Antenna & Coaxial Cable Installation

VERIPOS

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CONTENTS

1. INTRODUCTION

It is intended that this Document be used as a reference by technical personnel when installing a VERIPOS positioning system onto any type of offshore vessel.

This Guidance Document provides information about the signals received, common installation problems and the correct installation of the following antennas:

- **GNSS** – the positioning antenna
- **L-Band** – the primary VERIPOS augmentation antenna
- **MF** – the secondary VERIPOS augmentation antenna

This document also provides information regarding the correct routing, installation and termination of different types of **coaxial cables**.

The purpose of this Document is to provide information and guidelines on how to install the different types of antennas and coaxial cables in order to maximise the performance of the VERIPOS positioning system.

2. ABBREVIATIONS

BDE	Below Deck Equipment
BeiDou	Chinese GNSS satellite constellation
BER	Bit Error Rate
DGPS	Differential GPS
DGNSS	Differential GNSS
DOP	Dilution of Precision
DP	Dynamic Positioning
Galileo	European GNSS satellite constellation
GLONASS	GLObalnaya NAvigatsionnaya Sputnikovaya Sistema
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GUI	Graphical User Interface
HDOP	Horizontal Dilution of Precision
IALA	International Association of Lighthouse Authorities
MF	Medium Frequency
PDOP	Positional Dilution of Precision
QZSS	Japanese GNSS satellite constellation
SNR	Signal to Noise Ratio
TDR	Time Domain Reflectometer

3. INSTALLATION STANDARDS

All equipment installations should conform to the following parts of IEC 61108 - Maritime navigation and radio communication equipment and systems - Global Navigation Satellite Systems (GNSS):

- Part 1 - Global Positioning System (GPS) Receiver equipment – Performance standards, methods of testing and required test results.
- Part 2 - GLObalnaya NAvigatsionnaya Sputnikovaya Sistema (GLONASS) - Receiver equipment - Performance standards, methods of testing and required test results
- Part 4 - Shipborne DGPS and DGLONASS maritime radio beacon receiver equipment – Performance standards, methods of testing and required test results

The IEC61108 Standard should be referred to when installing GNSS systems onto offshore vessels with particular reference to the recommendations on distances between power sources and antennas.

The 61108 standard can be purchased from the IEC webstore: http://webstore.iec.ch/

4. SAFETY

The following information is for reference only and should not take precedence over your own company HSE policies and/or vessel HSE procedures, which should always be strictly adhered to.

4.1 WORKING AT HEIGHT

Make sure you are properly trained for working at height, that you are familiar with the safety equipment and how to use it effectively.

If you feel that you are inadequately trained for the job in hand, contact your supervisor immediately. Never attempt working at height if you are not comfortable or are not properly trained.

The safety of you and those around you should always be your number one priority.

If possible avoid working at height.

If working at height is unavoidable then plan the operation to mitigate risks to personnel and equipment.

An effective means of timely rescue should always be in place.

5. WHAT SIGNALS ARE RECEIVED BY EACH ANTENNA?

5.1 GNSS ANTENNA

V460
Dual Frequency GPS, GLONASS, GALILEO, BeiDou & QZSS
MF / L-Band

Alison AD491
L1/L2 GPS & GLONASS
L-Band

Trimble GA530
L1 / L2 GPS
MF
L-Band

The GNSS antenna receives signals from all visible satellites contained within the applicable satellite constellations; most of which are located within Medium Earth Orbit.

GPS Satellites orbit the Earth at an altitude of **20,200 km / 12,552 miles.**

The constellation consists of approximately 31 operational satellites (although the total number of operational satellites can vary) arranged into six orbital planes inclined at 55°; each orbital plane contains *at least* 4 satellites and each satellite completes approximately **two orbits** of Earth **every 24 hours**.

GPS **L1** Frequency: **1575.42 MHz**

GPS **L2** Frequency: **1227.60 MHz**

GLONASS Satellites orbit the Earth at an altitude of **19,100 km / 11,868 miles.**

The constellation is made up of 27 satellites arranged into three orbital planes inclined at 64.8° and each satellite completes approximately **two orbits** of Earth **every 24 hours**.

GLONASS **L1** Frequencies range from **1598.0625 MHz – 1609.3125 MHz**

GLONASS **L2** Frequencies range from **1242.9375 MHZ – 1248.6250 MHz**

Galileo Satellites orbit the Earth at an altitude of **23,222 km / 14,429 miles.**

The constellation is made up of 18 satellites (as of March 2017) arranged into three orbital planes inclined at 56°.

Galileo **E1** Frequency: **1575.42 MHz**

Galileo **E5b** Frequency: **1207.14 MHZ**

BeiDou Medium Earth Orbit satellites orbit an altitude of **21,500 km / 13,359 miles.**

The Beidou constellation currently (as of March 2017) consists of 6 Medium Earth Orbit, 8 inclined-geosynchronous and 6 geostationary satellites.

The geostationary satellites are situated over the Asia-Pacific region. The inclined geosynchronous satellites are in a figure of eight orbit, also over the Asia-Pacific region.

BeiDou **B1** Frequency: **1561.098 MHz**

BeiDou **B2** Frequency: **1207.14 MHz**

QZSS currently consists of one useable satellite (as of March 2017).

The QZSS satellite is in an inclined-geosynchronous orbit over Asia-Pacific region. There are plans for the QZSS constellation to consist of 3 inclined-geosynchronous and 1 geostationary satellite by 2018.

The primary purpose of the QZSS constellation is to increase GNSS availability in Japan's numerous urban canyons.

QZSS **L1C** Frequency: **1575.42 MHz**

QZSS **L2L** Frequency: **1227.60 MHz**

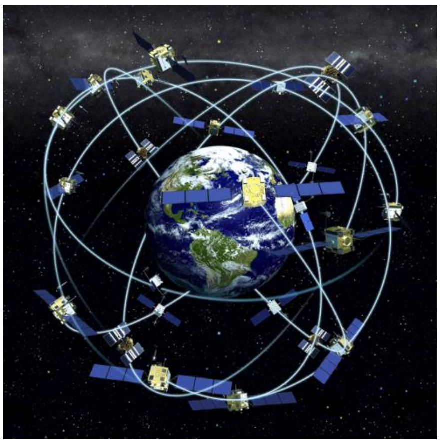


Diagram courtesy of defenceindustrydaily.com

* The GLONASS constellation is used by VERIPOS to supplement GPS by increasing satellite availability.

GLONASS reception is dependent on the VERIPOS Service tier in use, the reception hardware (GNSS antenna and receiver) and the availability of GLONASS enabled reference stations.

5.2 L-BAND ANTENNA

V86
L-Band
MF

Cybit 90984
L-Band only

Alison A420
L-Band only

V460
Dual Frequency GPS, GLONASS, Galileo, BeiDou, QZSS
*MF / **L-Band***

Trimble GA530
L-Band
L1/L2 GPS
MF

Alison AD491
L-Band
L1/L2 GNSS & GLONASS

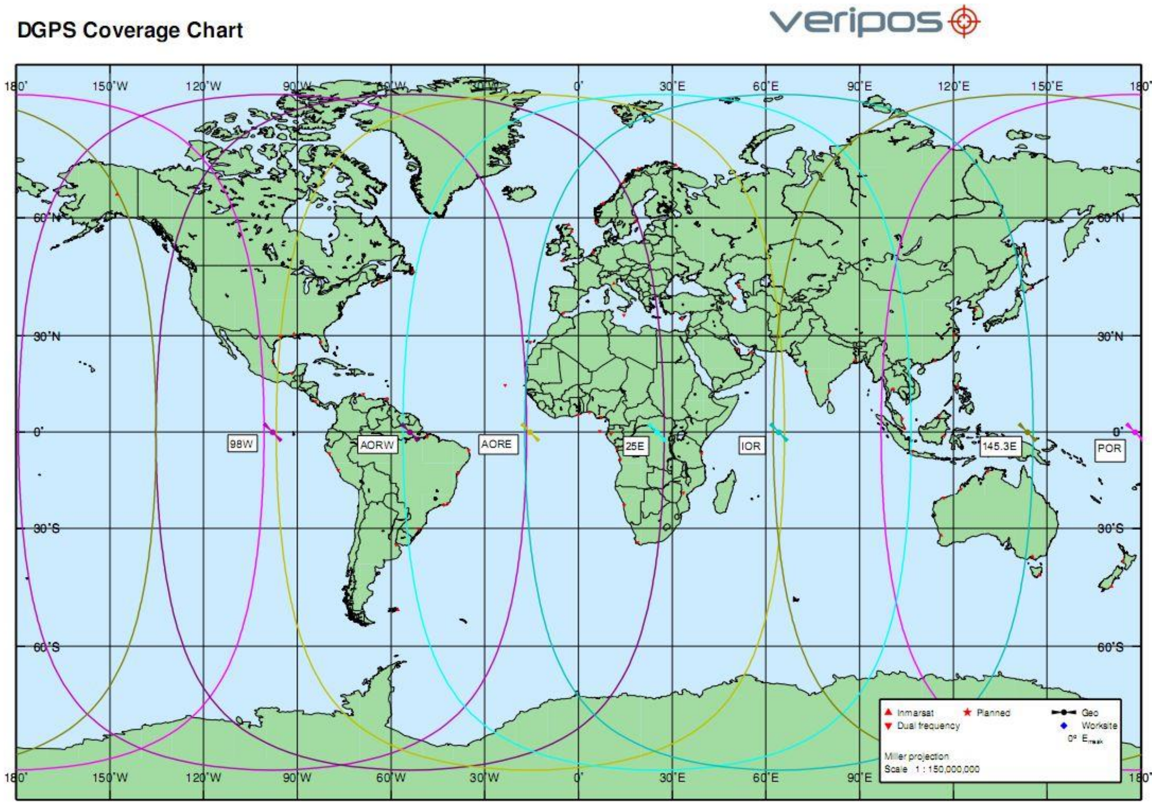
Unlike the GNSS antenna, which receives signals from multiple satellites, the L-Band (aka Spotbeam) antenna receives signals from **one** of **seven** Inmarsat satellites arranged in *geostationary* orbit above the equator at 35,786 km / 22,236 mi.

There are currently *seven* geostationary Inmarsat satellites that transmit VERIPOS signals at the **High Power** level **compatible** with the L-Band antenna.

Satellite	Frequency Name	Frequency	Data Rate (bps)	Power
143.5E	Asia	1539.9925	1200	High Power
POR	POR	1539.9425	1200	High Power
IOR	IOR	1539.9025	1200	High Power
25E	EAME	1539.8825	1200	High Power
AORW	AORW	1539.8925	1200	High Power
98W	AMER	1539.9025	1200	High Power
AORE	AORE	1539.9825	1200	High Power

Each Inmarsat satellite covers a different region of the Earth based on beam footprint:

Each geostationary Inmarsat satellite transmits the VERIPOS augmentation data used to correct and improve GNSS measurements within the beam footprint.



Beam coverage exists from approximately **-78°** to **+78° degrees of latitude**, and from approximately **-78°** to **+78° degrees of longitude** in relation to the satellites "fixed" longitudinal location above the equator.

The elevation of each satellite is at a **maximum of 90°** when working directly beneath it.

As the vessel moves towards the beam footprint boundary either in terms of increasing/decreasing latitude, longitude or a combination of both, the elevation of the satellite will steadily decrease down to only a few degrees of elevation near the absolute limit of the footprint.

5.3 MF ANTENNA

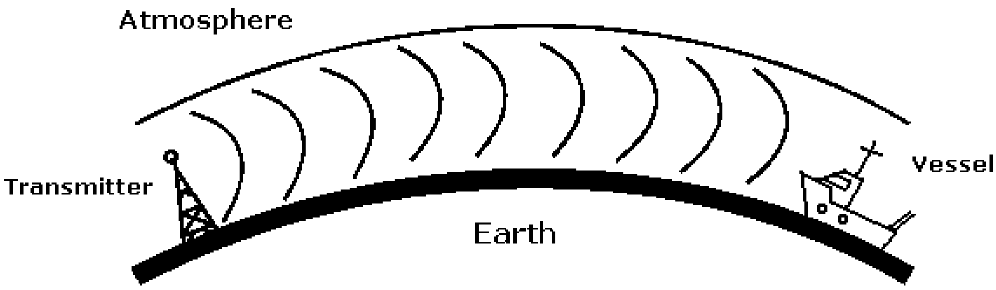
V86
MF
L-Band

A-30
MF
L1 GPS
L-Band

V460
MF
Dual frequency GPS, GLONASS, Galileo, BeiDou & QZSS
L-Band

Trimble GA530
MF
L1/L2 GPS
L-Band

The MF Antenna receives signals from terrestrial based transmitters, which transmit data via a “ground” or “surface” wave broadcasts.



MF Signals (IALA) are supported in VERIPOS hardware but VERIPOS has no control over the signal or its quality. The signal is transmitted between **283.5 KHz** and **325 KHz** and has a nominal range of **300 - 555 Km** depending on station setup and transmission power levels.

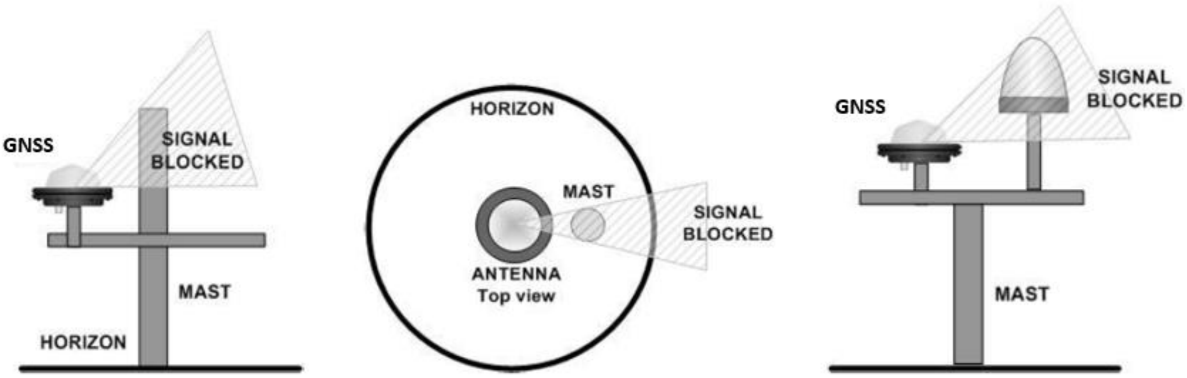
MF Stations Lists are available from the IALA website: http://www.iala-aism.org/

6. COMMON INSTALLATION PROBLEMS

6.1 SIGNAL MASKING

6.1.1 GNSS Antenna

Signal Masking occurs when the GNSS antenna is mounted in a location where part of the vessel structure or another antenna is partially masking the GNSS antenna's view of the sky.



Signal masking results in signals being blocked on certain headings, effectively reducing the amount of satellites that can be used in the position calculation. The result is an increase in DOP values indicating a drop in positioning performance; the calculated position becomes less stable.

GNSS signals are completely blocked by any metal object located in the signal path.

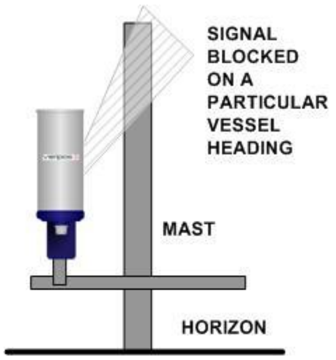
At times of lower satellite availability, signal masking can cause severe positional instability.

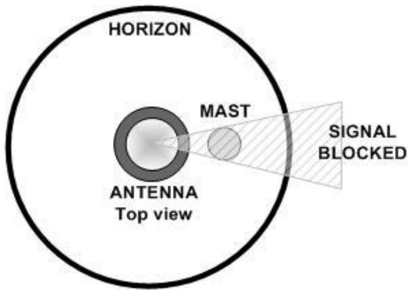
In extreme cases when satellite availability is reduced to the absolute minimum, signal masking can terminate the position computation.

Signal masking by smaller objects such as other antennas or antenna poles can also cause problems when the vessel is in motion since these obstructions can momentarily block GNSS signals, causing interruptions to the transmitted signal which adversely affects range measurements.

6.1.2 L-Band Antenna

As discussed in the previous sub section, signal masking occurs when the antenna is mounted in a location where part of the vessel structure or another antenna is partially masking the antenna's view of the sky.





The VERIPOS data received by the L-Band antenna is used to improve the position calculation to much greater accuracy and precision.

The VERIPOS signal is completely blocked by any metal object located in the signal path.

The signal is transmitted from a single source, therefore it is of the utmost importance that the antenna is installed so that the signal can be received effectively by line of sight, else the performance of the positioning system can be severely degraded.

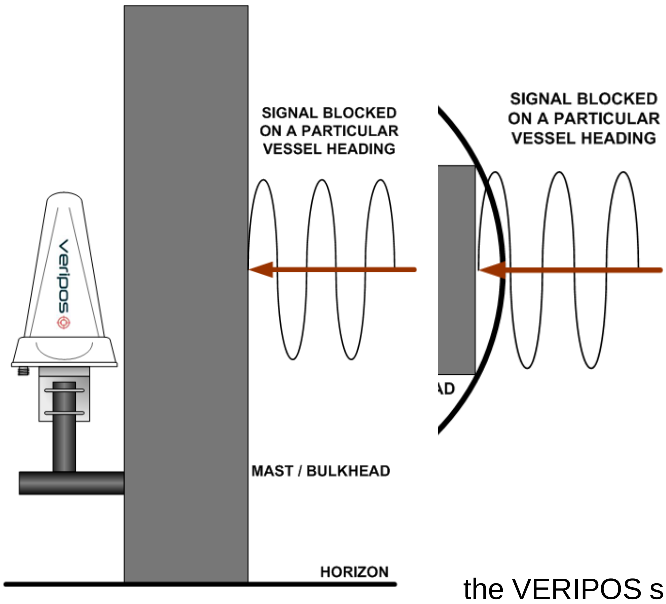
Depending on work location, the transmitting satellite can be as high as 90deg elevation, as low as a few degrees of elevation or anywhere in between.

Signal masking by smaller objects such as other antennas or antenna poles can also cause problems when the vessel is in motion since these obstructions can momentarily block the signals, causing interruptions which adversely affect data reception.

6.1.3

MF Antenna

Signal Masking occurs when the MF antenna is mounted in **extreme close proximity** to a bulkhead or mast, which blocks signal reception on certain headings.



The data received by the MF antenna is used to improve the position calculation to much greater accuracy and precision (compared to an uncorrected position).

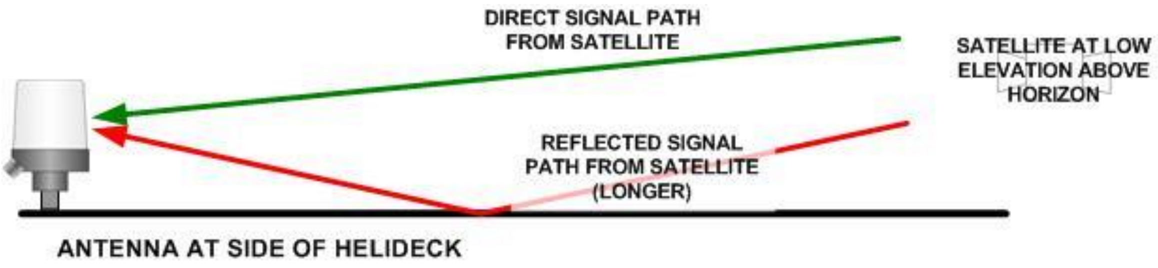
The MF correction signals are normally received *supplementary* to the VERIPOS signals transmitted by Inmarsat satellites and normally provide an extra source of correction data to the position calculation.

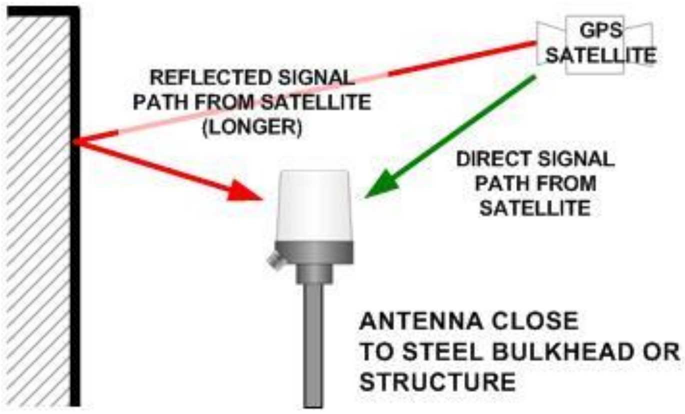
The MF signal is completely blocked by any large metal object that is in close proximity to the antenna and located in the signal path.

6.2 MULTIPATH SIGNAL RECEPTION

6.2.1 GNSS Antenna

Multipath signal reception occurs when the received signal is received directly from the satellite and also via reflections from solid surfaces on the vessel structure such as bulkheads or the Helideck.





The reflected signal path is <u>longer</u> than the direct signal path which effectively increases the computed range from the satellite. This can contribute to instability or range errors in the position calculation.

The effects of multipath include constructive and destructive interference, and phase shifting of the signal where the reflected signal is received out of phase with the direct signal.

The presence of multipath signals adversely affects both the code and carrier phase measurements of the received GNSS signals.

6.2.2 L-Band Antenna

Unlike the GNSS antenna, the L-Band antenna receives signals from a single source.

As with GNSS signals, the effects of multipath on the L-Band signal include constructive and destructive interference, and phase shifting of the signal where the reflected signal is received out of phase with the direct signal.

Multipath L-Band signals contribute to a 'noisy' environment where the Bit Error Rate (BER) of the received signal increases, effectively reducing performance.

In extreme cases it's possible to experience a momentary loss of synchronization of the signal, i.e. the signal drops out completely and corrections are lost.

6.2.3 MF Antenna

Since the frequencies of MF radio transmissions are low in comparison to GNSS and VERIPOS signals broadcast via Inmarsat, the wavelength of the signals are significantly larger. This means that the MF antenna is **much less susceptible** to multipath interference.

6.3 INTERFERENCE FROM TRANSMITTING DEVICES

6.3.1 Possible sources of interference

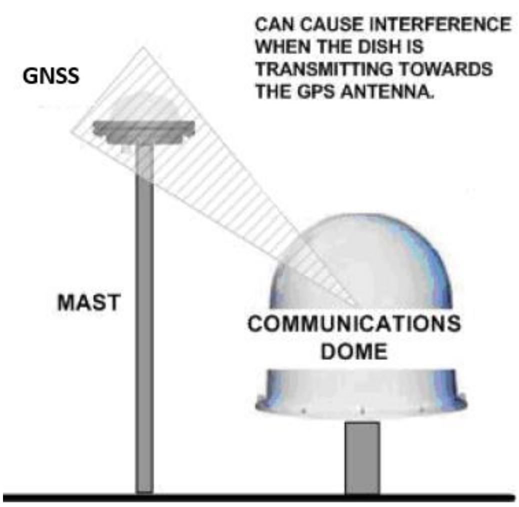
Every modern offshore vessel has a multitude of communication devices that transmit radio waves. Some examples are listed below:

- Radar
- VSAT
- Sat-B
- Sat-C - **a problematic source of interference and repeat offender**
- Iridium Phone
- Video Telemetry Systems (1.394GHz)
- Data Telemetry systems (900MHz)
- WiFi systems (2.4GHz)
- LRIT (Long Range Identification and Tracking)

6.3.2 GNSS Antenna

Since GNSS signals tend to be relatively weak at terrestrial level, it is easy for other sources of electromagnetic radiation to desensitize the GNSS receiver, making acquiring and tracking GNSS signals difficult or impossible.

Interference from these devices occurs when the GNSS antenna is mounted either in close proximity to the transmitting antenna or in the direct path of radio transmissions.



The Sat-C antenna is the biggest offender.

The Sat-C is well known to interfere with GNSS signal reception due to:

- High transmit power present at the antenna
- Omni-directional design of the antenna – transmits in all directions
- Transmit frequency close to that of GPS
- Antenna is mounted at the top of the mast - where the GNSS antenna should also be mounted.

All transmitting devices should be identified to allow the GNSS antenna to be installed in the best possible location; one that minimises or prevents interference.

Once the GNSS antenna has been carefully sited, the effects of each transmitting device should be tested by powering up each transmitting system and monitoring the effects on the positioning system.

It is recommended to install the GNSS antenna lower than the Sat-C antenna and at a minimum distance of 2.5 metres.

Verify-QC, Quantum, Verify-DP and Verify-DPx are all VERIPOS software applications which have GNSS SNR displays that can be used to identify signs of interference, such as loss of GNSS signal tracking when the transmitting device is energised. Interference can also affect other GNSS systems that are installed on the vessel and not just VERIPOS. Proprietary software such as Ashtech Evaluate or Topcon PCCDU should be used to monitor GNSS SNR's for systems where a GUI is unavailable.

As well as the transmitting devices mentioned in the previous pages, interference can also be caused by improperly terminated coaxial cables.

Even on receive-only GNSS systems, an incorrectly manufactured or terminated coaxial cable can re-radiate interference to other GNSS systems within a 100m / 300ft radius of the vessel.

6.3.3 L-Band Antenna

Since the VERIPOS signals received by the L-Band antenna are in the same frequency band as the GNSS signals, the L-Band antenna is also affected by interference from the same transmitting equipment mentioned above.

Radio transmissions from the vessels Sat-B dome will completely wipe out signal reception in the L-Band antenna if directly transmitting towards the antenna in close proximity. The frequency used by the Sat-B for radio transmission is extremely close to the frequency of the VERIPOS signals received by the L-Band antenna.

The power level of the Sat-B radio transmission is much higher than the signal received and will therefore flood the pre-amp in the antenna effectively killing the received signal.

Most VERIPOS IMU's have the ability to display L-Band signal status information.

The LD3 (which has no display panel) should be connected to a PC and the VERIPOS *L-Band Control* program so that the signal status can be monitored.

6.3.4 MF Antenna

The MF antenna receives signals via ground wave radio transmissions from terrestrial based transmitters.

All transmitting devices should be identified to allow the L-Band antenna to be installed in the best possible location; one that minimises or prevents interference.

Once the L-Band antenna has been carefully sited, the effects of each transmitting device should be tested by powering up each transmitting system and monitoring the effects on the positioning system.

Interference can occur when the MF antenna is installed in <u>close proximity</u> to radio whip antennas, radar or if the coaxial cable is run alongside or in close proximity to sodium type floodlights.

6.4

PROXIMITY OF OTHER ANTENNAS

OTHER RECEIVING ANTENNAS

The GNSS and L-Band antennas should be installed with the following minimum spacing that should be adhered to for all antenna installations:

1 metre / 3 feet

A faulty GNSS antenna can re-radiate signals, causing interference with other GNSS systems if the antennas are mounted too close.

Mounting the GNSS or L-Band antennas too close to other antennas can also cause signal masking.

TRANSMITTING ANTENNAS

Any transmitting antennas should be identified because installing GNSS or L-Band antennas too closely to a transmitting device can cause partial or total loss of signals. The recommended minimum distance from a transmitting device is:

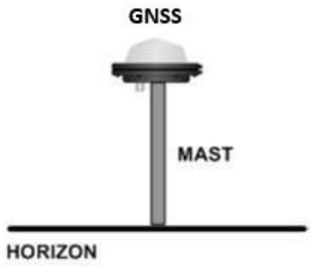
2.5 metres / 8 feet

7. CORRECT ANTENNA INSTALLATION

7.1 GNSS ANTENNA

Since GNSS satellite constellations are continuously moving across the sky in different directions from Horizon to Horizon, the GNSS antenna should be mounted with a clear 360° view of the sky as far down as the Horizon.

This usually means installing the antenna at the **top** of the mast.



Care should be taken when selecting an appropriate mounting location for the GNSS antenna so that the common installation problems previously discussed in this document are avoided.

The mounting location of the GNSS antenna is PARAMOUNT to the performance of the positioning system.

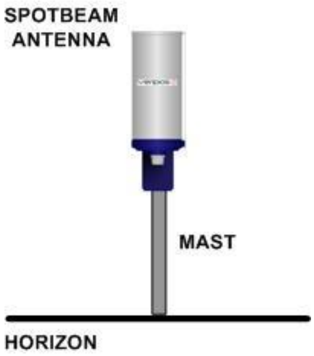
If the GNSS antenna is mounted in a suboptimal location or environment, you can fully expect the performance of the positioning system to be degraded.

There may be constraints forced upon the installer that dictate where the GNSS antenna can be installed – this is quite normal and therefore a compromise may have to be reached.

If the installer is forced to install the GNSS antenna in a suboptimal location or environment, the vessel operator should be made fully aware of the possible consequences.

7.2 L-BAND ANTENNA

As with the GNSS antenna, the L-Band antenna should be installed so that it has **clear view of the sky**, which usually means installing it at the **top** of the mast.



Each of the geostationary satellites that broadcast VERIPOS signals are located at different longitudes directly above the equator, therefore the elevation of each satellite is at a maximum of 90° when working directly beneath it.

Beam coverage exists from approximately **-78°** to **+78° degrees of latitude**, and from approximately **-78°** to **+78° degrees of longitude** in relation to the satellites "fixed" longitudinal location above the equator.

As the vessel moves towards the beam footprint boundary, either in terms of increasing/decreasing latitude, longitude or a combination of both, the elevation of the satellite will steadily decrease down to only a few degrees of elevation near the absolute limit of the footprint.

This should be taken into consideration when installing the L-Band antenna and is especially important if the vessel is destined to work at higher latitudes where the satellite will appear at lower elevations

There may be constraints forced upon the installer that dictate where the L-Band antenna can be installed – this is quite normal and therefore a compromise may have to be reached.

If the installer is forced to install the L-Band antenna in a suboptimal location or environment, the vessel operator should be made fully aware of the possible consequences.

7.3 MF ANTENNA INSTALLATION

The ground wave signals received by the MF antenna are best received when the antenna is mounted fairly high on the mast with a relatively clear 360 deg view of the Horizon.

Due to the higher wavelength of signal transmission, the antenna is less susceptible to signal masking by smaller obstacles and less susceptible to multipath interference, however larger obstacles should always be avoided.

A good **electrical ground** may be required when installing certain MF antennas:
The DHM5000 is one example that requires a ground connection.

Some antennas such as those currently supplied by VERIPOS: V86 and V460 **do not** require grounding.

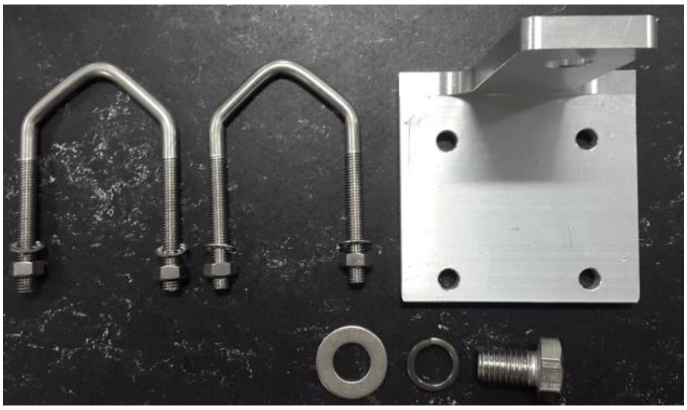
Always try to minimize the overall cable run and use the highest diameter earth cable that is practical.

If required, the ground wire should be firmly connected to the vessel superstructure, either by means of a **purpose built ground stud** or by **removing paint and oxidation** before strapping the ground wire in place with a stainless steel hose clamp. The connection should be sealed with self-amalgamating tape and/or vulcanizing fluid to prevent water ingress and corrosion.

To improve HF noise rejection performance in Radio Frequency noisy environments an in line filter (below) can be installed in the antenna feed close to the receiver.

7.4 ANTENNA MOUNTING BRACKETS AND FIXINGS

The mounting brackets and fixings supplied will vary depending on antenna type. In all cases it is important that all supplied washers are used.



In the example mounting kit shown above, various washers are supplied;

- **4 x M8 internal tooth washers**

  These washers **must** be used to prevent the U-bolts from becoming loose over time.

- **1 x 5/8" plain washer**

  This washer **must** be used to prevent excess load on the antenna base, which can potentially damage the antenna casing.

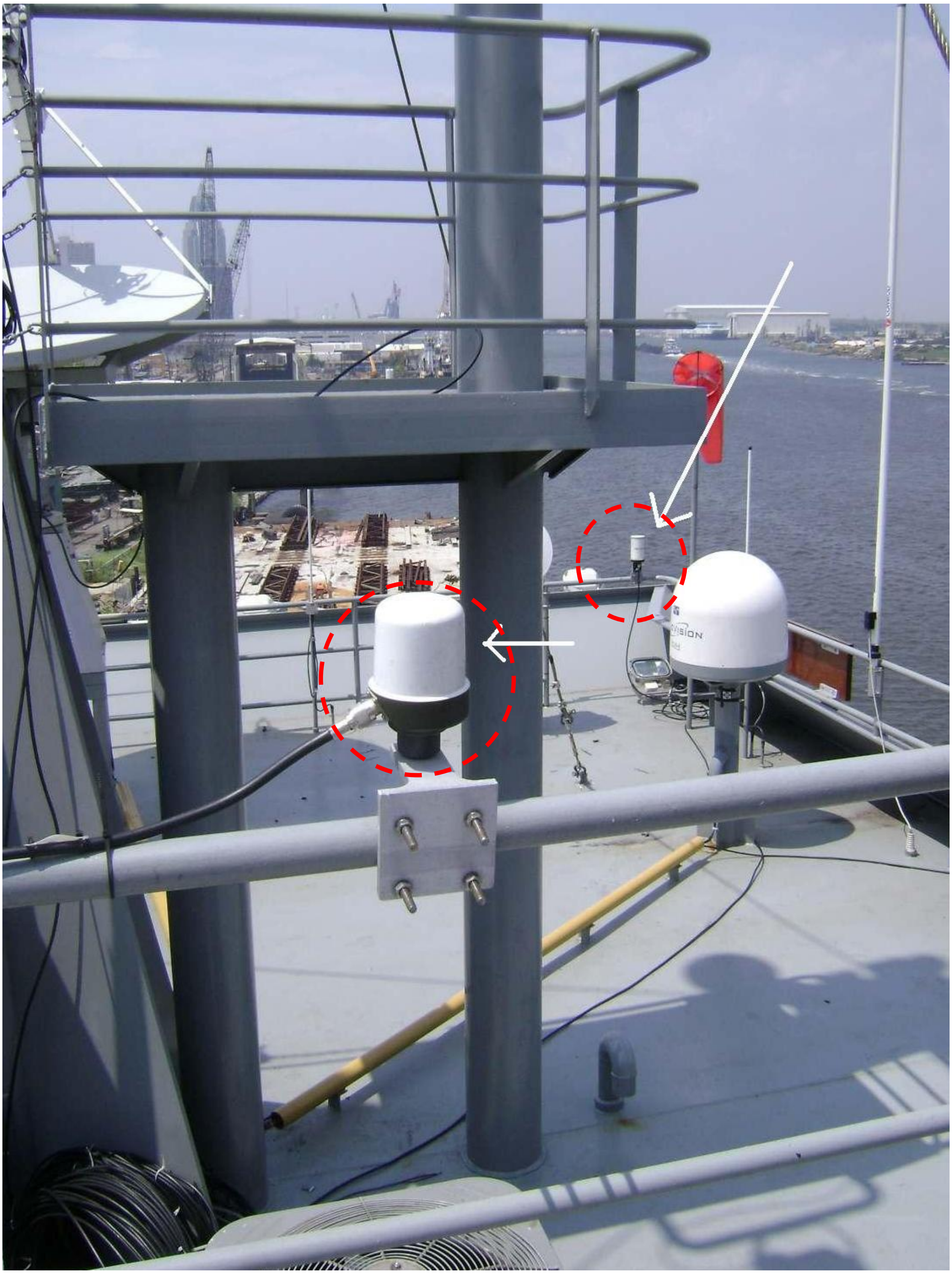
- **1 x 5/8" split washer**

  This washer **must** be used to prevent the antenna from becoming loose from the mount over time.

8. EXAMPLES OF BAD ANTENNA INSTALLATIONS

Antennas installed in very close proximity; signal masking experienced.

Antennas installed in very close proximity. Ray dome of AD410 GNSS antenna is level with ground plane of 90984 L-Band antenna; signal masking experienced.

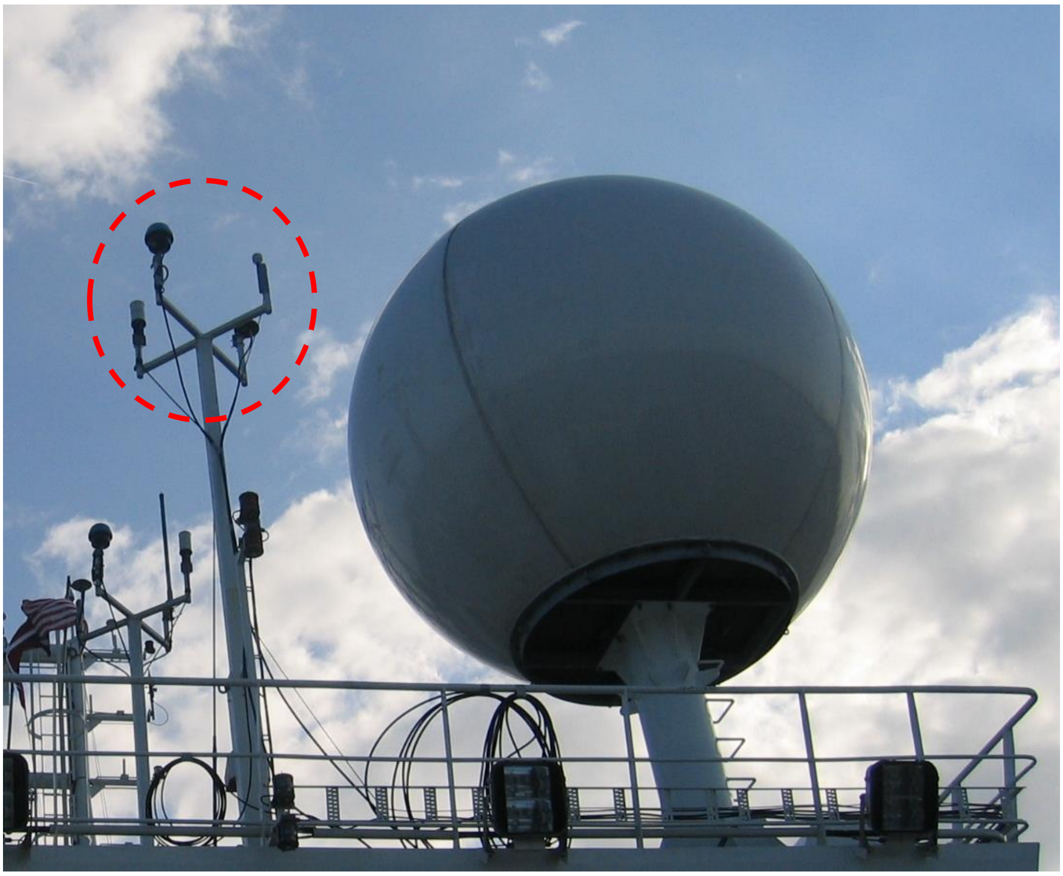


AD251 GNSS and 90984 L-Band antennas installed on handrail in close proximity to flat steel surfaces; multipath and signal masking experienced.

AD410 GNSS antennas installed in extreme close proximity to metal structures and Sat-C antennas; Signal masking and interference present.

90984 L-Band Antennas installed in extreme close proximity. Signal masking present on certain headings at higher latitudes.

AD410 GNSS antenna installed beneath Sat-B dome and in direct path of RADAR transmissions; signal masking and interference experienced.



Antenna mast installed in transmission path and in close proximity to VSAT; interference experienced

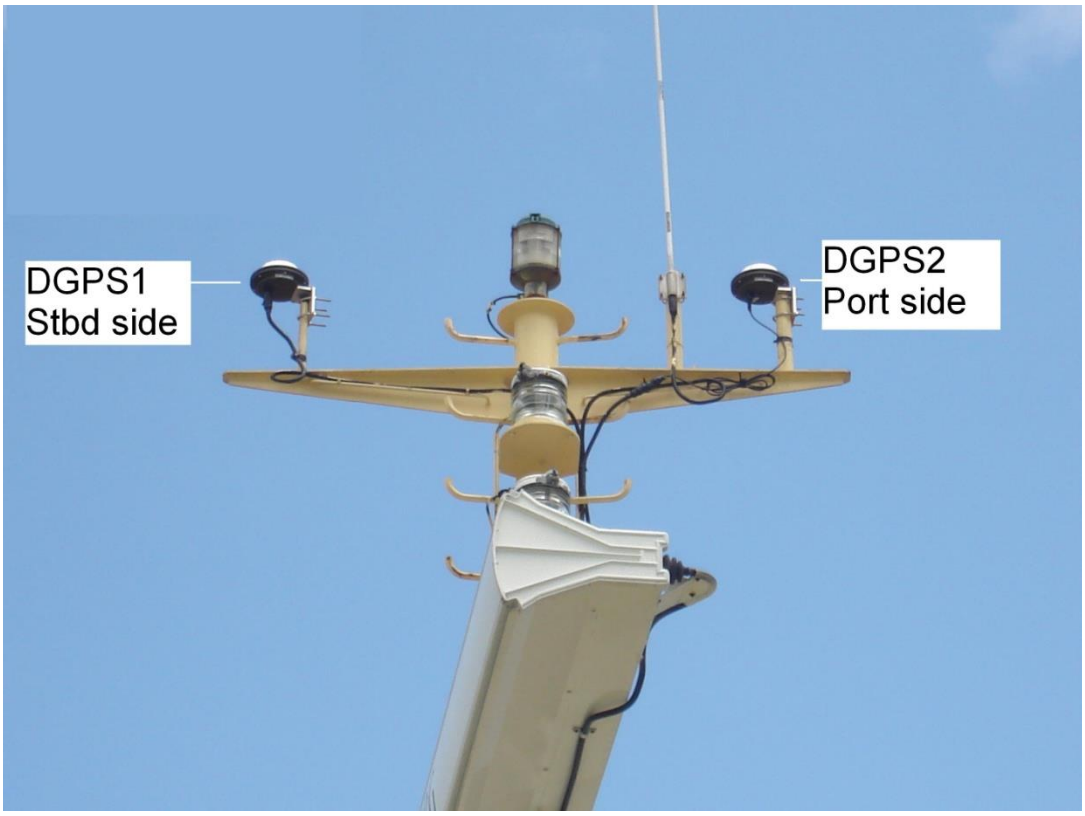
Antenna installed on main deck level underneath derrick; signal masking and multipath experienced

Antenna installed on main deck level underneath derrick base structure; signal masking and multipath experienced

9. EXAMPLES OF GOOD ANTENNA INSTALLATIONS

AD410 GNSS antenna and 90984 L-Band Antenna installed on navigation mast with clear 360deg view of sky. Minor GNSS signal masking by the 90984 is present, but only at low satellite elevations.

Antennas properly spaced at the same height with only minor signal masking from anemometers.



AD410 GNSS Antennas installed on top of mast with only minor signal masking from mast light at low elevations.

Antennas installed at top of mast on retractable mast extensions with good spacing.

10. COAXIAL CABLE INSTALLATION

A high proportion of requests for assistance concerning vessel installations can be traced to the practices adopted when handling, terminating or installing cables and their connections.

ONLY use high quality cables from trusted sources such as:

www.amphenolrf.com

www.timesmicrowave.com

www.andrew.com

www.telegartner.com

Before any work starts survey the route the antenna cable will follow, taking into account the following ten items:

1. The total length of the cable run does not exceed the manufacturers recommended length for the attenuation at the frequencies in use – see **Section 12** and **Section 13** for maximum permissible cable lengths and specifications.

   If the **cable run is too long** then either an in-line amplifier or lower loss cable must be used.

2. The cable will not **cross or run parallel with** single or three phase **mains** cable (**110v AC 220v AC or 440v AC**) or any **high power RF cables** such as those leading **to transmitting devices such as Inmarsat B and VSAT domes**.

3. The cable will **avoid fluorescent lights**.

4. A **tie wire** will be used if the cable run has to cross a free space. **Never** rely on cable ties alone.

5. Make sure there is sufficient space in the selected cable entry through the bulk head to pass the connectors through without damaging them. If this is not possible it may be necessary to cut the connector off and re-terminate once the cable has been passed – see **Section 14** for coaxial cable termination information.

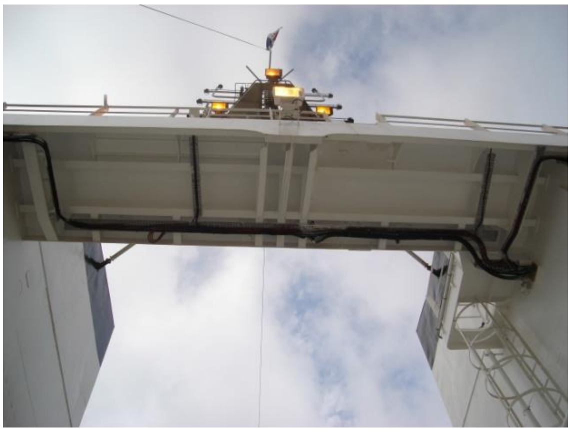
6. The cable will **not be pinched**.

7. There are **no burrs or sharp edges** that could damage the cable jacket.

8. All connectors and couplers are **properly sealed** from the environment with **silicon grease, self-amalgamating tape** and **electrical tape**.

9. There is **no stress** on any of the connectors, particularly the antenna connectors.

10. The **minimum bend radius** for the cable is not exceeded.



- In most cases the installation of coaxial cables is much easier when gravity is helping, although starting the run from the top of the mast is difficult and will often lead to entanglement, especially if the cable is coiled. Therefore it is better to start the installation of the cables from the bottom of the mast, beginning with the run up to the antenna sites.

- Begin by marking both ends of one cable with electrical tape to help identify it. Unwind the entire cable onto the deck making sure there are no twists or kinks. Use a pull rope to pull one end of the cable up the mast cable tray/route before securing it near the antenna with a cable tie. Connect the cable to the antenna. Once connected, secure the cable every metre (3ft) or so, working your way back down the mast.

- When routing the other end of the cable along the chosen route, make sure that it doesn't contact any sharp edges that might damage the outer jacket and avoid pinching or kinking. If the cable has to pass through a penetration, it should be installed in such a way that the outer jacket won't get damaged during pass through or when subsequent cables are installed. **The minimum cable bending radius must be strictly adhered to** – see **Section 13**.

- Once routed to the location of the equipment, leave enough slack before securing the cable with plastic cable ties beginning at the equipment and working your way back to the bottom of the mast. Be careful not to over tighten the ties because this can damage the cable jacket leading to signal degradation.

- If there's any slack left in the cable it can be strapped to a handrail near the bottom of the mast using opposing loops to reconstruct the coil. Although not electrically ideal, coiling and storing the cable in this way means the antenna can be relocated with relative ease should the need arise.

- Alternatively, the cable slack can be pulled to the equipment and secured either under the floor or above the ceiling. This should only be done if the antenna is known to be in a good position and won't need to be relocated.

- Custom cut cables offer the best performance since they can be cut to length, eliminating any and all excess slack. These should be used for all permanent type installations.

Installation should begin with either a length of coax that is known to be slightly longer than the intended run or a spool of cable. If starting with a length of coax, it is always best to terminate the antenna end of the cable with the appropriate coaxial connector before pulling the cable up the mast.

Once terminated, follow the cable routing process mentioned above and cut the excess cable from the BDE end before terminating it and installing it on the appropriate connector on the back of the BDE.

Starting with a spool of cable is a little trickier. Pull the cable from the spool, located at the bottom of the mast down to the BDE. Terminate the BDE end of the cable and then work back up to the bottom of the mast, pulling slack and securing the cable along the way.

Once back at the bottom of the mast, remove enough cable from the spool to reach up to the antenna site. This should be done by measuring the mast cable tray with either a length of rope or tape measure. Estimating the length is not advised because coming up short will require the entire cable to be removed and the run started over.

Once the cable has been cut, it is necessary to run the cable up to the antenna site and trim any slack so that the cable is the exact length needed. The cable should then be pulled back down the mast to a suitable location for the cable termination. Once the cable end has been terminated with the appropriate connector the cable can be run back up the mast and connected to the antenna.

In some cases there will be structured cable already installed on the vessel. This means that each antenna will have to be connected to the appropriate cable in the structured run through a cable box on the mast. The BDE will be connected to the appropriate cable in the rack/below deck cable box. This reduces the need for long lengths of coax and cuts installation time down significantly.

Always make sure that connections are sealed with self-amalgamating tape and electrical tape to protect the connections from the environment.

Coaxial cables that are already in place on the vessel should be properly inspected before they are used. Use of a TDR or Megger (www.megger.com) is also recommended to discover cable faults that cannot be identified by sight alone. Connectors should be thoroughly inspected for corrosion and water ingress.

If in doubt, always run a new cable.

11. MAXIMUM RECOMMENDED COAXIAL CABLE LENGTHS

The following table lists the four most commonly used coaxial cable types and the maximum recommended lengths for the type of signals being passed:

	L1 GNSS Only	L1/L2 GNSS	L-Band	MF / HF
RG213 (M17/163-00001)	40m / 125ft	30m / 110ft	65m / 210ft	100m / 328ft
LMR400	70m / 235ft	52m / 175ft	120m / 390ft	200m / 656ft
LDF4-50	130m / 425ft	110m / 360ft	210m / 700ft	350m / 1148ft
LMR600	110m / 360ft	90m / 300ft	180m / 600ft	300m / 970ft

Note – Maximum cables lengths will vary based on quality/type of connectors used, cable condition and with the use of in-line amplifiers.

12. COAXIAL CABLE SPECIFICATIONS

The following cables are suitable for use with all VERIPOS user equipment. Please note that figures quoted may vary between cable manufacturers. Consideration should be given to the **attenuation** when choosing coaxial cable for installation.

	RG213 (M17/163-00001)	RG214 (M17/164-00001)	RG223 (M17/84-RG223) **See note below**	LMR400	LMR600	LMR240 ULTRAFLEX **See note below**	LDF4-50 HELIAX	FSJ2-50 HELIAX
Diameter:	**0.375" / 9.53mm**	**0.375" / 9.53mm**	**0.212" / 5.38mm**	**0.375" / 9.53mm**	**0.5" / 12.7mm**	**0.240" / 6.10mm**	**0.5" / 12.7mm**	**0.375" / 9.53mm**
Impedance:	**50Ω**	**50Ω**	**50Ω**	**50Ω**	**50Ω**	**50Ω**	**50Ω**	**50Ω**
Attenuation dB/100ft @ 1500MHz:	**9.6**	**7.2**	**16.8**	**5.1**	**3.3**	**9.9**	**2.8**	**5.08**
Attenuation dB/100m @ 1500MHz:	**31.5**	**23.5**	**54.9**	**16.8**	**10.9**	**32.4**	**9.18**	**16.7**
Velocity of Propagation:	**66%**	**66%**	**66%**	**85%**	**87%**	**84%**	**88%**	**83%**
Minimum Bend Radius (Installation):	**5.0" / 127mm**	**5.0" / 127mm**	**1.0" / 25.4mm**	**1.0" / 25.4mm**	**1.5" / 38.1mm**	**0.75" / 19.1mm**	**5.0" / 127mm**	**1.0" / 25.4mm**
Minimum Bend Radius (Repeated):			**4.0" / 101.6mm**	**4.0" / 101.6mm**	**6.0" / 152.4mm**	**2.5" / 63.5mm**		

Note – The use of RG223 and LMR240 should be limited to short tails / whips. Due to the **higher attenuation** of these small diameter cables they should **not** be used for the entire cable run.

13. COAXIAL CABLE TERMINATION

A high proportion of requests for assistance concerning vessel installations can be traced to the practices adopted when handling, terminating or installing cables and their connections.

ONLY use high quality cables and connectors from trusted sources such as:

www.amphenolrf.com

www.timesmicrowave.com

www.commscope.com

www.telegartner.com

All work should be conducted in a safe manner, following the appropriate safety systems that are relevant on the site where the work is taking place.

Please note that the following illustrations apply to the exact make and model of the connector/cable mentioned. A slightly different model or its equivalent may have different connector components. Please refer to the manufacturer for termination instructions.

13.1 LMR400 – TIMES MICROWAVE EZ-400-NF-X N-TYPE FEMALE CONNECTOR

The Times Microwave **EZ-400-NF-X** connector comes with the following parts:

To properly terminate LMR400 cable with the **EZ-400-NF-X** connector, the following tools should be used:

Times Microwave Cable cutting tool:

PN: CCT-01

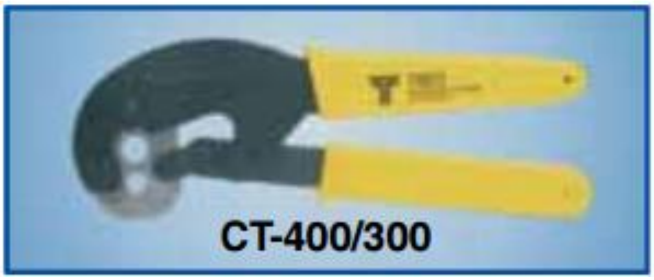
Times Microwave LMR400 cable prep tool:

PN: CST-400

Times Microwave deburring tool:

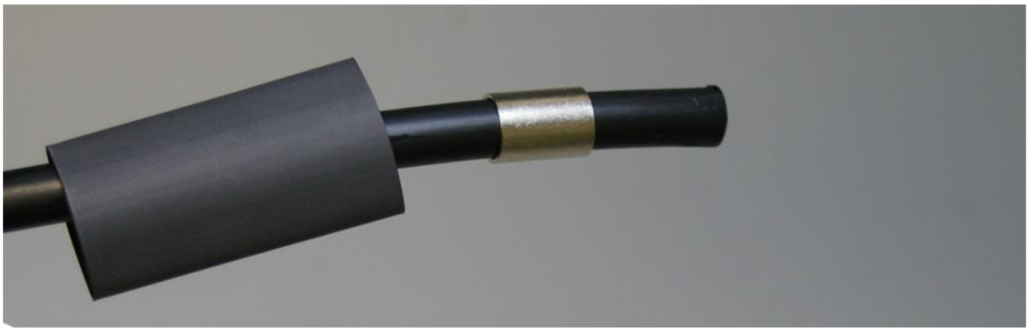
PN: DBT-U

Times Microwave LMR300/400 crimp tool:



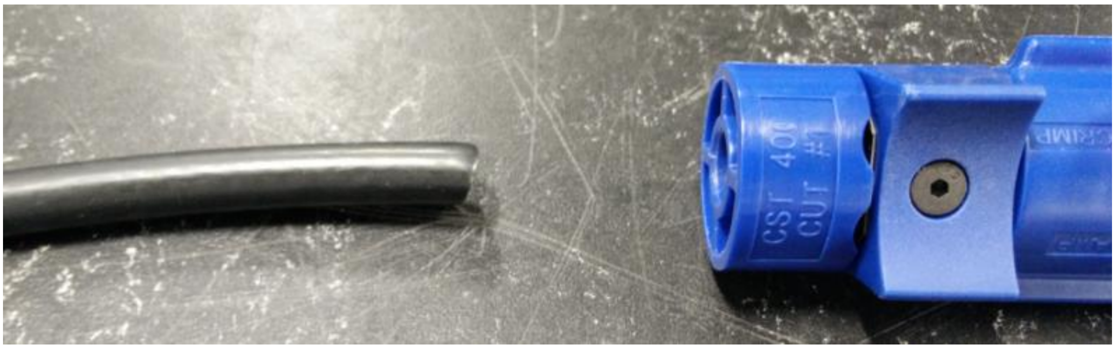
PN: CT-300/400

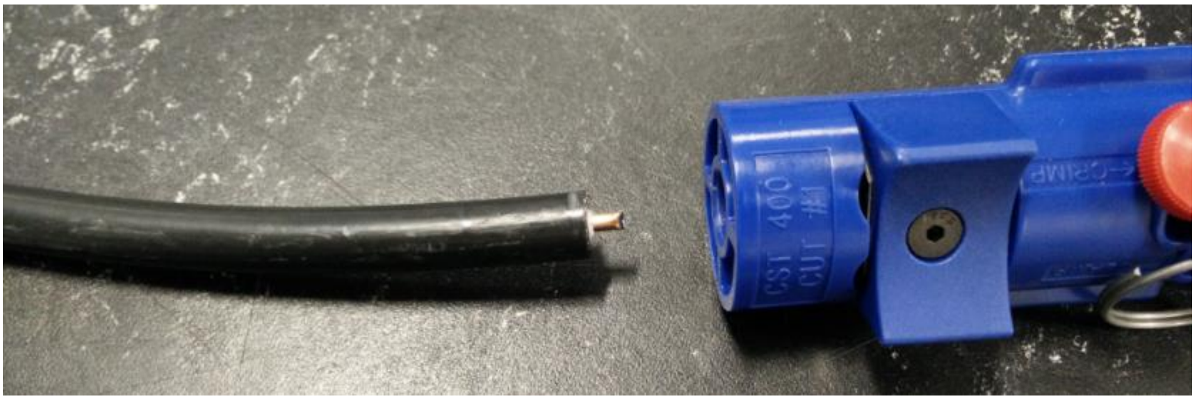
Step 1 – Slide adhesive lined heat shrink and crimp collar onto cable. Cut cable square.



Step 2 – Use side **1** of the cable prep tool to expose the centre conductor by inserting cable into tool and rotating tool clockwise until no resistance can be felt.

While rotating, push down on the thumb screw to activate the cutting blade.





If the cable prep tool is not available, carefully trim cable to the following dimensions (mm):

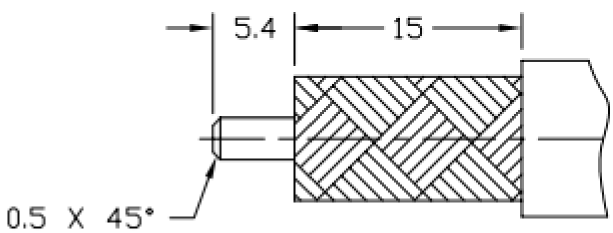
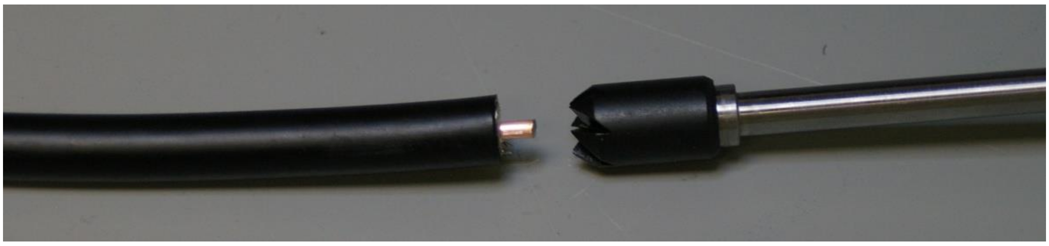
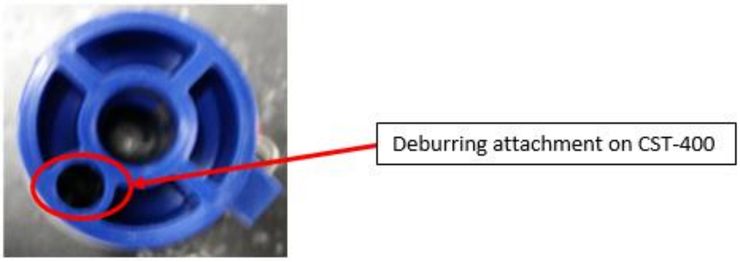


Diagram courtesy of Times Microwave

Step 3 – Remove any residual plastic from centre conductor before deburring with deburring tool or a fine metal file.

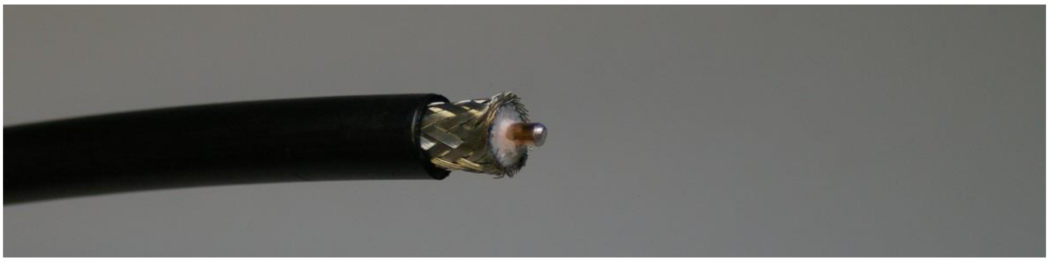


The CST-400 tool can also be used as it has a deburring attachment on the **side 2** end:



Step 4 – Ensure the CST-400 tool is set to Crimp. If currently set to Clamp, loosen the red thumb screw, slide to **Crimp** then re-tighten.

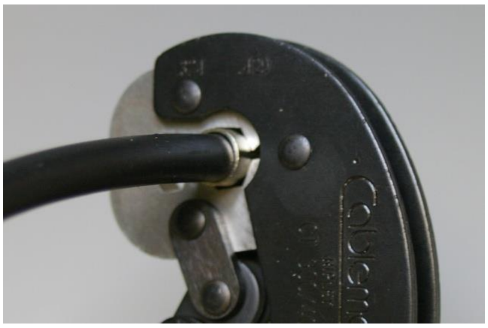
Trim cable jacket using side **2** of the cable prep tool by inserting cable and rotating tool clockwise until no resistance can be felt.



Step 5 – Flare the braid and check to make sure no aluminium foil is touching the centre core. Insert cable into connector body making sure that the braid remains outside.

Step 6 – Slide crimp collar over braid.

Step 7 – Use the crimp tool to crimp the collar onto the connector, making sure it's as tight to the back of the connector body as possible. Do not crimp rear of crimp collar.



Step 8 – Slide the adhesive lined heat shrink onto the back of the connector, applying heat from a heat gun or gas soldering iron to seal.

13.2 LMR400 – TIMES MICROWAVE TC-400-NMH-X N-TYPE MALE CONNECTOR

The Times Microwave TC-400-NMH-X connector comes with the following parts:

To properly terminate LMR400 cable with the **TC-400-NMH-X** connector, the following tools should be used:

Times Microwave Cable cutting tool:

PN: CCT-01

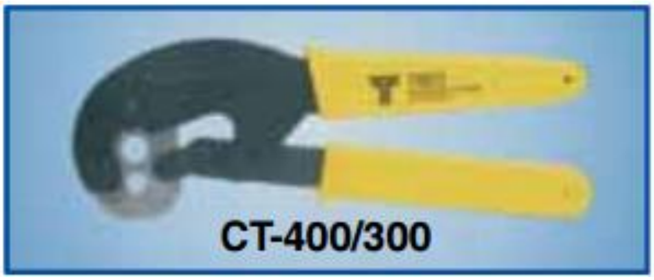
Times Microwave LMR400 cable prep tool:

PN: CST-400

Times Microwave deburring tool:

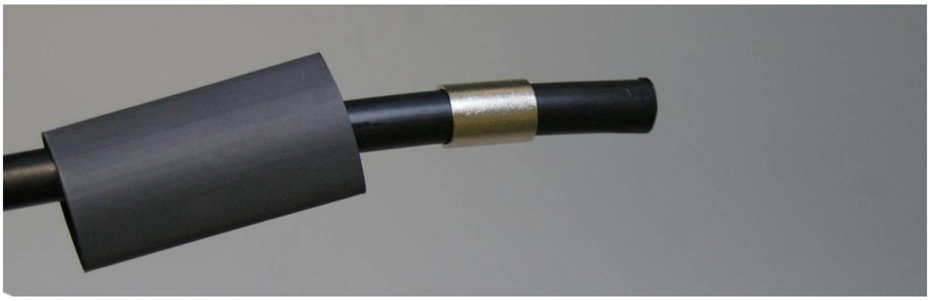
PN: DBT-U

Times Microwave LMR300/400 crimp tool:



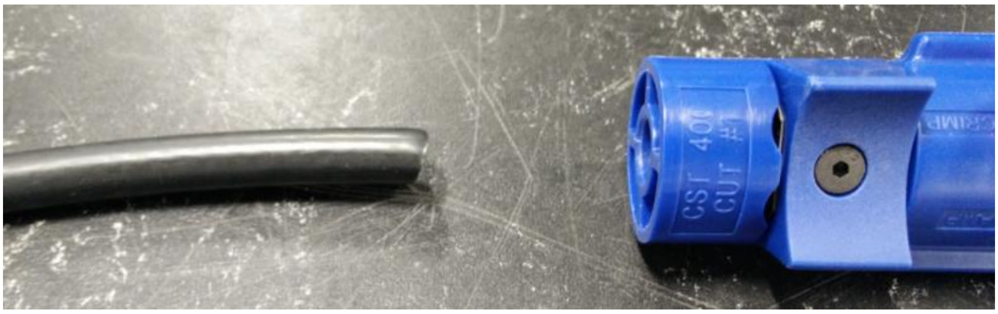
PN: CT-300/400

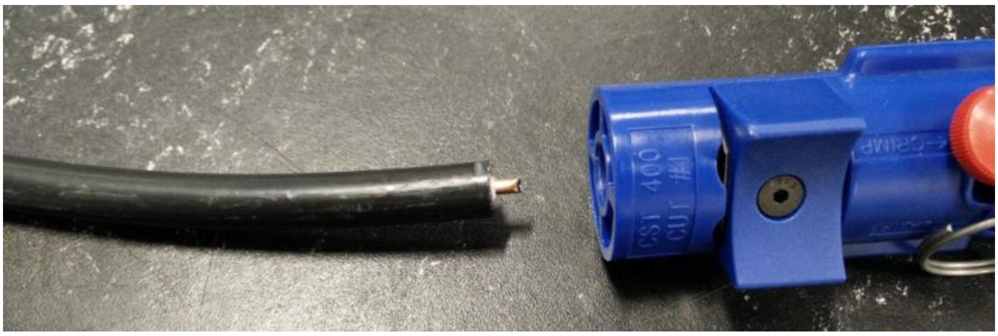
Step 1 – Slide adhesive lined heat shrink and crimp collar onto cable. Cut cable square.



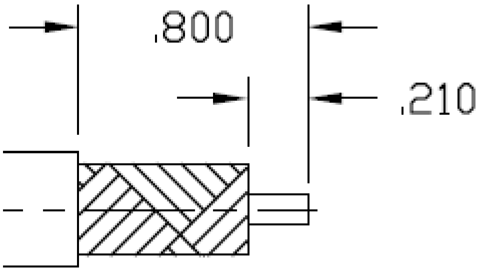
Step 2 – Use side **1** of the cable prep tool to expose the centre conductor by inserting cable into tool and rotating tool clockwise until no resistance can be felt.

While rotating, push down on the thumb screw to activate the cutting blade.

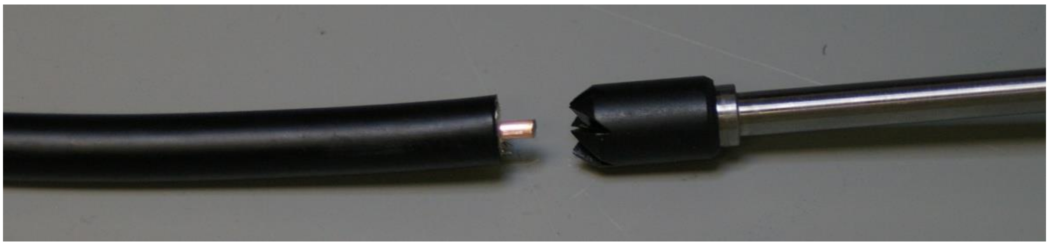




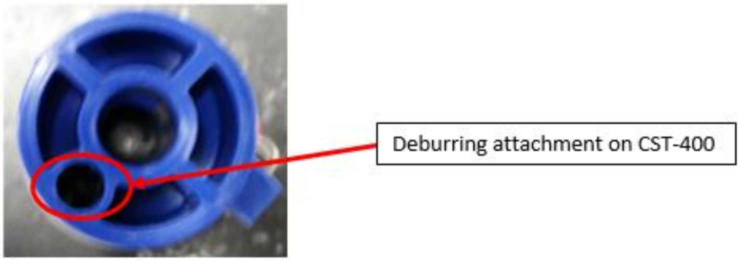
If the cable prep tool is not available, carefully trim cable to the following dimensions (inches):



Step 3 – Remove any residual plastic from centre conductor before deburring with deburring tool or a fine metal file.

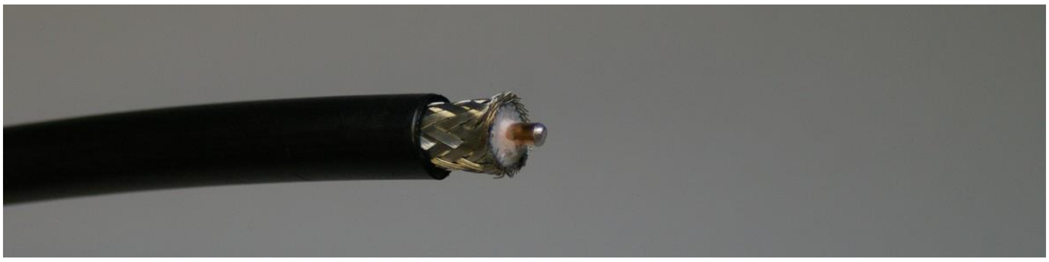


The CST-400 tool can also be used as it has a deburring attachment on the **side 2** end:

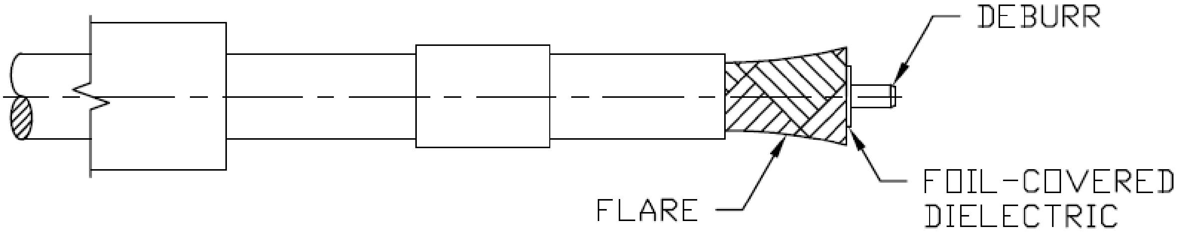


Step 4 – Ensure the CST-400 tool is set to Crimp. If currently set to Clamp, loosen the red thumb screw, slide to **Crimp** then re-tighten.

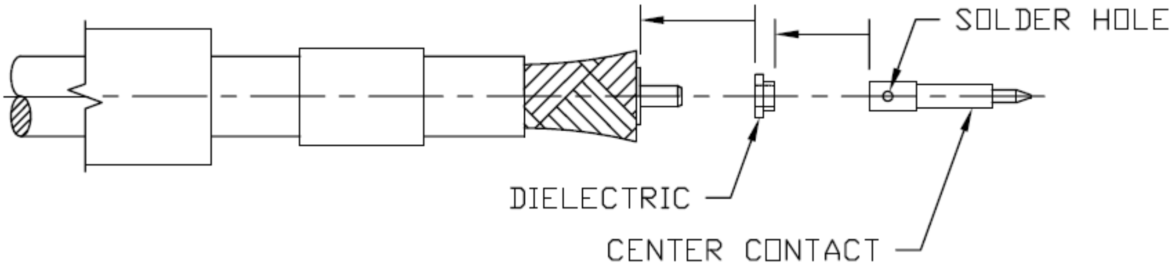
Trim cable jacket using side **2** of the cable prep tool by inserting cable and rotating tool clockwise until no resistance can be felt.



Step 5 – Flare out the cable braid away from the foil. Deburr the cable centre conductor:

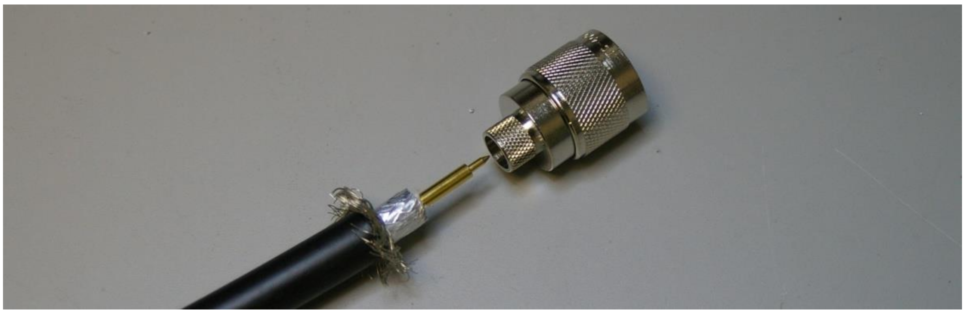


Step 6 – Slide the dielectric spacer (larger face first) onto the cable centre conductor. Fit centre pin onto centre conductor. Solder in place by applying a minimal amount of solder to the hole in the side of the pin:



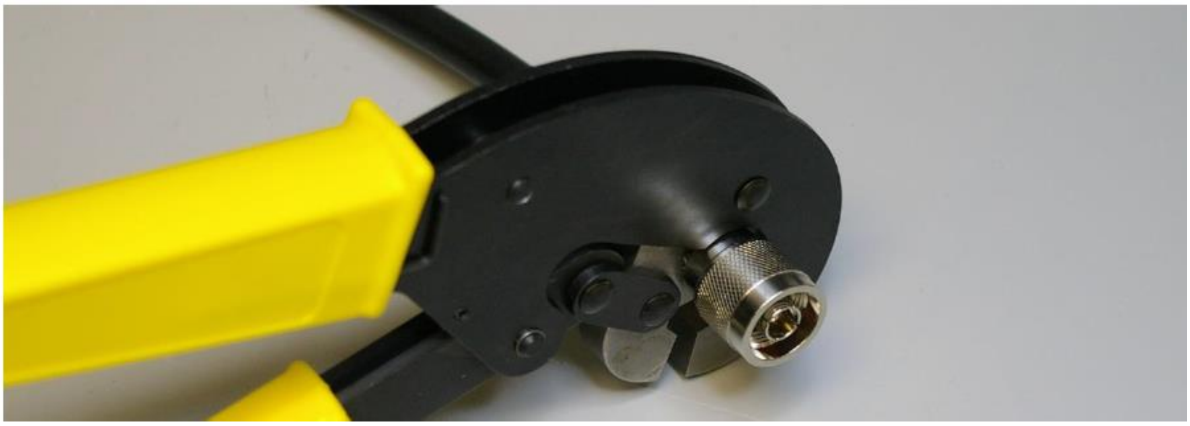
The soldering iron should be set to a high heat setting and tinned before being applied to the centre pin. The application of heat should be done carefully since too little will result in a poorly soldered joint, which will adversely affect performance, and applying too much will melt the dielectric.

Step 7 – Install the connector subassembly over the centre pin and dielectric and under the flared braid.



Step 8 – Slide the crimp collar over the braid and trim any excess braid carefully.

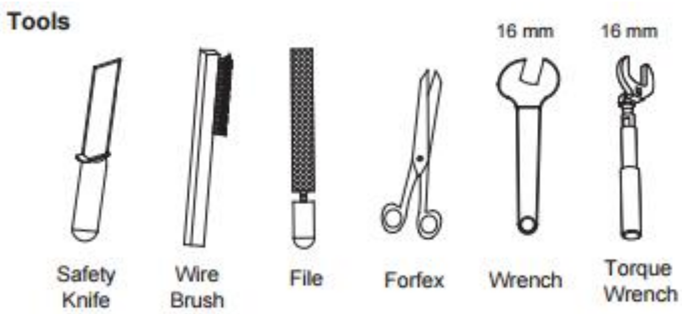
Step 9– Use the crimp tool to crimp the collar onto the connector, making sure it is as tight to the back of the connector body as possible. Do not crimp rear of the collar.



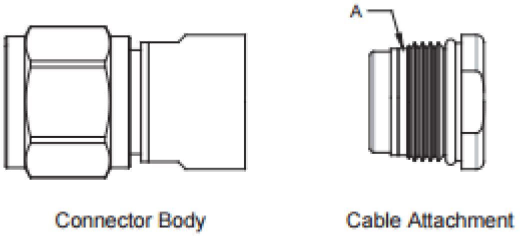
Step 10– Slide the adhesive lined heat shrink onto the back of the connector, applying heat from a heat gun to seal.

13.3 LMR400 – COMMSCOPE 400BPNM-C N-TYPE MALE CONNECTOR

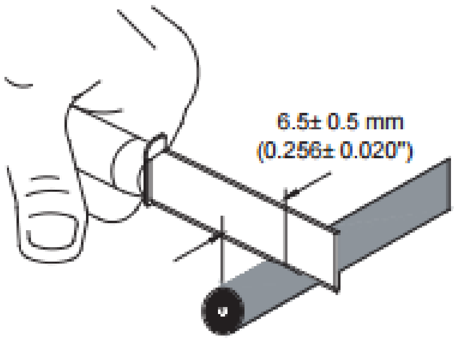
To properly terminate LMR400 cable with the CommScope 400BPNM-C connector, the following tools should be used:



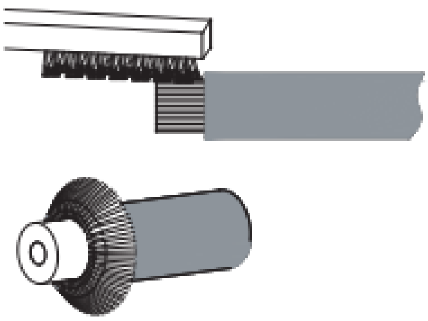
The CommScope 400BPNM-C connector consists of the following parts:



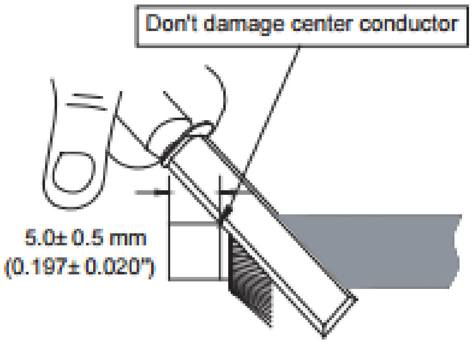
Step 1– Using a suitable knife, remove 6.5mm of the outer cable jacket:



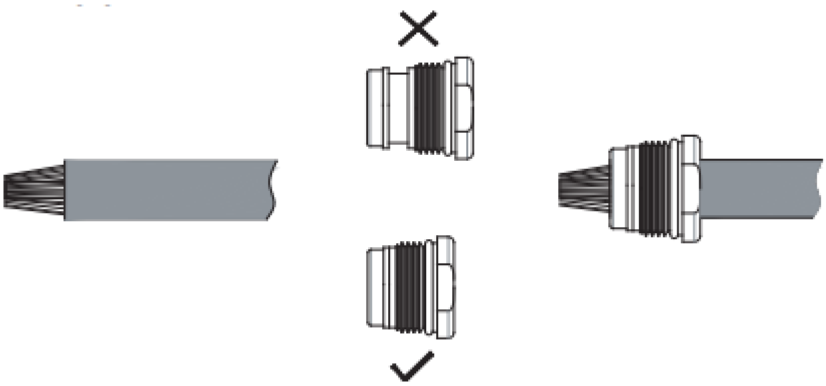
Step 2– Comb the exposed braid straight with a wire brush and fold back as shown:



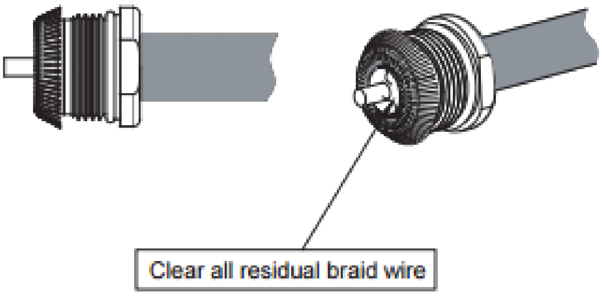
Step 3– Remove 5.0mm of foil and foam, exposing the centre conductor. Remove all foam and adhesive from the centre conductor:



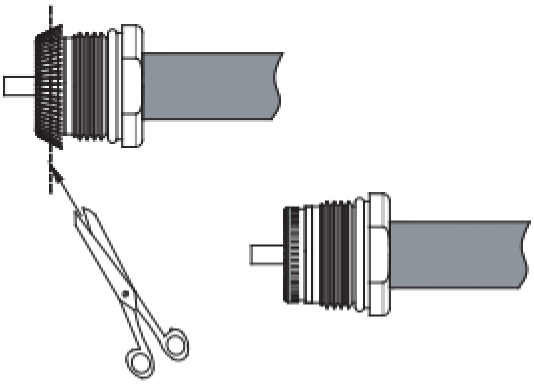
Step 4– Taper the braid towards centre conductor as shown. Push and rotate the cable attachment onto the cable taking care not to damage the braid:



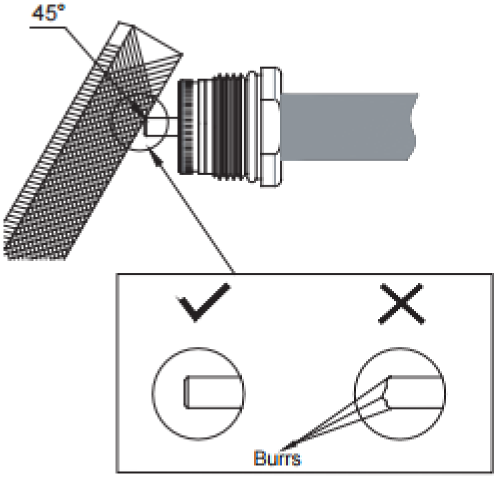
Step 5– Fold the braid back over the cable attachment. Use a wire brush to ensure the braid is straight and equally spaced:



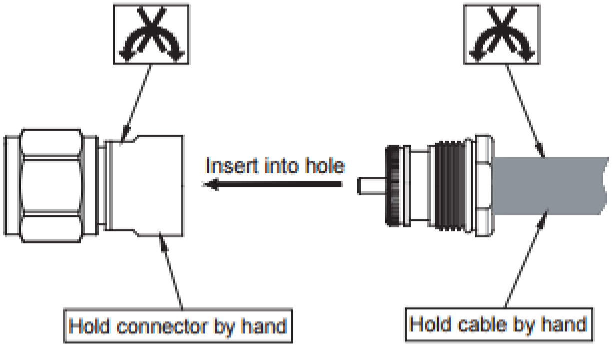
Step 6– Trim back the excess braid as shown:



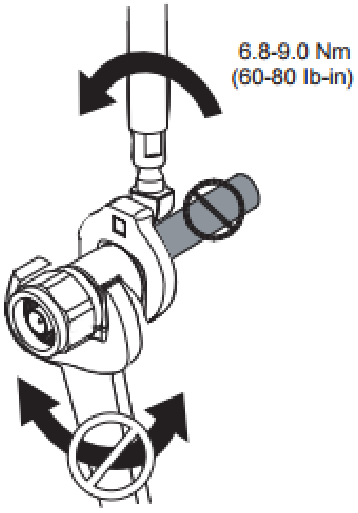
Step 7– Using a small file, taper the cable centre conductor at a 45° angle:



Step 8– Place connector onto cable, ensuring all is correctly aligned and the cable centre conductor is inserted into the connector inner fingers:



Step 9– Using a torque wrench, tighten the connection to the torque value of 6.8-9.0 Nm (60-80 lb-in). Do not turn connector body, turn only the connector clamp nut:

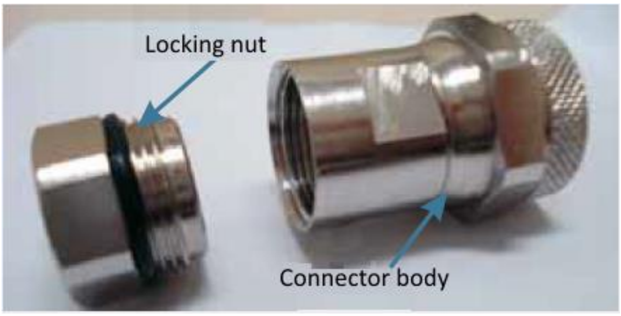


13.4 LMR400 – AF DATALINK C019 N-TYPE MALE CONNECTOR

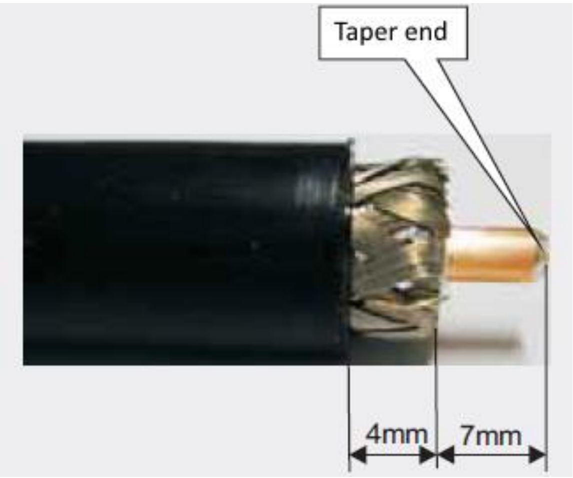
To properly terminate LMR400 cable with the AF Datalink C019 connector, the following tools should be used:

1. Ruler
2. 2 x 5/8" spanner
3. Small file
4. Knife

The AF Datalink C019 connector consists of the following parts:



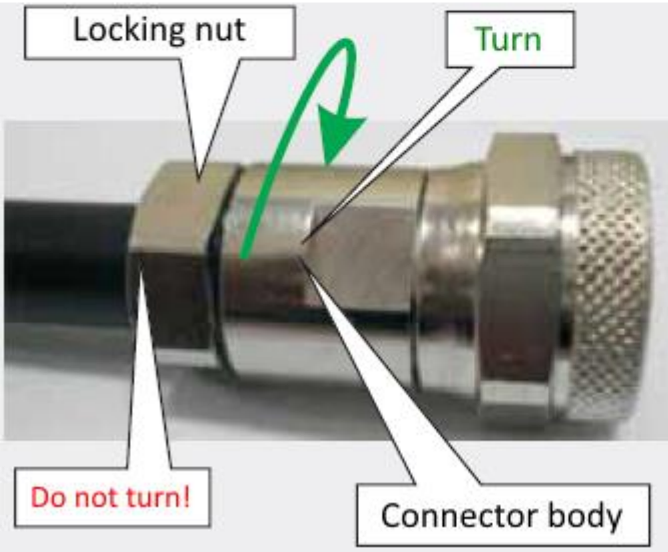
Step 1– Using a suitable knife or blade, remove the first 11mm from the cable outer jacket. Remove 7mm of the cable dielectric to expose the centre conductor. Use a file to taper the end of the centre conductor:



Step 2– Place the connector locking nut over the cable braid:

Step 3– open the cable braid so that it makes contact with the connector locking nut:

Step 4– Connect the connector body using 2 x 5/8” spanners. While tightening, do not rotate the locking nut, turn only the connector body:

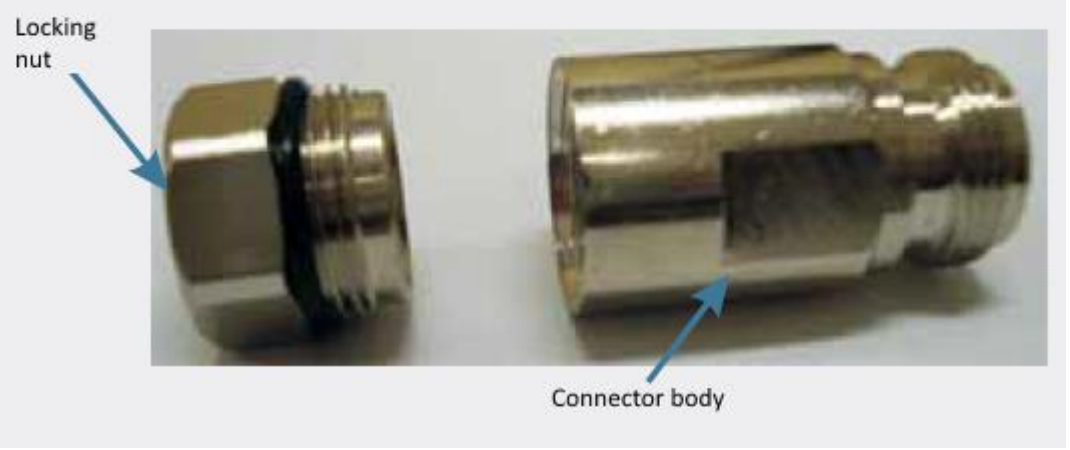


13.5 LMR400 – AF DATALINK C009 N-TYPE FEMALE CONNECTOR

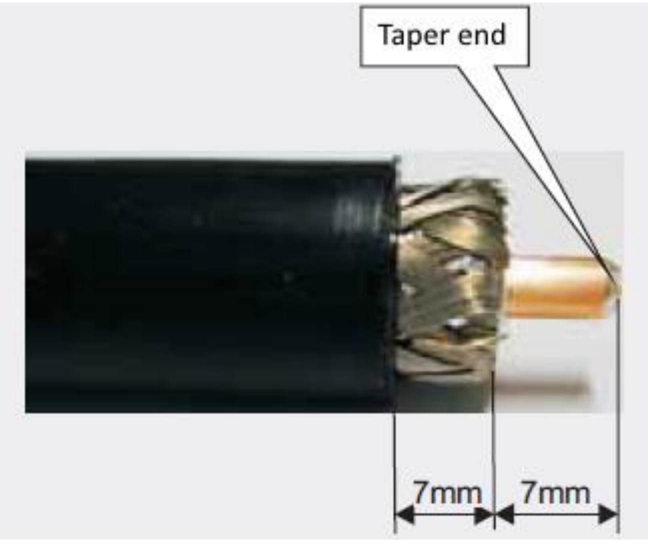
To properly terminate LMR400 cable with the AF Datalink C009 connector, the following tools should be used:

5. Ruler
6. 2 x 5/8" spanner
7. Small file
8. Knife

The AF Datalink C009 connector consists of the following parts:



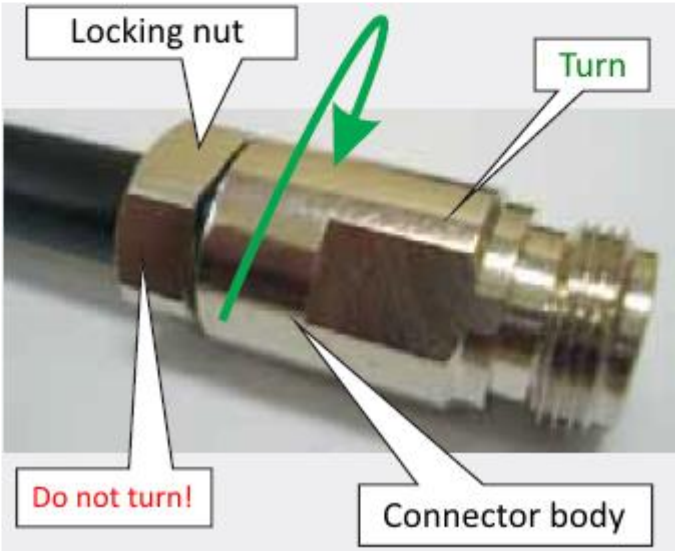
Step 1– Using a suitable knife or blade, remove the first 14mm from the cable outer jacket. Remove 7mm of the cable dielectric to expose the centre conductor. Use a file to taper the end of the centre conductor:



Step 2– Place the connector locking nut over the cable braid:

Step 3– open the cable braid so that it makes contact with the connector locking nut:

Step 4– Connect the connector body using 2 x 5/8” spanners. While tightening, do not rotate the locking nut, turn only the connector body:

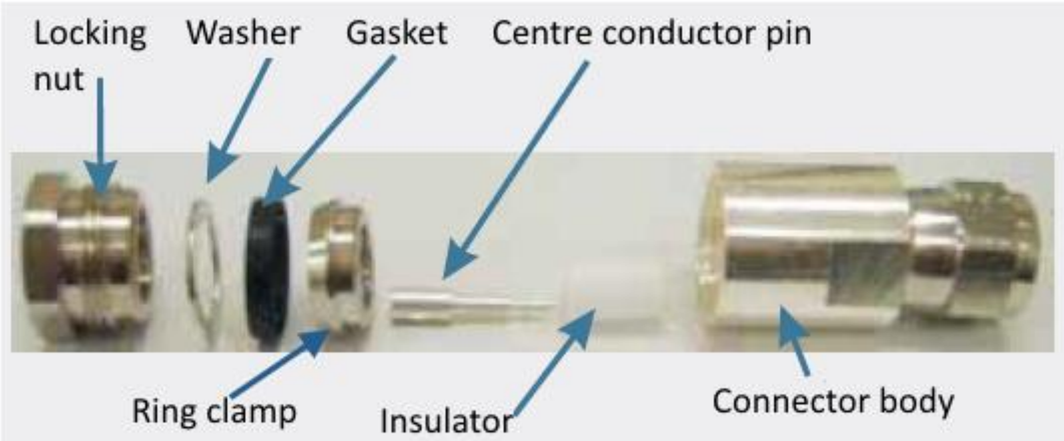


13.6 LMR400 – AF DATALINK C120 TNC MALE CONNECTOR

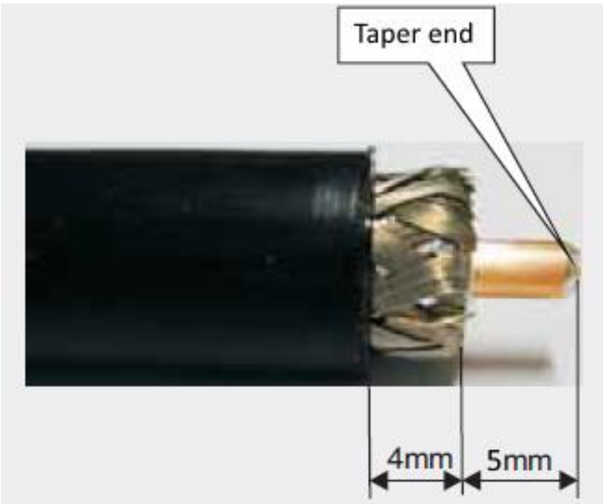
To properly terminate LMR400 cable with the AF Datalink C120 connector, the following tools should be used:

1. Ruler
2. 2 x 5/8” spanner
3. Small file
4. Knife
5. Soldering iron
6. Solder

The AF Datalink C019 connector consists of the following parts:

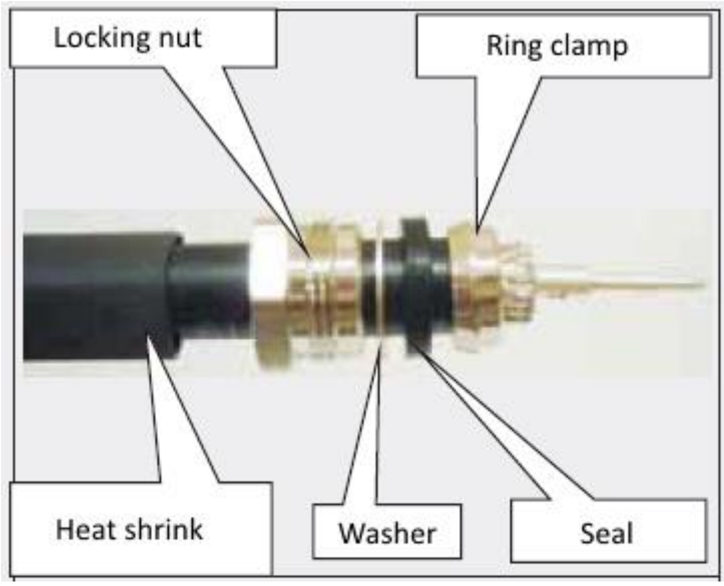


Step 1– Using a suitable knife or blade, remove the first 9mm from the cable outer jacket. Remove 5mm of the cable dielectric to expose the centre conductor. Use a file to taper the end of the centre conductor:

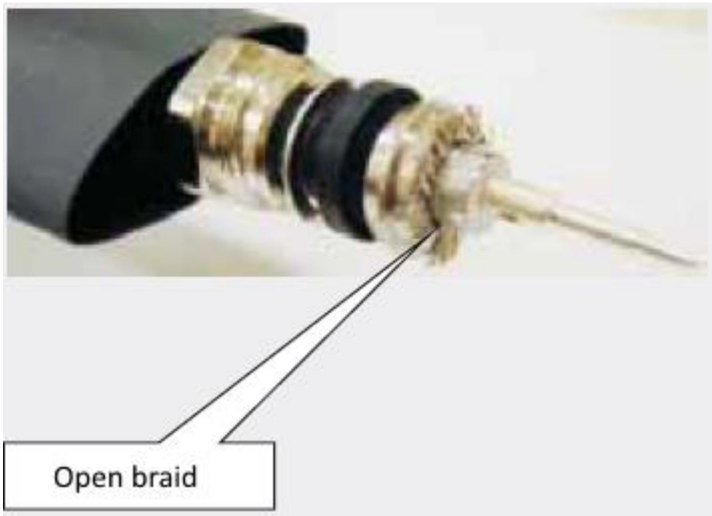


Step 2– Solder the pin onto the centre conductor. Take care not to use too much solder:

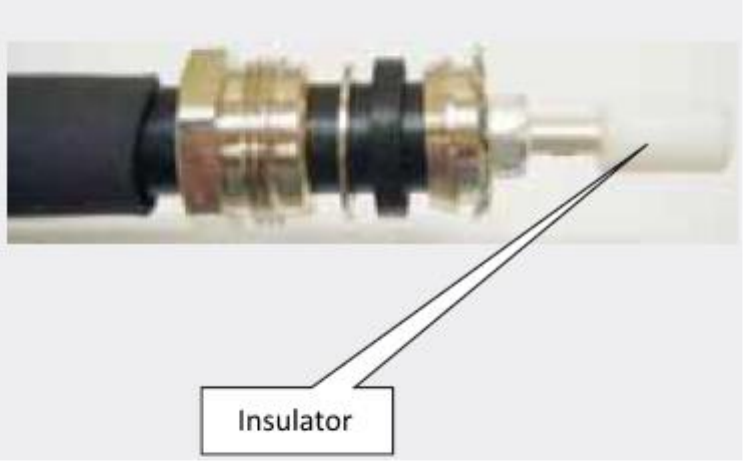
Step 3– Fit the following parts in this order: heat shrink, locking nut, washer, seal and ring clamp:



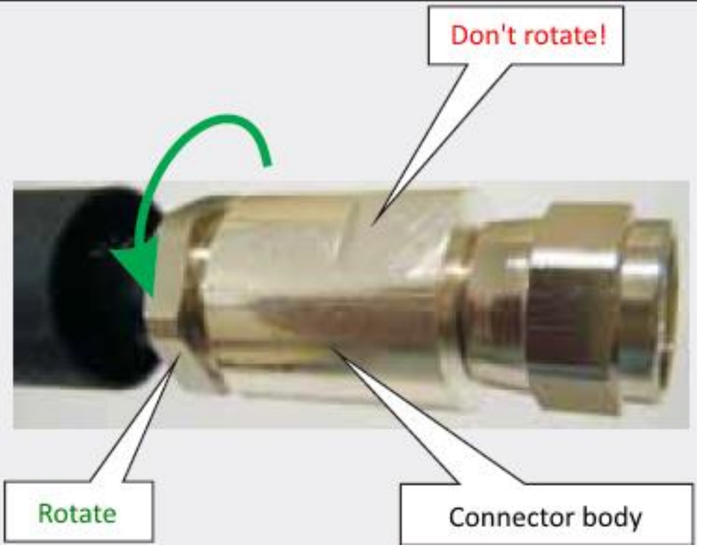
Step 4– Open up the braid so that is in contact with the ring clamp:



Step 5– Slide the insulator over the centre conductor pin:



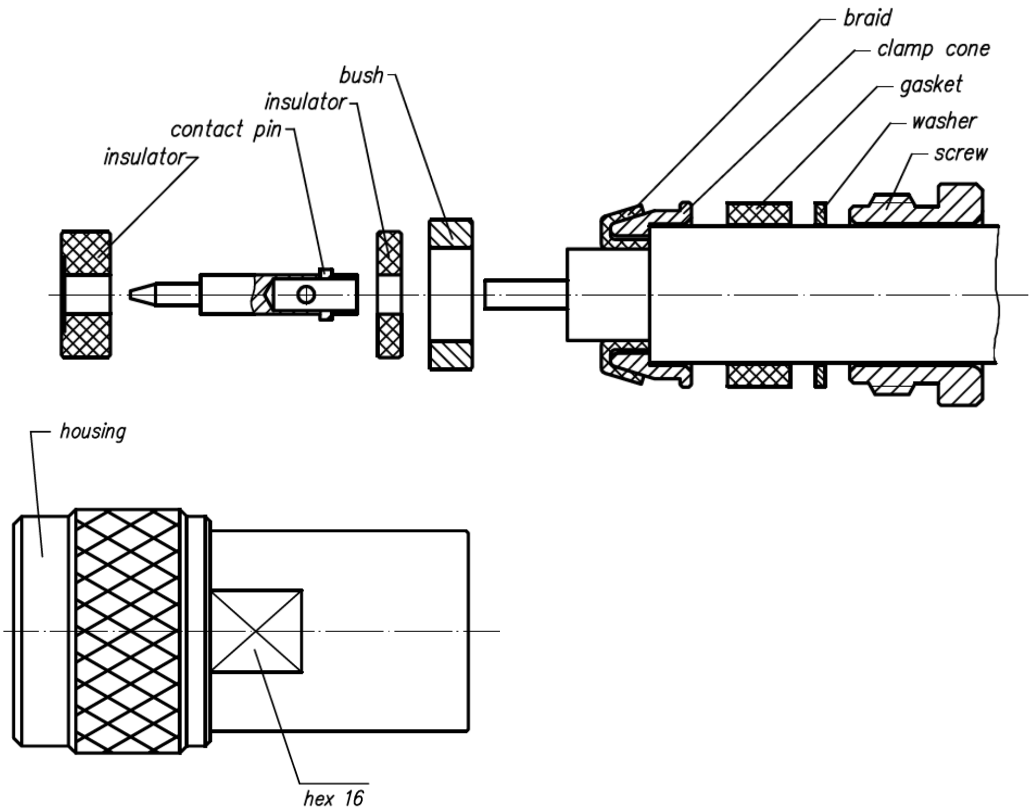
Step 6– Connect the connector body using 2 x 5/8” spanners. While tightening, do not rotate the connector body, turn only the locking nut:



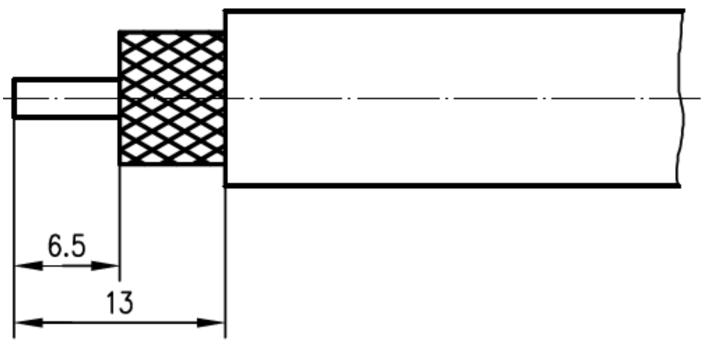
Step 7– Using a heat gun, apply heat to the heat shrink until it has moulded to the connector and cable. **Note: Heat shrink is not provided with the connector**:

13.7 RG213 – TELEGÄRTNER J01020I1070 – N-TYPE MALE CONNECTOR

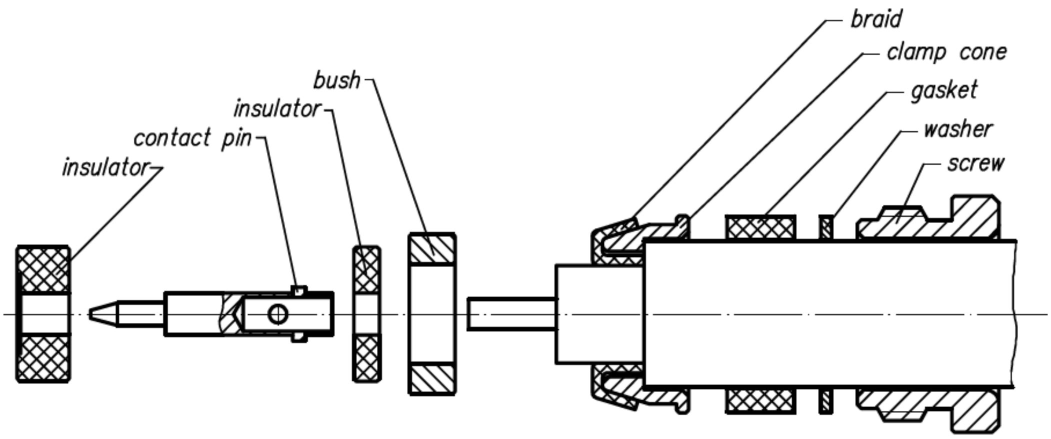
The Telegärtner J01020i1070 connector consists of the following parts:



Step 1– Using a suitable knife or blade, remove the first 13mm of the cable outer jacket. Then remove 6.5mm of the cable dielectric to expose the centre conductor:

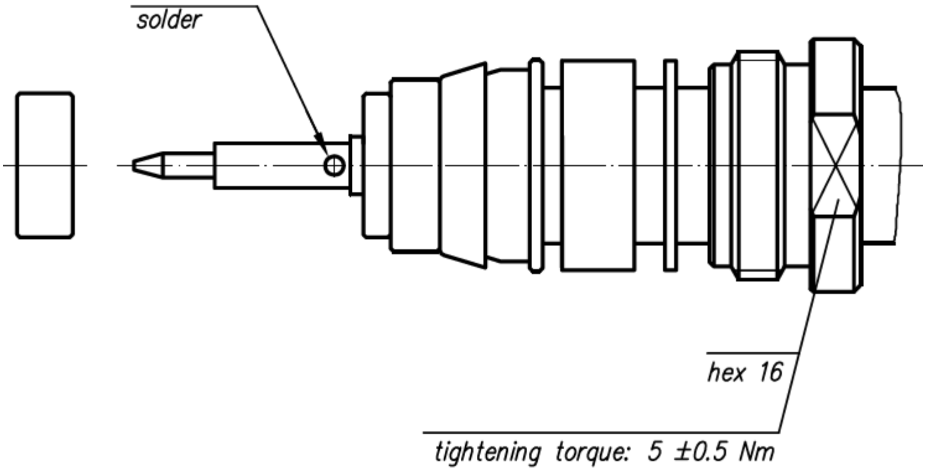


Step 2– Fit the components of the connector as shown. The cable braid should be folded over the clamp cone prior to fitting the bush:



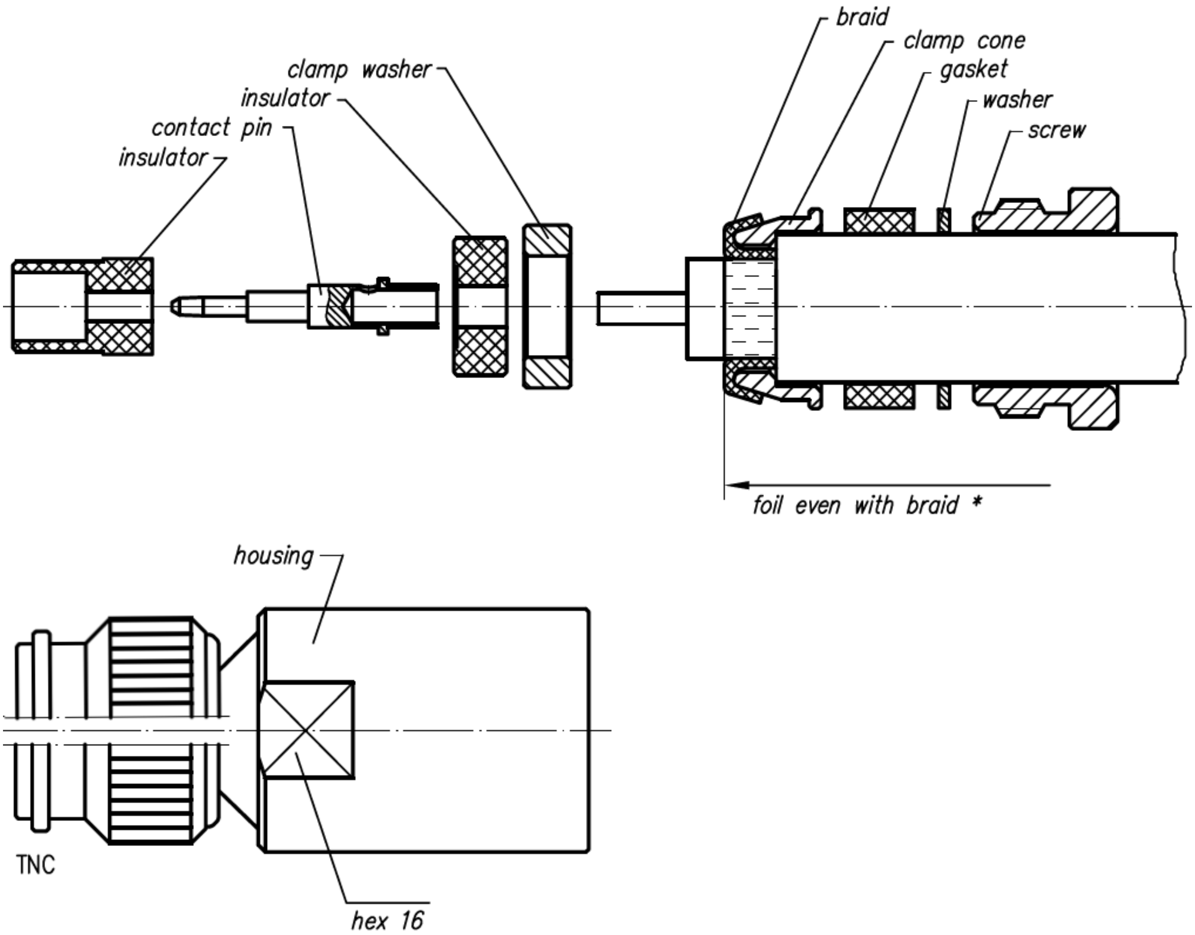
Step 3– solder the conductor centre pin in place, taking care not to apply too much solder. Then fit the insulator over the pin.

Step 4– Place the connector housing over the cable and tighten using 2 x 16mm spanners:



13.8 RG213 – TELEGÄRTNER J01010A2940 – TNC MALE CONNECTOR

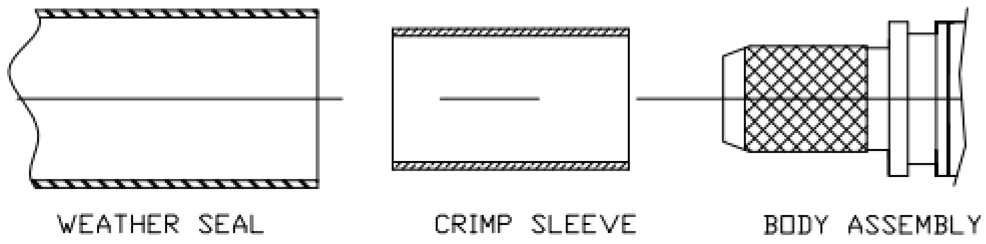
The Telegärtner J01010A2940 connector consists of the following parts:



The termination process of this connector is the same as described in **Section 13.7**. Substitute the relevant parts where appropriate.

13.9 LMR240 ULTRAFLEX – TIMES MICROWAVE EZ-240-TM-X TNC MALE CONNECTOR

The Times Microwave **EZ-240-TM-X** connector comes with the following parts:

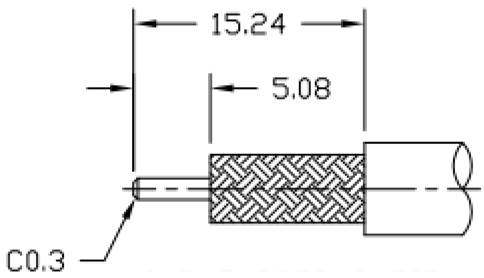


Diagrams courtesy of Times Microwave

To properly terminate LMR240 cable with the **EZ-240-TM-X** connector, the following tools should be used:

1. Times Microwave Cable Preparation tool CST-240
2. Crimp tool with 0.255" / 6.48mm hex die
3. Heat gun

The termination procedure for the EZ-400-NF-X connector **(Section 13.1)** can be followed, substituting the relevant parts where appropriate. Below dimensions are in mm.



13.10 LMR240 ULTRAFLEX – TIMES MICROWAVE EZ-240-NMH-X N-TYPE MALE CONNECTOR

The Times Microwave **EZ-240-NMH-X** connector comes with the following parts:

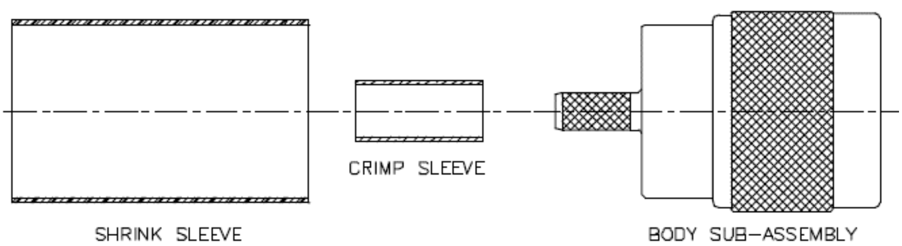
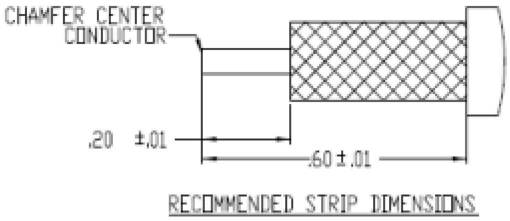


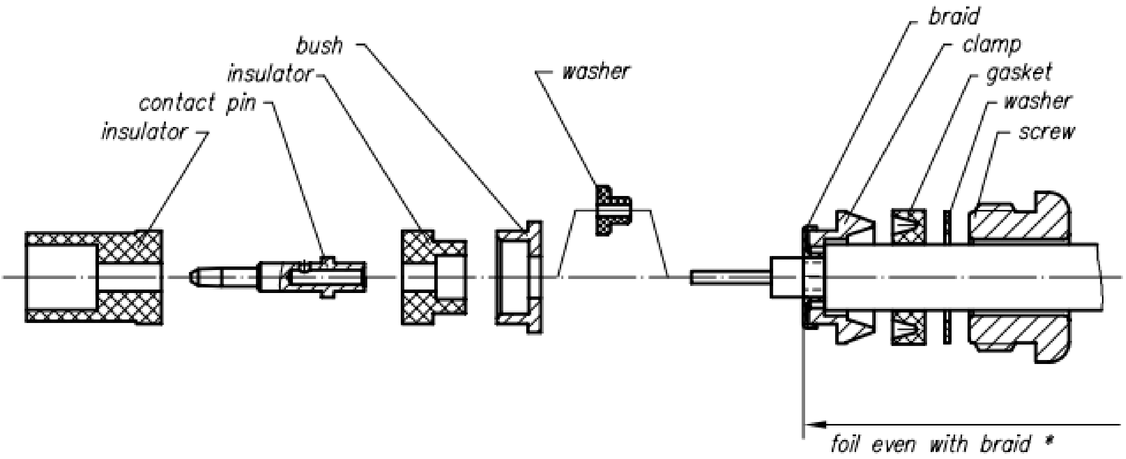
Diagram courtesy of Times Microwave

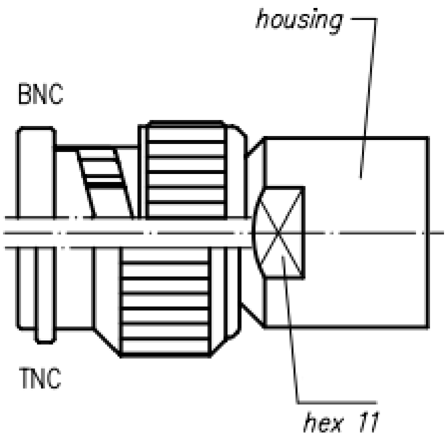
The termination procedure for **EZ-400-NF-X (Section 13.1)** can be followed, substituting the relevant parts where appropriate. Below dimensions are in inches.



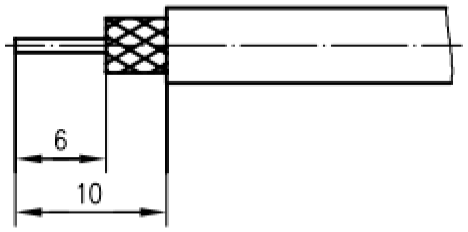
13.11 LMR195 – TELEGÄRTNER J01010A2608 - TNC MALE CONNECTOR

The Telegärtner J01010A2608 connector comes with the following parts:

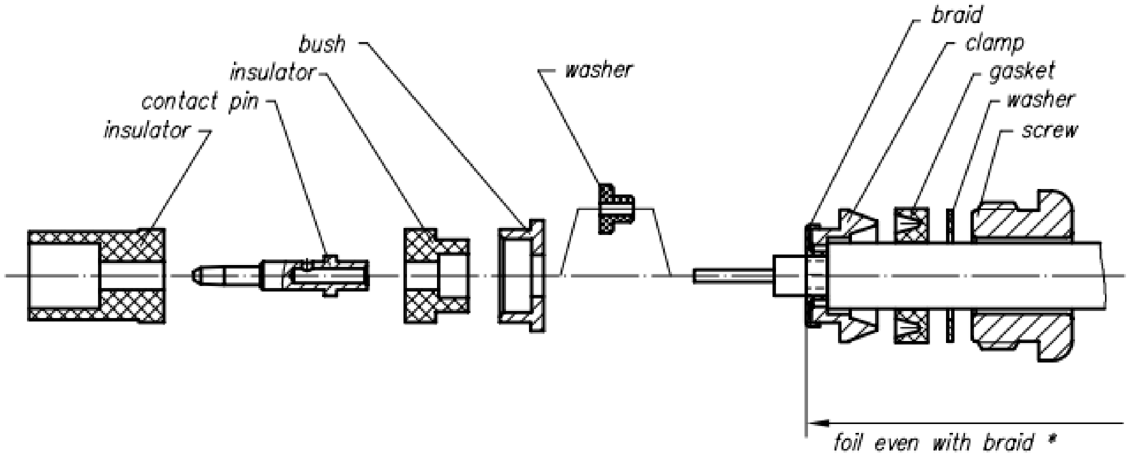




Step 1– Using a suitable knife or blade, remove the first 10mm of the cable outer jacket. Then remove 6mm of the cable dielectric to expose the centre conductor:

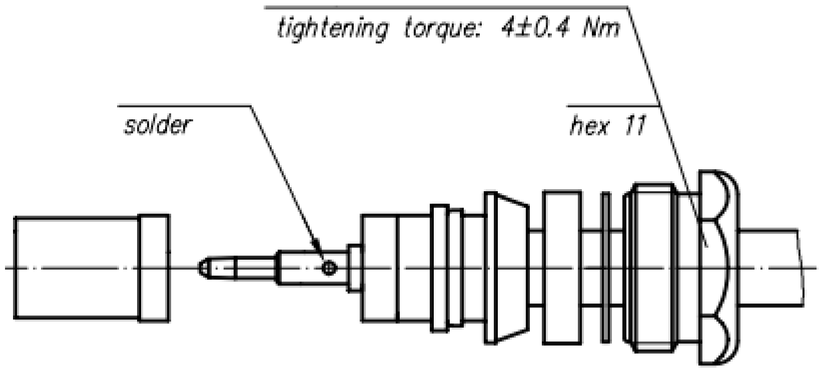


Step 2– Fit the components of the connector as shown. The cable braid should be folded over the clamp cone prior to fitting the washer:



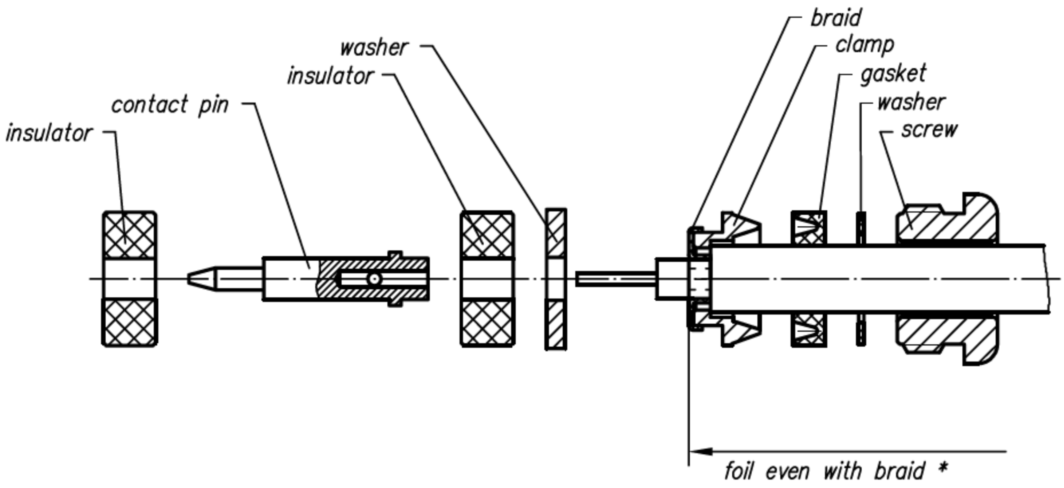
Step 3– solder the conductor centre pin in place, taking care not to apply too much solder. Then fit the second insulator over the pin.

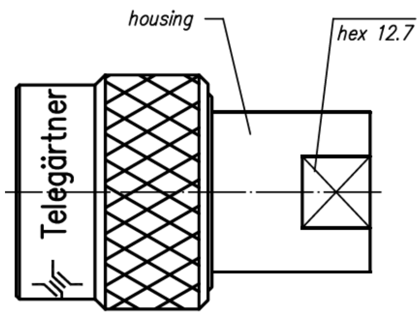
Step 4– Place the connector housing over the cable and tighten using 2 x 11mm spanners:



13.12 LMR195 – TELEGÄRTNER J01020C1276 – N-TYPE MALE CONNECTOR

The Telegärtner J01020C1276 connector comes with the following parts:

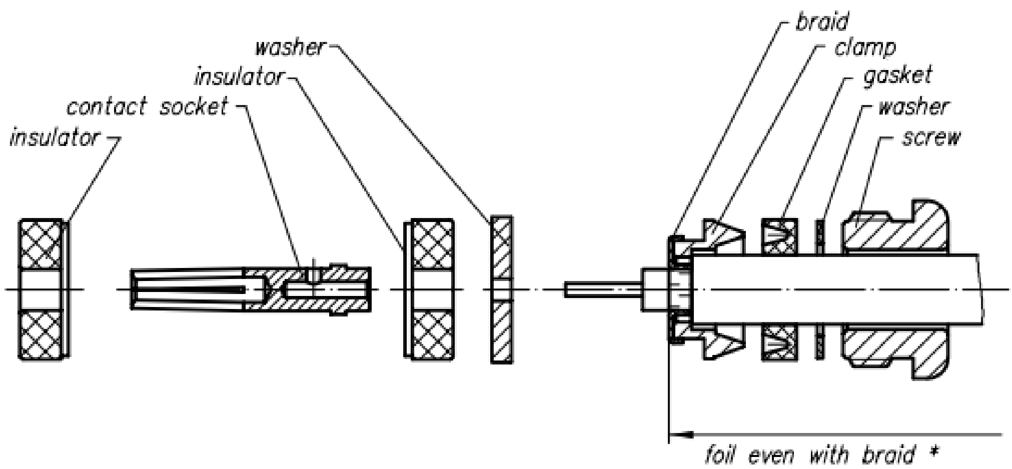


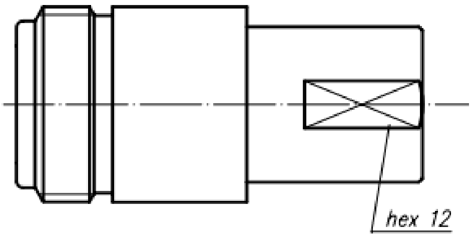


The termination process of this connector is the same as described in **Section 13.11**. Substitute the relevant parts where appropriate.

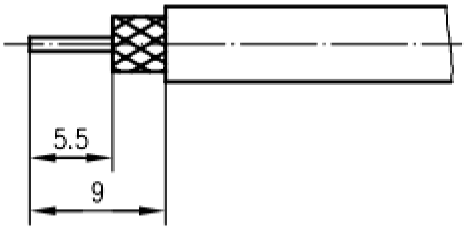
13.13 LMR195 – TELEGÄRTNER J01021H0021 – N-TYPE FEMALE CONNECTOR

The Telegärtner J01020C1276 connector comes with the following parts:

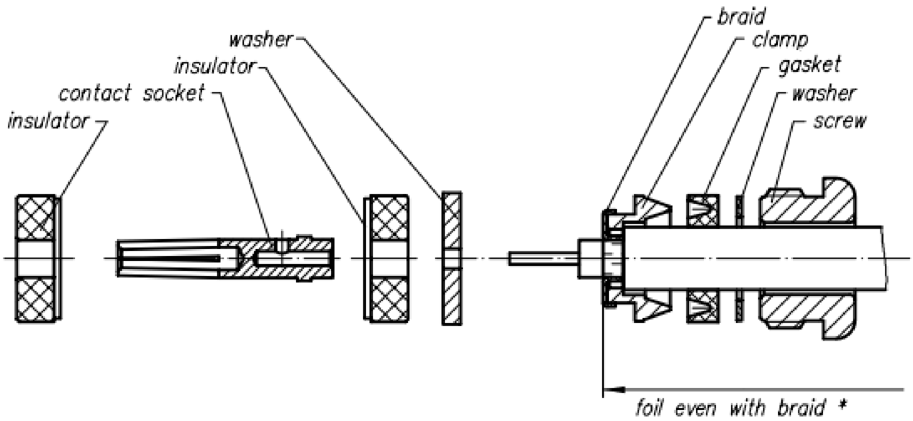




Step 1– Using a suitable knife or blade, remove the first 9mm of the cable outer jacket. Then remove 5.5mm of the cable dielectric to expose the centre conductor:

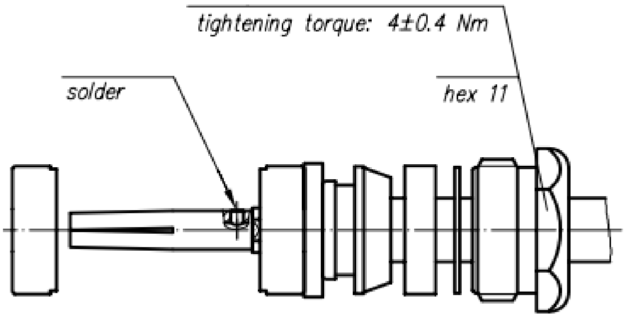


Step 2– Fit the components of the connector as shown. The cable braid should be folded over the clamp prior to fitting the washer:



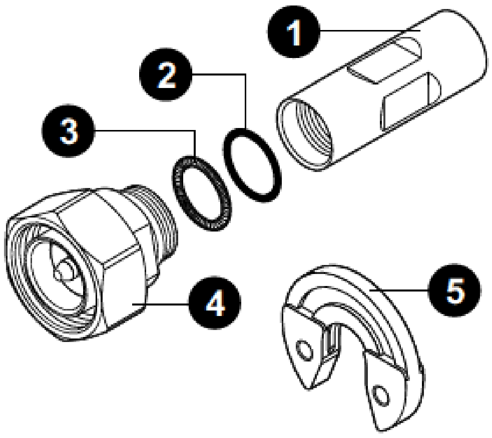
Step 3– solder the conductor contact socket in place, taking care not to apply too much solder. Then fit the second insulator over the pin.

Step 4– Place the connector housing over the cable and tighten using 11mm and 12mm spanners:



13.14 LDF4-50 HELIAX – COMMSCOPE L4TNM-PSA N-TYPE MALE CONNECTOR

The CommScope L4TNM-PSA connector comes with the following parts:



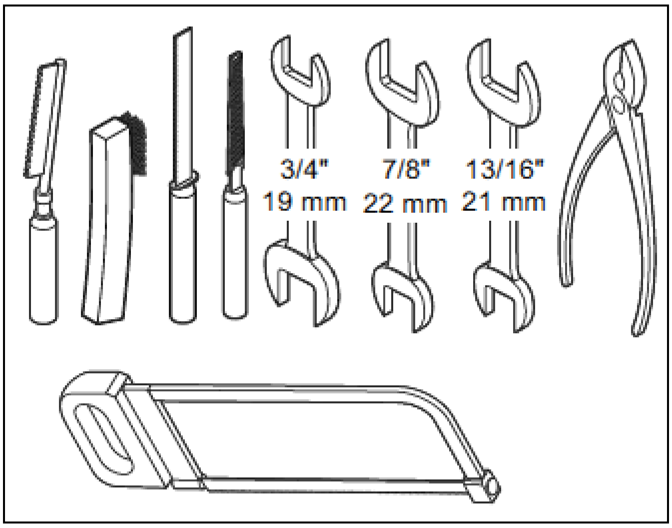
Diagrams courtesy of commscope.com

Note: The below instructions apply to both the male (L4TNM-PSA) and the female (L4TNF-PSA) connectors.

The instructions detailed below assume that the cable preparation tools are not available therefore cable preparation in done manually.

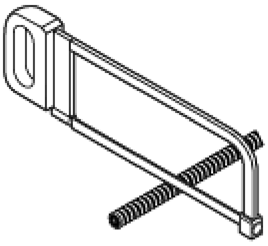
To properly terminate LDF4-50 cable with the L4TN-PSA connector, the following tools should be used:

1. Cable prep tool - PN: MCPT-L4 (Optional)
2. Cable prep tool – PN: CPT-12U (Optional)
3. Flare tool – PN: 224363 (Optional)
4. Hacksaw
5. Ruler
6. 19mm Wrench
7. 21mm Wrench
8. 22mm Wrench
9. Small metal file
10. Small brush for debris removal
11. Knife
12. Pliers

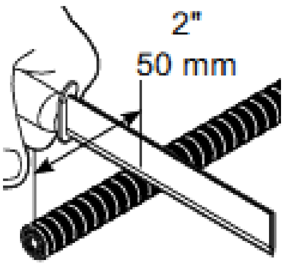


A suitable knife or another appropriate cutting blade can be used instead of the optional cable prep tool, however, the cable prep tool is recommended where possible from both a safety and quality standpoint.

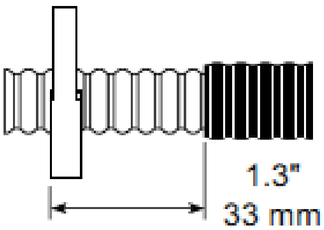
Step 1 – Using a hacksaw, cut the end of the LDF-450 cable at 90° to leave a clean edge:



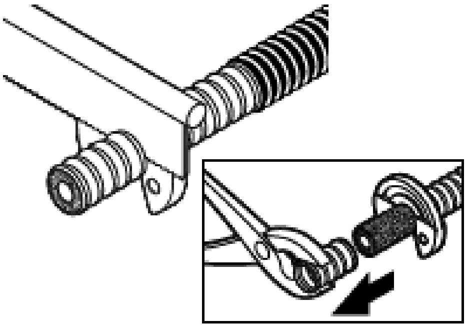
Step 2 – Measure 50mm from the end of the cable and remove the outer cable jacket using an appropriate cutting blade:



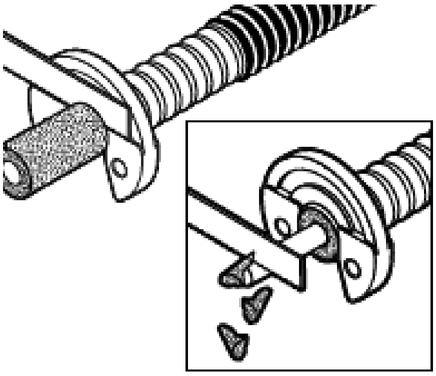
Step 3 – Position the saw guide (supplied with connector) as shown:



Step 4 – With the saw guide still in place, cut the outer conductor. Then remove the outer conductor using pliers:

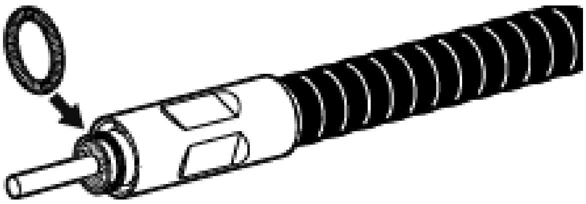


Step 5 – Remove foam and adhesive leaving the centre conductor exposed:

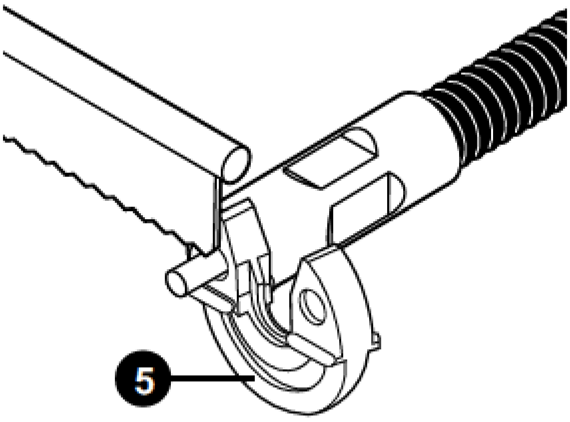


Step 6 – Place O-ring in the position shown below:

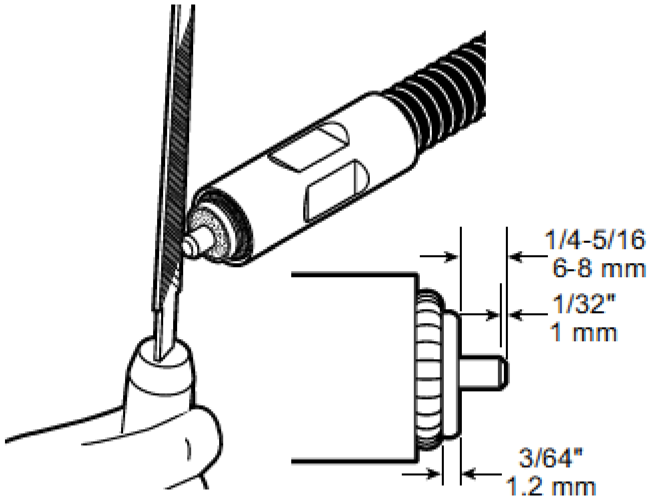
Step 7 – Fit connector body by applying gentle pressure and rotating. Install spring ring on first corrugation:



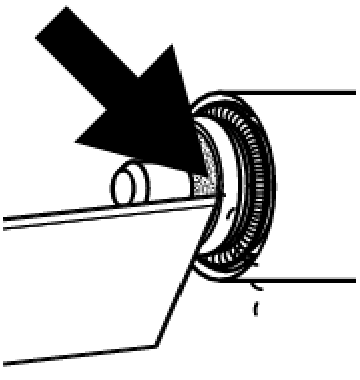
Step 8 – Fit the provided saw guide as shown and cut the centre conductor to length:



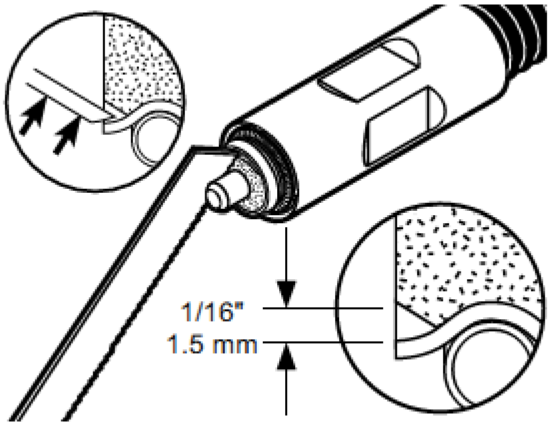
Step 9 – taper the end of the centre conductor using a small file or deburr tool (if available):



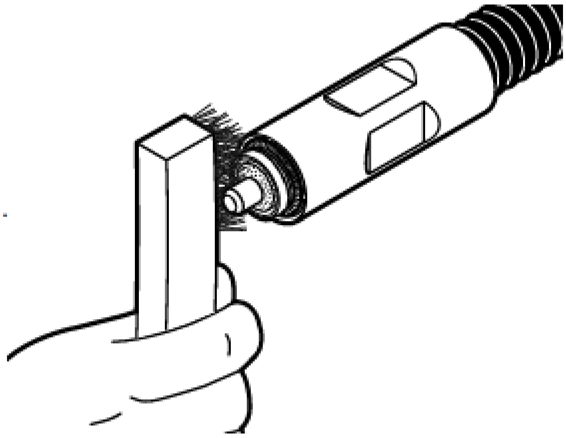
Step 10 – Deburr the inside edge of the outer conductor:



Step 11 – Compress the foam as shown to create a gap between the foam and the outer conductor:



Step 12 – Remove debris using a small wire brush:



Step 13 – Fit the N-Type connector and tighten using wrenches. Do not rotate the wrench at the front of the connector, only the wrench located towards the back of the connector should be rotated as illustrated below: