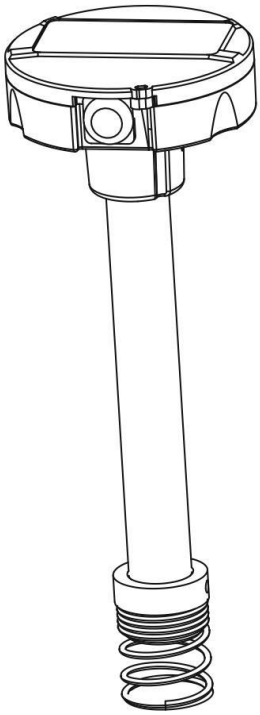
FUEL LEVEL SENSOR



DUT-E S7

OPERATION MANUAL

Version 2.0

TECHNOTON

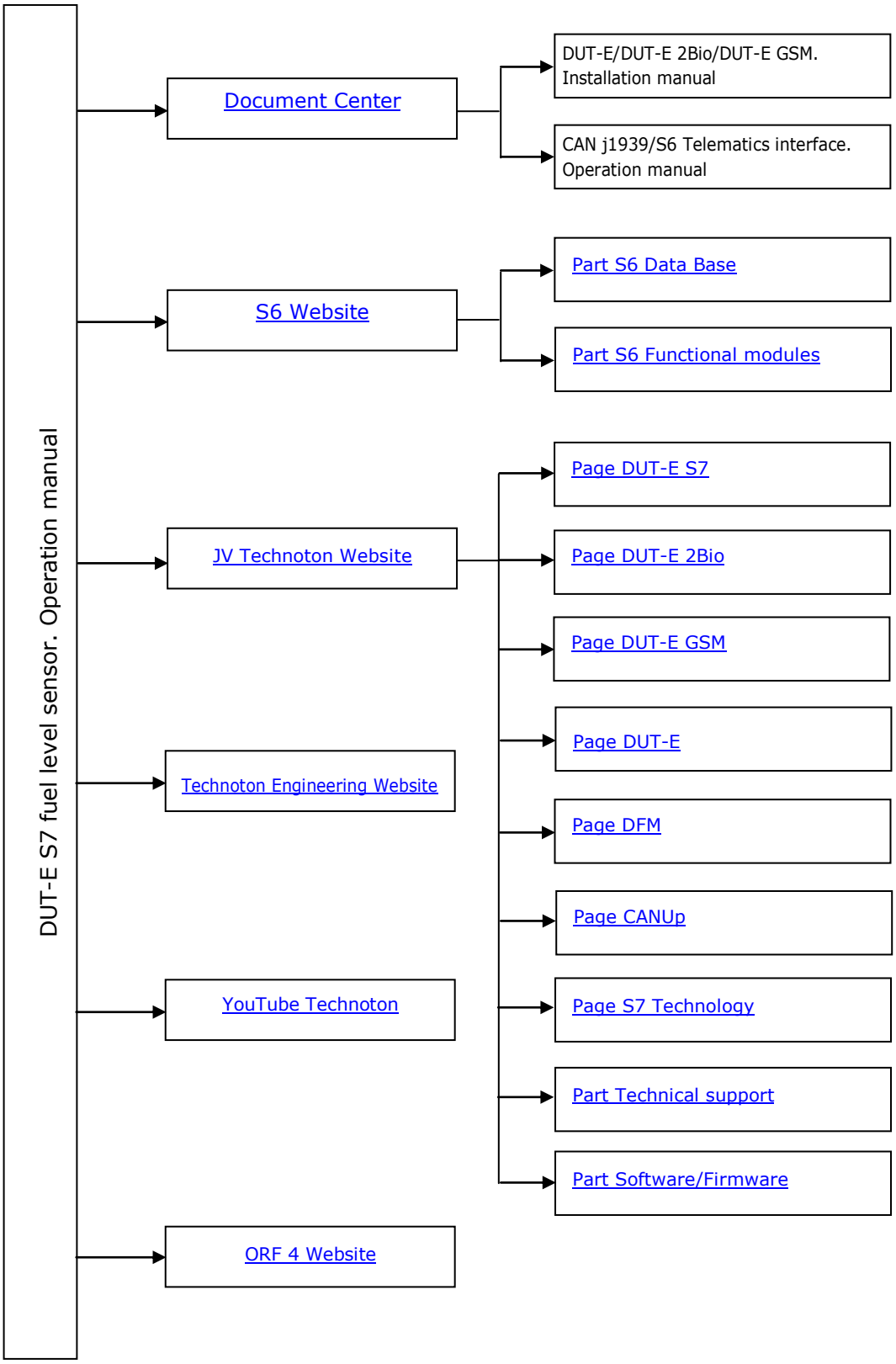
ADVANCED VEHICLE TELEMATICS

Contents

Revision history

Version	Date	Editor	Description of changes
1.0	01.2019	OD	Basic version.
1.1	03.2019	OD	Added information about the certificate of explosion protection of sensor.
2.0	08.2019	OD	• Information on the new mobile application — Fuel tank monitor, which is designed for displaying the sensor indications using Android devices (instead of Service S7 DUT-E service mobile application) is added. • DUT-E S7 technical specifications and the delivery set are updated.

Structure of external links



Terms and Definitions

S7 — Technology designed for wireless collection of data from unattended sensors in systems of industrial and automobile Telematics. S7 Technology is recommended for use in facilities where wiring is impossible or hard to install.

S7 Technology implements Bluetooth 4.X Low Energy (BLE) as a communication channel.

S7 Technology provides ultra-low power consumption and a long period of independent operation for smart sensors and other IoT devices.

On the application level, S7 Technology is fully compatible with S6 Technology which uses cabling.

Advantages of S7 Technology:

- Simple design of data transmission protocol;
- Low power consumption, a potential for fully independent operation of sensors for several years;
- Option of data collection by several data recipients at one time.

DUT-E S7 fuel level sensor is based on S7 Technology.

S6 is the Technology of combining smart sensors and other IoT devices within one wire network for monitoring of complex stationary and mobile objects: vehicles, locomotives, smart homes, technological equipment etc. The Technology is based and expands SAE J1939 automotive standards.

Information on cabling system, service adapter and S6 software refer to CAN j1939/S6 Operation manual.

PGN (Parameter Group Number) — is a combined group of S6 parameters, which has common name and number. Functional modules (FM) of the Unit can have input/output PGNs and setup PGNs.

SPN (Suspect Parameter Number) — informational unit of S6. Each SPN has determined name, number, extension, data type and numerical value. The following types of SPN exist: Parameters, Counters, Events. SPN can have a qualifier which allows qualification of parameter's value (e.g. – Onboard power supply limit/Minimum).

GNSS (Global Navigation Satellite System) — System for area positioning of an object through satellite signal processing. GNSS is composed of space, ground and user segments. Currently, there are several GNSSs: GPS (USA), GLONASS (Russia), Galileo (EU), BeiDou (China).

Onboard reports (the Reports) — information about vehicle which is returned to a user of Telematics system in accordance with inputted criteria. The Reports are generated by a terminal unit both periodically (Periodic reports) and on Event occurrence (Event report).

Parameter — time-varying or space characteristic of the Vehicle (SPN value). For example, speed, fuel volume in the tank, hourly fuel consumption, coordinates. Parameter is usually displayed in the form of graph, or averaged data.

Server (AVL Server) — hardware-software complex of Telematics service ORF 4, used for processing and storage of Operational data, formation and transmission of Analytical reports through Internet by request of ORF 4 users.

Event — relatively rare and sudden change in SPN. For example, the attempt to falsify values of “Instant fuel consumption” counter by applying electromagnetic field to fuel flow meter will be recognized as “Interference” Event. An Event can have one or several characteristics. “Interference” Event has the following: date/time and duration of interference. When the Event occurs, a terminal unit registers the time of occurrence, which is later mentioned in a report on the event. Thus, the Event is always attached to exact time and place of occurrence.

Counter — cumulative numerical characteristic of Parameter. Counter is displayed by a single number and over time its value is increasing. Examples of counters: fuel consumption, trip, engine hours counter etc.

Telematics terminal (Tracking device, Telematics unit) is a unit of Telematics system used for reading the signals of Vehicle standard and additional sensors, getting location data and transmitting the data to the Server.

Telematics system — complex solution for vehicle monitoring in real time and trip analysis. The main monitored characteristics of the vehicle: Route, Fuel consumption, Working time, technical integrity, Safety. In includes On-board report, Communication channels, Telematics service ORF 4.

Vehicle is an object controlled by the Vehicle Tracking System. This is generally a truck, a bus or a tractor, sometimes a locomotive, a ship, a utility vehicle. From the point of view of Vehicle Tracking System, static equipment such as diesel generators, heating boilers, burners, and so on are considered vehicles.

Function module (FM) unit-embedded component of hardware and software combination, executing a group of special functions. Uses input/output PGNs and settings PGNs.

Unit is an element of Vehicle on-board equipment compatible with S6 bus, which uses S6 Technology or S7 Technology.

Introduction

Recommendations and guidelines contained in this Operation Manual are related to **DUT-E S7 fuel level sensor** (further on — DUT-E S7), model code — **07** manufactured by JV Technoton, Minsk, Republic of Belarus.

Model code of DUT-E S7 is identified by third and fourth digits of its serial number engraved at its measuring probe or printed on its packing label (see figure 1).

Figure 1 — Finding out model code of DUT-E S7

This document contains information on the design, principle of operation, specifications, recommendations for operation of DUT-E S7.

DUT-E S7 — wireless sensor, used within Telematics system or autonomously, for accurate level measurement of fuel and of other non-conductive liquids in vehicle tanks and stationary storages (tanks).

DUT-E S7 key features:

- wireless transmission of data using S7 Technology via **Bluetooth Low Energy** channel simultaneously to many receiving devices (Android-based smartphones/tablets, the Telematics terminal, the display in the driver's cabin);
- operation in the «advertising» mode (BLE-radio) — continuous transmission of measurement results, with no need of integration with receiving devices;
- ultra-low power consumption provides completely independent sensor operation during up to 5 years from the inbuilt battery, without the external power supply;
- availability of Explosion protection certificate — safe sensor operation in explosion-dangerous environments;
- no signal cable– quick installation without a need of electrical connection;
- no signal cable — explosive and fire safety of the sensor is ensured without using additional modules of explosion protection;
- no signal cable – increase resistance to sabotage;
- function of digital self-diagnostics for sensor quality control;
- automatic compensation of ambient temperatures effect on the electronic sensor module.

DUT-E S7 has all the advantages of "classical" DUT-E fuel level sensor models:

- shortening/extending length of measuring probe;
- full set of mounting accessories and connection cable included;
- ergonomic bayonet mount allows to save installation time;
- bottom spring for better mounting rigidity;
- screen filter** for secure protection from water and mud;
- sealing possibility to avoid unauthorized intrusion and tampering;
- ergonomic grooves in body allow comfortable grip of sensor's "head" when fastening it in bayonet mounting plate;
- high-quality technical support and documentation;
- conformity with European and national automotive standards.

See figure 2 for identification codes for DUT-E S7 ordering.

Figure 2 — DUT-E S7 order identification codes

Example of DUT-E S7 ordering identification codes:

"Fuel level sensor DUT-E S7 L = 1000 mm"
(wireless S7 interface, measuring probe length 1000 mm).

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* Can be manufactured with any custom measuring probe length up to 1400 mm.
**Not included into the delivery set.

To receive the sensor indications by means of S7 Technology with a smartphone/tablet based on Android 5.X and higher operating system (further on — Android device), **Fuel tank monitor** mobile application is used, its functionality enables the user to:

- Monitor current values of:
  - fuel level in the tank;
  - volume of fuel in the tank;
  - frequency of the sensor measuring generator;
  - temperature of fuel in the tank.
- Receive messages of recorded Events:
  - "Fuelling"/"Fuel Discharge from the tank";
  - "Low level of fuel in the tank";
  - "High/Low temperature of fuel in the tank".
- Conduct the calibration of the measuring system and the fuel tank calibration.
- Enable/disable the feature of compensation of thermal expansion/compression of fuel in the tank.
- Monitor the received signal strength indicator (RSSI) and the time of the latest message reception from the sensor.
- Monitor the current mode of the sensor operation.
- Monitor the sensor malfunctions.
- Receive the sensor ID data (serial number, firmware version, MAC address of BLE-module).
- Record (log) current values of the measuring generator frequency, fuel temperature, fuel level in the tank.
- Conduct operations with the sensor profile.

The user may download the Fuel tank monitor application from Google Play (rearch request "Technoton") and subscribe to it.

ATTENTION: It is strongly recommended to follow strictly the instructions of the present Manual when using, mounting or maintaining DUT-E S7.

The Manufacturer guarantees DUT-E S7 compliance with the requirements of technical regulations subject to the conditions of storage, transportation and operation set out in this Manual.

ATTENTION: Manufacturer reserves the right to modify DUT-E S7 specifications that do not lead to a deterioration of the consumer qualities without prior customer notice.

1 General information and technical specifications of DUT-E S7

1.1 Purpose of use, operation principle and application area

is used for:

- accurate level and volume (remaining) measurement in fuel tanks of vehicles and stationary units (see figure 3);
- measurement of current fuel temperature in the tank;
- wireless transfer of data using S7 Technology.

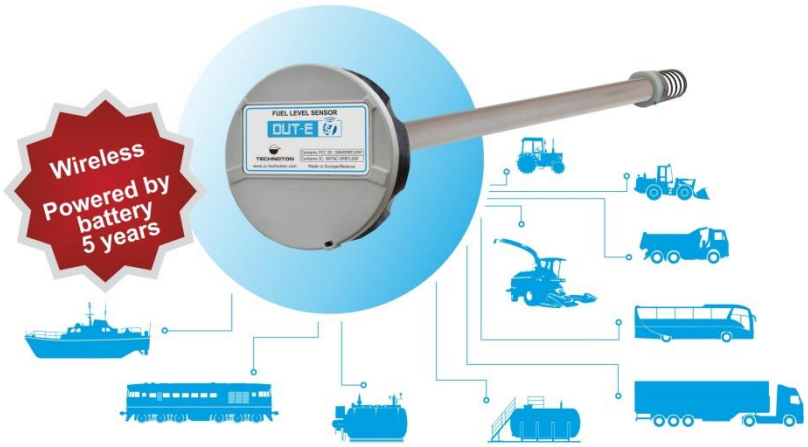


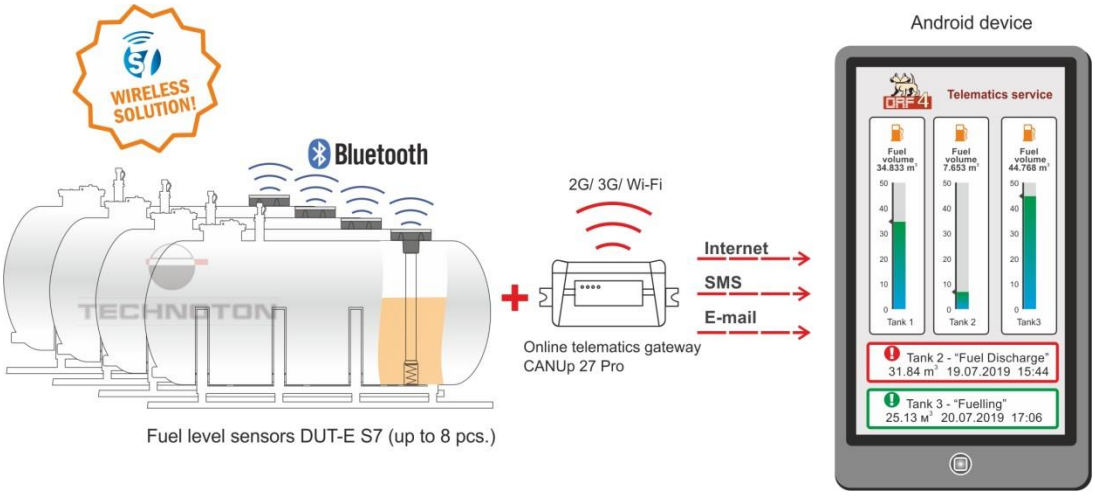
Figure 3 — Purpose of DUT-E S7

Operating principle: DUT-E S7 has an inbuilt Bluetooth low energy module (BLE-module) which, due to a special data transmission algorithm, enables the sensor operation with ultra-low power consumption. The BLE-module transmitter switches on automatically once in 5 s to transmit the current indications. Such a mode of operation enables the sensor to operate completely independently during no less than 5 years without using any external power sources; power is supplied only from the inbuilt battery.
Data from DUT-E S7 can be received at a distance of up to 50 meters by unlimited number of various receiving devices (Telematics units, GPS trackers, Android-smartphones/tablets etc.), which are equipped with Bluetooth 4.X module.

Application areas: DUT-E S7 may be applied both independently, and within the Telematics system (it may operate without using services of a Server) for wireless monitoring the fuel volume:

1) In fuel tank of any Vehicle (see figure 4 a).
2) In fixed tanks (employed in oil products storage facilities, boiler equipment, diesel generators sets etc.) (see figure 4 b).

a) example of fuel volume monitoring in Vehicles tanks



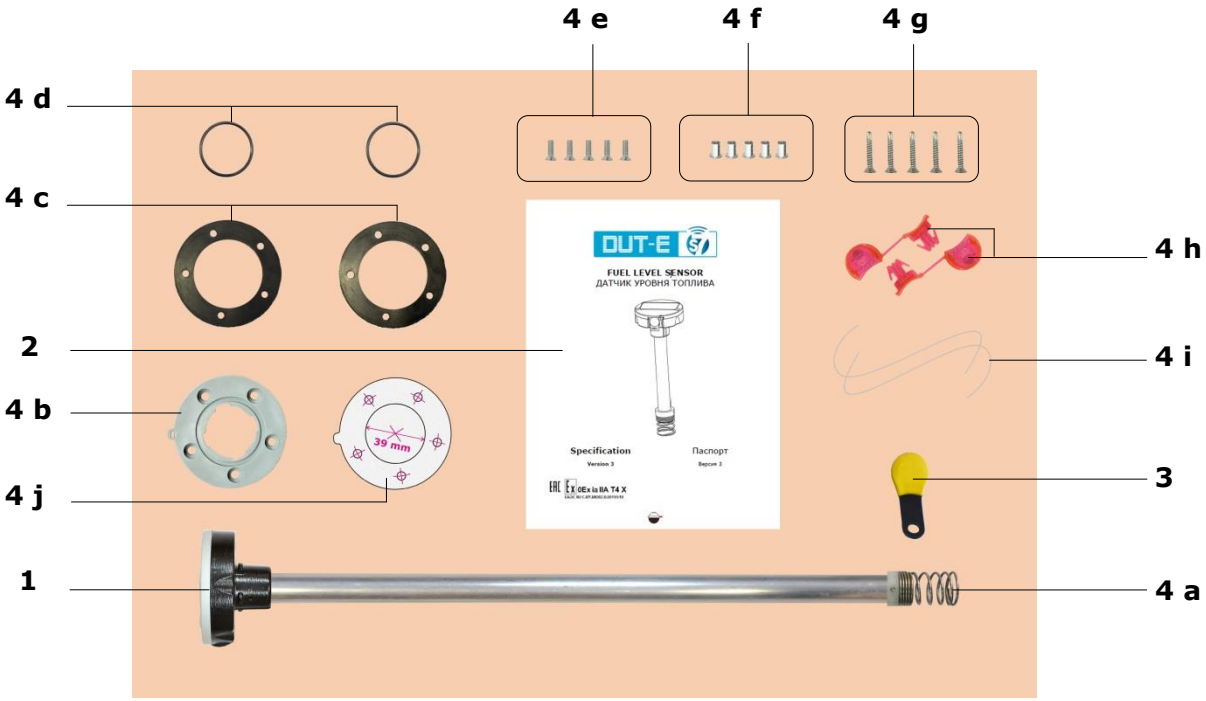
b) example of fuel volume monitoring in fixed tanks

Figure 4 — Application areas of DUT-E S7

Due to the availability of the inbuilt BLE-module in DUT-E S7, up to 8 wireless fuel level sensors can operate using S7 Technology together with CANUp 27 Pro Telematics gateway; this enables to monitor in real time:

- accurate current value of fuel level and fuel volume in tank;
- accurate volume of fuel fill-ups and drains;
- fuel temperature;
- sensor specification data (passport);
- sensor malfunctions.

1.2 Exterior view and delivery set



1	DUT-E S7 fuel level sensor	– 1 pc.;
2	Specification	– 1 pc.;
3	Magnetic key	– 1 pc.;
4	Mounting kit (1 pc.) including:	
	a) bottom stop	– 1 pc.;
	b) plastic mounting plate	– 1 pc.;
	c) rubber gasket	– 2 pcs.*;
	d) sealing rubber ring	– 2 pcs.*;
	e) bolt	– 5 pcs.;
	f) threaded rivet	– 5 pcs.;
	g) self-tapping screw	– 5 pcs.;
	h) plastic seal **	– 2 pcs.*;
	i) sealing cord	– 2 pcs.;
	j) pattern of mounting holes location	– 1 pc.

Figure 5 — DUT-E S7 delivery set

* 1 pc. is for initial DUT-E S7 mounting and 1 pc. as a spare part.
The delivery set may include just 1 gasket of 4 mm.

** Exterior of seal can be different.

1.3 Design

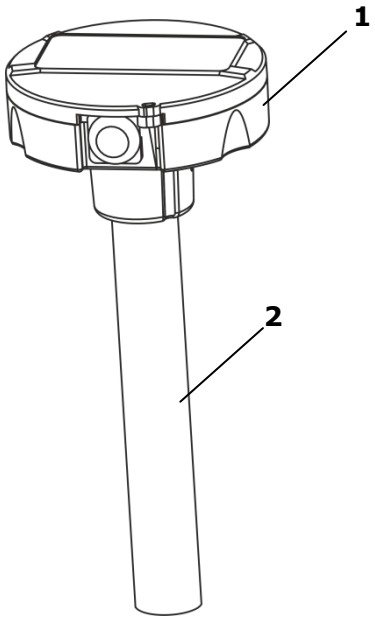


Figure 6 — Structure of DUT-E S7

Inside measuring "head" of sensor **(1)**: electronic measuring unit, BLE module for wireless data transfer using S7 Technology and built-in battery (see figure 6).

Measuring part **(2)** of the sensor composed of two coaxial tubes that form condensate coating. Changes of sensor electrical capacity depend on the diving depth of measuring probe into fuel (dielectric liquid according to its properties).

WARNING: Capacitive principle ensures highest accuracy of liquid measurement when the liquid has **constant dielectric permeability coefficient**. Otherwise, additional inaccuracy of measurement may appear.

1.4 Technical specifications

Powered of DUT-E S7 only by the built-in battery.

DUT-E S7 can be used in the conditions of temperate and cold climate.

For resistance to mechanical impact DUT-E S7 is shake and shockproof.

1.4.1 Main specifications

Table 1 — DUT-E S7 main specifications

Parameter, measuring unit	Value
Fuel level sensor operating principle	Capacitive
Sensor sensitivity to fuel level changes, mm	0.1
Relative measuring error (to the length of the measuring part), %, not more than	±1.0
Wireless data transfer interface	Bluetooth 4.1
Tx Power, dBm	+4
Maximum distance between sensor and receiving device, m	20 (if mounted on a Vehicle or in indoor locations) 50 (when mounted within line-of-sight range)
Data transfer interval, s	5
Estimated lifetime of the sensor (battery life), years	5
Maximum cutting of the measuring probe	up to any length required
Maximum length extension of the measuring probe, mm, not more	3000*
Temperature range, °C	-30…+80
Ingress protection rating	IP55/57
Certificates of BLE module electromagnetic compatibility	CE FCC and IC (see annex B), TELEC BQE
Explosion safety certificate	0Ex ia IIA T4 X ЕАЭС RU C-BY.МЮ62.В.00195/19 (see annex C)
Weight, kg, not more than	1.0 (at L=1000 mm) 0.9 (at L=700 mm)
Overall dimensions, mm, not more than	see figure 8
* In case you need the measuring probe of extended length up to 6000 mm, it can be manufactured upon order	

1.4.2 Data composition of DUT-E S7 output message

DUT-E S7 wireless fuel level sensor transmits data by means of S7 Technology, without integration with receiving devices and without acknowledgement of data reception.
The data in the form of Advertising packets are transmitted automatically with 5 s periodicity in the continuous data transfer mode. The structure of the data packet transmitted by DUT-E S7 is provided in figure 7.

Service field (AD0) (permanent values)			**Data field (AD1)** (variable values)					
Data length (AD Length) (1 byte)	**Data type (AD Type)** (1 byte)	**Data (Data)** (1 byte)	**Data length (AD Length)** (1 byte)	**Data type (AD Type)** (1 byte)	**Company identifier (Company ID)** (2 bytes)	**Unit firmware version (Soft Ver)** (1 byte)	**PGN number (PGN)** (2 bytes)	**PGN data (PGN Data)** (0…21 bytes)
0x02	0x01	0x06	0xXX	0xFF	0xFFFF	0xXX	0xXXXX	…

Figure 7 — Structure of data packet transmitted by DUT-E S7

The application layer of the output message protocol of DUT-E S7 conforms with S6 Database (see table 2)

Table 2 — Data composition of DUT-E S7 output message

Field number	Length	Parameter	Name
Fuel Level Sensor. RAW Data PGN 63277 (0xF72D)			
1	4 bytes	SPN 521440	Frequency, Hz
2	1 byte	SPN 521457	Temperature, °C
3	2 bytes	SPN 5347*	Lateral acceleration extended range, m/s^2
4	2 bytes	SPN 5348*	Longitudinal acceleration extended range, m/s^2
5	2 bytes	SPN 5349*	Vertical acceleration extended range, m/s^2
6	4 bytes	SPN 521488	Unit DTCs mask (see table 3)
8	6 bytes	-	Reserve
* In the process of preparation for introduction.			

Table 3 — Numerical values of malfunction mask (DTCs Mask) of DUT-E S7

Numerical value	Description of malfunction
1	Fuel temperature. No data or incorrect data
64	Current frequency of sensor's measuring generator is higher by more than 100 Hz, compared to the stored value obtained during the calibration of the sensor's "minimum"
512	Defective measuring generator. Possible locking of the measuring module pipes
1024	Low battery charge (<10 %)
2097152	Real time clock. Clocking is off

SPN values of the sensor output message may be calculated according to the formula (1) using attributes from table 4.

$$\textbf{Parameter value = SPN Content} \cdot \textbf{Factor (Resolution) + Offset} \quad (1)$$

Table 4 — Attributes for calculation of current values of DUT-E S7 parameters

Parameter	Factor (Resolution)	Offset
SPN 521440	0.001	0 Hz
SPN 521457	1	-50 °C
SPN 5347	0.01	-320 m/s²
SPN 5348	0.01	-320 m/s²
SPN 5349	0.01	-320 m/s²

The fuel level value ($\mathbf{L_{act}}$) may be calculated according to the formula (G.2):

$$\mathbf{L_{act} = L_s \cdot F_1 \cdot \ (F_0/F_{act}-1)/(F_0-F_1), \ mm} \quad (2)$$

where $\mathbf{L_s}$ – length of the sensor measuring probe after cutting, mm;
$\mathbf{F_0}$ – frequency of the dry sensor measuring generator, Hz;
$\mathbf{F_1}$ – measuring generator frequency of the sensor fully plunged into the fuel, Hz;
$\mathbf{F_{act}}$ – current value of the sensor measuring generator frequency, Hz.

1.4.3 Compatibility with receiving devices

DUT-E S7 can be used with receiving device (Android smartphones/tablets, Telematics units, GPS tracker and other devices for data receiving, logging and displaying), which have Bluetooth 4.X and high.

Recommendations on wireless connection of DUT-E S7 to Telematics terminals can be obtained upon request at Technoton technical support service by e-mail: support@technoton.by.

RECOMMENDATION: The best compatibility with DUT-E S7 sensor during its operation using S7 Technology is provided by CANUp 27 Pro 3G/ CANUp 27 Pro Wi-Fi Telematics gateway. The procedure for connection of wireless Units to the Gateway please, see in CANUp 27 Operation Manual.

1.4.4 Overall dimensions

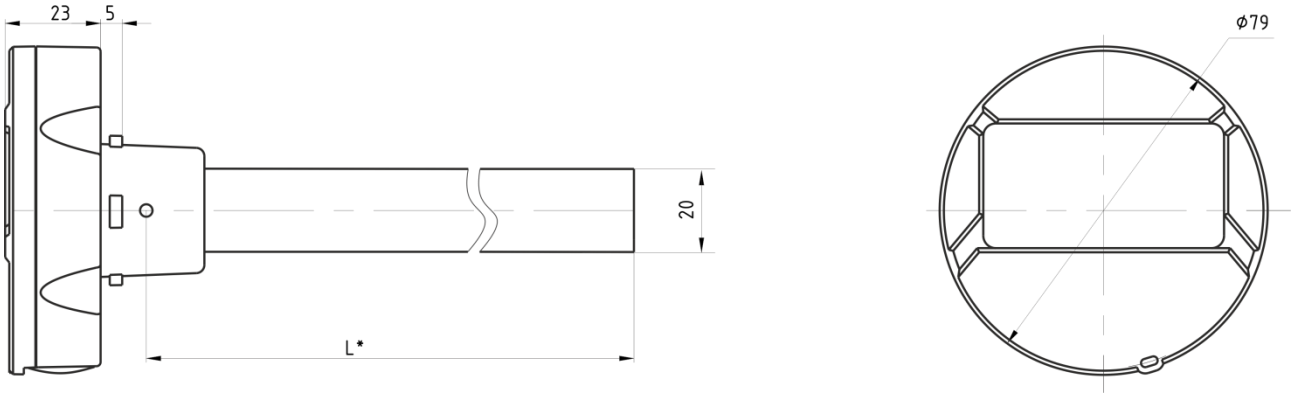


Figure 8 — DUT-E S7 overall dimensions

***** Nominal measuring probe length (700 or 1000 mm).

2 DUT-E S7 installation

For DUT-E S7 correct operation its mounting and configuration should be carried out by certified specialists who have passed corporate technical training.

ATTENTION: Strictly follow safety rules of automobile repair works as well as local safety rules of the customer company when mounting sensor.

2.1 Exterior inspection prior to works start

It is necessary to conduct DUT-E S7 exterior inspection for the presence of the possible defects arisen during transportation, storage or careless use.

Contact the product supplier if there any defects.

2.2 Mounting

Recommendations on installation, length shortening and extension, screen-filter installation, fastening and fixation of DUT-E S7 are identical to the respective recommendations for "wired" DUT-E sensors, described in DUT-E/DUT-E 2Bio/DUT-E GSM installation manual.

2.3 Wireless transfer of sensor indications to the Android device

For wireless monitoring of DUT-E S7 by means of S7 Technology, first, download the Fuel tank monitor application on your smartphone/tablet from Google Play (search request "Technoton") and subscribe to it.

IMPORTANT:
1) To eliminate connection failures between the DUT-E S7 and the Android device, you need to make sure that there are no sources of electromagnetic interference near your working place (radio telephones, video signal transmission units and other wireless devices operating within 2.4 or 5 GHz frequency bands, as well as running electric motors, powerful transformers and switching equipment, welding equipment, high-voltage lines etc).
2) The maximum allowed distance between the DUT-E S7 and the Android device depends on the quality of the Bluetooth connection of the Android device. To assure the stable data transmission, it is recommended that this distance should not exceed 20 m.

2.3.1 BLE-module activation

WARNING: The transfer of DUT-E S7 indications to the Android device is possible only after activation of the sensor BLE-module.

DUT-E S7 has the following modes of operation determined by the status of its BLE-module:

- **"Storage"** — the sensor is in this mode from the moment it is manufactured. The BLE-module of DUT-E S7 is disabled, no data transmission at all.
- **"Manufacturing"** — in this mode, the BLE-module of DUT-E S7 is activated for data transmission only for the period of the sensor testing or checking its operability with Fuel tank monitor application.
  To activate this mode, you need to apply the magnetic key (see the delivery set) for **(5…8) s** to the cap of the sensor "head" (see figure 9 a). **4 h** later or after another touching the sensor cap by the magnetic key, the BLE-module of DUT-E S7 again becomes inactive.

  "Operating" — this mode is enabled, when the sensor is mounted in the tank of a Vehicle or in a fixed tank. In this mode, the BLE-module is fully enabled, without the possibility to return to the inactive state. After that, DUT-E S7 is ready to transmit data by means of S7 Technology throughout its service life. To enable the "Operating" mode, you need to span the pipes contacts of DUT-E S7 measuring probe with a small screwdriver and simultaneously apply the magnetic key for **(30…40) s** to the cap of the sensor "head" (see figures 9 a and 9 b).

a) apply the magnetic key to the cap of the sensor "head"

b) span the pipes of the measuring probe (only during the activation of the "Operating" mode)

Figure 9 — Activation of DUT-E S7 BLE-module

2.3.2 Establishment of communication between the sensor and the Android device

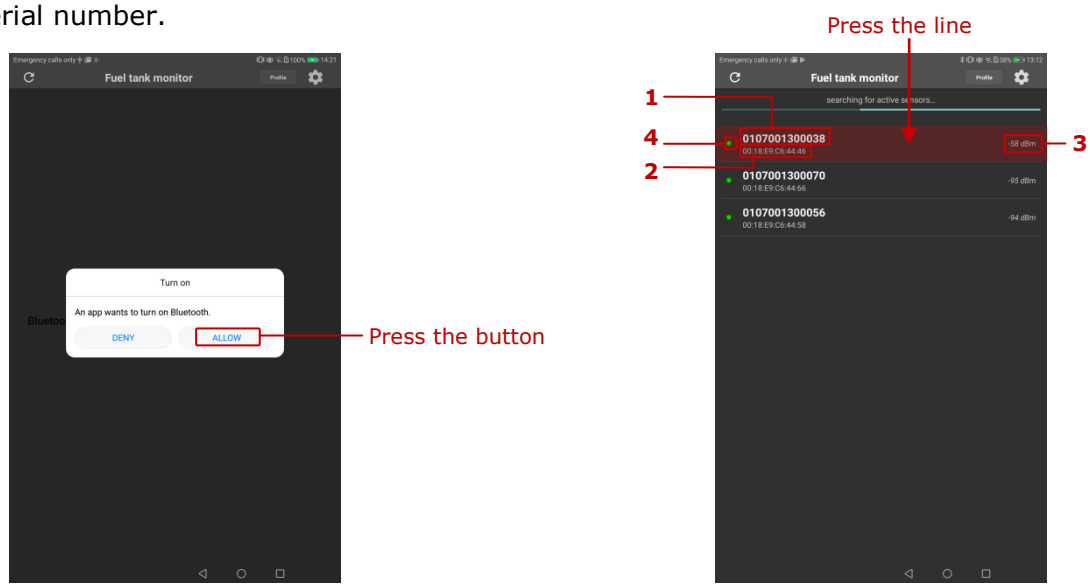
Launch the Fuel tank monitor mobile application with  icon from the main menu of the Android device.

From the moment of BLE-module activation (enabling "Operating"/"Manufacturing" mode) DUT-E S7 is ready to operate in Fuel tank monitor.

Right after it is launched, the Fuel tank monitor will offer to allow enabling the Bluetooth of the Android device (see figure 10 a). After the Bluetooth is enabled, it will search and identify active DUT-E S7 units. Each sensor detected is automatically entered by the application into the list of accessible devices; the following data are being displayed (see figure 10 b):

- Serial number **(1)**;
- MAC-address of the BLE-module **(2)**;
- Received signal strength indicator (RSSI) **(3)**;
- Time the latest message was received **(4)**.

To select the required sensor from the list of accessible devices, press the line containing its serial number.



a) offer to allow the Bluetooth connection

b) selection of the sensor to be monitored from the list of accessible devices

Figure 10 — Establishment of connection between DUT-E S7 and the Android device with Fuel tank monitor application

During DUT-E S7 operation, signals of indicator time of receiving last message from the sensor on the Android device should be displayed in Fuel tank monitor app (see table 5).

Table 5 – Values of signals of time indicator of receiving last message from DUT-E S7

Signal type	Signal color	Signal values
	Green	Less than 20 s passed after receiving last message from the sensor
	Yellow	(20…40) s passed after receiving last message from the sensor
	Orange	(40…60) s passed after receiving last message from the sensor
	Red	More than 60 s passed after receiving last message from the sensor

2.3.3 Interface of Fuel tank monitor application

The interface of Fuel tank monitor application consists of **Information and Configuration Area** and **Tools Panel** (see figure 11).

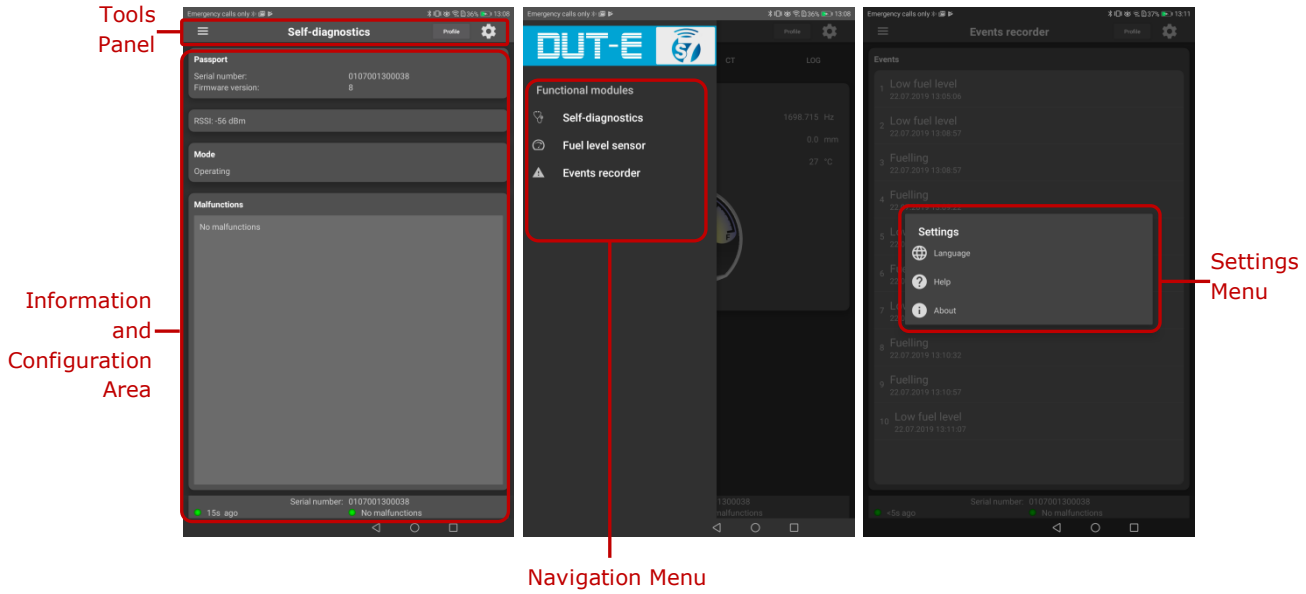


Figure 11 — Interface of Fuel tank monitor mobile application

In the **Information and Configuration** area current parameters and settings of the sensor Functional modules (FM) are displayed.

In the **Tools Panel** area there are the following elements for use during work with Fuel tank monitor application:

- button to display the **Settings Menu** (selection of the interface language, help and software information);
- button to select operations with the sensor Profile;
- name of selected FM of the sensor;
- icon to display the **Navigation Menu** (selecting FM of the sensor, monitoring of indications, configuration of notifications of Events, measuring system calibration, tank calibration, diagnostics of malfunctions etc.).

When working with DUT-E S7, the Fuel tank monitor mobile app operates with data (PGN and SPN) from S6 databases.

2.3.4 Operations with the sensor Profile

Profile is a set of PGN (passport/specification data and configuration of Functional modules).

To perform any operations with the DUT-E S7 Profile, the menu **Profile** is used which is opened by pressing the appropriate button on the **Tools Panel** (see figure 12).

The **Profile** menu contains the following options for operations:

- Load from a file — is used to load the Profile saved in the memory of the Android device before. In the window where the file is to be loaded you need to find and select the Profile file (**DUT-E_S7_*.prf7**);
- Save to a file — is used to save the changed settings of the Profile in the Android device memory;
- Load a default profile — is used for loading a profile with standard settings.

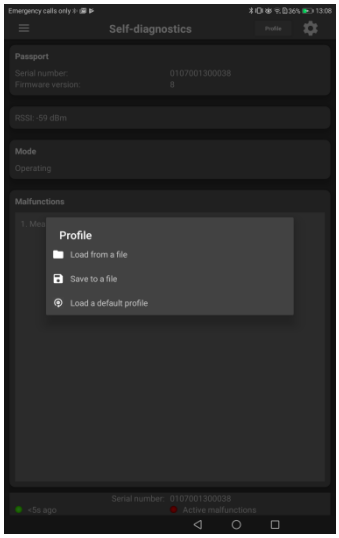


Figure 12 — View of Profile menu Fuel tank monitor mobile application

IMPORTANT: All configuration changes made in Fuel tank monitor app are not stored in the sensor, but in memory of Android device. Configuration changes are saved in a file, placed in folder, where Fuel tank monitor is installed: **Service S7 DUT-E/DUT-E_S7_*.prf**.

Note — If needed, you may save the sensor profile file with the file name which is different from the file name assigned by default. However, in this case, the Fuel tank monitor application will not be able to find automatically the required profile, when the communication with the sensor is established.

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* DUT-E S7 serial number.

2.4 Calibration of the measuring system

The calibration of the measuring system is necessary for correct displaying of the fuel level measurement readings by a **specific** Android device.

IMPORTANT: In case of replacing old Android device, it is necessary to copy profile of particular sensor into memory of new Android device (see 2.3.4) or repeat the measuring system calibration operation.

In the process of the measuring system calibration, minimum and maximum possible levels of fuel measurement in tank are stored into the memory of Android device in **Sensor calibration** bar of the Fuel tank monitor application (Fuel Level Sensor MF submenu, **Settings** tab) (see figure 13).

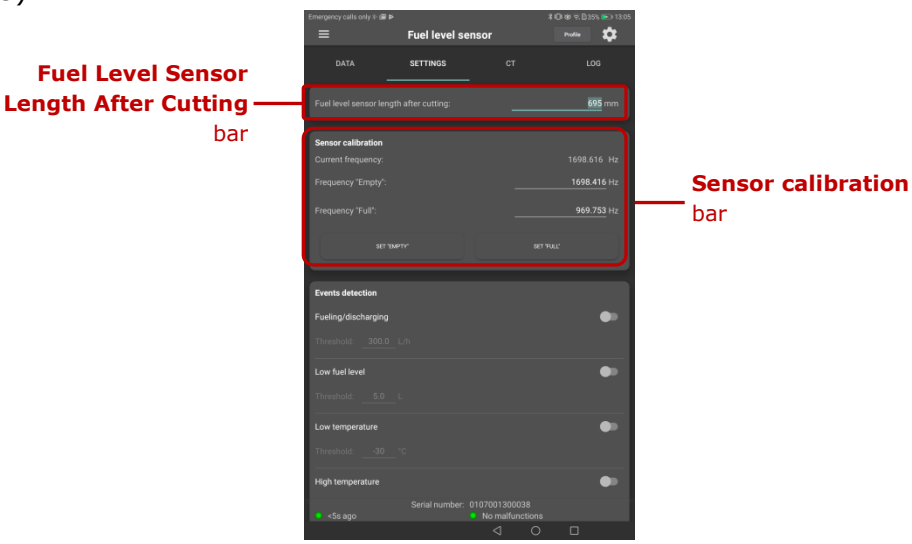


Figure 13 — Measuring system calibration with Fuel tank monitor application

For the measuring system calibration make the following steps:

1) Select the desired sensor from the list of available devices (see 2.3.2).

2) Get the sensor out of the fuel tank and wait for (30…60) seconds so that all fuel run off the probe.

3) Measure sensor probe length L (mm) from ending of tubes to draining hole (see figure 14) and enter the measured value in **Fuel Level Sensor Length After Cutting** field (see figure 13).

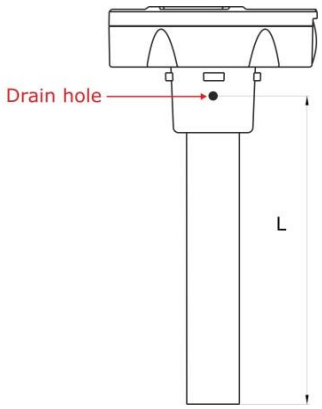


Figure 14 — Measuring probe length of DUT-E S7

4) To calibrate minimum (lowest) point of level measurement, press 

button in **Sensor calibration** bar.

ATTENTION: When the measuring system calibrating to minimum level, there should not be fuel residues on surface of tubes of probe.

5) Dip the probe's tubes fully into the fuel. Wait for (10…20) seconds for sensor readings stabilization.

6) To calibrate maximum (highest) point of level measurement, press 

button in **Sensor calibration** bar.

7) Save the changes of the profile in the memory of the Android device.

8) Measuring system calibration is finished.

IMPORTANT: If frequency values of the sensor measuring generator for the maximum and minimum fuel levels are known, it is sufficient to enter these values in the fields **Frequency "Empty"** and **Frequency "Full"** of **Sensor calibration** bar respectively, instead of the calibration operation (see figure 13).

2.5 Fuel tank calibration table

Fuel tank monitor app recalculates the measured value of fuel level into the fuel volume in the tank according to the calibration table. To set up calibration table it is required to carry out **calibration of fuel tank**.

Calibration procedure is a sequence of fuel fillings by fixed portions from empty to full state of the fuel tank (see video Fuel level DUT-E installation).

IMPORTANT: To measure the volume of fuel portions it is necessary to use measuring reservoir with inaccuracy not more than 0.25 %.

To make fuel tank calibration correctly, where the sensor is installed, it is required to follow the procedure:

- the Vehicle should not be loaded and stand on the flat horizontal surface;
- fuel tank should be empty;
- the vehicle wheels must be of standard size;
- the tire pressure should match with the prescribed for this Vehicle;
- the vehicle should not move, ignition off, engine off;
- pause between fuel fillings by portions into the tank should be not less than 60 seconds.

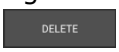
Tank calibration table is stored in memory of **specific** Android device using Fuel tank monitor app (Fuel Level Sensor MF submenu, **CT** tab) (see figure 15).

Figure 15 — Making fuel tank calibration table using the Fuel tank monitor app

IMPORTANT: In case of replacing old Android device, it is necessary to copy profile of particular sensor into memory of new Android device (see 2.3.4). Alternatively, fuel tank calibration should be repeated with new Android device.

Select DUT-E S7 which is installed in a calibrated tank from the list of available devices (see 2.3.2).

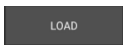
The data is entered as a table of correspondence between measured fuel level value (**Level, mm** column) and fuel volume in the tank (**Volume, l** column).

- To add lines into the calibration table, press  button. In the process of adding new batches of fuel into the tank with a measuring vessel, each time a new batch is added the current value of the fuel level in the tank will be displayed on the left side of this button, as well as the value of the measuring generator frequency that corresponds to it. Whenever the button is pressed, these values are automatically entered into the next line in **Level, mm** and **Freq., Hz** columns.
- New entries are automatically sorted from low to high fuel level value. To delete the line, place the cursor into any of the cells and press 

button.

  Button 

is used for deleting all entries of calibration table.
- As soon as the calibration is over, clicking 

button will allow saving the table as a ***.ttr** file in memory of Android device.
- To load previously saved table from file click 

button (for example, in case of replacement of fuel level sensor).
- As soon as the creation of the calibration table is completed, save the changes of the sensor profile in the Android device memory.
- Fuel tank calibration is finished.

ATTENTION:

1) The number of calibration table points is proportional to the measurement accuracy of fuel volume. The recommended number of calibration pints is not less than 15. The maximum possible number of calibration points in Fuel tank monitor app is **60**.

2) The maximum possible volume of the tank to be calibrated is **250000 l**.

3) In the process of entering the calibration points, it should be borne in mind that the Fuel tank monitor application displays data with **10 s** filtration time lag.

4) If needed (e.g. in case of a repeated calibration of the measuring system), you may manually correct the measuring generator frequency in points of the calibration table (column **Freq., Hz**). The fuel level values (column **Level, mm**) will be recalculated respectively.

2.6 Adaptation of indications for specific conditions of exploitation

To adapt indications for specific conditions of exploitation, you may enable the Fuel tank monitor settings which are located in **Temperature correction** and **Events detection** bars (Fuel Level Sensor MF submenu, **Settings** tab) (see figure 16).

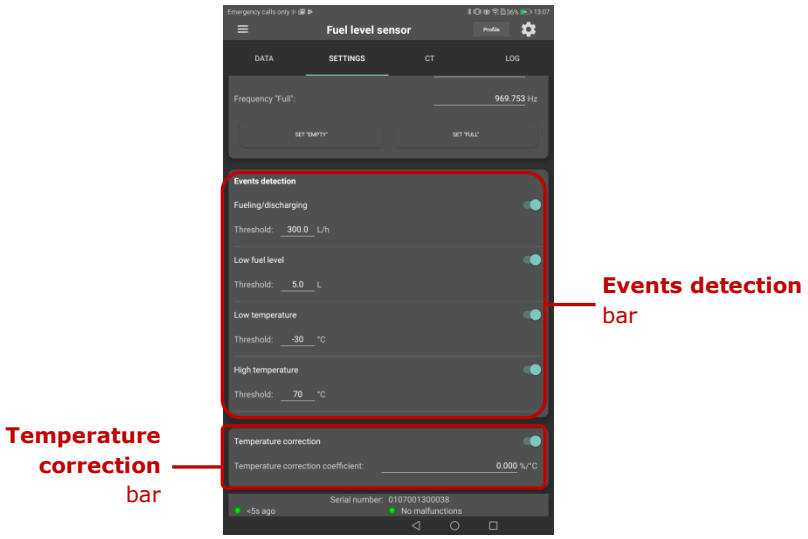


Figure 16 — Fuel tank monitor settings for specific conditions of exploitation

Select the desired sensor from the list of available devices (see 2.3.2).

1) Function **Thermal correction** compensate the thermal expansion/contraction of the fuel.

ATTENTION: Thermal expansion/contraction of the fuel caused by the temperature deviation, alters the volume of fuel in the tank. As consequence, the sensor transmits a significant increase or decrease of fuel level to Android device.

Automatic thermal compensation is disabled by default. To turn it on you need to shift the blue slider to the right in **Temperature correction** bar, then insert the required coefficient value into the field **Temperature correction Coefficient, %/°C**. To turn off the thermal compensation insert the coefficient value **0.0** or shift the blue slider to the left.

Thermal correction coefficient $K_{ther.corr.}$ is determined by formula (3):

$$K_{ther.corr.} = (-1) \cdot \frac{(V_{max} - V_{min}) \cdot 100}{(T_{max} - T_{min}) \cdot V_{min}} \quad (3)$$

where T_{min} and T_{max} — respectively the minimum and the maximum measured values of fuel temperature in the tank during 24 hours;

V_{min} and V_{max} — measured values of fuel volume in the tank with minimum and maximum fuel temperature respectively.

IMPORTANT:

1) The values of V_{min} , V_{max} ,T_{min} , T_{max} determined by the DUT-E S7 readings.

2) When measuring values V_{min} , V_{max} ,T_{min} , T_{max} during 24 hours follow the requirements:

- Vehicle is not moving with engine off.
- Ambient temperature should correspond to normal operating conditions of the Vehicle.
- Tank should be filled with fuel not less than 10 % of the total fuel volume.
- There should be the same fuel volume in the tank (refueling or draining is not allowed).

2) For automatic identification of Events and the user notification of their occurrence, there are the following settings in the Fuel tank monitor application, in **Events detection** bar (see figure 16):

- In the bar **Fueling/Discharging**, in order to enable the identification of "Fuelling"/ "Fuel Discharge from the tank" Events, you need to shift the blue slider to the right. In the field **Threshold**, enter the threshold value of the fuel consumption. In case this value is exceeded, the application will display information of the respective Event.
- In the bar **Low fuel level**, in order to determine the volume of the emergency fuel balance, you need to shift the blue slider to the right. In the field **Threshold**, enter the value of the minimum volume of fuel in the tank below which the application will display information of the respective Event.
- In the bar **Low temperature**, in order to enable determining the minimum fuel temperature at which starting the engine is allowed, you need to shift the blue slider to the right. In the field **Threshold**, enter the value of the minimum temperature of fuel in the tank, below which the application will display information of the respective Event.
- In the bar **High temperature**, in order to enable determining the maximum fuel temperature at which the engine operation is allowed, you need to shift the blue slider to the right. In the field **Threshold**, enter the value of the maximum temperature of fuel in the tank above which the application will display information of the respective Event.

Information windows appearing on the Android device display in case of Events (see figure 17) are accompanied by sound and vibration signals*****.

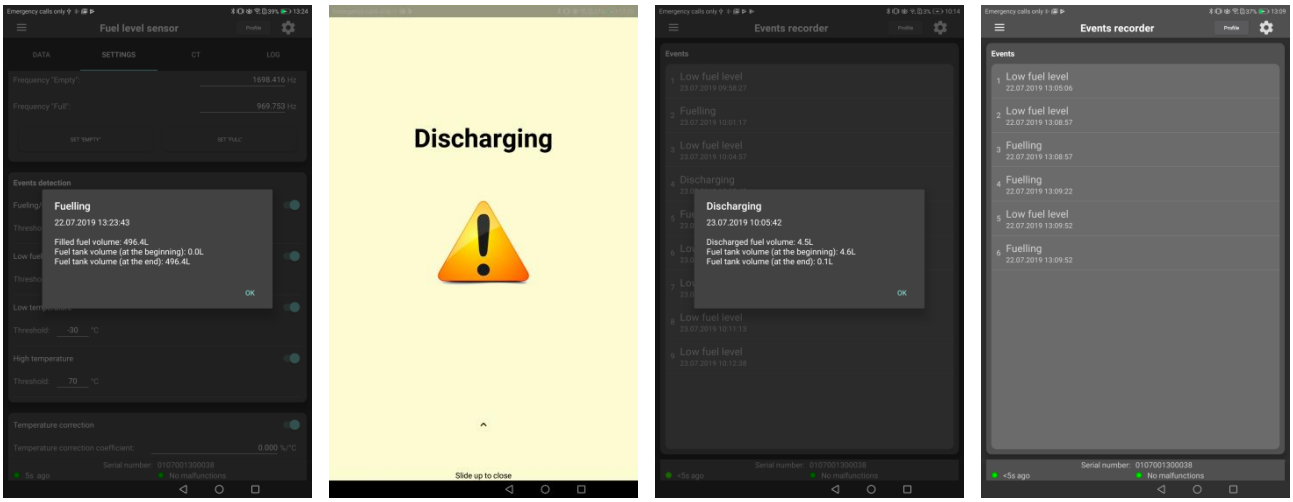
For fuel tank "Fuelling"/"Fuel Discharge from the tank" Event the following information is displayed (see figure 17 a):

- data and time of the Event occurrence;
- volume of fill-up/drained fuel;
- fuel volume in the beginning and at the end of the Event.

For other Events, only the date and time of their occurrence as well as the current value of the Parameter, specified in **Threshold** field are displayed.

A list of all Events recorded during the working session with DUT-E S7, till the moment of closing the Fuel tank monitor application is displayed in **Events** bar in Events Registrator FM submenu (see figure 17 b).

***** With sound and vibration signals ON in the Android device which is being used.



a) example of information windows of Events "Fuelling"/"Fuel Discharge from the tank"

b) example of a list of registered Events in Events Registrator FM

Figure 17 — Display Events information in the Fuel tank monitor application

IMPORTANT: Enabling and correct operation of the feature of automatic identification of "Fuelling"/"Fuel Discharge from the tank" Events is possible only after the measuring system calibration (see 2.4) and entering the calibration table into the memory of the Android device being used (see 2.5).

3 Sealing

It is required to seal the sensor with sealing cord and disposable plastic seal* to prevent fuel thefts or unauthorized interference into DUT-E S7 operation. Seals and cord are included into DUT-E S7 delivery set (see figure 18).

To seal the sensor put the sealing cord through the special holes of the mounting plate and DUT-E S7 body. Then put the ends of the cord through the holes in the center of the plastic seal body. Latching the seal will lock the cord. Seal removal will be impossible without its damaging

Figure 18 — Sealed DUT-E S7

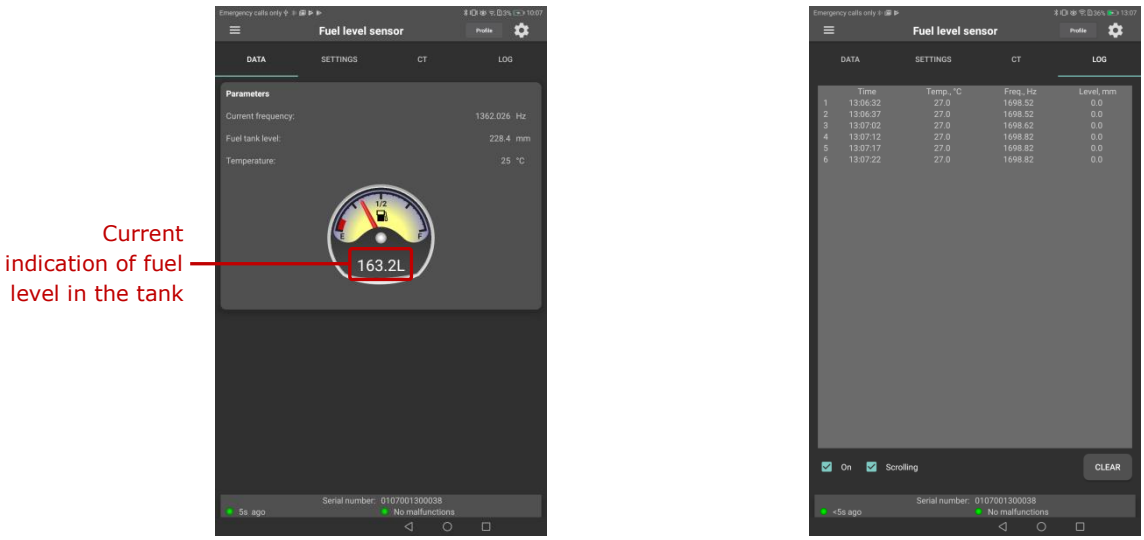
WARNING: Sealing rope should not touch the fuel tank body!

* Design of the seal supplied within the delivery set can differ from the one displayed in figure 18.

4 Monitoring of indications using the Android device

IMPORTANT: Correct monitoring of indications with Fuel tank monitor application is possible only after the measuring system calibration (see 2.4) and entering the calibration table into the memory of the Android device being used (see 2.5).

For monitoring of indications, select the required sensor from the list of accessible devices in the Fuel tank monitor application (see 2.3.2) and open **Data** tab of (Fuel Level Sensor MF submenu) (see figure 19 a).



a) example of displaying the current indication *b) example of logging the current indication*

Figure 19 — Monitoring of indications in the Fuel tank monitor application

With the Fuel tank monitor application, the user can monitor in real time current values of the following Parameters on the display of the Android device:

- fuel level in the tank;
- fuel volume in the tank;
- frequency of the sensor measuring generator;
- fuel temperature in the tank.

To carry out the indications analysis, you may enable (**On** field, **Log** tab of the Fuel level sensor FM submenu) the registration (logging) of current values of the fuel temperature, frequency of the sensor measuring generator and the fuel level (see figure 19 b), with their recording in the log file **(*.txt)**.

The maximum number of control points displayed — 200. The number of points recorded in the log file — not limited.

Scrolling field serves to display each new line of Parameters added in the lower portion of the **Log** tab.

CLEAR button serves to clear the list of all control points registered during logging.

The recorded log files are automatically placed into the installation folder of the application, in the memory of the Android device (**\Fuel tank monitor\Log**). The log file name is generated automatically and contains the sensor serial number, the current date and time of starting the data recording.

5 Measurement accuracy check

5.1 Basic principles

DUT-E S7 accuracy check test is conducted to determine the reduced and absolute error of fuel volume measurement on the particular vehicle fuel tank.

The procedure of DUT-E S7 accuracy check requires filling/draining of the fuel tank and comparing sensor data with the actual amounts of filling/draining.

Fuel drain is carried with manual or mechanical pump.

Calibrated measuring containers must be used to determine the exact amount of drained/refilled fuel.

ATTENTION: The amount of any fuel filling/draining during the accuracy test should not be less than 20 % of total tank capacity.

5.2 Check tests procedure

Check tests should be carried out in the following order:

1) Drain a fixed volume of fuel.

2) Determine the exact amount of drained fuel with the calibrated measuring container.

3) Record the data into the Check test report.

4) Wait for the fuel getting still in the tank (for stable DUT-E S7 readings).

5) Refuel the tank with the previously drained fuel.

6) Record the data into the Check test report.

7) When analyzing accuracy errors, "Drain" and "Refill" Parameters are estimated as a percentage relative to the total tank capacity.

See annex A for check test report template and error calculation formula.

6 Malfunction diagnostics

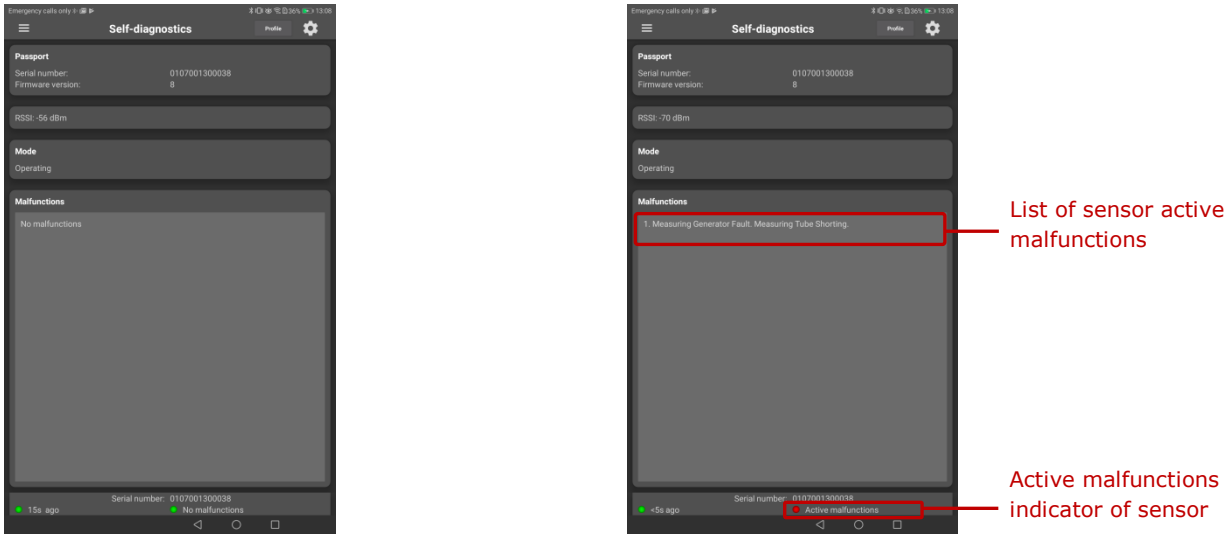
WARNING: DUT-E S7 indications in the Fuel tank monitor application will be invalid if the measuring tubes are closed by conducting mud or water.

For operability check of a particular DUT-E S7, indicator of active malfunctions (see table 6) is permanently displayed in right lower corner of Fuel tank monitor app window.

Table 6 — Meaning of signals of active malfunctions indicator of DUT-E S7

Signal type	Signal color	Signal values
	Green	No active malfunctions detected
	Red	Active malfunctions are detected (see table 3)

When active malfunctions are detected, **Malfunctions** field (Self-diagnostics FM submenu) will contain the name of malfunction (see figure 20).



a) without active malfunctions *b) there are active malfunctions*

Figure 20 — Sensor Quality Control in the Fuel tank monitor application

7 Maintenance

7.1 General instructions

DUT-E S7 visual inspection and operation check is recommended at least once per year.

IMPORTANT: We recommend to check annually the correctness of the measuring system calibration for minimum and maximum levels of fuel in the tank (provided that the tank has not lost its shape and was not replaced). In case of incorrect indication, repeat the measuring system calibration. Re-calibration of the fuel tank of Vehicle in this case is not required.

DUT-E S7 repair works are carried out only by certified **Regional Service Centers** (RSC). Full list of RSC can be found at https://www.jv-technoton.com/.

7.2 Demounting

Clean the tank surface nearby the mounting location before DUT-E S7 demounting.

Prepare a clean napkin to clean the fuel from the sensor probe.

Cut the sealing cord carefully.

Unfasten DUT-E S7 by turning its body counterclockwise.

Mount the fuel tank plug (be ordered separately) for protection from any possible clogging through mounting opening.

Remove screen-filter and bottom stop from the end of measuring tubes.

ATTENTION:
1) Screen-filter dismantling should be done carefully to avoid breaking latches of fixator.
2) In case of repeated installation of DUT-E S7 — replace the old rubber gasket with a new one.

7.3 Examination

DUT-E S7 is demounted conduct a visual examination to detect the following defects:

- visible damages of the sensor head body, measuring probe;
- backlash of measuring unit tubes relative to each other and/or the body;
- presence of mud or paraffin between the tubes of the measuring probe;
- damage of the plastic mounting plate and traces of fuel leaks through the rubber gasket of the mounting plate.

Contact RSC or Manufacturer if the defects detected.

7.4 Cleaning

During DUT-E S7 operation mud or paraffin formation is possible on the surface of the measuring probe pipes. Pollution of the cavity between the pipes of the measuring probe can lead to significant increase of accuracy error.

ATTENTION: Mud coating inside the inner measuring tube does not affect DUT-E S7 normal operation. Examine the space between two tubes of measuring part and between measuring part and additional electrode for mud and paraffin.

To clean the tubes wash them with the clean fuel. If there is paraffin in the cavity between the tubes, it is necessary to slightly warm the measuring part with a heat gun to remove it. It is also recommended to wash the screen filter as well.

ATTENTION: Avoid fuel getting on DUT-E S7 head body, interface cable and its connector when washing the tubes.

8 Packaging

DUT-E S7 delivery sets come in cardboard boxes of the following shape (see figure 21).

Figure 21 — DUT-E S7 packaging

Label sticker with information on the product name, serial number, firmware version, manufacture date, weight as well as Quality Control seal and QR code is stuck on two sides of the DUT-E S7 box (see figure 22).

Figure 22 — DUT-E S7 packaging label

Note — Label design and contents can be modified by the Manufacturer.

9 Storage

DUT-E S7 is recommended to be stored in dry enclosed areas.

DUT-E S7 storage is allowed only in original packaging at temperature range from +10 to +30 °C and relative humidity from 45 to 75 % at 25 °C.

Do not store DUT-E S7 in the same room with substances that cause metal corrosion and/or contain aggressive impurities.

DUT-E S7 shelf life must not exceed 24 months.

10 Transportation

Transportation of DUT-E S7 is recommended in closed transport that provides protection for DUT-E S7 from mechanical damage and precipitation.

When transporting by air, DUT-E S7 must be stored in heated pressurized compartments.

Air environment in transportation compartments should not contain acid, alkaline and other aggressive impurities.

Shipping containers with packed DUT-E S7 sensors should be sealed.

11 Utilization/re-cycling

DUT-E S7 does not contain precious metals in amount that should be recorded.

The inbuilt lithium-thionyl chloride battery of DUT-E S7 contains harmful substances and components that are hazardous to human health and environment.

DUT-E S7 must not be disposed of together with general domestic waste.
The Buyer is responsible for the disposal of DUT-E S7 by means of its delivery to the hazardous waste collecting center; this will ensure safety for human health and environment.

Technoton bears no responsibility for any non-compliance with the above disposal and recycling requirements for DUT-E S7.

Contacts

Distribution, technical support and service

Tel/Fax: +375 17 240-39-73

https://www.jv-technoton.com/

marketing@technoton.by

support@technoton.by

Manufacturer

Zavod Flometr

Tel/fax: +375 1771 3-29-21

office@flowmeter.by

Annex A
Template of check test report

Report

Date: _____

DUT-E S7 serial number	
Vehicle type, model, registration number	

Drainage volume	According to calibrated container V_M, liters	
	According to the indication on the display of the Android device $V_{Android}$, liters	
Accuracy error	Absolute error $\Delta = V_{Android} - V_M$, liters	
	Normalized to total tank volume $\delta = \frac{V_{Android} - V_M}{V_{total\_volume}} \cdot 100, \%$	

Refueling volume	According to calibrated container V_M, liters	
	According to the indication on the display of the Android device $V_{Android}$, liters	
Accuracy error	Absolute error $\Delta = V_{Android} - V_M$, liters	
	Normalized to total tank volume $\delta = \frac{V_{Android} - V_M}{V_{total\_volume}} \cdot 100, \%$	

Resume:

The results of drain measurement **match**/**do not match** specifications.

The results of refueling measurement **match**/**do not match** specifications.

Comments: _____

representative of the CUSTOMER: _____/_____/

representative of the CONTRACTOR: _____/_____/

Annex B
Electromagnetic compatibility of BLE-module of DUT-E S7

BLE-module installed in DUT-E S7 is certified and found to comply with:

- FCC Rules Part 15 (marking on sensor — Contains FCC ID: S9NSPBTLERF);
- IC Rules, RSS-210 (marking on sensor — Contains IC: 8976C-SPBTLERF).

WARNING: Any changes or modifications of BLE-module, which are not approved by the party responsible for compliance with FCC and IC certificates, may deprive the user of the sensor of the right to operate it.

1) BLE-module complies with the restrictions for Class B digital device in accordance with Part 15 of the FCC Rules and RSS-210 of the IC Rules.

These restrictions are used for providing protection from harmful interference when operating in residential premises. BLE-module generates and can transmit/receive radio frequency energy. If it is not installed and is not used in accordance with the instructions, it may cause harmful interference to radio communication. There is no guarantee that interference will not occur in a particular installation. If BLE-module creates harmful interference to the reception of radio or television signals, what can be determined by turning BLE-module on and off, it is recommend for a user to try to eliminate the interference in one or more of the following ways:

- change the direction or location of the receiving antenna;
- increase the distance between the equipment and the receiver;
- plug the equipment into an outlet on a circuit different from that to which receiver is connected;
- contact the dealer or an experienced radio / television technician for a help.

2) BLE-module complies with the restrictions for Class A digital device in accordance with Part 15 of the FCC Rules and RSS-210 of the IC Rules.

These restrictions are designed to provide reasonable protection against harmful interference when the BLE-module is operated in a commercial environment. BLE-module generates and can transmit / receive radio frequency energy. If it is not installed and is not used in accordance with the instructions, it may cause harmful interference to radio communication. Operation of BLE-module in a residential area may cause harmful interference in which case the user will be required to correct the interference at his own expense.

Annex C
Explosion protection of DUT-E S7

1) DUT-E S7 fuel level sensors (compliance certificate № ЕАЭС RU C-BY.МЮ62.В.00195/19 valid from 01.03.2019 to 29.02.2024) comply with requirement of explosion protection according to the following standards:

- TR of ECU 012/2011 – Technical Regulation of Eurasian Customs Union ("On the safety of equipment for operation in explosive environments");
- GOST 31610.0-2012 — Electrical equipment for explosive gas environments. Part 0. General requirements;
- GOST 31610.11-2012 – Electrical equipment for explosive gas environments. Part 11. Spark-safe electrical circuit "i".

2) Ex marking od DUT-E S7: **0Ex ia IIA T4 X**
Where **X** means, that when installing and operating the sensor, special actions should be carried out to avoid occurrence of sparks caused by hits and frictions.
Ex marking is placed on measuring "head' of the sensors as pictured on figure C.1.

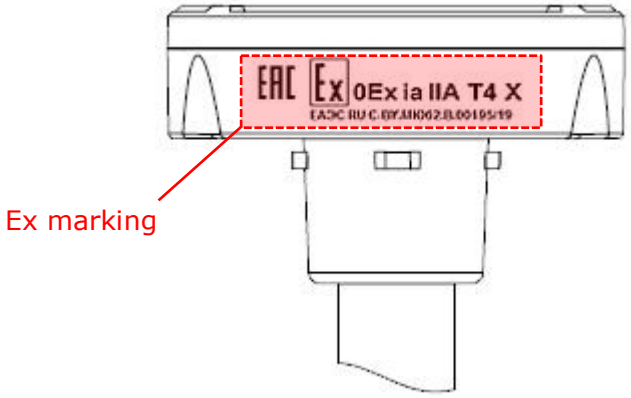


Figure C.1 — Placing of Ex mark on DUT-E S7

3) DUT-E S7 application area in hazardous locations of classes 0, 1 and 2 according to IEC 60079-10-1:2006 (GOST IEC 60079-10-1-2011), categories of explosive IIA mixtures according to IEC 60079-20-1:2010 (GOST R MEK 60079-20-1-2011), according to Ex marking of equipment, IEC 60079-14:2007 (GOST IEC 60079-14-2011) and other regulatory documents governing the use of electrical equipment in potentially hazardous locations.

4) Technical specifications of DUT-E S7 linked to explosion protection:

- ambient temperature: -30…+80 °C;
- ingress protection from external impacts: IP 55/IP57;
- nominal voltage of built-in battery: 3.6 V;
- capacity of built-in battery: 2100 mAh.

Annex D
Videography

1) Animation DUT-E 2Bio fuel level sensor.

Check out the link: https://www.youtube.com/watch?v=WR1556gaN7o

2) Animation DUT-E GSM fuel level sensor.

Check out the link: https://www.youtube.com/watch?v=ixBaKMzKtG8

3) Video clip DUT-E 485 fuel level sensor installation.

Check out the link: https://www.youtube.com/watch?v=X0gUSF3dRWk

4) Video clip length extension of measurement part DUT-E Using measuring sections KDC

Check out the link: https://www.youtube.com/watch?v=dWuY_JJfhFw

5) Video clip Filter Screen of DUT-E fuel level sensor

Check out the link: https://www.youtube.com/watch?v=B5dcYxGfSqQ

6) Animation DUT-E fuel level sensor

Check out the link: http://www.jv-technoton.com/fuel_level_sensor

7) Other Technoton videos are on the YouTube channel which is regularly updated:

https://www.youtube.com/channel/UCq7EF3DHrgI7fOWB2ynsR-A