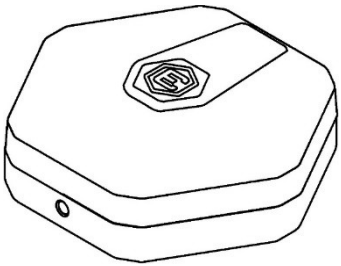
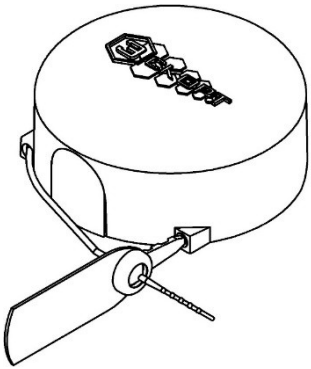




Wireless tilt angle sensor

‘ESCORT DU-BLE’

Datasheet

Serial number S
Date D
MAC-address M

1. GENERAL INFORMATION

Device full designation:	WIRELESS TILT ANGLE SENSOR ‘Escort DU-BLE’
Device short designation	Angle sensor DU-BLE
Unit serial number:	S
Date of production:	D

2. GENERAL INFORMATION

2.1 The wireless tilt angle sensor ‘ESCORT DU-BLE’ (hereinafter - ‘Device’, ‘DU-BLE’, ‘angle sensor’) is to be used along with the BLE-RS485 ADAPTER BA-BLE 5.0 LR or a compatible GPS tracker or other similar device that supports BLE communication.

2.2 the Device is designed to measure the tilt angle, determining the direction of revolutions and revolutions per minute of different parts of vehicles and machinery units and then transmit its readings to an external compatible device at 2.4 GHz frequency.

2.3 DO NOT USE THE DEVICE UNDER THE OPERATING CONDITIONS DIFFERENT FROM THE STATED IN THE PRESENT DATASHEET!

2.4 AVOID PHYSICAL DAMAGE TO THE DEVICE, ITS PARTS OR WIRES DURING THE INSTALLATION AND USE.

3. DATASHEET

Table 1. Technical specs DU-BLE

Parameter, units	Value
Bluetooth radio frequency, GHz	2,4
Battery voltage, V	from 3 to 3.7
Nominal battery voltage, V	3,6
Max battery voltage U0, V	3,7
Power consumption, mA (not more than)	17
Average power consumption, µA (not more than)	70
Data communication interface	Bluetooth LE (BLE)
Bluetooth receiver's and transmitter's max power, dBm	-96 / 4
Data communication protocol	Escort BLE
Range (under normal operating conditions in the absence of interference and obstacles when working with the BLE-RS485 or BA-BLE adapter), m (not less than)	10
'Container' mode's value range, units	0- 65535
Angle measurment's margin of error, degrees	±1°
RPM measurement's margin of error, RPM	±1
Min number of revolutions at constant speed required for RPM calculation, revolutions	3
RPM range, RPM	0 to 30
Revolution counter's margin of error, revolutions	±1
Operating conditions: - ambient temperature, °C - atmosphere pressure, kPa	 -45 to 50 84 to 106.7
Ingress protection	IP69S
Type of explosion protection	intrinsically safe electrical circuit ("ia" level of protection)
Explosion proof mark	0Ex ia IIB T6 Ga X
Dimensions, mm (not more than)	100X100x50
Weight, kg (not more than)	0.35

Note:

X in the Ex-marking implies that:

1) The device can be operated only with SAFT LS 14500 or SAFT LS 17500 batteries

2) The extraction and/or replacement of the battery in hazardous areas is strictly prohibited

3) The device need to be protected against physical impact

4. SCOPE OF DELIVERY

Table 2. DU-BLE’s scope of delivery

Device code designation:	**Qty**	**Ser.№**	**Note**
Mark I			
Wireless tilt angle sensor ‘ESCORT DU-BLE’	1		
Installation kit	1		
Datasheet	1		in electronic form
Packaging	1		
Mark II			
Wireless tilt angle sensor ‘ESCORT DU-BLE’	1		
Installation kit	1		
Datasheet	1		in electronic form
Packaging	1		
Mark III			
Wireless tilt angle sensor ‘ESCORT DU-BLE’	1		
Self-tapping screws 5,5x51	4		
Cable seal ‘Multilock Cable Seal’	1		
Datasheet	1		in electronic form
Packaging	1		
The manufacturer reserves the right to make changes in the product’s design and in its scope of delivery without prior notice to the customer.			

5. OPERATING MODES

Angle sensor DU-BLE has several operating modes.

If the BA-BLE ADAPTER is used, the data transmitted by the Device is retransmitted to an external compatible device via the RS-485 or RS-232 interface in accordance with the LLS data communication protocol.

While directly connected to a GPS tracker or similar device that supports BLE technology, the sensor transmits tilt angle (revolutions or container counter), battery charge and “event notification” (RPM).

The event notification parameter is defined by the operating mode and the settings. For more information, please, see Table 3.

Table 3. Operating modes of the wireless tilt angle sensor

MODE	BRIEF DESCRIPTION	«Event notification»
Transporting	Used during the transportation and storage	–
Vertical rotation control	**RPM only** The mode is used to calculate the total number of revolutions and to determine the speed of the revolutions (revolutions per minute or RPM). The revolutions that are parallel to the ground will not be detected by the Device.	**Data transmission if BA-BLE or BLE-RS485 adapter is used:** 0 – no rotation; 1 - 32767 – rotation in the direction A (positive values) 65535 - 32768 – rotation in the direction B (negative values) **Data transmission if paired directly via Bluetooth** 0 – no rotation; 1 to 50 – rotation in the direction A (positive values) -50 to -1 – rotation in the direction B (negative values)
	Direction only Used to determine the direction in which the sensor is revolving relative to the axis perpendicular to the sensor’s 0 (horizon) set by the user (except for when the sensor is rotating in parallel relative to the ground).	0 – no rotation 1 – rotation in the direction A 2 – rotation in the direction B The value of the event notification for each direction can be configured as any value from 1 to 255.

Table 3 continuation

MODE	BRIEF DESCRIPTION	«Event notification»
Horizontal rotation control	**RPM only** The mode is used to calculate the total number of revolutions and to determine the speed of the revolutions (revolutions per minute or RPM). The revolutions that are parallel to the ground will not be detected by the Device.	**Data transmission if BA-BLE or BLE-RS485 adapter is used:** 0 – no rotation; 1 to 32767 – rotation in the direction A (positive values) 65535 - 32768 – rotation in the direction B (negative values) **Data transmission if paired directly via Bluetooth** 0 – no rotation; 1 to 50 – rotation in the direction A (positive values) -50 to -1 – rotation in the direction B (negative values)
	Direction only Used to determine the direction in which the sensor is revolving relative to the axis perpendicular to the sensor's 0 (horizon) set by the user (except for when the sensor is rotating in parallel relative to the ground).	0 – no rotation 1 – rotation to the left 2 – rotation to the right The value of the event notification for each direction can be configured as any value from 1 to 255.
Angle control[1]	Used to determine the tilt angle of the machinery part relative to the sensor's horizon (0). Event notifications are transmitted once the sensor tilts at the angle equal to the reference angle set by the user.	0 – the reference angle is not crossed 1 - the reference angle is crossed (configurable as any value from 1 to 255)
Container	Used to monitor the number of containers collected by a waste management truck.	The cumulative counter's value increases by 1 from 0 to 65535 every time one container is lifted and emptied. the Device must be installed on the manipulator's arm that lifts the containers. Once the Device crosses two control angles twice, the counter increases by 1. After reaching the max value of 65535 the counter is reset to 0.

Table 3 continuation

MODE	BRIEF DESCRIPTION	«Event notification»
Bucket	Used to determine if an excavator (or similar machinery) is active or inactive, i.e. if its arm is actively moving and digging the ground.	0 – inactive 1 – active (configurable as any value from 1 to 255)
Plow[2]	Used to determine if the snow plow of a truck (or any similar machinery unit) is active or inactive.	0 – inactive 1 – active (configurable as any value from 1 to 255)
Vertical inclinometer	**1 axis** Used to measure the angle of tilt relative to Z axis (roll) when the Device is installed in the vertical position.	–
	2 axis Used to measure the angle of tilt relative to Z axis (roll) and to Y axis (pitch) when the Device is installed in the vertical position.	–
Horizontal inclinometer	**1 axis** Used to measure the angle of tilt relative to Z axis (roll) when the Device is installed in the horizontal position.	–
	2 axis Used to measure the angle of tilt relative to Z axis (roll) and to Y axis (pitch) when the Device is installed in the horizontal position.	–

[1] - if the Device is exposed to vibrations provoked by the operation or during the transportation of the mechanism it is installed on, there is high probability of false reports of activity.

[2] - using the Device to monitor the mechanisms whose tilting movement is limited to a range lesser than 0 to 10° is not recommended. An example of such mechanism would be the middle blade of the grader.

5.1 Rotation control modes

There are two rotation control modes: Vertical and horizontal rotation control mode. These modes are applicable in concrete mixers to monitor their rotations' directions and/or RPM and total rotations. In the vertical rotation control mode, the Device must be installed on the frontal side of the mixer.

In the RPM only configuration, the Device transmits:

- Positive values from 0 to 50 in case of rotations in one direction
- Negative values from -50 to 0 in case of rotations in the opposite direction
- «0» value is transmitted when there is no rotation.

This mode allows monitoring the direction of rotations based on the '+' or '-' sign of the RPM values received. To achieve that, the monitoring platform must have two virtual sensors: one used to process negative values and the other used to process the positive values.

In the 'RPM only' configuration, the Device transmits:

- '1' (configurable as value from 1 to 255) in case of rotations in the direction A
- '2' (configurable as value from 1 to 255) in case of rotations in the direction B
- «0» value is transmitted when there is no rotation.

In the horizontal rotation control mode, the Device must be installed on the lateral side of the mixer. See Figure 1.

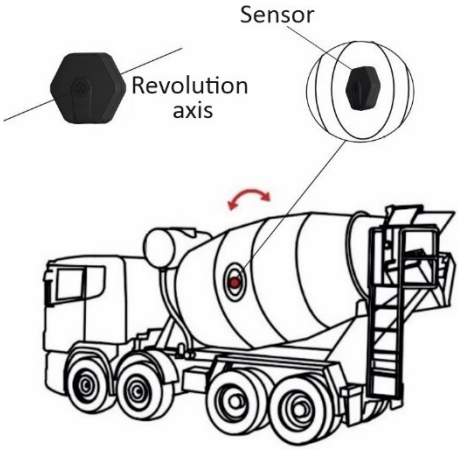


Figure 1. Installing DU-BLE on a concrete mixer
Horizontal rotation control mode

In the Vertical rotation control mode, the Device must be installed on the frontal side of the mixer. See Figure 2.

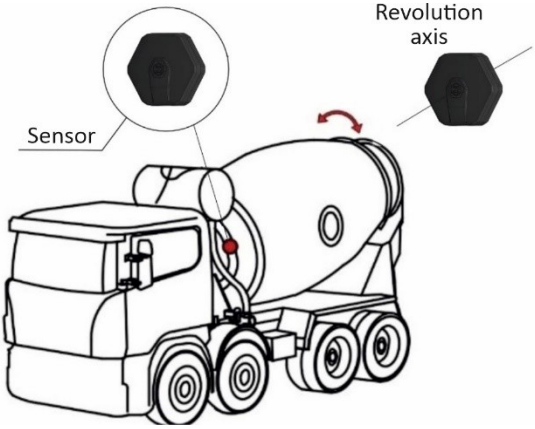


Figure 2. Installing DU-BLE on a concrete mixer
Vertical rotation control mode

5.2 Inclinometer modes

The Inclinometer modes are used to monitor the angle and direction of a mechanism's tilt. There are two Inclinometer modes: Horizontal and Vertical Inclinometer mode. Installation examples for these modes are provided hereby (Figure 3 and 4).

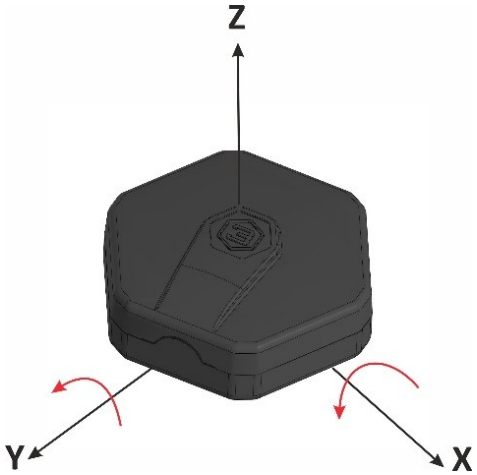


Fig. 3 Installation in Horizontal inclinometer mode

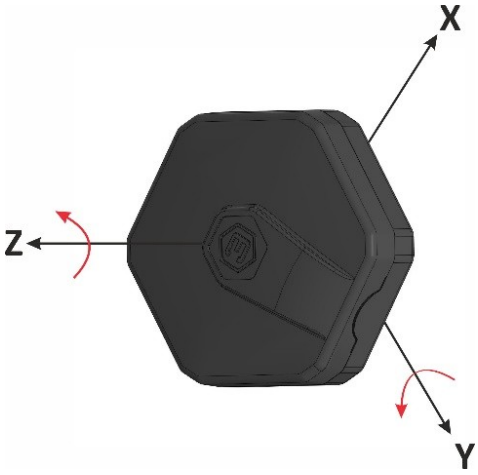


Fig. 4 Installation in Vertical inclinometer mode

Horizontal inclinometer mode can be used in two configurations:

1 axis - angle of roll tilt is measure (relative to X axis) in the horizontal position, ZY plane must be at 90° relative to the surface the sensor is installed on. The 0 (reference point) of the sensor must be set after fixing the sensor. 360° measurement range. No event notification.

2 axis - angle of roll (Y axis) and pitch (X axis) tilt is measured in the horizontal position. The 0 (reference point) of the sensor must be set after fixing the sensor. 180° measurement range. No event notification.

Vertical inclinometer mode can be used in two configurations:

1 axis - angle of roll tilt is measure (relative to Z axis) in the vertical position, XY plane must be parallel to the surface the sensor is installed on. The 0 (reference point) of the sensor must be set after fixing the sensor. 360° measurement range. No event notification.

2 axis - angle of roll (Y axis) and pitch (Z axis) tilt is measured in the vertical position. The 0 (reference point) of the sensor must be set after fixing the sensor. 180° measurement range. No event notification.

The Filtration algorithm is to be used to offset accidental changes in the angle readings of the Device. The higher the Filtration level is, the more smooth the angle changes become but the speed of measurement decreases. 4 Filtration levels are available: Low, Medium, High, Extra High.

5.3 Bucket mode

This mode is designed for monitoring working hours of excavators and similar machinery units. The installation of the Device is shown in the Figure 5.

The Measurement interval sets the time interval at which the angle is measured. Two consecutive measured angles are compared to each other.

If the difference between two angle measurements is equal to or higher than the Delta, the event notification is sent (the value of the event notification can be selected from the 1 to 255 range in the ‘Transmit as event notification’ settings). The event notification reports the activity of the excavator.

The Delta is the number of degree to which the difference between two consecutive angle readings is compared to in order to determine if there is any activity of the excavator’s arm or not. If the excavator's arm stops or two consecutive angle measurements accidentally are equal to each other of the difference between them is less than the Delta, the Turn OFF delay timer sets off. Once the Turn OFF delay timer runs out, the angle reading is compared to the previous one again to double check if there's any movement and only after that the event notification is active or inactive. This algorithm helps you determine if the excavator's arm is active or not and prevents false notifications of inactivity.

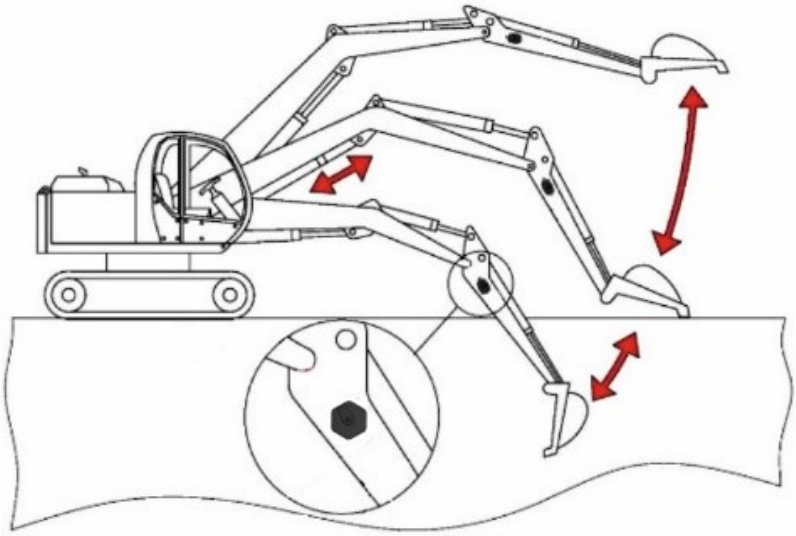


Figure 5– Installation of the DU-BLE on the excavator arm

5.4 Plow mode

This mode is designed to control snow plows, graders and similar devices installed on heavy vehicles (see Figure 6).

Attention! Using the Device to monitor the mechanisms whose tilting movement is limited to a range lesser than 0 to 10° is not recommended. An example of such mechanism would be the middle blade of the grader.

When the plow moves from the stowed position to the deployed one, the sensor installed on the plow crosses Upper limit and Lower limit angles.

Once the plow is lowered past the Lower limit angle, the sensor sets the Turn ON delay timer. If after the Turn ON delay timer runs out the plow is still below the Lower limit, the sensor transmits the event notification as 1 (configurable within 1 to 255 range), confirming that the plow is working.

If the plow is raised above the Lower limit, the sensor sets the Turn OFF delay timer. If after the Turn OFF delay timer is over the plow is still above the Lower limit, the sensor transmits the event notification as 0, confirming that the plow is not working.

However, if during the TURN OFF delay the plow is lowered past the DOWN limit again, the TURN OFF delay timer is reset and stopped: the sensor transmits the event notification 1, confirming that the plow is working again.

If the plow is raised directly back to the stowed position, which means that the sensor has crossed the Upper limit angle, the sensor transmits 0 value, as the plow is not being used.

This algorithm avails users more precise data on the plow's work by eliminating false notifications of the plow not working when it is raised temporarily when the vehicle needs to maneuver around obstacles or to turn around.

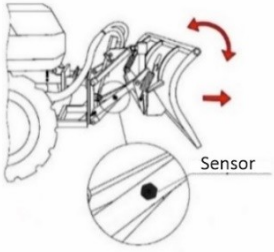


Figure 6– Installation of the DU-BLE on plow-type devices

Note: regardless of the mode selected, after any angle change of the sensor the current angle value will be transmitted as a separate parameter.

5.5 Rotation control modes

Angle control mode can be employed to control the activity of a crane, garbage truck arm, dump truck bed or other similar specialized vehicles. In this mode, the sensor transmits the event notification when it crosses the upper and lower limits at the angles set by user. The upper and lower limit angles are set in the Upper and Lower limit settings, respectively. Once the Device on which the sensor is installed is moving from the stowed position to the deployed position and crosses the upper limit angle, the sensor transmits the notification event as 1, which means the Device is actively working. When the Device is moving back to the stowed position, the sensor crosses the lower limit angle and transmits the notification event value as 0, confirming that the Device is not actively working anymore. The angle control mode's logic is shown in the Figure 7. The installation of the sensor is shown in the Figure 8.

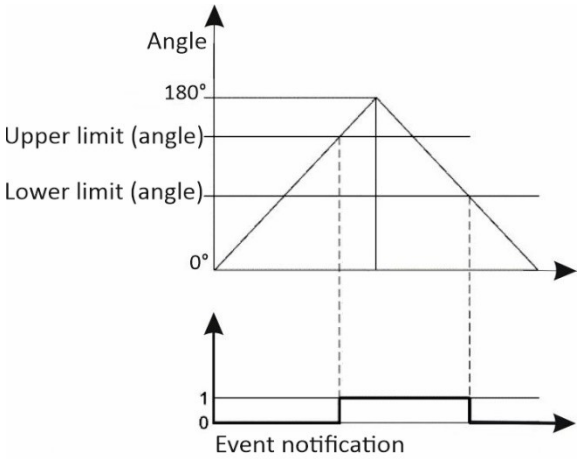


Figure 7– The angle control mode demonstration

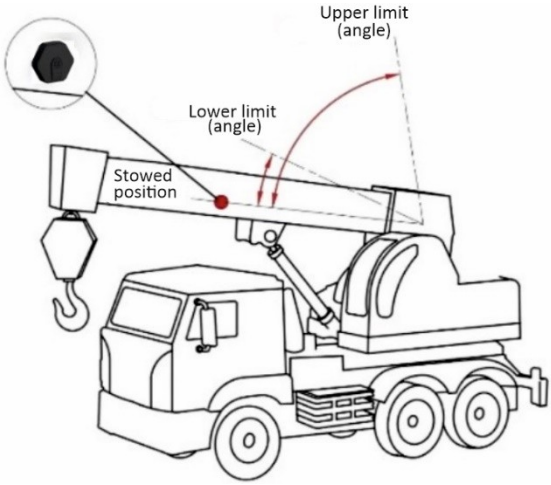


Figure 8– Installation of the DU-BLE in the angle control mode

5.6 Container mode

This mode is designed to track the number of waste containers collected by waste management trucks. Every time the trucks' manipulator moves from stowed to deployed position and backwards to lift and empty the container, the Device registers that.

While moving, the Device crosses the lower and upper control angles. This event is recorded by the Device and its counter's value increases by 1. The upper and lower limit angles are set in the Upper and Lower limit settings, respectively. The counter resets upon achieving the max value of 65535.

5.7 Transportation mode

The Device's default mode in which the accelerometer is disabled to reduce power consumption.

6. PRECAUTIONARY MEASURES

During the installation, operation and maintenance of the Device follow general safety instructions for electric devices and equipment.

7 SERVICE AND SHELF LIFE, WARRANTY

7.1 Guaranteed service and shelf life is 3 years after the Device is shipped from the manufacturer’s warehouse.

7.2 Service life – 4 years.

7.3 The manufacturer guarantees that the Device meets all specifications and requirements if the user adheres to transportation, storage and operation requirements.

7.4 If any defect is found, contact the manufacturer.

7.5 The warranty does not cover any defects caused by failure to meet the operation, storage and transportation requirements.

7.6 The warranty does not cover power components. The stated service life also does not include power components.

7.7 The manufacturer reserves the right to make changes in the Device’s design and in its scope of delivery without prior notice to the customer.

8 DATE OF MANUFACTURE AND ACCEPTANCE CERTIFICATE

Wireless tilt angle sensor Escort DU- BLE s/n _____S_____ is manufactured in accordance with the current technical documentation and is declared to be ready for use.

9 PACKING CERTIFICATE

Wireless tilt angle sensor Escort DU- BLE s/n _____S_____is packed in accordance with the current technical documentation.

10 INSTALLATION CERTIFICATE

Wireless tilt angle sensor Escort DU- BLE Nr.

_____ _____S_____

Name serial number / public number

_____ / _____ / _____

signature Full name day, month, year

is installed in accordance with the current technical documentation for the Device:

_____

notes

11 MAINTENANCE NOTES

11.1 Primary verification

Date	Conclusion	VERIFICATION OFFICER SIGNATURE	VERIFICATION OFFICER SEAL

11.2 Recurrent verification

Date	Conclusion	VERIFICATION OFFICER SIGNATURE	VERIFICATION OFFICER SEAL

12 TRANSPORTATION AND STORAGE

12.1 The Device shall be transported in the original packaging in enclosed vehicles or craft. To store indoors dry and at temperatures of +10 °C to +30 °C and humidity not higher than 75 %. Do not store in spaces with conductive dust, aggressive substances and their vapors that cause corrosion of parts and destruction of electrical insulation of the Device.

12.2 Set the product to Transportation mode during the transportation and storage.

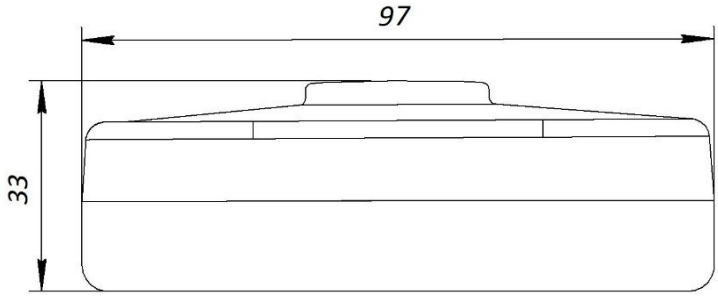
13 DISPOSAL

13.1 The Device shall be disposed by the user in accordance with the regulations applicable the country where the Device is operated.

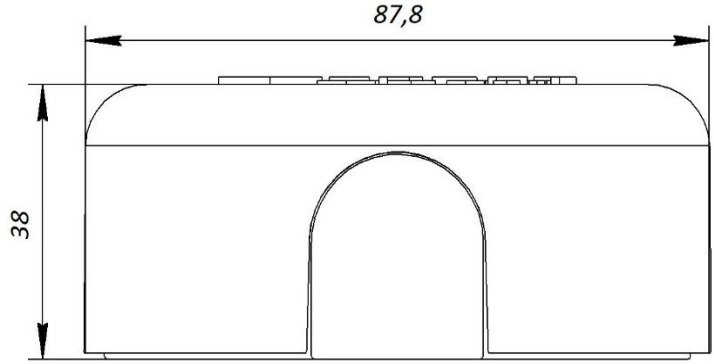
13.2 The Device does not contain precious metals in the amount to be accounted for.

ANNEX 1 Escort DU-BLE’s dimensions

Mark I, II

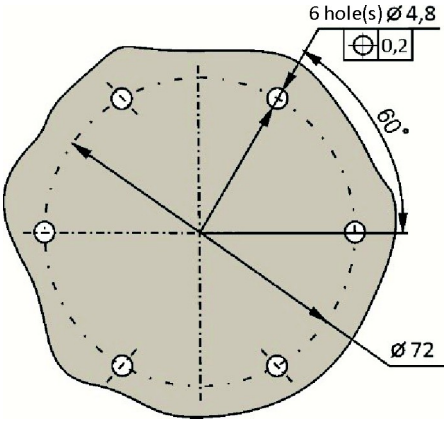


Mark III



ANNEX 2 Escort DU-BLE’s fitting dimensions

Mark I, II



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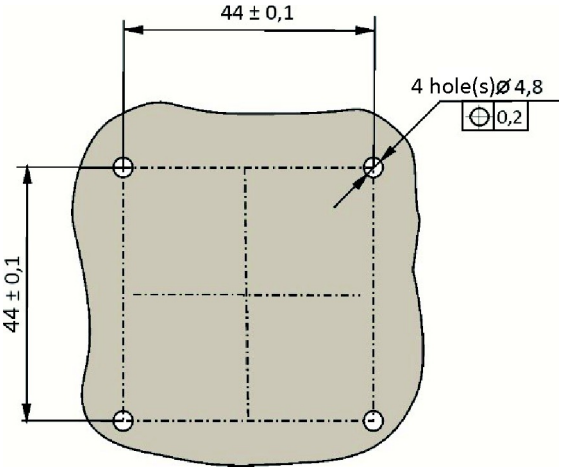
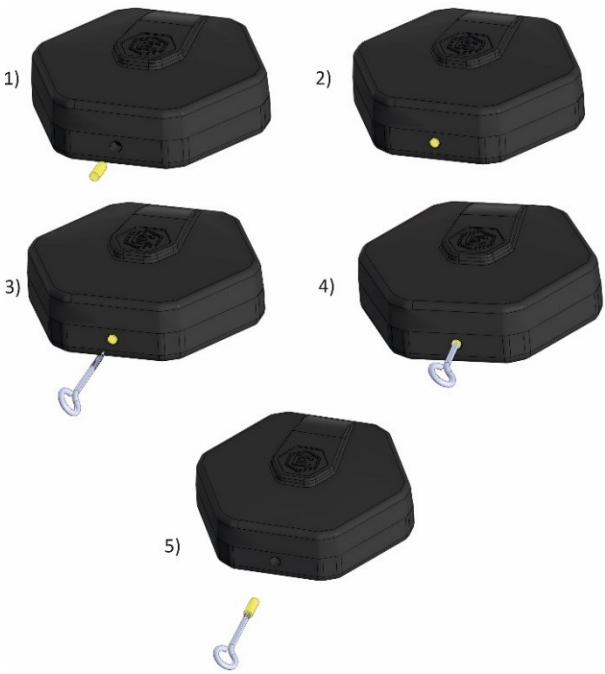


ANNEX 3 Escort DU-BLE's sealing

Mark I, II



Mark III

For notes