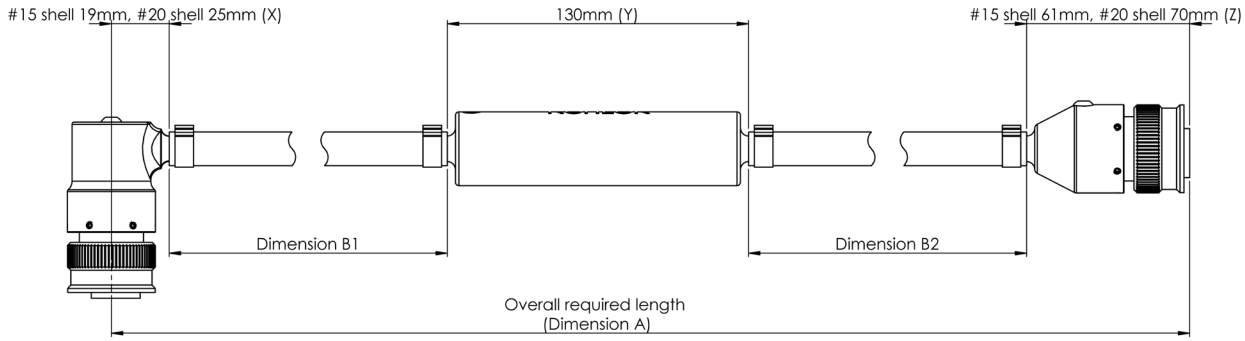
20. Using the 2.4mm flat-blade screwdriver release each terminal clamp and insert the relevant conductor. Ensure you give each wire a small tug after insertion to ensure the clamp has gripped correctly.
21. Push any excess wire back into the flexible tube so the loom is laid neatly beside the terminal strip and will not be caught or deformed when the termination assembly cover is reinstalled.
22. Repeat steps 7-22 for any subsequent electrical connectors.
23. Using Table 1 of **Annexure 1** completed in step 2, check the conductor matrix is correct using a multimeter. Check the pin to pin, and pin to case insulation using a Megger (250V) and record your readings in Table 3 of **Annexure 1**.
24. Apply another smear of Dow-Corning 111 O-ring grease to both O-rings on the inner frame and slide the assembly cover back into position. Apply a smear of Dow-Corning 111 O-ring grease to a new 4 x 1mm O-ring and install on the 10-32 x ¼" SHCS. Pass the screw through the hole in the assembly cover and install into the threaded port in the inner frame. Tighten firmly using a 5/32" hex key.
25. Using a pair of NormaClamp® Cobra pliers (or a pair of slip-joint pliers) re-install all required hose clamps back into their position(s) on the flexible tubing, ensuring there is at least 1/8" (2.5mm) of tube protruding past the clamp.
26. Fill the cable cavity as per the **Draining and filling cavity with oil** section.
27. Double check all exposed fasteners and hose clamps for tightness. The cable is now ready for use.

Assembly from scratch

1. Assemble all parts and fasteners required, including the following tools and lubricants:
   - 1/16", 5/32" and 1/8" hex (Allen) keys
   - 2.4mm flat-blade screwdriver
   - NormaClamp® Cobra pliers *or* medium-sized flat-blade screwdriver and pair of slip-joint pliers
   - Small pair of electronics-style flush diagonal cutters
   - Good quality pair or wire strippers
   - Pair of soft-tube cutters or retractable blade knife (with new blade)
   - 60/40 solder bar, solder pot & gel flux (preferable); or 60/40 flux core solder & large tip iron (minimum)
   - Isopropyl alcohol and clean rags / disposable wipes for cleaning off flux after wire-tinning
   - Tape measure, small steel ruler & Sharpie marker
   - Oil-impervious heat-shrink cable markers
   - Dow-Corning 111 O-ring grease, WD40 & Aqua Shield marine grease
   - Oil-soak pads and/or rags & safety glasses
2. Take note of the required conductor matrix (pin-outs) and record in a similar table to the one below (or photocopy **Annexure 1**).

End	Connected Equipment	Connector Type	Conductor Matrix							
A	Vehicle J-Box	Burton™ 55P1-2008	1	2	3	4	5	6	7	8
B	Lower colour camera	Burton™ 55P1-1508	3	2	6	4	5	7	1	2

3. Measuring from the face of each penetrator, identify the length of cable required for a neatly routed path. Ensure that it is long enough to avoid sharp bends or undue stress (especially if connected to moving components), but not too long that excess coiling is required. Record this dimension (A) in Table 2 of **Annexure 1**.

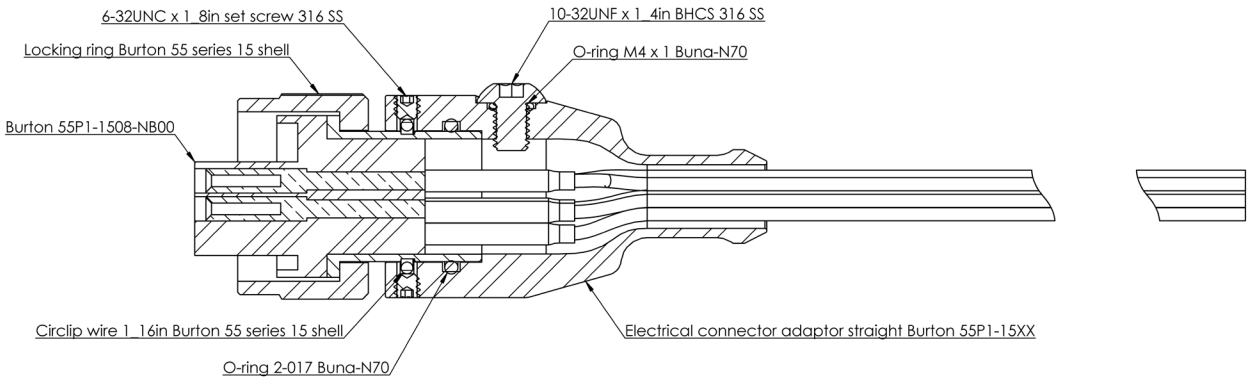


4. Prepare a clean workspace and gather the following component parts (*note: this list is for a Burton™ PBOF plug 55 series 15 shell. Refer to alternative documentation if other shell size / electrical connector type is used*):
   - Electrical connector Burton PBOF plug 55 series 15 shell 8 circuit
   - Locking ring Burton 55 series 15 shell
   - Electrical connector adaptor straight / 90deg Burton 55Pl-l5XX
   - Circlip wire 1 _ l 6in Burton™ 55 series 15 shell
   - 2-017 Buna-N70 O-ring
   - 4 x 1mm Buna-N70 O-ring
   - 10-32UNF x 1_4in BHCS 316 SS
   - 6-32UNC x 1_8in set screw 316 SS
   - Clear flexible polyurethane tubing, 8.5mm ID, 14.5mm OD (P/N RO-TUB-001)
   - NormaClamp® Cobra 15-8 W4 (white band) hose clamps x 2

5. Locate the clear flexible polyurethane tubing, 8.5mm ID, 14.5mm OD (P/N RO-TUB-001). Subtract dimensions X, Y, Z and B2 from A and record this dimension (B1) in Table 2 of **Annexure 1**. Measure and mark the tubing and use a pair of soft-tube cutters or sharp knife to cut the flexible tube squarely to the tube axis at this point.
6. Generously lubricate the 2-017 O-ring with Dow Corning 111 compound and install in the rear groove of the electrical connector adaptor.
7. Sparingly lubricate wire circlip with Aqua Shield and install in front groove ensuring gap in circlip is in-between set-screw holes. Loosely install the six 6-32 x 1/8in radial set-screws, ensuring they are still above the outer surface of the connector adaptor. **DO NOT** use Loctite.
8. Install locking collar onto electrical connector(s). Ensure that the connector's wiring loom is at least 6 inches (150mm) longer than the flexible tubing. Pass the loom through the bore of the electrical connector adaptor and insert the electrical connector in the adaptor until it seats firmly against the machined internal shoulder.

- ***Note:*** *If electrical connector(s) is(are) unwired, wire using 18AWG conductors with TFE or other oil-impervious insulation and MILSPEC soldering instructions at* ***Annexure 4****, ensuring the loom is at least 6" (150mm) longer than the flexible tubing. Record this dimension (C) in Table 2 of* ***Annexure 1****.*
- ***Note:*** *If using a 45 or 90-degree electrical connector adaptor, ensure you note the required cable to plug orientation before seating the electrical connector into the connector adaptor. This avoids the possibility of significantly stressing the wiring loom (by twisting more than 15deg) once assembled, if the orientation is incorrect and needs to be adjusted.*

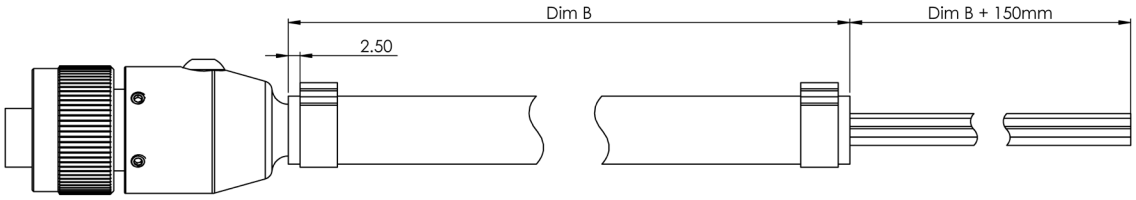
9. Tighten the six radial set-screws in two stages. Firstly, tighten until all screws are just touching the wire circlip, then, progressively tighten screws 1/8 of a turn at a time until all are tight. Loctite **IS NOT** required. Your assembly should now look as follows:



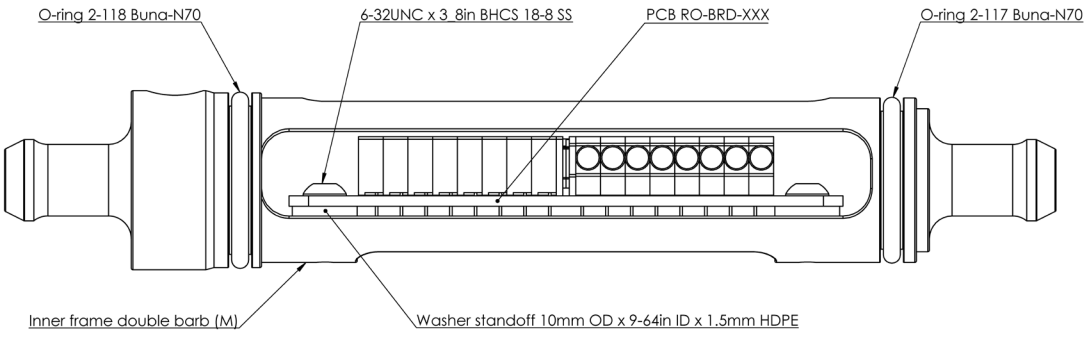
- ***Note:*** *At this point it can be useful to install a small piece of heat shrink or electrical tape to the free end of the loom to keep all the wires together and make feeding the loom through flexible tubing easier. If the loom is longer than 6' (2m) it may be necessary to first attach a 'leader' made from some stout straight wire to assist pull-through.*

10. Place the two NormaClamp® Cobra 15-8 W4 (white band) hose clamps onto the flexible tubing, straighten tubing and feed the wiring loom through. **A generous spray of WD40 inside of the tubing before insertion will greatly assist assembly.** Install the end of the flexible tubing snugly onto the electrical connector adaptor hose barb and using a pair of NormaClamp® Cobra pliers or (or a pair of slip-joint pliers) secure with one of the clamps, ensuring there is at least 1/8" (2.5mm) of tube protruding past the clamp.

11. Apply a smear of Dow-Corning 111 O-ring grease to a new 4 x 1mm O-ring and install on the 10-32 x ¼" BHCS. Loosely install in the threaded port in the electrical connector adaptor using a 1/8" hex key. Your assembly should look as follows:

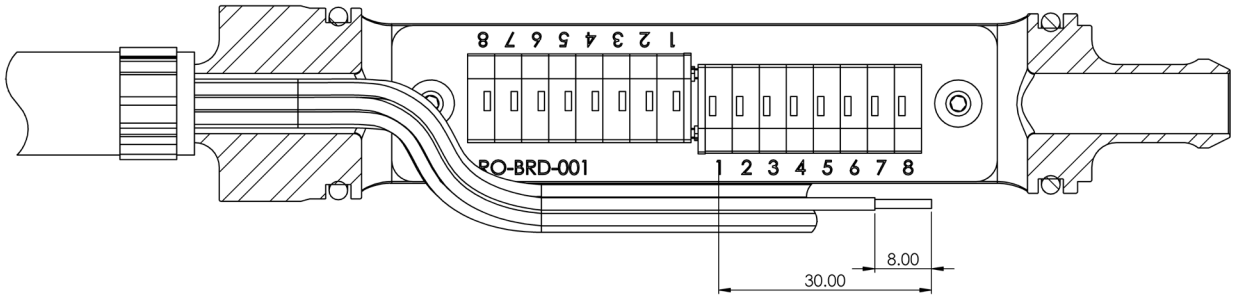


12. Repeat steps 4-11 for any subsequent connectors and place the electrical connector assemblies aside for now.
13. Prepare a clean workspace and gather the following component parts:
    - Inner frame double barb (M)
    - Assembly cover (M)
    - PCB RO-BRD-XXX (depending on application)
    - 2-117 Buna-N70 O-ring
    - 2-118 Buna-N70 O-ring
    - 4 x 1mm Buna-N70 O-ring
    - 10-32UNF x 1_4in SHCS 316 SS
    - 6-32UNC x 3_8in BHCS 18-8SS (x 2)
    - Washer standoff 10mm OD x 9-64in ID x 1.5mm HDPE (x 2)
14. Install the PCB in the inner frame using two 6-32UNC x 3_8in BHCS. Ensure you use a 10mm OD x 9-64in ID x 1.5mm HDPE spacing washer between the circuit board and the inner frame at each end to provide an insulation gap. Tighten the two BHCS firmly. **DO NOT** use Loctite.
15. Generously lubricate the 2-117 and 2-118 O-rings with Dow Corning 111 compound and noting their differing sizes, install into the O-ring grooves on the inner frame. Ensure they are not slit or nicked by any sharp edges during assembly. Your Inner frame assembly should now look as follows:



16. Locate the electrical connector assemblies completed at step 12. Pass the first loom through the termination assembly cover (if applicable) and feed the loom into the termination assembly, exiting to the right of the terminal strip on the circuit board. Install the end of the flexible tubing snugly onto the termination assembly hose barb. It is advised not to install the second hose clamp until all electrical tests have been completed
17. Ensure wires in loom are not excessively twisted around each other and give each wire of the loom a good tug to make sure they are all the same length inside the flexible tube.
18. As standard, our wiring looms are manufactured using the MILSPEC colour coding system. This can be found at **Annexure 5**. If your cable loom is not colour coded, or conductors are not otherwise marked with their connected pin designation, identify conductors' number with a multimeter and mark them now using oil-impervious heat-shrink cable markers.

19. Pull each conductor tight along its axis beside the terminal strip. Trim 1-¼" (30mm) longer than the position of the terminal clamp into which it will be connected. Remove 5/16" (8mm) of insulation and, **lightly tin** the exposed conductor strands to keep them from splaying when inserting into terminal clamps.



- ***Note:*** *If the pinouts are not completely known (such as when RS232 / 485 TX and RX lines may need to be reversed), it is strongly advised that you add an extra 3/8 inch (10mm) length to the shortest conductor when terminating to allow the conductors to be swapped if required. This extra length can be easily pushed back into the flexible tubing just prior to final assembly.*

28. Using the 2.4mm flat-blade screwdriver release each terminal clamp and insert the relevant conductor. Ensure you give each wire a small tug after insertion to ensure the clamp has gripped correctly.
29. Push any excess wire back into the flexible tube so the loom is laid neatly beside the terminal strip and will not be caught or deformed when the termination assembly cover is reinstalled.
30. Repeat steps 16-29 for subsequent electrical connectors.
31. Using Table 1 of **Annexure 1** completed in step 2, check the conductor matrix is correct using a multimeter. Check the pin to pin, and pin to case insulation using a Megger (250V) and record your readings in Table 3 of **Annexure 1**.
32. Apply another smear of Dow-Corning 111 O-ring grease to both O-rings on the inner frame and slide the assembly cover back into position. Apply a smear of Dow-Corning 111 O-ring grease to a new 4 x 1mm O-ring and install on the 10-32 x ¼" SHCS. Pass the screw through the hole in the assembly cover and install in the threaded port in the inner frame. Tighten firmly using a 5/32" hex key.
33. Using a pair of NormaClamp® Cobra pliers (or a pair of slip-joint pliers) re-install all required hose clamps back into their position(s) on the flexible tubing, ensuring there is at least 1/8" (2.5mm) of tube protruding past the clamp.
34. Fill the cable cavity as per the **Draining and filling cavity with oil** section.
35. Double check all exposed fasteners and hose clamps for tightness. The cable is now ready for use.

Annexure1: Assembly tables

ROV system:

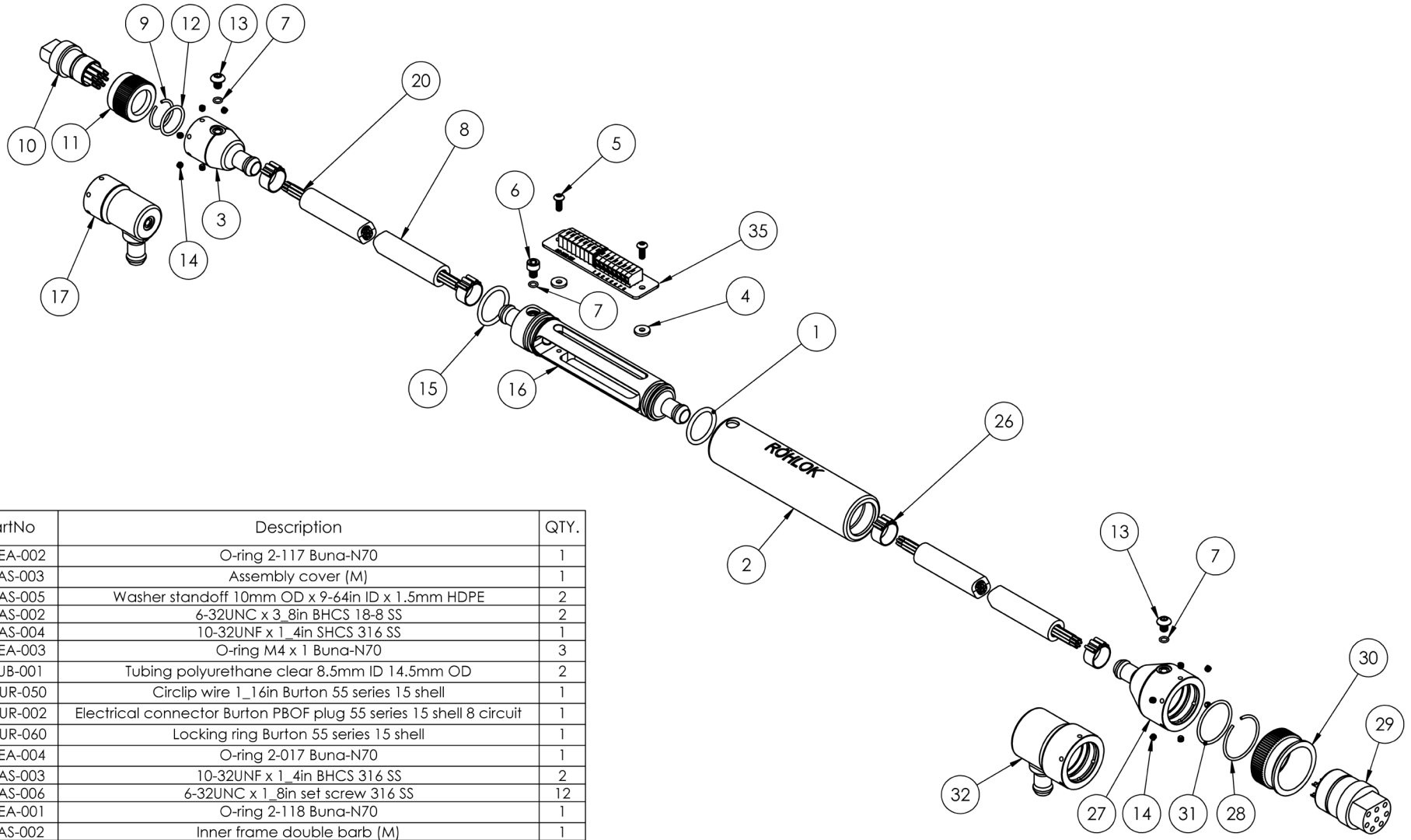
Date:

Table 1 - Assembly configuration										
End	Connected equipment	Connector type	Conductor matrix							
1										
2										

Table 2 - Tubing and wiring loom length calculator			
Dimension	Description	Formula	Result
A	Total length of cable required:	User defined	
B1	Length of flexible tube #1	A – (B2 + X + Y + Z)	
B2	Length of flexible tube #2	A – (B1 + X + Y + Z)	
X	Centreline of Burton™ connector to end of flexible tube	Constant	19mm/25mm
Y	Width of termination assembly	Constant	130mm
Z	Face of Burton™ connector to end of flexible tube	Constant	61mm/70mm
C	Length of Burton™ wiring loom #1	B1 + X + 150mm	
D	Length of Burton™ wiring loom #2	B2 + Z + 150mm	

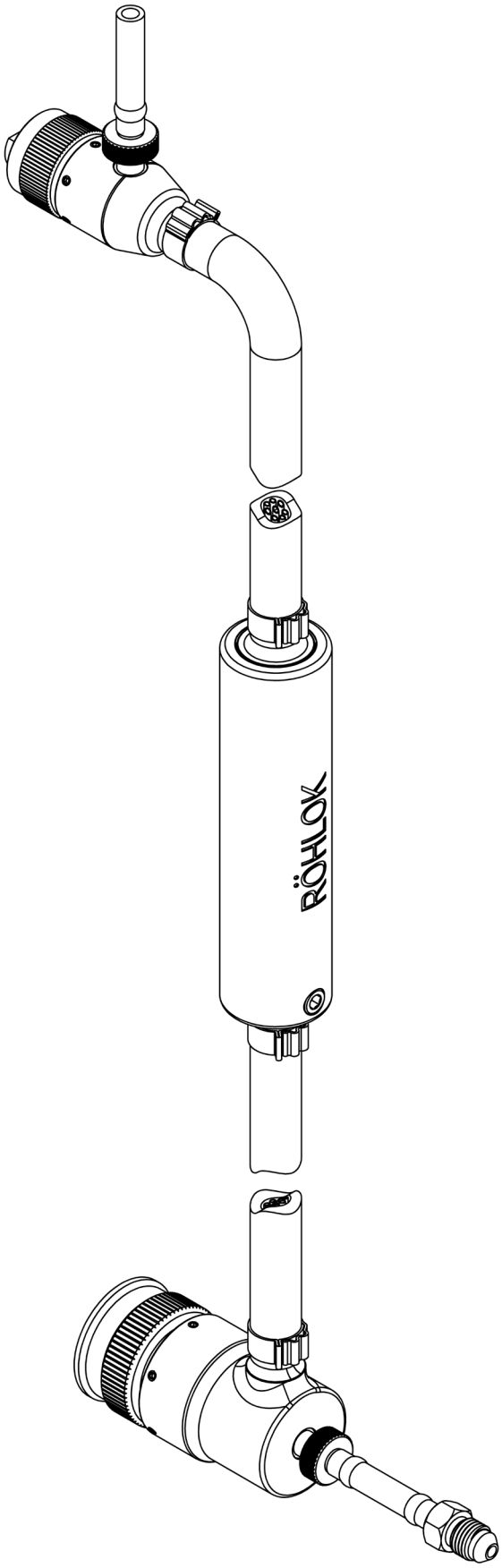
Table 3 - Insulation readings (use 600V setting)										
	1	2	3	4	5	6	7	8	Connector shell	Term ass'y housing
1										
2										
3										
4										
5										
6										
7										
8										

Annexure 2: Exploded diagram & parts list



ITEM NO.	PartNo	Description	QTY.
1	RO-SEA-002	O-ring 2-117 Buna-N70	1
2	RO-TAS-003	Assembly cover (M)	1
4	RO-FAS-005	Washer standoff 10mm OD x 9-64in ID x 1.5mm HDPE	2
5	RO-FAS-002	6-32UNC x 3_8in BHCS 18-8 SS	2
6	RO-FAS-004	10-32UNF x 1_4in SHCS 316 SS	1
7	RO-SEA-003	O-ring M4 x 1 Buna-N70	3
8	RO-TUB-001	Tubing polyurethane clear 8.5mm ID 14.5mm OD	2
9	RO-BUR-050	Circlip wire 1_16in Burton 55 series 15 shell	1
10	RO-BUR-002	Electrical connector Burton PBOF plug 55 series 15 shell 8 circuit	1
11	RO-BUR-060	Locking ring Burton 55 series 15 shell	1
12	RO-SEA-004	O-ring 2-017 Buna-N70	1
13	RO-FAS-003	10-32UNF x 1_4in BHCS 316 SS	2
14	RO-FAS-006	6-32UNC x 1_8in set screw 316 SS	12
15	RO-SEA-001	O-ring 2-118 Buna-N70	1
16	RO-TAS-002	Inner frame double barb (M)	1
17	RO-ECA-005	Electrical connector adaptor 90deg Burton 55P1-15XX	1
20	RO-WIR-000	Loom 8 x 18AWG single conductor TFE jacket	2
26	RO-FAS-008	NormaClamp Cobra 15-8 W4 15.5-17mm	4
27	RO-ECA-002	Electrical connector adaptor straight Burton 55P1-20XX	1
28		Circlip wire 1_16in Burton 55 series 20 shell	1
29	RO-BUR-003	Electrical connector Burton PBOF plug 55 series 20 shell 8 circuit	1
30	RO-BUR-061	Locking ring Burton 55 series 20 shell	1
31	RO-SEA-005	O-ring 2-023 Buna-N70	1
32	RO-ECA-006	Electrical connector adaptor 90deg Burton 55P1-20XX	1
35	RO-BRD-001	PCB RO-BRD-001 (8-8 universal)	1

Annexure 3: Oil-fill orientation



Annexure 4: MILSPEC soldering technique for high density connectors

Step 1.
To ensure the cleanest, strongest solder bond, remove impurities from the solder cups by cleaning with isopropyl alcohol and a pipe cleaner or Q-Tip.

Step 2.
Strip your wires using a thermal or a good quality mechanical wire stripping tool. The correct amount of insulation to be removed should be determined by placing the stripped wire into an empty solder cup. There should be 1/16" (1.5mm) of bare wire exposed above the cup before the insulation starts.

Step 3.
Clean your solder by dragging it through a folded tissue soaked with isopropyl alcohol. Lightly tin the tip of the soldering iron. Remove the excess solder by briefly wiping the tip on a wet sponge immediately before you tin the wires.

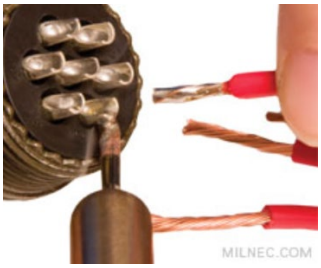
Step 4.
Apply a very small amount of solder to the tip of the iron (to act as a heat-bridge) and touch the tip to the underside of the wire. Apply solder **only** to the wire not the tip as this will ensure the wire is hot enough to allow the solder to melt and wick through the strands and not just sit on top. Do not apply too much solder or you may have trouble inserting the wire into the cup.

Step 5.
Clean the cooled wires with isopropyl alcohol to remove all traces of flux or other impurities. Ideally, there should be about 0.5mm of untinned wire before the insulation starts. This ensures no corrosive flux is *underneath* the insulation where it cannot be removed.

Step 6.
Cut a piece of solder to the same length as the inside of the solder cup. Before cutting, ensure you clean the solder as per step 3. As cup sizes differ, you may need to experiment with different thicknesses of solder.

Step 7.
With your connector in a vice or similar, insert a piece of pre-cut solder into the cup. **Lightly** tin your soldering tip and apply to the outside of the cup. **NEVER** insert the tip into the inside of the cup.

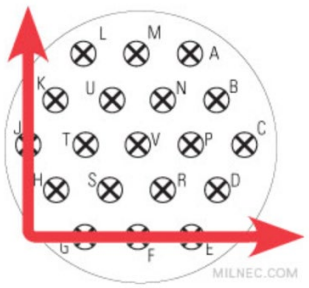
Step 8.
When the solder melts, quickly insert the wire into the solder cup so the wire tip is touching the bottom and the rest of the wire is lying flat against the lower side of the cup. Remove the iron and hold the wire in place whilst the joint cools. **Do not** blow on it, let it cool naturally or a dry joint can develop.



Step 9.
Once the joint is cool, clean with isopropyl alcohol and a pipe cleaner or Q-Tip. Inspect the termination to ensure there is a **concave** fillet of solder between the wire and the entire inside surface of the cup. Inspect the outside of the cup to ensure there is no excess solder attached. If there is, remove it with an Exacto-Knife.

Step 10.
Repeat steps 7-9 for the rest of your terminations.

Don't solder yourself into a corner! For high density inserts it is recommended to begin soldering from the bottom row left to right, then starting on the row above. This ensures good visibility as you progress.



Images courtesy of Milnec.com

Avoid cold solder joints:

- *A cold solder joint is brittle and prone to physical failure. It may also have a very high electrical resistance.*
- *Cold solder joints occur when the temperature of the solder cup is at a different temperature from the molten solder. Another common cause is moving the wire before the joint has completely cooled.*
- *To avoid cold solder joints, ALWAYS heat the solder cup and let the heat transfer melt the solder. This ensures both the cup and solder heat and cool evenly forming a perfect joint. NEVER melt your solder directly with your soldering iron tip.*

Annexure 5: MILSPEC wire colour-code chart

Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	9