OVERHEAT
INNOVATIVE STRATEGIES FOR CONTAINERSHIP FIRES PREVENTION AND MANAGEMENT

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ABSTRACT

This document contains the user manuals for IoT sensors used for the OVERHEAT project.

The CARGOSAFE project, as well as the discovery test sessions performed during the project, have demonstrated that the most effective way of promptly detecting the development of a fire in a container is to use sensors that are directly placed as replacements of the standard ISO vents that are normally present on all containers.

Furthermore, the use of gas sensors that can be trained to detect early precursors of a fire, and even to detect that type of material that has developed (or that may be soon developing) a fire, is especially effective. Through the training process a single sensor may be trained to detect multiple types of fire, and therefore the use of multiple sensor types, which was initially assumed at the beginning of the project, appears now superfluous as a single sensor may act as a combination of sensors integrated into a single device.

This document, being a user manual, does not address the activities to be performed for the sensor training phase. These activities are performed as a part of the development phase (or of the early operational phases), while sensors actually deployed on field for the actual used are supposed to having been trained already.

TABLE OF CONTENTS

ACRONYMS

BLE – Bluetooth Low Energy

CE – Marking that appears on many products traded on the extended Single Market in the European Economic Area (EEA), stating that the product has been assessed to meet high safety, health, and environmental protection requirements.

ID – Identifier (generic – used to identify a sensor or a container in this context).

IoT – Internet of Things.

IP – Ingress Protection, indicating how well a device is protected against water and dust. It is defined by the International Electrotechnical Commission (IEC) under the international standard IEC 60529.

ISO – International Organization for Standardization.

WEEE – Waste from Electrical and Electronic Equipment.

INTRODUCTION

The OVERHEAT IoT sensors described in this manual combine multiple functions into a single device conceived for being installed as a replacement of the standard ISO vents that are supposed to be present on every container.

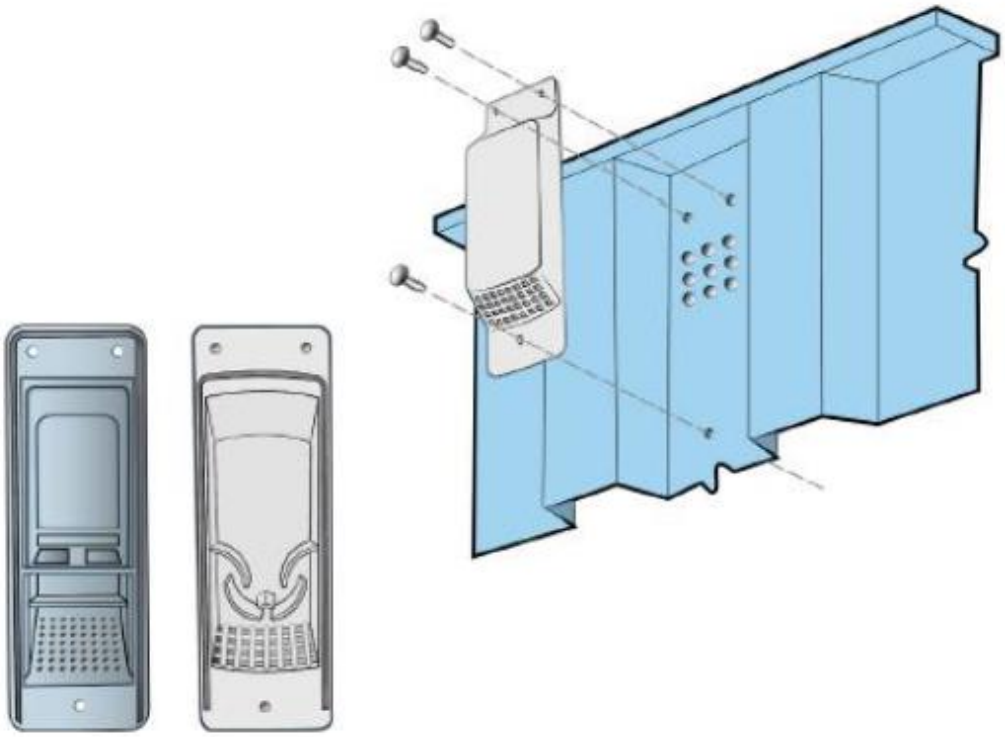

Figure 1 – Standard ISO vents of containers

The OVERHEAT IoT sensors are larger than the standard ISO vents, however the shape is similar and compatible for being mounted as a replacement of the vents. All container vents are supposed to be replaced with sensors. For the demonstration phase a magnetic mount has been foreseen for the sensors so that it is not necessary to drill additional holes on the containers. However, in an operational phase, a suitable screw mount should be foreseen.

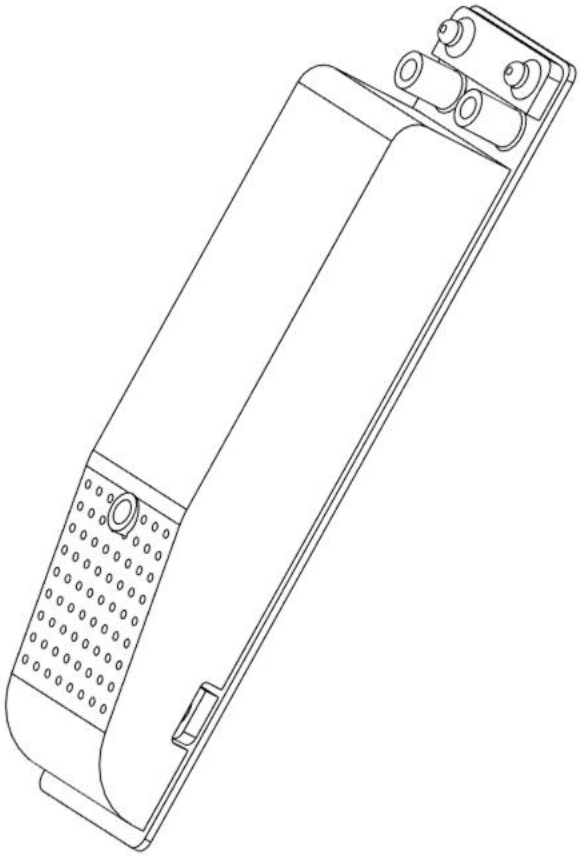

Figure 2 – The OVERHEAT IoT sensor

The following functions are integrated in an OVERHEAT IoT sensor:

- *Artificial Intelligence gas detection*. This is the most important function allowing an early detection of a fire that is developing inside a container. Through the appropriate training of the gas detector, fire precursors may be identified even before the fire develops;
- *LoRa and Bluetooth Low Energy communication*. These functions are intended to send a fire alarm to the digital systems and to the personnel in charge of fire management operations. LoRa is used when only few containers (to the limit, just one container) on the vessel are equipped with the OVERHEAT IoT sensors. In this case the alarm is collected by two LoRa gateways installed on the deck of the vessel: one LoRa gateway is installed at the bow of the vessel, and another LoRa gateway is installed at the stern. By comparing the signal level of the alarm received by the gateways, the location of the container on fire (or where fire precursors are detected) can be approximately determined. Bluetooth Low Energy is used instead when all (or almost all) containers are equipped with the OVERHEAT IoT sensors. In this case, a collaborative communication scheme is used: the IoT sensor that first detects a fire communicates the alarm to the neighbouring IoT sensors, which then act as repeaters

and propagate the alarm to the further neighbouring sensors, and so on until the alarm signal reaches the bow and the stern of the deck where Bluetooth Low Energy gateways (conceptually similar to the LoRa gateways) are installed. The number of "hops" (i.e., the number of times the alarm is repeated by another IoT sensor until the alarm reaches the Bluetooth Low Energy gateway) is used to approximately determine the location of the container on fire. In the demonstration phase only LoRa communications is used as only one or few containers are equipped with the OVERHEAT IoT sensors, although Bluetooth Low Energy is also used for some sensor configuration and verification purposes (for example, to trigger a test alarm);

- *Battery for power supply*. To facilitate the operations during the demonstration phase a rechargeable lithium battery is used, including suitable recharging circuitry. In an operational phase, batteries having high capacity and a very low self-discharge rate, such as thionyl chloride primary batteries, will be likely used instead;
- *Horn and flashing light*. They are used to facilitate crew members to identify the container where a fire is possibly developing, after an approximate localisation of the container is provided as described above.

SAFETY INSTRUCTIONS

- Before use, check that the device is intact and shows no signs of damage;
- The device must be used exclusively in an industrial/professional environment by personnel who have been trained on the safety warnings. The device is not designed and manufactured for use by untrained personnel;
- The device must not be tampered with. Do not attempt to open the case except to carry out procedures described in this manual, and do not introduce foreign objects in the device;
- The device may be able to cause interference to other devices, as well as be subject to interference from other devices with possible malfunctions. In case of apparent malfunctions of the device itself or other devices present in the vicinity, try to move the devices away from each other. In any case, report the problem to technical support.

INSTALLATION

The installation of the OVERHEAT IoT sensor requires to uninstall the existing ISO standard vents that are supposed to be present on the container. The ISO standard does not precisely specify the type of screws that are supposed to be used to fix the vent to the container wall, so it is convenient to be prepared with tools that can be adapted to different screw sizes and heads (slotted, cross, torx, etc.).

Once the existing vent is removed, the OVERHEAT IoT sensor must be placed on the space where the existing vent was located, in such a way that the air inlet of the sensor corresponds to the air outlets of the container that were originally covered by the vent.

Figure 3 – Aligning OVERHEAT IoT sensor with the container air outlets

The OVERHEAT IoT sensors used for the demonstration phase include magnets that ensure a good adhesion of the sensor to the container wall. The use of screws to fix the sensor to the container wall is possible, however it should not be necessary unless the demonstration requires that the

container is moved using a crane after the sensor is installed. In that case, a drill may be required to make additional holes on the container wall so that the sensor can be then fixed using screws.

The sensor is supplied with a battery installed but disconnected from the system. The battery is connected by connecting terminal **A** to its receptacle **B**.

Each cable is labelled for an easy identification.

Figure 4 – Battery connection cables of the OVERHEAT IoT sensor

This connection can be made without removing the device's protective cover.

CONFIGURATION AND INTEGRATION

The OVERHEAT IoT sensor is already configured for operations. The only configuration and integration activity required is to take note of the association between the sensor ID and the ISO standard ID of the container. In the case of a fire alarm, this allows to know the ID of the container where the sensor in alarm is placed.

The OVERHEAT IoT sensor ID is printed on the label placed on it, where the CE marking is also present. The sensor ID can be also captured through the QR code printed on the same label.

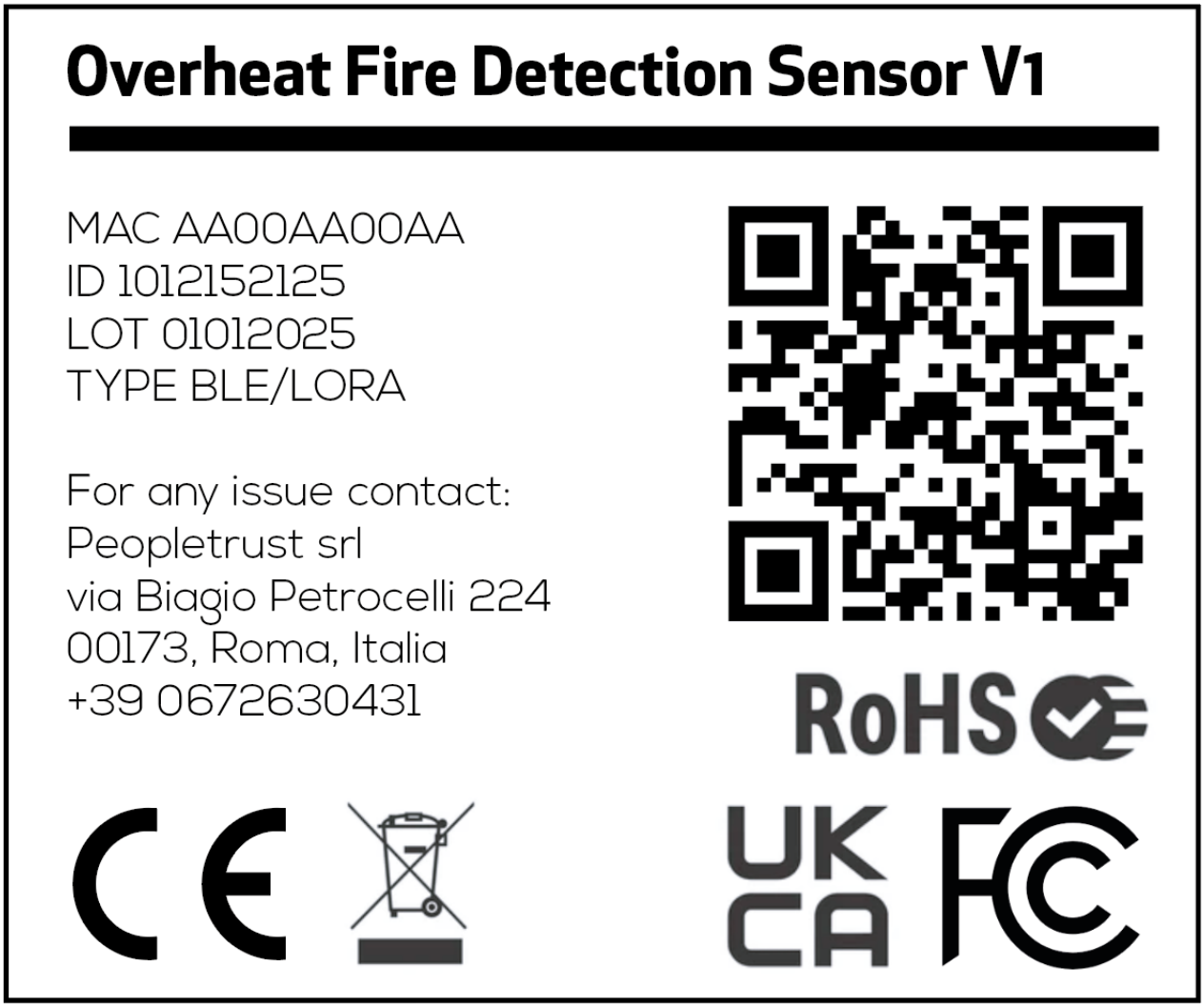

Figure 5 – OVERHEAT IoT sensor label

The ID of the container is supposed to follow the ISO 6346 standard. The data to be captured to identify the container and to associate it to the sensor are the owner prefix, the serial number, and the check digit, as shown in the following picture.

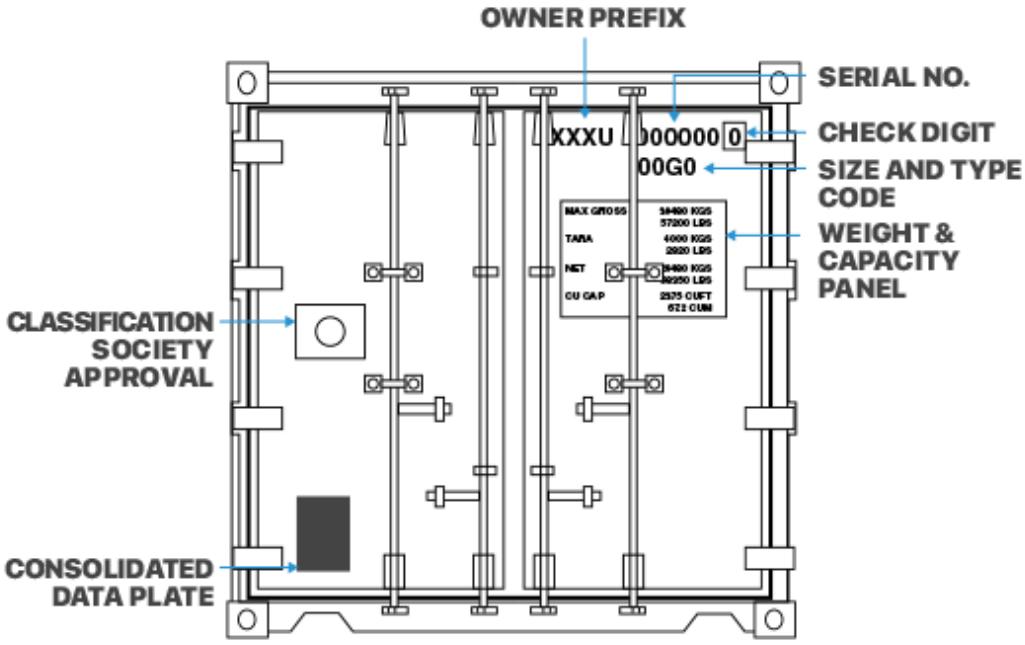

Figure 6 – ISO 6346 identification of the container

For the demonstration phase these data (sensor ID and container ID) are manually gathered by the operator who carries out the installation of the sensor, to be reported to technical support. In an operational phase the process may be partially automated using an app for smartphone or tablet that gets a picture of the QR code on the sensor and of the container ID, performs the optical recognition of the twos, and sends the associated pair of IDs to suitable digital systems.

TEST AND VERIFICATION

Testing the OVERHEAT IoT sensor after the installation requires two additional tools:

- A smartphone where the OVERHEAT IoT sensor installation app is installed;
- A LoRa gateway duly powered and located not far away from the sensor (up to several dozen meters).

The following steps are required:

- Using the app, check that the Bluetooth Low Energy (BLE) signal transmitted by the sensor is present. It can be recognised with respect to other BLE signals in the area because the sensor ID is exposed. Check that the battery level is close to 100%, otherwise perform the operations described in the “Maintenance” section hereafter;
- Using the dedicated function on the app, trigger a test alarm. The flashing light of the sensor should start blinking, and the sound of the horn should be audible;

- Within few seconds, the app should show that the alarm was sent and acknowledged by the LoRa gateway;
- Using the dedicated function on the app, stop the test alarm. The flashing light of the sensor should stop blinking, and the sound of the horn should disappear.

Should any of the above steps fail, please refer to the section “Troubleshooting guide” next.

MAINTENANCE

The OVERHEAT IoT sensor is powered by a rechargeable lithium battery. Whenever a demonstration is carried out, it is convenient that the power level of the battery is close to 100%. The charge level can be checked by means of the installation app. If the charge level is significantly lower than 100%, this may be due either to the energy already used for previous demonstrations, or to the self-discharge of the battery, especially when the sensor was not used for several weeks or months. In these cases, the battery should be recharged as follows:

- To charge the battery, remove the sensor from the container.
- Once removed from container, cable A and its connector B will be visible inside the opening.
- Disconnect cable A from connector B.
- Now connect cable A to the supplied charger into the port T100-A or T100-B.
- The charger display will show the charge percentage.

It's okay to leave the device charging beyond 100%; the charger is smart and will enter maintenance mode as soon as the optimal charge level is reached.

If the OVERHEAT IoT sensor is installed since some time (several weeks or months) it is convenient to check that the air outlet of the sensor is free from dust or other obstacles that may impair the

flow of air from the container air outlet to the sensor air outlet. In that case, remove any dust or other obstacles, using for example a brush.

TROUBLESHOOTING GUIDE

Problem	Possible cause	Solution/action
The installation app does not show any signal exposing the ID of the sensor.	The battery of the sensor may have failed, or the charge level may be too low.	Try to recharge the battery. If the battery does not recharge or if the problem persists after the battery is fully charge, contact technical support.
When a test alarm is triggered, the flashing light blinks, however there is no sound.	The horn may have failed.	Replace the sensor with a spare. Contact technical support to arrange the repair of the defective sensor.
When a test alarm is triggered, sound is heard, however the flashing light does not blink.	The light may have failed.	Replace the sensor with a spare. Contact technical support to arrange the repair of the defective sensor.
When a test alarm is triggered, the flashing light does not blink and no sound is heard, however the app reports that the alarm was sent and acknowledged.	Both the light and the horn may have failed.	Replace the sensor with a spare. Contact technical support to arrange the repair of the defective sensor.

When a test alarm is triggered, the flashing light blinks and a sound is heard, however the app reports that the alarm was sent but not acknowledged.	The communication with the LoRa gateway may have failed.	Check that the LoRa gateway is powered and running, and that it is placed not too far away (LoRa coverage normally covers several hundred metres, up to some kilometres). Replace the LoRa gateway with a spare if the problem persists. Contact technical support to arrange a check of the LoRa gateway.
When a test alarm is stopped, the flashing light and the horn remain active.	Communication with the smartphone was lost.	Restart the smartphone, restart the app, and perform the alarm trigger and stop procedure again. Contact technical support if the problem persists.

The reference contact for technical support is marked on the sensor's label.

DISPOSAL

The OVERHEAT IoT sensor is to be considered as electrical and electronic equipment. The disposal must follow the local regulations concerning the Waste from Electrical and Electronic Equipment (WEEE). Please follow the local WEEE regulations. Please consider that a lithium rechargeable battery is present, so specific local provisions may apply.

TECHNICAL SPECIFICATIONS AND REGULATORY INFORMATION

- Size: 310x72x53
- Weight: approx. 250g
- Battery capacity: 10.000mAh
- Operational temperature range: 0 °C ÷ +60 °C
- Storage temperature range: -20 °C ÷ +75 °C
- Storage humidity: 95% max, not condensing
- IP grade: 40

The OVERHEAT IoT sensors used for the project demonstration phase are prototypes and therefore they are to be considered as “validating pre-production units”. Regulations concerning the CE marking do not apply. Nevertheless, the following regulations have been considered during the design phase as well during prototypes manufacturing:

- Directive 2011/65/EU regarding the restriction of the use of certain hazardous substances in electrical and electronic equipment;
- Directive 2014/35/EU regarding electrical equipment designed for use within certain voltage limits;
- Directive 2014/30/EU regarding electromagnetic compatibility;
- Directive 2014/53/EU regarding radio equipment and telecommunications terminal equipment.

A preliminary risk analysis has been carried out according to the regulations above. The safety instructions provided in this manual result from such analysis.

The CE marking present on the label of the device is purely illustrative of the marking that may be present on a final, fully validated version of the product. It does not state any compliance to the regulations mentioned above, even though the product is designed to meet all the relevant regulatory requirements.

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