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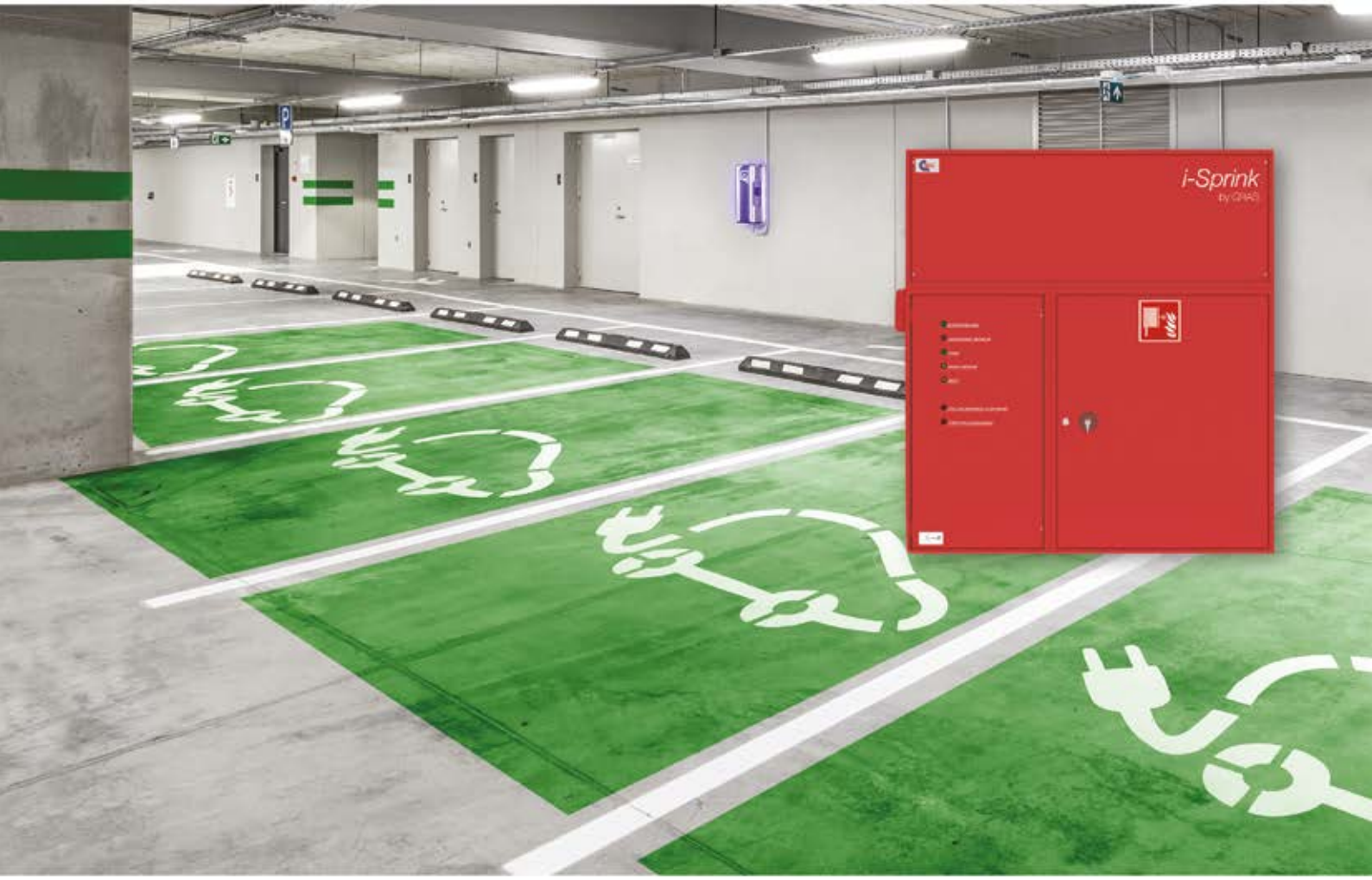

i-Sprink

Fire hydrant with water spray system – kit

intended for fire suppression of electric and hybrid vehicles

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Fire hydrant with water spray system – kit – type i-Sprink has a patent No. P.440341 pending in the Polish Patent Office

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Introduction

We live in interesting times, when world around is changing at an unprecedented pace. In a world where the only constant is change. In Gras we fully understand the need of quality and innovation, not only to maintain, but also 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 the 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 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 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 kit with a sprinkler system, used to protect the places where vehicles equipped with lithium-ion batteries can be parked. We paid special attention to underground garages, including places for charging cars. Our idea was to be simple, reliable and, above all, effective. For its implementation, we used water resources commonly available in buildings and hydrant infrastructure, supplemented with additional components enabling local fire detection and suppression in the initial stage of its development, until the start of the rescue operation by the Fire Brigade units.

In this folder we would like to present you our latest idea of combined fire hydrant and 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 strategy would turn out interesting and useful in a practical sense.

Lithium-ion batteries. Fire hazards

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

At this point is 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, toxicity of smoke and fire gases, firefighting strategies and tactics etc. Practice shows that electric vehicles with lithium-ion batteries burn hotter, faster and require far more water to reach final extinguishment. Thus despite the market saturation with EVs is still relatively low we already need to solve really serious problem.

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), 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 heat release rate in 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 significant increase of heat release rate in its 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 burning car may reach the value of 1000°C, which is almost twice as high as in the case of fires in conventional combustion cars.

Here we come to the fundamental point. Regardless of what car is burning, it is necessary to start fight the fire and try to put it out as quickly and effectively as possible. In the case of conventional 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 a 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.

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

Fires of hybrid and electric cars equipped with lithium-ion batteries are difficult to extinguish and require the use of large amounts of an extinguishing agent with high cooling efficiency, e.g. water.

Fire hydrant with water spray system – kit – type i-Sprink

Description

Fire hydrant with water spray system type i-Sprink is a fire protection device intended for automatic suppression of the fire in its initial phase, before the start of firefighting and rescue operation carried out by the fire brigades. The device uses water supplies and water distribution installation as for standard sizes of fire hydrants.

Intended use

The device is intended for automatic fire protection of selected spaces, in the event of fire, in buildings of various purposes, e.g. residential buildings, public buildings, industrial buildings e.g.:

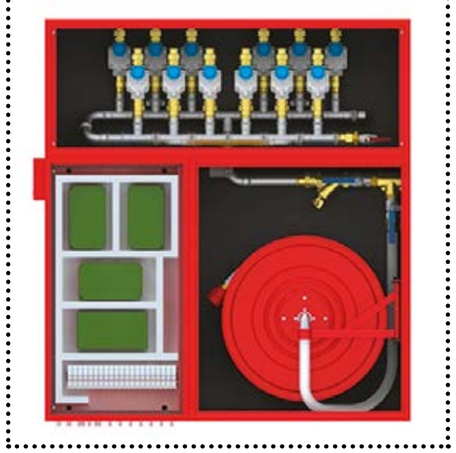
- parking spaces adapted to charging cars equipped with lithium-ion batteries in an underground car parks (primary use),
- parking spaces with parking platforms in underground car parks,
- parking and charging spaces for battery operated forklift trucks,
- warehouse storage spaces and production lines in industrial buildings.

Principle of operation

The principle of operation of the i-Sprink kit is based on automatic use of local water spray system to suppress electric or hybrid car fire in its initial stage. Water supply is provided by means of standard internal hydrant installation. Early fire detection system consists of two smoke and heat detectors and contactless temperature sensor (optional) per each parking space. If a fire has been detected, the unit controller opens 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 space. Each i-Sprink kit enables standard use of the internal hydrants and extinguishing a fire using hydrant hose. The hydrant valve is fitted with a limit switch which, when opened, automatically closes the section valve in the control valve module. If more i-Sprink kits are used in a common space, they are integrated into a system and with data transmission loop.

Operating modes

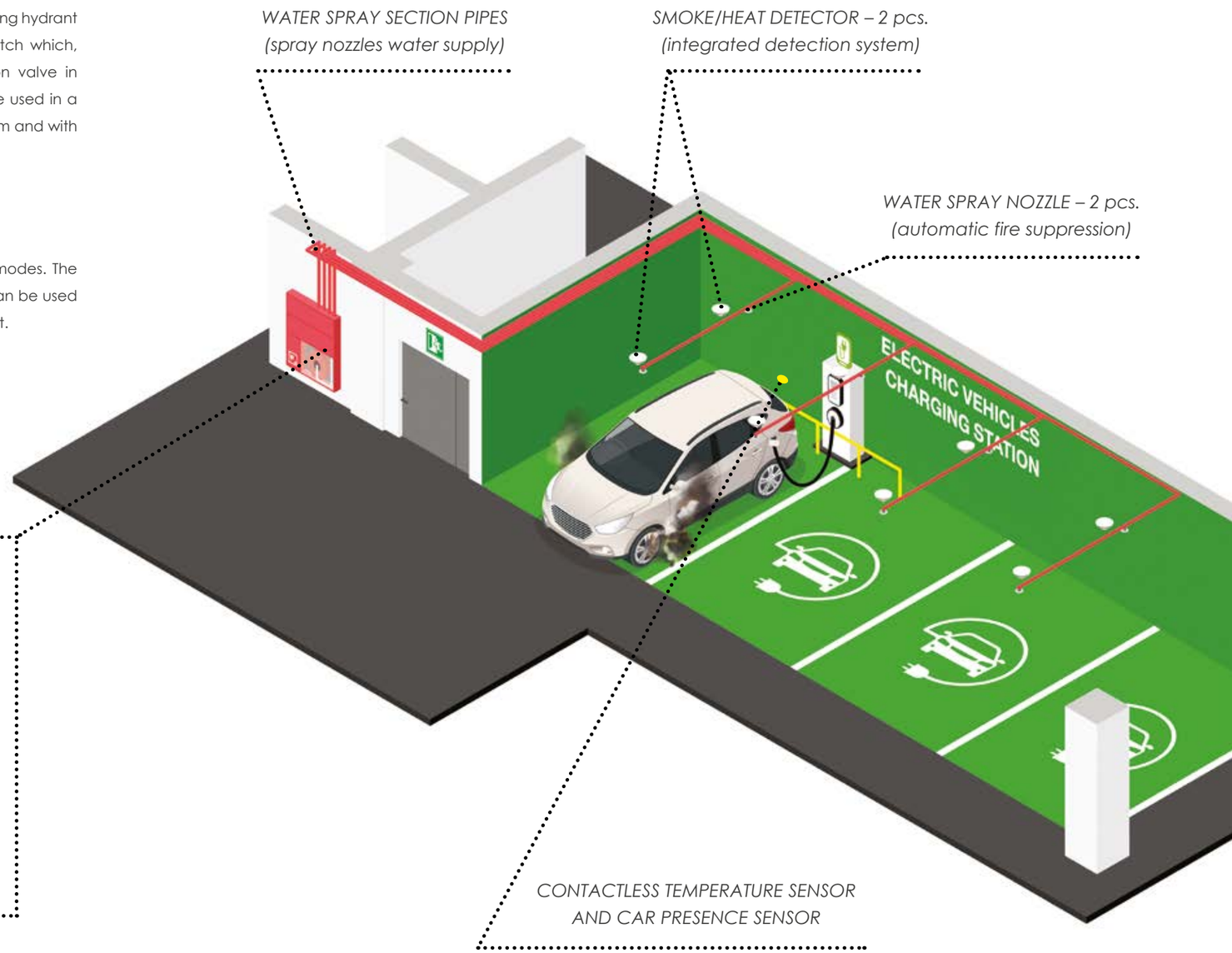
Each i-Sprink kit has two predefined operating modes. The device works automatically, but in any case it can be used manually, in the same way as a standard hydrant.



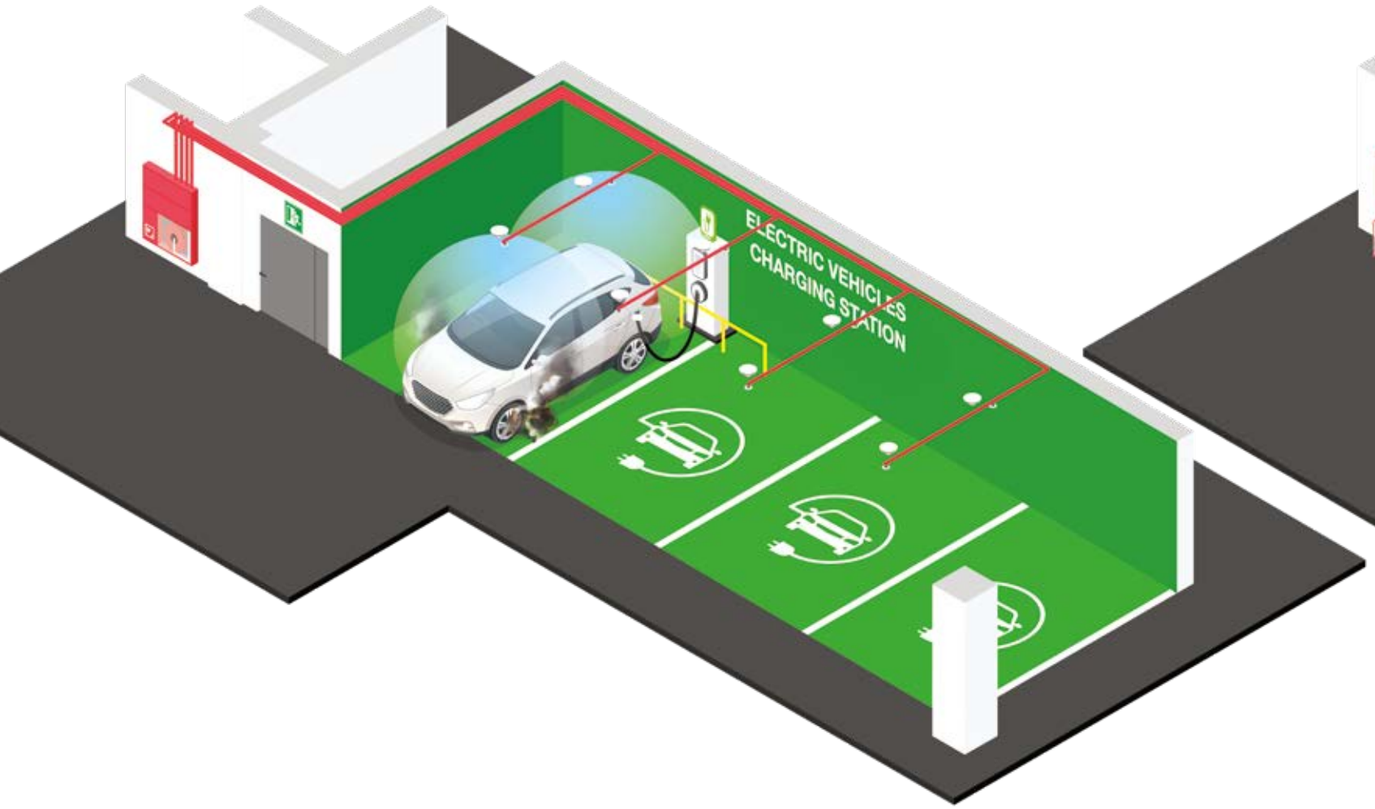
FIRE HYDRANT KIT

- *fire hydrant module*
- *control valve module*
- *control-power supply module*

Structure and key components of fire hydrant with water spray system type i-Sprink



Automatic fire suppression mode (detection of smoke or/and heat)



Early fire detection by means of an integrated smoke/heat/gas detectors:

- fire alarm – coincidence of two smoke/heat/gas detectors located in protected space e.g. parking space in underground car park,
- automatic shutdown of electric vehicle charging station (optional),
- fire alarm transmission to fire alarm system (FAS) and/or building management system (BMS),
- opening specific section valve in the control valve module and activation of water jet nozzles in the protected space where fire has been detected e.g. parking space in underground car park,
- activation of optic-acoustic signaling device (optional).

Manual fire suppression mode (use of the hydrant hose)

- manual opening of the hydrant valve (limit switch opening),
- automatic closure of specific section valve and cutting-off water supply to water jet nozzles,
- use of the hydrant hose to 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 kit cabinet.

i-Sprink kit can be used in newly designed and existing buildings and is based on the use of commonly available building infrastructure for fire hose reels. 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 z 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 x height x depth)	1320 × 1450 × 300 mm***			

* 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.

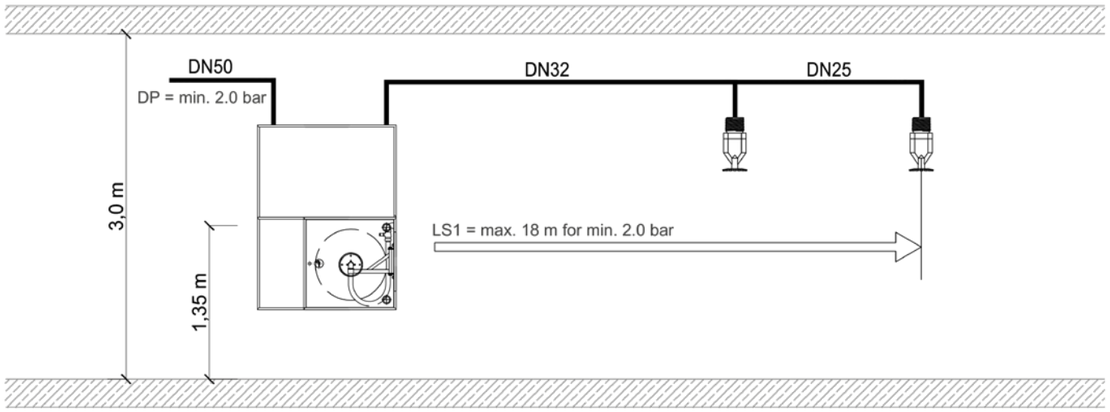
Communication between different i-Sprink kits is provided by means of loop architecture digital data transmission bus (loop topology). In the such case one kit acts as master controller (Master) and all others act as slave controllers (Slave).

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 example



Developed view of exemplary water spray section piping

Required water supply pressures and corresponding maximum allowable lengths of section piping to the farthest water jet nozzle.

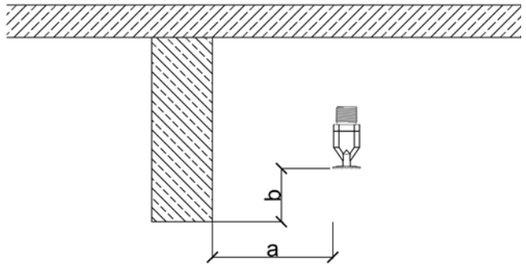
Number of water spray section piping	Maximum length of the water spray section piping (from i-Sprink kit inlet to the farthest water jet nozzle in the section)	Maximum number of elbows 90o in water spray section piping	Nominal diameter of i-Sprink kit water supply	Minimum diameter of water spray section piping to the nearest water spray nozzle	Minimum diameter of water spray section piping to the farthest water spray nozzle	Minimum i-Sprink kit water supply pressure
[-]	[m]	[pcs.]	[mm]	[mm]	[mm]	[MPa]
S1	18	6	50	32	25	0.20
S2	20					0.20
S3	23					0.21
S4	26					0.22
S5	29					0.23
S6	32					0.23
S7	35					0.24
S8	38					0.24
S9	41					0.25
S10	44					0.25
S11	47					0.26
S12	50					0.26

Note: This is an overview table for illustrative purposes. It is recommended to carry out calculations of hydraulic resistance of the i-Sprink type installation and validate its real operating parameters.

Type and location of water spray nozzles

i-Sprink kit uses hanging water spray nozzles with parabolic water discharge, which enable even distribution of water to cover entire protected space below the nozzles.

Type of the nozzle:	Armco ZP-15
Position:	hanging
Supply:	DN25
Size of the nozzle:	K42
Spraying intensity:	5 mm/min
Covered space:	8 m^2
Operating time:	min. 30 min; max 60 min
Minimum operating pressure:	0.10 MPa (1 bar)
Maximum operating pressure:	0.14 MPa (1.4 bar)
Connecting thread:	external, taper in accordance with EN 10226 R½"
Finishing:	brass – standard, on request: chrome plating, painting (any color)



Minimum distances between the joists beams and water spray nozzles

Minimum distance between the water spray nozzles installed in common section piping	2.5 m
Maximum distance between the water spray nozzles installed in common section piping	2.8 m
Minimum distance from water spray nozzle deflector to the nearest surface below	0.5 m

Note: It is not allowed to locate joists, beams, ducts, pipelines which may hinder water distribution below the water spray nozzles. In case of any obstructions above the protected space minimum distances between such components and water spray nozzles have to be maintained. See drawing below.

Distances from the water spray nozzles to beams and joists in accordance with VdS 2109:2021-01 – VdS Guidelines for Water Spray Systems – Planning and Installation.

Minimum horizontal distance between the vertical axis of symmetry of the water spray nozzle and side surface of the joist or beam	Maximum vertical distance from the water spray nozzle deflector to the bottom edge of joists or beams (+) above / (-) below	
a	b	
[m]	[m]	
	water spray nozzle	
	standing	hanging
0.2	- [1]	- [1]
0.4	0	0
0.6	0.02	0.06
0.8	0.03	0.12
1.0	0.05	0.20
1.2	0.10	0.28
1.4	0.13	0.36
1.6	0.16	0.47
1.8	0.18	0.67

[1] not allowed
Note: Data may be interpolated.

Pressure reduction

At the design stage i-Sprink water supply pressure has to be validated taking into consideration calculated hydraulic resistance of each section pipes. In the case when allowable operating pressure is exceeded pressure reductor has to be applied and taken into account in hydraulic calculations.

Interactions between different fire protection systems in buildings

In most modern buildings, the real level of safety in the event of fire is the result of the effectiveness of various systems used to control the spread of smoke and heat considered together. For this reason, already at the design concept stage potential interactions between different technical solutions shall be assessed.

To ensure proper operation of fire hydrant with water spray system – kit – type i-Sprink, early fire detection is indispensable e.g. a specific parking place. As a consequence, in some cases, it may be required to separate individual parking spaces equipped for charging cars, with the use smoke curtains, e.g. D30 (30 min <600°C).

In the case of newly designed buildings it is recommended to consider potential interactions between the i-Sprink type kits and various smoke and heat control systems e.g. jet fan or ducted ventilation systems including additional fire scenario to make use of potential synergies e.g. extraction points near the parking spaces protected with i-Sprink kit. It is also recommended to include i-Sprink kits water spray systems in the general concept of the fire ventilation system as well as in the computer simulation (CFD).

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