

Last updated by  
Last updated

Harald Sleire  
2021-03-02



Project **702202 Swarm S2**  
Document no. **702202-252-01** rev. **00**

# Swarm<sup>®</sup>S2 Installation and User Manual

## Revision history

00	First issue	AF/RN	HSL	HSL	2021-03-02
Revision	Change log	By	Chk. by	Appr. by	Appr. date

## Table of Contents

List of Tables .....	2
List of Figures .....	2
1 Introduction .....	3
1.1 Warnings and safety notice .....	3
2 Document change log .....	4
3 Referred documents .....	4
4 Safety .....	4
4.1 Operator qualifications for installation .....	4
5 Swarm S2 product overview .....	5
5.1 The Swarm S2 Datalogger variants .....	6
5.2 The Swarm S2 ultrasound sensor variants .....	8
6 Installation .....	9
6.1 Recommended Safety equipment .....	9
6.2 Swarm S2 LT Sensor installation .....	9
6.2.1 Box contents .....	9
6.2.2 Required equipment .....	9
6.2.3 Pipe preparation .....	10
6.2.4 Swarm S2 LT Sensor mechanical installation .....	10
6.3 Swarm S2 (U)HT Sensor installation .....	17
6.3.1 Box contents .....	17
6.3.2 Required equipment .....	17
6.3.3 Pipe preparation .....	18
6.3.4 Swarm S2 (U)HT Sensor mechanical installation .....	18
6.4 Swarm S2 LT and (U)HT Datalogger installation and configuration .....	23
6.4.1 Box content .....	23
6.4.2 Required equipment .....	23
6.4.3 Swarm S2 Datalogger(s) mechanical installation .....	24
6.4.4 Electrical connection .....	26
6.4.5 Start-up .....	28
7 Operation .....	29
7.1 Connecting to Swarm S2 Datalogger .....	30
7.1.1 Bluetooth .....	30
7.1.2 USB .....	30
7.2 "Swarm S2 Config Tool" .....	31
7.3 Micro switches .....	31
7.4 Configuration .....	31
7.4.1 Processing parameters .....	31
7.4.2 Ultrasound parameters .....	32
7.4.3 ISA100.11a Radio .....	33
7.5 Data retrieval .....	34
7.5.1 Swarm S2 service application .....	34
7.5.2 µSD card .....	34
8 Safe operation of the Swarm S2 System .....	37
8.1 Safety Description and Electrical I/O Parameters .....	37

8.2	Product marking Swarm S2 LT and (U)HT .....	37
8.3	Conditions for safe use .....	38
8.4	Changing the Battery Box .....	39

## List of Tables

Table 1	Document change log.....	4
Table 2	Referred documents.....	4
Table 3	Swarm S2 Datalogger variants .....	7
Table 4	Swarm S2 Sensor variants .....	8
Table 5	Swarm S2 LT Sensor installation.....	16
Table 6	Swarm S2 (U)HT Sensor installation.....	22
Table 7	Swarm S2 Datalogger mechanical installation .....	26
Table 8	Changing the battery box .....	40
Table 9	Changing the Battery Cells .....	41

## List of Figures

Figure 1	Swarm S2 System block diagram (interconnection diagram) .....	6
Figure 2	Swarm S2 LT Sensor deployment system .....	9
Figure 3	Swarm S2 (U)HT Sensor deployment system (from HotSense® instructions) .....	17
Figure 4	Swarm S2 Temperature probe .....	17
Figure 5	Pipe preparation prior to ultrasound sensor installation (from HotSense® instructions) .....	18
Figure 6	Swarm S2 Datalogger mounting bracket and conduit(example) .....	23
Figure 7	Swarm S2 Datalogger installation .....	24
Figure 8	Swarm S2 Sensor connections .....	26
Figure 9	The Temperature probe.....	27
Figure 10	Battery connection.....	28
Figure 11	Swarm S2 operating panel .....	29
Figure 12	Swarm S2 datalogger: micro switches, SD card slot, and USB C port .....	30
Figure 13	Swarm S2 LT product label.....	37
Figure 14	Swarm S2 (U)HT product label.....	37
Figure 15	Swarm S2 LT Sensor product label.....	38
Figure 16	Battery Box (Yokogawa) .....	39

## 1 Introduction

The purpose of this manual is to give field engineers, installation personnel, and end user sufficient information to be able to do safe installation and operation of the PipeMonit® Swarm® S2 in an Ex Hazardous zone. The document is structured in four main sections, one describing the product family, one describing the physical installation, one describing the configuration of the system via the service port (Bluetooth®) and ISA100 network and the final one describing safe operation.

Note: This manual does not contain how to setup or build up an ISA100 wireless infrastructure (network), it is assuming that wireless infrastructure is installed and operational when attempting to initiate the Swarm S2 ISA100 versions.

### 1.1 Warnings and safety notice

#### Modifications

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

#### Interference

**This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.**

**This Device complies with Industry Canada License-exempt RSS standard(s). 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.**

#### Exposure

**To comply with FCC/IC RF exposure limits for general population / uncontrolled exposure, the antenna(s) used for this transmitter must be installed on outdoor permanent structures to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.**

## 2 Document change log

Rev. no.	Description
00	First issue

*Table 1 Document change log*

## 3 Referred documents

Document No.	Title
[1] EN 60079-0:2018	Explosive atmospheres - Part 0: Equipment - General requirements
[2] IEC 60079-0 7 <sup>th</sup> ed	Explosive atmospheres - Part 0: Equipment - General requirements
[3] EN 60079-11:2012	Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"
[4] IEC 60079-11 6 <sup>th</sup> ed	Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"
[5] 702202-252-02	Swarm S2 EX Safety Manual
[6] 702202-252-03	Swarm S2 SW Configuration Manual

*Table 2 Referred documents*

## 4 Safety

Safety of personnel, equipment and the environment are paramount prior to and during all use of this product. No work should be started unless it can be completed safely. Therefor read this manual before attempting field installation and make sure you have the right work permits to execute the job in hazardous area.

Please make sure not to open the battery box in hazardous condition and ensure that batteries are disposed of according to local rules.

### ***Think safety!***

### 4.1 Operator qualifications for installation

Operator should be familiar with mechanical installation and work in hazardous area. Operator should have gone through basic training for installation Swarm Systems, that is, have complete knowledge of the content of this manual. Operator should be familiar with use of grinders (in case of surface preparation is required) and should be familiar with use of torque wrenches and hand tools.

Operator should be familiar with NDT equipment to the extent that taking a wall thickness reading and evaluating an ultrasound echo is managed with confidence.

Operator should be familiar with setting up and communicating with external devices via Bluetooth from a Windows computer, and should have familiarised himself with the configuration tool described herein.

## 5 Swarm S2 product overview

The Swarm S2 System and all its components are intended to be used in outdoor industrial environment and to be installed on pipelines and vessels with the purpose to monitor metal loss of the pipe/vessels walls. The equipment is intended to be used in wet environment complying to IP65.

The main specifications of the system are:

Operating voltage	7,2VDC
Current consumption	80mA active/0.12mA idle
Frequency of UT sensor	4-5MHz
Relative humidity	Up to 100%
Max altitude	2000m
Operating Temperature range	-40 until 70°C
Pollution degree (environment)	4 (industrial)
Protection grade	IP65
Hazardous classification	Zone 1 (IEC Ex (ATEX) Exib IIB T4)
Battery life	3-5 years (one measurement per day)

Swarm S2 has two basic configurations, Low Temperature version (LT) and High Temperature version (U)HT. The only difference between the two is the interface to the sensors, as can be seen from the images on the next pages indicating the different connector interfaces. Both the LT and the (U)HT Dataloggers come in two basic variants one with only Bluetooth® interface and one with Bluetooth® and ISA100 wireless interface.

The system can be supplied with 3 different sensor types:

- Swarm S2 LT Sensor, handling temperature from -40°C to +150°C.
- Swarm S2 HT Sensor, handling temperature from -+150°C to +380°C.
- Swarm S2 UHT Sensor, handling temperature from +350°C to +550°C.

In this respect the temperature given is indicative of the surface temperature of the pipe onto which the sensor is mounted. For the LT and HT, they will though handle ambient temperatures up to the limit.

The Swarm S2 datalogger is equipped to measure up to 4 UT sensors simultaneously allowing for easy installation and monitoring of top and bottom of line corrosion in addition to any other relevant locations, like for example any known phase transitions (liquid/gas) that may occur in the pipe. Or one can apply up to 4 sensors along a bend to monitor erosion in bend.

The Swarm System is easily connected between the sensors and the Datalogger with cables provides with the delivery. The LT sensor have connectors whereas the (U)HT sensors come with fixed cables.

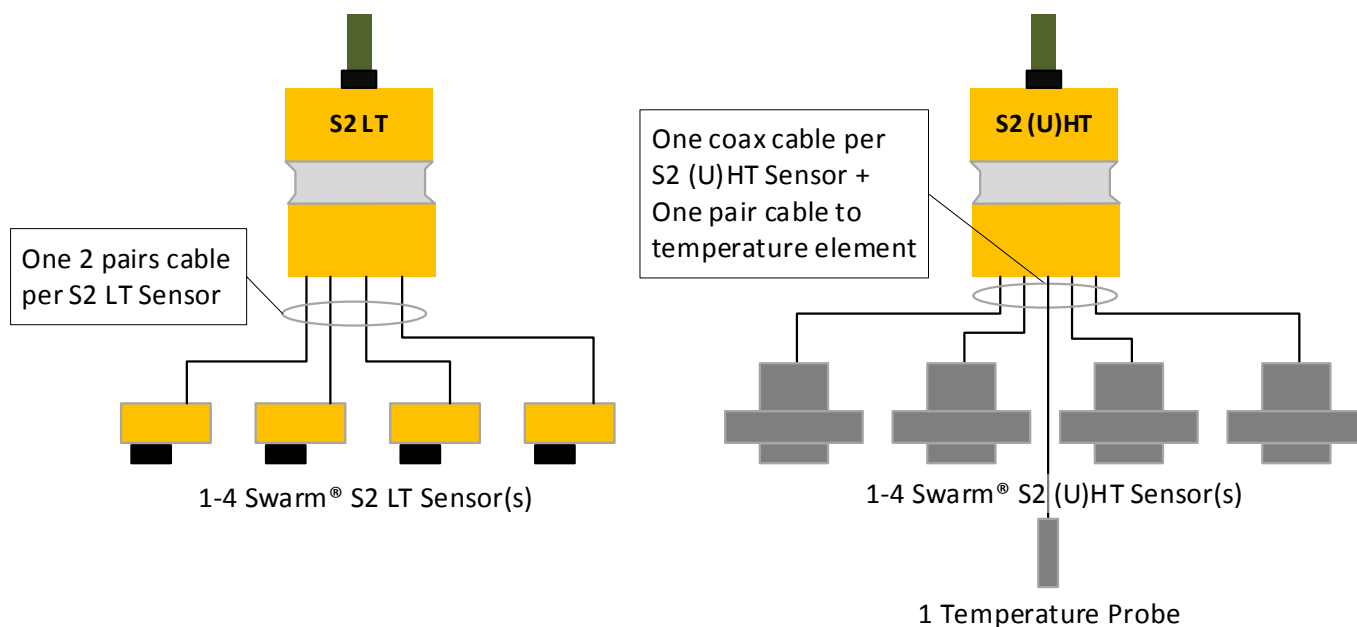



Figure 1 Swarm S2 System block diagram (interconnection diagram)

## 5.1 The Swarm S2 Datalogger variants

Product	Main features	Picture of unit
Swarm® S2 LT	Contains Bluetooth® radio interface and connects to <u>low</u> temperature ultrasonic sensors	







Product	Main features	Picture of unit
<b>Swarm® S2 LT ISA100</b>	Contains Bluetooth® and ISA100 radio interface and connects to <u>low</u> temperature ultrasonic sensors	 
<b>Swarm® S2 (U)HT</b>	Contains Bluetooth® radio interface and connects to <u>high</u> temperature ultrasonic sensors	 
<b>Swarm® S2 (U)HT ISA100</b>	Contains Bluetooth® and ISA100 radio interface and connects to <u>high</u> temperature ultrasonic sensors	 

Table 3 Swarm S2 Datalogger variants

## 5.2 The Swarm S2 ultrasound sensor variants

The UT sensors are contact probes with direct contact to the pipe.

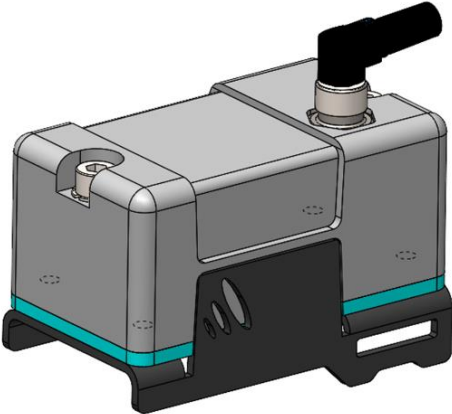


Product	Main features	Illustration of unit
<b>Swarm® S2 LT Ultrasound Sensor</b>	<ul style="list-style-type: none"> <li>– Body in aluminium</li> <li>– Deployment kit in 304SS</li> <li>– Contain 1 UT sensor + 1 temp sensor.</li> <li>– Cable: 1-5m standard 4wire cable with connectors</li> <li>– Metal loss capability better than 10µm*</li> <li>– Temperature Range -40°C to +150°C</li> </ul>	
<b>Swarm® S2 HT Ultrasound Sensor</b>	<ul style="list-style-type: none"> <li>– Body and deployment kit in 304SS</li> <li>– Delay: line 25mm</li> <li>– Cable: 300mmMIMS + 2m R316 (variable extensions available)</li> <li>– SMA Connector</li> <li>– Metal loss capability better than 20µm*</li> <li>– Temperature Range +150°C to +380°C</li> </ul>	
<b>Swarm® S2 UHT Ultrasound Sensor</b>	<ul style="list-style-type: none"> <li>– Body and deployment kit in 304SS</li> <li>– Delay: line 75mm</li> <li>– Cable: 300mmMIMS + 2m R316 (variable extensions available)</li> <li>– SMA Connector</li> <li>– Metal loss capability better than 30µm*</li> <li>– Temperature Range +350°C to +550°C</li> </ul>	
<p>* Metal loss capability is defined as the system's ability to distinguish wall thickness variations measured at the same location and temperature over time (repeatability).</p>		

Table 4 Swarm S2 Sensor variants

## 6 Installation

For installation of Swarm S2 LT follow the instructions in Section 6.2, for installation of Swarm S2 (U)HT follow the instructions in Section 6.3 and for Swarm S2 Datalogger installation and configuration follow the instructions in Section 6.4 .

### 6.1 Recommended Safety equipment

Adhere to any local rules and regulations for protective equipment but the following is a minimum requirement:

- Safety shoes, hard hat, ear protection as required
- Safety glasses
- Gloves

### 6.2 Swarm S2 LT Sensor installation

In this section the mechanical installation and electrical connection of the Swarm S2 LT Sensor is explained in detail.

#### 6.2.1 Box contents

To install the Swarm S2 LT Sensor(s) the following is required:

- 1-4 Swarm S2 LT Sensor(s) as shown in Table 4, shipped in its own box.
- 1-4 Swarm S2 LT Sensor mounting bracket(s) as shown in Figure 2, shipped in the Swarm S2 LT Sensor box.
- Stainless steel band as shown in Figure 2, shipped separately.
- Band buckle as shown in Figure 2, shipped separately.
- Galvanic separation band as shown in Figure 2, shipped separately.
- Protective conduit, as required, as shown in Figure 2, shipped separately.



Figure 2 Swarm S2 LT Sensor deployment system

#### 6.2.2 Required equipment

- Molycote/Dow Corning High Vacuum Grease or similar for acoustic coupling between ultrasound sensor and the pipe
- Copper paste for threads
- Sandpaper/machine with 120 to 400 grit for smoothening/cleaning the pipe surface
- 4mm hex key for assembly of sensors
- 3&5mm hex key for assembly of band buckle

- Torque wrench for tightening the steel band buckle up to 4 Nm
- 5mm hex torque wrench bit
- Ruler or tape measure to measure installation bend length

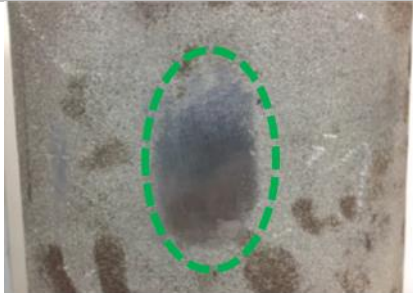
### 6.2.3 Pipe preparation




Prior to installation of the Swarm S2 LT Sensors, the pipe surface should be prepared through the following steps (for installation of up to four sensors on one band). Please note that the four sensors may also be installed on individual bands if monitoring requirements requires that:

1. If the pipe is insulated, about 150mm of the insulation in the flow direction should be removed from the whole circumference of the pipe. No residual should be left on the pipe.
2. The desired installation point for each sensor should be identified.
3. If the sensors are to be installed on a weld between two pipe sections, the weld cap should be grinded flush to the pipe outer wall at each sensor installation location.
4. An area of roughly 20mm diameter should be cleaned and smoothened at each sensor installation location. Note that the goal here is to get a smooth surface and NOT to flattening the pipe. Therefore, excessive material removal should be avoided.

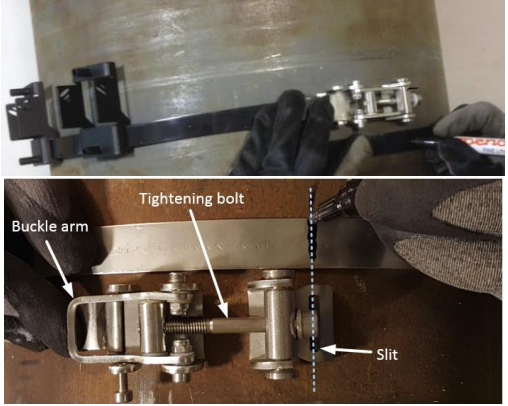



### 6.2.4 Swarm S2 LT Sensor mechanical installation

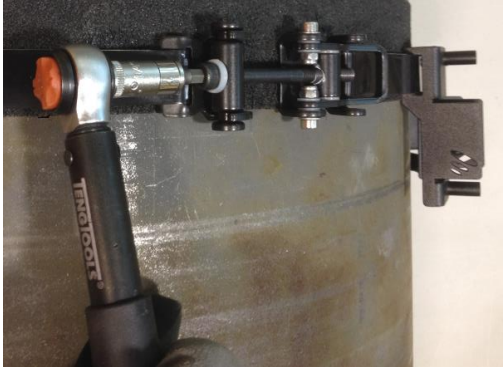


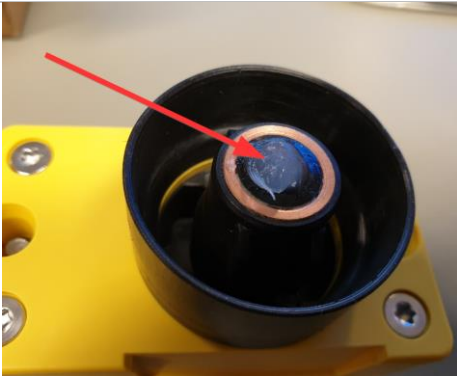
Follow the steps in Table 5 to install a single band with up to 4 Swarm S2 LT Sensors on the pipe.

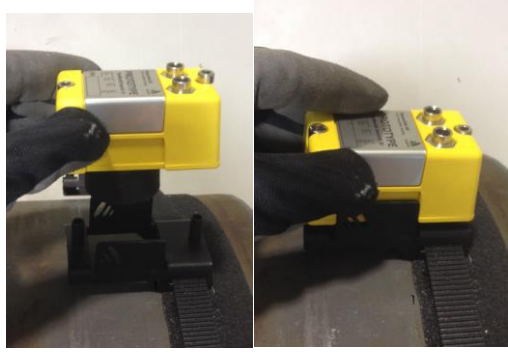

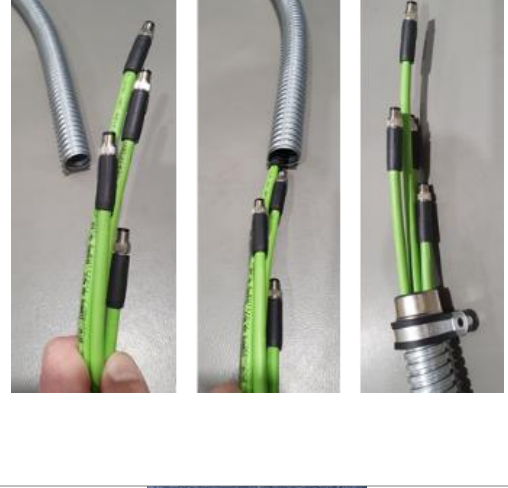

Step	Description	Illustration
1.	Identify the Thickness Monitoring Location (TML) where you intend to install the sensors. Evaluate the surface and attempt to measure the wall thickness with an UT instrument. Clean and polish the area of the TML with a sandpaper to a smooth and preferably shiny surface.	

Step	Description	Illustration
2.	<p>If galvanic separation between the pipe and the PipeMonit® Swarm® installation is required, tape synthetic galvanic separation band around the circumference of the pipe before continuing.</p> <p>Make sure the galvanic insulation does not cover the TML. The galvanic insulation shall only be underneath the steel band, buckle, and sensor brackets.</p>	
3.	<p>Place the steel band around the pipe and cut it approximately 100cm longer than the circumference of the pipe on which the sensors will be installed.</p>	
4.	<p>Prepare the buckle by applying the copper paste to the tightening bolt.</p>	

Step	Description	Illustration
5.	Insert one of the free ends of the band into the slit of the buckle from the upper side.	
6.	Pull the free end of the band through the buckle approximately 50 cm. Make sure the band is thoroughly folded as the brackets should be able to slide over.	
7.	Bend the steel band back at approximately 15cm to leave approximately 30cm under the buckle as shown in the picture. <b>NB! Make sharp folds on the steel band.</b> The sensor brackets shall be able to slide over the folded steel band if they shall be located close to the buckle.	
8.	Insert the free end of the band into the first bracket to be installed.	
9.	Repeat until you have all the brackets to be installed on the band.	

Step	Description	Illustration
10.	<p>Strap the band (including brackets) around the pipe. Tighten the band by hand as firm as possible. Make a mark on the band aligned with the slit of the free end of the buckle (see illustration).</p> <p>Note that the tightening bolt should be loosened to maximum length, and the buckle arm should be in <u>closed</u> position when doing this step.</p> <p><b>If this is not done properly, the final tension of the band could turn out not to be sufficient, and further installation of the band difficult!</b></p>	
11.	<p>Make a sharp bend at the marked length. A wrench can be used to ensure a sharp bend.</p> <p>Cut away excessive band but ensure that min 10cm of band remained after folding, see illustration.</p>	
12.	<p>Install the free end of the buckle onto the folded end of the band at the bend just prepared in step 11.</p>	
13.	<p>Install the band (including brackets) using the buckle. Position the sensor brackets at the TML(s).</p> <p>Tighten by hand and close the buckle.</p>	

Step	Description	Illustration
14.	Tighten the band by using 5mm hex key and a torque wrench to 4 Nm on the buckle bolt.	
15.	Fasten the M4 locking bolt and spring washer using a 3mm hex key.	
16.	Attach the protective silicon gasket.	
17.	<p>Apply a small amount of grease on the surface of the sensor in the centre. Make sure that the grease does not trap air bubbles so smoothen it towards the edges and leave a cone in the middle.</p> <p><b>Note: In the following illustrations the sensor apar yellow and with two connectors. The Swarm S2 LT Sensor is black aluminium housing and have only one connector.</b></p> <p><i>The installation of Swarm S1 and Swarm S2 LT Sensor is identical, thus the use for the same illustrations</i></p>	

Step	Description	Illustration
18.	Install the Swarm S2 LT Sensor into the sensor bracket.	
19.	Secure the Swarm S2 LT Sensor(s) with the two bolts using a 4mm hex key. Fasten firmly but not to any specific torque.	
20.	<p>Bundle the cables together if needed and pull them through the conduit as shown.</p> <p>Secure the conduit in the pipe end but make sure the cables are not in direct contact with the pipe if the pipe surface temperature exceeds the cable specification.</p> <p>Sensor Ser.No.: _____ Clock position _____</p> <p>Sensor Ser.No.: _____ Clock position _____</p> <p>Sensor Ser.No.: _____ Clock position _____</p> <p>Sensor Ser.No.: _____ Clock position _____</p>	
21.	Install the Swarm S2 Bracket and Datalogger as described in Section 6.4.3.	

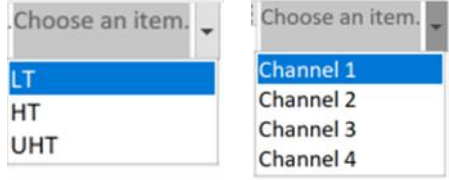
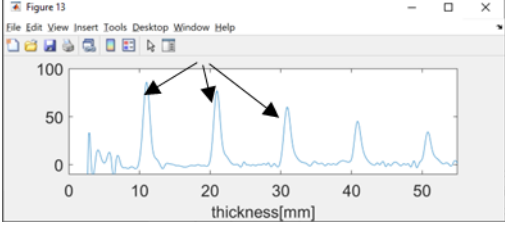
Step	Description	Illustration
22.	Open the Swarm S2 user interface and choose the right type of ultrasound sensor and channel number the sensor is connected to. Type the nominal thickness of the pipe and run the live view of the trace.	
23.	You should now see the ultrasound trace which is updated every 10-15 seconds. You should now be able to clearly see at least 3 backwall echoes, as shown in the picture for a 10mm thick sample.	
24.	The installation of the sensor is now complete	

Table 5 Swarm S2 LT Sensor installation

### 6.3 Swarm S2 (U)HT Sensor installation

In this section the mechanical installation and electrical connection of the Swarm S2 (U)HT Sensor(s) is explained in detail. Please note that the HT and UHT sensor is installed in the same manner and sequence, the only difference is the height of the sensor body, the UHT sensor being 50mm higher than the HT sensor.

#### 6.3.1 Box contents

Swarm S2 (U)HT Sensor(s) comes with the following:

- 1-4 HT or UHT ultrasound sensors as shown in Table 4, these are shipped in individual boxes.
- 1-4 deployment kits, one for each (U)HT sensor, as shown in Figure 3, these are shipped in a separate box.
- 1 K-element temperature probe as shown in Figure 4 is packed in the same box as the deployment kit.

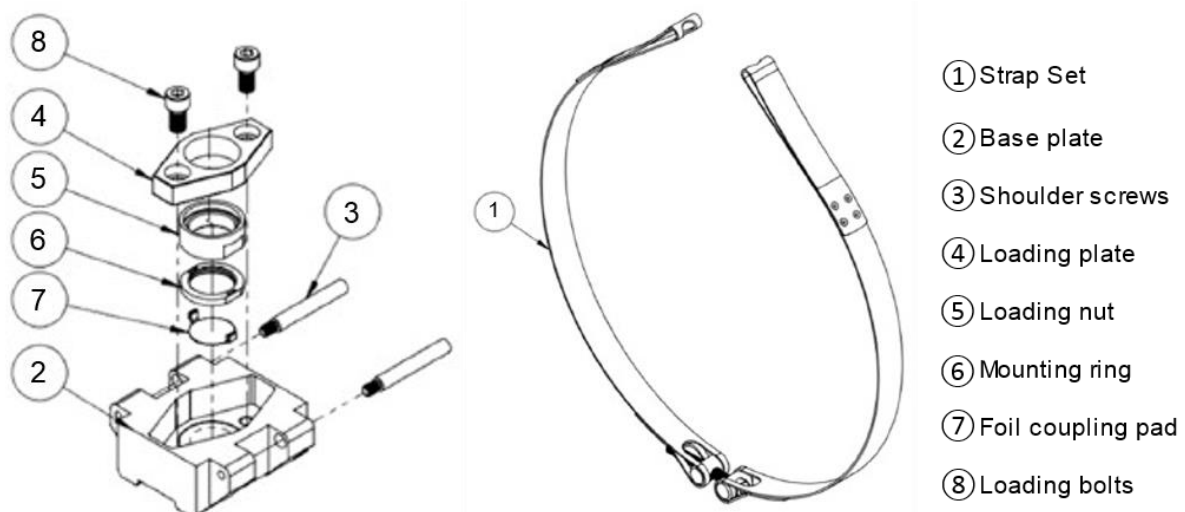


Figure 3 Swarm S2 (U)HT Sensor deployment system (from HotSense® instructions)

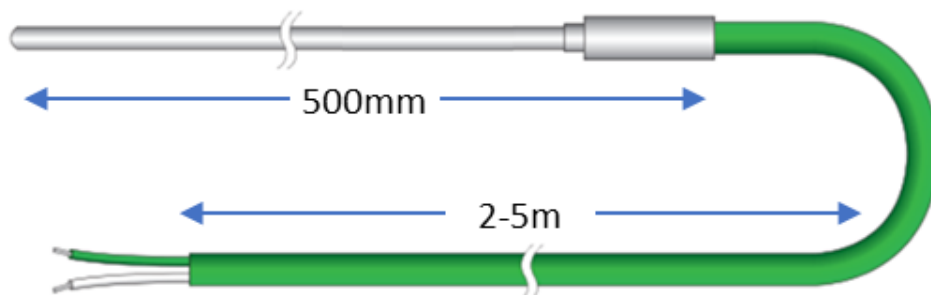


Figure 4 Swarm S2 Temperature probe

#### 6.3.2 Required equipment

The following hardware is required for the installation of Swarm S2 (U)HT:

- Sandpaper/machine with 120 to 400 grit.
- 6mm hex key
- Copper paste
- Torque wrench for tightening up to 25Nm
- 6mm hex torque wrench bit

- Calliper to monitor the deployment kit alignment

### 6.3.3 Pipe preparation

Prior to installation of the (U)HT ultrasound sensors, the pipe surface should be prepared through the following steps (for each sensor):

1. If the pipe is insulated, about 150mm of the insulation along the flow direction should be removed from the whole circumference of the pipe. No residual should be left on the pipe.
2. At the desired installation point, an area of roughly 30mm diameter should be cleaned and sanded until a smooth finish is reached (see Figure 5). Note that the goal here is to get a smooth surface and NOT to flattening the pipe. Therefore, excessive material removal should be avoided.

**Please consult with pipe owner about this process!**



Figure 5 Pipe preparation prior to ultrasound sensor installation (from HotSense® instructions)

### 6.3.4 Swarm S2 (U)HT Sensor mechanical installation

Follow the steps in Table 6 to install an (U)HT ultrasound sensor on the pipe. For installation on bends and other curved surfaces please make sure that the deployment system attaches in all four corners (see Stem 13) and that the strap is secured against sliding off its position. If install on large pipes and vessels one may use an extension to the steel band, please consult Sensorlink Swarm for guidance.


The description anticipates the pipe to be at ambient temperature. In case installation is done at full operational temperature, please confer with the pipe operator to instate all necessary HSE precautions required to work on hot pipes.

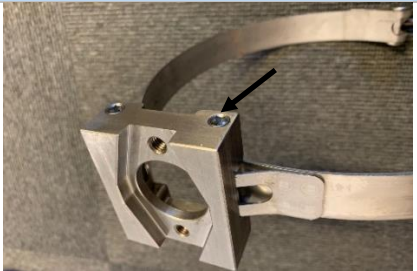











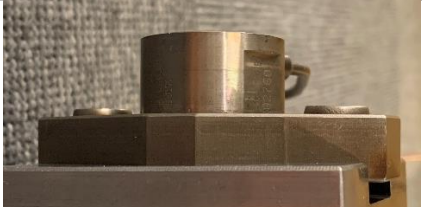
**WARNING:**



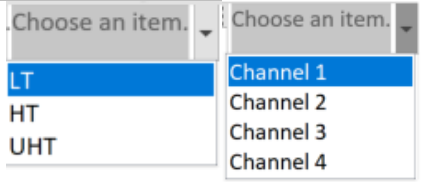
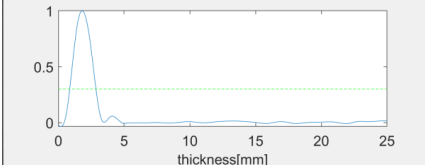
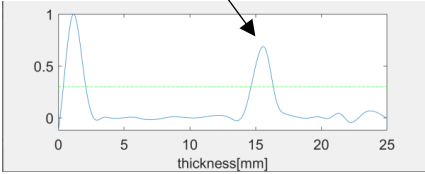
Working on hot pipe surfaces up to 550°C represent an immediate danger for severe health risk and imminent danger to body and limbs. Please only attempt to perform such installation under the strict guidance of the pipeline operator/owner or other assigned competent management.

Required PPE and procedures should be supplied and specified by the competent body.

Step	Description	Illustration
1.	Apply the copper paste to all threaded components of ①③⑤⑥⑧.	

Step	Description	Illustration
2.	Install the straps ① onto the base plate ② by placing the free loop on each strap in line with the plate holes, and secure by pushing through a shoulder screw ③. Tighten using the hex key until each screw sits flush with the base plate (indicated with the arrow).	
3.	Place the straps ① over the pipe and position the central hole of the base plate ② over the prepared spot of the pipe.	
4.	Join the two straps together by pushing the M8 cap head screw into the corresponding strap counterbore. Ensure that the screw is located securely.	
5.	Tighten the M8 screw with a torque wrench to 20 Nm (for pipes NPS 6" or larger, this load may be increased to 25 Nm). Visually check to ensure all four corners of the base plate are in contact with the pipe. Make sure that the base plate ② is aligned with the pipe, the hole in the base plate is aligned with the prepared area to be monitored, and all slack has been removed from the strap around the pipe. <b>If the base plate is not properly aligned open the bolts in ①, reposition and try again. The base plate must sit on all four corners and the strap must be firm on the pipe with no slack.</b>	
6.	Make sure that the sensors front face is free from scratches and contamination.	
7.	Place the loading plate ④ onto the sensor with the hole counterbores facing the rear of the sensor.	

Step	Description	Illustration
8.	Screw on the loading nut ⑤ to the sensor and tighten by hand.	
9.	Carefully bend the tabs of the foil coupling pad ⑦ and insert them into the holes in the mounting ring ⑥. Push the tabs all the way through and fold out the tabs down the outside of the mounting ring. Do not bend or crease the central section of the foil pad.	
10.	Screw the mounting ring ⑥ and coupling pad ⑦ onto the sensor until it is tight against the loading nut ⑥.	
11.	The coupling pad ⑦ should be positioned in the centre of the sensor. Ensure the coupling pad ⑦ is not damaged, creased or scratched prior to installation.	
12.	Position the assembled transducer into the hole in the base plate ②. Align the sensor cable in the desired direction ensuring it does not pass directly over the holes in the loading plate ④. The cable can be bent to shape, <b>but repeated bending should be avoided.</b>	
13.	Insert the loading bolts ⑧ and screw gently by the hex key, ensuring that the loading plate ④ remains parallel with the base plate ②. <b>Check that the loading plate is parallel with the base plate using a calliper as small misalignment may reduce the performance of the sensor.</b>	

Step	Description	Illustration
14.	<p>Connect the Swarm S2 Datalogger according to Section 6.4.3, this is required to be able to use the datalogger for the signal evaluation in the subsequent steps.</p> <p>Bundle the cables together if needed and pull them through the conduit as shown and connect them as described in Section 6.4.3.</p> <p>Secure the conduit in the pipe end but make sure the cables are not in direct contact with the pipe if the pipe surface temperature exceeds the cable specification.</p> <p>Sensor Ser.No.: _____ Clock position _____</p> <p>Sensor Ser.No.: _____ Clock position _____</p> <p>Sensor Ser.No.: _____ Clock position _____</p> <p>Sensor Ser.No.: _____ Clock position _____</p>	
15.	<p><b>Install the temperature probe</b></p> <p>The Temperature probe tip should be squeezed between the (U)HT Deployment kit or band and the pipe, see illustration. Make sure that this does not interfere with the alignment of the Deployment kit.</p> <p>Bend the sheathed part of the temperature sensor so that it runs in parallel with the (U)HT sensor sheathed cable and into the conduit.</p> <p>For terminating the Temperature probe to the datalogger see Section 6.4.4</p>	
16.	<p>Open the Swarm S2 user interface and choose the right type of ultrasound sensor and channel number the sensor is connected to. Type the nominal thickness of the pipe and run the live view of the trace.</p>	
17.	<p>You should now see the ultrasound trace with the first delay line echo in the beginning. The ultrasound trace is updated every 10-15 seconds.</p>	
18.	<p>Using the torque wrench, turn each of the loading bolts ⑧ alternating with 90° turns (1/4 turns) until a torque of 20 Nm is reached on both (for pipes NPS 6" or larger, this load may be increased to 25 Nm). The back wall echo should start rising at the expected thickness (around 14 mm for the example shown here) as the loading bolts ⑧ are tightened. When the torque is at 20(or 25) Nm the backwall echo should have passed the acceptable level marked with the horizontal line. The torque should <b>NOT</b> be increased over 20 (or 25) Nm if the echo is lower than the</p>	

Step	Description	Illustration
	acceptable level as this may destroy the installation band and the sensor. In this case installation of the sensor should be repeated from step 12 (omitting Step 14-15), starting with checking the pipe and the sensor surface.	
19.	<p>Now loosen the probe loading bolts ⑧ until the probe is no longer loading the pipe. Note that you do not need to remove the loading plate ④ or loading bolts ⑧ from the base plate ②. Now re-tighten the M8 bolt of the straps ① to 20Nm (25Nm for pipes NPS 6" or larger) and re-torque the loading bolts ⑧ up at 20 Nm (25 Nm for pipes NPS 6" or larger) according to step 18.</p> <p><b>This step is performed to ensure that all the slack of the deployment kit is removed and is mandatory for the system to work over the specified temperature range.</b></p>	
20.	<b>Important note:</b> step 19 should be done two times to make sure all the remaining slack is removed from the straps.	
21.	<b>Repeated step 1-20 (omitting Step 14-15) for the number of sensors to be installed. Note that only one sensor can be installed on each deployment kit.</b>	

Table 6 Swarm S2 (U)HT Sensor installation

## 6.4 Swarm S2 LT and (U)HT Datalogger installation and configuration

IN this section we address the mechanical installation of the datalogger and the considerations in case wireless interface is to be used. We also explain the configuration of the datalogger, the signal evaluation, setup of data logger for wireless communication and use of the service port to configure the datalogger and download data. These instructions are valid for all configurations of the Swarm S2 Datalogger (LT/(U)HT, Bluetooth and ISA100 versions).

### 6.4.1 Box content

Swarm S2 Datalogger comes with the following:

- Swarm S2 LT or (U)HT Datalogger as shown in Table 3, shipped in its own box.
- Swarm S2 Datalogger Mounting bracket as shown in Figure 6, shipped in the Swarm Datalogger box.
- The Cable conduit in Figure 6 is shipped separately, and may be shipped in customer defined lengths

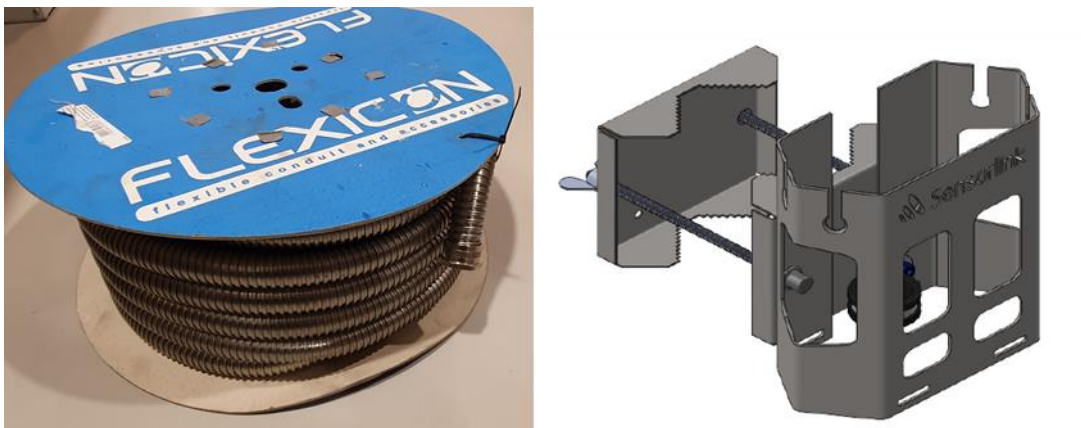


Figure 6 Swarm S2 Datalogger mounting bracket and conduit(example)

### 6.4.2 Required equipment

The following hardware is required for the installation of Swarm S2 (U)HT:

- Hex 4 to close the P-clip
- Hex 5 key to open the Datalogger and fasten it to the bracket
- Straps for bundling cables (metal and plastic, depending on the sensors and ops range)
- Nylon wire-pull-spring if wires are to be pulled through conduit, only relevant for conduits longer than 1.5m


**Precondition:** A 3inch pole is available within the reach distance of the cables to be used (max 5m) cable distance from sensor to datalogger





### 6.4.3 Swarm S2 Datalogger(s) mechanical installation

The illustration in Figure 7 gives an overview of typical installation environment for a Swarm S2 system.



Figure 7 Swarm S2 Datalogger installation

Step	Description	Illustration
	<p><b>Selecting a location for the Swarm S2 Datalogger, please consider the following:</b></p> <ol style="list-style-type: none"> <li>1) Find a location that is convenient to reach to ease future battery exchange</li> <li>2) Find a location with as few metal or concrete obstacles as possible between the Datalogger and the ISA100 access point (line of sight is preferred for long distances, &gt;30m)</li> <li>3) Find a location that limits the heat radiation from hot pipes to where the Datalogger is located. Use heat shields if needed</li> <li>4) If location is exposed to sun and anticipated black bulb temperature may reach &gt;60-70°C, install a sun shield.</li> <li>5) A 3" vertical pole should be available at location for mounting the Datalogger bracket. Make sure the pole does not run higher than the datalogger body. This is to avoid shielding the antenna by the pole (may reduce the radio range of the ISA100 communication).</li> </ol> <p><b>Please note that the assembly procedure is identical for Swarm S2 LT and Swarm S2 (U)HT Dataloggers, it is only the cables and connectors that are different.</b></p>	

Step	Description	Illustration
1.	<p>Install the Swarm S2 Bracket on the pole less than 5m (cable length) from the sensors on the pipe.</p> <p>Assemble the bracket by inserting the threaded bolts into the nuts and lock them with Loctite® or similar.</p> <p>Clamp the bracket over the pole and tighten the wing nuts.</p> <p>If the pole is subject to vibration, you may use some form of thread lock (Loctite® or similar) on the wing nuts as well.</p>	
2.	<p>Secure the conduit at the pipe or near the pipe and run it to the Swarm S2 Bracket, secure the conduit in the P-clip at the bracket.</p> <p>Pull a draw wire or pull-line through the conduit to ease the pulling back of the cables and pull back the cables.</p>	
3.	<p>Hold the Swarm S2 Datalogger above the bracket and start connecting. In this step one may be two persons or secure the Datalogger temporarily to the bracket by strapping it upside down to the outside of the bracket.</p> <p>Connect the cables to the Swarm S2 Datalogger bottom interface using only hand force on the SMA connectors. When all cables are in place, tighten the connectors finger tight.</p> <p><b>Pay attention to the keying of the connectors and do not use excessive force when tightening them, no tools required only finger tightening.</b></p> <p><b><u>If a Swarm S2 (U)HT system is installed,</u></b> the cables and connectors will be different. The connectors are SMA type. These should be hand tightened, but a small, fixed spanner may be used after the threads are engaged, but without excessive force.</p> 	


Step	Description	Illustration
4.	<p>When the cables are secured put the Datalogger onto the bracket and tighten the four screws that hold the Datalogger to the Bracket with a 4mm hex key.</p> <p>Make a note of which cable(sensor) is connected to which channel:</p> <p>Channel 1: Clock position _____</p> <p>Channel 2: Clock position _____</p> <p>Channel 3: Clock position _____</p> <p>Channel 4: Clock position _____</p>	
5.	<p>Now open the top lid using a 5mm hex key and continue to Start-up Section 6.4.5 to power up the unit.</p>	

Table 7 Swarm S2 Datalogger mechanical installation

6.4.4 Electrical connection

Electrical installation consists of connecting the sensor cables to the bottom interface connectors on the Swarm S2 datalogger and connecting the battery.

The Swarm S2 LT sensors are connected using the supplied cable with the correct connectors. Pay attention not to force the connectors in place and ensure that the pin/keying is correct before trying to lock the threads.

The Swarm (U)HT sensors are connected using an extension cable with and SMA connector mating to the Swarm S2 datalogger. Pay attention that the centre pin of the SMA is not damaged and mate properly before locking the threads.

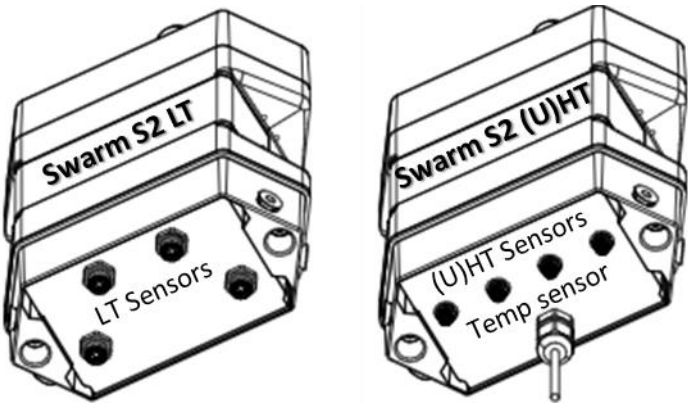


Figure 8 Swarm S2 Sensor connections



In both cases, do not use excessive force to tighten the connectors as this will damage the threads.

6.4.4.1 Temperature probe connection

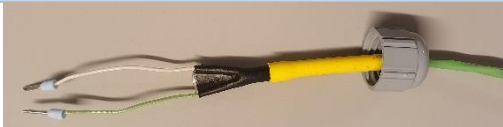


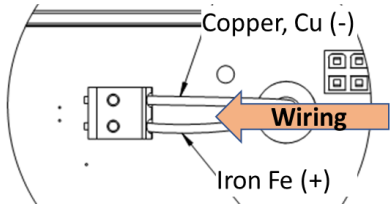
For the UHT version, the temperature probe needs to be inserted through the cable gland in the bottom lid. This should be performed before the instrument is brought into the field.


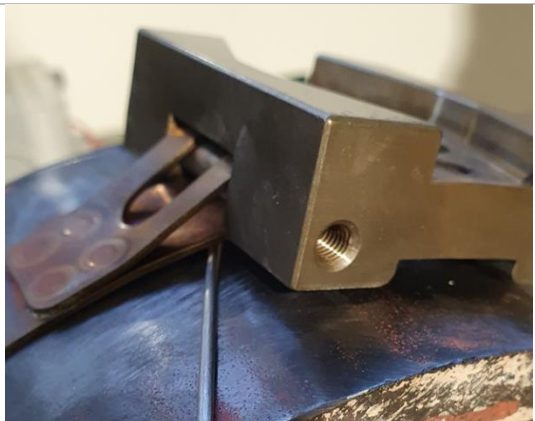


Figure 9 The Temperature probe

Make sure the battery is not connected, or disconnect the battery as described in Section 6.4.5.

Open the bottom lid by opening to two hex bolts. These are loose and will fall out from the lid when open.

Step	Description	Illustration
1.	Prepare the temperature wire probes ends with crimp terminals as shown. Make sure to thread the gland cap and rubber seal onto the wire before the next step	
2.	Pull the wires through the bottom lid. This may be a bit challenging if the plastic crimp of the temperature probe is rigid but squeeze it flat with your fingers and push it through.	
3.	Arrange the wires as shown and connect the temperature probe as shown and pay attention so the wire does not interfere with the interface connector.	
4.	Make sure the connection is as indicated. + Iron = Green ÷ Copper = White	

Step	Description	Illustration
5.	Reassemble the bottom lid and make sure to tighten the gland so that it seals around the temperature probe wire. If the wire is too thin use an additional crimp sleeve around the wire before entering it into the gland	
6.	The Temperature probe tip should be squeezed between the (U)HT Deployment kit or band and the pipe. Make sure that this does not interfere with the alignment of the Deployment kit. Bend the sheathed part of the temperature sensor so that it runs in parallel with the (U)HT sensor sheathed cable and into the conduit.	

#### 6.4.5 Start-up

Before powering the PipeMonit Swarm S2 check that all cables are properly connected. Verify that Intrinsically Safe cables, conduits, and cable trays are segregated (no direct contacts with other non I.S. conductors).

Start-up is done by connecting the power socket from the battery pack to the top board, please note that this needs to be done while the Swarm S2 Datalogger top lid is open. This can be done without a hot work permit since the product is intrinsically safe.

Open the top lid using a hex key and pull the top lid straight up until the connector let go, then flop then lid over as illustrated. The lid will hang safely in the rubber hinge, and the bolts are secured with retaining washers so that do not fall out during this operation. See also Section 8.4

Regardless of this, use caution when connecting the battery.

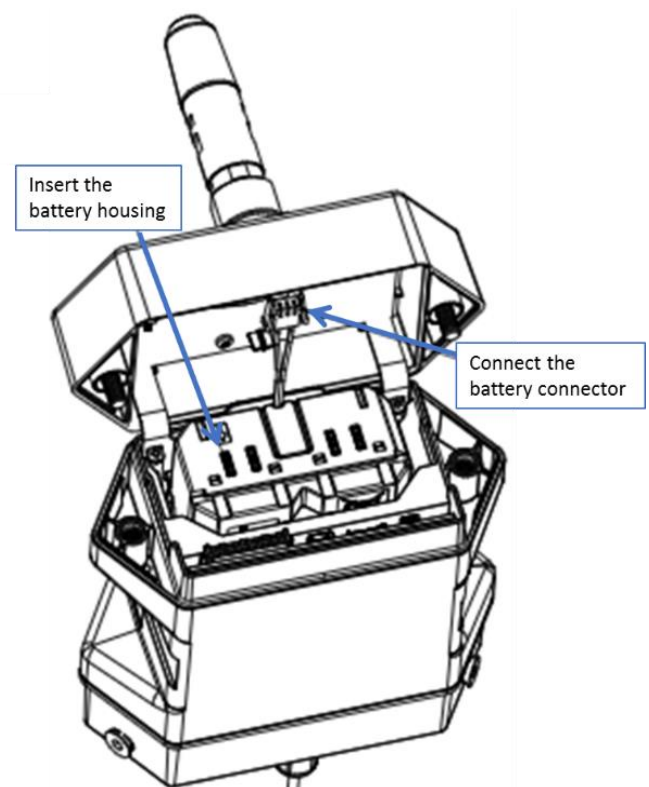


Figure 10 Battery connection

## 7 Operation

The PipeMonit Swarm S2 data logger is in Ex context always operated indirectly via the ISA100 wireless network or via the Bluetooth service interface. Details about data logger installation and configuration can be found in the available system installation manuals [[5]].

The datalogger has an operational panel on the top of the module with the following features:



Figure 11 Swarm S2 operating panel



The blue LED to the left shows the status of Bluetooth communication:

Pattern	State
Off	Sensor is operating normally.
One flash	Bluetooth is active, waiting for a computer to connect.
Two flashes	Bluetooth is connected to a computer.
On	Bluetooth is active. Sensor is in bootloader mode. See section 6.3.



The green LED to the right shows the status of ISA100.11a radio communication:

Pattern	State
Off	Radio is online, or radio is not activated.
One flash	Radio is waiting to become online to ISA100.11a gateway
Two flashes	S2 has received a squawk command from ISA100.11a gateway



The Service Button in the middle has the following function:

Action	State
Push once	<b>Normal operations -&gt; Enter Service mode:</b> all measurement and on-line communication is terminated, and the datalogger enters service mode. Bluetooth is activated and advertise for two minutes to allow the operator to connect via smartphone, tablet, or PC. Once connected, the operator can retrieve data, perform diagnostics, or change configuration parameters.
Push once more	<b>Service Mode -&gt; Enter normal operation</b>

## 7.1 Connecting to Swarm S2 Datalogger

This chapter describe how to start the Swarm S2 config application and how to connect to the Swarm S2 datalogger from a USB or Bluetooth device.



Figure 12 Swarm S2 datalogger: micro switches, SD card slot, and USB C port

### 7.1.1 Bluetooth

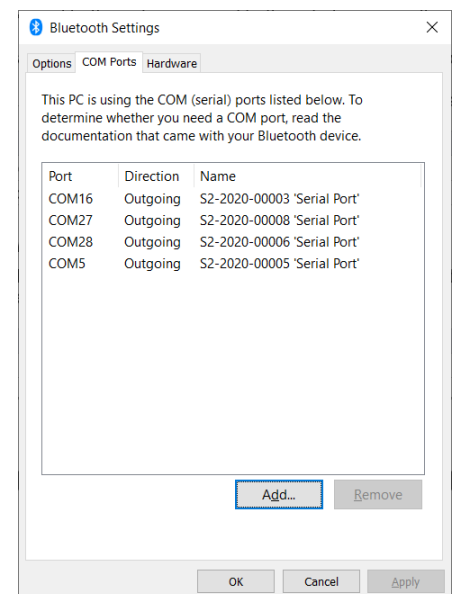
Swarm S2 supports Bluetooth V4.2 Serial Port Profile. To allow communication, S2 must be set in service mode and paired with your PC. Then a virtual COM port running SPP must be set up.

Activate Bluetooth by pushing the pushbutton on the Lid. When activated, it publishes using S2-<serial number>. Serial number can be found on the product label.

Before using this connection, it must be paired. How to do this varies with your computer OS. When paired, it pops up as a Bluetooth serial port. This example is from Windows 10 paired with 4 different Swarm S2 sensors. Swarm S2 remembers the last 16 computers paired and will accept a connection from these computers without a new pairing.

The Bluetooth interface can be deactivated like this:

- If no computer has been connected for 2 minutes.
- By a command.
- By pressing the pushbutton again.



### 7.1.2 USB

The USB interface is activated by connecting your computer to the USB-C connector on the Swarm S2, Figure 12.

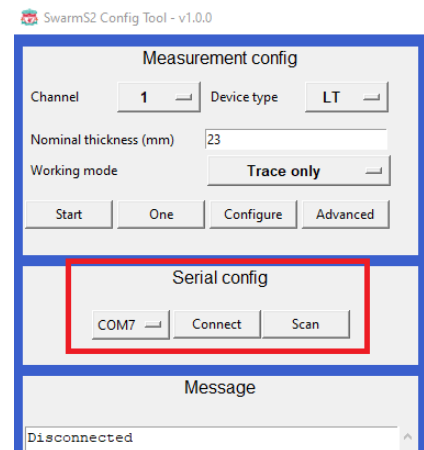
The USB port supplies power to S2. When powered from USB, the supply voltage is lower than normal, so the ultrasound excitation pulse is approx. 20% lower than normal. To achieve full excitation power, it is possible to apply external power while USB power is connected. This must be done after the USB port is activated.

When connected to the PC the Swarm S2 identifies as a USB serial port, and a virtual COM port is created using windows Plug'n Play.

## 7.2 “Swarm S2 Config Tool”

Connecting the Swarm S2 Config Tool:

1. Start the Swarm S2 config tool application, SwarmS2Config.exe.
2. Click the scan button.
3. Select serial communication port assigned in chapter 7.1.1 or 7.1.2.
4. Click the connect button.



## 7.3 Micro switches

S2 main board has a micro switch block with 4 switches marked 1 to 4. Normal operation is selected when all switches are off (up), Figure 12. Other modes are selected like this:

#	Name	Functionality when on (down)
1	Radio off	ISA100.11a radio is disabled, even when lid is equipped with a radio connector.
2	Console	Enables console interpreter. Turn off to enable UltraMonit interpreter.
3	Reserved	Do <u>not</u> turn on (down).
4	Reserved	Do <u>not</u> turn on (down).

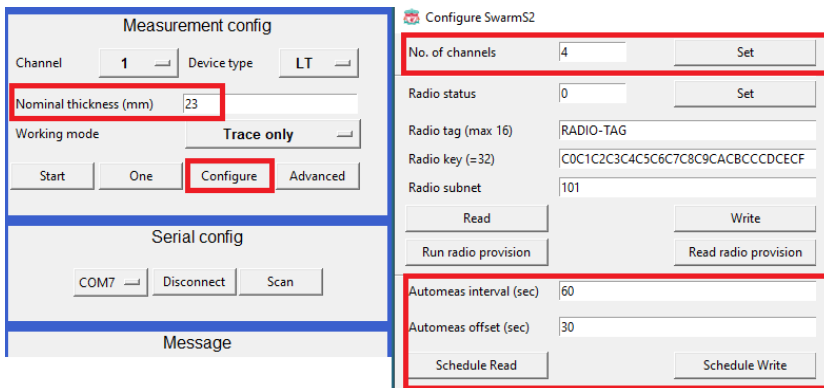
## 7.4 Configuration

In this version of the Swarm S2 Config Tool the number of user adjustable parameters is limited.

### 7.4.1 Processing parameters

The following user adjustable processing parameters can be entered. The parameter values will be stored in the instrument.

Name	Description
Auto interval	Minutes between each scheduled measurement. 0 disables scheduled measurements.
Auto offset	Offset of measurements. E.g., to measure every day at 16:00 set log interval to 1440 and log offset to 960.
Nominal wall thickness	Nominal wall thickness used in wall thickness calculations [mm].
No. of channels	Number of transducers connected. 1 to 4 transducers can be connected, and they will be assigned continuously from 1 to 4.

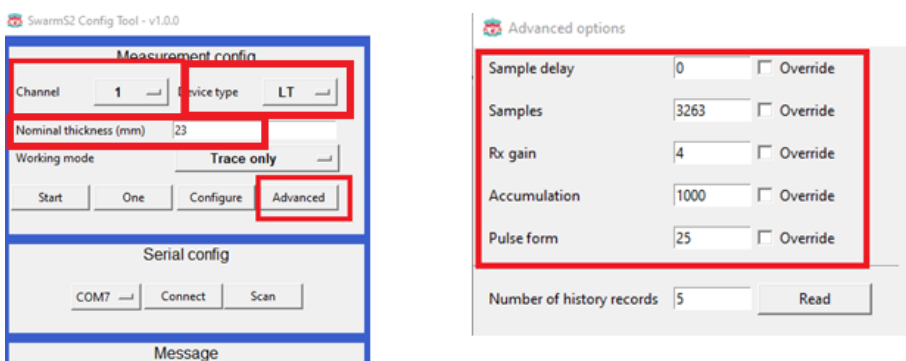


## 7.4.2 Ultrasound parameters

To setup the ultrasound parameters insert the value for the “nominal wall thickness” and choose transducer type: LT, HT or UHT. The parameter values will be stored in the instrument.

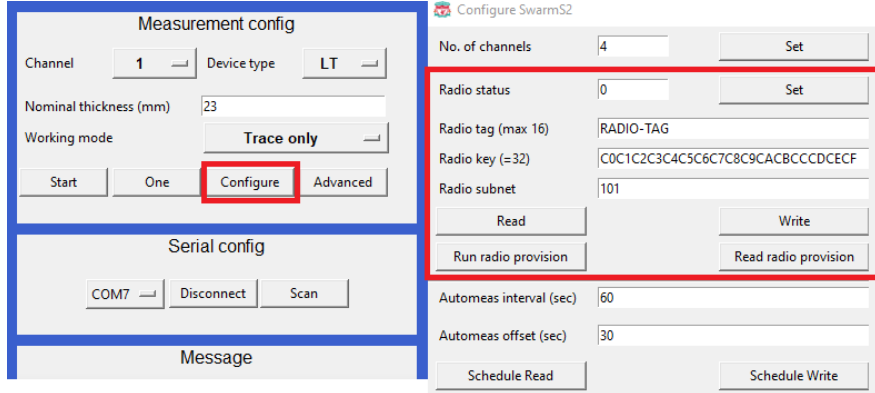
Parameter	LT	HT	UHT
Tx delay	50000	50000	50000
Sample delay	0	900	3000
Pulse form	25	0	0
Accumulations	1000	1000	1000
Samples		Calculated based on nominal wall thickness	
Rx gain status		Calculated based on nominal wall thickness	
Process front wall	1	1	1

These values can be overridden in the advanced dialog. Choose the channel in the main view, then click the advanced button.



### 7.4.3 ISA100.11a Radio

This chapter describe how to parametrize and provision the ISA100.11a radio.



#### 7.4.3.1 Radio parameters

The following ISA 100.11A radio parameters must be configured:

Name	Factory default	Data type
Radio data tag	SWARMS2	Up to 16 characters [0-9, A-Z, -, _]
Radio join key	C0C1C2C3C4C5C6C7C8C9CACBCCCDCECF	32 hex characters [0-9, A-F]
Radio subnet	100	2 – 65535

Radio data tag must be unique for all units existing in the same ISA100.11A radio subnet. Radio join key and radio subnet must match the values expected by the radio network.

#### 7.4.3.2 Radio Provisioning

This chapter describe the procedure for connecting to a Yokogawa ISA100.11a network, for other ISA100 networks please consult the vendor documentation.



**Due to radio regulations, the ISA100.11a radio is powered off when the Bluetooth interface is activated. Powering on the radio while connected to Bluetooth should only be done during commissioning and to test radio operations.**

Do the following steps to integrate Swarm S2 into the ISA100.11a network:

1. Power ON the ISA100 radio using the command write “Radio status” = 2, wait until it becomes operative, then continue.
2. Set the radio parameters to correct values as described in section 7.4.3.1.
3. Run a radio provision sequence to transfer the radio parameters to the radio module using command “Run provisioning”.
4. Read out the radio provisioning string from Swarm S2 using command “Read radio provisioning”.
5. Store this string in a .csv file. Use this file as input to the Yokogawa FMPDFFileGenerator tool to create a .ypif file. (consult Yokogawa documentation for this)
6. Use the .ypif file to configure your Yokogawa ISA100.11a gateway.

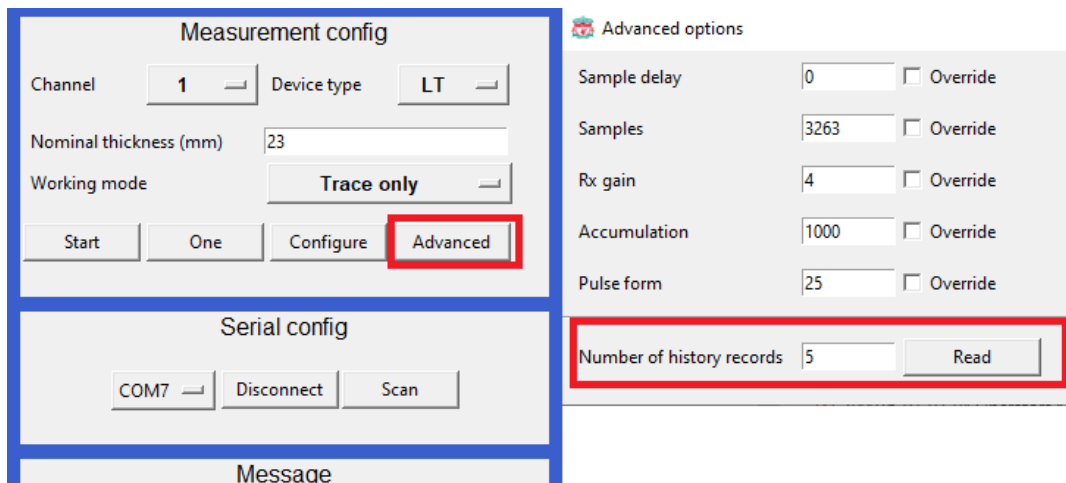
Verify that the radio operates as intended:

- Verify that green LED on Swarm S2 stops flashing. This means that radio module has successfully joined the ISA100.11a radio network.
- Use the tools supplied with your ISA100.11a gateway to verify that you receive the intended data.
- If needed, read the radio status (command: “Read radio status”) from Swarm S2 to verify that it operates as intended.

## 7.5 Data retrieval

### 7.5.1 Swarm S2 service application

Historical data can be retrieved from the instrument and stored in a csv file by enter the “Number of history records” and press the “Read” button. Setting the “Number of history records” as shown in the image below equal to 5 will store the newest measurement in addition to 4 older records.



The screenshot shows the 'Measurement config' window with the following settings:

- Channel: 1
- Device type: LT
- Nominal thickness (mm): 23
- Working mode: Trace only
- Buttons: Start, One, Configure, **Advanced** (highlighted with a red box)

The 'Advanced options' window is also visible, showing the following settings:

- Sample delay: 0
- Samples: 3263
- Rx gain: 4
- Accumulation: 1000
- Pulse form: 25
- Number of history records: 5
- Buttons: **Read** (highlighted with a red box)

### 7.5.2 µSD card

When equipped with an µSD card, each measurement is logged in a separate .JSON file, Figure 12. Various data including information about the instrument, measurements, ultrasound traces and calculated data are stored on the card. The SD card must be formatted as FAT32 or ExFAT. Cards up to 32 GB will be formatted as FAT32, larger cards will be formatted as ExFAT.

Log files are named using the S2 serial number and measurement sequence number. They are grouped into folders holding up to 1000 measurements. E.g., measurement number 23089 on sensor 2020-00005 will be stored in file:

X:\00023XXX\2020-00005-00023089.JSON

### 7.5.2.1 JSON file format

Typical JSON file, containing only 1 transducer channel:

```
{
  "measument_time": "2020-07-22 13:49:51",
  "measurement_index": 23089,
  "sys_unique_id": "2020-00005",
  "product_type": "SWARMS2",
  "location": {
    "name": "Some Position Somewhere",
    "gps_position": "LON=63.67143;LAT=4.12345"
  },
  "versions": {
    "algo": "1.4.1",
    "app": "0.0.4",
    "bl": "0.4.2",
    "fpga": "0.0.4"
  },
  "housekeeping": {
    "temperature": 24.938,
    "battery": 20.27441,
    "processing_time": 17.53
  },
  "settings": {
    "speed_of_sound": 5920.0,
    "temperature_offset": 25.0,
    "transmit_delay": 2000,
    "incremental_delay": 1,
    "probe_type": "Standard"
  },
  "measurements": [
    {
      "ut_no": "UT01",
      "location": {
        "x": 0,
        "y": 0
      },
      "sampling_frequency": 120,
      "samples": 4000,
      "sampling_delay": 0,
      "accumulations": 1000,
      "gain": 0,
      "use_frontwall": 0,
      "pulse": 2,
    }
  ]
}
```

```

    "nominal_thickness": 5.0,
    "maximum_thickness": 10.0,
    "temperature_coefficient": 105.0,
    "temp_pipe": 0.248,
    "trace": [346563, 192107, 40891, -114564, -244512, ... ],
    "calculation_results": {
      "error": 0,
      "quality": 3,
      "thickness_comp": 6.21551847,
      "thickness_uncomp": 6.1994071,
      "backwall_1": 262.34653,
      "backwall_2": 513.67383,
      "backwall_3": 765.0011,
      "reference": {
        "backwall_1_ref": 269.0975342,
        "backwall_1_offset": 0.247783184,
        "thickness_comp_ref": 6.21551847,
        "ref_opt_1": 0.0,
        "ref_opt_2": 0.0
      }
    }
  }
}

```

## 8 Safe operation of the Swarm S2 System



**SUBSTITUTION OF COMPONENTS OR MODIFICATIONS TO THE UNIT MAY IMPAIR INTRINSIC SAFETY AND SHALL NOT BE ATTEMPTED!**

**The system or its components shall not be used for other than their intended purpose by the manufacturer**

### 8.1 Safety Description and Electrical I/O Parameters



**Ex II 2 G Ex ib IIB T4 Gb**

Parameter	Value	Remark	Terminal	Parameter	Value
Device group	II	All other explosive areas than mines	Radio module interface	Uo	5.355V
Category	2	Zone 1 (Class 1 Zone 1)		Io	0.62A
Atmosphere	G	Gas		Po	0.85W
Type of protection	Ex ib	Intrinsic safety, high level of protection	Sensor interfaces	Uo	7.8V
Explosion group	IIB	Typical gas is Ethylene		Io	1.275A
Temperature class	T4	≤ 135°C		Po	5.72W
Equipment protection level	Gb	High level of protection		Ci	129.2uF
				Li	265uH

### 8.2 Product marking Swarm S2 LT and (U)HT



Figure 13-Swarm S2 LT product label



Figure 14-Swarm S2 (U)HT product label



Figure 15 Swarm S2 LT Sensor product label

### 8.3 Conditions for safe use

The system should be operated within its temperature limitation **-40°C to +70°C**.

Due to the internal batteries the unit should not be exposed to direct sunlight that may cause heating of the unit above this limit (reaching black bulb temperatures higher than +70°C).

Cleaning of the device is not normally needed. The sensors never need to be cleaned and one should avoid cleaning them, particularly with high pressure water jets.

The Dataloggers may be cleaned if covered in dust or other deposits. Do not use sharp object but a light detergent and a rug, avoid dry cleaning with rugs as this may cause static charging.

The protection degree of the Datalogger is IP65 and ensure that unused connectors have protective caps as depicted (S2 LT) when not populated (The (U)HT version have different protection caps, SMA types)



## 8.4 Changing the Battery Box

The **Tadiran SL-2780/S** and **TL-5930/S** are high energy Lithium Thionyl Chloride D cell batteries storing 19Ah of energy. For Battery Box and batteries replacement please refer to [5].

These batteries are not suited for air cargo and to ease the operations for Sensorlink as well as the customer, these batteries should be supplied in the local market. This will be done by Sensorlink Swarm AS' local representatives or agents.

Therefore, the Swarm S2 Datalogger is normally shipped without battery installed.

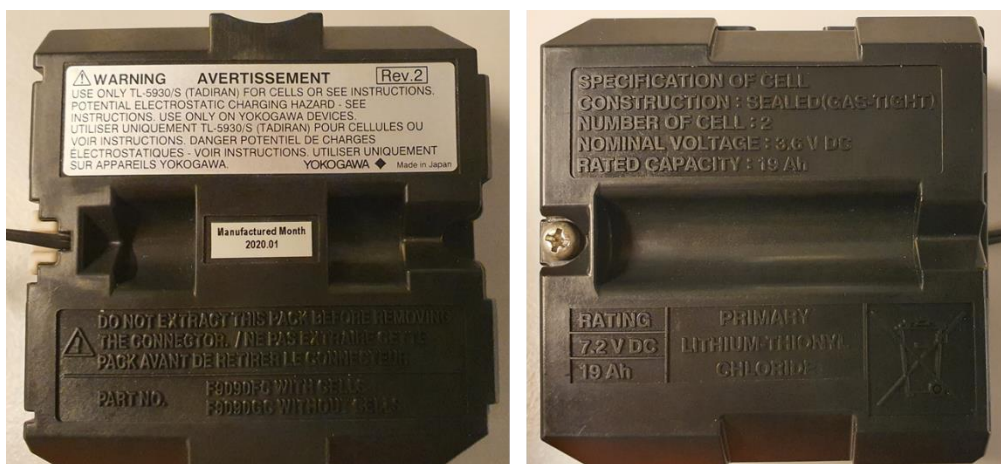


Figure 16 Battery Box (Yokogawa)

**Only use Tadiran SL-2780/S or TL-5930/S batteries in the Battery Box.**



**Potential electrostatic charging hazard use personal ground strap or touch ground when first touching the Battery Box.**



**Do not extract the battery box before removing the connector.**



**For Battery Box and batteries replacement please refer to [5].**



**Do not dispose of batteries in general waste, recycle according to local regulations for Lithium Thionyl Chloride cells.**

Changing the battery box can be performed in the field as the Swarm S2 Datalogger can be opened in Hazardous environment since it is intrinsically safe. When opening the lid, the power from the battery is disconnected and the unit is powerless even if the battery connector is still connected.



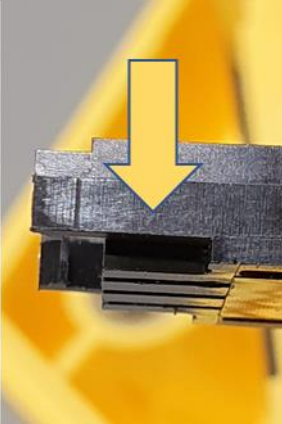


Step	Changing the Battery Box	Illustration	
1.	Open the top lid by: <ol style="list-style-type: none"> <li>1) Unscrewing the two Hex 6 bolts</li> <li>2) Pulling the top lid carefully straight upwards until the connector releases and is free</li> <li>3) Tilt the top lid over the edge and it will remain there fixed in the rubber hinge</li> <li>4) The hex bolts are held in place by retaining washers.</li> </ol>		
2.	Release the connector in the top lid by pulling it gently backwards and pressing the locking flaps simultaneously.  <b>When reconnecting the battery box make sure that the slots on the connector (indicated by the arrow) is facing downwards towards the circuit board in the top lid.</b>  You can now take out the battery box		
3.	Grab the battery box with your thumb and index finger pull firmly upwards to release the battery box.		
4.	Insert a new battery box in the reverse order, connect the battery connector paying attention to its direction. Close the lid.  Make sure the O-ring seal is undamaged and in place when closing the lid and tighten the bolts hand tight. Inspect the joint between the main body and then lid to ensure it is sealing correctly.		

Table 8 Changing the battery box

### Changing the battery cells of the battery box



**THE NEXT STEPS ONLY TO BE DONE IN SAFE SONE, DO NOT ATTEMPT TO EXCHANGE THE BATTERY CELLS IN HAZARDOUS AREA/ENVIRONMENT**

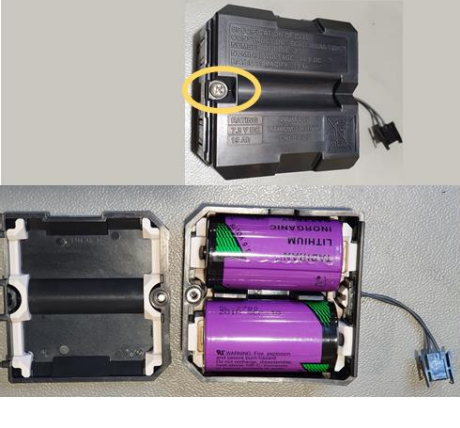



1.	Open the Phillips 2 screw in the top lid of the battery box and removed the lid	
2.	<p>Pull out the batteries from the bottom case. This may be hard, and a small flat screwdriver may assist in pulling them out.</p> <p>Pay close attention to the soft rubber tension elements (white) not to damage them or drag them out of position.</p> <p>Perform the extraction carefully and slowly.</p>	
3.	<p>Insert the batteries also paying very close attention of how you press the rubber tension element (the white elements) not to damage or misalign them.</p> <p>It is best to insert the battery while pressing firmly towards the minus pole when attempting to press the cell downwards into the battery box.</p>	
4.	<p>Pay attention to the polarity and check that the voltage over the indicated poles is 7.2V after replacement.</p> <p>If possible, you should also check the voltage on the battery case plug after assembling the lid</p>	
5.	Insert the top lid and fasten it with the Phillips 2 screw.	

Table 9 Changing the Battery Cells