Motorised Fire & Smoke Protection in Ventilation Ducts

Mechanical Smoke Extraction

ASHRAE Seminar

College of the North Atlantic, Doha, Qatar

20th April 2013

Agenda

- **Introduction**
- **Benefits of Motorising Fire & Smoke Dampers**
- **Mechanical Smoke Extraction (Smoke Control)**
- **Monitoring & Control Systems for F&S applications**
- **UL / EN Comparison**

Introduction

Belimo Safety Solutions Europe

Fire protection in buildings – The 3 pillars of fire protection

Constructional

- Fire compartments
- Smoke compartments
- Use of fire retardant materials
- Escape routes, emergency exits

Technical

- Fire dampers
- Fire alarm system
- Extinguishing systems (e. g. sprinkler)
- Smoke control systems
- Overpressure systems

Organisational

- Alarm and evacuation plans
- Emergency concepts
- Training of staff
- Periodical evacuation trainings
- Briefing of the fire brigade

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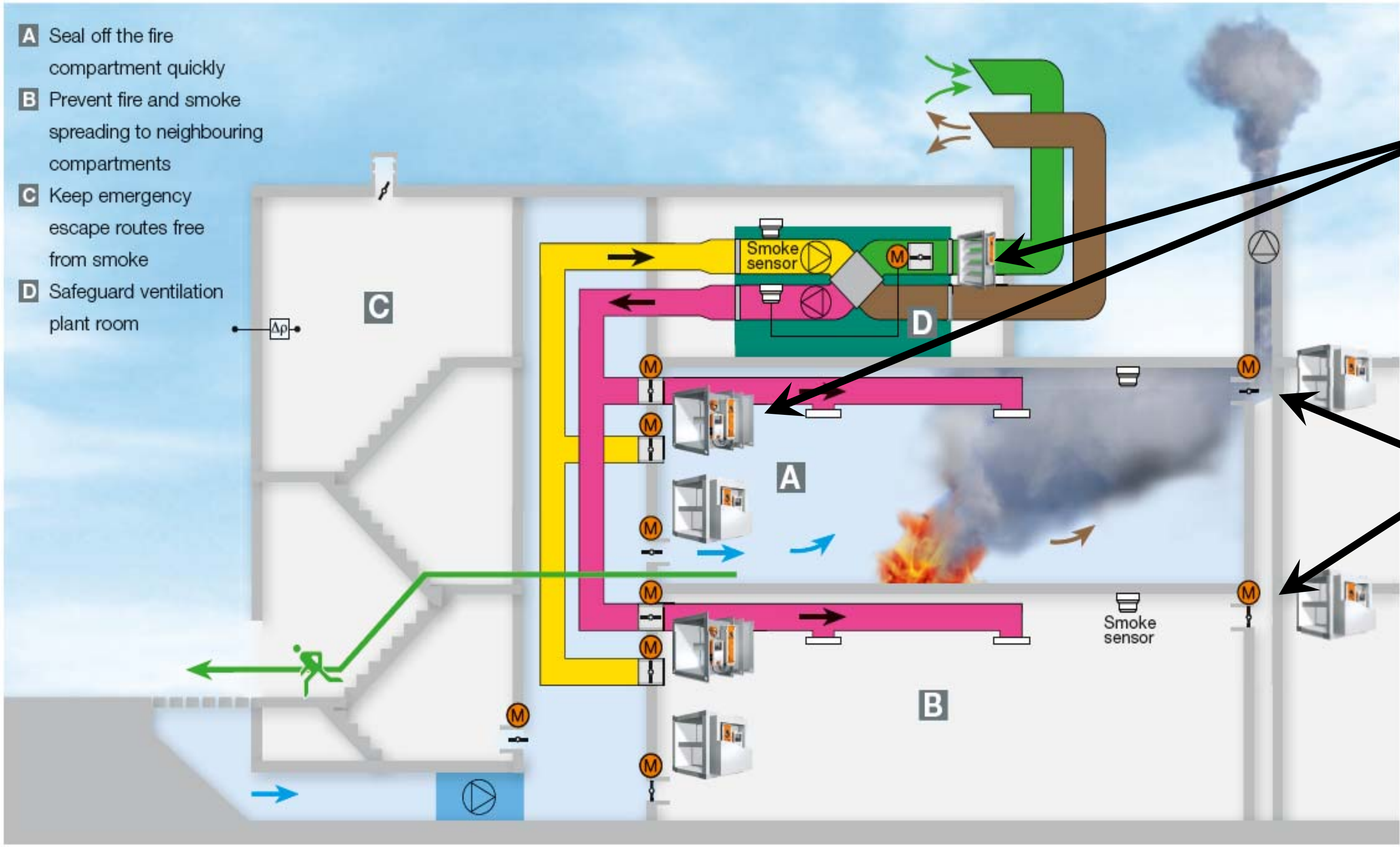
Field of applications



Fire protection:
Motorisation of fire and smoke dampers

Smoke control / smoke extraction:
Motorisation of smoke control dampers

Benefits of Motorising

Fire & Smoke Dampers

Motorised Fire & Smoke Dampers

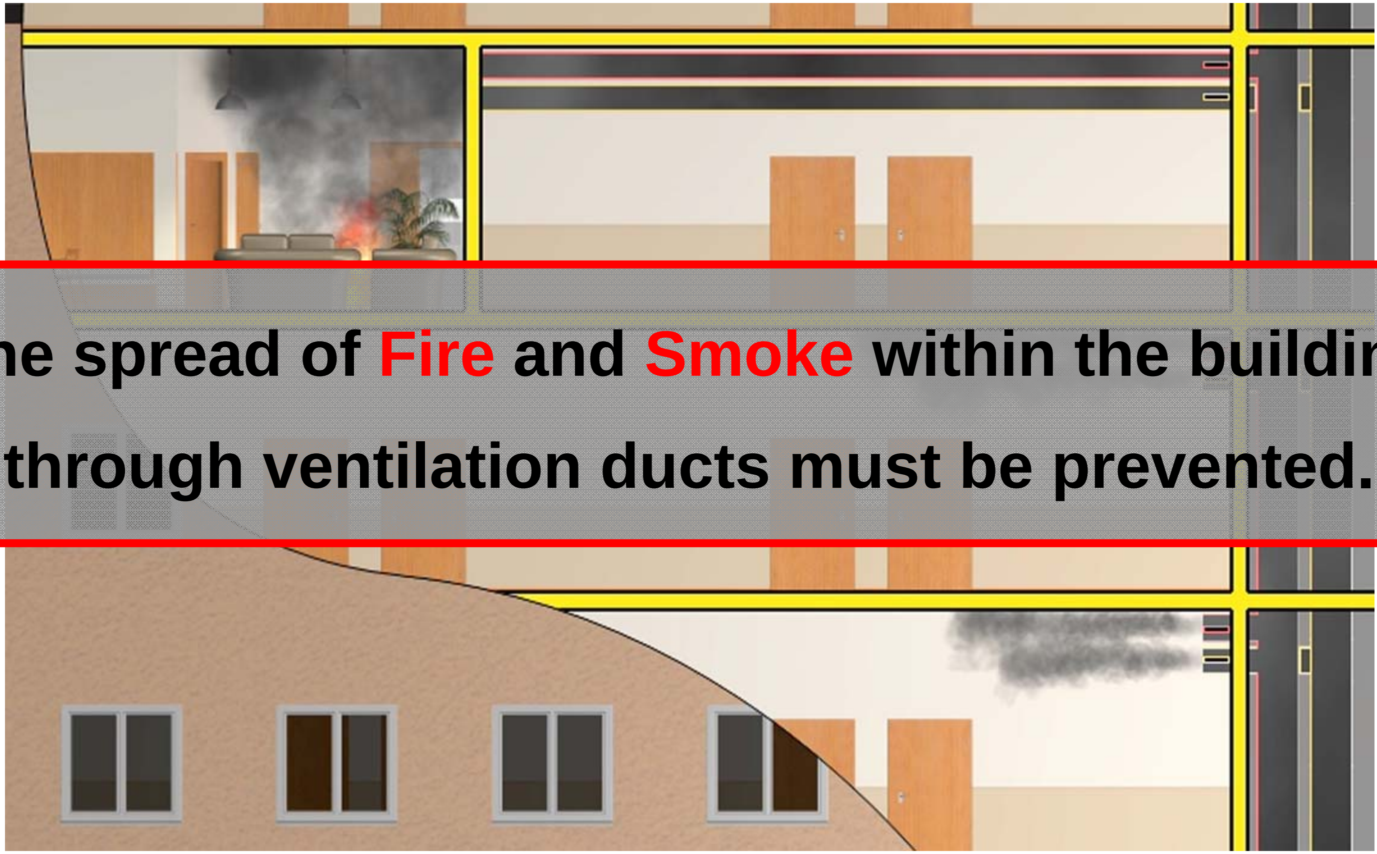
Impact of fires:

Loss and damage of…

- Lives
- Assets
- Environment
- Business operation
- Adjacent buildings

Motorised Fire & Smoke Dampers

Main protection target:



The spread of Fire and Smoke within the building through ventilation ducts must be prevented.

Motorised Fire & Smoke Dampers

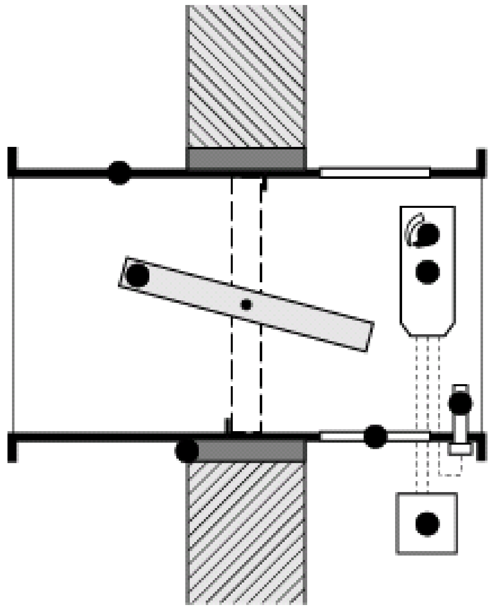
Where are fire dampers required?

- **Basic principle: The defined protection targets from the fire safety concept of a building must be reached.**

  → The spread of fire and smoke through ventilation ducts must be prevented.

- **Fire dampers have to be used when:**
  - Ventilation ducts penetrate fire walls
  - Ventilation ducts penetrate fire rated ceilings

Note: Fire dampers must be installed in such a way, that cleaning and maintenance work is supported.

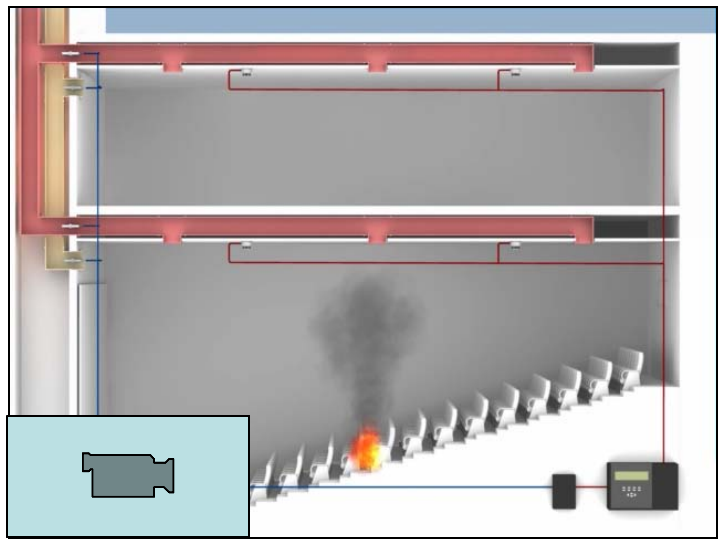


Motorised Fire & Smoke Dampers

Early sealing of compartment with motorised fire dampers

- **Activation of fire dampers by fire alarm system**
- **Activation directly by a relevant smoke detector**
- **Activation by the building managament system**

→ Today's state of the art solution



Motorised Fire & Smoke Dampers

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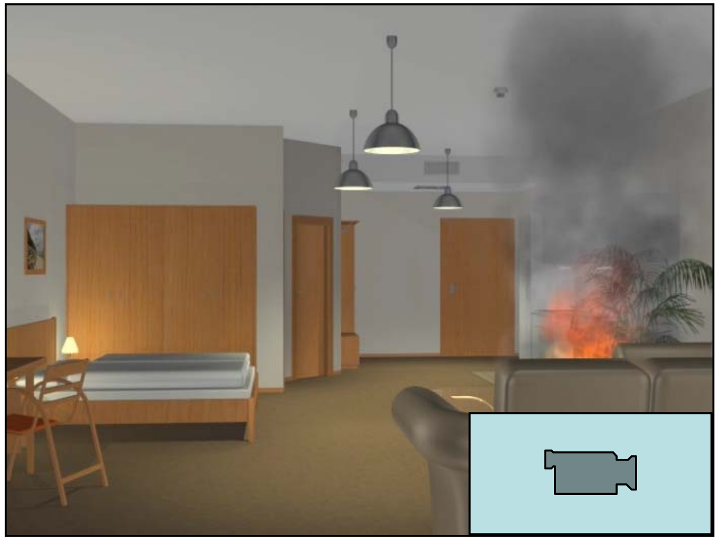
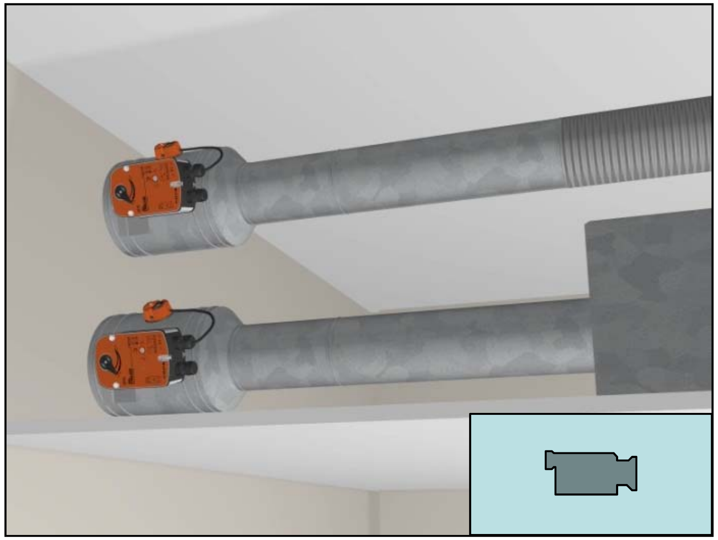
Early sealing of compartment with motorised fire dampers

- **Example animation "Hotel room"**
- **Ventilation off situation**



Non-motorised FDs



Motorised FDs

Motorised Fire & Smoke Dampers
Smoke Flow and Temperature Simulations

By AFC Air Flow Consulting AG, Zurich, Switzerland

- **Project objective**
  - To demonstrate possible advantages (time gain) of the activation of a fire damper installed in the outlet air duct by a smoke detector compared to the activation by a thermal fuse (fusible link)
- **Approach**
  - CFD simulations (Computational Fluid Dynamics) of a standardised office fire on the basis of various room types

Motorised Fire & Smoke Dampers
Smoke Flow and Temperature Simulations

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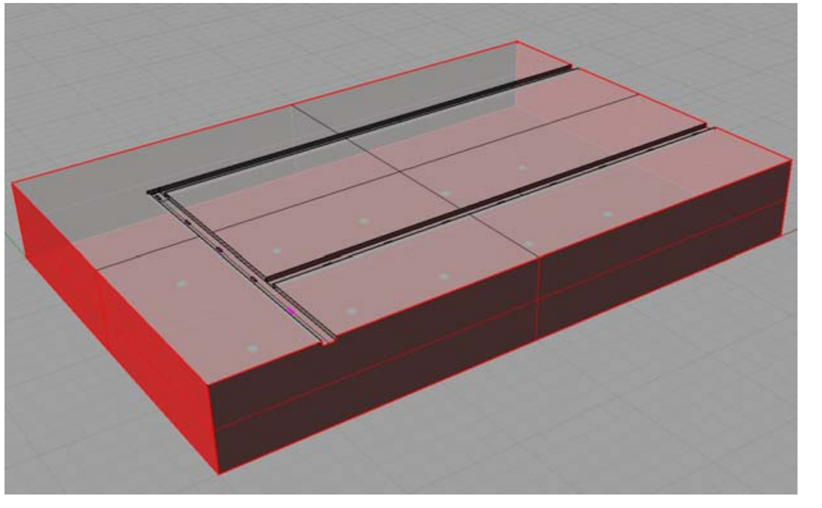
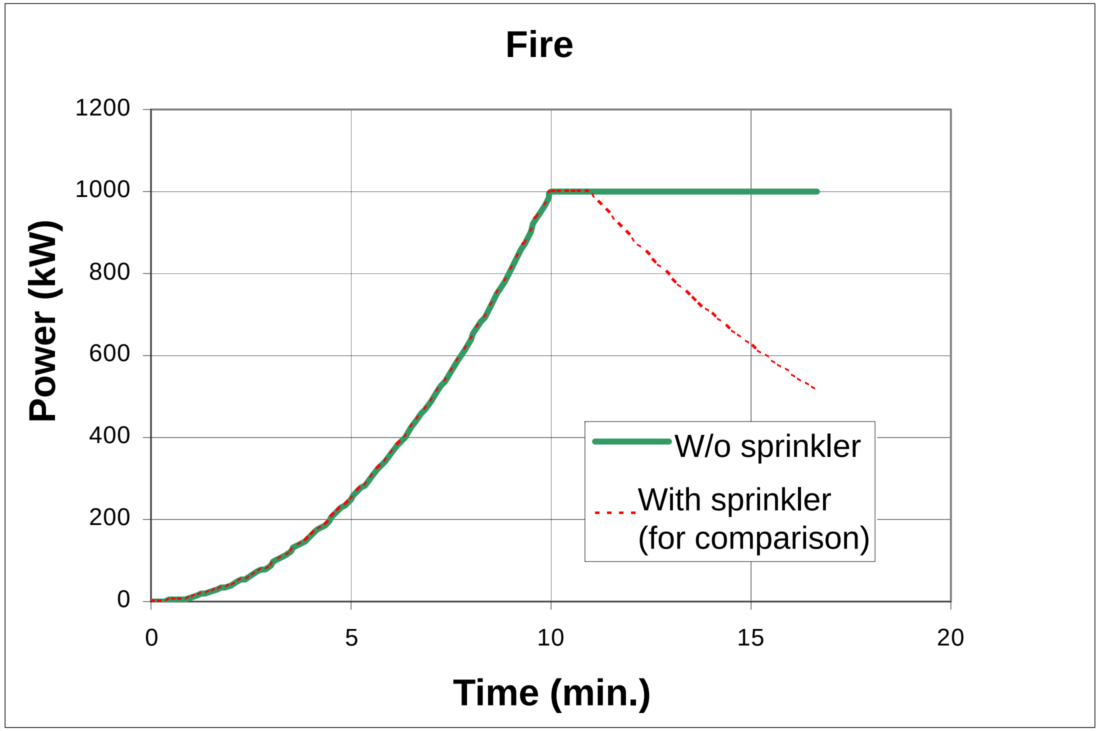
- **Basic definitions**
  - Typical office building
  - Room dimensions
    - Small: 600.0 m^2 (20 x 30 m)
    - Medium: 1'200.0 m^2 (30 x 40 m)
    - Large: 2'400.0 m^2 (40 x 60 m)
  - Room height: 4.0 m
  - Ventilation
    - Standard ventilation system
    - No smoke control system
  - Sprinkler system: None



Motorised Fire & Smoke Dampers
Smoke Flow and Temperature Simulations

Smoke flow simulations

- **Fire definiton**
  - Slowly developing fire
  - No sprinkler system
  - Power: max. 1 MW

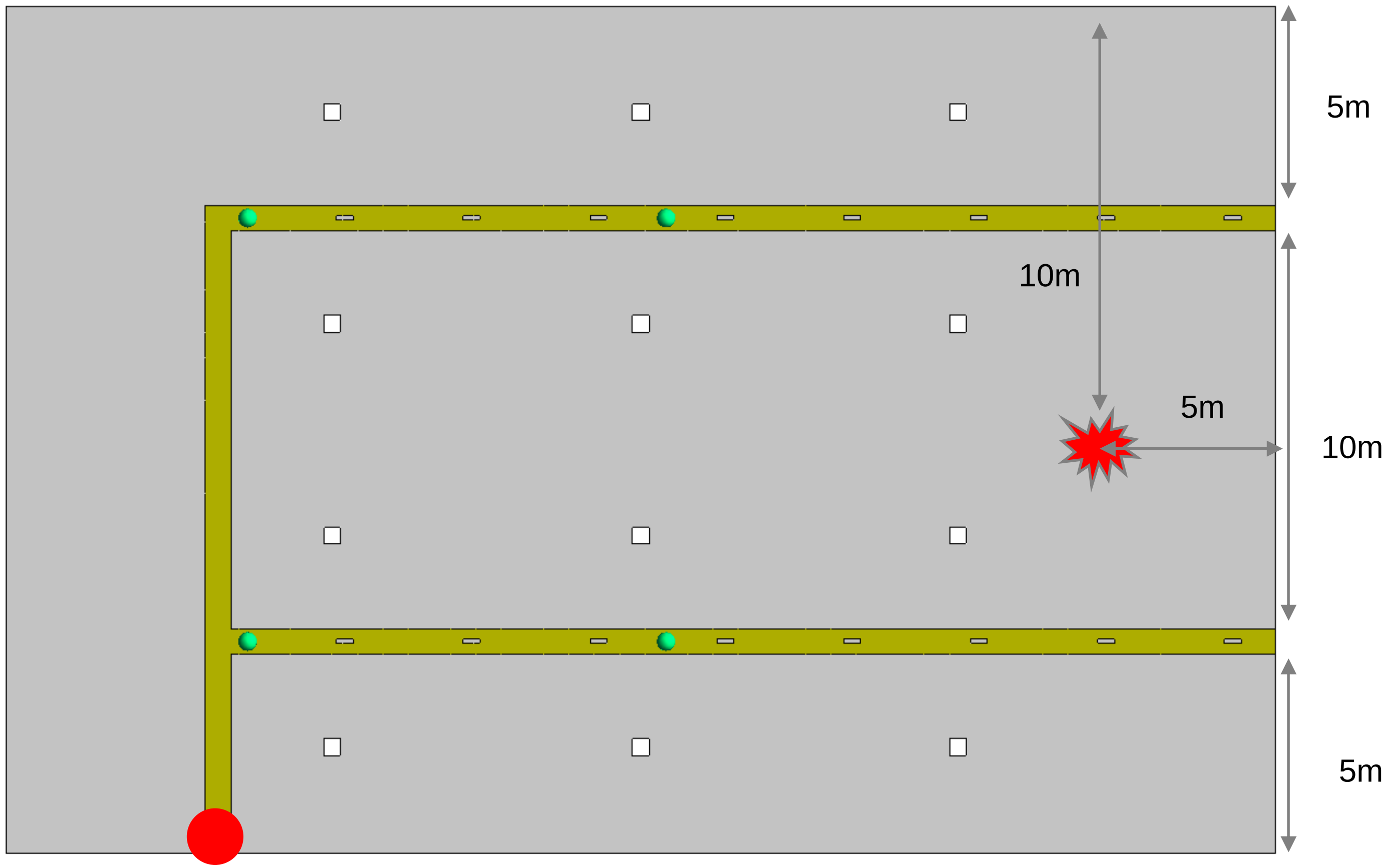


Motorised Fire & Smoke Dampers
Smoke Flow and Temperature Simulations

- **Room layouts and location of the fire source**
  - Small room 20 x 30 m

Measuring point
a) Thermal fuse
b) Smoke detector

Fire source



Motorised Fire & Smoke Dampers
Smoke Flow and Temperature Simulations

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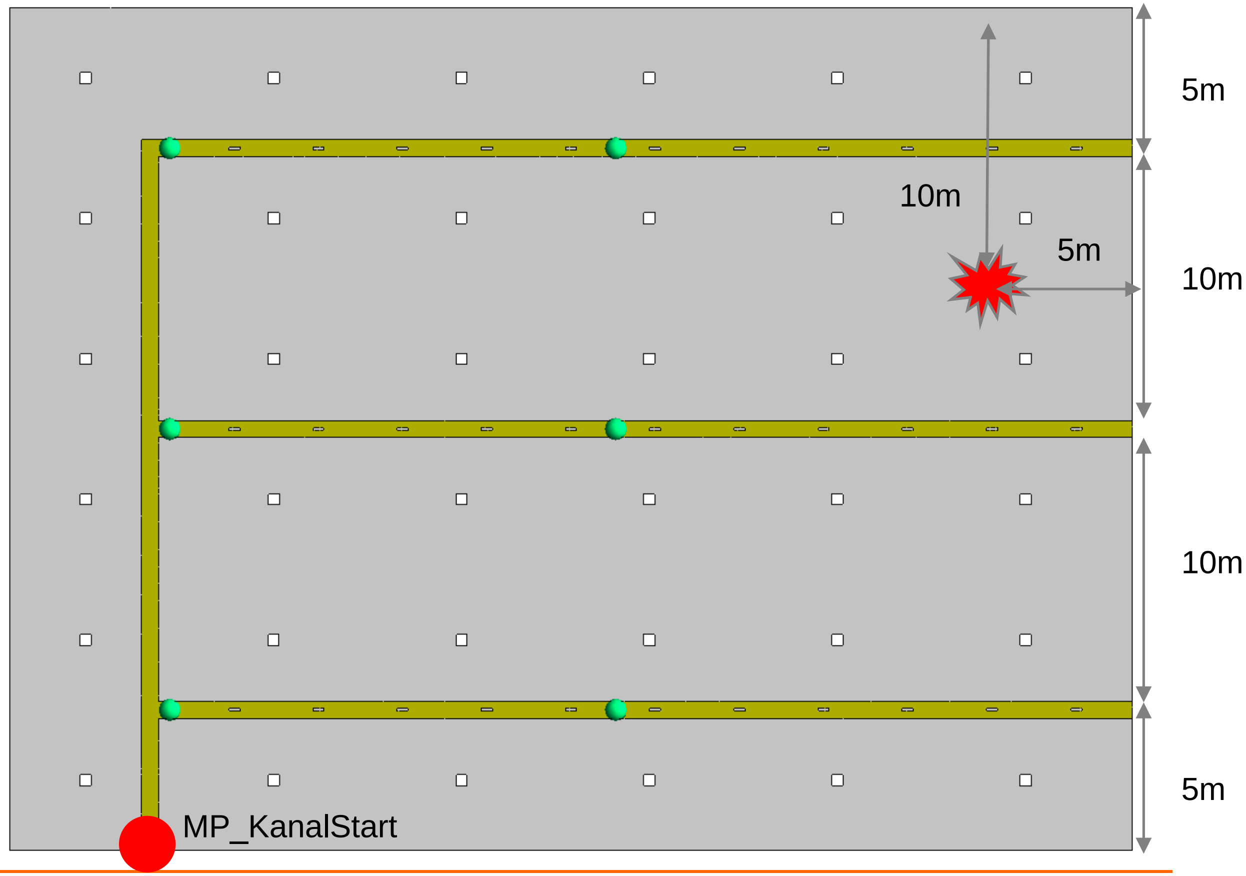
- **Room layout and location of the fire source**
  - Medium room 30 x 40 m

Measuring point
a) Thermal fuse
b) Smoke detector

Fire source



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Smoke Flow and Temperature Simulations

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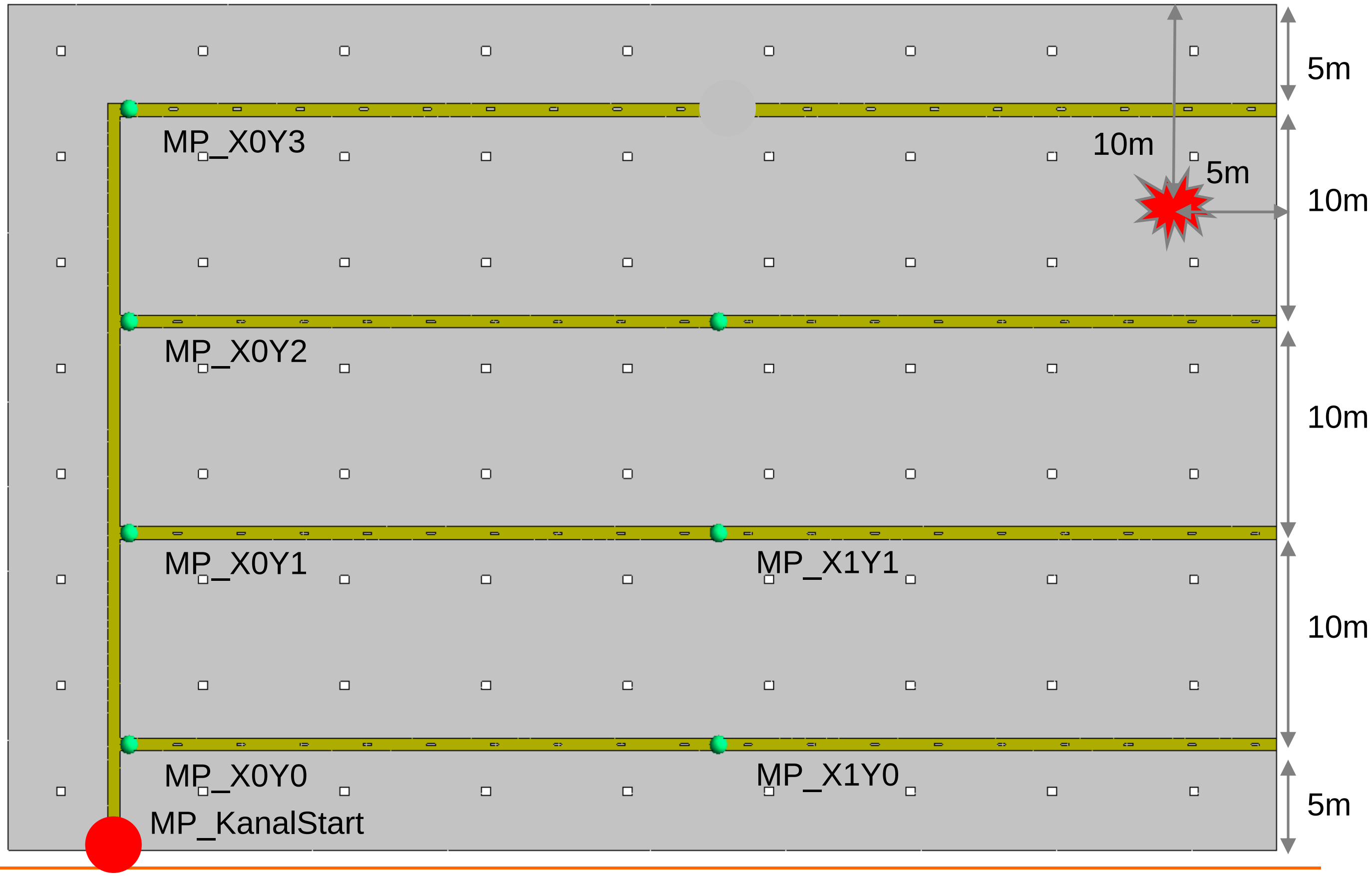
Room layouts and location of fire source

- Large room 40 x 60 m

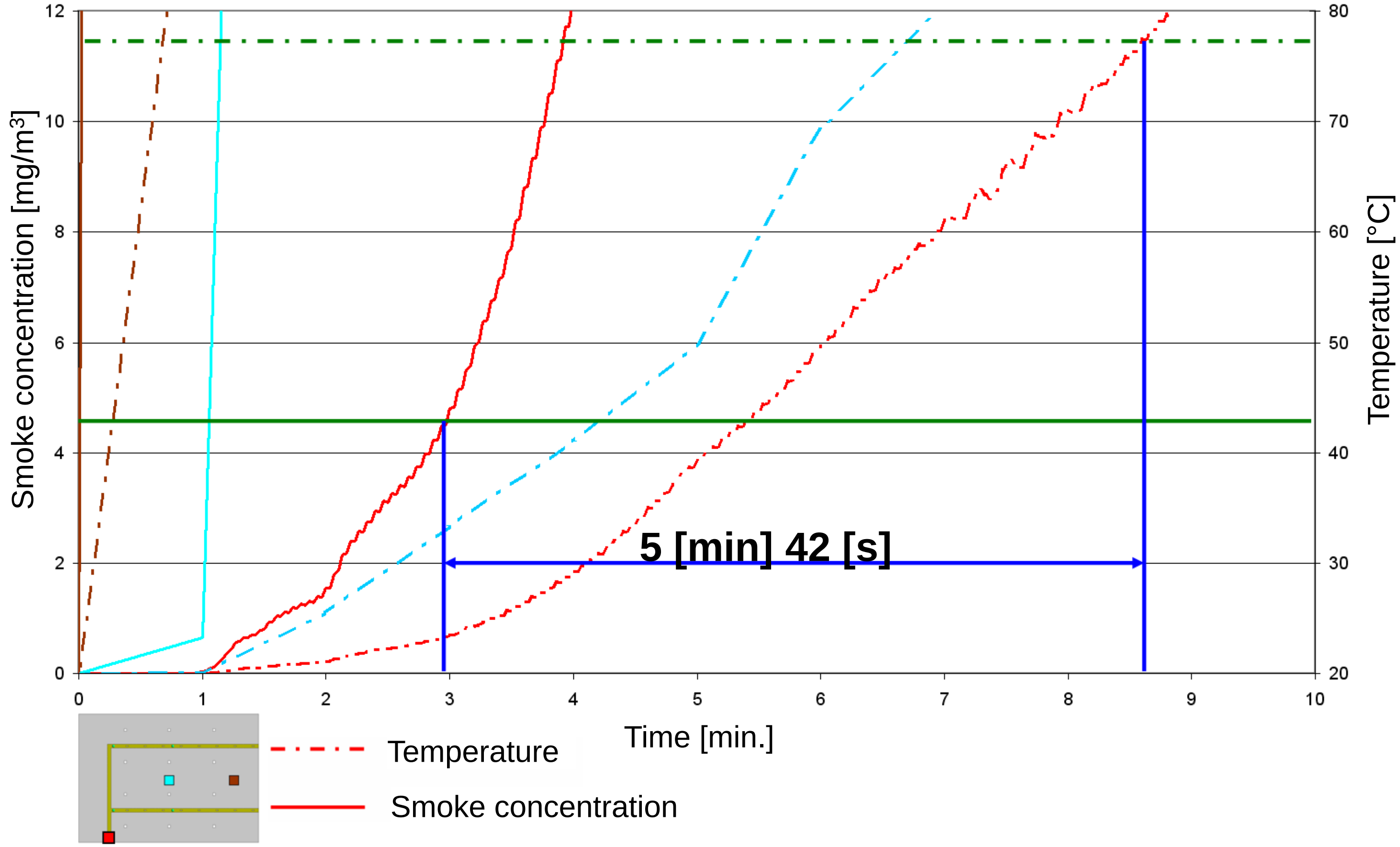
Measuring point
a) Thermal fuse
b) Smoke detector

Fire source



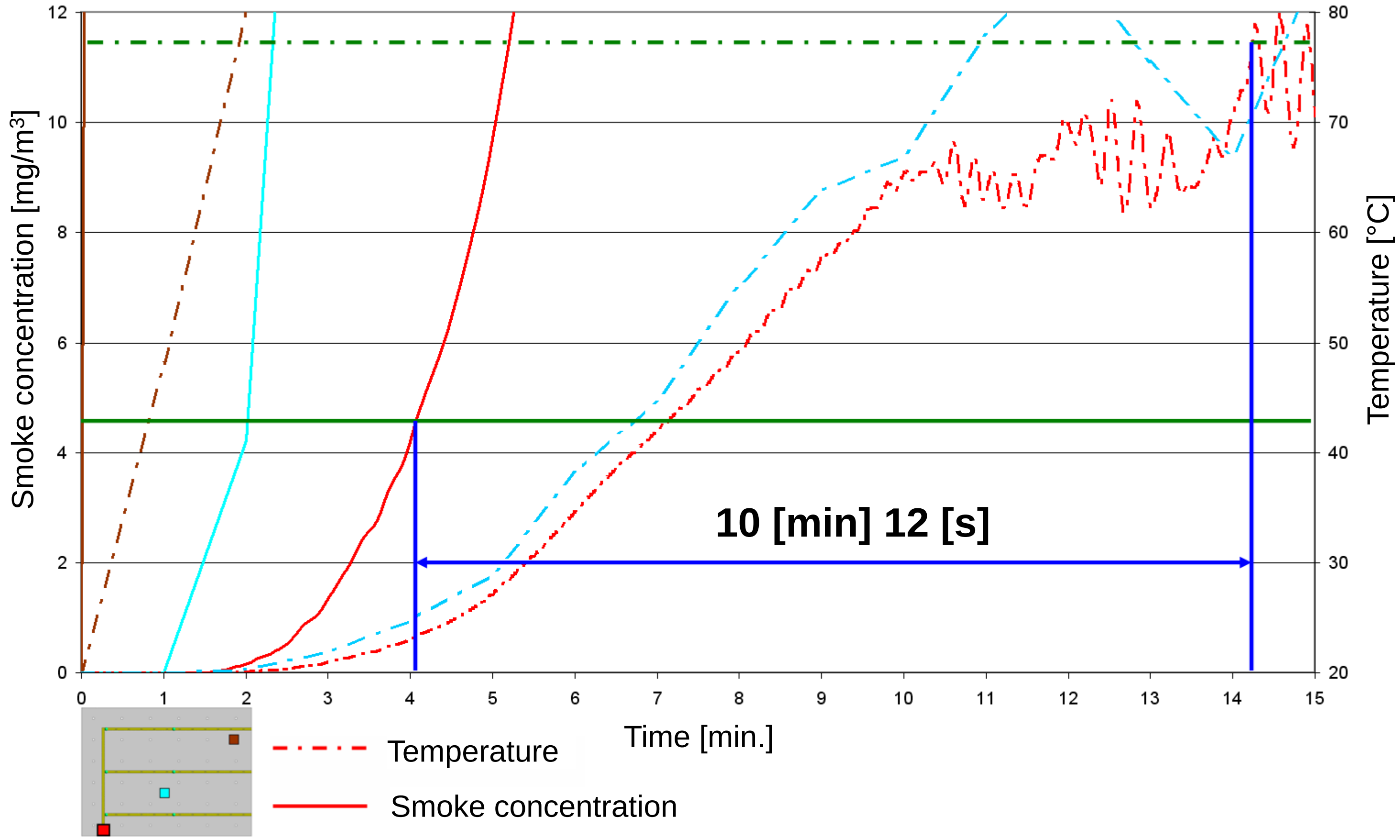
Motorised Fire & Smoke Dampers
Smoke Flow and Temperature Simulations

- **Simulation results: Small room (600 m², 2‘400 m³/h)**



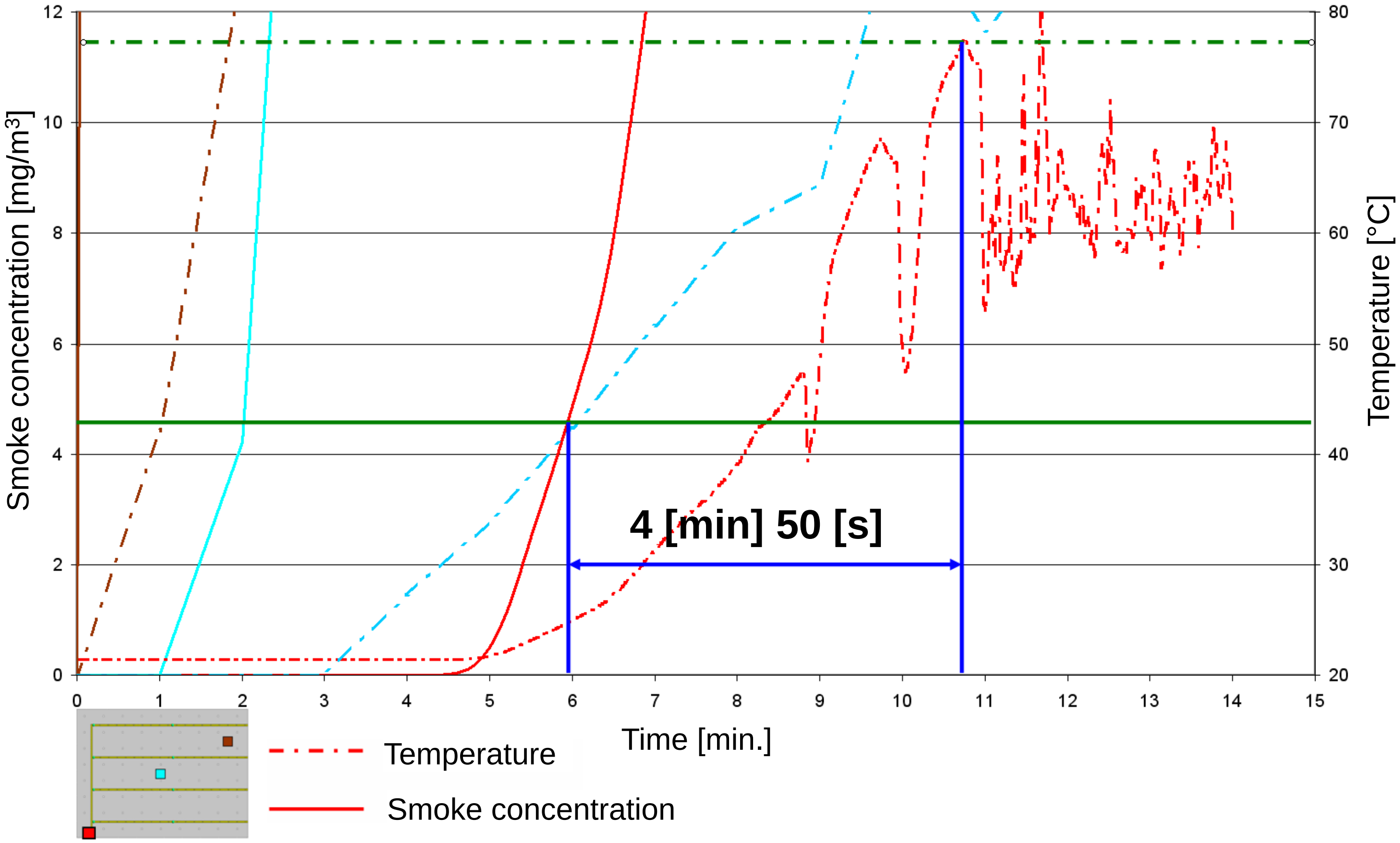
Motorised Fire & Smoke Dampers
Smoke Flow and Temperature Simulations

- **Simulation results: Medium room (1‘200 m², 4‘800 m³/h)**



Motorised Fire & Smoke Dampers
Smoke Flow and Temperature Simulations

- **Simulation results: Large room (2‘400 m², 9‘600 m³/h)**



Motorised Fire & Smoke Dampers
Smoke Flow and Temperature Simulations

- **Summary of the results / conclusions**
  - All results depend strongly on the fire szenario, the room layout and the location of detection
  - All conclusions are valid under consideraton of the limits of the used model
  - Thanks to the use of a smoke detector fire dampers can close from 3:00 up to approx. 10:00 min earlier compared to temperature triggering
  - There are even fire scenarios where the operating temperature is never reached at the measuring point!
  - Smoke detectors in combination with motorised fire dampers allow the most reliable and earliest activation in case of a fire.

Motorised Fire & Smoke Dampers
BRE Real Fire Test – Conclusions

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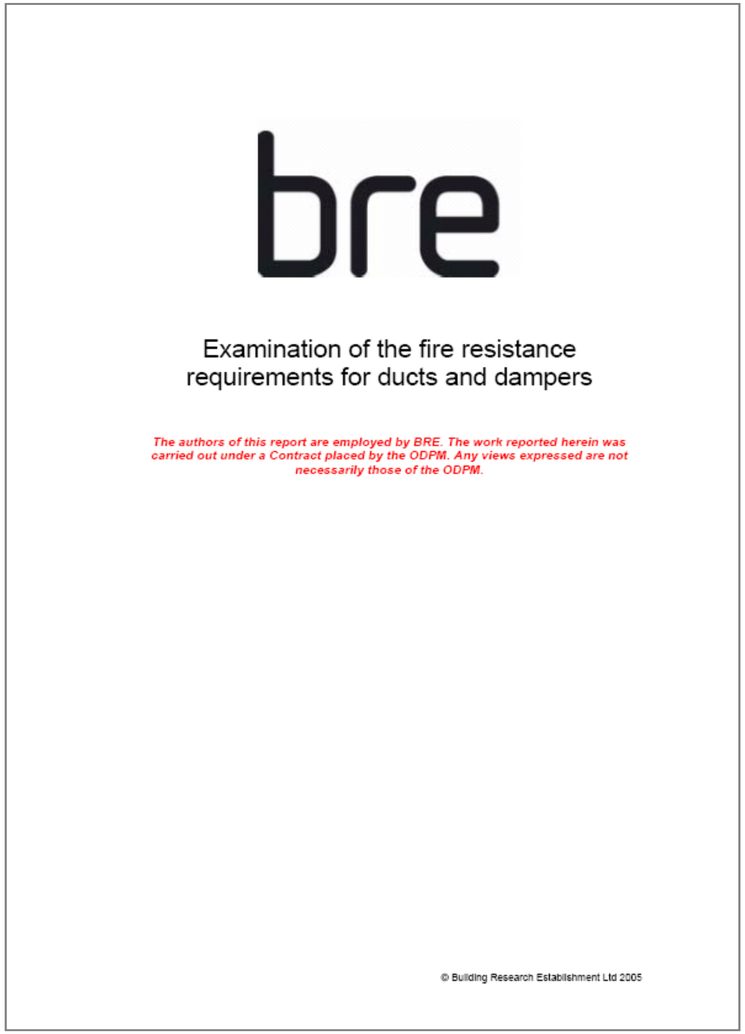

bre

Examination of the fire resistance requirements for ducts and dampers

The authors of this report are employed by BRE. The work reported herein was carried out under a Contract placed by the ODPM. Any views expressed are not necessarily those of the ODPM.

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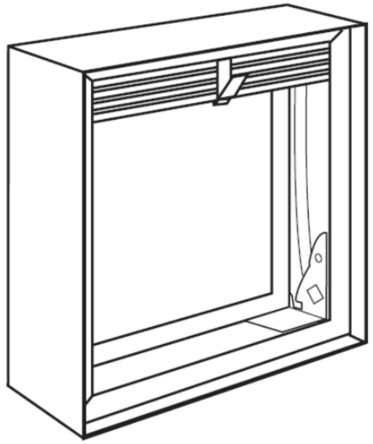
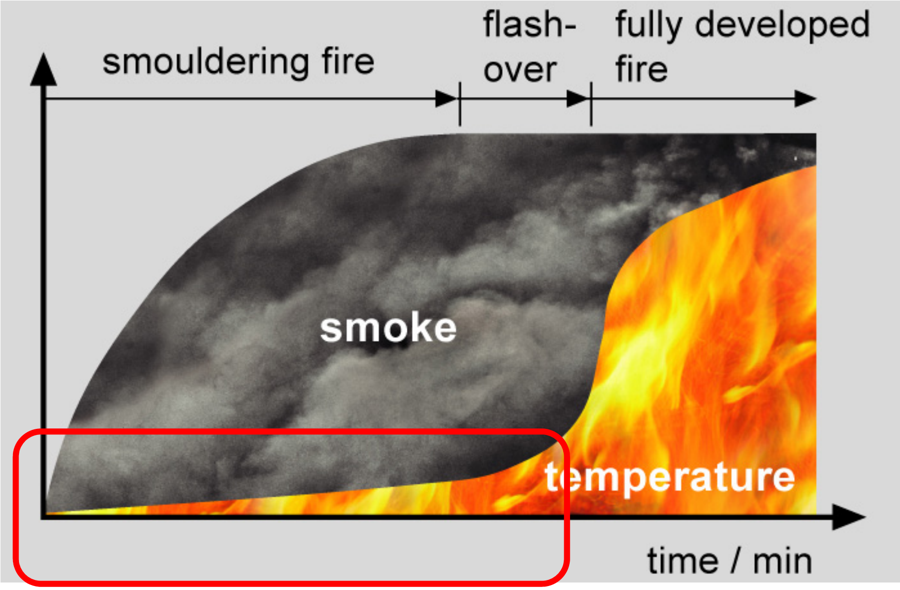


Public download:
http://www.bre.co.uk/filelibrary/pdf/rpts/partb/ducts_and__dampers.pdf

Motorised Fire & Smoke Dampers
BRE Real Fire Test – Conclusions

This report summarises the work carried out during this project. This includes a literature search and review of fire loss reports and data from actual fires relating to fires involving HVAC systems from UK and US sources which sought to identify relevant trends in performance during different fire situations. In addition, the results of the experimental programme are presented. The experimental work was carried out in two stages, one stage looked at the fire resistance of three different duct and damper installations built to current industry based codes. The second stage consisted of a detailed examination of the activation of dampers contained within the ductwork when exposed to developing fires.

Focus on the developing phase of a fire



Motorised Fire & Smoke Dampers BRE Real Fire Test – Conclusions

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The results of this work showed that dampers vary in terms of their activation characteristics. In the early stages of a developing fire, this project has indicated that dampers relying only on fusible links may not shut in a fan-off situation because the gas temperatures recorded at the fusible link at the damper position may be below the operating temperature of the fusible links (70ºC).

←fan-off

In some cases, it has also been shown that dampers may not close in the fan-on situation and this is partly dependent on the position of the fusible link within the duct. If the fusible link is low down in the duct , it will be exposed to lower gas temperatures and may not reach its activation temperature. It is also to be noted that intumescent dampers in general, are designed to activate at higher temperatures than fusible links.

←fan-on

In some applications, it is therefore considered that fire and smoke combination dampers intended to prevent the spread of smoke and fire that are activated only by fusible links may not be suitable.

The multi-blade, circular single blade and intumescent fire dampers functioned extremely well in the fire resistance test which was designed to replicate three typical damper/duct/wall installations. All dampers closed/sealed and were able to provide the required fire resistance. Therefore, in a post-flashover fire situation, as represented by the fire resistance test, our work has shown that dampers can close and contribute to the maintenance of compartmentation.

Motorised Fire & Smoke Dampers
BRE Real Fire Test – Conclusions

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	FAN ON 500kW	FAN ON 300kW	FAN OFF after 2 Min.
Average Closing Time	406s	551s	-
Did not Activate	2 out of 7	1 out of 9	4 out of 4

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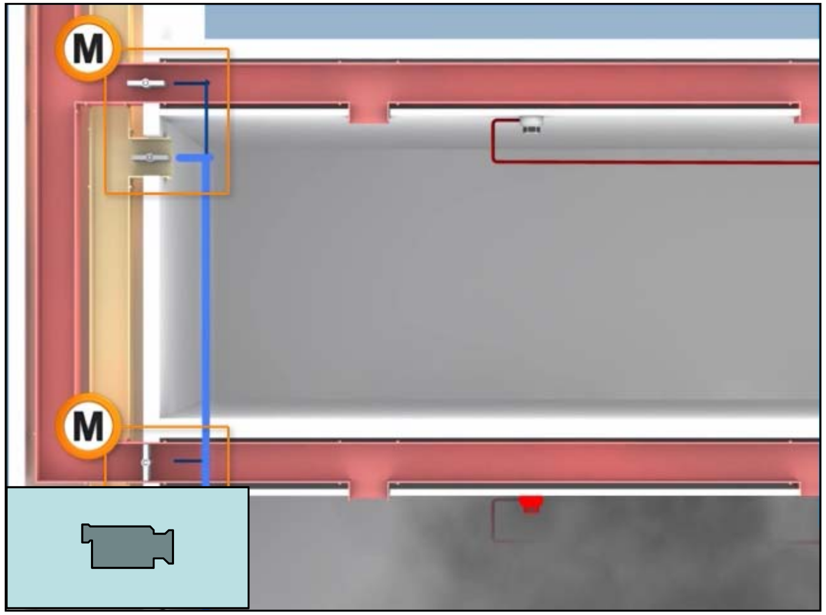
Sequence control of motorised fire dampers

- Sealing of compartment and overpressure generation



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Summary Non-motorised vs. motorised fire dampers

Conventional fire dampers

- Only activates when temperature reaches 72°C local to the damper – does not protect against the spread of cool smoke
- Maintenance is difficult, costly and complicated.
- Testing is seldom achieved.
- Restricted applications not suitable for:
  - fan on systems
  - means of escape
  - sleeping risk dwelling
- Fixed position – no control.

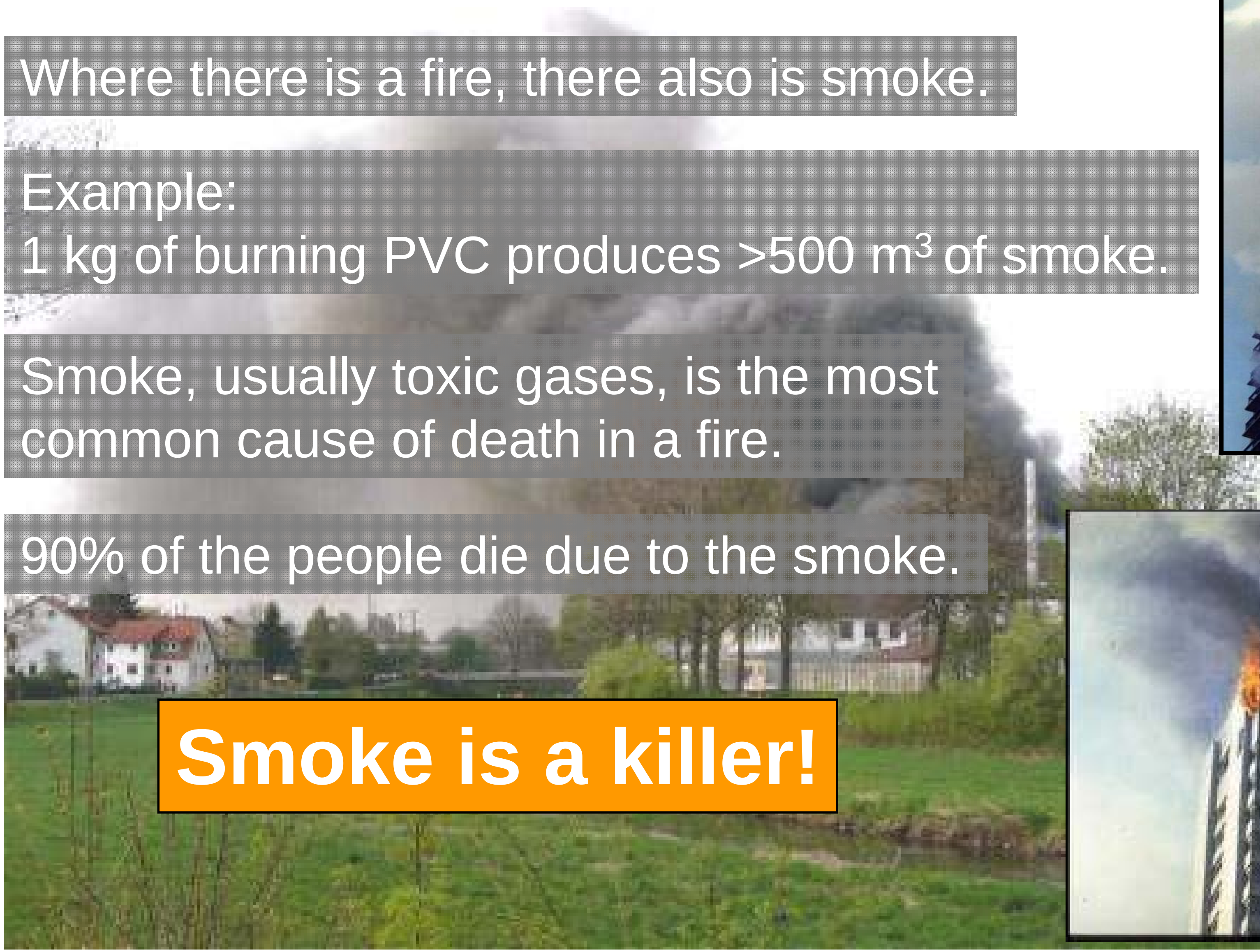
Motorised fire dampers

- Fast activation via the fire detection system – therefore giving increased protection against the spread of cool smoke
- Remote testing:
  - regular functional checks
  - operating diagnostics
- Privides compartmentation:
  - early zone compartmentation in the event of fire
  - night shutdown
  - non-occupancy
- Suitable for all applications.

Mechanical Smoke Extraction

(Smoke Control)

Some Facts



Where there is a fire, there also is smoke.

Example:
1 kg of burning PVC produces >500 m^3 of smoke.

Smoke, usually toxic gases, is the most common cause of death in a fire.

90% of the people die due to the smoke.

Smoke is a killer!

Toxic Effects of Smoke

Composition of smoke:

- Toxic gases
- Irritant gases
- Pyrolysis products (VOC)
- Solid particles (carbon)

Symptoms:

- Headache, vertigo, shortage of breath, scraping in the throat, sickness
- Loss of consciousness, breakdonwn, edema of the lung, death

→ Five breaths are enough to die.

Psycological Effect of Smoke

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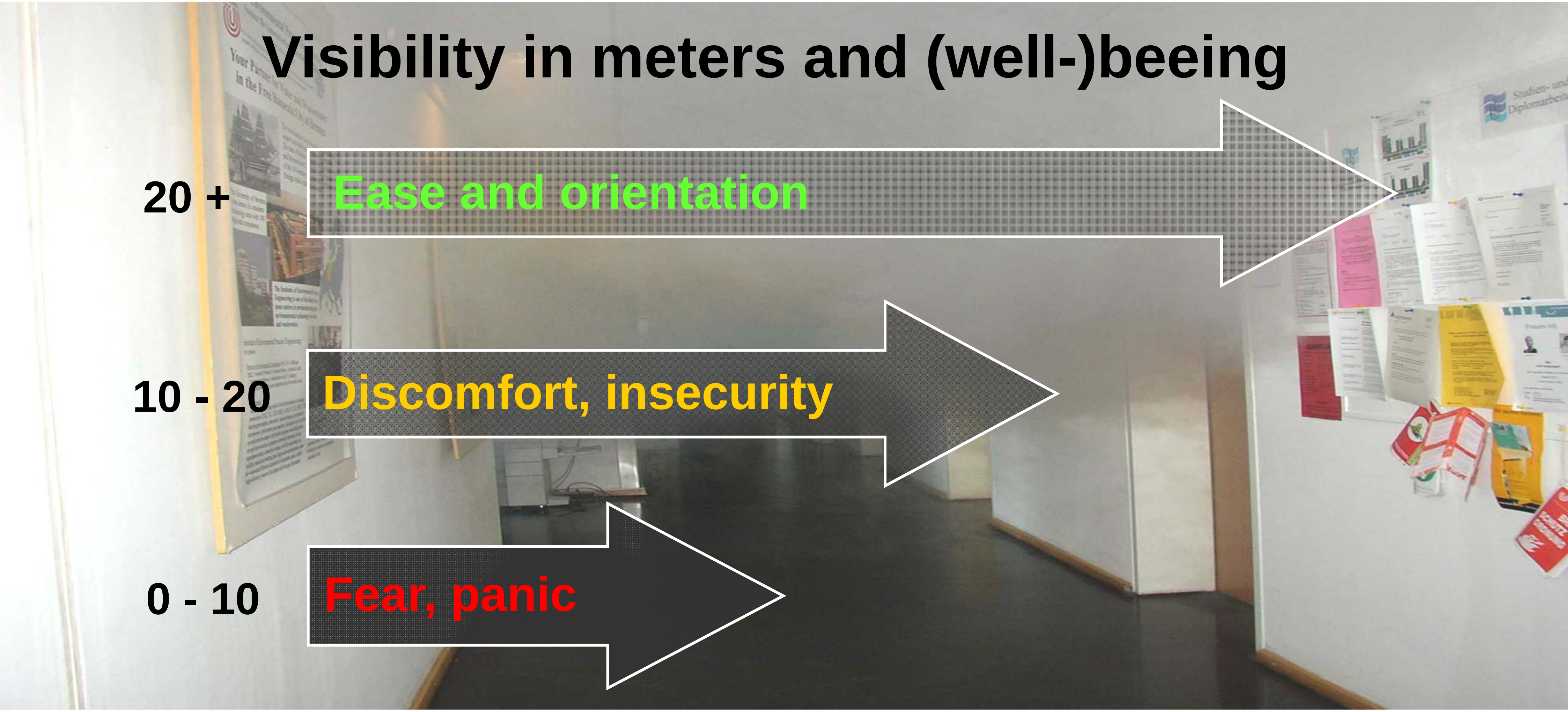


Movement and Spread of Smoke

- Smoke gets a lift (buoyancy) from hot gases in the burning zone
- Smoke spreads within the burning zone
- With the stack effect smoke can spread in the entire building
- Wind pressures on the facade of a building have an influence on the movement of smoke, as well as ventilation and air conditioning systems and elevators
- Smoke is rather difficult to control, depending of what is burning, the size of the fire and how hot it is

Source: University of Greenwhich

Movement and Spread of Smoke

- **Not only people are in danger of smoke, also assets values and the operability of businesses and organisations.**

- **Fire safety concepts for buildings should mandatorily also contain most effective measures for the protection against smoke (not only against heat).**

Mechanical Smoke Extraction (Smoke Control)

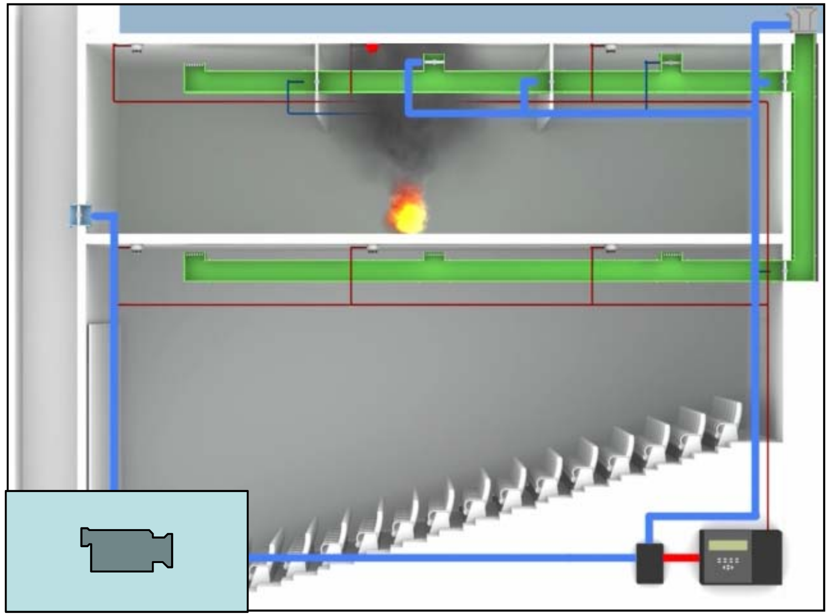
Where are smoke control systems required?

- **Basic principle: The defined protection targets from the fire safety concept of a building must be reached.**
- **Depending on the construction and the use of a building, this can only be reached by using a powered smoke control system.**
- **Typically smoke control systems are used in buildings with "special utilisation", e. g.:**
  - Cinemas
  - High rise buildings
  - Hospitals
  - Hotels
  - Car parks, underground parking
  - Malls, shopping centers
  - Museums

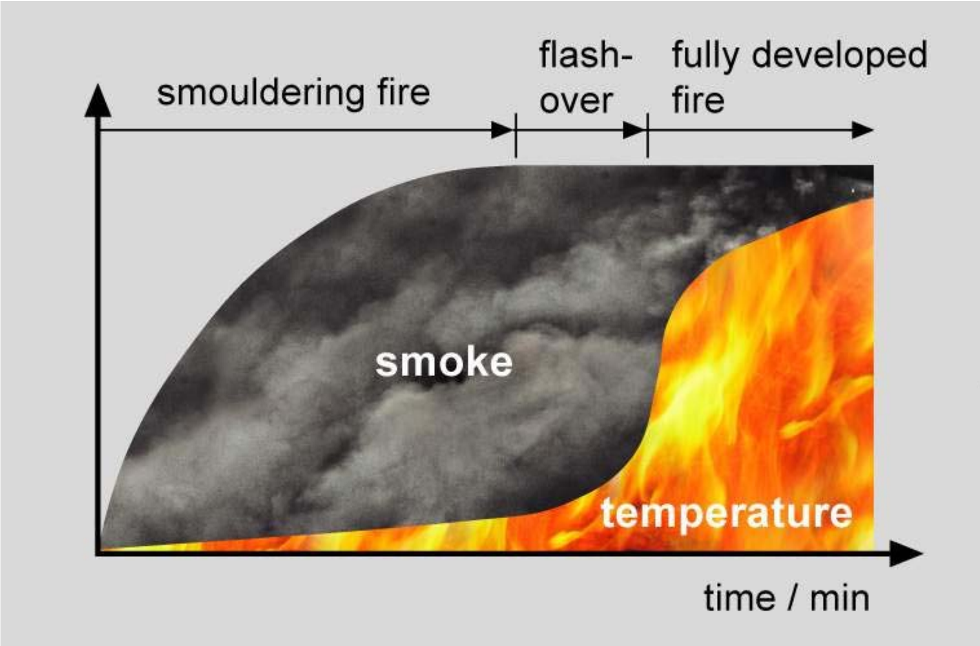
Basic Principle of Smoke Control

Mechanical Smoke extraction

- **Example animation "Cinema"**

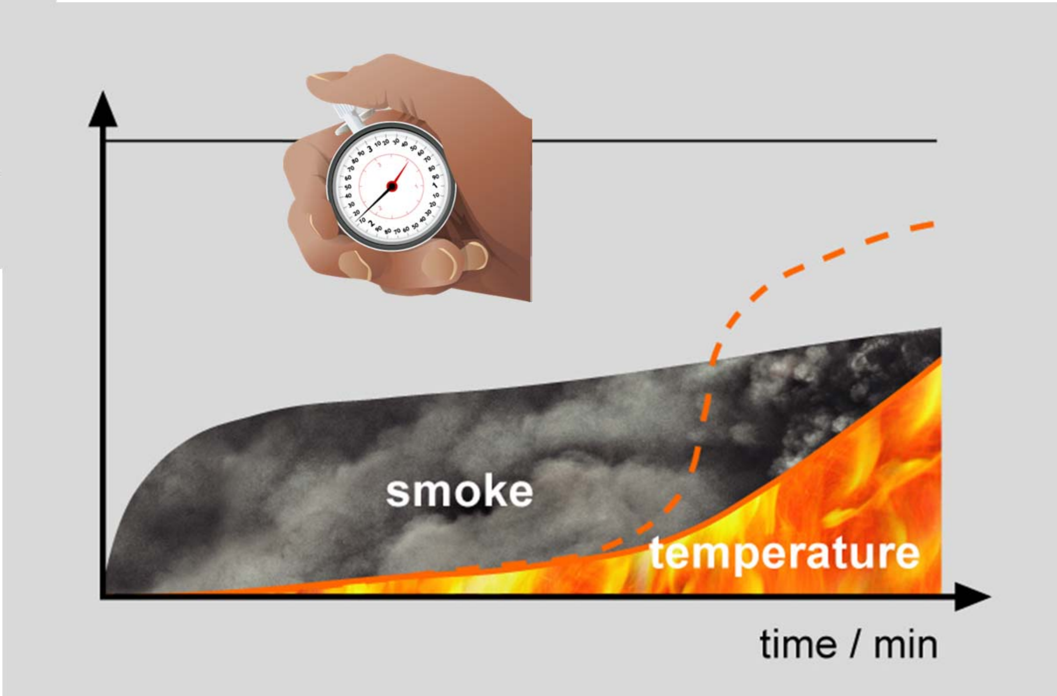


Influence of Extracting Smoke



Without extraction of smoke

With extraction of smoke



Benefits of Extracting Smoke

Supports the evacuation of people and animals by creating a smoke free layer

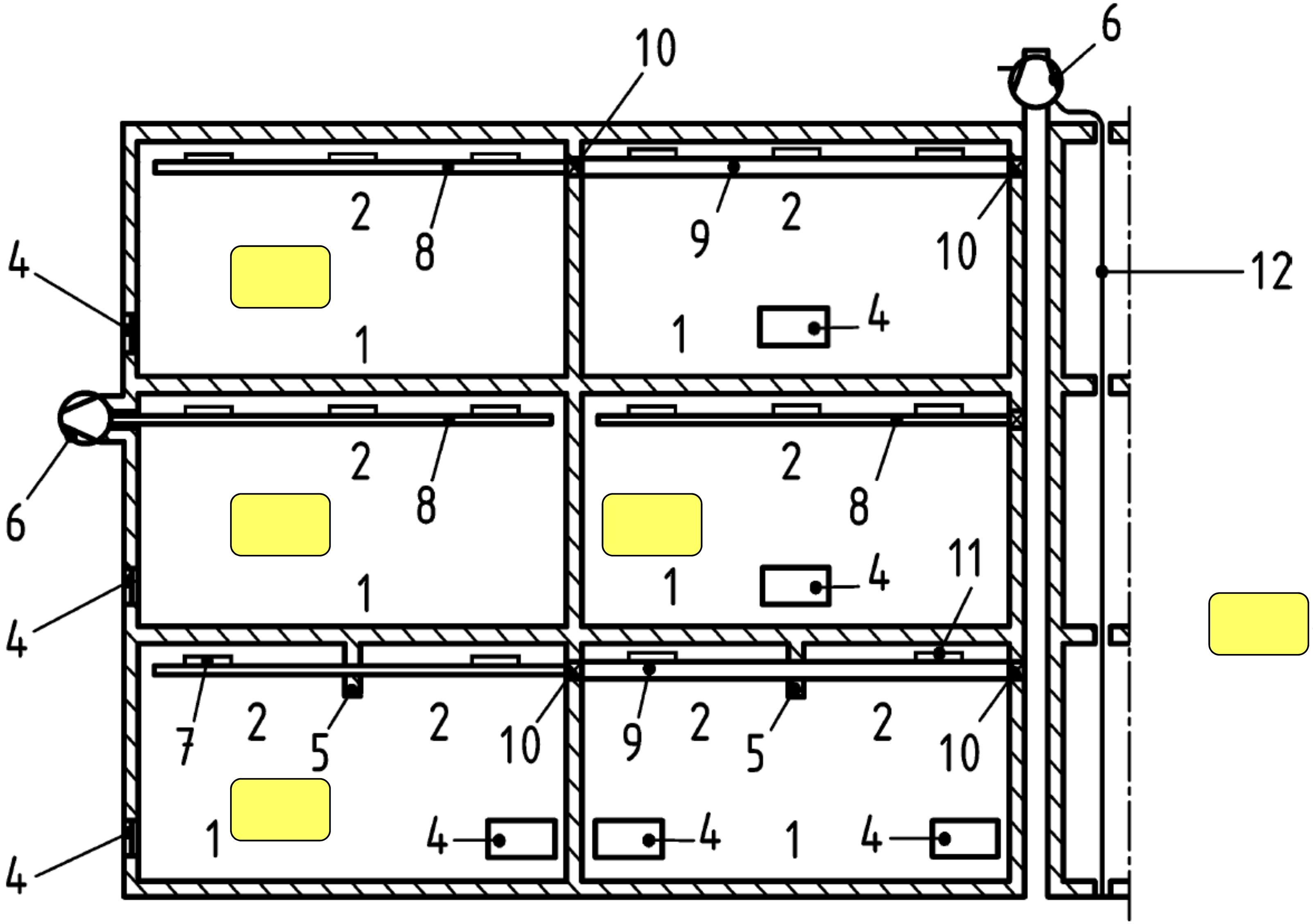
Cools the fire compartment and delays / prevents flash and the subsequent development of the fire

Supports rescue and fire fighting work

Protects assets and reduces the thermal effects on structural components during a fire

Definitions of Smoke Control Systems

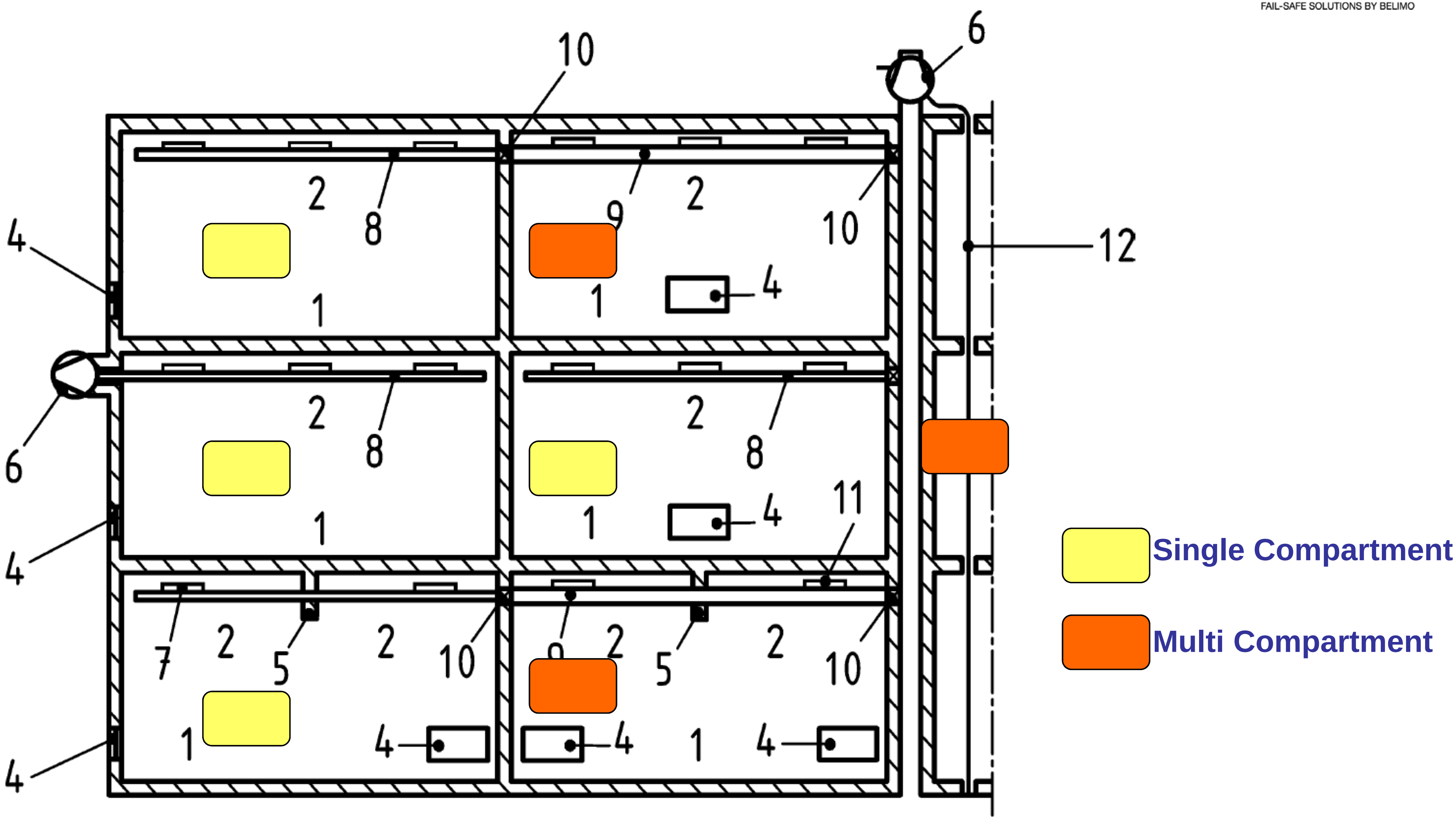
As an example acc. to EN 12101-8 (Product Standard SC Dampers)

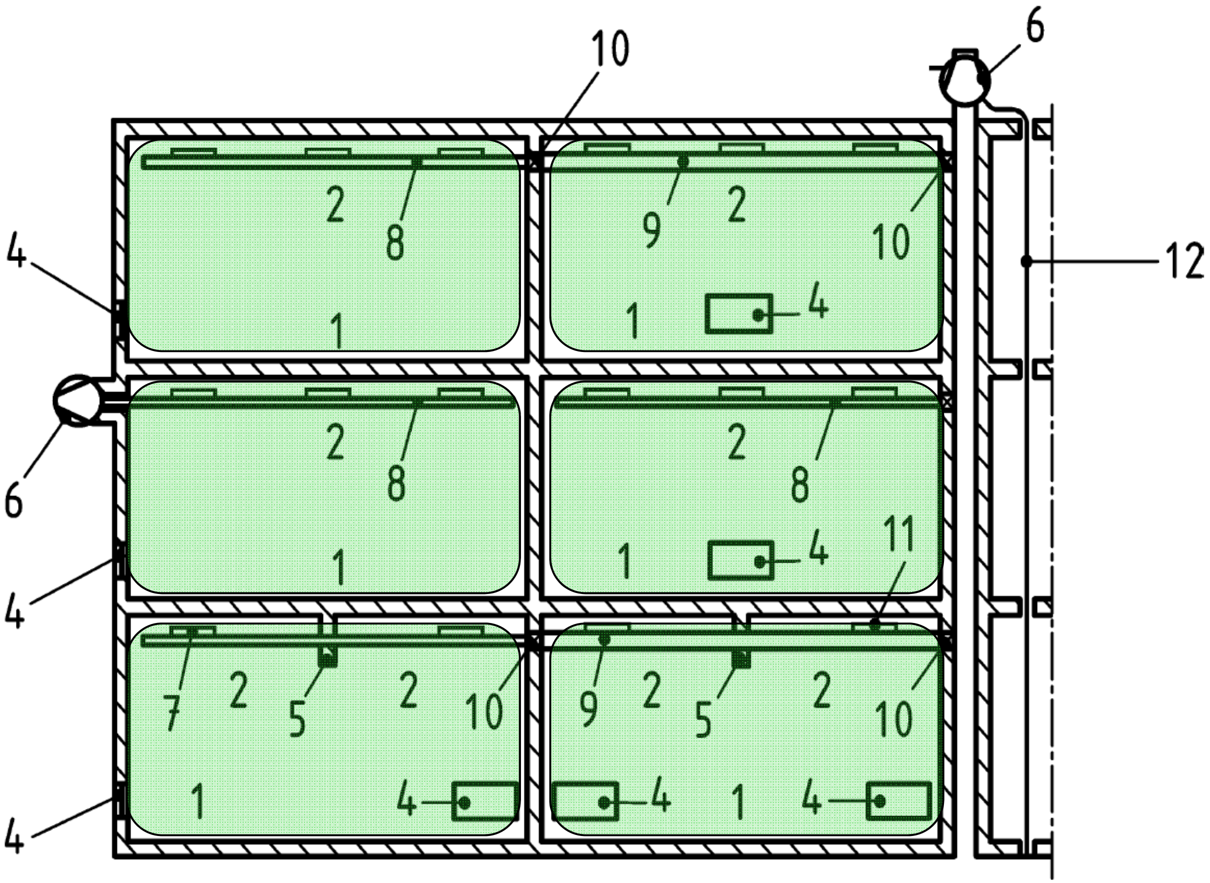


Single Compartment

Definitions of Smoke Control Systems

As an example acc. to EN 12101-8 (Product Standard SC Dampers)





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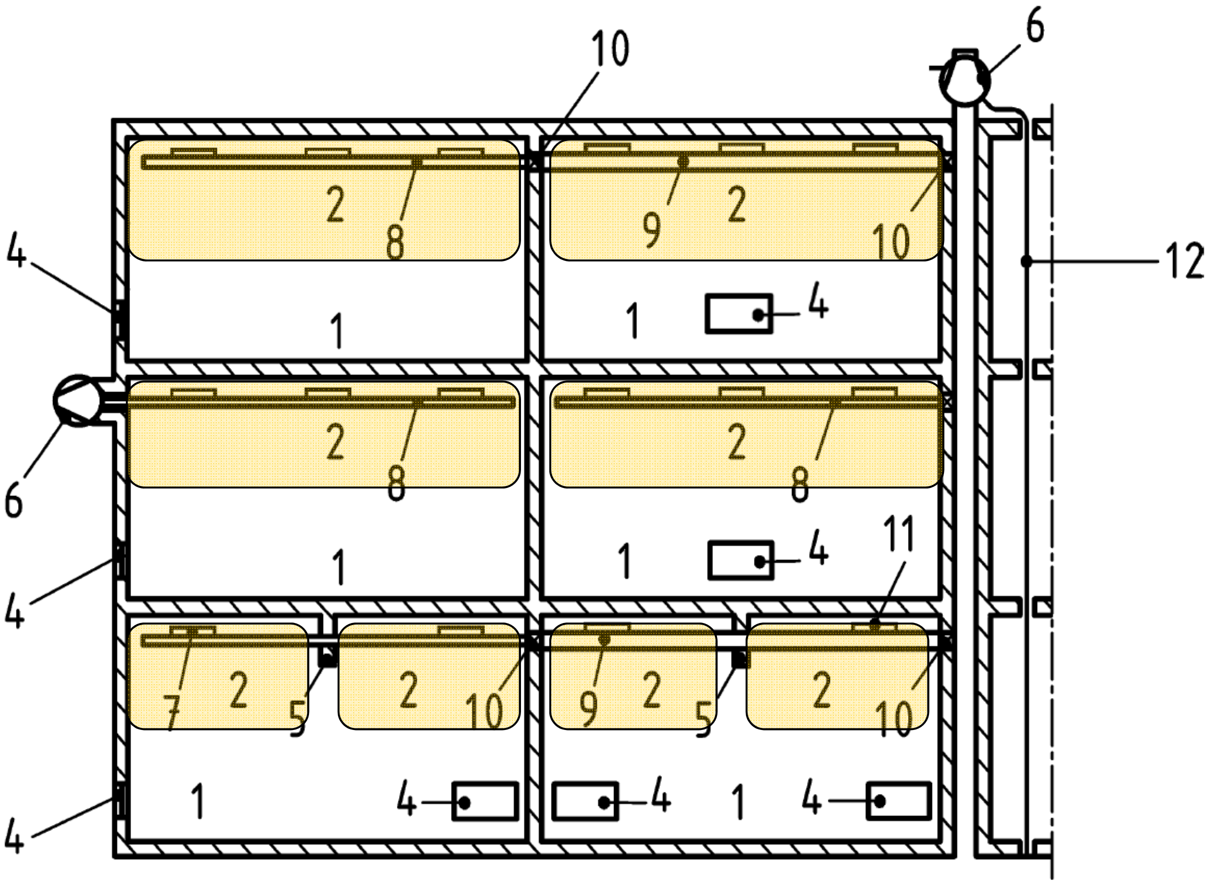
Key

1	Fire compartment
2	Smoke reservoir
4	Air inlet
5	Smoke barrier
6	Powered smoke and heat exhaust ventilator (fan)
7	Smoke control dampers for single compartments (EN12101-8 and EN1366-10)
8	Smoke control ducts for single compartments (EN12101-7 and EN1366-9)
9	Smoke control ducts for multi compartments (EN12101-7 and EN1366-8)
10	Smoke control dampers for multi compartments (EN12101-8 and EN1366-10) mounted inside or outside of wall or floor
11	Smoke control dampers for multi compartments (EN12101-8 and EN1366-10) mounted on the surface of the duct
12	Electrical equipment



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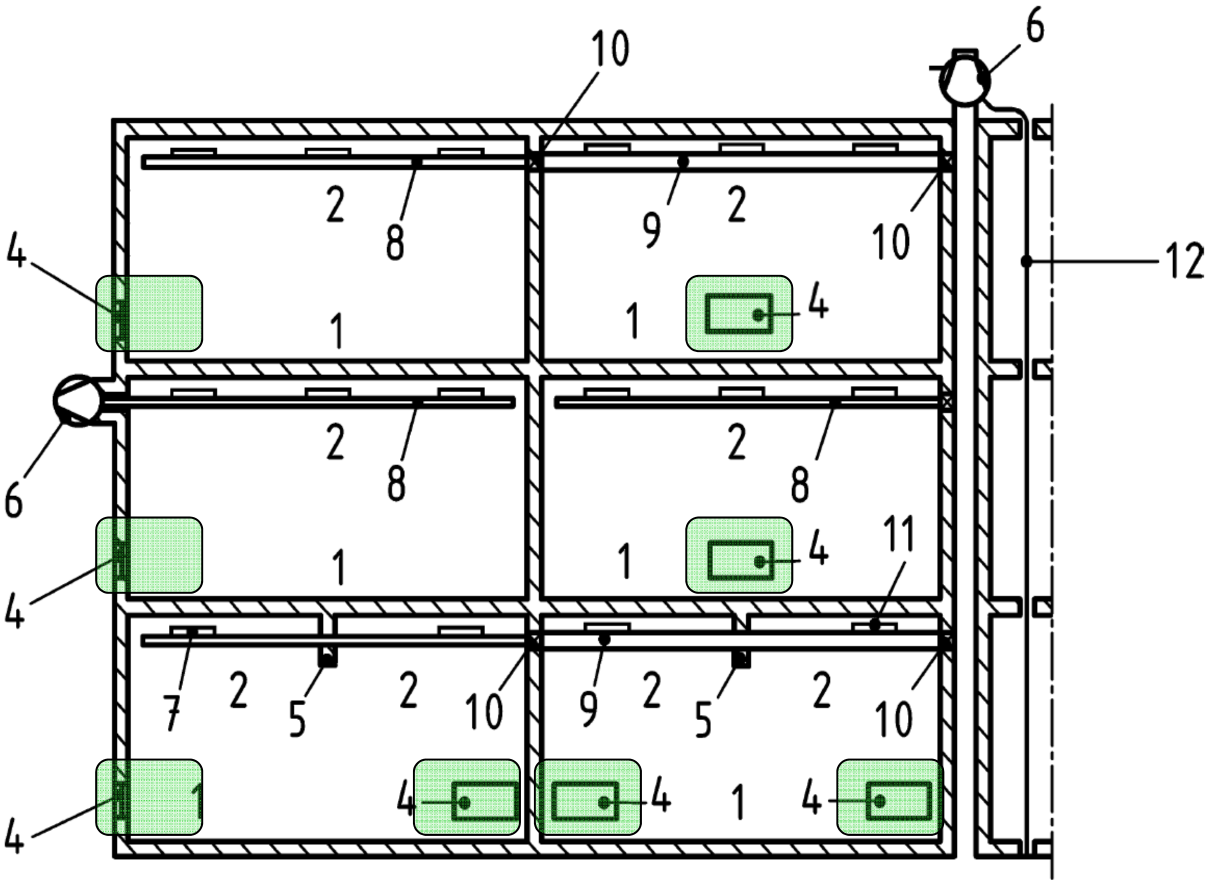

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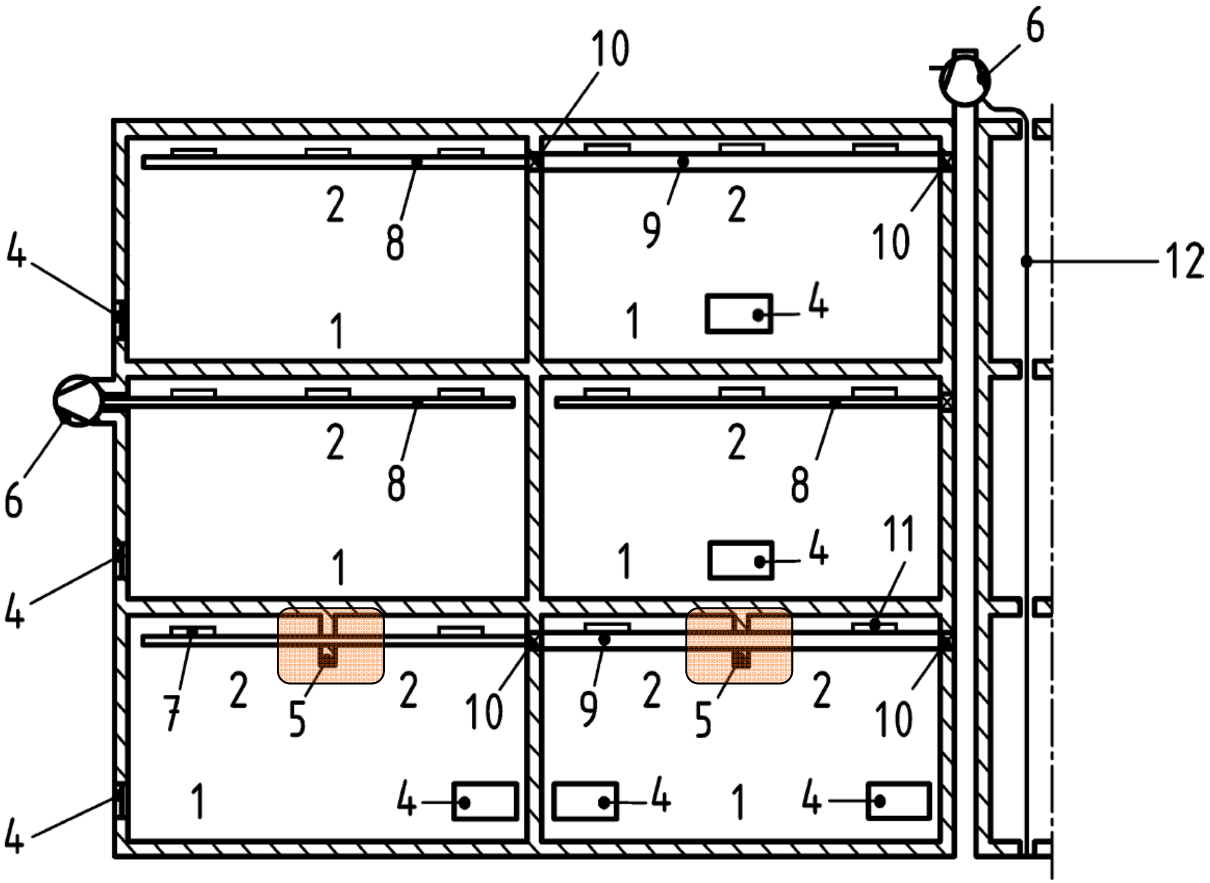

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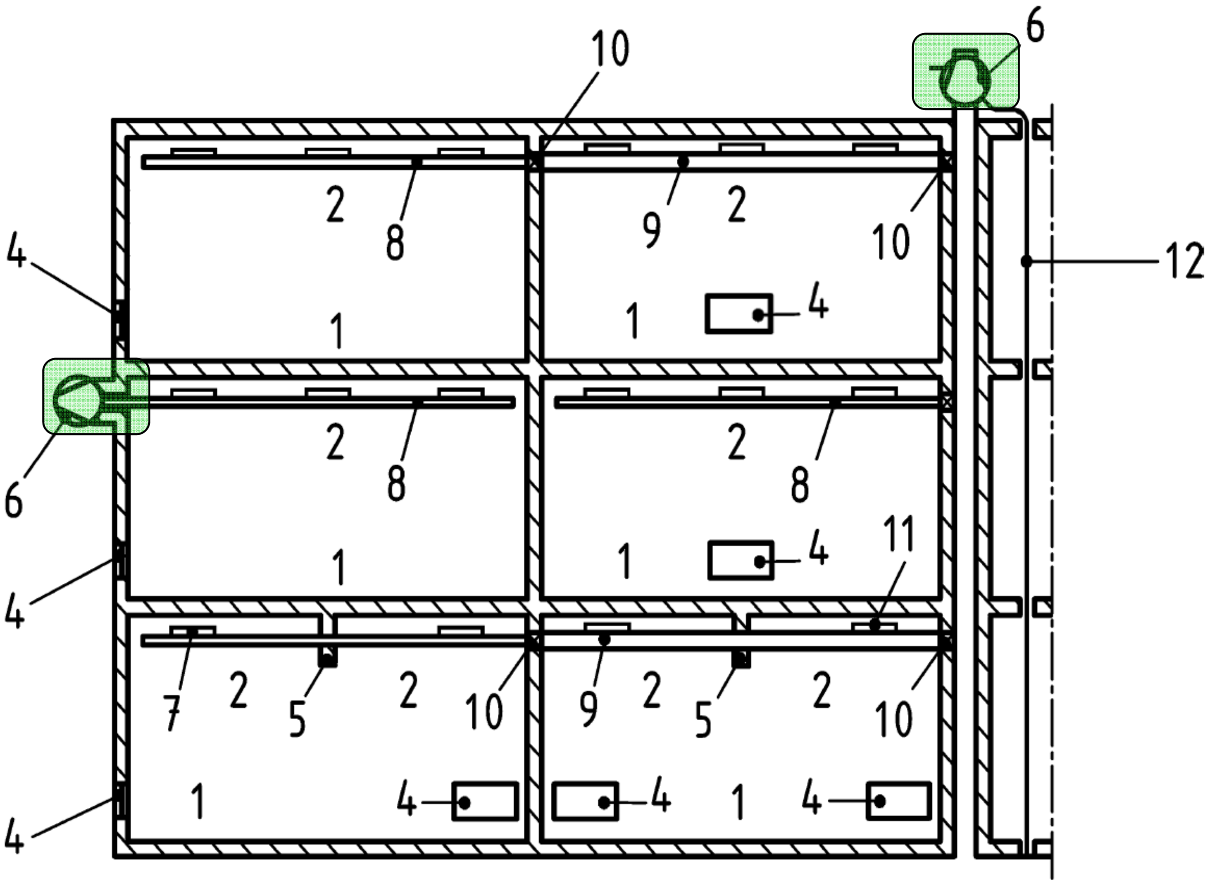

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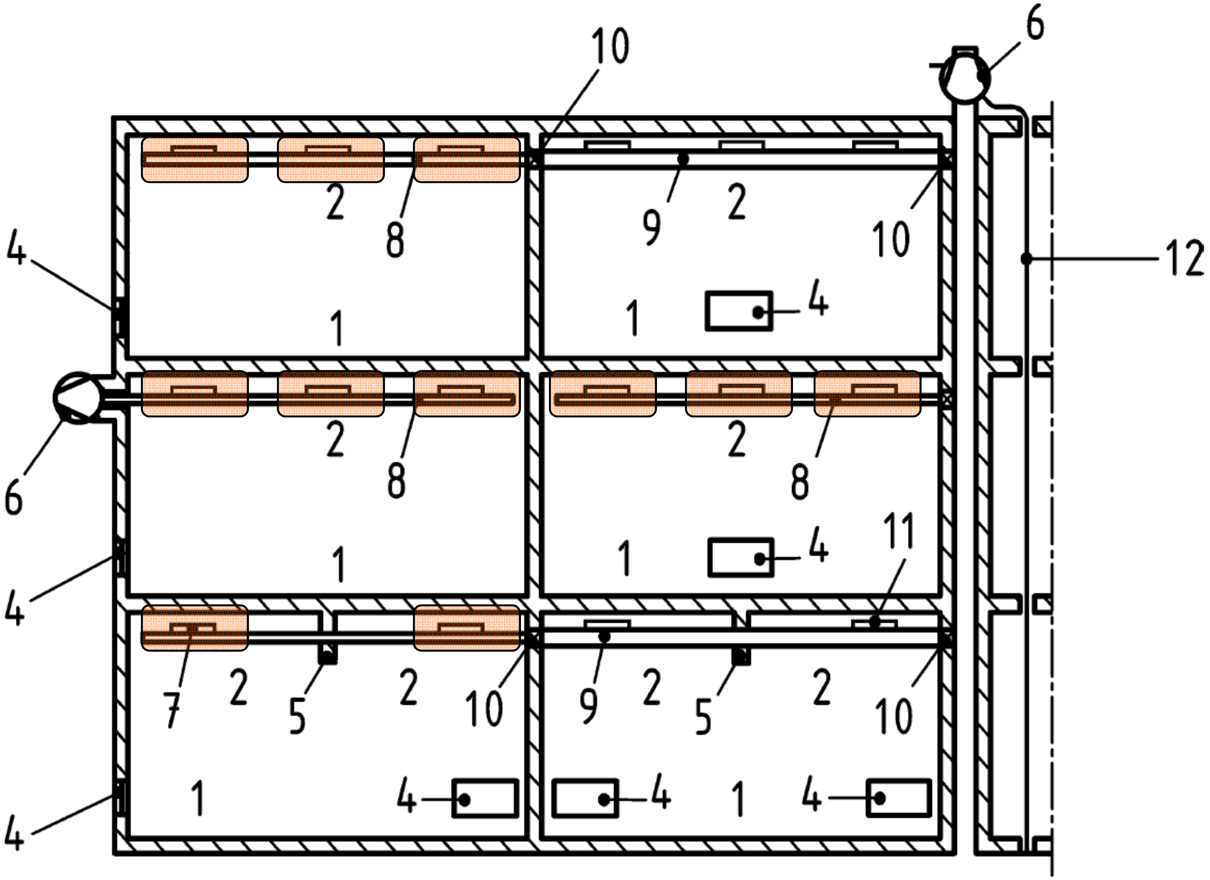

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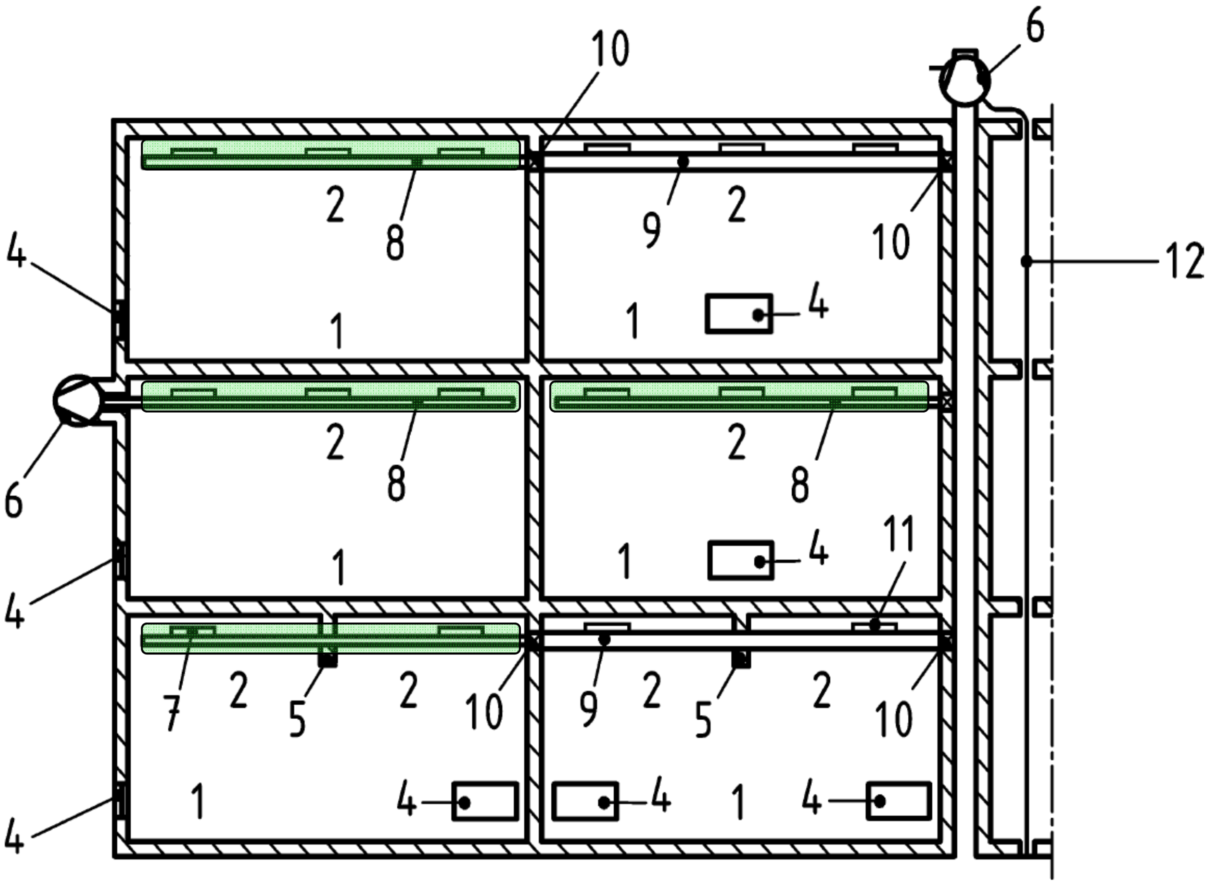

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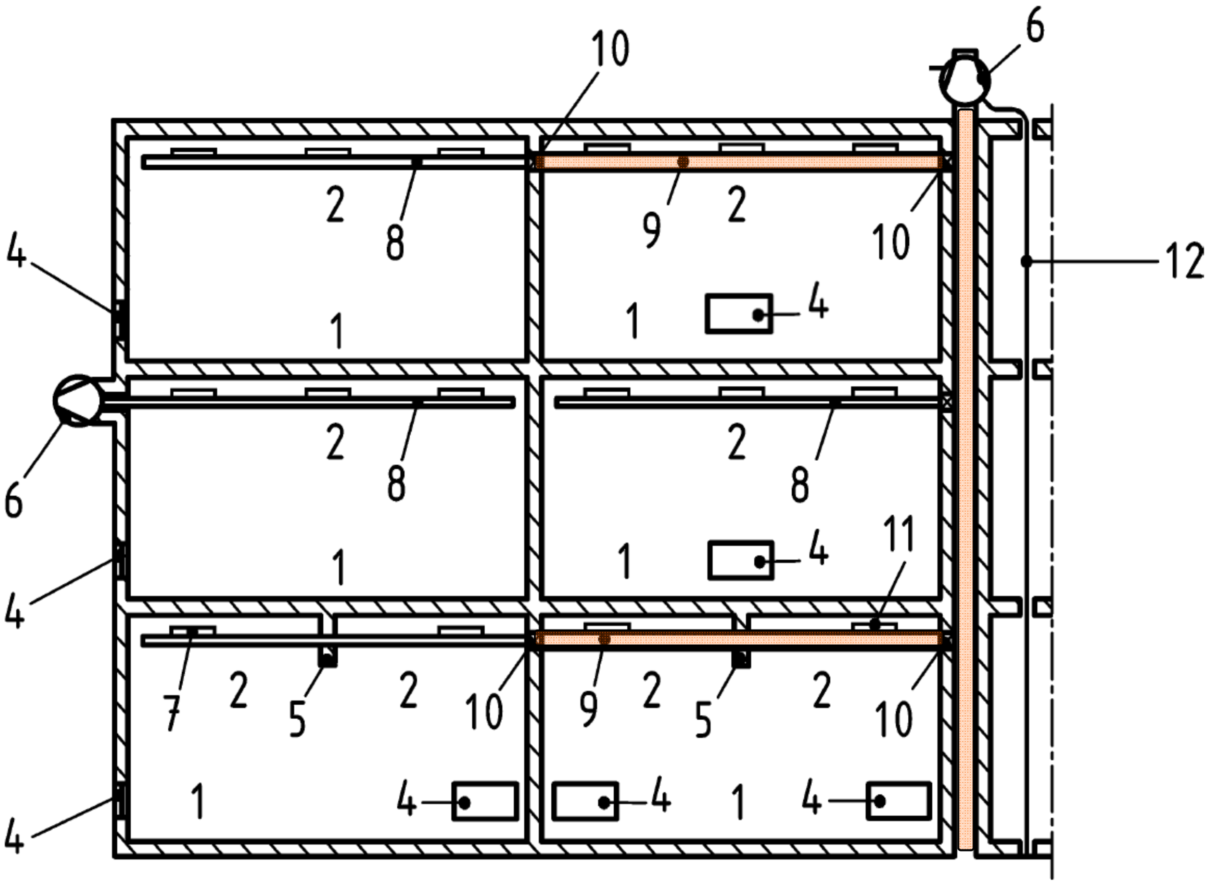

Key

1 Fire compartment
2 Smoke reservoir
4 Air inlet
5 Smoke barrier
6 Powered smoke and heat exhaust ventilator (fan)
7 Smoke control dampers for single compartments (EN12101-8 and EN1366-10)
8 Smoke control ducts for single compartments (EN12101-7 and EN1366-9)
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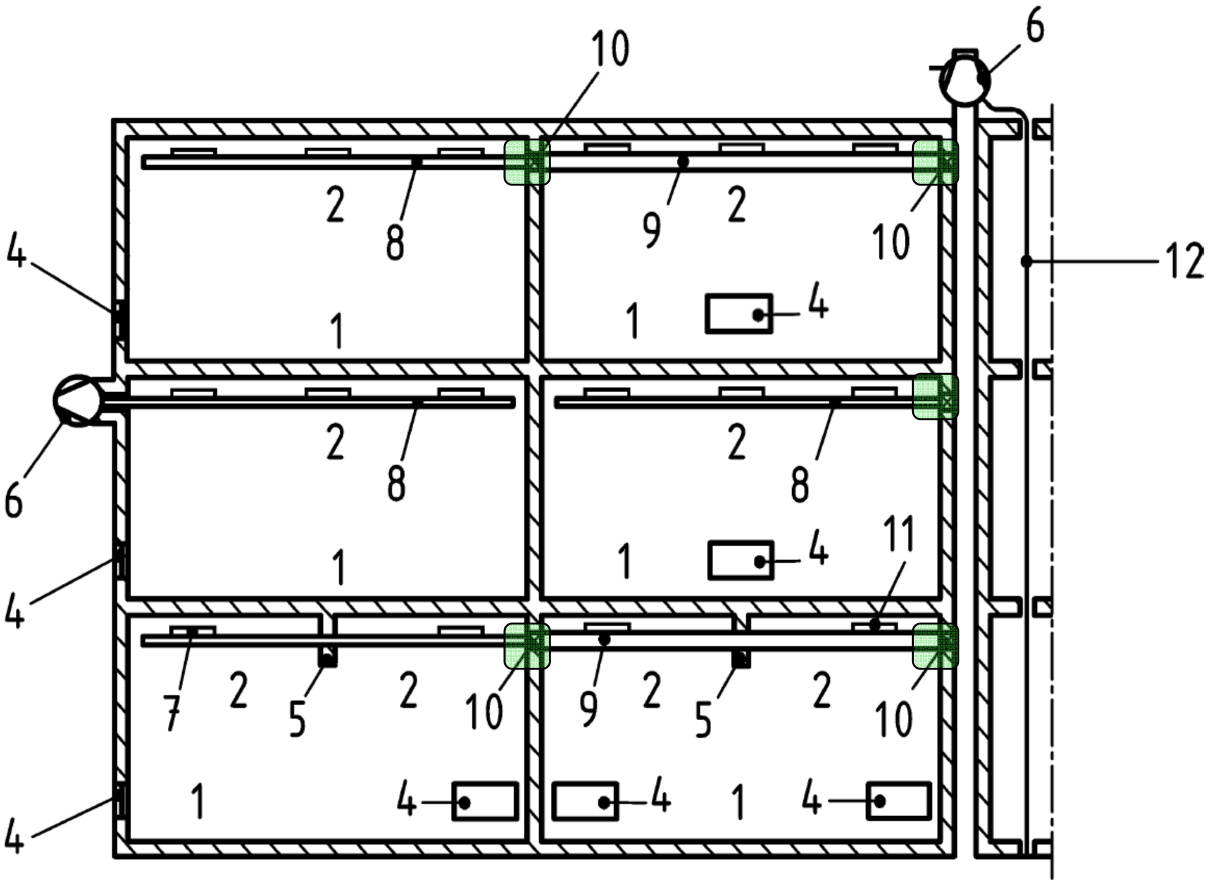

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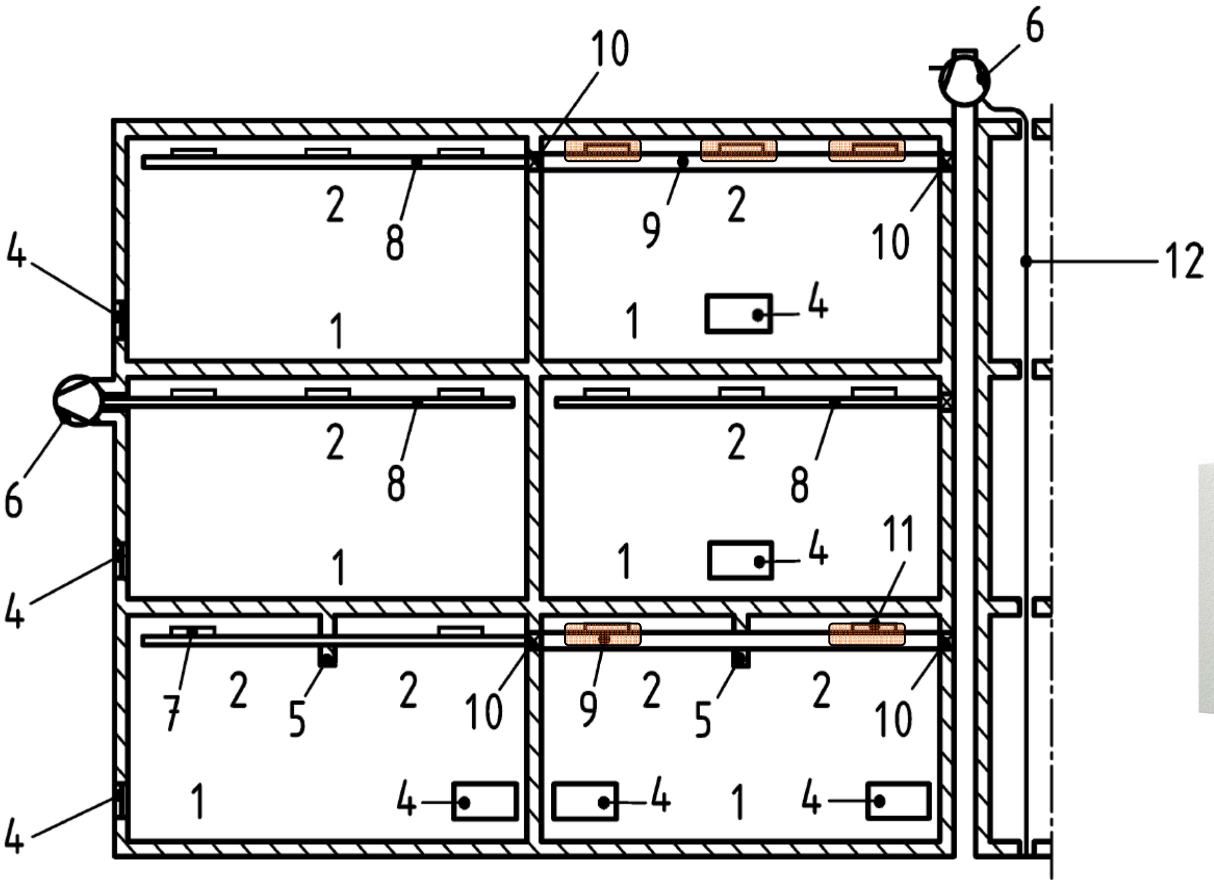

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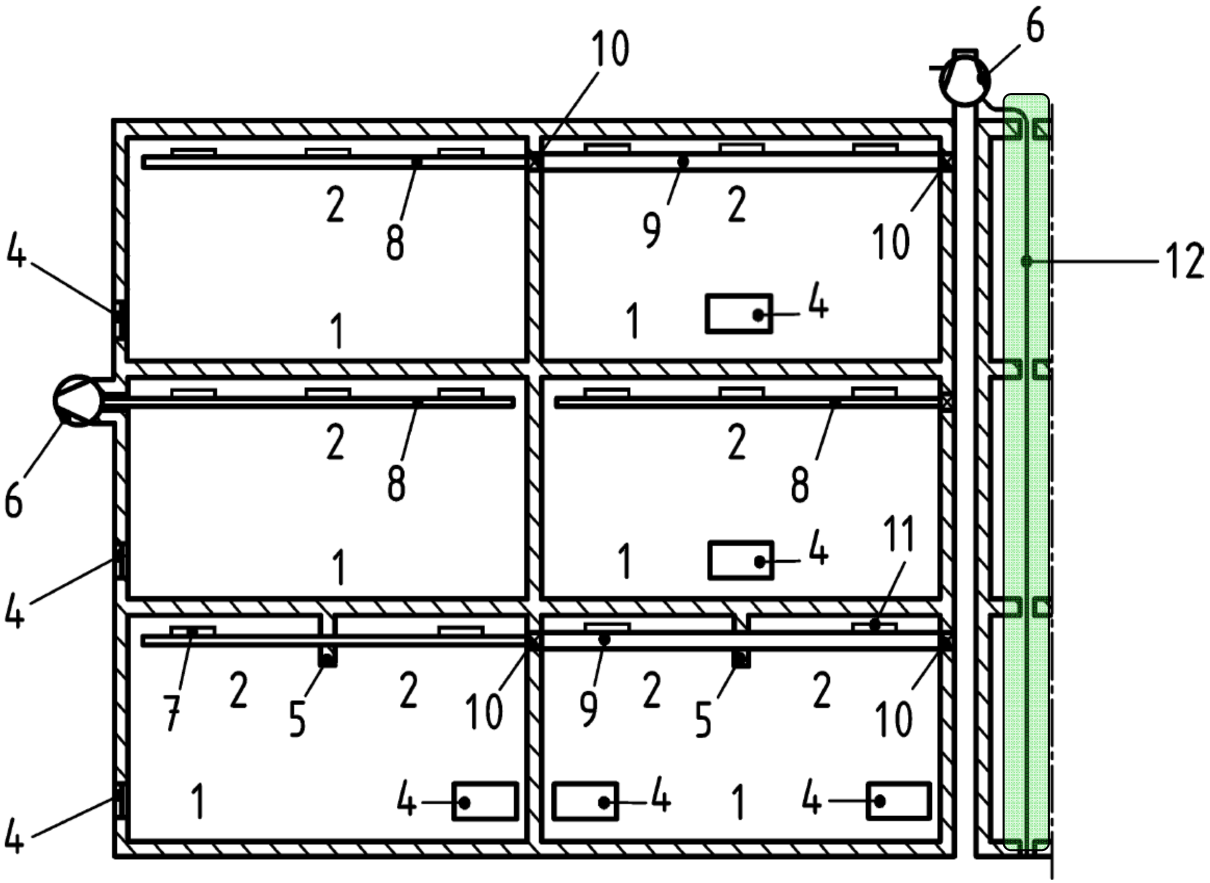

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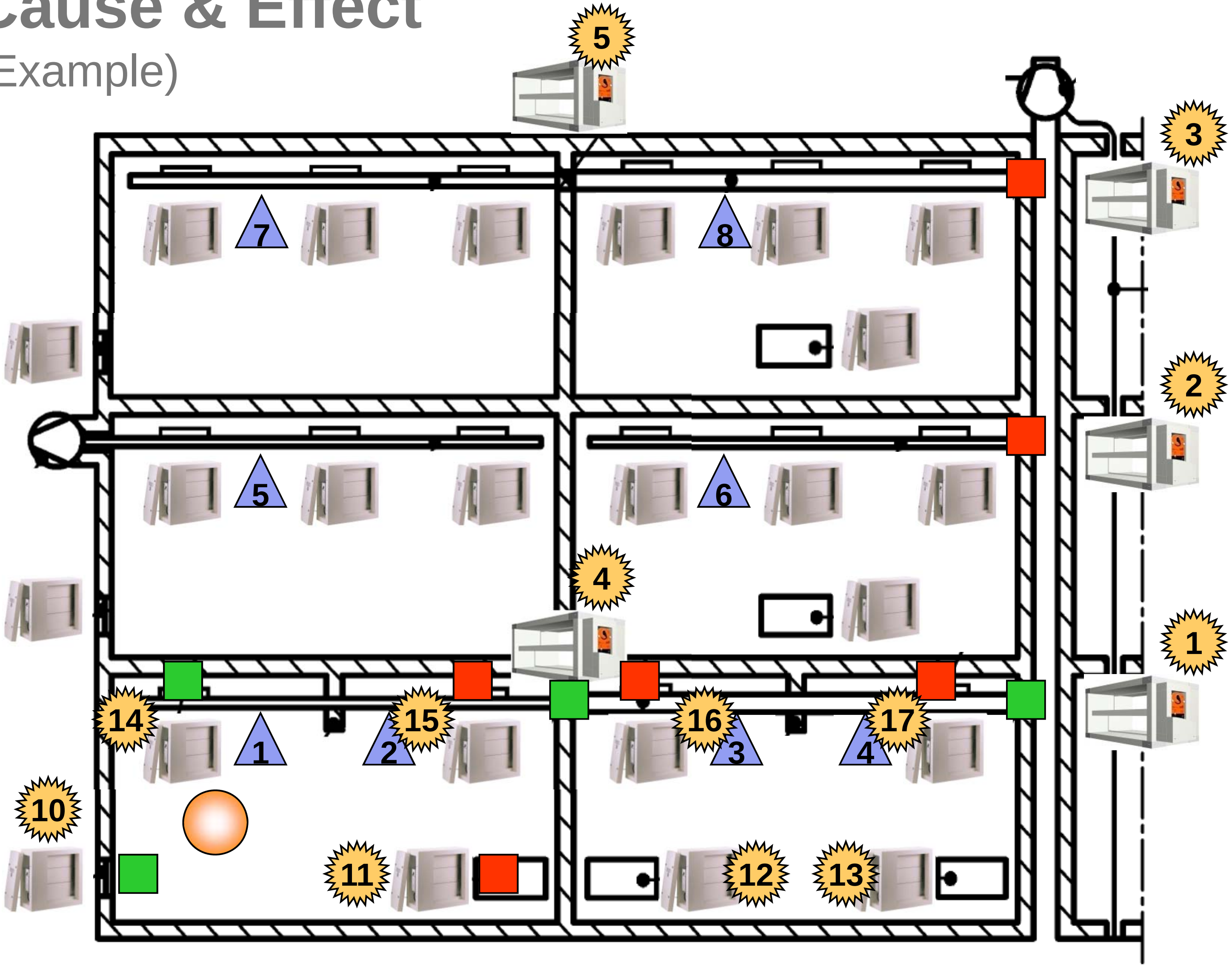
Cause & Effect
(Example)



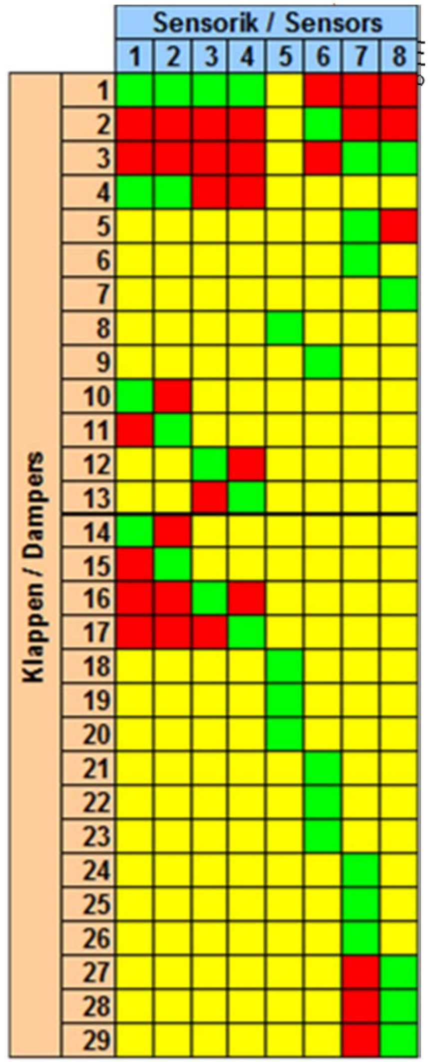
Damper OPEN

Damper CLOSED

Fire

Sensor No.

Damper No.

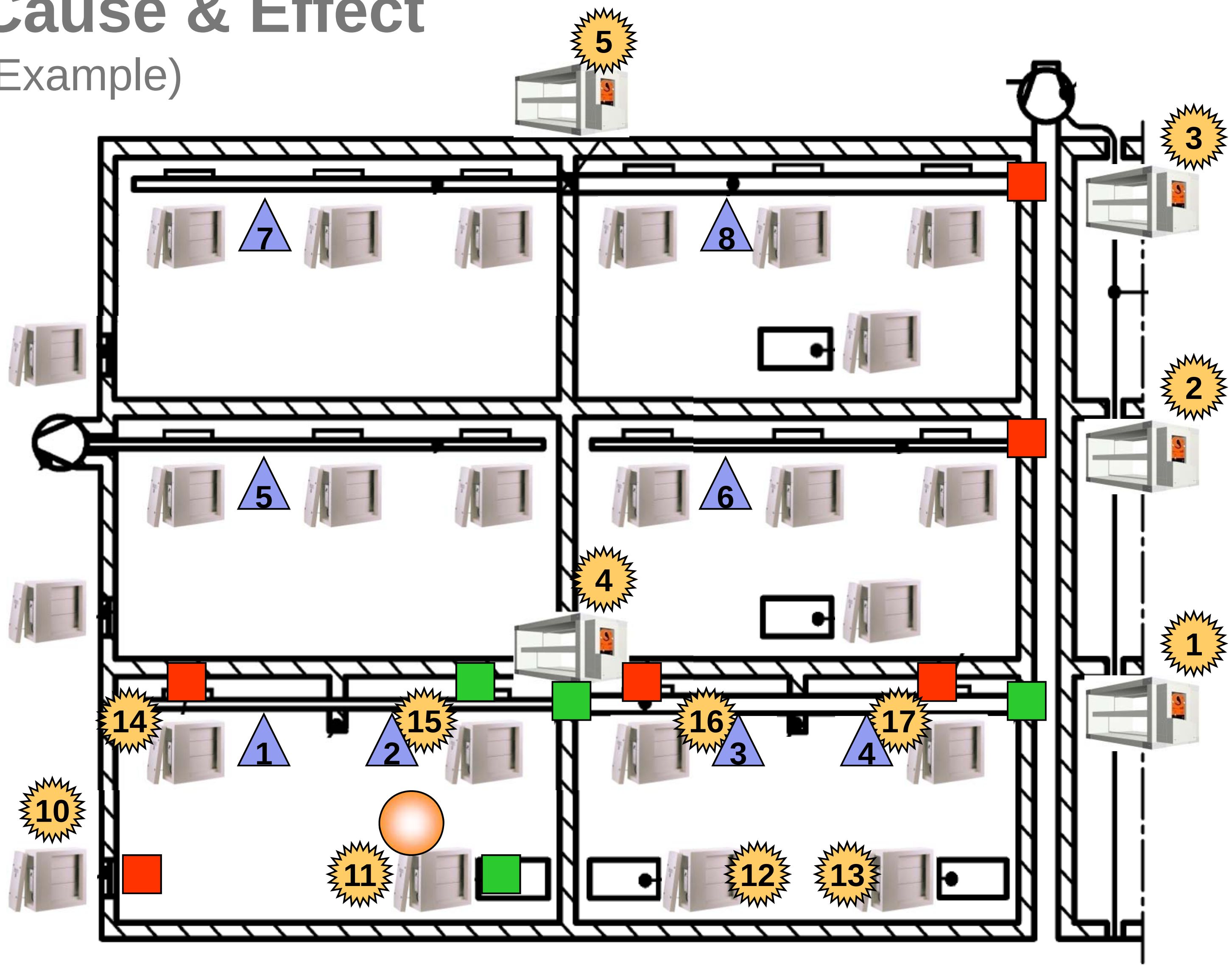


Scenario Matrix

1

Scenario

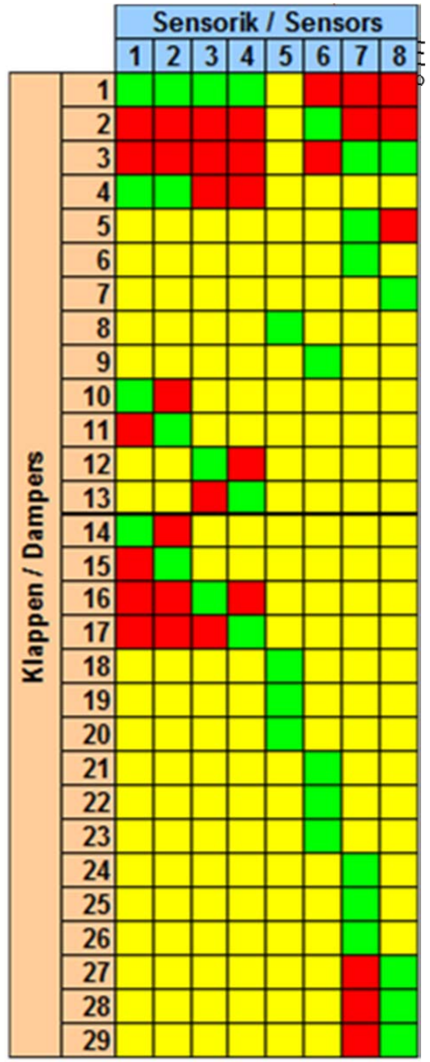
Cause & Effect
(Example)



Damper OPEN

Damper CLOSED

Fire



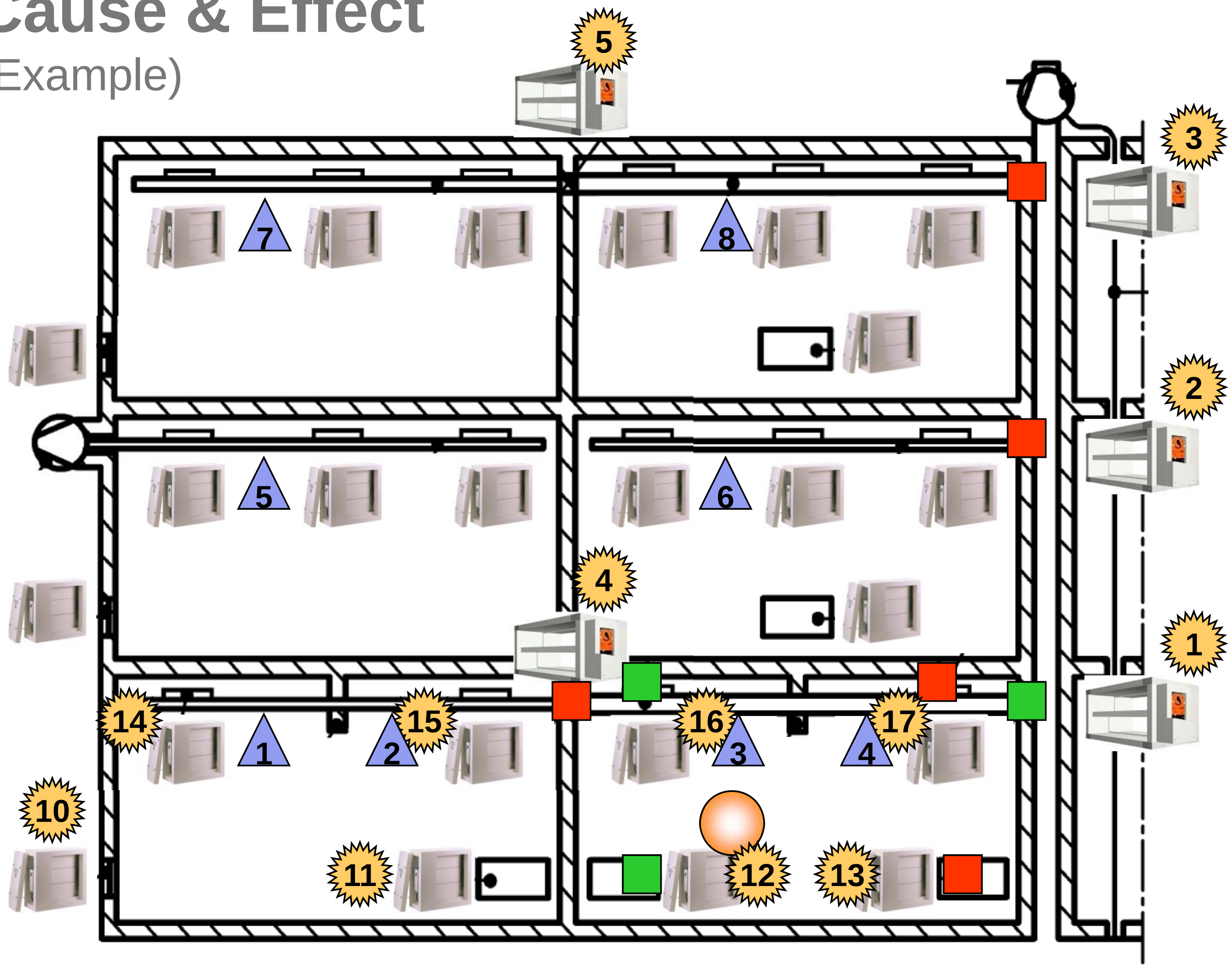
Scenario Matrix

2

Scenario

Cause & Effect

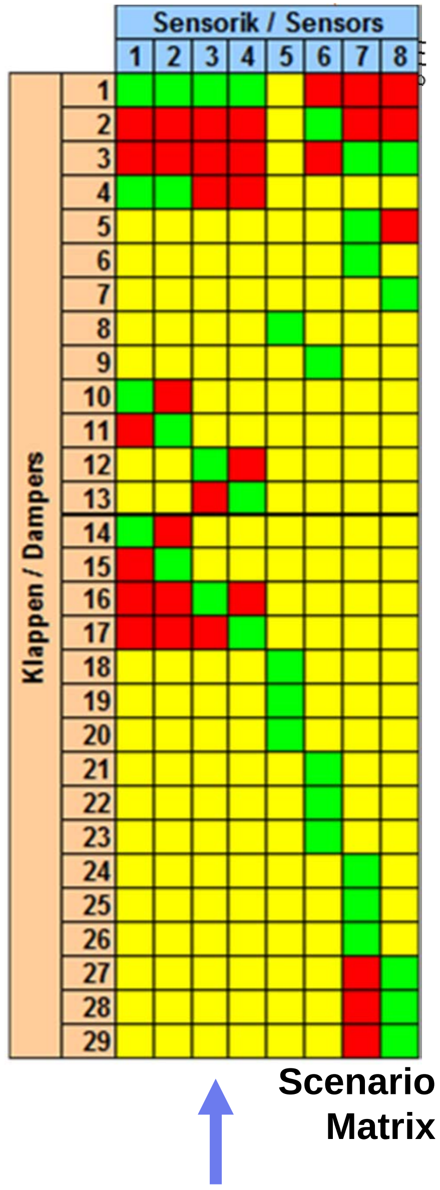
(Example)



Damper OPEN

Damper CLOSED

Fire



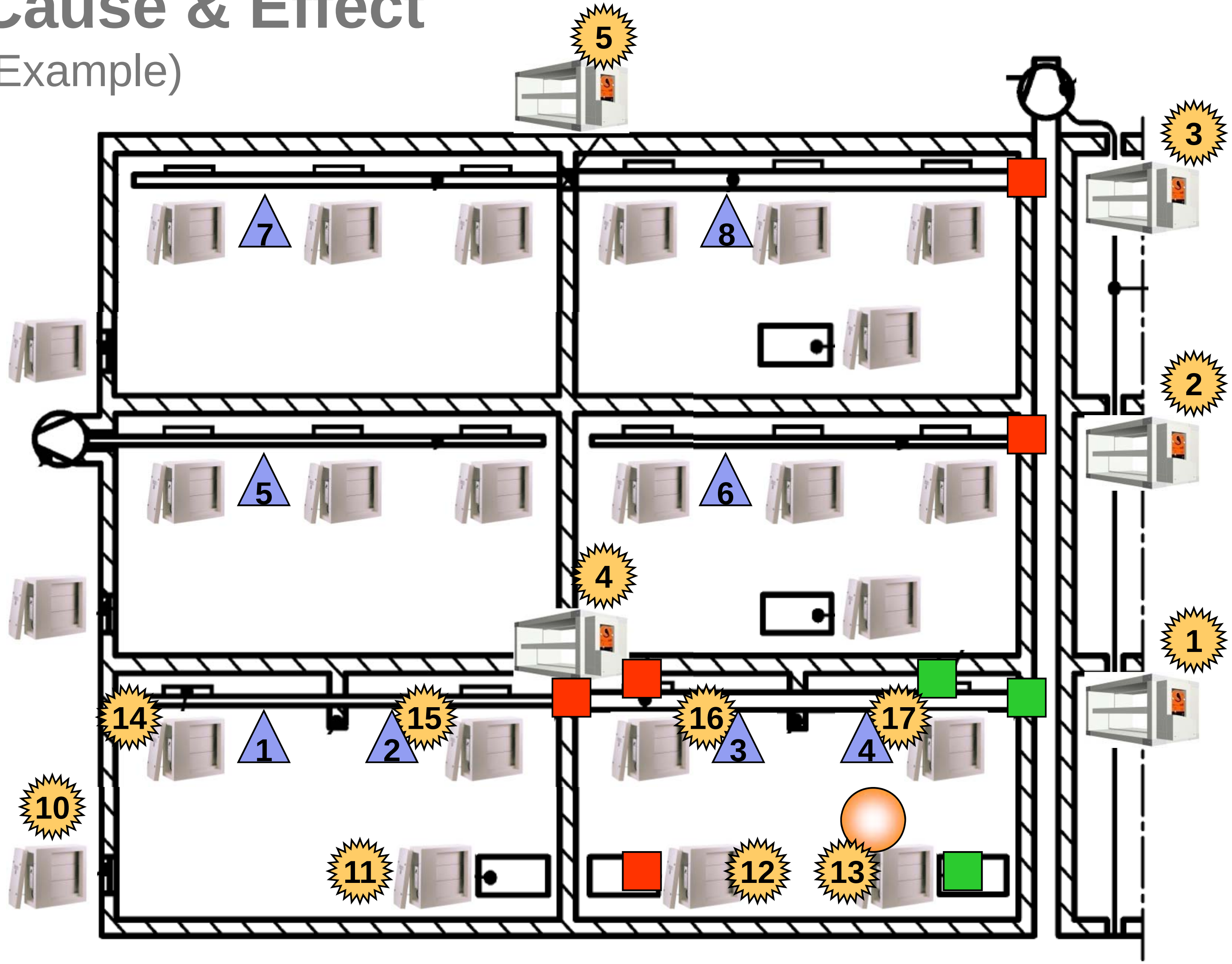
Scenario Matrix

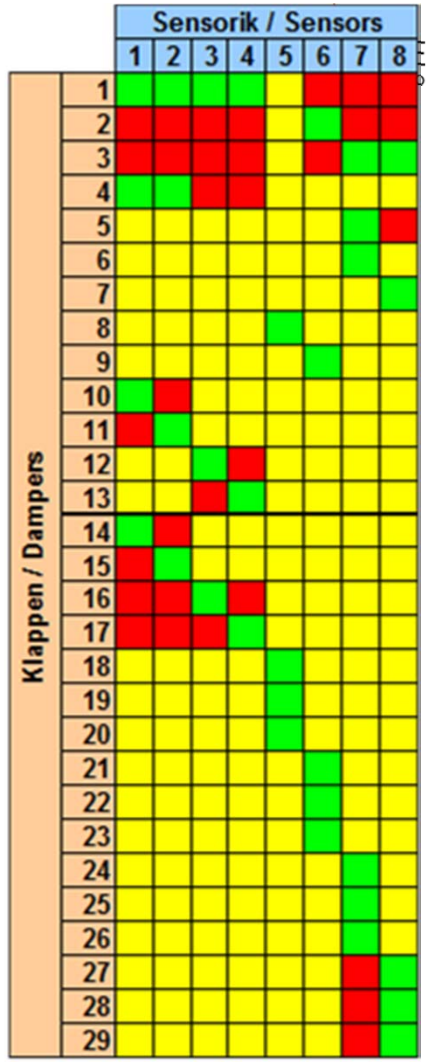
3

Scenario

Cause & Effect

(Example)





Scenario Matrix

Damper OPEN

Damper CLOSED

Fire

4

Scenario

Special Topic:

Sprinkler Systems

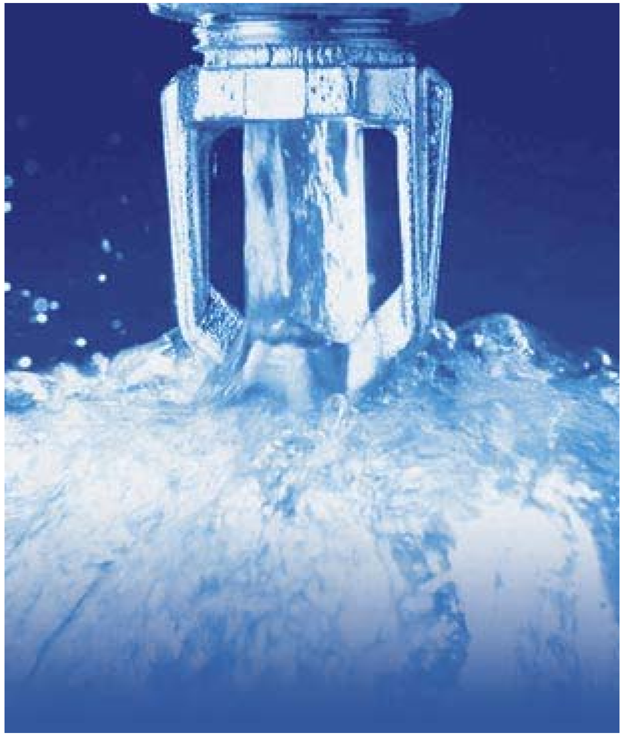
Effects of Sprinkler Systems from a Smoke Control Point of View

Positive:

- **Extinguishing the fire**

Not positive:

- **Production of low temperature smoke**
- **Production of moist and dense smoke**
- **Creates more smoke volume**



Side-Effects of Sprinkler Systems (1/2)

If mechanical (non-motorised) fire dampers are installed and/or no smoke control system is available the following side-effects can be expected:

- **Low temperature smoke passes through the ventilation system without triggering the fusible link. It also reduces the buoyancy of the smoke layer.**
- **Moist smoke produces sulphuric acid and smoke adhesion**
- **Dense smoke reduces visibility**
  - Impedes the evacuation of people
  - Reduces the effectiveness of fire fighting
- **Increased smoke volume generates overpressure**
  - Increasing the speed of smoke travel through the system
  - Entering neighbouring zones
  - Contributes to the stack effect

Side-Effects of Sprinkler Systems (2/2)

How to avoid the side-effects of sprinkler systems:

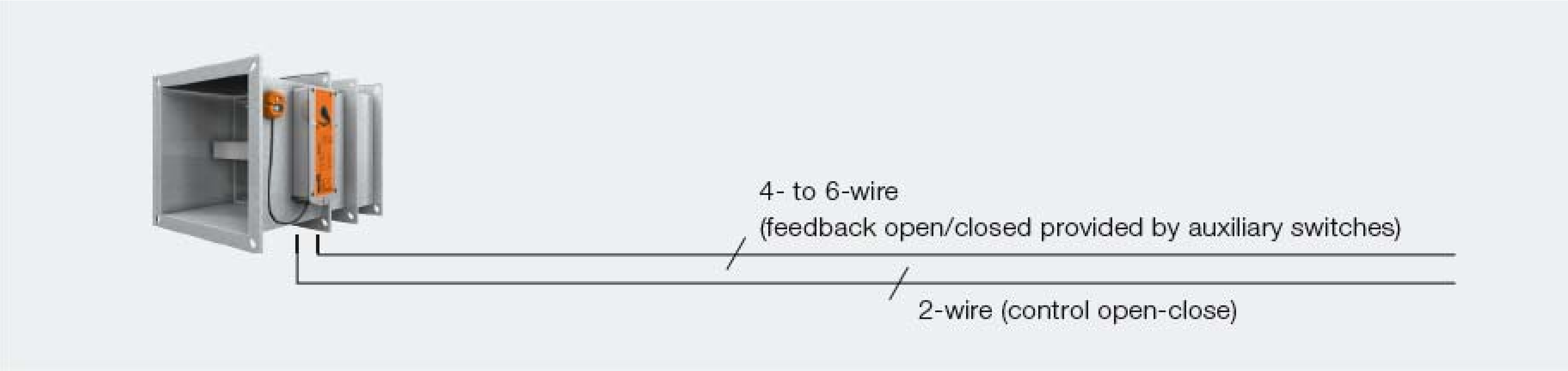
- **Motorise all fire dampers (controlled by smoke detectors)**
  - Stops the spread of fire and smoke – gains time
  - Regular checking of safety systems – only as good as the last time it was tested
  - MTBF is increased
  - Closing the dampers during the night (most fires start at night)
  - Energy saving
- **Provide a smoke control system**

Monitoring & Control Systems

for F&S Applications

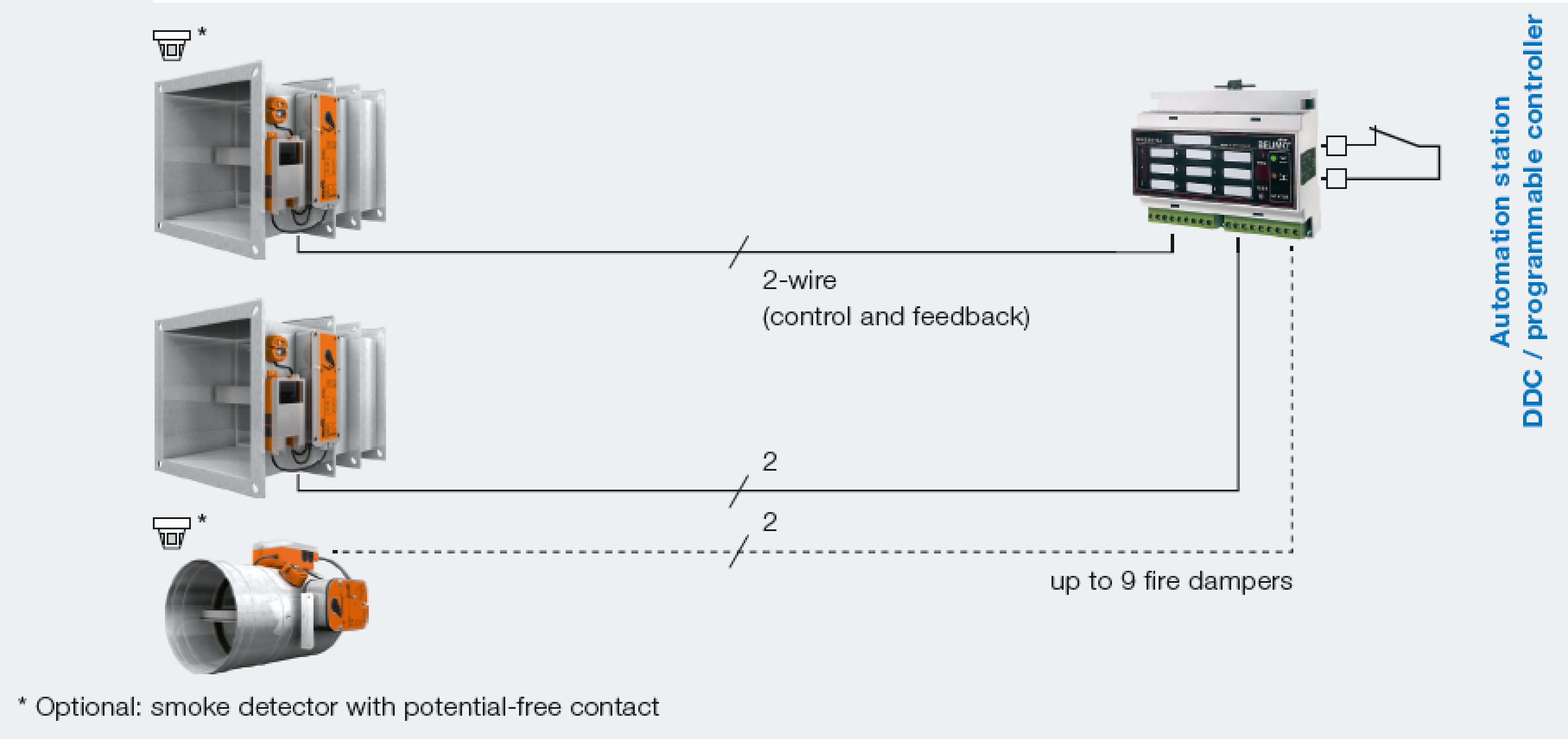
Monitoring & Control Systems

- **Integration solutions**
  - Conventional control with position feedback



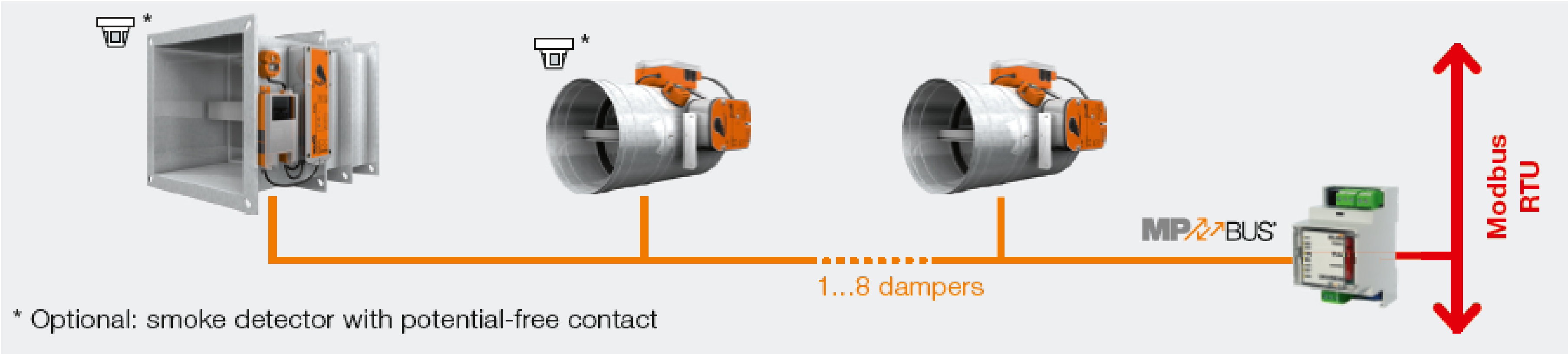
Monitoring & Control Systems

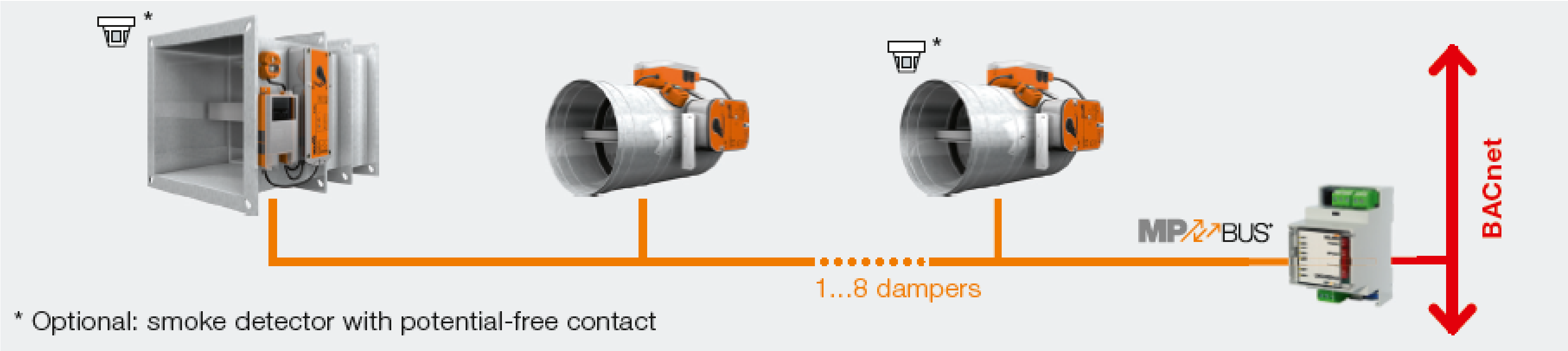
- **Integration solutions**
  - Zone solution with controller



Monitoring & Control Systems

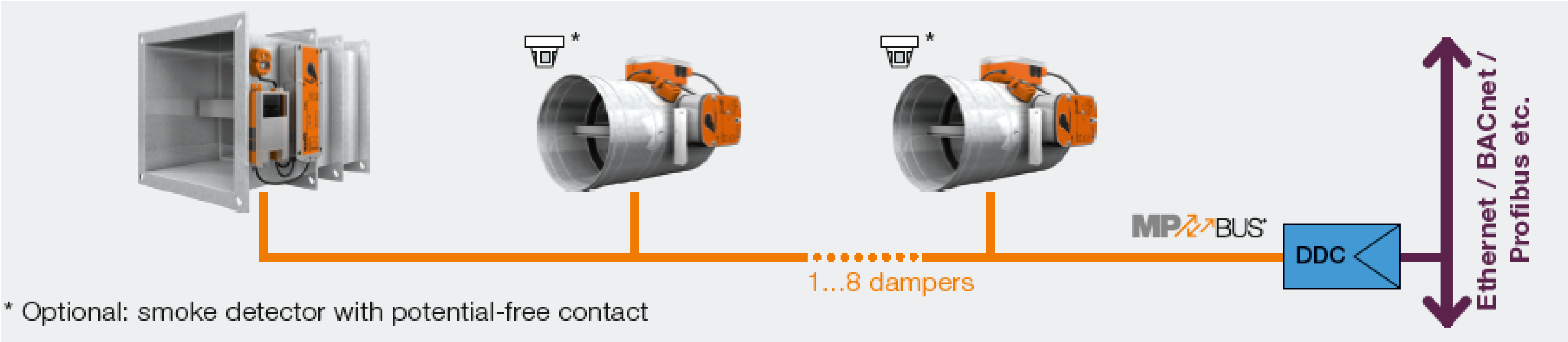
- **Integration solutions**
  - Bus networks such as Modbus RTU or BACnet MS/TP





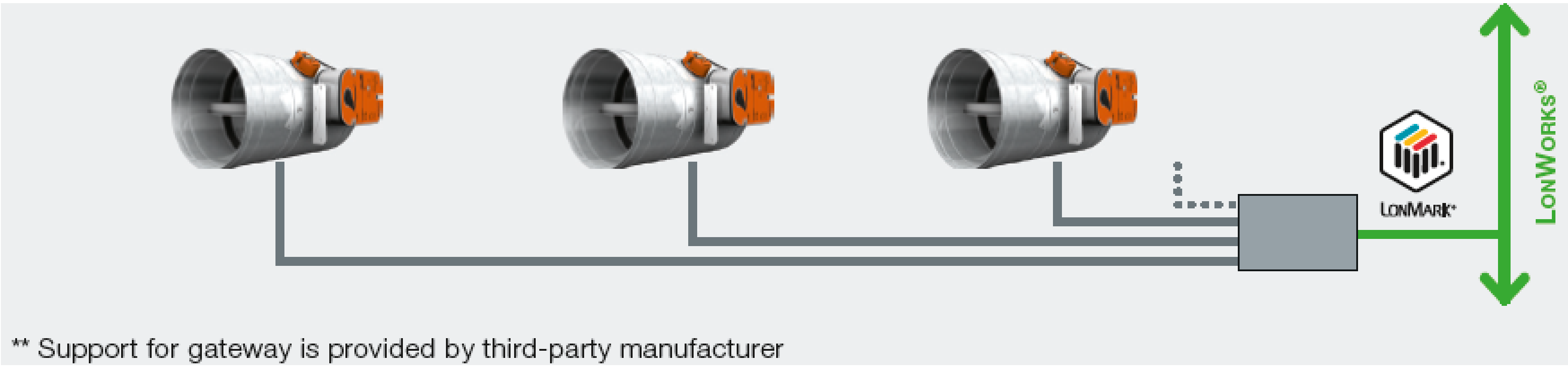
Monitoring & Control Systems

- **Integration solutions**
  - Various protocols via DDC controller



Monitoring & Control Systems

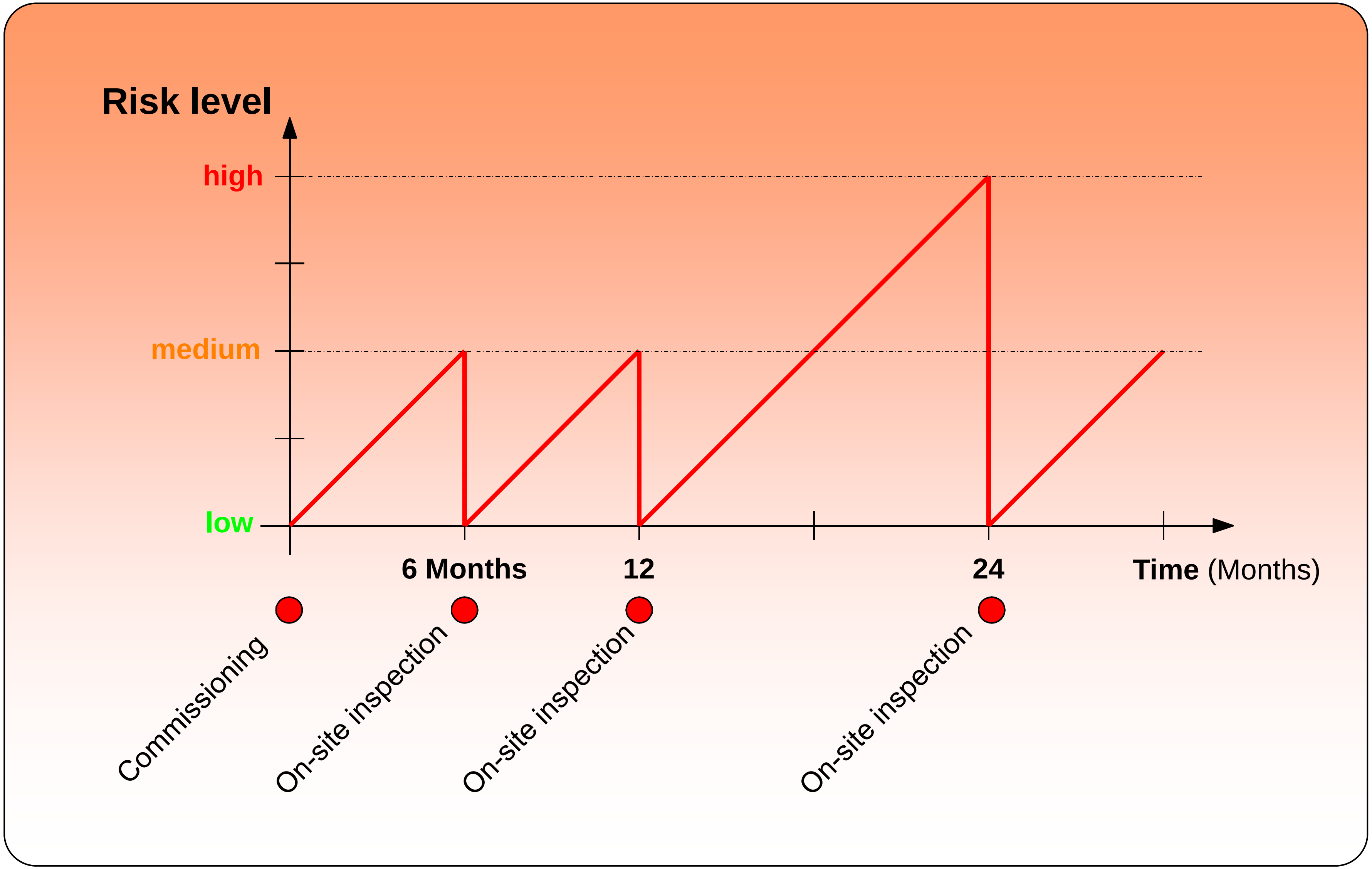
- **Integration solutions**
  - LONWorks® via gateways



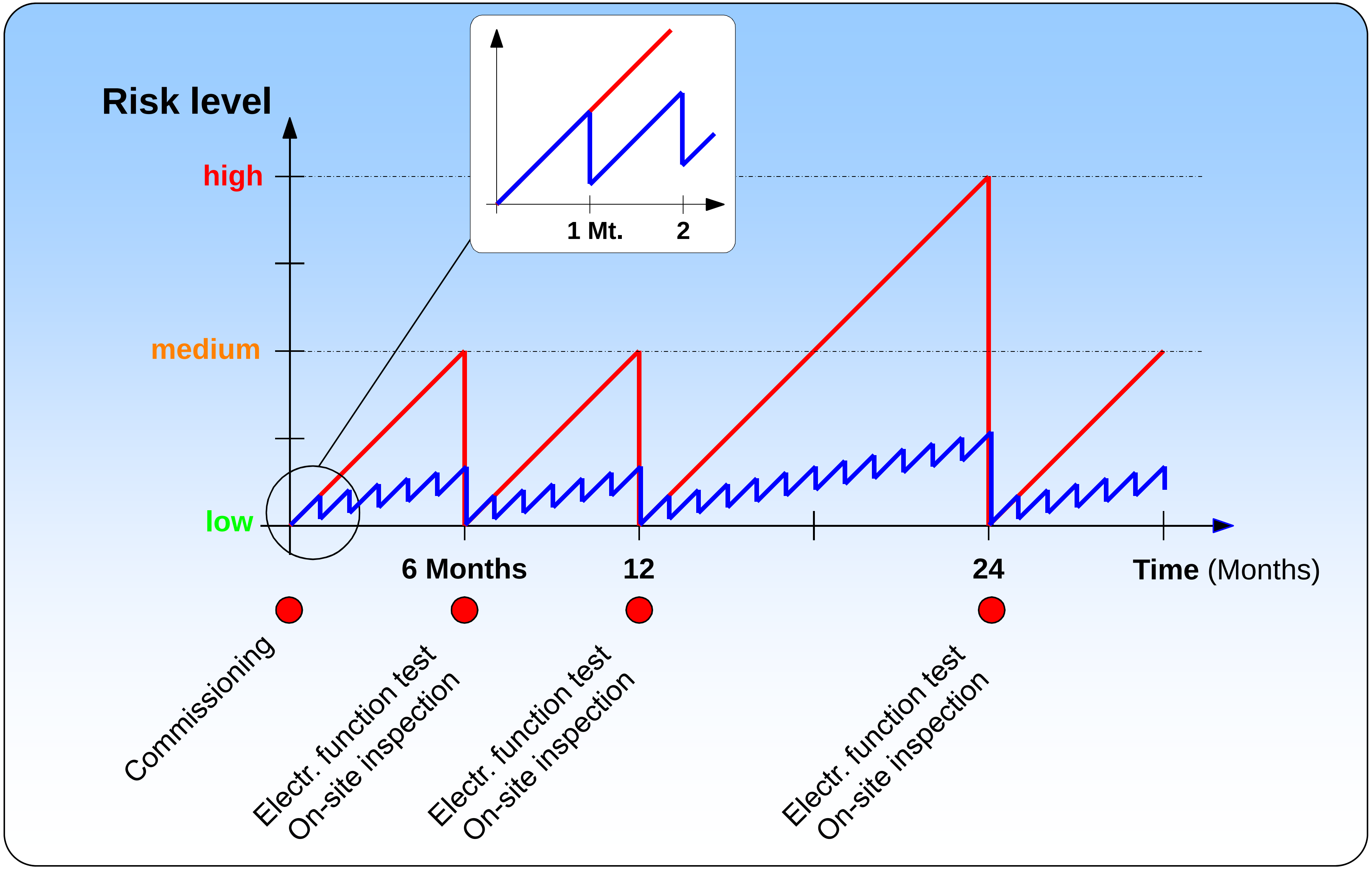
Monitoring & Control Systems

- **Main advantages of monitoring & control systems for F&S dampers**
  - Reduced costs during the operation of the building
  - Considerable reduction of wiring effort
  - Considerable reduction of fire load within the building
  - Full transparency througout the building
    - Event logging
    - Failure protocols
    - Regular testing → Reduced risk level within the building

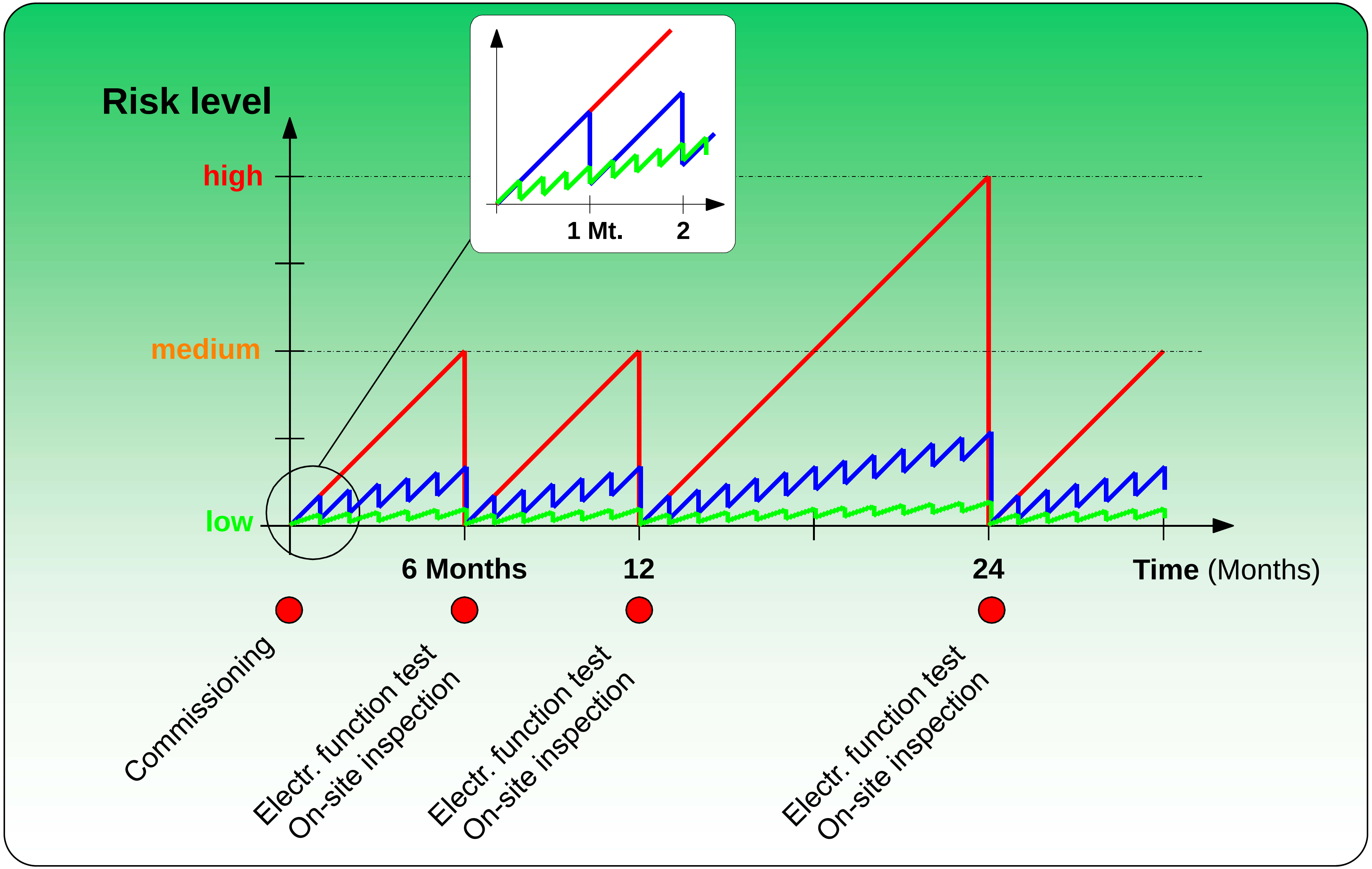
Regular Testing → Reduced Risk
Non-motorised Fire Damper



Regular Testing → Reduced Risk
Motorised Fire Damper (Conventional Actuator)



Regular Testing → Reduced Risk
Motorised Fire Damper (Communicative Actuator)



UL / EN Comparison

UL / EN Standards Comparison

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PROTECT LIFE
FAIL-SAFE SOLUTIONS BY BELIMO

Underwriters Laboratories

Communauté Européenne

UL / EN Standards Comparison
Main Standards

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PROTECT LIFE
FAIL-SAFE SOLUTIONS BY BELIMO

Fire Dampers

- UL 555 Test Standard

Smoke Dampers

- UL 555S Test Standard

Fire Dampers

- EN 15650 Product Standard
- EN 1366-2 Test Standard
- EN 13501-3 Classification Standard

Smoke Control Dampers

- EN 12101-8 Product Standard
- EN 1366-10 Test Standard
- EN 13501-4 Classification Standard

UL / EN Standards Comparison
Additional Standards

UL		EN	
UL 33	Heat Responsive Links for Fire-Protection Service	ISO 10294-4	Test of thermal release mechanism
UL 873	Temperature-Indication and -Regulating Equipment	EN 60730	Automatic electrical controls for household and similar use

UL / EN Standards Comparison
Main Differences – Typical Fire Dampers

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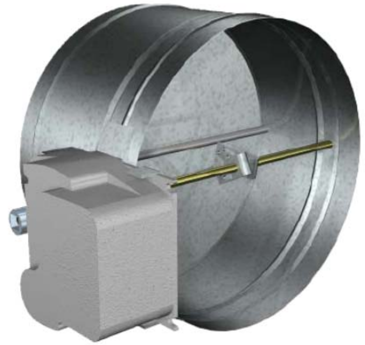
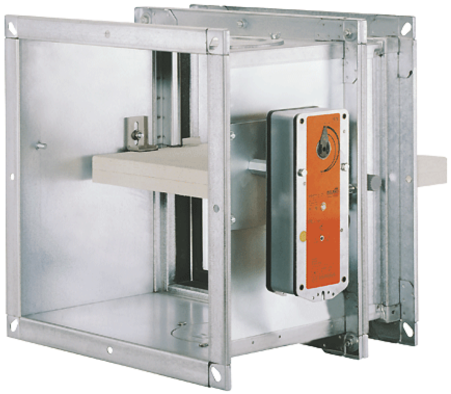
Typical Fire Damper
(Curtain Damper)

Typical Multi-Blade Fire Damper

Typical Combination
Fire Smoke Damper



Single-Blade
Round Fire Damper



Single-Blade
Square Fire Damper

Single-Blade
Round Fire Damper

Multi-Blade
Fire Damper

UL / EN Standards Comparison
Main Differences – Fire dampers (1/2)

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FAIL-SAFE SOLUTIONS BY BELIMO

	UL	EN
Operational reliability	Fire endurance Hose stream	50 cycles Fire test (Standard temp. curve)
Response delay	n.a.	2min. (3min.)
Fire resistance		
- integrity (E)	Fire endurance Hose stream	360m3/h*m2 @ 300Pa
- insulation (I)	not applicable	140°C / 180°C @ 300Pa
- smoke leakage (S)	147, 367, 1469m3/h*m2 @ 1'100Pa	200m3/h*m2 @ 300Pa
Durability	250, 20'000, 100'000 cycles	300, 10'200, 20'000 cycles
Type	Combination Fire Smoke Damper	Fire Damper

UL / EN Standards Comparison
Main Differences – Fire dampers (2/2)

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FAIL-SAFE SOLUTIONS BY BELIMO

	UL	EN
Actuator		
- Design, Construction	diecast aluminium	steel, form-fit, manual operation
- Connection to BAE	n.a.	protected cable (shortcut)
- Test-Switch BAE	n.a.	yes
- Status indicator	n.a.	yes
- Aux. Switches	n.a.	integrated, fix position, form-fit
Type	Combination Fire Smoke Damper	Fire Damper

UL / EN Standards Comparison
Main Differences – Smoke Control Dampers (1/2)

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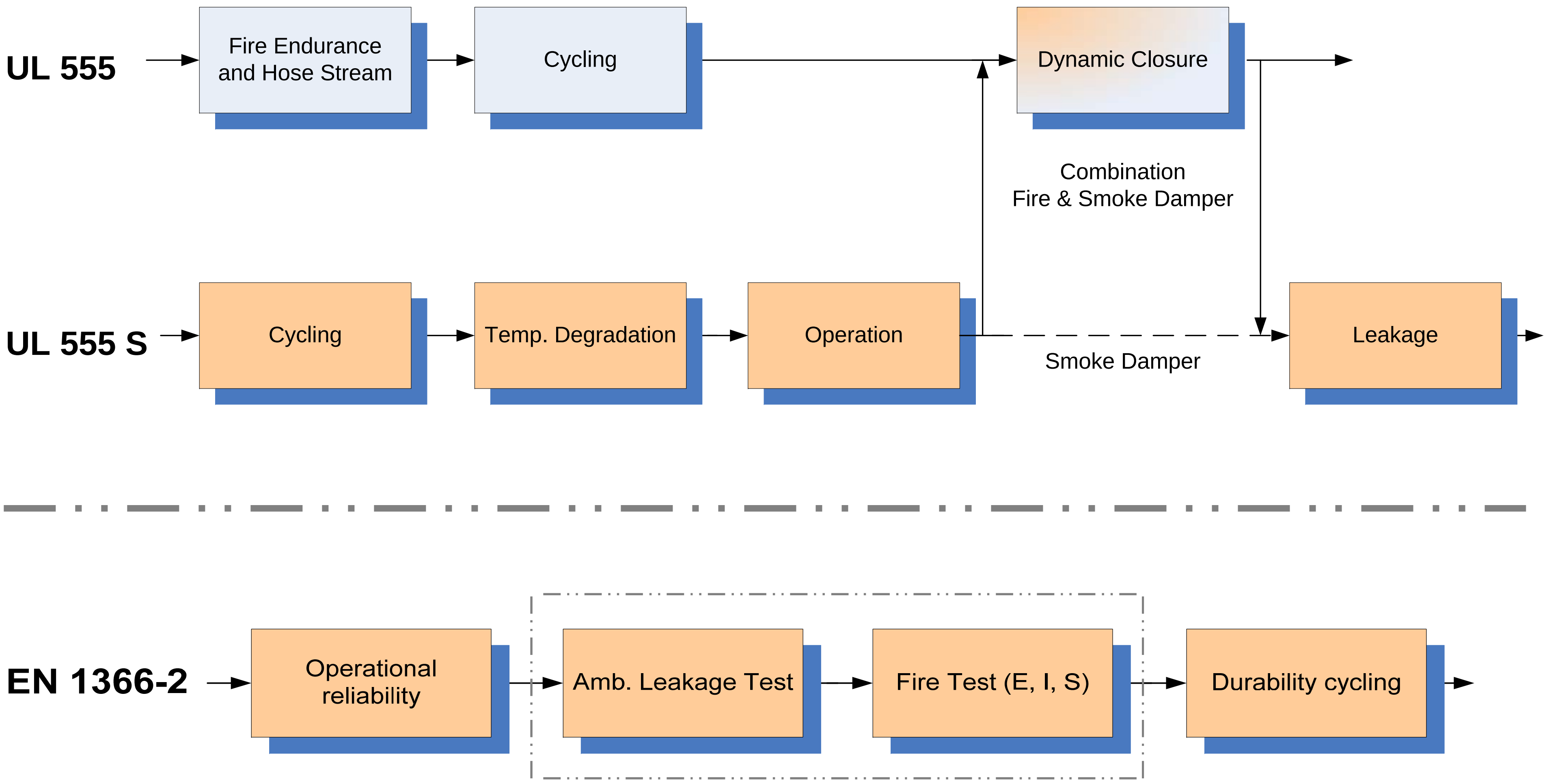
PROTECT LIFE
FAIL-SAFE SOLUTIONS BY BELIMO

	UL	EN
Operational reliability	20'000, 100'000 cycles	300, 10'200, 20'000 cycles
Response delay	75s	60s
Nominal activation	n.a.	man. / aut. activation (MI, AA)
Fire resistance		
- integrity (E)	Fire endurance Hose stream	360m3/h*m2 @ 300Pa
- insulation (I)	not applicable	140°C / 180°C @ 300Pa
- smoke leakage (S)	147, 367, 1469m3/h*m2 @ 1'100Pa	200m3/h*m2 @ 500, 1'000, 1'500Pa
- cross section	n.a.	Maintenance of cross section
- compartmentation	n.a.	Single / Multi
Mechanical stability	xy	Md vs. area
Type	Combination Fire Smoke Damper	Smoke Control Damper

UL / EN Standards Comparison
Main Differences – Smoke Control Dampers (2/2)

	UL	EN
Actuator		
- Design, Construction	diecast aluminium	steel, form-fit, manual operation
- Controls	ON / OFF	1-wire- / 2-wire- controls
- Torque running	pressure, air volume	min. 33Nm @ 45° (800x1'500mm2)
- Torque holding	n.a.	50Nm
- Aux. Switches	n.a.	integrated, fix position, form-fit
Safety Positions	1 (closed)	2 (open, closed)
Type	Combination Fire Smoke Damper	Smoke Control Damper

UL / EN Standards Comparison
Main Differences – Test Procedures




Thank you for your attention!