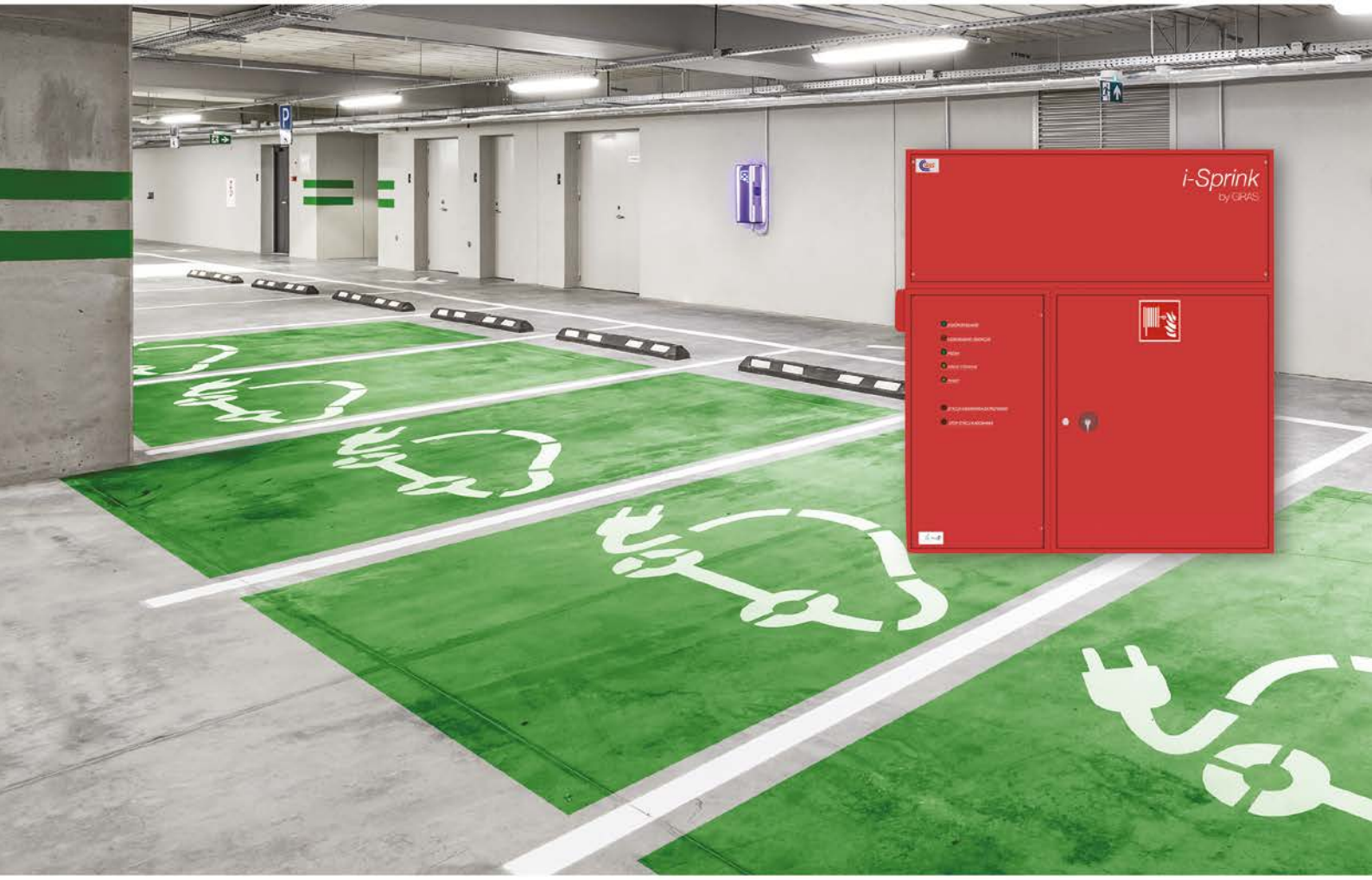
GRAS®
Est. 1985

Our innovation, Your safety



i-Sprink

Internal hydrant with automatic local water spray system – kit

intended for fire suppression
of electric vehicle fires

2023 Edition

www.gras.pl

Authors

MSc Eng. Grzegorz Sypek
MSc Eng. Przemysław Grabowski
Eng. Jarosław Wiche
MSc Eng. Robert Zapała
MSc Eng. Adam Masłowski

Internal hydrant with local water spray system – kit type i-Sprink has a patent application No. P.440341 registered in the Polish Patent Office

As part of the continuous improvement of the offered products and in accordance with market and legal requirements, the manufacturer GRAS P.P.P.H. reserves the right to introduce design changes to this product at any time, without changing their general nature and updating this document.

Table of contents

Introduction

We live in interesting times when the reality around us is changing at an unprecedented pace. In a world where the only constant is change. At Gras, we fully understand the need for quality and innovation, not only to maintain but also to increase the pace of our development.

Consequently, most of us face new challenges and decisions that will have a significant impact on the quality of our lives. This problem also affects manufacturers of products used in fire protection and specialists providing various consulting services in this industry. An excellent example of these changes can be energy transformation, zero-emission buildings, or electromobility, which is of particular interest to us. Electric vehicles, from a nice curiosity and gadget, have become quite imperceptibly an integral part of our cities, streets, and garages. The potential of the aforementioned changes and the directions of development are difficult to predict today, however, real problems can already be identified that require coordinated action from all of us, not so much in the future as here and now. This applies in particular to the issue of fire safety in buildings where vehicles fitted with lithium-ion batteries are parked and charged. Analyzing the current situation in this respect, in order to meet the expectations of the market, we present you this short study, which is an attempt at a systemic approach to the issue of fire safety in buildings where electric and hybrid vehicles may be located. We would like to present to you the general concept of an internal hydrant combined with a local water spray system, intended to protect the places where electric vehicles are parked. We paid special attention to underground garages, including spaces equipped with chargers. Our idea had to be simple, reliable, and above all, efficient. For its implementation, we used water resources commonly available in buildings and internal hydrant systems, supplemented with additional components enabling early fire detection and automatic suppression in the initial stage of its development, before rescue services arrive on site. In this folder, we would like to present you our latest idea of a combined internal hydrant and local water spray system with the trade name i-Sprink, intended for fire suppression of vehicles equipped with lithium-ion batteries. We believe our concept and overall strategy would turn out interesting and useful in a practical sense.

Lithium-ion batteries. Fire hazards

The growing popularity of electromobility and related technologies across the world causes a constant discussion on the real fire hazards of this process and available ways to mitigate its potential risks. Unfortunately, these considerations are often reduced to one question. Which cars burn most often? Or else whether the risk of an electric car fire is higher than the car with a combustion engine?

At this point, it should be clearly emphasized, that focusing only on the number of fires is a vast oversimplification. When assessing overall fire risk and its consequences, other important factors shall be also taken into consideration e.g. dynamics of fire growth, the toxicity of smoke and fire gases, firefighting strategies and tactics, etc. Practice shows that electric vehicles may burn hotter, faster and require far more water to reach final extinguishment compared with conventional ICE cars. Thus despite the market saturation with EVs is still relatively low we already need to solve a really serious problem resulting from the fires often resulting from li-ion battery malfunctions. A full battery pack consists of a number of cells, a voltage regulator, battery management systems (BMS), and cooling systems. The cell consists of a cathode, an anode, a separator, and a vent hole. The separator is a thin plastic filter that only allows ions to pass through. During the charge-discharge cycle of the battery, heat is released. According to tests, the temperature inside a lithium-ion battery can reach up to c.a. 130°C. This heat is generated because the electrolyte and the anode offer electrical resistance to the reverse voltage created during charging. A battery fire usually starts with the occurrence of a thermal runaway (TR), which occurs when a cell, or area within the cell, achieves elevated temperatures due to thermal failure, mechanical failure, internal/external short-circuiting, and electrochemical abuse. In the event of a fire, gases of different characteristics and toxicity are produced, e.g. carbon monoxide (CO) – asphyxiant gas, carbon dioxide (CO_2) – causing hypoxia, and with increasing temperature, additionally toxic gases are emitted, e.g.

hydrogen fluoride (HF), phosphorus pentafluoride (PF5), and phosphoryl fluorine (POF3). An additional risk, especially in the case of confined spaces, is the possibility of an explosion of gases emitted from a burning lithium-ion battery. If an EV powered by a lithium-ion battery catches fire, most dry fire retardants will not work since such fire is a chain reaction. Firefighters will be exposed to toxic fumes, so they will have to use special breathing equipment. The fire may continue for a period of up to 24 hours if the entire battery pack ignites. Based on available literature data, it can be assumed that the heat release rate in the case of an average electric car fire shall not exceed 6 MW. However, in comparison to cars with internal combustion engines, electric and hybrid car fires show a significant increase in heat release rate in their initial stage (different fire growth dynamics). In addition, the shape of the curve corresponds to the process of sequential ignition of subsequent battery modules, which results in periodic, heat release rate jumps. In the event of a fire of high-power lithium-ion batteries, the temperature in the vicinity of the burning car may reach the value of 1000°C, which is almost twice as high as in the case of fires in conventional ICE cars. Here we come to the fundamental point. Regardless of what car is burning, it is necessary to start fighting the fire and try to put it out as quickly and effectively as possible. In the case of ICE cars with internal combustion engines (ICE), extinguishing is based on limiting the oxygen (most fires require at least 16% oxygen content to burn) e.g. by covering it with foam (CAFS). In the case of electric car (EV) fires, measures to ensure high cooling efficiency, e.g. water, are recommended. Batteries are difficult to extinguish, and they can burst into flames again several hours later – in some cases, right up to a week later. In the event of a lithium-ion battery fire, the water supply is aimed at reducing its temperature and dissipate the energy generated by the ignition of subsequent modules. The battery cooling time required to completely extinguish the fire can reach up to 24 hours. The amount of water needed to completely extinguish a battery fire can be up to 10,000 liters. In a situation where the amount of water is insufficient, secondary ignition may occur. Therefore, it is recommended to check the extinguishing and cooling effects of the battery periodically with the use of a pyrometer and a thermal imaging camera. In practice, the firefighting strategy for lithium-ion batteries is based on:

- use of electric car fire blanket with dimensions of 8 × 6 m, made of quartz-based material, resistant to temperatures up to approx. 1600°C. Covering the vehicle with a blanket will reduce the effects of fire but may not be able to extinguish the fire;

- the technique of sinking the entire vehicle in a dipping container adapted for towing, equipped with a closed-circuit water supply system with recirculation is also commonly used. If such a method is used, attention should also be paid to the risk of significant contamination of the water used to extinguish lithium-ion batteries, which absorbs the chemical compounds released from the burning cells.

Note: both firefighting strategies are applicable to electric car fires located outside the building e. g. outdoor parkings and may be impossible to implement in the multi-storey underground parkings with limited access to the source of the fire.

Dipping container intended for extinguishing electric and hybrid (li-ion) cars fires

Source: https://cfpa-e.eu/container-puts-out-inextinguishable-fires-in-electric-cars

Electric vehicle fires are difficult to extinguish and require the use of large amounts of an extinguishing agent with high cooling efficiency, e.g. water supplied at the possibly early stage of the fire.

Internal hydrant with local water spray system – kit type i-Sprink

Description

An internal hydrant with a water spray system type i-Sprink is a fire protection device intended for early fire risk detection and automatic suppression of the fire in its initial phase before the fire services arrive on site. i-Sprink kit uses a water supply and distribution system (fire hydrant system) commonly available in buildings for various purposes.

Intended use

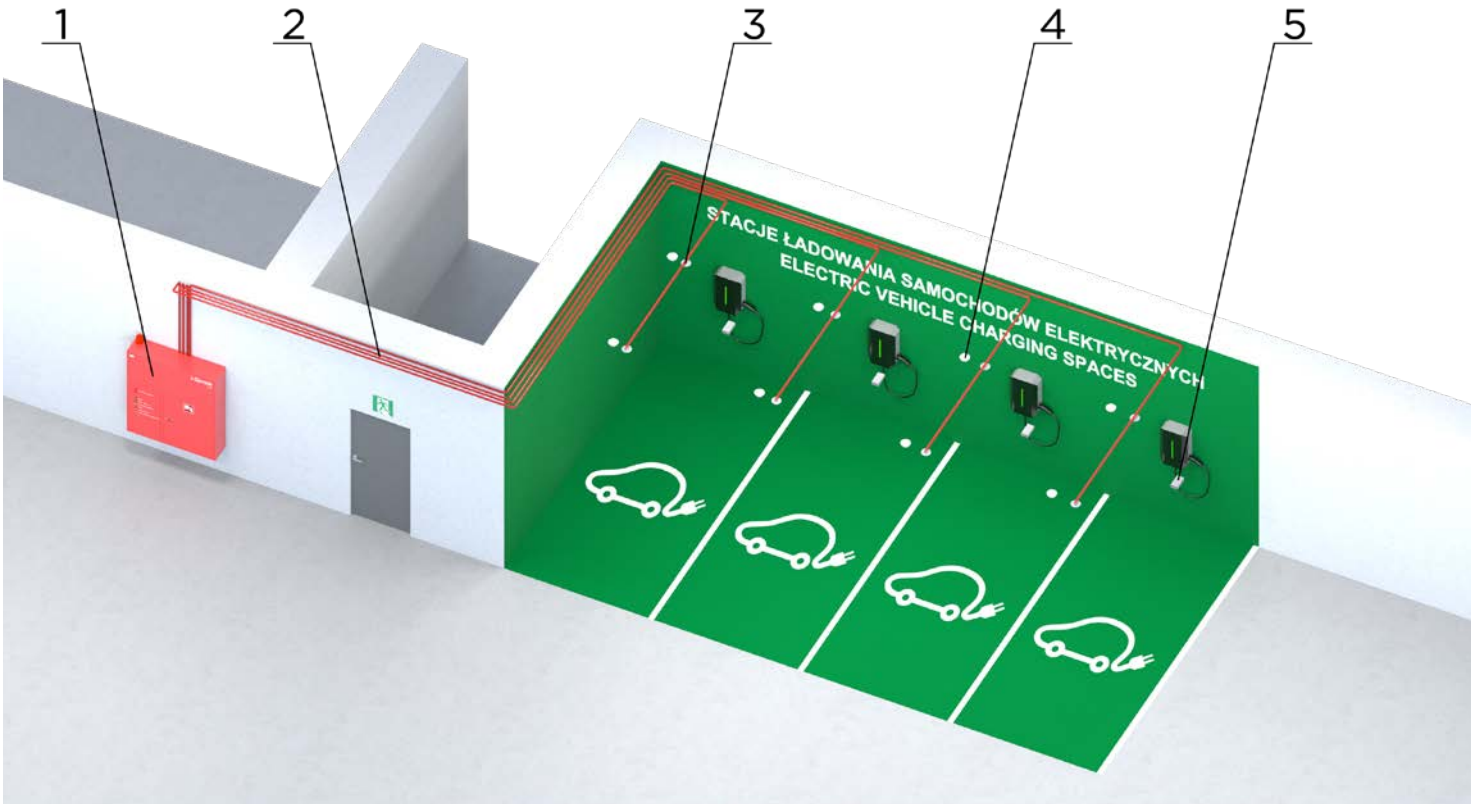
i-Sprink type kit is intended for automatic fire protection (suppression) of selected spaces, in the event of a fire, in buildings for various purposes, e.g. residential buildings, public buildings, industrial buildings e.g.:

- parking spaces fitted with chargers for electric vehicles equipped with lithium-ion batteries in an underground car park (primary use),
- parking spaces with parking platforms in underground car parks,
- parking and charging spaces for battery-operated forklift trucks,
- warehouse storage spaces and production lines in industrial buildings,
- parking spaces for electric bikes and scooters.

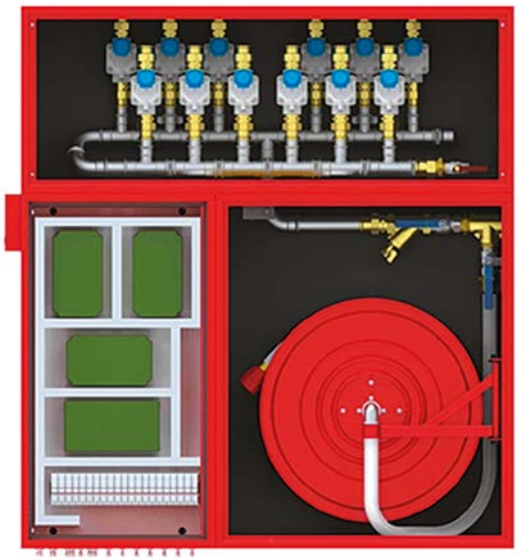
Principle of operation

The principle of operation of the i-Sprink kit is based on the automatic use of a local water spray system to suppress electric or hybrid car fires in their initial stage. Water supply is provided by means of a standard fire hydrant system (depending on local requirements). The early fire detection system consists of a contactless fire location indicator (WMP) combined with a set of smoke and heat detectors. If a fire has been detected, the unit controller opens a specific section valve located in the control valve module to enable water supply to the correct water spray section pipe and two water jet nozzles installed above the protected parking space. Each i-Sprink kit enables manual use of the internal hydrants in order to suppress or extinguish a fire using an internal hydrant hose. The main hydrant valve is fitted with a limit switch which, when opened, automatically closes the motorized section valve in the control valve module. If two or more i-Sprink kits are used in a common space (fire zone), they are integrated (connected) into a system with dedicated communication and data transmission loop.

Structure and key components of the i-Sprink type kit



1 – central unit
2 – water supply pipes (local water spray system – dry system)
3 – water spray nozzles (two nozzles per each parking space)
4 – smoke/heat detector (1 per each parking space)
5 – contactless fire location indicator – WMP (2 per each parking space – located above the lines separating parking spaces e. g. 3 indicators per 2 parking spaces)



Central unit

Each i-Sprink type kit consists of a modular central unit and a range of additional components depending on local requirements and design objectives. The general structure of the central unit is presented below.

- internal hydrant module (fire hose with the limit switch)
- control valves module (water spray system water supply)
- control-power supply module (power supply, controls, and communication loop)

Innovative fire risk detection system

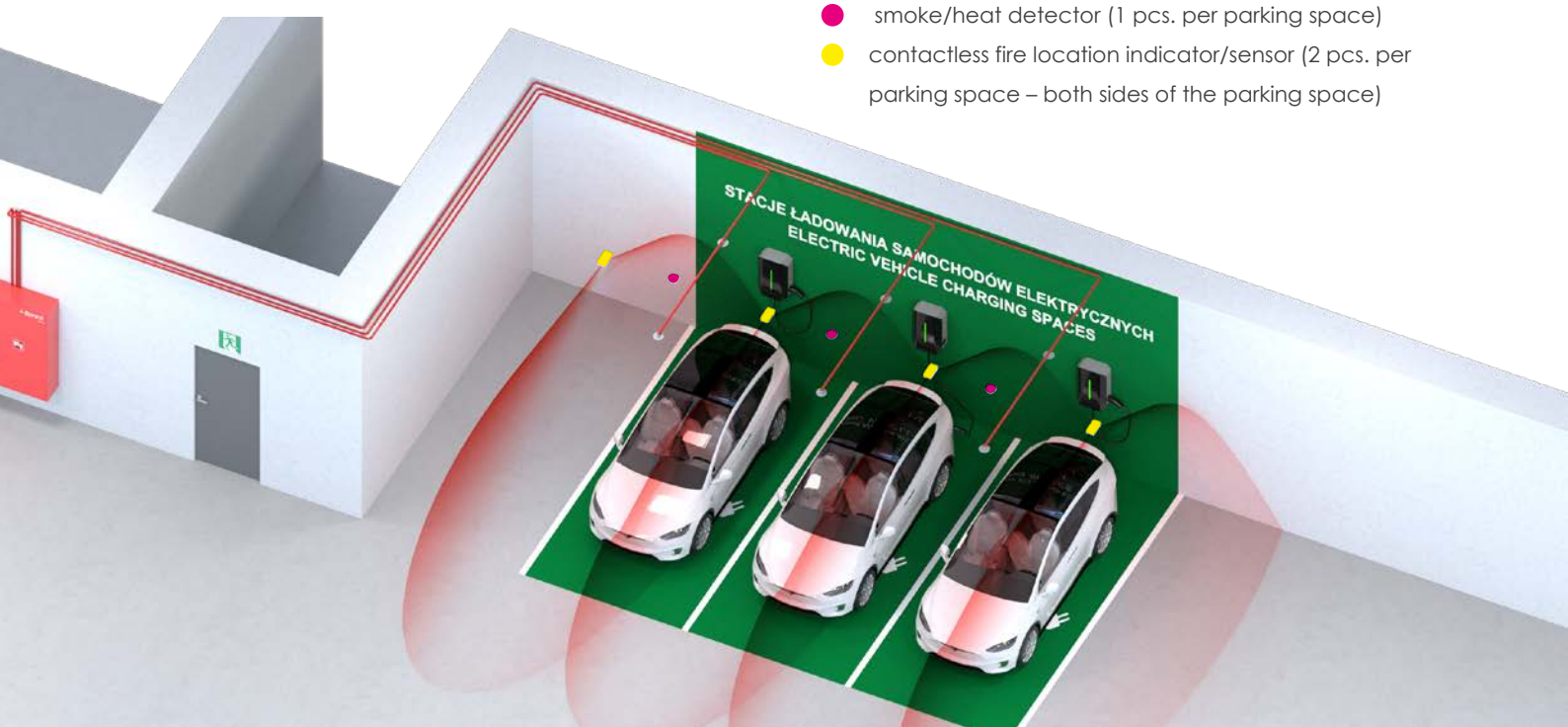
Each i-Sprink type kit is delivered with an innovative fire risk detection system that enables continuous monitoring of the temperature field below each indicator/sensor. The purpose of such a solution is to measure the change in temperature within the monitored field e. g. temperature rise (abnormalities). Each indicator/sensor monitors a specific area and is addressable. All indicators/sensors are interconnected transmitting measured values directly to the control unit. If any abnormality in the temperature field is detected it can be precisely located within a specific parking space. The local water spray system (2 water jet nozzles above the specific parking space only) is activated when any smoke/heat detector being a part of the kit is triggered. The described solution enables fast detection and accurate location of the fire in order to activate a specific group of water jet nozzles.

Contactless fire location indicator/ sensor – technical specifications

- Operating temperatures: -25, +75°C
- IP rating: IP54
- Power supply: 24VDC
- Communication: MODBUS RTU (default); wireless (option)
- Relay outputs: 3 (2 × fire alarm, 1 × failure)
- Temperature matrix resolution: 24 × 32 (default angle: 90° – symmetrical around the vertical axis andcustomized depending on the installation height)
- Distance matrix resolution: 8 × 8
- Dimensions: 80 × 80 × 55 [mm]
- Temperature measurement range: 0-300°C
- Temperature field measurement corrected depending on the distance of the measurement
- Maximum installation height above the floor: 5 m
- Additional features: status of the parking space (occupied/vacant)

Innovative fire risk detection system (example of application)

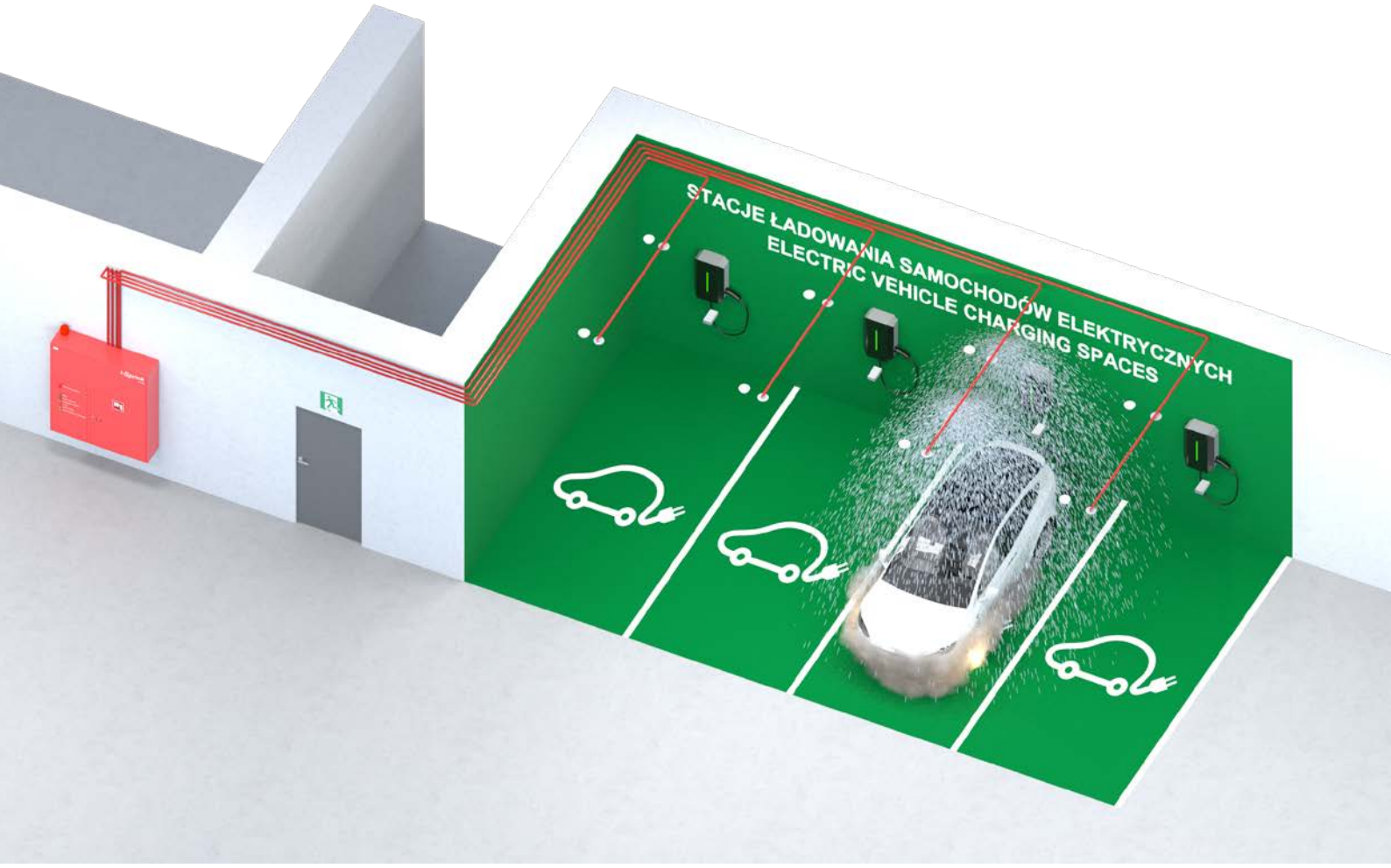
- smoke/heat detector (1 pcs. per parking space)
- contactless fire location indicator/sensor (2 pcs. per parking space – both sides of the parking space)



Operating modes

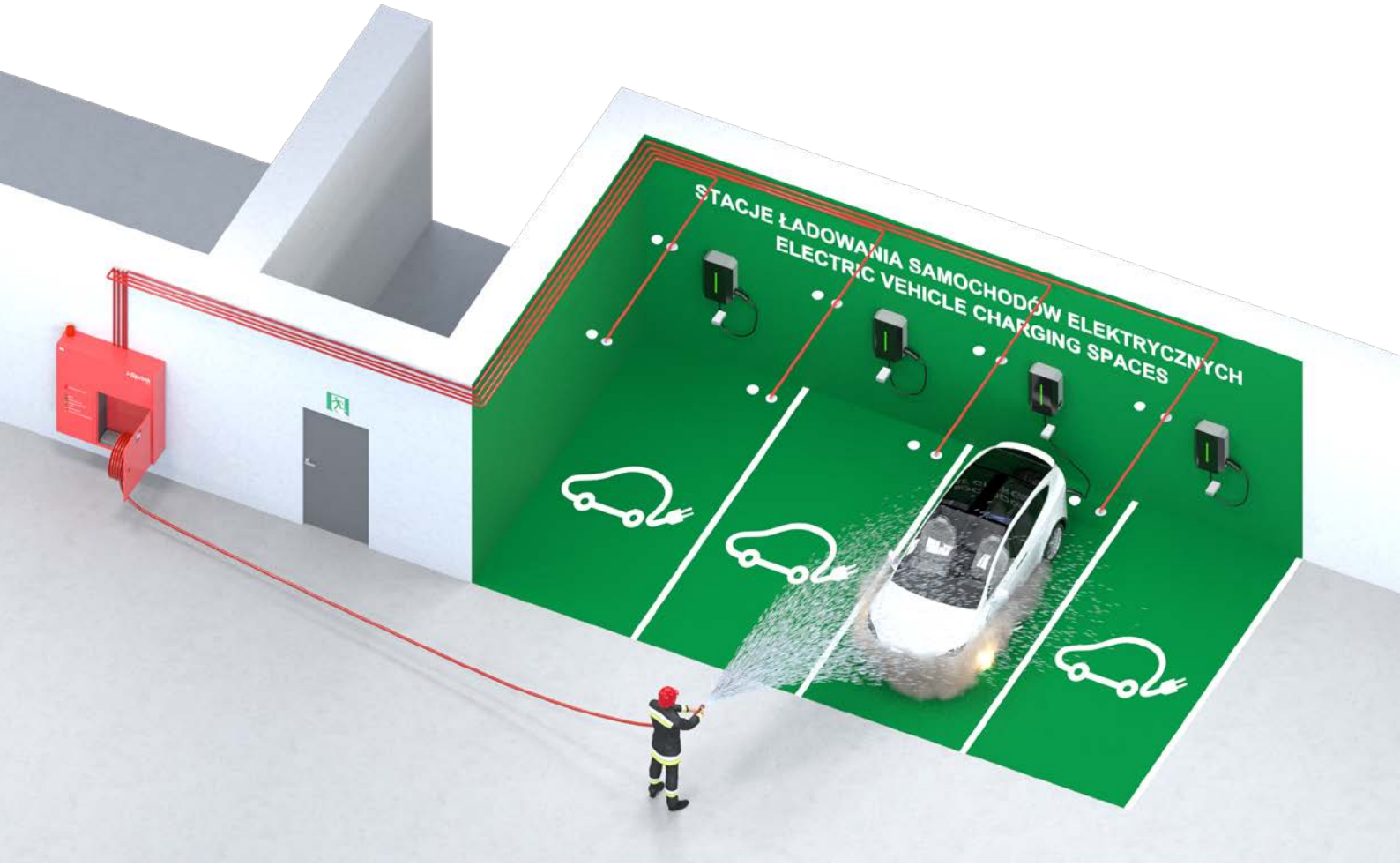
By default, every i-Sprink kit has two predefined operating modes. The device works automatically (automatic activation of the water spray system), but in any case, it can be used manually, in the same way as a standard internal hydrant (manual use of the fire hose).

Automatic fire suppression mode – water jet system activated (fire risk location by means of WMP and fire detection by means of smoke/heat detection)



- fire detection as a result of the coincidence of the specific increase in the temperature measured by means of the WMP and smoke/heat detection,
- automatic power off of the charging station by the central unit,
- opening of the specific motorized valve located in the control valves section of the central unit (water supply to the water jet nozzles located above the protected parking space),
- transmission of the fire alarm to the defined building system e. g. fire alarm system (FAS), building management system (BMS), or directly to a cloud-based building manager application.

Manual fire suppression mode – water jet system deactivated and manual use of the internal hydrant (based on building user decision)



Note: the possibility of the manual use of the internal hydrant shall be individually assessed by the trained and properly equipped building staff.

- manual opening of the hydrant valve (limit switch opening),
- automatic closure of the open motorized section valve located in the control valves module (central unit),
- standard use of the hydrant hose in order to suppress or extinguish the fire.

Note: after the extinguishing is finished, it is recommended to drain the water from the used hydrant by opening the drain valve in order to dry the unheated section pipes led outside the heated central unit.

i-Sprink kit can be used in newly designed and existing buildings and is based on the use of commonly available building fire hydrant systems. The use of the i-Sprink device, does not require interference with the existing water supply system for firefighting purposes.

Technical parameters of hydrant and control valves modules

Fire hydrant with water spray system – kit – type i-Sprink can be used in buildings equipped with internal hydrants DN19, DN25, DN32 and DN52.

INTERNAL HYDRANT SIZE	DN20	DN25	DN32	DN50
hydrant diameter	¾" (19 mm)	1" (25 mm)	1 ¼"(32 mm)	2" (52 mm)
fire hose reel	self-breaking with full discs			
fire hose nozzle	D7	D6/D8D/10	D12	D13
fire hose (in accordance with EN 694)	20 m or 30 m	20 m or 30 m	20 m or 30 m	20 m or 30 m
valve hose connector	1" (25 mm)	1" (25 mm)	1 ¼"(32 mm)	-
ball valve with limit switch	1"	1" or 2"	1 ¼" or 2"	2"
minimum capacity of the hydrant (in accordance with EN671-1)	42 l/min	60 l/min	90 l/min	150 l/min
minimum i-Sprink kit water supply diameter	DN40			
minimum capacity of 1 water spray section pipe (2 water jet nozzles size K42) at P≥0.2 MPa	90 l/min; 5mm/min*			
i-Sprink kit operating pressures range	min. 0.2 MPa, max. 0.7 MPa**			
mesh filter	1 ½"			
heater 230 V/50 Hz	150 W			
control valves module water supply diameter	DN40 (1 ½") crimped fittings system			
section valve types	electromagnetic valve EV220B with servo control, G, 1 ¼" or motorized ball valve Belimo DN32 with actuator NRQ24A			
i-Sprink cabinet size (width × height × depth)	×			

* Design capacity of water spray system based on EN 12845+A1:2020-05 Fixed firefighting systems – Automatic sprinkler systems – Design, installation and maintenance. Mentioned standard covers various sprinkler systems application which can be also used for the purposes of automatic fire suppression of electric and hybrid vehicles. Based of the conducted general fire risk analysis, the car parks were classified into the OH_2 category with an average fire risk, for which the required spraying intensity is 5 mm/min.

** In the case when i-Sprink type kit water supply pressure exceeds 0.7 MPa pressure reduction unit shall be used.

*** Control valves module is thermally insulated with synthetic rubber foam 9 mm thick (density – 60 kg/m³); thermal conductivity 0.036 W/m·K; maximum operating temperature 110°C; reaction to fire D-s3, d0.

Technical parameters of control and power supply module

Control and power supply modules are available in seven different configurations depending on total number of protected spaces corresponding to the number of section valves in control valves module and number of interconnected i-Sprink kits.

Key components of control and power supply module are listed below:

- control and power supply module HT-1000,
- main control module HT-1101 (implementation of control algorithms),
- DI/DO module HT-1103,
- smoke detectors and manual smoke vent manual call point module HT-1107,
- control and power supply module HT-2000,
- power supply ZSPM-15-10 (guaranteed power supply 24 VDC),
- smoke detector OSD-63 (optical-thermal),
- pressure sensor DS. 40XX-EU (hydrant water supply pressure monitoring),
- limit switch PAP1 T31 PZ11,
- internal wiring.

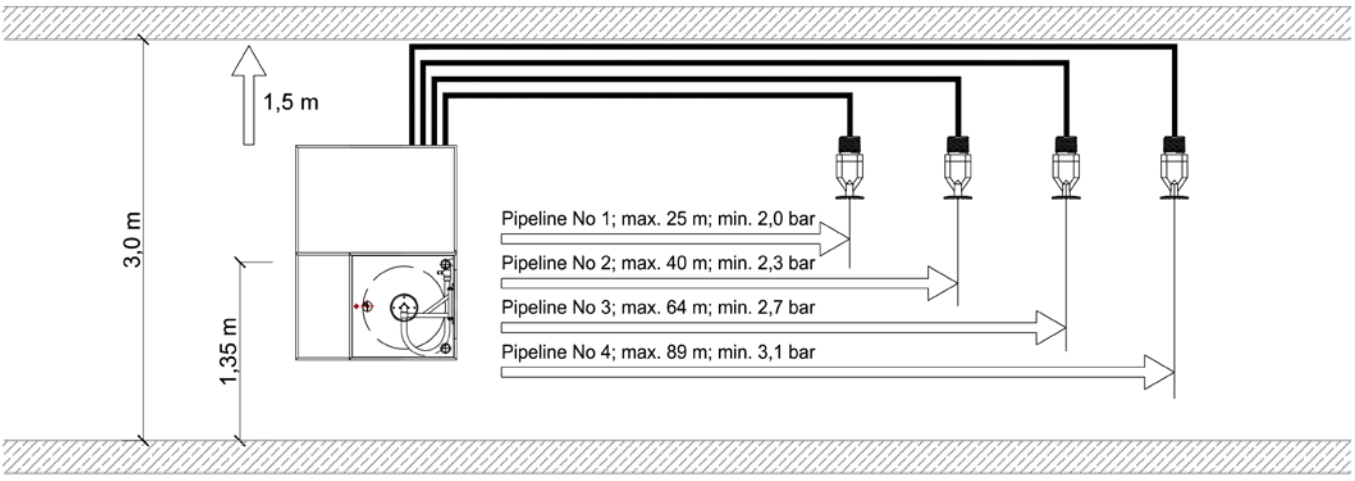
Communication between different i-Sprink kits is provided by means of loop architecture digital data transmission bus (loop topology). In the such case one kit acts as master controller (Master) and all others act as slave controllers (Slave).

Reference documents

Standards:

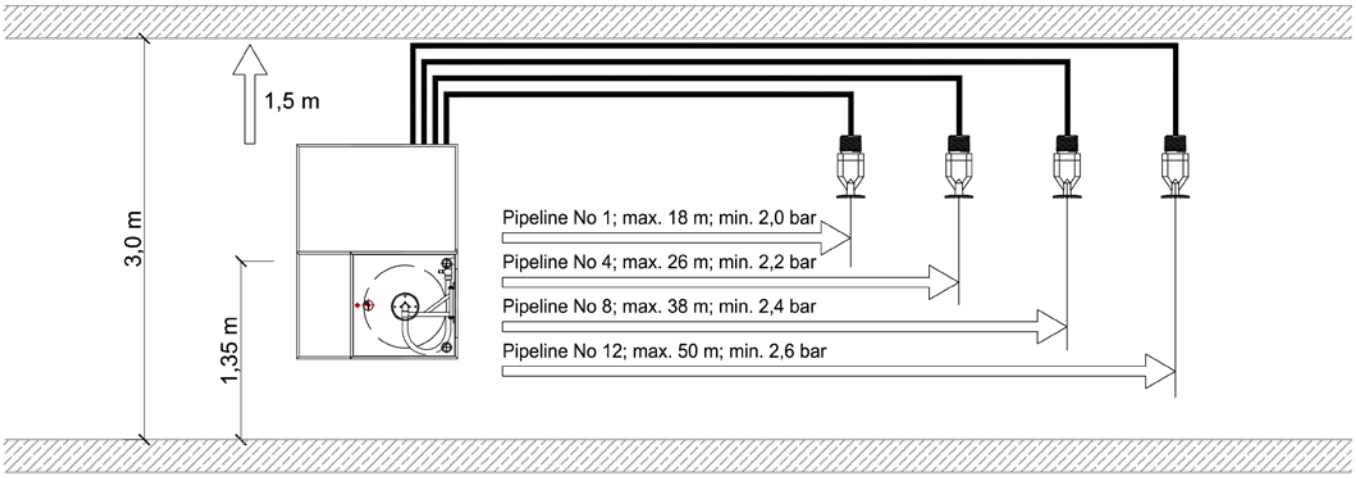
- EN 671-1:2012 – Fixed firefighting systems – Hose systems – Part 1: Hose reels with semi-rigid hose;
- EN–12845+A1:2020-05 – Fixed firefighting systems – Automatic sprinkler systems – Design, installation and maintenance (with reference to car parks),
- VdS 2109:2021-01 – VdS Guidelines for Water Spray Systems – Planning and Installation.

Quick selection examples (required water supply pressures and corresponding maximum allowable lengths of section piping to the farthest water jet nozzle)



Developed view of exemplary water spray pipelines – control valves module fitted with ball valves R2…-S with Belimo NRQ24A actuators

Minimum internal hydrant water supply diameter	50 mm
Minimum water spray system supply pipe diameter (to the first nozzle)	32 mm
Minimum water spray system supply pipe diameter (to the last nozzle)	25 mm
Maximum distance between the central unit and the furthest nozzle	89 m
Maximum number of elbows (90°)	6 pcs.
Additional fittings (after the central unit)	N/A
Additional fittings (before the central unit)	pressure reducer (option)
	shut-off valve (option)



Developed view of exemplary water spray pipelines – control valves module fitted with electromagnetic valves EV220B, G, 1 ¼

Minimum internal hydrant water supply diameter	50 mm
Minimum water spray system supply pipe diameter (to the first nozzle)	32 mm
Minimum water spray system supply pipe diameter (to the last nozzle)	25 mm
Maximum distance between the central unit and the furthest nozzle	50 m
Maximum number of elbows (90°)	6 pcs.
Additional fittings (after the central unit)	N/A
Additional fittings (before the central unit)	pressure reducer (option)
	shut-off valve (option)

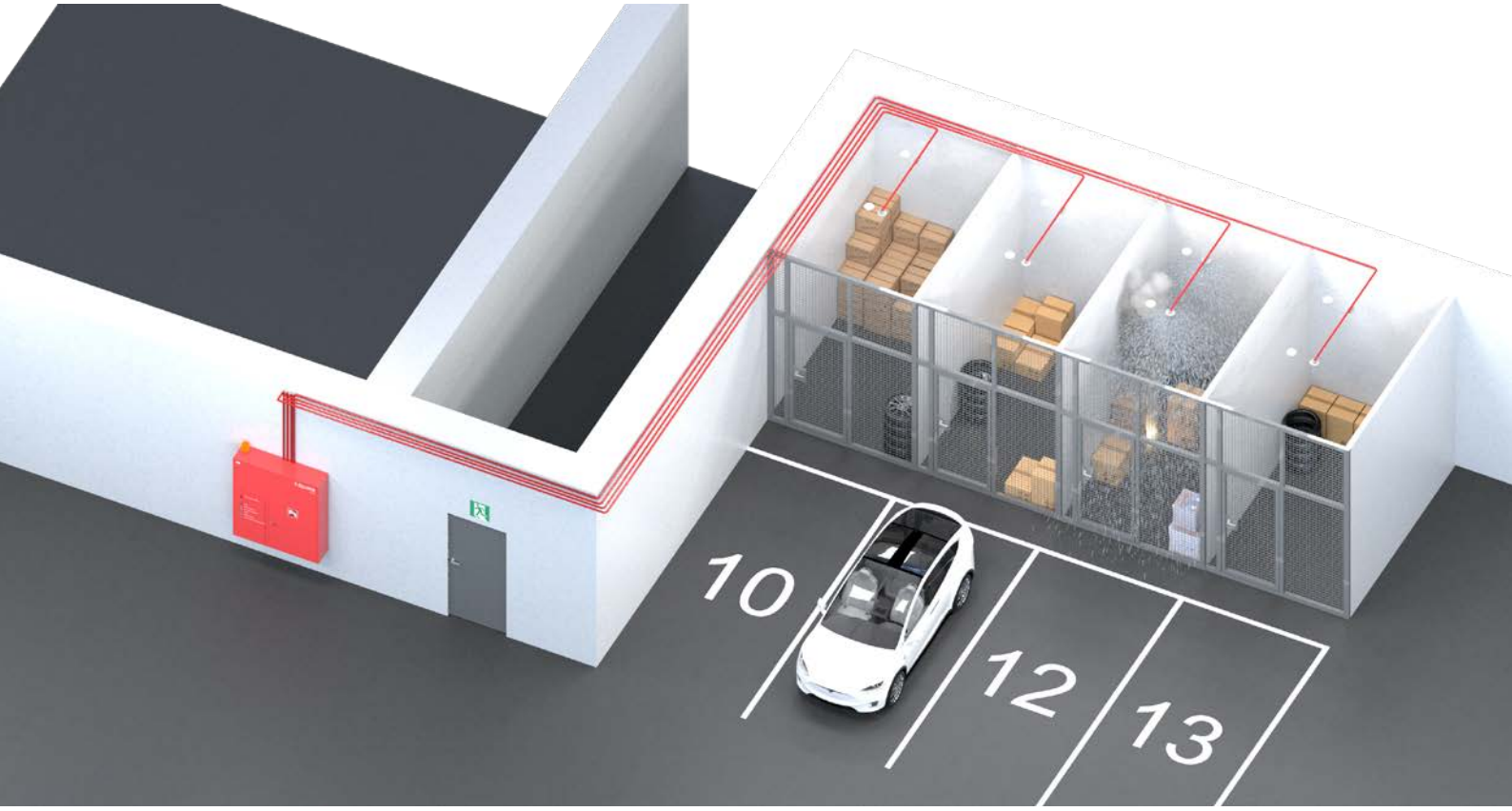
Note:

- quick selection data for illustrative purposes only (data can be interpolated),
- in the case of exceeded lengths of the pipelines or numbers of fittings to be installed in the water spray system it is necessary to carry out full hydraulic resistance calculations,
- equivalent pipe length for fittings and valves in accordance with VDS2109pl:2021-01 VdS Guidelines for Water Spray Systems – Planning and Installation

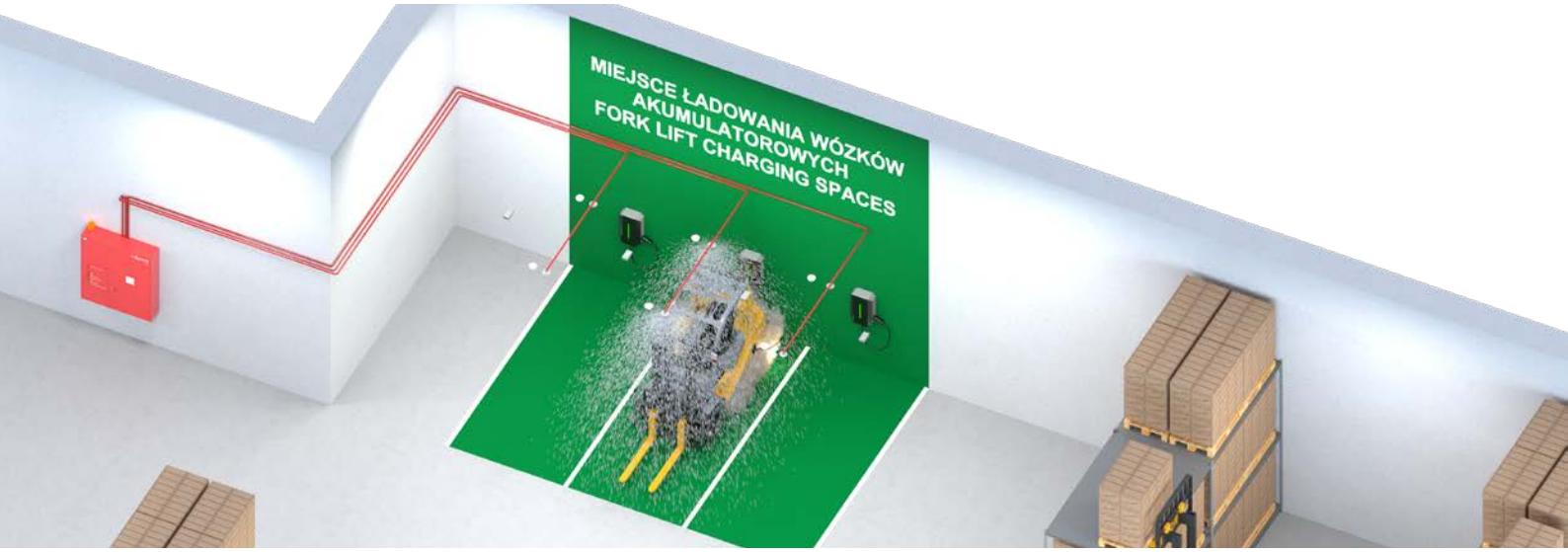
Examples of i-Sprink type kit applications

i-Sprink kit can be used in newly designed and existing buildings and is based on the use of commonly available internal hydrant systems infrastructure. The use of the i-Sprink device does not require interference with the existing internal hydrant water supply system or with the building structure.

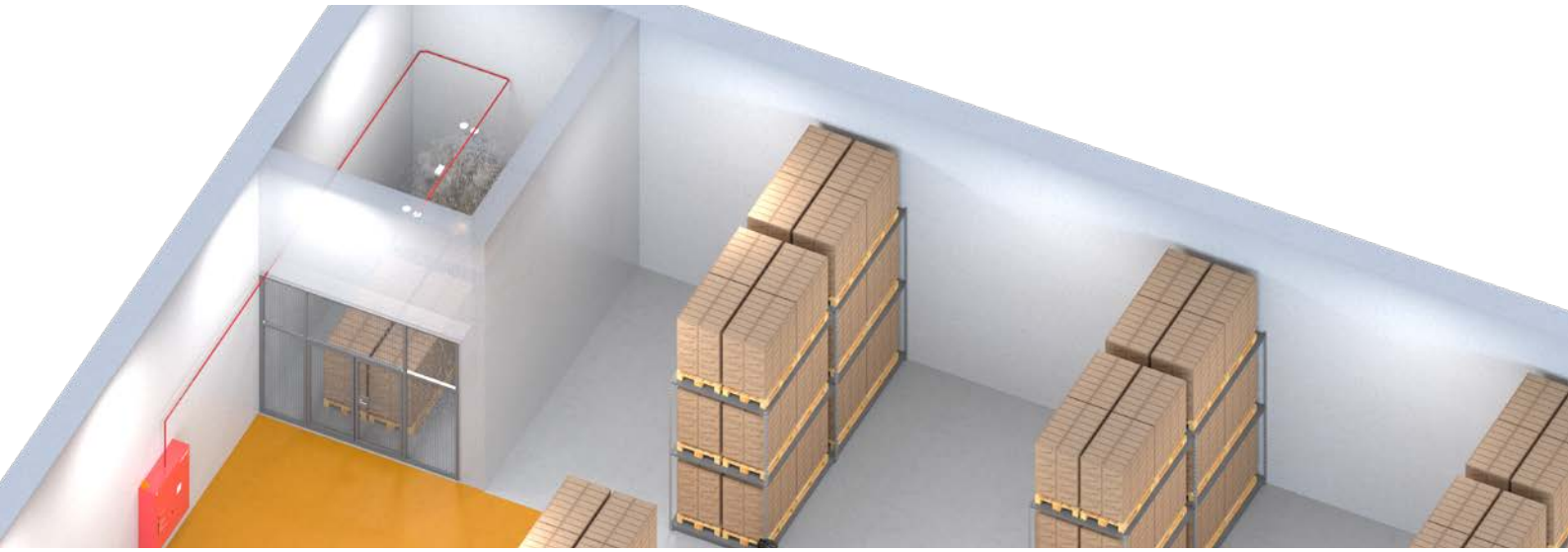
i-Sprink type kit used to protect storage rooms adjacent to the parking spaces in the underground car park in case of a fire



i-Sprink type kit used to protect parking and charging spaces for battery-operated forklift trucks in the warehouse building

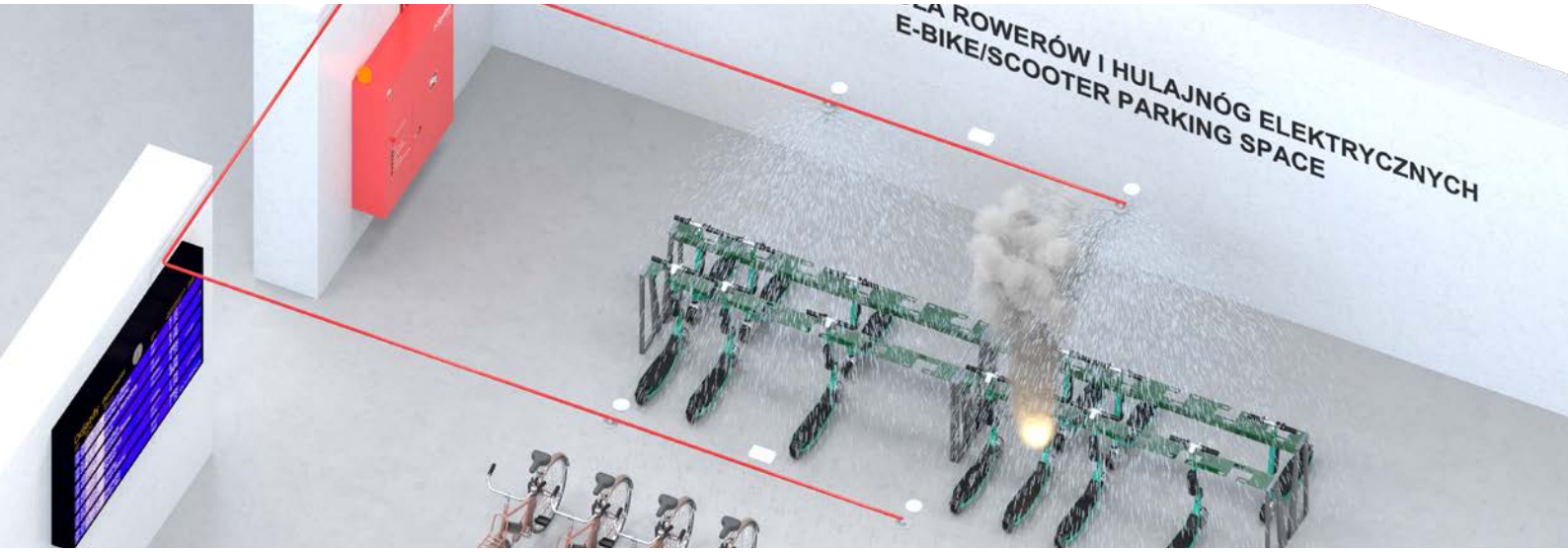


i-Sprink type kit used to protect separate storage rooms in the warehouse building in case of a fire



i-Sprink type kit used to protect selected parts of the manufacturing line in the production facility in case of a fire

i-Sprink type kit used to protect selected parking spaces for electric bikes and scooters in case of a fire



Note: on demand, the i-Sprink type kit can be customized in order to meet specific requirements in the scope of automatic fire detection and suppression in various different applications.

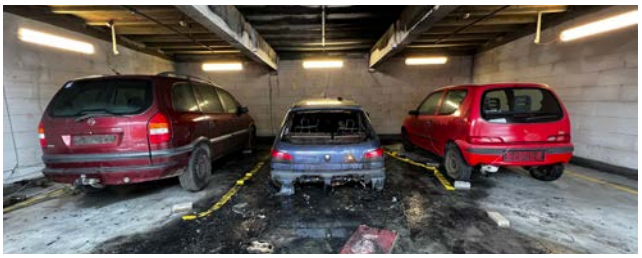
Capacity and effectiveness (reference design standard)

The effectiveness of the i-Sprink type kit is confirmed by the use of components with fixed spraying intensity of 5 mm/min (90/min), designed in accordance with the European standard EN 12845+A1:2020-05 Fixed firefighting systems. Automatic sprinkler systems. Design, installation, and maintenance as per ordinary hazard group 2 (OH2) applicable for car parks (garages).

Real scale tests

i-Sprink type kit has been thoroughly tested on a real scale during the experiments carried out by the Gras Research and Development team under the supervision of the Scientific and Research Centre for Fire Protection National Research Institute (CNBOP-PIB) headquartered in Józefów, Poland. The conducted research included comprehensive tests of the effectiveness of the innovative detection system and fire risk localization for various variants of the simulated fire and comparative tests of passenger car fires initiated by the ignition of lithium-ion cells. Both series of real-scale tests confirmed the high reliability and sufficient efficiency of the i-Sprink kit to control development and limit the spread of the fire involving li-ion batteries to single parking space (one car) only.

View of the test rig used for the real-scale assessment of the innovative fire fire risk detection and localization system



Test no 1 – i-Sprink kit activated (automatic fire suppression)

Test no 2 – i-Sprink kit deactivated (no fire suppression)

View of the test rig used for the comparative real-scale fire suppression system tests

Conducted research and tests confirmed that the architecture and technical specifications of the i-Sprink type kit are appropriate and sufficient to indicate the location of fire risk at a specific parking space and limit the spread of the fire to one car only. The maximum temperatures measured on the surface of the neighboring cars were 40-50°C with the local fire suppression system activated, compared to ca. 600°C without the control. The maximum temperature measured under the ceiling above the burning car was 150°C with an automatic fire suppression system activated, compared to 900°C for an uncontrolled fire during the entire test.

Laboratory tests and certification

Internal hydrant with local water spray system – kit type i-Sprink is an innovative fire protection device intended for use in fire protection based on the national assessment and verification of constancy of performance (OiW SWU) carried out by the Scientific and Research Centre for Fire Protection National Research Institute (CNBOP-PIB) headquartered in Józefów, Poland. The device is placed on the market on pursuant to:

- National Technical Assessment (KOT) CNBOP-PIB-KOT-2023/0376-1004 issued by CNBOP-PIB
- National Certificate of Constancy of Performance No 063-UWB-0525 issued by CNBOP-PIB
- National Declaration of Performance No 01/2023/B issued by PPPH Gras
- Additionally in the course of research and laboratory tests of the contactless fire location indicator/sensor (WMP) has obtained the recommendation of suitability for use in fire protection No RP-0012/2023 issued by CNBOP-PIB.


KRAJOWY CERTYFIKAT STAŁOŚCI WŁAŚCIWOŚCI UŻYTKOWYCH Nr 063-UWB-0525

National Certificate of Constancy of Performance No 063-UWB-0525


KRAJOWA OCENA TECHNICZNA CNBOP-PIB CNBOP-PIB-KOT-2023/0376-1004 wydanie 1

National Technical Assessment (KOT) CNBOP-PIB-KOT-2023/0376-1004


KRAJOWA DEKLARACJA WŁAŚCIWOŚCI UŻYTKOWYCH

National Declaration of Performance No 01/2023/B


Rekomendacja przydatności do stosowania w ochronie przeciwpożarowej nr RP-0012/2023

Recommendation of suitability for use in fire protection for the WMP No RP-0012/2023

Interactions between different fire protection systems in buildings

In most modern buildings, the overall safety level in the event of a fire is the result of the combined effectiveness of various systems used to control smoke and heat assessed together (coupled analysis). For this reason, the proper location and configuration of the i-Sprink type local fire suppression system shall be considered at the design concept stage taking into account potential interaction with different fire safety systems and processes e. g. smoke and heat control, passive fire protection, evacuation scenario, and firefighting tactics. Thus it is highly recommended to consider additional fire scenarios for electric vehicle fires, especially for parking spaces fitted with chargers.

A general recommendation shall also be to take into consideration the activation of the i-Sprink type local fire suppression system and its influence on the fire development in the numerical analysis (CFD) and evacuation simulations.

Note: use of the i-Sprink type kit can significantly improve overall conditions in the protected space for means of evacuation and firefighting e. g. active protection of building users, rescue services and property.

UE Patent application no P.440341

GRAS PPPH
Sławieńska 12 street, 77-230 Korzybie, POLAND
phone +48 59 857 7302 (03), fax. +48 59 858 6304
www.gras.pl
gras@gras.pl

Supplier of electronic parts
for GRAS i-Sprink system