

LUMEN TERRAIN

User's Manual





LUMEN Terrain

Sensor Solutions Fugitive Methane Leak Detection

User's Manual

910-XXX Rev. A

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Product Registration

Thank you for purchasing Lumen Terrain from BHGE. Please register your product at www.gemeasurement.com/productregistration for product support such as the latest software/firmware upgrades, product information and special promotions.

Services

BHGE provides customers with an experienced staff of customer support personnel ready to respond to technical inquiries, as well as other remote and on-site support needs. To complement our broad portfolio of industry-leading solutions, we offer several types of flexible and scalable support services including: Training, Product Repairs, Service Agreements and more. Please visit www.gemeasurement.com/services for more details.

Typographical Conventions

Note: *These paragraphs provide information that provides a deeper understanding of the situation, but is not essential to the proper completion of the instructions.*

IMPORTANT: *These paragraphs provide information that emphasizes instructions that are essential to proper setup of the equipment. Failure to follow these instructions carefully may cause unreliable performance.*



CAUTION! This symbol indicates a risk of potential minor personal injury and/or severe damage to the equipment, unless these instructions are followed carefully.



WARNING! This symbol indicates a risk of potential serious personal injury, unless these instructions are followed carefully.

NOTICE

NOTICE This symbol indicates information considered important but not hazard related

Safety Issues



WARNING! It is the responsibility of the user to make sure all local, county, state and national codes, regulations, rules and laws related to safety and safe operating conditions are met for each installation.



Attention European Customers! To meet CE Mark requirements for all units intended for use in the EU, all electrical cables must be installed as described in this manual.

Auxiliary Equipment

Local Safety Standards

The user must make sure that he operates all auxiliary equipment in accordance with local codes, standards, regulations, or laws applicable to safety.

Working Area



WARNING! Auxiliary equipment may have both manual and automatic modes of operation. As equipment can move suddenly and without warning, do not enter the work cell of this equipment during automatic operation, and do not enter the work envelope of this equipment during manual operation. If you do, serious injury can result.



WARNING! Make sure that power to the auxiliary equipment is turned OFF and locked out before you perform maintenance procedures on this equipment.

Qualification of Personnel

Make sure that all personnel have manufacturer-approved training applicable to the auxiliary equipment. Please make the factory aware of any customer visits so that any further support to the customer can occur immediately.

Personal Safety Equipment

Make sure that operators and maintenance personnel have all safety equipment applicable to the auxiliary equipment. Examples include safety glasses, protective headgear, safety shoes, etc.

Unauthorized Operation

Make sure that unauthorized personnel cannot gain access to the operation of the equipment. Security levels need to be set properly at the completion of any customer visit.

Product Security

The customer shall provide adequate physical site security measures to protect the Lumen Terrain Sensor Nodes, Base Station, and supporting hardware (antennas, solar panels, weather station, etc.) from damage due to vandalism, airborne debris, theft, security breaches.

Lumen Terrain provides data encryption to protect customer data from intentional snooping that is transmitted via the RF over the air interfaces (between base station and sensor node and between the base station and cloud).

The system also has built in diagnostics for monitoring of the health of system components in the event of sub system degradation or failure. The equipment requires adequate physical security to protect the equipment from damage or intrusion due to forces beyond the design intent of the system.

NOTICE

THIS INSTRUMENT IS INTENDED TO BE USED IN CLOSED NETWORK ENVIRONMENTS. CUSTOMERS SHOULD TAKE STANDARD CYBER SECURITY PRECAUTIONS WHEN ADDING THIS DEVICE TO THEIR NETWORK INFRASTRUCTURE (I.E. NETWORK FIREWALLS, ANTI-VIRUS, ETC.) THIS IS ONLY A CONCERN WHEN THE INSTRUMENT IS CONNECTED VIA ETHERNET.

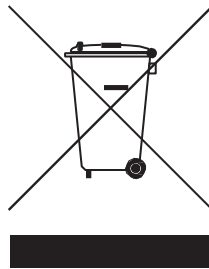
Environmental Compliance

RoHS

The Sensor Solutions Lumen-Terrain fully complies with RoHS regulations (Directive 2002/95/EC).

Waste Electrical and Electronic Equipment (WEEE) Directive

BHGE is an active participant in Europe's *Waste Electrical and Electronic Equipment* (WEEE) take-back initiative (Directive 2012/19/EU).



The equipment has required the extraction and use of natural resources for its production. It may contain hazardous substances that could impact health and the environment.

In order to avoid the dissemination of those substances in our environment and to diminish the pressure on the natural resources, we encourage you to use the appropriate take-back systems. Those systems will reuse or recycle most of the materials of your end life equipment in a sound way.

The crossed-out wheeled bin symbol invites you to use those systems.

If you need more information on the collection, reuse and recycling systems, please contact your local or regional waste administration.

Please visit <http://www.gemeasurement.com/environmental-health-safety-ehs> for take-back instructions and more information about this initiative.

FCC Statements

In order to comply with FCC / ISED RF Exposure requirements, this device must be installed to provide at least 20 cm separation from the human body at all times.

“Afin de se conformer aux exigences d'exposition RF FCC / ISED, cet appareil doit être installé pour fournir au moins 20 cm de séparation du corps humain en tout temps.”

FCC Interference Statement (Part 15.105 (b))

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Part 15 Clause 15.21

“Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment”

FCC Part 15.19(a)

“This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.”

ISED RSS-Gen Notice (in English and French):

“This device complies with Industry Canada's licence-exempt RSSs. Operation is subject to the following two conditions:

- (1) This device may not cause interference; and
- (2) This device must accept any interference, including interference that may cause undesired operation of the device.”

“Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

- 1) l'appareil ne doit pas produire de brouillage;
- 2) l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.”

ISED Canada ICES-003 Compliance Label

“CAN ICES-3 (B)/NMB-3(B)”

Base Station

FCC ID: 2ATKJ-LTBS

IC: 24840-LTBS

Contains FCC ID: N7NMC7455 and Contains IC: 2417C-MC7455

Sensor Node

FCC ID: 2ATKJ-LTSN

IC: 24840-LTSN

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Chapter 1 .Introduction

1.1. Overview

Fugitive methane emissions reduction is one of the most pressing needs in the Oil & Gas industry today. Traditional measurement practices are often inaccurate and inefficient – putting you at risk of dangerous, damaging and costly leaks. In response to this, BHGE has developed a unique and flexible digital platform, that integrates continuous 24/7 monitoring ground-based sensors.

The LUMEN TERRAIN is a high accuracy fugitive methane gas leak detection system that will continuously and remotely detect leaks without the need for human intervention. This ground-based monitoring technology provides real-time quantification and notification of methane emissions both indoors and outdoors while enabling prescriptive analytics for preventative maintenance.

1.2. Theory of Operation

The LUMEN TERRAIN uses metal oxide semiconductors to detect methane. When semiconductor particles are heated, they absorb methane which changes the resistance of the semiconductor. This change is a linear and proportional relationship to the methane concentration. Once calibration has been done at the factory, measuring the semiconductor's resistance will provide the methane concentration.

In order to accurately pin-point the location of fugitive methane emissions, an array of these methane detectors needs to be spread around an area of interest. The sensors are mounted onto the Sensor Nodes of the system, which will transmit data back to the Base Station and to the cloud for analysis.

1.3. System Components

The system contains a main hub – the Base Station, and several other smaller units – the Sensor Nodes.

1.3.1. Base Station

Being the hub of the system, the Base Station is responsible for collecting data transmitted by the Sensor Nodes and sending this data into the cloud where it will be analyzed.

The Base Station consists of the stainless steel enclosure, the 50W solar panel, and the weather station. The stainless steel enclosure contains the electronic boards, wireless router, battery, and a magnetic stylus to reset the Sensor Nodes. Primary power comes from the solar panels while the batteries will act as a backup during nighttime or low sunlight. The battery is expected to keep the system running for 7 days without solar power if data is transmitted twice a day.

1.3.2. Sensor Node

The Sensor Nodes contain the metal oxide semi-conductor methane sensors and temperature/humidity sensors. Ideally, multiple Sensor Nodes are to be installed in an array that is spread out in the area of interest to best pinpoint the location of fugitive methane emissions.

Each Sensor Node contains the electronic enclosure and a 30W solar panel. Inside the electronic enclosure is a battery that is charged by the solar panel. Primary power comes from the solar panel, while the battery can supply power for the Sensor Node for 7 days at data transmission rate of twice per day.

Chapter 2 . Installation

2.1. Installation Guidelines

This section provides general information with respect to the mechanical and electrical installation, and should be thoroughly reviewed before the system is installed. To ensure safe and reliable operation of the LUMEN TERRAIN, the system must be installed in accordance with the established guidelines per application engineering drawing. Those guidelines, explained in detail in this chapter, include the following topics:

- Unpacking the LUMEN TERRAIN System
- Installing the Base Station, Sensor Nodes, and Solar Panels
- Site Considerations
- Making Electrical Connections



WARNING! The LUMEN TERRAIN Sensor Nodes are installed in hazardous areas where flammable methane gas may be present. The importance of proper safety practices cannot be overemphasized.



WARNING! Be sure to follow all applicable local safety codes and regulations for installing electrical equipment. Consult company safety personnel or local safety authorities to verify the safety of any procedure or practice.



Attention European Customers! To meet CE Mark requirements, all cables must be installed as described in Appendix D,.

2.2.Unpacking the LUMEN TERRAIN System

The LUMEN TERRAIN will typically be packaged in a wooden crate, the size of which will depend on the number of Sensor Nodes ordered for the system.

Please inspect the Base Station, Sensor Nodes, and Solar panels upon receiving the package. Each instrument manufactured by Sensor Solutions from Baker Hughes, a GE company is warranted to be free from defects in material and workmanship. Before discarding any of the packing materials, account for all components and documentation listed on the packing slip. If anything is missing or damaged, contact BHGE Customer Care immediately for assistance.

2.2.1. Inspection

Prior to installation, inspect all material to be used in the installation, including:

- Nuts & Bolts - check for debris and damaged threads
- Solar Panels – check for cracks or delamination of solar cells.

2.3.Site Considerations

Proper installation of the LUMEN TERRAIN is important to achieve optimum performance from the system. The following installation recommendations provide general guidelines of how this system should be installed. If the following recommendations cannot be met, please consult an application engineer for a more detailed review of the application to see what performance may be achievable. Following these recommendations may not be the solution for all, since every installation is different.

2.3.1. Installation Location



WARNING! Installation of the Base Station in areas other than General Purpose may create a dangerous environment that may include fires and explosions that may lead to serious injury, or death.

2.3.1.1. Base Station

The Base Station is not rated for hazardous locations and must be installed in a general purpose area. Following local building and electrical codes, the customer is responsible in providing a pre-installed pole for the Base Station to mount on. The standard pole is an 8-ft tall, 3" SCH 40 pole. This is the minimal recommended size due to the weight of the Base Station and solar panel, and external loads from the environment, such as snow accumulation and wind gusts.

2.3.1.2. Sensor Nodes

The Sensor Nodes have a Class I Division 2 rating, meaning it can be installed in hazardous locations that will occasionally contain ignitable concentrations of gases or vapors and is rated for IP65. It is recommended to spread out the installation of the Sensor Nodes in the area of interest. Following local building and electrical codes, the customer is responsible in providing a pre-installed pole for the Base Station to mount on. The standard pole is an 8-ft tall, 2" SCH 40 pole. This is the minimal recommended size due to the weight of the Sensor Node and solar panel, and external loads from the environment, such as snow accumulation and wind gusts.

2.4. Base Station Installation

This section will guide you through the installation of the Base Station enclosure, solar panel, weather station, and necessary electrical connections.



CAUTION! The Base Station weighs 52lbs and requires two people to lift and install.

2.4.1. Enclosure Installation

Once a pole suiting the requirements listed in Section 2.3.1.1 is installed or located, the Base Station enclosure can then be mounted. The enclosure is to be installed at the recommended height of 49 inches measured from the base of the pole to the bottom of the enclosure.

When the enclosure is raised to the specified height, insert the routing clamps into the struts mounted on the back of the enclosure and torque the bolts to 9 ft-lbs. See Figure 1 for proper installation of the routing clamps.

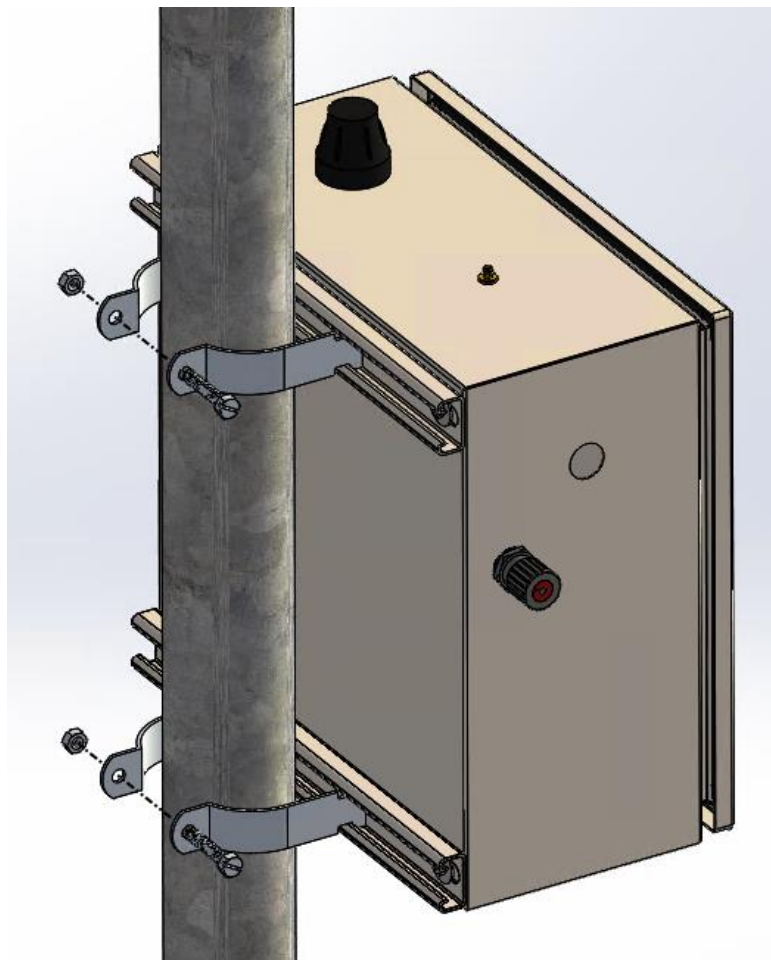


Figure 1: Base Station Enclosure Installation

2.4.2. Solar Panel Installation

The solar panel is to be installed at a height close to 87 inches measured from the top of the solar panel to the base of the pole. To assemble the solar panel bracket and attach the solar panel, see Figure 2. The orientation of the bracket will depend on location of the site. As a rule of thumb, always orient the bracket so the solar panel will face towards the equator. The optimum angle heavily depends on the latitude of the location. In the Northern Hemisphere, the best tilt angle is the latitude plus 15° while the best tilt angle in the Southern Hemisphere is the latitude minus 15°. Torque all fasteners to 6 ft-lbs. Punch out one of the two bottom knockouts on the solar panel Once the solar panel has been attached to the solar panel mounting bracket, the entire assembly can be mounted on to the pole as seen in Figure 3 and the U-bolts torqued to 6 ft-lbs. A cap to seal off the top of the pole is recommended.

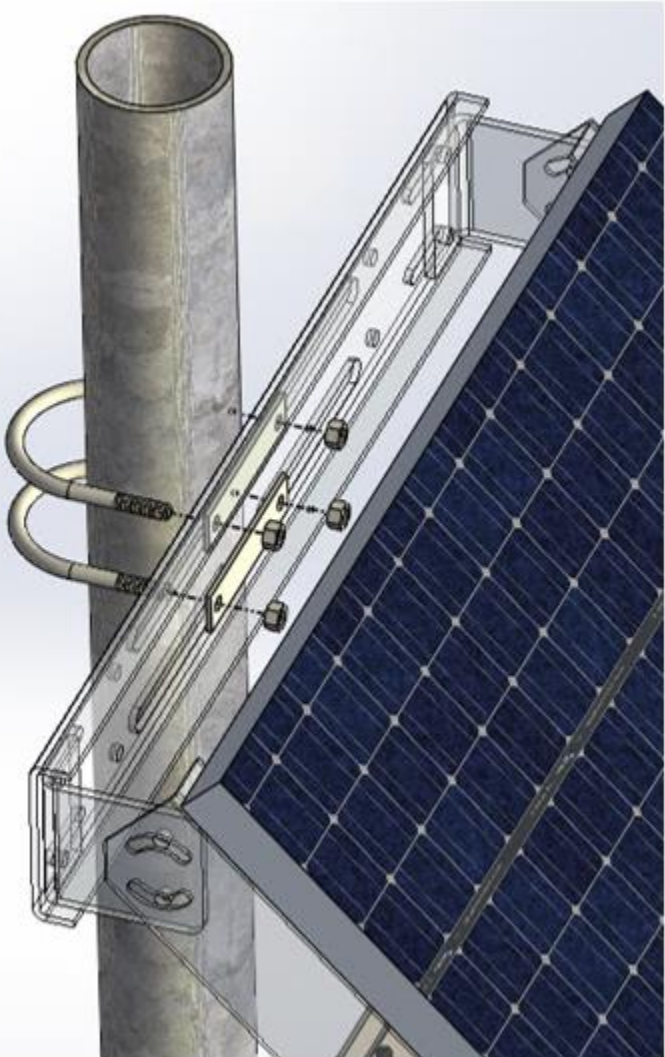
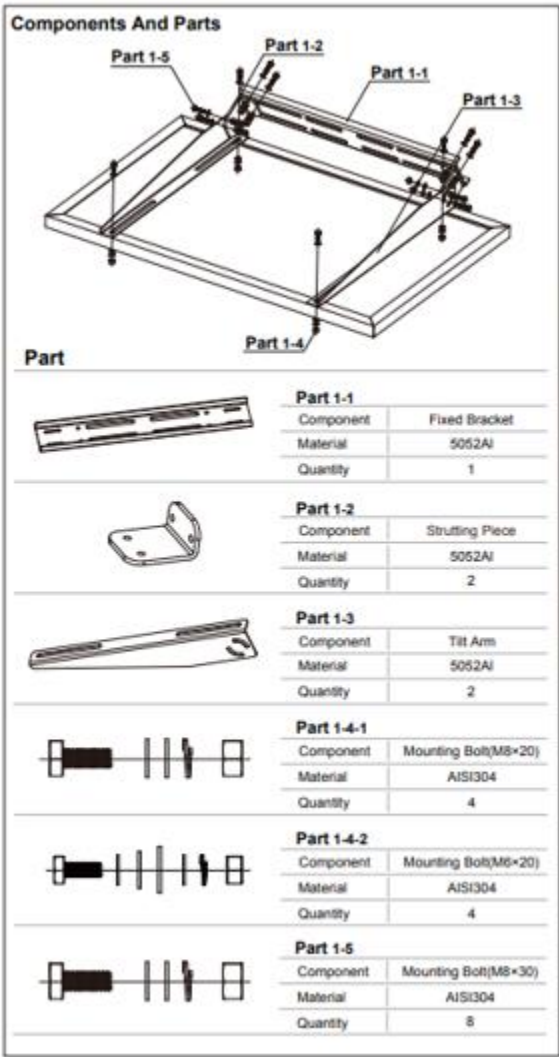


Figure 2: LEFT: Solar Panel Mounting Bracket Parts and Assembly
Figure 3: RIGHT: Mounting Solar Panel Assembly to Pole

2.4.3. Weather Station

The weather station should be mounted last due to its fragility. It is to be mounted at a height above the solar panel bracket mounts.

Assemble the Weather Station mounting brackets to the pole and weather station. Install the Weather Station on the pole as shown in Figure 4 and torque the nuts to 6 ft-lbs.

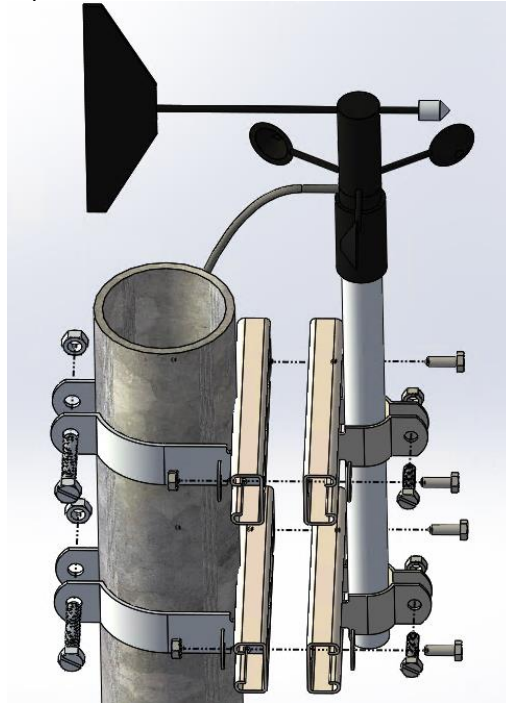


Figure 4: Weather Station Mounting

2.4.4. Base Station Conduit Wiring Connection (Enclosure End)

For the Base Station Conduit installation, all instructions will refer to the following figure:

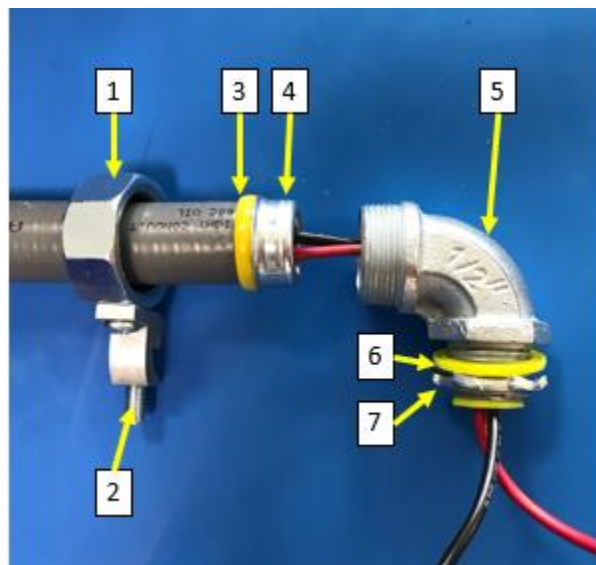


Figure 5: Right Angle Conduit Detail

To attach the right-angle conduit adapter to the base station enclosure, loosen Item 1 from Item 5 so they are disconnected as shown in the figure above. Note that Items 3 and 4 should already be attached to the conduit as shown. Ensure Item 4 is fully inserted by turning it clockwise until there is no more movement. Remove the cables from Item 5 and remove the lock nut (Item 7). There is a supplied washer kit – one metallic ring (Item 8) and one rubber ring (Item 9) – to adapt Item 5 to the hole in the enclosure. Insert the metal ring without the rubber into Item 5 such that it is next to Item 6 and insert into the enclosure hole as shown in the following figure:

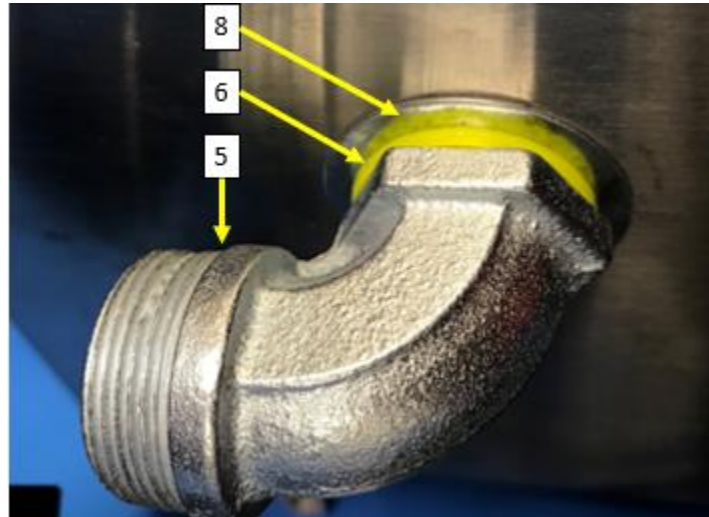


Figure 6: Exterior Connection of Right Angle Adapter

On the interior of the base station enclosure, insert the rubber ring (Item 9) in such a way that the raised rubber groove is fitted into the enclosure hole. Note that the groove will not sit perfectly flush with the enclosure wall. See following figure for interior connection.

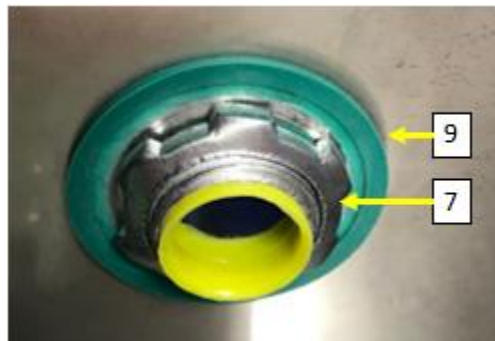


Figure 7: Interior Connection of Right Angle Adapter

Tighten Item 7 first to get the lock nut to grip onto Item 9. Then turn Item 5 until the opening is tight while facing up. Note that Items 7 and 5 might need to be adjusted to achieve this orientation. If Item 5 is hand tight but the opening is not facing up, loosen both Items 7 and 5 slightly and reorient Item 7 such that Item 5 will be hand tight when the opening faces up. Once Item 5 has been hand-tightened, use a wrench and give Item 5 one complete turn. Visually inspect that Item 6 is compressed to ensure a watertight connection. Remove Item 2 from Item 1 and ensure the cables from the conduit reach the interior of the enclosure via Item 5. Reattach Item 1 into Item 5 until it is hand-tight. Use a wrench and tighten Item 1 by giving it 1.5 turns. Reinstall Item 2 into Item 1. If Item 1 is oriented in such a way that Item 2 cannot be attached, Continue tightening Item 1 until there's enough clearance for Item 2.

The finished assembly should look similar to the following figure. Note that the orientation of Item 2 may be different.

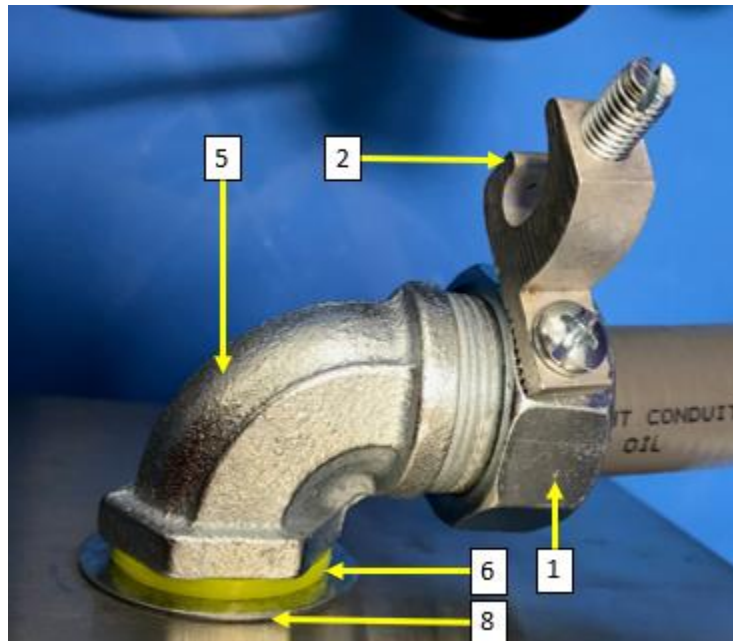


Figure 8: Finished Right Angle Conduit Connection

2.4.4.1. Wiring Connection, Enclosure

On the Base Station enclosure end, connect the red cable from the conduit to the '+' terminal of the Solar Panel Connection on the PCB and connect the black cable from the conduit to the '-' terminal of the solar panel connection on the PCB as shown in the following figure:

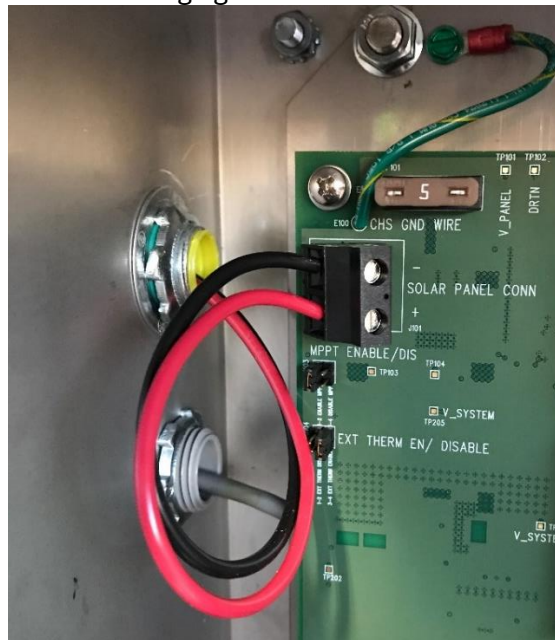
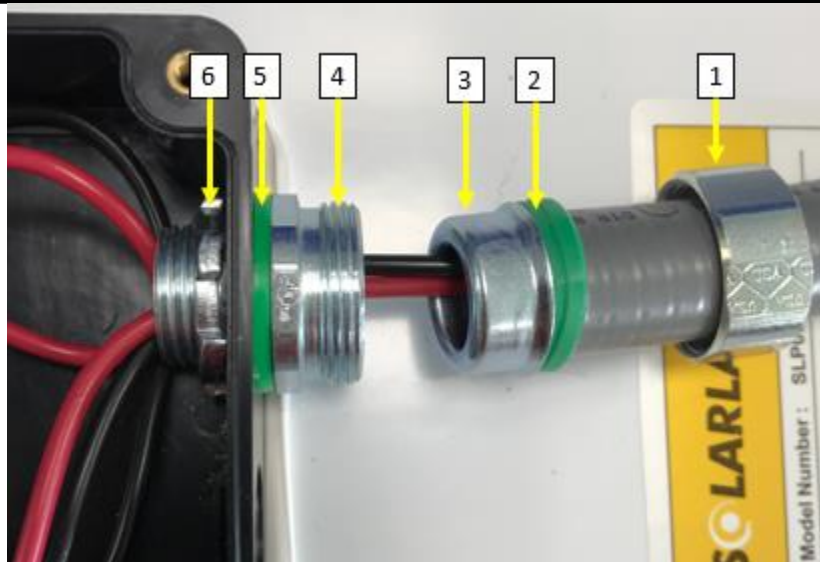


Figure 9: Conduit Wire Connection in Base Station Enclosure

2.4.5. Conduit Wiring Connection (Solar Panel End)

Refer to the following image for item callouts on the solar panel end of the conduit installation:



Remove Item 1 from Item 4. Items 2 and 3 should be already installed in the conduit but check to see if Item 3 is secure by turning it clockwise. Remove the lock nut (Item 6) and insert Item 4 into knockout created previously with Item 5 sitting on the outside of the solar panel junction box. Tighten Item 6 such that it grips to the interior of the junction box and hand tighten Item 4. Use a wrench to tighten Item 4 by giving it 1 complete rotation. Visually inspect Item 5 to ensure a watertight connection. Hand-tighten Item 1 into Item 4 followed by wrench tightening Item 1 by turning it 1.5 turns.

2.4.5.1. Wiring Connection, Solar Panel

In the solar panel, remove the plastic bracket shown in the following figure and connect the wire lugs of the conduit at the solar panel end to the terminals inside the junction box of the solar panel as seen in Figure XXX, ensuring that the red wire (positive) plugs into the terminal connected to the side of the diode with the gray strip. Place the plastic bracket back as seen in Figure AAA

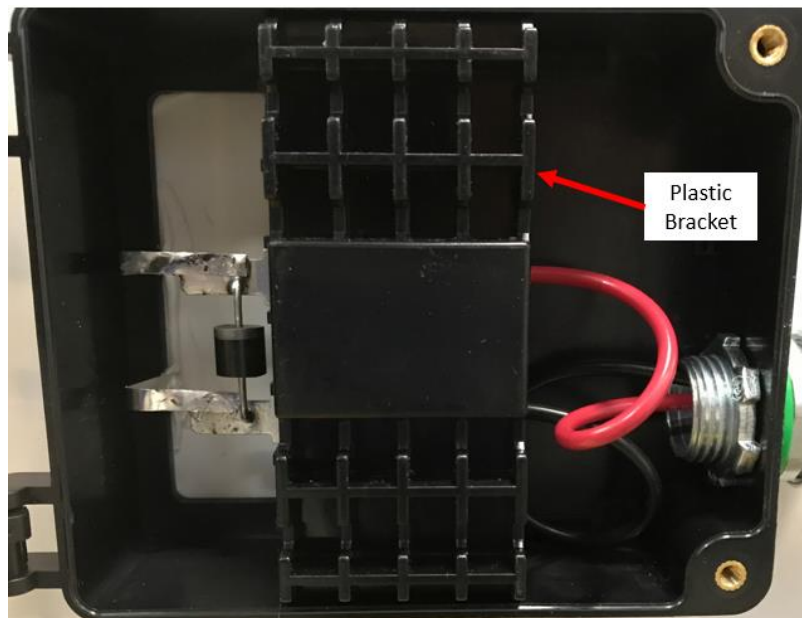


Figure AAA: Plastic Bracket in Solar Panel

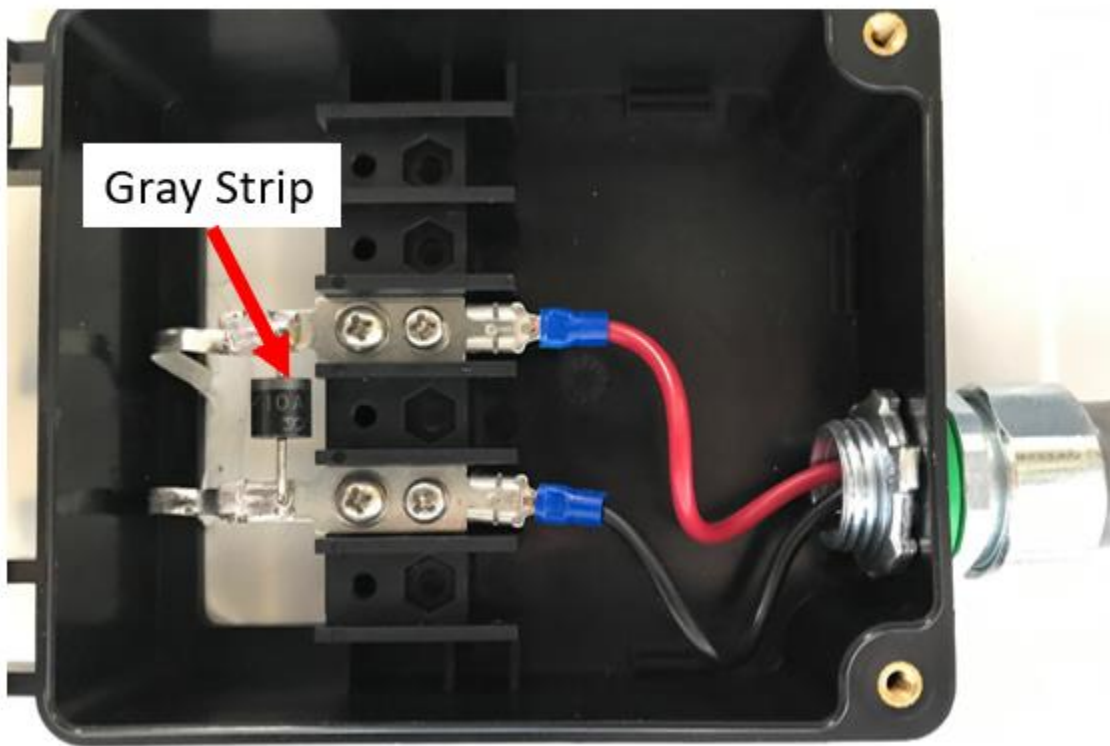


Figure XXX: Solar Panel Wiring Connection

2.4.6. Antenna Installation

Due to the length of the Sub-1G antenna, the antenna does not come installed on the Base Station. Remove the protective cap on top of the Base Station enclosure and torque the supplied Sub-1G antenna on the exposed bulkhead to 5 in-lbs as shown in Figure 10.

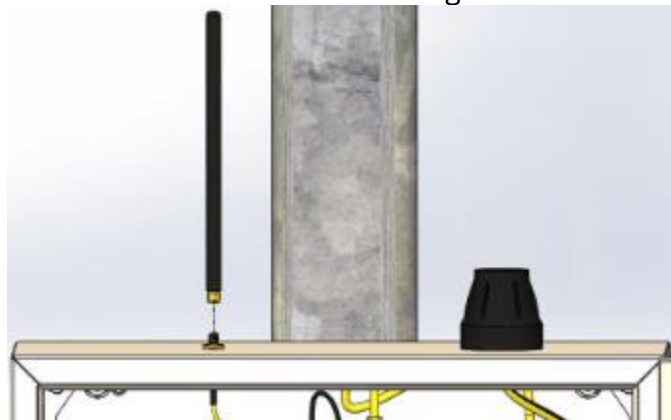


Figure 10: Base Station Antenna Installation

2.4.7. Weather Station Wiring

Insert the weather station cables into the gray plastic adapter and wire the colored wires corresponding to the labels found on the screw terminal as shown in 11.



Figure 11: Weather Station Wiring Connection

2.4.8. Battery Connection

Connect the leads of the wires from the conduit in the Base Station enclosure to the terminal board. Follow the indicated color labels near the terminal as shown in Figure 12.

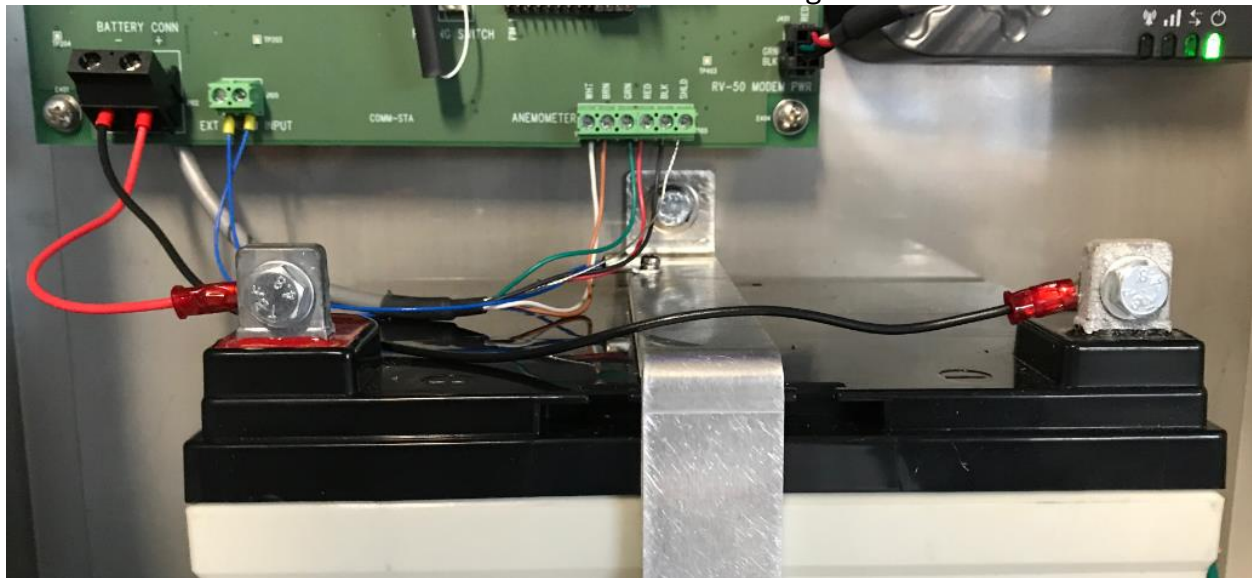


Figure 12: Base Station Battery Connection

2.5. Sensor Node Installation

This section will guide you through the installation of the Sensor Node enclosure, solar panel, weather station, and necessary electrical connections.

2.5.1. Sensor Node Enclosure Installation

After a pole with the requirements mentioned in Section 2.3.1.2 is installed or located, the Sensor Node enclosure can be mounted. The enclosure should be installed at a recommended height of 64 inches measured from the base of the pole to the top surface of the enclosure.

When the enclosure is raised to the specified height, insert the 2 inches U-bolts onto the elongated holes of the enclosure as shown in Figure 13 and torque the U-bolts to 90 in-lbs. Ensure that the backplate rests on the pole itself and not on the flange of the enclosure.

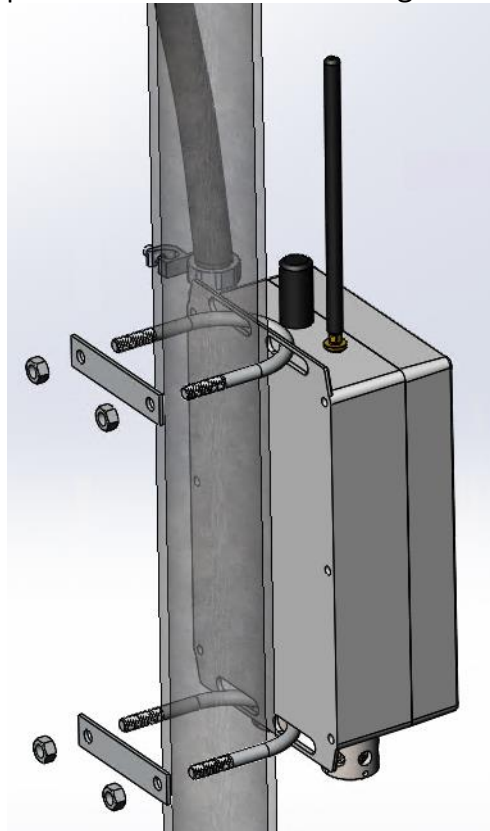


Figure 13: Node Enclosure Installation

2.5.2. Sensor Node Solar Panel

Install the Sensor Node solar panel on the pole at a height close to 90 inches measured from the top of the solar panel to the base of the pole.

Assemble the Sensor Node solar panel mounting bracket parts and attach the Sensor Node solar panel as shown in Figure 14. As a rule of thumb, always orient the bracket so the solar panel will face towards the equator. The optimum angle heavily depends on the latitude of the location. In the Northern Hemisphere, the best tilt angle is the latitude plus 15° while the best tilt angle in the Southern Hemisphere is the latitude minus 15°. Knock out one of the two indentations on the side of the solar panel junction box. Install the entire assembly on to the pole at specified height as shown Figure 14 and torque the U-bolts to 90 in-lbs.

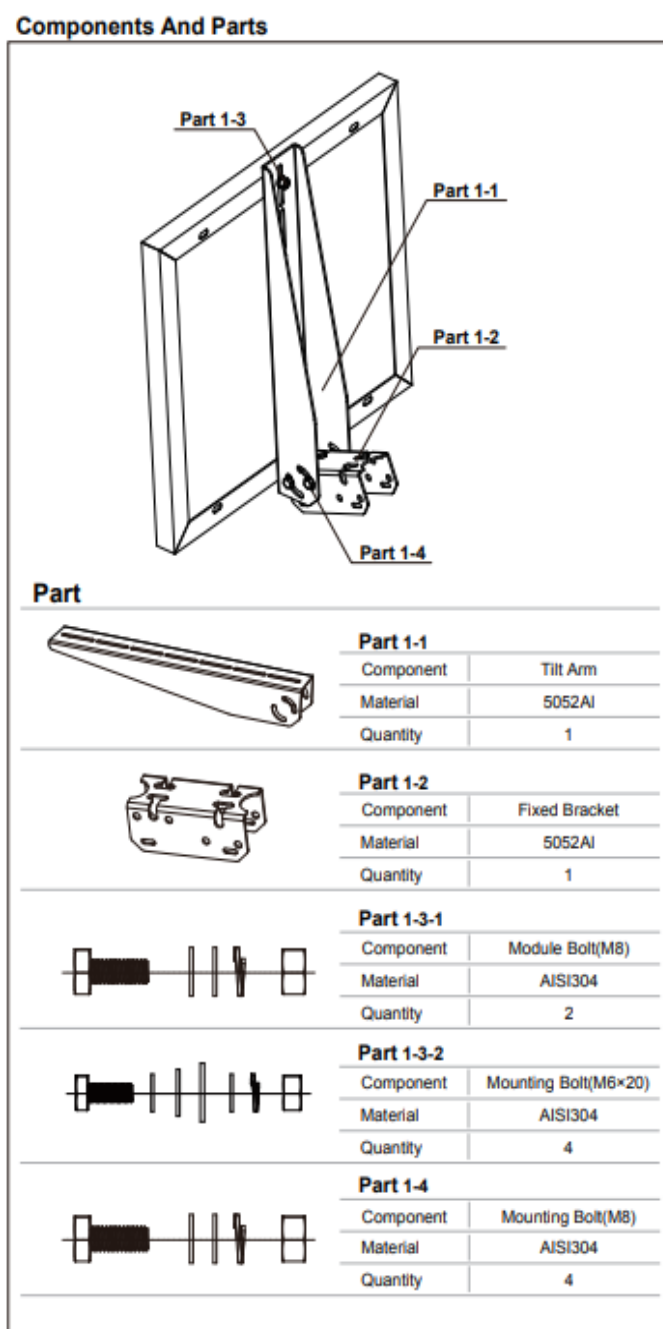


Figure 14: Solar Panel Mount Assembly

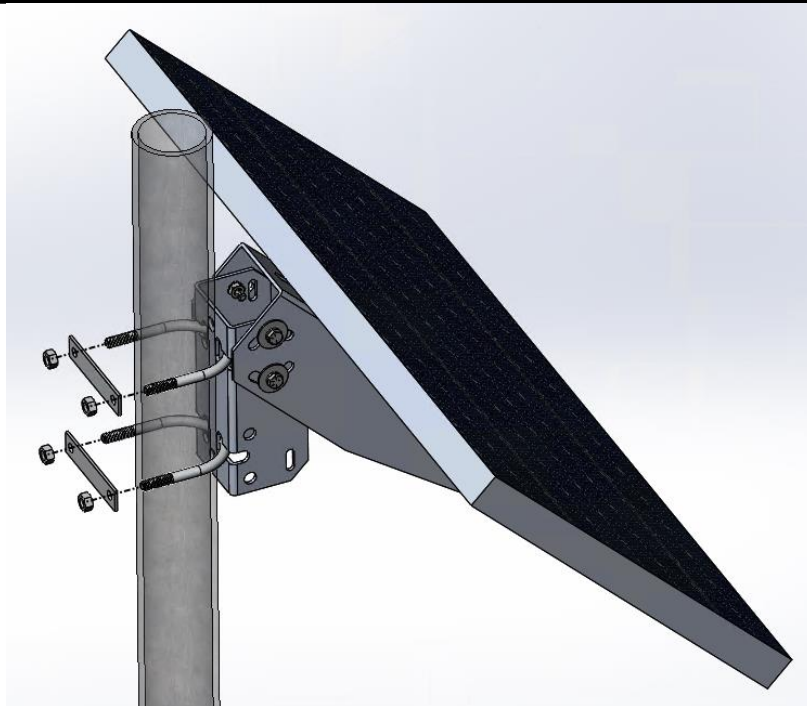


Figure 15: Solar Panel Assembly Pole Mount

2.5.3. Sensor Node Conduit Wiring Connection

Refer to the following figure for Item callouts:

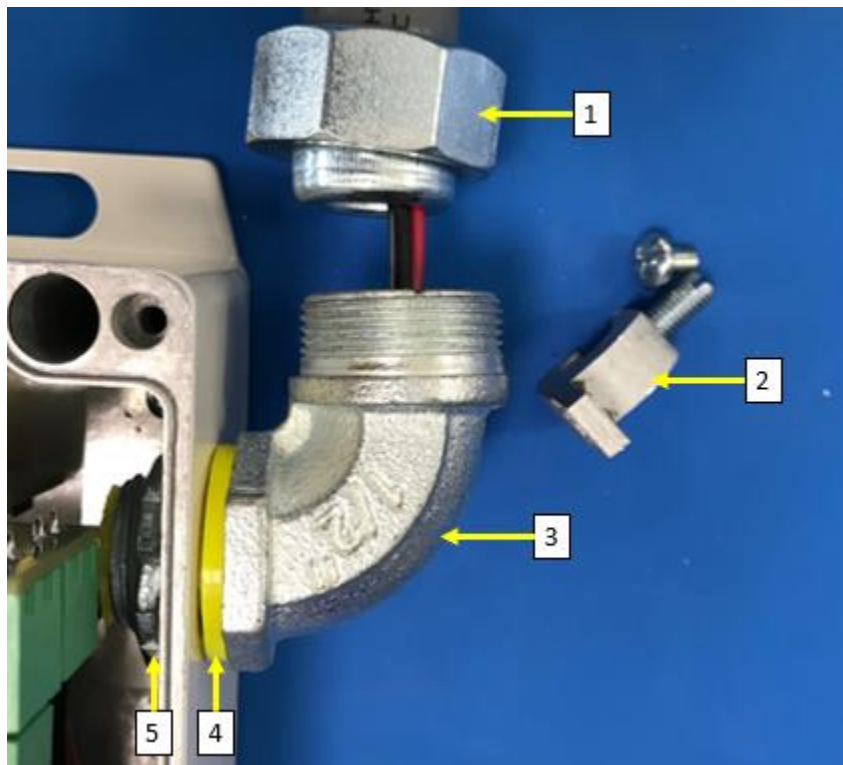


Figure 16: Sensor Node Right Angle Adapter Item Callouts

Remove Item 1 from Item 3 along with the red and black cables. Remove Item 5 from Item 3 and insert that end into the open hole of the Sensor Node enclosure such that Item 4 is on the outside of the enclosure as shown above. Similar to how the Base Station right angle adapter was installed, Items 5 and 4 will need to be adjusted in a way that the opening of Item 3 faces up once it is hand-tight. Once hand tight, use a wrench and turn Item 3 one full turn and visually inspect that Item 4 is compressed to ensure a water-tight connection. Pull the red and black cables from the conduit and through Item 3.

Remove Item 2 from Item 1 and hand-tighten Item 1 into Item 3. Using a wrench, tighten Item 1 by turning it 1.5 turns to ensure a water-tight connection is made. Reattach Item 2 into Item 1. If Item 1 is oriented in such a way that Item 2 cannot be attached, continue tightening Item 1 until there's enough clearance for Item 2. Finished installation should look similar to the following figure, with orientation of Item 2 varying.

For connection to the junction box on the solar panel, follow instructions in Section 2.4.5 – Conduit Wiring Connection (Solar Panel End) and for wiring connection, follow the instructions in Section 2.4.5.1

2.5.3.1. Battery and Solar Panel Wiring, Enclosure

Fully insert the red wire from the conduit into the Solar Panel Fuse Assembly as shown in the figure below. Note that the assembly highlighted in blue is the Solar Panel Fuse Assembly. For the black wire, remove the Solar Panel Terminal and insert the black wire into the remaining opened port and secure the wire by tightening the screw terminal. Plug the Solar Panel Terminal back into the PCB into the position shown in Figure XXX.

The battery end of the Battery Fuse Cable should be connected to the battery connections, under the Battery Terminal Shield, from the factory. Attach the Battery Terminal to the PCB as shown in Figure XXX.

Once both green connectors are blocked in, use the supplied 8" cable tie to secure the connections as shown below and cut off excess length.

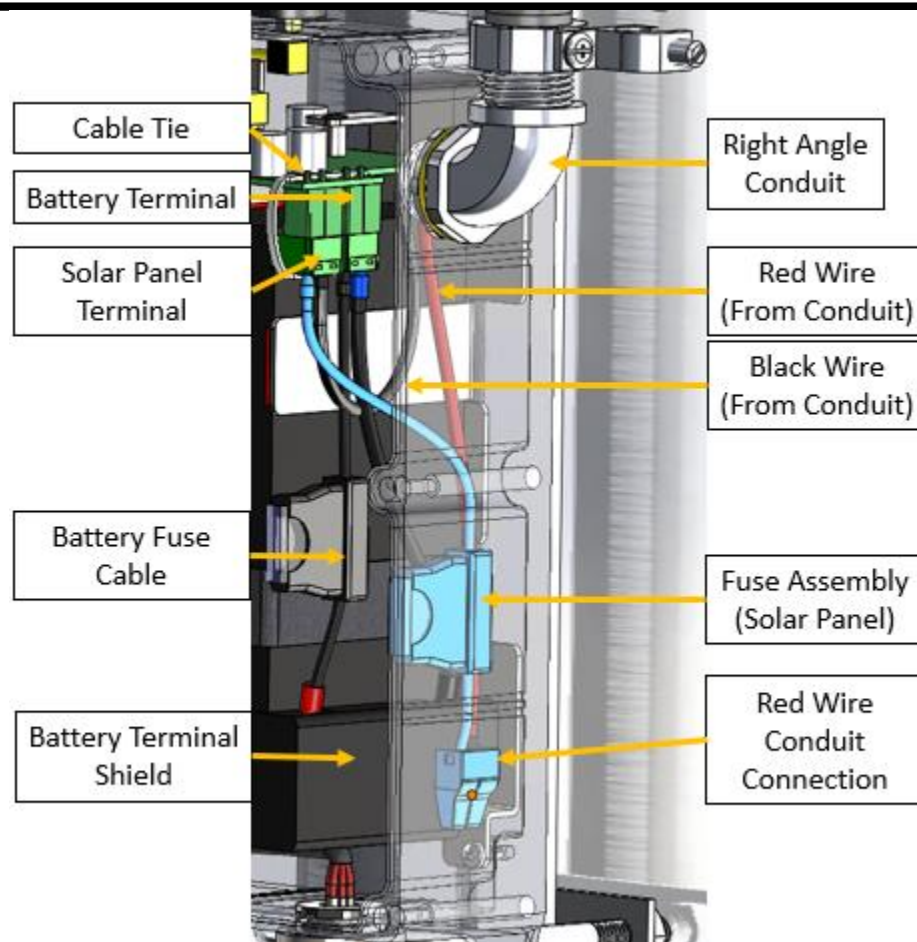


Figure XXX: Battery and Solar Panel Wiring Connections.

2.5.4. Antenna Installation

Due to the length of the Sub-1G antenna, the antenna does not come installed on the Base Station. Simply remove the protective cap on top of the Base Station enclosure and torque the supplied Sub-1G antenna on the exposed bulkhead to 5 in-lbs as shown in the following figure.



Figure 17: Sensor Node Antenna Installation

2.5.5. Battery and Solar Panel Wiring

Chapter 3 . Software Initialization

3.1. TBD

3.1.1. TBD

3.1.1.1. TBD

3.2. TBD

3.3. TBD




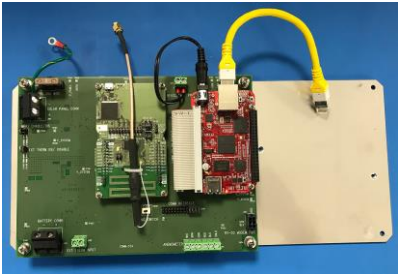

3.4. TBD


Chapter 4 . Spare Parts

This section lists all the spare parts for the Lumen system if troubleshooting procedures has indicated a hardware failure.

4.1.Base Station Spare Parts

Table 1: Base Station Spare Parts

BHGE PN	Description	Picture
126M6391	50W Solar Panel	
126M6398	12V Battery	
130M9040	Sub 1G Antenna	
134M9103	Comm Station Board Stack	
130M8606	Sierra Wireless Modem	

132M5508	5A Fuse	
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4.2.Sensor Node Spare Parts

Table 2: Sensor Node Spare Parts

BHGE PN	Description	Picture
129M4502	Sensor Node Assembly	
130M1103	30W Solar Panel	
128M5166	9V Battery	
130M9040	Sub 1G Antenna	

Appendix A: Torque Specifications

A.1. Base Station

Table 3: Base Station Torque Specifications

Component	Torque
Exterior	
Sub-1G Antenna	5-5.25 in-lbs (56-59 cNm)
Sierra Wireless Antenna	54-57 in-lbs (610-644 cNm)
Solar Panel Adapter (locknut)	1 turn pass hand-tight
Solar Panel Adapter (conduit)	1.5 turns pass hand-tight
Right Angle Adapter (locknut)	1 turn pass hand-tight
Right Angle Adapter (conduit)	1.5 turns pass hand-tight
Weather Station Enclosure Adapter	½ turn pass hand-tight
Solar Panel Brackets	6-6.3 ft-lbs (68-72 cNm)
Solar Panel Bracket U-bolts	6-6.3 ft-lbs (68-72 cNm)
Weather Station Struts and Poles	6-6.3 ft-lbs (68-72 cNm)
Enclosure Routing Clamps	9-9.5 ft-lbs (108-113 in-lbs)
Interior	
Battery Cables	5-5.25 ft-lbs (60-63 in-lbs)
Solar Terminals	7-7.35 in-lbs (80-84 cNm)
Weather Station/Thermistor Terminals	3.5 in-lbs (40 cNm)
All SMA Connections	5-5.25 in-lbs (56-59 cNm)
Main PCB Board Stack	7-7.35 in-lbs (80-84 cNm)

A.2. Sensor Node

Table 4: Node Torque Specification

Component	Torque
Sub-1G Antenna	5-5.25 in-lbs (56-59 cNm)
Enclosure Cover	12-12.6 in-lbs (136-143 cNm)
Solar Panel Brackets	6-6.3 ft-lbs (72-76 in-lbs)
Solar Panel U-bolts	90-94.5 in-lbs (1017- 1068 cNm)
Enclosure U-bolts	90-94.5 in-lbs (1017- 1068 cNm)
Right Angle Adapter (locknut)	1 turn pass hand tight
Right Angle Adapter (conduit)	1.5 turns pass hand tight
Solar Panel Adapter (locknut)	1 turn pass hand-tight
Solar Panel Adapter (conduit)	1.5 turns pass hand-tight

Warranty

Each instrument manufactured by Panametrics flow meter from Baker Hughes, a GE company is warranted to be free from defects in material and workmanship. Liability under this warranty is limited to restoring the instrument to normal operation or replacing the instrument, at the sole discretion of Panametrics & Panametrics Flow meter. Fuses and batteries are specifically excluded from any liability. This warranty is effective from the date of delivery to the original purchaser. If Panametrics & Panametrics Flow meter determines that the equipment was defective, the warranty period is:

- One year from delivery for electronic or mechanical failures
- One year from delivery for sensor shelf life

If Panametrics & Panametrics Flow meter determines that the equipment was damaged by misuse, improper installation, the use of unauthorized replacement parts, or operating conditions outside the guidelines specified by Panametrics & Panametrics Flow meter, the repairs are not covered under this warranty.

The warranties set forth herein are exclusive and are in lieu of all other warranties whether statutory, express or implied (including warranties or merchantability and fitness for a particular purpose, and warranties arising from course of dealing or usage or trade).

Return Policy

If a Panametrics & Panametrics Flow meter instrument malfunctions within the warranty period, the following procedure must be completed:

1. Notify Panametrics & Panametrics Flow meter, giving full details of the problem, and provide the model number and serial number of the instrument. If the nature of the problem indicates the need for factory service, Panametrics & Panametrics Flow meter will issue a RETURN AUTHORIZATION NUMBER (RAN), and shipping instructions for the return of the instrument to a service center will be provided.
2. If Panametrics & Panametrics Flow meter instructs you to send your instrument to a service center, it must be shipped prepaid to the authorized repair station indicated in the shipping instructions.
3. Upon receipt, Panametrics & Panametrics Flow meter will evaluate the instrument to determine the cause of the malfunction.

Then, one of the following courses of action will then be taken:

- If the damage is covered under the terms of the warranty, the instrument will be repaired at no cost to the owner and returned.
- If Panametrics & Panametrics Flow meter determines that the damage is not covered under the terms of the warranty, or if the warranty has expired, an estimate for the cost of the repairs at standard rates will be provided. Upon receipt of the owner's approval to proceed, the instrument will be repaired and returned.

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