

The background of the cover features a dramatic scene of fire and smoke. In the bottom left corner, bright orange and yellow flames are visible. The rest of the image is dominated by thick, dark grey smoke that rises and billows. In the center of the smoke, there is a metallic, shield-shaped icon with a diagonal slash and a textured surface.

TRON life

magazine no. 23

TRON

Fire + Smoke.

Fire protection and smoke
extract systems.



project report 1
High-rise residential refurbishment in Dresden.
Communication is key.
 Page 4



project report 2
Ventilation and smoke extract concept.
Red Bull Base underground car park.
 Page 12



forum & economy
Fire damage costs billions.
 Page 18



highlights
Burning topics.
 Page 22



reportage
Drones provide early warning of forest fire risk.
 Page 30



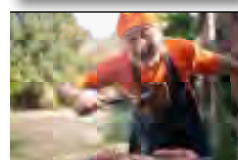
science & technology
Flash, fire and autoignition point.
Important aspects for fire and smoke protection.
 Page 34



interview
In conversation with Oliver Holstein.
 Page 38



trox news
TROX at ISH 2023.
 Page 44



humour
Barbecue season: fire and smoke.
 Page 60

Fire protection and smoke extraction. Investments in safety.

Fire protection and smoke extraction are two topics that have accompanied me throughout a large part of my professional life and continue to do so. So it's no wonder that, as well as being totally convinced of the effectiveness of mechanical smoke extract systems, I am also a firm advocate of these absolutely vital protective measures for buildings.

It was back in 1971 when TROX X-FANS developed the first fan that quickly and effectively removed dangerous smoke gases from buildings in the event of a fire. This marked the birth of the smoke exhaust fan – a solution that is constantly being developed and optimised to this day.

TROX X-FANS has also established a comprehensive smoke extract programme – work led in no small part as a result of the devastating fire that took place at Düsseldorf Airport. With this programme, the company has moved from being a component manufacturer to a system supplier. Whether smoke control dampers or subsystems such as mechanical smoke extract systems, pressurisation systems, underground car park smoke extract systems or metro and tunnel systems – all of these safety-related, intelligently networked components and systems are certified to European standards, continuously monitored and maintained.

Smoke extraction and fire protection are more than simply mechanical engineering, which is why we have established the 'Fire protection and smoke extraction' working group in the VDMA's Air Handling Technology section. The members are experts from a whole host of different sectors – from competitors and scientists to fire protection experts and registered inspectors. Together, we are developing solutions and responses to the key issues in this area – and all through consensus.

For me personally, it has always been important that the basic laws of physics are what lay the foundations in the committees and in the specifications and publications they produce. For example, this is how the VDMA's well-known basic paper on smoke extraction came about. During the coronavirus pandemic, however, we unfortunately established that even scientifically proven and generally recognised fundamental laws can be interpreted in different ways. As a negative example, I'd like to name the renowned Max Planck Institute for Chemistry. With a DIY ventilation system for schools, an employee has called the fundamental laws of engineering and how they work into question in a completely unfounded way. This harms everyone, not least the users of public buildings.

We can only hope that we will reflect and find our way back to the fundamental principles of our systems and solutions. We wish to take a step in the right direction with this issue of TROX life and, with this in mind, have brought together a wide range of fascinating facts, references and useful information on the topic of fire protection and smoke extraction. And, of course, we couldn't miss the opportunity to have a quick look back at ISH, the world's leading trade fair for HVAC and water, which was held in Frankfurt back in March.



I hope you enjoy reading this issue.

Yours Udo Jung
 TROX Board of Management

High-rise residential refurbishment in Dresden.

Communication is key.



When it comes to smoke extraction in high-rise buildings, communication is key to advancing safety. In a refurbishment project in Dresden's Prohlis district, the solution to the specific fire safety engineering challenges has proven not only to be safe, but also exceptionally cost-effective.

The topics of building refurbishment and fire protection are not always straightforward – but the right concepts and systems provide certainty!

Over the last 20 years, 400 people on average have died in Germany due to fires, and between approx. 4500 and 6000 people have been seriously injured. Smoke poses the greatest danger. There are two reasons for this: firstly, smoke is highly toxic – almost all those who die in a fire (95%) do not succumb to the flames, but rather to the poisonous smoke gases that develop during the smoulder phase. They die from the consequences of smoke inhalation caused by the odourless gases carbon monoxide and carbon dioxide – just a few breaths of carbon monoxide are fatal. What's more, smoke obstructs a person's view, meaning that they are unable to orient themselves and exit the building quickly via the escape and rescue routes.

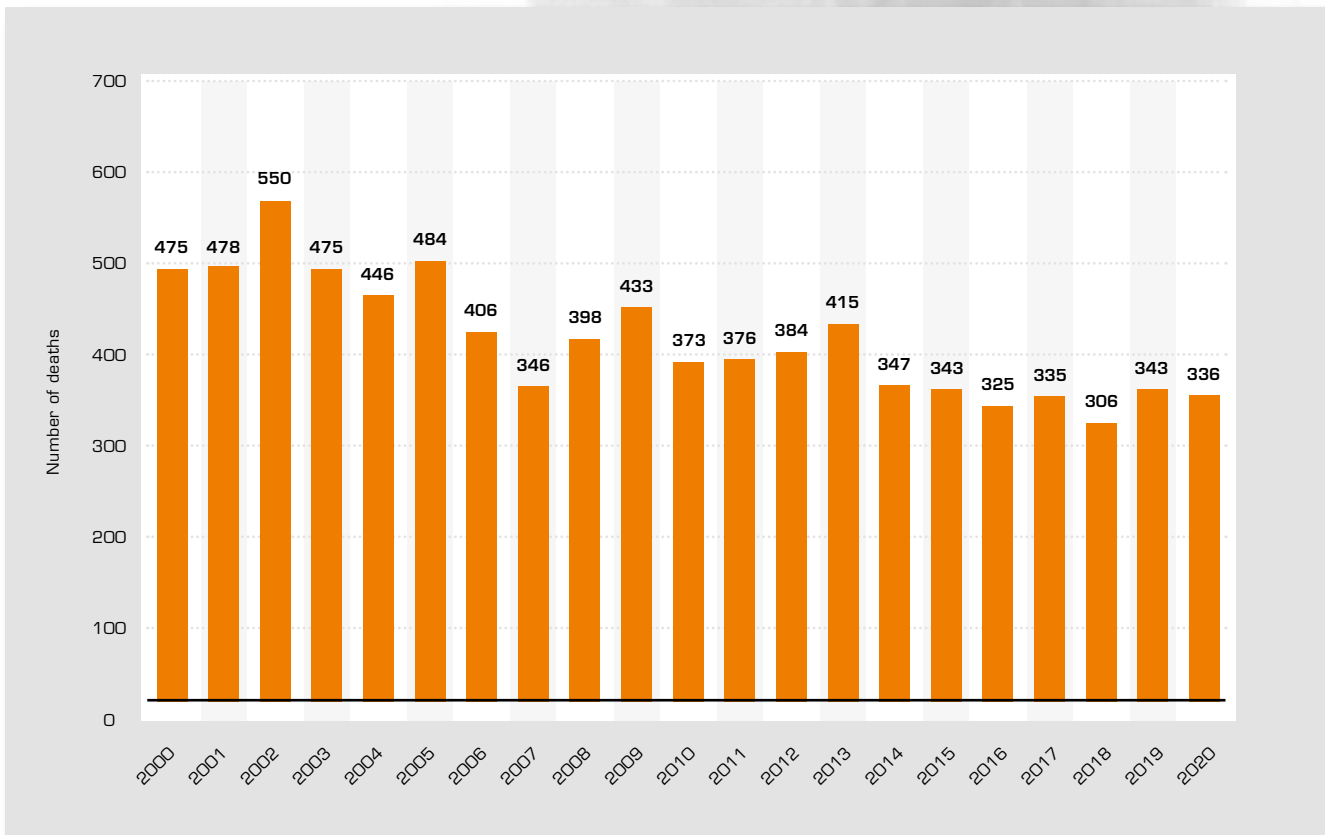
The annual cost of damage caused by fires amounts to several billion euros. Insurance companies will only pay out for the damage, provided all building regulations and technical codes of practice have been met. This applies to new and existing buildings alike.

Against this backdrop, expert fire protection consultations are increasingly gaining in importance – particularly when it comes to refurbishing existing buildings, especially older high-rise residential buildings that no longer meet the valid building regulations and current technical codes of practice. A fire safety upgrade is ideal for carrying out alongside the energy-efficiency measures that are currently popular when buildings are renovated.



High-rise residential buildings in Dresden-Prohlis.

Number of deaths due to smoke, fire and flames in Germany from 2000 to 2020



Source: Statista 2022

This is exactly what happened when it came to Dresden's urban development. Here, the aim was to further improve living conditions in the city's Prohlis district, making it more attractive and livable.

These requirements were collated in a tailored fire protection concept including the applicable building regulations.

Particular fire safety engineering challenges in Dresden-Prohlis.

The Prohlis district of Dresden is characterised by high-rise residential buildings that posed a particular fire safety engineering challenge when it came to refurbishing them.

The following safety standards – not least requirements to provide modern, functional and appealing spaces to rent and use – had to be met on the 16-storey buildings:

- Inspection of structural fire engineering – fire compartments
- Safety level that meets modern safety standards, e.g. fire alarm system covering the entire building
- Escape and rescue routes – requirement for a second rescue route
- Escape and rescue routes supported by smoke extract systems





AS-i

AS-Interface bus system



A further advantage of the AS-i system is its free topology. With conventional point-to-point wiring, the components are wired up to the switch cabinet, whereas with the AS-i system, ring, star and free topologies are possible, meaning that the bus system can be adapted to the conditions in the building.

A free topology was chosen for the high-rise residential building in Dresden-Prohlis. It was split into three sections with bus cables using AS-i technology. Across 16 floors, the bus cables were installed separately for manual call points (one manual call point on each floor), multileaf dampers and smoke control dampers for all floors.

Visitors to the ISH trade fair were able to find out how a smoke protection system works based on a building model.



Space and cost savings guaranteed!

The first step was to apply the compartmentalisation principle to divide the building into fire compartments. Next, the escape and rescue routes had to be planned with the smoke extract system. Here, it quickly became apparent that it would not be easy to install a conventional smoke extract system due to space constraints. So the decision was made to go with a bus system using AS-i technology. Communication and the power supply are routed via a cable – a solution that reduces fire loads and saves huge amounts of space.

*After the refurbishment:
A 1000 x 1000 mm switch cabinet was large enough
for the 16-storey residential project in Dresden-Prohlis.*





Three bus cables are plenty: one power supply for the switch cabinet, one power supply for the smoke exhaust fan and one communication cable for the TRGX X-FANS BVD 315 smoke exhaust fan on the roof of the high-rise residential buildings in Dresden-Prohlis.



In Dresden-Prohlis, existing 16-storey high-rise residential buildings have been extensively refurbished. The work involved complying with various requirements under applicable building regulations and an individual fire protection concept.



A BVD 315 roof-mounted smoke exhaust fan was used to convey the smoke gases out of the building's floors in the event of a fire. And one of the things that makes it so special is that only one smoke exhaust fan is required for several fire compartments. When carrying out a refurbishment project, this significantly reduces costs, while also saving valuable space. Less planning work is required, installation and commissioning work takes less time and maintenance costs are reduced.

Conclusion:

It can often be difficult to refurbish high-rise residential buildings such as those in Dresden-Prohlis. Fire protection in existing buildings has often been neglected over many years, meaning that the buildings no longer meet the applicable building regulations. To tackle this, creative solutions and concepts have to be devised. A bus system is the perfect choice for fire protection refurbishment projects of this kind. It is simple to install and put into operation and is able to take appropriate action remotely during commissioning or should any faults arise.

The concept has worked so well that the fifth high-rise residential building has now been equipped with the same fire protection concept involving an AS-i system. A complete success thanks to bus technology from TROX.





Underground car parks.

Effective protection using smart smoke extraction.

Large fires in underground car parks are much more common than one might expect. According to statistics from the German Insurance Association (GDV), around 15,000 vehicle fires occur in Germany alone every year. If smouldering damage is added to this, there are as many as 40,000 cases per year, meaning around 100 per day. Some of these fires take place in car parks. In modern cities, there is an increasing trend to locate parking spaces beneath residential buildings or shopping centres. This is another reason why the risk of fire in underground car parks is on the rise.

Underground car park fires have a high potential for escalation and pose a great challenge for the fire brigade. Complex building layouts that are often not visible from the outside, quickly spreading fires and the danger of rapid flashover due to high fire loads all complicate the efforts of the emergency services. Since underground garages are also often below residential buildings, any fire poses a direct threat to life.

Key safety objectives when operating an underground car park:

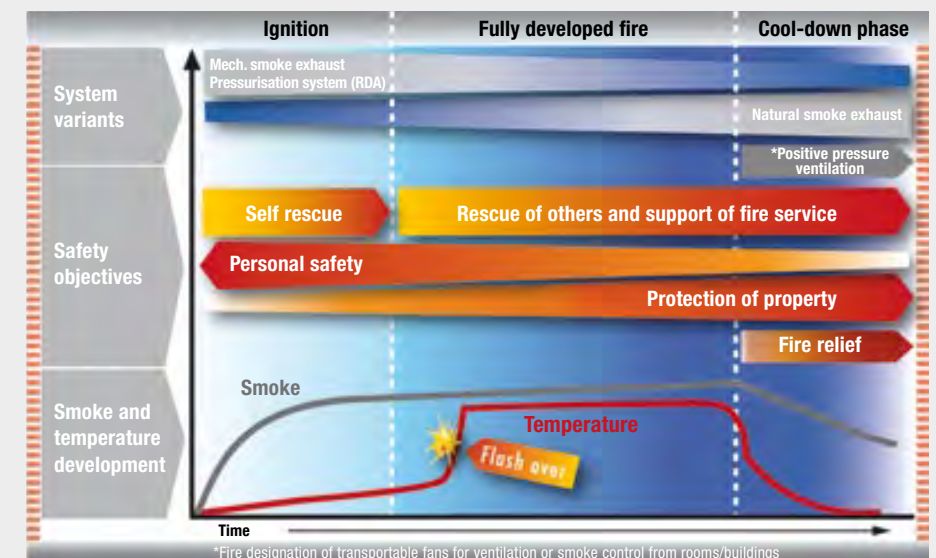
- **Personal safety**
Any person in the underground car park must be able to evacuate themselves quickly and unaided from the danger zone. People in residential buildings or shopping centres above the car park must not be exposed to the harmful effects of the fire (fumes).
- **Protection of property**
The fire and any after-effects should be confined to the fire compartment (i.e. the underground car park). This means stopping the spread of smoke and preventing fire flashover between garage and building.

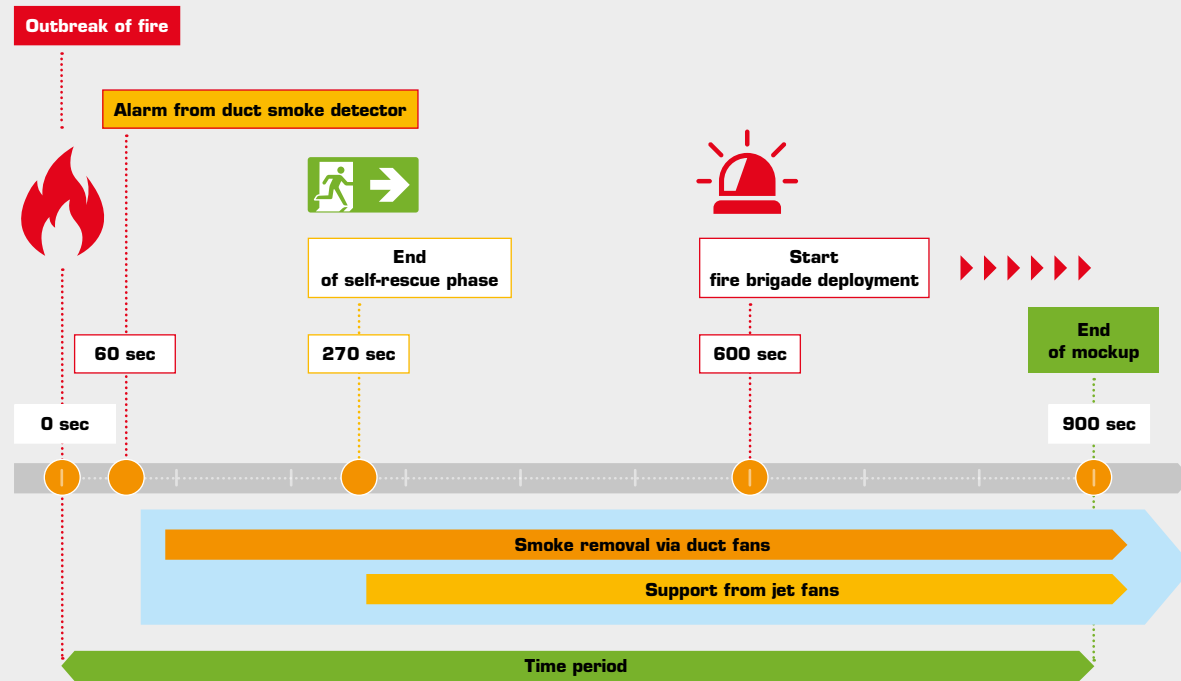
- **Fire-fighting support**
The fire brigade must have good visibility in the underground garage and ideally unobstructed access to seat of the fire.

- **Fire relief**
Once the fire brigade has tackled the blaze, special transportable fans called positive pressure fans are often placed in front of the fire opening, for example in front of a stairwell or entrance to the underground car park, to expel the smoke. These fans have no temperature requirements and must not be confused with smoke exhaust fans and associated smoke exhaust systems.

If such fans are used, the smoke gases must be expelled from the building on an outward-facing side. If the fire crew inadvertently pushes the smoke back into the building complex, the fire gases could cause considerable damage. Just imagine this in a shopping centre with luxury boutiques! And anyone in residential or commercial premises above the source of the fire could potentially be in danger.

Safety objectives relating to smoke and temperature evolution.





The following example from Stuttgart illustrates the damage that can be caused by a fire in an underground car park:

Two motorbikes in the underground car park had caught fire. Despite a natural smoke extraction system (NRA) being triggered in the car park on detection of smoke and the alarm being sounded, by the time a total of 160 firefighters had arrived, the blaze had turned untamed into a huge fire.

Because the doors were open, dangerous clouds of smoke entered the stairwell. The fire doors were wedged open. This happens quite a lot when residents are unloading their cars and taking shopping upstairs, for example. Residents are also often tempted to leave stairwell doors open in summer to allow cooler temperatures to circulate. This caused the fire and its toxic fumes to spread rapidly. As a result, nine people were hospitalised with severe smoke poisoning and 92 people had to be put up in emergency accommodation. Millions of euros worth of damage was caused because the apartment building above the underground car park had to be demolished for structural reasons.

Natural smoke extraction (NRA).

Natural smoke extraction systems for underground car parks are usually open light wells or masonry shafts with natural supply openings. Natural smoke extraction works on the basis of a temperature difference between the fire compartment (underground car park) and the outside environment. In addition, natural cross-flow only works when the weather conditions are right. A fire in NeckarPark car park 7, also in Stuttgart, is proof of this. There was no wind in this car park, which was open on three sides, meaning that smoke and heat could not be dissipated fast enough. Property damage, including to at least 21 vehicles, amounted to millions of euros, but luckily no one was injured.



Smoke tests using fog generators and, in some cases, gas heaters to increase the temperature.

Smoke test equipment:

- 2 Fog generators
Type: Look Solutions Viper 2.6
– Max fog output per generator: 80,000 m³/h
– Continuous fog output (60%) both generators: 96,000 m³/h
- Eurolite P2D professional /extreme fog fluid
- 1 Gas heater, 30 kW, controllable

Mechanical smoke extraction (MRA).

Mechanical smoke extract systems in underground garages usually have two functions: in the event of a fire, they must safely remove any toxic fumes. For day-to-day running of the car park, they must remove vehicle exhaust gases and provide an ample supply of fresh air.

A key component of an extract air system is a twostage axial fan, with the first fan usually providing ventilation. The second axial fan switches on in the event of a fire. Using sophisticated ductwork, the fans then extract the smoke from the various fire compartments within the car park.

To that end, the fans used are smoke exhaust fans with a temperature resistance of 300 °C / 120 min, tested to EN 12101-3.

A proven alternative to these underground car park smoke extract systems are jet fan systems. The combined effects of air jets and induction result in a particularly uniform distribution and thorough mixing of air in ventilation mode so that in the event of a fire, even dead corners are purged.

While smoke extract ducts can be combined with a jet fan system, these ducts are not mandatory in car parks. Strategically positioned central shafts fitted with smoke exhaust fans remove just the right amount of exhaust air.

The jet fans also provide sufficient fresh air so that carbon monoxide levels are kept as low as possible. For optimum system operation and performance, it is crucial that air can be adequately circulated, e.g. via entrances and exits or via installed supply air fans.

Effective smoke extract management mitigates risks.

When it comes to personal safety, German building regulations merely stipulate the use of timely alarms, short escape routes and partitioning panels. However, many experts believe that, depending on the type of building, these measures not go far enough. Nowadays, the highest level of safety can be achieved through the strategic use of state-of-the-art smoke extract management systems.

The German Association of Engineering (VDMA) has pooled together recognised experts in the field of smoke removal to produce a 'Basic paper on smoke extraction' as a sound technical basis for design and decision-making. Its purpose is to help users select the most appropriate smoke extraction solution and system design. The paper also aims to resolve any conflict of interest between financial constraints and optimum safety.

This is a hot topic for fire safety planners and experts, the fire brigade and anyone involved in fire safety and smoke extraction in the construction trade. In the future, they will have to contend with far more responsibility. Whereas in the past, it was enough to comply with just the minimum requirements of regional building law, these days smoke extraction management should be reassessed for every new build.

Building regulations.

From a legislation point of view, most underground car parks meet all building regulations. Had, in line with regulations, the fire doors been closed in our example in Stuttgart, it is unlikely that anyone would have been injured. However, the extensive property damage associated with the new building would still have occurred.

Building regulations focus on self-rescue through clearly marked, unobstructed escape routes. Provided these regulations are met, and subject to any special provisions, permission to build is usually granted. The problem is that unforeseen 'human' intervention such as a wedge under a door or a blocked escape route happens time and again. Sometimes, as well, the prescribed second escape route might be blocked by the fire. Which, as anyone involved in construction knows, is by no means uncommon.

If appropriate safety measures are in place in the building, the fire brigade no longer needs to worry about rescuing people in the fire compartment. A fully functioning smoke management system allows people to safely extricate themselves from the building.

Fire-fighting can be deemed to be a success if the crew has prevented the fire from spreading to neighbouring parts of the building. Investors and operators also need to shift their way of thinking. It ought to be obvious to everyone that building regulations only guarantee a minimum level of safety and that without smoke extraction management there is the very real risk of damage amounting to millions.



Burnt out vehicles in the Vienna General Hospital underground car park.



Smoke exhaust fans on the open area above Vienna General Hospital underground car park.



Smoke exhaust fan, Vienna General Hospital.

Professional fire protection and smoke extract management.

A fire in the underground car park at Vienna's General Hospital is living proof that mechanical smoke extract systems can limit damage and effectively support fire-fighting efforts. According to the fire chief, Gernot Haidvogel, the smoke extracted by the fan meant that the fire brigade had enough visibility to be able to quickly bring the blaze under control. The following account of the fire-fighting mission demonstrates this:

The central fire alarm system sent the alarm (vehicle fire in the car park's 2nd basement) directly to the fire brigade. On arrival, the emergency services discovered two cars on fire and a layer of smoke approximately 1.5 m above the floor. The mechanical smoke extraction meant that both cars were clearly visible.

A wall-mounted hydrant close to the source of the fire allowed the blaze to be quickly brought under control. The fire brigade opened a door. This improved the circulation of air and consequently smoke dispersal by the fan.

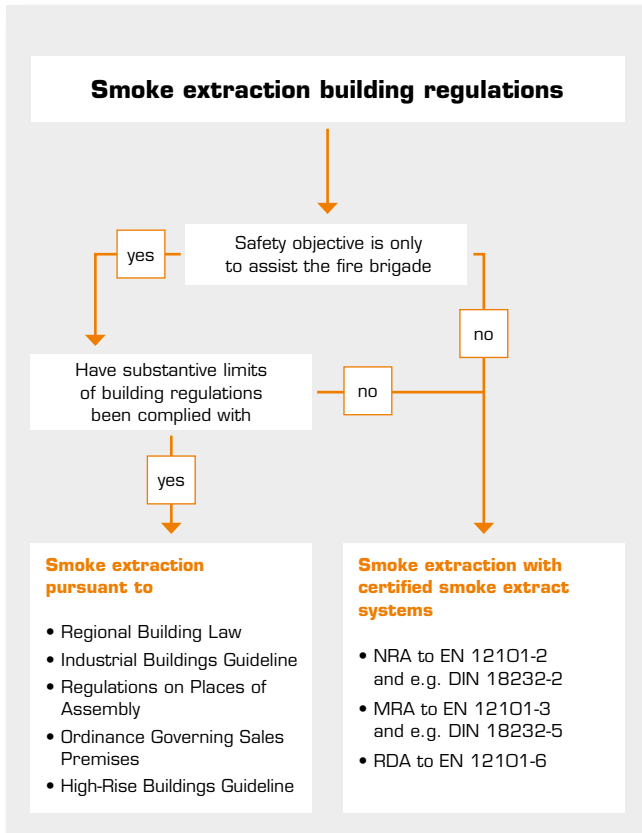
Once the fire had been extinguished, the smoke exhaust fan extracted smoke and fumes in a controlled manner.

The fire brigade's conclusion:

Vienna's fire chief, Gernot Haidvogel, is absolutely convinced of the need for mechanical smoke extraction in underground car parks. The rapid containment of the fire in the Vienna car park demonstrates that the fire crew was helped by the good visibility. The duct smoke exhaust fans which were started automatically also ensured that smoke and especially heat were dissipated early on, therefore avoiding any flashover.

Conclusion:

Investment in smart and reliable fire protection and smoke extraction measures pays off in complex buildings such as underground car parks: they facilitate the self-rescue of users and residents in the floors above and reduce hazards for fire-fighters. The Vienna fire brigade's positive experience with smoke extract systems is a clear argument in favour of fire protection and smoke extract management.



Fire damage costs billions.

Global warming is causing increasing numbers of forest fire disasters to be reported. And the consequences are devastating: the loss of trees – important absorbers of CO₂ – is further exacerbating global warming, while the fires cause damage running into the billions. The serious forest fires that swept through California – known as the Mill Fire – forced thousands of people to leave their homes.



Satellite images from NASA reveal an alarming picture of the Earth. Serious forest fires are happening in more and more regions, and in some, fire brigades are no longer able to keep them under control. More than 300,000 people worldwide die from the consequences of forest fires every year.

Building fires: generally caused by human error or defective electrical lines.

The statistics regarding victims of building fires also present a sobering picture. In Germany alone, almost 400 people every year are still dying from fires in buildings. Electricity is the most dominant cause. It is the principle factor behind one in every three fires, with electric appliances (55%) and defective electrical installations (28%) being the key causes. Fires caused by electricity are also set to increase as a result of the rise in e-mobility.

death rate is attributed to fires in private residential buildings, accounting for around 80% of fatalities.

Every year, the International Association of Fire and Rescue Services (CTIF) collects data in 48 countries on the fire situation on Earth – in sum, for around one sixth of the world’s countries and one third of the global population. In general, more than 3.5 million fires are reported, with two people per 100,000 inhabitants dying as the result of a fire. Most casualties of fires are actually due to accidents in their own homes at night. When people are asleep, their sense of smell does not work quite as well, causing them to be suffocated by the smoke.

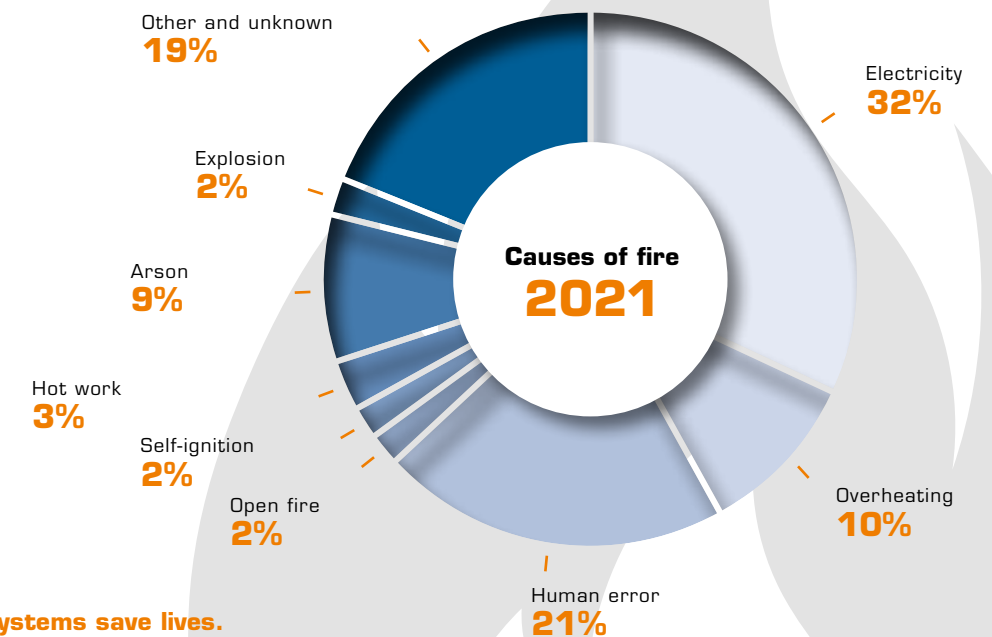
In the USA, there were just under 1.4 million fires in 2020, and they resulted in 3500 deaths. These fires caused property damage amounting to approximately 14 billion dollars. In the USA too, the highest

Trend of the number of fire deaths in Germany

| | 2019 | 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2005 | 2000 | 1990 |
|--------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Deaths | 387 | 355 | 370 | 348 | 367 | 372 | 439 | 384 | 376 | 373 | 484 | 475 | 787 |

Source: Deutscher Feuerwehrverband (German fire brigade association)

Causes of fire 2021



Smoke and heat extract systems save lives.

CTIF statistics show that the number of victims is lower in countries with stricter fire and smoke protection laws and regulations. Fire and smoke protection measures do obviously have a positive effect. Investment saves lives.

Causes of fire in 2021 according to the causes of fire statistics provided by the IFS institute Source: www.ifs-ev.org

Number of forest fires in selected countries worldwide between 2012 and 2018*

| Country | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|-----------|---------|---------|---------|---------|---------|---------|---------|
| Brazil | 400,260 | 219,869 | 310,254 | 418,549 | 331,805 | 385,910 | 218,970 |
| Australia | 473,105 | 190,535 | 256,472 | 239,328 | 159,395 | 265,749 | 280,018 |
| USA | 136,722 | 102,113 | 98,590 | 146,577 | 112,252 | 147,182 | 130,078 |
| China | 95,233 | 117,699 | 150,235 | 122,597 | 97,791 | 108,079 | 77,452 |
| Canada | 39,980 | 67,576 | 78,884 | 73,633 | 27,083 | 94,378 | 63,738 |
| Mexico | 66,760 | 81,814 | 41,154 | 55,929 | 65,246 | 79,816 | 61,426 |
| Indonesia | 71,932 | 54,440 | 116,020 | 179,424 | 24,629 | 18,204 | 37,494 |
| Greenland | 29 | 22 | 33 | 40 | 140 | 141 | 9 |

Date of publication
October 2019
Region
Global
Survey period
2012 to 2018

Quelle: Statista 2022

*As of 1 October 2019.

Burning topics.

Fires are nothing new. Probably the most legendary fire in history raged in ancient Rome. Emperor Nero was accused of setting the fire, but there is hardly any evidence to support this.

Active fire protection has been a familiar topic in German-speaking countries for around 1000 years already. In the middle of the 19th century, the development of regulations as we know them today gathered pace.

Urban fires from ancient times to the present.

Alexandria, 48 BC: The legendary fire in the Egyptian port city has proven to be a historical fake. What probably happened is that Roman emperor Julius Caesar, who had docked his fleet in the port, set his own ships on fire for military reasons.

Rome, 19 July 64 AD, during the Nero era: Large parts of this megalopolis fell victim to this legendary fire disaster and hundreds of thousands of people were made homeless.

Lübeck, 1157, 1251, 1276: Large swathes of this Hanseatic city burned down three times within 120 years. Ultimately, timber buildings were banned and strict fire regulations were introduced.

Munich, 13 February 1327: A glowing piece of coal in a cloister sparked a devastating fire in the city. A third of the medieval city, including its timber houses, went up in flames. Subsequently, the emperor enacted strict fire regulations that banned timber houses and straw roofs, among other things.

London, 2 September 1666: The Great Fire of London, which began at a bakery, was one of the worst fire disasters in human history. Almost the entire medieval building stock of the City of London was destroyed.



Rome, 64 AD



London, 1666



Hamburg, 1842

Hamburg, 5 May 1842: The largest fire disaster in the Hanseatic city broke out at a cigar factory and destroyed around 1700 buildings over the course of the next three days. A quarter of the urban area was affected.

Chicago, 8 October 1871: Three decades later, the Great Chicago Fire reached an even greater magnitude than the 'Great Fire' in Hamburg, destroying around 17,000 buildings.

Thessaloniki, 5 August 1917: Two thirds of the Greek city went up in flames in a huge fire that destroyed 9500 houses.

Yokohama, Tokyo, 1 September 1923: The huge fire disaster, which claimed the lives of 142,800 victims, was caused by a powerful earthquake. Around 1.9 million residents lost their homes.

Hamburg, 28 July 1943: At the height of the allied forces' air raids, a devastating firestorm reaching temperatures of approximately 1000 °C broke out, killing around 30,000 people.



Chicago, 1871



Düsseldorf, 1996

Düsseldorf Airport, 11 April 1996: The catastrophic fire in the capital of North Rhine-Westphalia started as a smouldering fire in the arrivals hall of Terminal A at around 3.30 p.m. and was caused by a scorched cable in the suspended ceiling. 17 people lost their lives and a further 88 were injured.

Grenfell Tower, London, 14 June 2017: 72 people died in the 24-storey building.



London, 2017

A history of fire protection.



The earliest evidence of fire-fighting literature dates back to Egypt in **1200 BC** when annual fire reports in Egypt were delivered in hieroglyphics.

Compiled by Eike von Repgow **between 1220 and 1230**, the Sachsenspiegel code of law contained several rules relating to fire safety that went on to be regarded as the authoritative provisions.

1251 and 1276: After the city of Lübeck was largely burned down around 100 years after it had been founded, it was deemed time for the first regulations on fire protection to be established: these took the form of mandatory building regulations, which, alongside a legendary fire wall decree, were primarily characterised by fire prevention measures and provisions.



'Churfürstliche Sächsische gnädigst CONFIRMIRTE Feuer-Ordnung / Des Rahts zu Dresden, 1662.' Fire regulations for Dresden dating back to 1662. Source: Prof. Dr.-Ing. habil. Gerd Geburtig

Fire safety equipment in a Scottish castle



Stirling Castle, Scotland

A castle in Scotland: an information board explains what protective measures the knights of the past could take to 'rake' burning parts from the roof during attacks involving burning arrows. Opposite: the modern fire safety measures.

Drones provide early warning of forest fire risk.



Heat and drought over extended periods of time have dramatically increased the risk of forest fires in recent years. In the extreme summer of 2018, devastating fires of historic proportions raged in Greece, California and other countries across the globe.



The German Aerospace Center (DLR) has launched the HEIMDALL project and, as part of this, drones equipped with cameras and thermal imaging sensors are already recording small forest fire hotspots. The drones explore a region autonomously and exchange the data they acquire with each other.

In an experiment involving a swarm of three autonomous Unmanned Aerial Systems (UAS) that was carried out in March 2019, visible-light cameras and thermal imaging cameras were used to gather and evaluate georeferenced data at three different locations in the Spanish region of Catalonia, with the aim of detecting a fire source at an early stage, enabling large-scale forest fires to be prevented.

In further experiments, hotspots consisting of wood, straw and sepiolite were ignited. The cameras recorded the various phases of the hotspot dynamics – from ignition to the extinguished fire. In total, 37 different hotspots were successfully analysed during 19 flights at altitudes of between 30 and 130 m.

The experiments showed that an autonomously operating swarm of drones can be used to detect forest fires. The UAS were able to identify even very small hotspots of less than 15 cm from an altitude of 90 m.

Source: German Aerospace Center (DLR)

Drones set fires.

In the USA, research is also being conducted into the use of drones to prevent forest fires – as well as to ensure the controlled spread of fire.

The sea of native grassland that once carpeted the American Great Plains has steadily disappeared. Unwanted shrubs and trees are growing in its place. To get rid of these and encourage grass to grow, controlled burns have deliberately been set. But the fires didn't bring about the desired success.

According to Dirac Twidwell, an ecologist at the University of Nebraska, more extreme fire is needed. With this in mind, he developed what are known as 'dragon eggs', balls filled with chemicals that are dropped by drones to spark controlled burns.

Twidwell tested extreme fire during a drought in Texas and in the Nebraska Sandhills and found that the fire burned easily through juniper and that the grasses recovered noticeably.

His important finding was that the use of drones helps manage fires safely, while also keeping costs manageable.

Source: education.nationalgeographic.org





The molecular structure of a material and its specific oxidation capacity determine whether and how it burns.

Flash, fire and autoignition point.

Important aspects for fire and smoke protection.



Many common building materials such as sand, concrete and steel are – fortunately – non-combustible. Fibreglass and expanded polystyrene concrete contain low quantities of combustible substances.

 **The flash point.**

This is the temperature at which a material can be ignited with a spark under normal air pressure. If a fuel heats so intensely that its flame point is reached, two reactions are possible:

- If the heat is sufficient, local combustion begins. However, it will not spread further initially, as even more energy would be needed for a chain reaction.
- Under certain circumstances, a gas-air mixture can explode spontaneously. This potential risk of explosion, which also depends on the mixing ratio, is what makes the flame point so important, particularly in the work of the fire brigade.

Methylated spirits have a flash point of 12 °C, diesel catches fire at approx. 55 °C and rapeseed oil ignites only at 230 °C.

 **The fire point.**

This is a few degrees higher than the flash point. The fire starts to spread only once the fire point has been reached. It then has sufficient energy to initiate the further oxidation of the fuel in a chain reaction.

The fire point does not allow predictions to be made regarding combustibility. It is possible that a material is only flame-resistant, but will burn very intensely under the right temperature and pressure conditions. Diesel fuel is a good example of this.

 **The right extinguishing agent.**

A European standard has been established to make it easier to choose the right extinguishing agent. It divides all combustible materials into fire classes. All materials included in a specific fire class are characterised by similar reaction to fire behaviour, but different fire and flash points.

 **The autoignition point.**

Gases, liquids and solids can auto-ignite under certain conditions. Autoignition depends, among other things, on the quantity of combustible material, the mixing ratio with oxygen and the temperature. Also known as the ignition temperature, the autoignition point varies depending on the material.

This is what makes autoignition so dangerous, as it often happens without warning and, under certain circumstances, can cause devastating explosions. Examples include grease fires in the kitchen, as well as coal dust and flour dust explosions.



In conversation with Oliver Holstein.

Oliver Holstein, Head of Sales at TROX X-FANS, Bad Hersfeld, is the expert contact for our customers when it comes to the topic of smoke extraction. He believes intelligent smoke extract systems are vital to saving people's lives in a fire.



Mr Holstein, you work in Bad Hersfeld, where you are responsible for sales of smoke exhaust fans, smoke extract systems and pressurisation systems. This must be a difficult task given that fire and smoke protection is not exactly the favourite topic of specialist consultants and system owners due to the costs involved?

Not at all. Smoke extraction helps save lives and enables fire brigades to quickly gain access to the source of a fire – meaning that people are protected and the consequential damage of a fire can be reduced.

Fire and smoke protection is hugely important right now. That wasn't always the case. We only have to think back 25 years. At that time, the fire at Düsseldorf Airport cost many lives.

After the devastating fire, the airport was extensively refurbished and the highest possible investments were made in safety. The fire and smoke protection work involved in this refurbishment essentially marked the birth of effective and energy-efficient smoke extraction. For example, we equipped the terminals with state-of-the-art X-FANS smoke exhaust fans.

You also address the topic of energy efficiency?

Of course. Ultimately, smoke extract systems need to do more than simply remove smoke effectively – they also need to work economically, especially if fans are also used to ventilate large spaces such as factory halls. Our fans are constantly being optimised by our research and development department. Our aim is to achieve high levels of efficiency combined with full functionality.

To name one example, the consistent reduction of electrical power consumption, obtained thanks to efficient frequency inverters and motors, not only saves energy, but also allows the integration of the fan into a complex total control system. The output power of the required ventilation is adapted due to continuous rotational speed control, meaning adapted airflow with significantly reduced power consumption.

And efficiency is not just limited to saving energy. Condition-based diagnosis with the TROX X-FANS fan diagnosis system (VD) guarantees that the systems will be available for use, while also ensuring that motors and bearings won't need to be replaced as often. This also dramatically reduces costs and, with our volume flow rate measuring unit (VME), our customers are always in safe hands!

What's more, we support specialist consultants, HVAC contractors and system owners with the design of their individual smoke extract concept. We have a dedicated back office and external sales team that will personally take care of a project from the design stage right up to its completion.

Naturally, advancing digitisation also requires enhanced support.

With this in mind, are artificial intelligence and system-led approaches pressing subjects for you?

Absolutely. The intelligent networking of our components to form a functioning system is an absolutely crucial factor. Because this allows the gears to mesh more effectively. Just like in the human body, where the brain and nervous system provide the vital impulses.

At the ISH trade fair, we showcased the innovative TROX O_x system platform, which is set to make work much easier for our partners. As a comprehensive control and monitoring system, TROX O_x is suitable for ventilation and air-conditioning systems, as the basis for complete building automation – yet it can also easily be used for subsystems. One software basis for the entire system means fewer interfaces, less planning work, reduced system configuration requirements, less time spent and lower costs.

Supply bottlenecks, shortages of raw materials, price rises and staff absences due to illness are currently dominating the discussion in business. How are you coping with this situation?

Preventative measures have thankfully enabled us to avoid large-scale staff absences. We are able to respond to supply bottlenecks by expanding our assembly capacity. Material availability and raw material prices in particular have given us huge headaches. We are working to combat this, at least in part, by changing how we use materials. In addition, we have built up stocks of critical components.

Changing the subject, electric cars have become a talking point due to the increased fire risk they pose. Is that correct?

What is clear is that the fire risk posed by an electric car is no higher than that of a petrol car. However, extinguishing a burning battery is often more complicated and time-consuming.

In general, it can be said that the fire load of modern cars is currently much higher than it was several years ago due to the cars' increasing size and the increased use of plastics, including in the bodywork.

Due to their high fire load, modern vehicles burn with higher energy and smoke development than cars from the 1980s, for example. The significant increase in the amount of smoke and heat released is, however, broadly unrelated to the car's type of powertrain.

By implication, this means that smoke extraction in underground and multi-storey car parks is becoming ever more important.

I can recall two fires that happened in Stuttgart – one close to the Mercedes Benz Arena, which caused huge material damage, and another in an underground car park beneath an apartment block. Nine of the apartment block's residents had to be taken to hospital with smoke inhalation, while 31 suffered minor injuries. A modern smoke extract system would have been able to prevent this.

Mr Holstein, thank you for your time.



▶ **Oliver Holstein**

The questionnaire was developed by Marcel Proust and popularised in Germany by the FAZ newspaper. We use it to ask quick-fire questions about people's likes and dislikes.

GETTING PERSONAL

Where would you most like to live?

South Tyrol: its hospitality, food, wine is simply amazing.

What does real happiness mean to you?

Laughing, enjoying oneself and contentment. Having a drink with good friends on a nice summer's evening either at home or in a good beer garden.

What kind of mistakes are you most likely to forgive?

Mistakes happen, it's only human. Intentional errors take me longer to come to terms with.

Your favourite fictional heroes?

I always take a book away on holiday with me, but I hardly ever get around to reading it. So I'm still looking for my heroes!

Your favourite historical figure?

I haven't decided on one yet.

Your favourite composer, musician or band?

Sunrise Avenue – Herbert Grönemeyer.

What's your favourite pastime?

Mountain biking and travelling to sunny climes.

What's your favourite food?

Bockwurst sausage with potato salad.

Which qualities do you most value in friends?

Straightforwardness, openness, mutual trust and being a good listener.

What's your biggest weakness?

I find it really hard to say no.

What would be the worst thing that could happen to you?

To live without my wife, friends and joy.

What's your favourite colour?

Green.

And your favourite flower?

The sunflower.

Your favourite animal?

Dog.

Your favourite book?

I'm still searching – as well as for my fictional hero

What motto do you live by?

Be guided by joy – we can complain later.



ISH 2023

TROX at ISH 2023.

TROX showcased itself at ISH under the slogan 'New system solutions, fascinating experiences, time for encounters and conversations'. The focal point of interest was of course the new TROX O_x system platform which provides users with huge benefits: fewer interfaces, simple plug-and-play connections, straightforward system configuration – all in a digital, well-organised and intuitive package.



TROX Creator Studio.

With the TROX Creator Studio, we established a communication platform at ISH 2023 that provided space for ideas and creativity, bringing together experts and professionals from across a wide range of industries.

In panel sessions, interviews and our new podcast, we discussed current trends, the future of building services engineering, increasing digitisation and approaches for modern, safe and comfortable ventilation solutions live and in person. All formats were recorded, meaning that selected content could also be viewed on-demand on our YouTube channel once the trade fair had ended. You can find the relevant links on our home page.



TROX O_x

TROX O_x – the uniform digital solution.

With TROX O_x, the diverse requirements for safety and comfort in buildings are brought together for the first time in a uniform digital system. This is based on the new TROX CONFIGURATOR and new TROX O_x Components.

The TROX CONFIGURATOR allows central and integrated planning of aspects including fire protection and ventilation technology over several levels down to the individual room. A configuration wizard supports the selection and design as a virtual assistant.

New TROX O_x components form the intelligent interfaces and manage different TROX solutions. Simple integration into a central building management system is also possible via various bus systems. Operation and management are carried out via smart touch displays or, optionally, via the integrated web browser. Trend data, alarms and maintenance messages can be viewed centrally here.

Advantages at a glance:

- Uniform hardware and software platform
- Plug-and-play solution
- Central operation via display, web browser and cloud
- Individual scalability of projects
- Harmonisation and central control of different solutions
- One solution for all TROX products
- Software and components made in Germany
- Uniform user interface in the configurator and web browser
- Holistic and future-proof system solution
- Easy connection to the central building management system
- Integrated fault management and energy monitoring

TROX O_x reduces interfaces between the different applications and components, and significantly simplifies installation and commissioning. All components can be integrated quickly and effortlessly via plug and play. TROX O_x is both downward and upward compatible and, as a scalable system, is suitable for both new buildings and refurbishments.

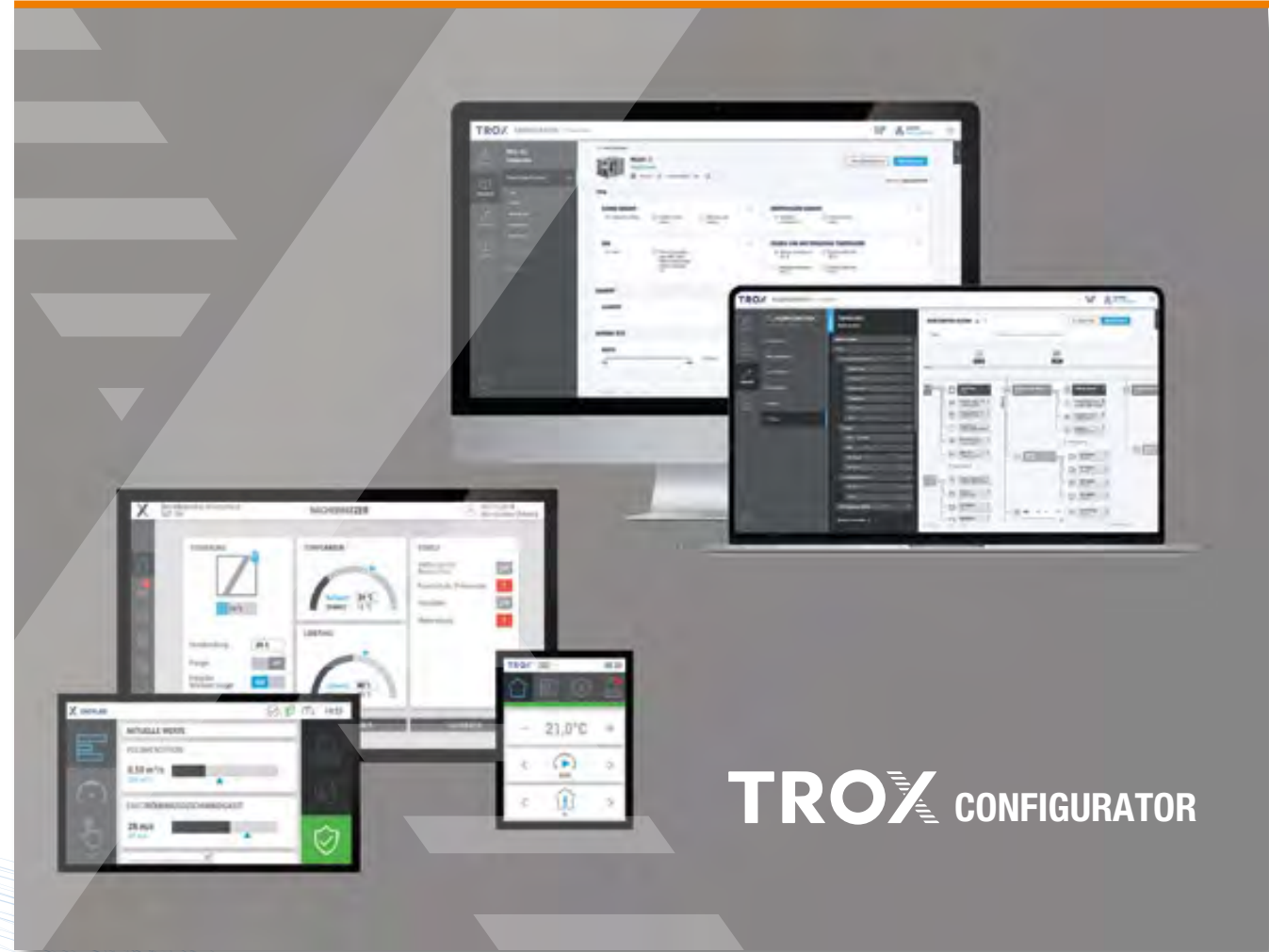
The new TROX O_x system platform.

For specialist consultants and HVAC contractors, different hardware and software systems are synonymous with huge expense when it comes to connecting subsystems, hardware and software. While the same hardware components are often used, they are connected to different pieces of software depending on the application.

That's why TROX has made it its mission to develop its own system platform that in future will make work with ventilation, fire protection and smoke extract systems much simpler: TROX O_x.

The TROX booth clearly reflected advancing digitisation.





TROX CONFIGURATOR

Simple. Online. Planning.

With the TROX CONFIGURATOR, central planning of the complete ventilation system becomes very simple. The comprehensive online tool for the design of the new TROX O_x system solutions as well as all other TROX products required for a project is accessed via a personal myTROX account. It enables simplified planning and designing of complex building projects. To support the configuration, there are several wizards as virtual assistants.

The award-winning interface design of the TROX CONFIGURATOR is self-explanatory and intuitive to use. The TROX O_x wizards enable an initial system

design with product proposals, prices and tender texts even in early project phases, which can be continued and detailed at a later stage of the project. In addition to the visualisation of the system solution, the exchange of information in the planning process is simple and interactive.

From the user's perspective, the system platform will offer considerable cost benefits, provide a high level of reliability and planning security and ensure adherence to schedules.



Advantages at a glance:

- Comprehensive, project-based design tool without the need for program installation
- Secure online access via myTROX portal
- Wizards help with product selection and configuration
- Can be used from the concept phase up to design planning
- Uniform and intuitive user interface with award-winning design
- Consistent data use for tenders, quotations, commissioning and monitoring
- Documentation and tender texts
- System visualisation (representation of system topology)
- Supports digital planning process



And the winner is: TROX!

TROX wins the prestigious 'Design Plus powered by ISH 2023' award.

The 'Design Plus powered by ISH' award is an international prize for exhibitors at ISH and is awarded by the German Design Council for Messe Frankfurt. It rewards exceptional product performance that cleverly combines technology and design.

During an award ceremony, the jury announced TROX as a winner for its TROX O_x HMI system. The project description for the award-winning system states the following:

'From drafting and detailed planning to commissioning and monitoring, TROX combines proven and new applications under one umbrella with TROX O_x. The focus of the configurator and HMI development is on tools: system configurator and system controller. In addition to the optimisation of usability, the 360° user experience for TROX novices and experts, and the rollout of a new corporate design, the development also focused on the compatibility of the interfaces and a uniform look and feel.'

2023 WINNER
DESIGN PLUS
powered by ISH



ISH 2023

In addition to the system platform, there were a whole host of other products to discover at the TROX booth.

TVE-Q VOLUME FLOW CONTROLLER.

Small space requirement.

The compact TVE-Q controller does not require external measurement tubes. The differential pressure is transmitted to the sensor via the patented shaft. The measuring principle is based on the map strategy. If dynamic transducers are used, the controller allows a variable airflow direction from both sides.

In addition, the design, which is flow-insensitive, enables installation locations that cannot be realised with standard terminal units, as upstream ducts do not need to be considered during planning.



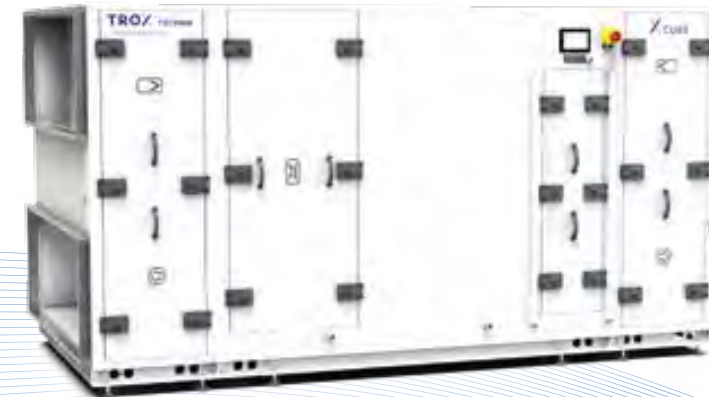
TVE-Q volume flow controller with patented shaft that transmits the differential pressure directly to the sensor. TVE-Q therefore does not require external measurement tubes.

Air handling units

X-CUBE X2 COMPACT (volume flow rates of 600 to 15,000 m³/h).

Lighter. Smarter. More powerful.

Much more compact – and the performance has also been increased once again. Highly efficient heat recovery is carried out via a rotary or counterflow heat exchanger, depending on the version. Due to the small sizes and the variable versions with vertical or horizontal duct connection, installation of the pre-assembled unit is possible in the smallest of spaces. It can then be configured and put into operation in no time at all using X-CUBE Control.



X-CUBE X2 compact with highly efficient heat recovery system.

ISH 2023



X-CUBE Control, saves time thanks to the simple and standardised M12 connection between the modules, among other aspects.

X-CUBE CONTROL.

Commissioning that's even faster and smarter.

X-CUBE Control scores particularly well when it comes to time – thanks to the simple and standardised M12 connection between the modules, intelligent and easily accessible control cabinet architecture and the smart, intuitively operated control panel. Cloud-based control is also possible via a web connection.

Instead of complex star-shaped wiring, the modules are now connected via the integrated plug-in bus wiring, which includes 24 V power supply for the components. The product is therefore a genuine plug-and-play solution in line with industrial standards and saves a huge amount of time when it comes to commissioning.

X-CUBE CONFIGURATOR.

Schnell zum passenden Gerät.

Find the right unit – fast.

For the secure and quick design of X-CUBE X2 units, the myTROX portal offers the web-based X-CUBE CONFIGURATOR, which enables optimum unit selection even without expert knowledge.

In addition, the configurator has a life-cycle cost tool, which was developed in cooperation with the E.ON Energy Research Center at RWTH Aachen University. The LCC tool uses a simulation procedure to determine the expected operating costs and CO₂ emissions for any location worldwide.

TROX CONFIGURATOR

Use the X-CUBE CONFIGURATOR to design X-CUBE X2 units securely and fast.

X-CUBE SCHOOLAIR S-HV.

Decentralised air supply – ready to operate and powerful.

The decentralised floor-standing unit X-CUBE SCHOOLAIR S-HV offers a compact, stand-alone solution that can be installed quickly even during the regular running of a school.

One single unit is sufficient to efficiently ventilate a fully occupied classroom or meeting room. The integrated CO₂ sensor enables a demand-based supply of fresh air. The heat and humidity of the extract air are recirculated via a highly efficient rotary heat exchanger. A heating coil can additionally adjust the air temperature and powerful filters ensure the reduction of fine dust and pollen.



X-CUBE SCHOOLAIR S-HV, compact, stand-alone solution.

X-CUBE SCHOOLAIR V-HV.

Fresh air through the façade.

The SCHOOLAIR V-HV is the ideal alternative for installation in the façade. Unique in this category is the integrated rotary heat exchanger, which achieves increased efficiency and means the whisper-quiet SCHOOLAIR V-HV consumes less power than a laptop.



X-CUBE SCHOOLAIR V-HV for installation in the façade. Equipped with an integrated rotary heat exchanger – a feature that is unique in this category.

ISH 2023

**CFE, CFS, CHS, CHM
WALL DIFFUSERS.****New options for air distribution.**

The installation of suspended ceilings is becoming less popular. The air exchange then often takes place via the corridors directly through the wall. The new CFE, CFS, CHS and CHM wall diffusers offer the perfect solution here, not only visually but also acoustically, for both supply air and extract air.

CFE wall diffuser



CHS wall diffuser

CFS wall diffuser



CHM wall diffuser

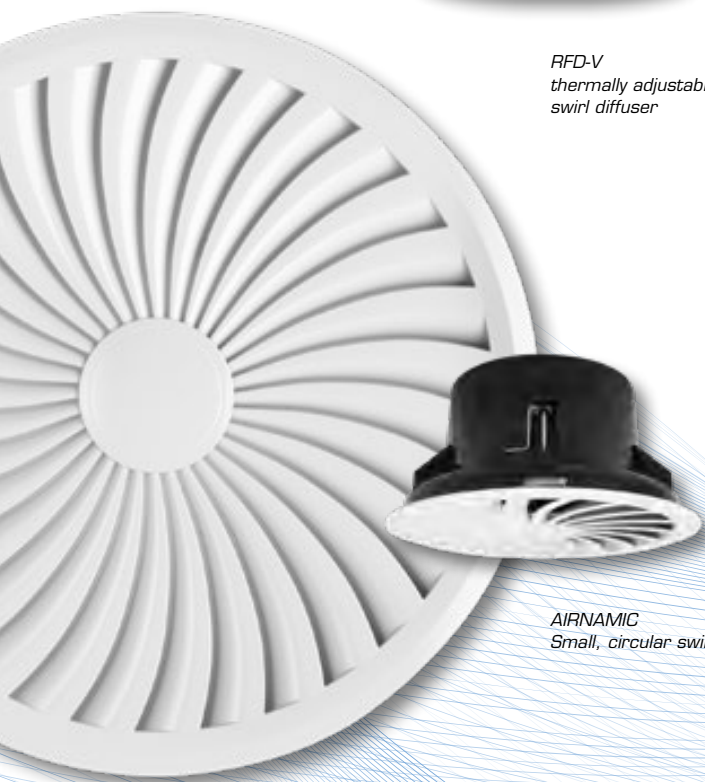
**RFD-V
THERMALLY ADJUSTABLE SWIRL DIFFUSER.****Variable air distribution for heating and cooling.**

More and more often, air terminal devices are mounted freely suspended. The new adjustable swirl diffuser RFD-V is optimised for this task. The special shape of the swirl blades in conjunction with the wider discharge nozzle enables horizontal air discharge in cooling mode and thus prevents draughts.

However, if the air brought in shall be warmer than the room air, the supply air must be brought into the room vertically against the buoyancy. The new RFD-V achieves this through its automatic adjustment, which enables large penetration depths. The mechanism reacts automatically to temperature changes in the supply air.

RFD-V
thermally adjustable
swirl diffuser**AIRNAMIC SWIRL DIFFUSER.****Small, quiet and powerful.**

The small round swirl diffusers AIRNAMIC in nominal widths of 160 and 250 mm allow perfect air supply even in the lower volume flow range. They have three-dimensional contoured plastic blades that not only ensure high induction, but also significantly improve acoustics due to an upstream sawtooth profile.

AIRNAMIC
Small, circular swirl diffuser**TFC
CEILING-MOUNTED PARTICULATE FILTER AIR
TERMINAL DEVICE - NEW GENERATION.****Optimised as desired.**

The TFC supply air casing is a particulate filter air terminal device for clean rooms. In the new generation, the requirements of customers were taken into account specifically and the safe filter replacement process has been greatly simplified through the use of a special press-on frame. It is now also possible to install the air terminal device without tools thanks to a quick-release fastener.

TFC
Ceiling-mounted
particulate filter air
terminal device**TFEA
CEILING DIFFUSER FOR EXTRACT
AIR APPLICATIONS.****Supply and extract air from a single source.**

The TFEA extract air casing for clean rooms, together with the TFC type, forms a system for supply and extract air applications. It fits into the same ceiling openings. What's more, almost all TFC diffuser faces can be used here for a uniform ceiling design.

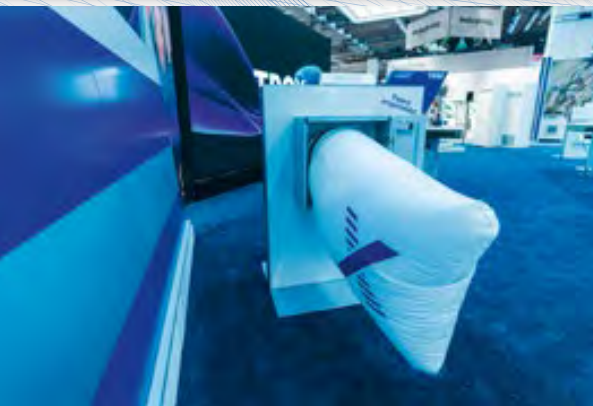
TFEA
Ceiling diffuser for
extract air applications**FK2-EU FIRE DAMPER - ODA VERSION.****Thermally insulated. Condensate-free. Safe.**

If fire dampers are used in conjunction with outside air inlets, the temperature difference to the interior can cause condensate to form and – later down the line – result in moisture damage to the building structure.

With the newly developed ODA version of the TROX FK2-EU and FKR2-EU, this is effectively avoided. All-round vapour diffusion-tight insulation provides the necessary insulation for mortar installation in walls and ceilings.

FK2-EU fire damper -
ODA version

ISH 2023



1.

WAX-LI LOW-PULSE SUPPLY AIR SYSTEM.

Effective smoke control thanks to low-pulse supply intake.

In order to effectively keep escape and rescue routes free of smoke in the event of a fire, a very low-pulse supply air with uniform velocity near the floor is indispensable for smoke extraction with stratification. This applies to both mechanical smoke extraction systems and natural smoke extraction systems. In order to guarantee these low velocities in the supply air flow, large supply air areas are usually required in the building envelope.

2.

With WAX-LI, TROX X-FANS offers a unique low-pulse supply air system that requires only small openings in the building.

Small opening area – low supply air velocities.

For smoke extraction, the WAX-LI system, which was developed together with the TH Mittelhessen University of Applied Sciences – can supply up to 25,000 m³/h of fresh air with a wall opening of only 1 m².

3.

Thereby, the thermal insulation of the building envelope is maintained and the energy demand is minimised. A special textile hose provides the necessary increase in surface area while reducing the airflow velocity to below 1 m/s at the same time. A natural airflow would require a wall opening of more than 7 m² to achieve the same effect.

4.

Product of the Year 2023
Winner 2023
 Category: Plant fire protection
TROX X-FANS GmbH
 Supply air module WAX-LI



WAX-LI – low-pulse supply air system



Barbecue season: fire and smoke.



The summer is on its way. And the first wafts of smoke from balconies, gardens and picnic areas are wending their way through towns and villages. A mouth-watering scent of grilled meat is in the air.



The tribe flocks around the fire, each one gnawing at a scrap of meat – barbecuing is an ancient art. It dates back to the Stone Age. And the roles are clearly allocated: the man stands at the fire; the woman keeps her distance.

This Stone Age theory is indirectly supported by a barbecuing survey conducted by the discounter Lidl. According to the survey, 80% of men would give up the barbecue tongs only reluctantly, while 13% wouldn't stand for anyone else helping them with the barbecue. Two thirds of the women surveyed even stated that they have no interest whatsoever in taking control of the barbecue. The women prefer to attend to the side dishes, such as the salad.



So, proud as punch, the menfolk stride over to their monster barbecues. A comparison with the car springs to mind – both in terms of price, size and weight, as well as the maximum capacity of the high-performance broiler or smoker. Currently on trend is the Beefer, which, according to the manufacturer, is able to conjure up the perfect steak in a record time of 90 seconds (two blasts of 45 seconds) thanks to temperatures of 800 °C. But it's not just the temperature that reaches 800 – at 800 euros, the basic model also comes at a sizzling price! (We previously reported on this in life no. 11.)

The barbecue – the last bastion of masculinity.

Are men perhaps clinging onto their barbecue tongs because women have grabbed hold of the sceptre in so many other areas of life? Cultural scientist Hirschfelder argues the following: 'For the man, barbecuing is a kind of post-modern reflex. With the emancipation of women, he has lost his evolutionary rights. Loss of power also always implies trauma. With the barbecue,



the man has a refuge. 'This is where he can wield his sceptre.

Gas or coal? That is the question.

Die-hard barbecuers swear by charcoal, sourced from local beech. However, this is not only being usurped by the growing number of

gas barbecues (although the word 'barbecue' hardly seems to fit the kitchen-sized dimensions that these appliances now assume). No, the sun now also has the humble piece of charcoal in its sights. With sustainability in mind, solar-powered barbecue are making their way onto the market. Mirrors and the sun's rays sizzle steaks, pork neck, spare ribs and sausages. Or vegetarian and vegan alternatives.

As a meat lover, I have to admit that, when it comes to barbecuing, I go with the book by Heinz Strunk: 'Meat is my vegetable'.



Published by:
TROX GmbH
Heinrich-Trox-Platz
47504 Neukirchen-Vluyn, Germany
Phone: +49 (0) 2845 202-0
Fax: +49 (0) 2845 202-265
trox-de@troxgroup.com
www.troxtechnik.com

Production:
TR advertising GmbH
Arnulfstraße 33
40545 Düsseldorf, Germany

Editors:
Christine Roßkothén, TROX GmbH
Klaus-Arndt Hueter, TROX GmbH
Klaus Müller, Kommunikation & Marketing

Associate editors:
Thorsten Dittrich
Ralf Joneleit
Udo Jung

Printed by:
MD-Digital GmbH
Niederrheinallee 320
47506 Neukirchen-Vluyn,
Germany

Art director:
Alexandra Höver

Photo editors:
Alexandra Höver
Klaus Müller

Image sources:
Cover/back page: iStock
P. 2/3: TROX GmbH
P. 4/5: iStock, picture alliance
P. 6/7: iStock, Luftbildvertrieb Monika Müller
P. 8/9: TROX GmbH, iStock
P. 10/11: TROX GmbH, iStock
P. 12-15: TROX GmbH, iStock
P. 16/17: TROX GmbH, Vienna fire brigade, iStock
P. 18-25: iStock
P. 26/27: iStock, picture alliance
P. 28/29: iStock, Exhibition at Stirling Castle, Castle Esplanade, Stirling
P. 30-37: iStock
P. 39-43: TROX GmbH
P. 44/45: TROX GmbH, iStock
P. 46/47: TROX GmbH
P. 48-59: TROX GmbH, iStock
P. 60-63: iStock

Published in August 2023



TROX GmbH
Heinrich-Trox-Platz
47504 Neukirchen-Vluyn
Germany
Phone: +49 (0) 2845 2020
Fax: +49 (0) 2845 202265
trox-de@troxgroup.com
www.troxtechnik.com