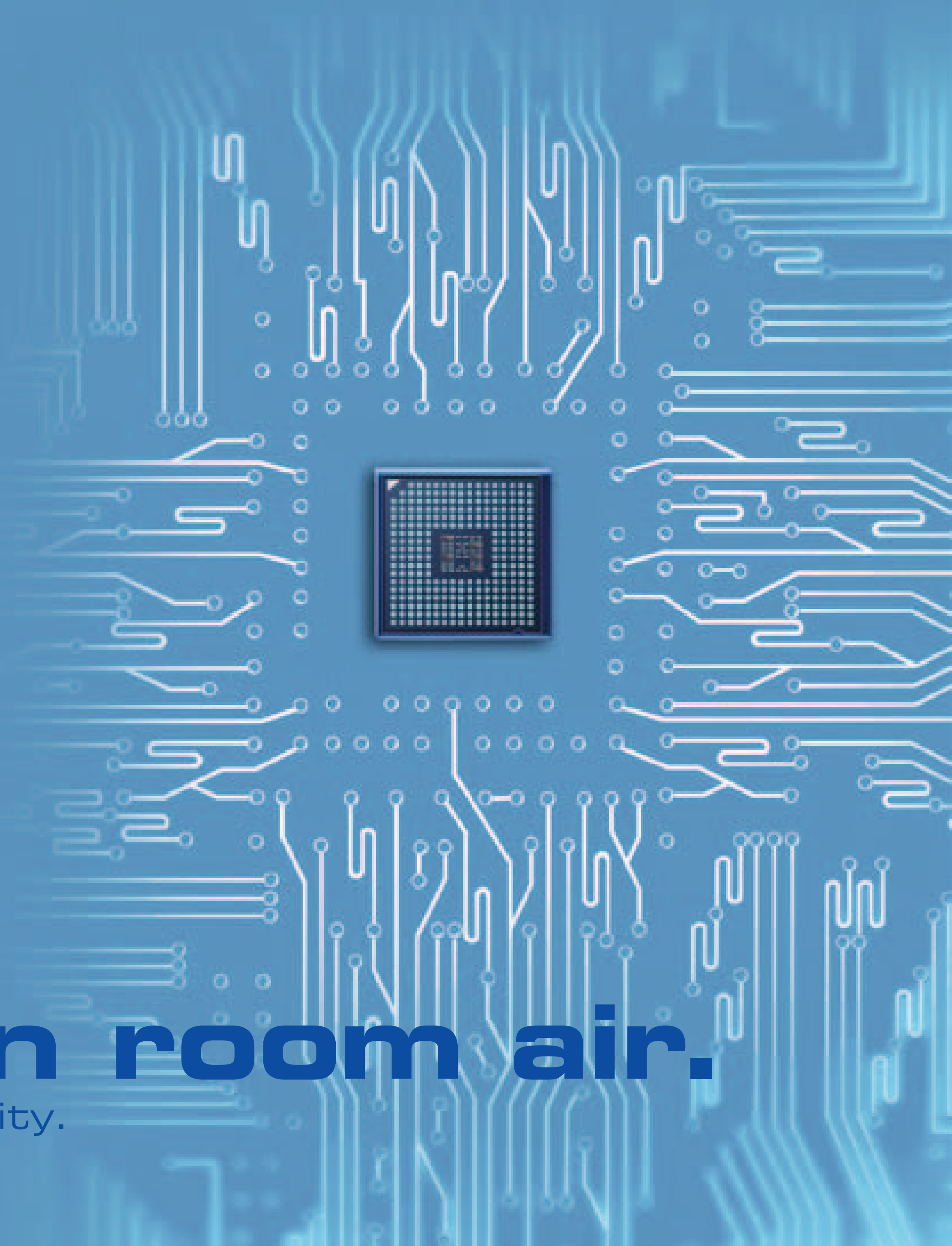
TROX life

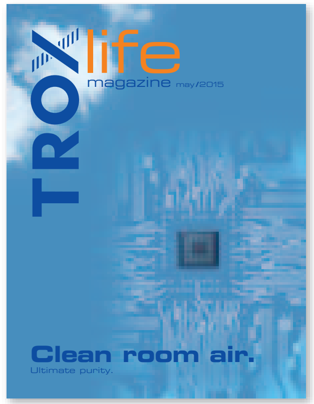
magazine may/2015



Clean room air.

Ultimate purity.

contents



viewpoint

Clean air.

Clean room technology and clean room management systems are found in many more areas than you may think, and not only in operating theatres, life sciences or semiconductor production. Clean room conditions are also needed in the nano industry, in breweries, commercial bakeries, pharmacies, livestock facilities, in automotive engineering, and in control rooms and meeting rooms: in short, wherever the requirements of hygienic air and pressure control are high.

In contrast to the other areas of ventilation and air conditioning, which revolve around the human being, ventilation and air conditioning in clean rooms is meant to protect a product. Filters in particular have to be efficient and meet the most stringent requirements. In microelectronics, integrated circuits with an unbelievably high number of electronic components find place on a semiconductor chip of only a few square millimetres. The new Apple iPhone processor A8X, for example, is fitted with 3 billion transistors. To ensure the functional reliability of such tiny circuits, filters must be able to separate submicrometre particles, including atoms and molecules of gases. Almost unimaginable.

Today we are standing on the threshold to the next industrial revolution. The 'Internet of Things' will enable us to build artificial intelligence into everyday products and parts. This is the fascinating topic of our reportage.

Controlling the factors which influence air cleanliness and safety is an issue that we also dealt with at the recent ISH fair. Our main goal, however, was to show visitors how TROX has developed from a manufacturer of components to a provider of systems. Our booth was fitted with a complete ventilation and air conditioning system of perfectly integrated components – all made by TROX. Visitors were able to trace the way of the air from A to X, from the AIRNAMIC diffuser back to the X-CUBE air handling unit.

And now: Enjoy our magazine!

Yours

M. Bauer

Michael Bauer
Chairman of the Board of Management, TROX GmbH

EnEff: Clean rooms.

Maximum air cleanliness with minimum energy.

More than 2500 terawatt hours of energy are consumed in Germany every year, including 120 terawatt hours, or nearly 5 %, for the ventilation and air conditioning of rooms. And the figure is increasing. More and more clean room production facilities spring up, in electronics and the pharmaceutical industry, in microbiology, genetic engineering, medicine, cosmetics, food processing, and in automotive engineering.

Hermann-Rietschel-Institut
Gebäude-Energie-Systeme

Gigantic savings potential.

A gigantic energy savings potential lies dormant in clean rooms, but the behaviour of airflows has not been sufficiently researched yet. This is why Berlin Technical University initiated at the end of 2014 the 'EnEff: Clean Rooms' research project. The project is led by Professor Martin Kriegel and subsidised by the German Federal Ministry for Economic Affairs and Energy with one million euros. According to an estimate by Prof. Kriegel, it should be possible to reduce the required volume flow rates by up to 40 % – and save 48 TWh of energy per year. This is equivalent to the total energy consumption of Portugal.

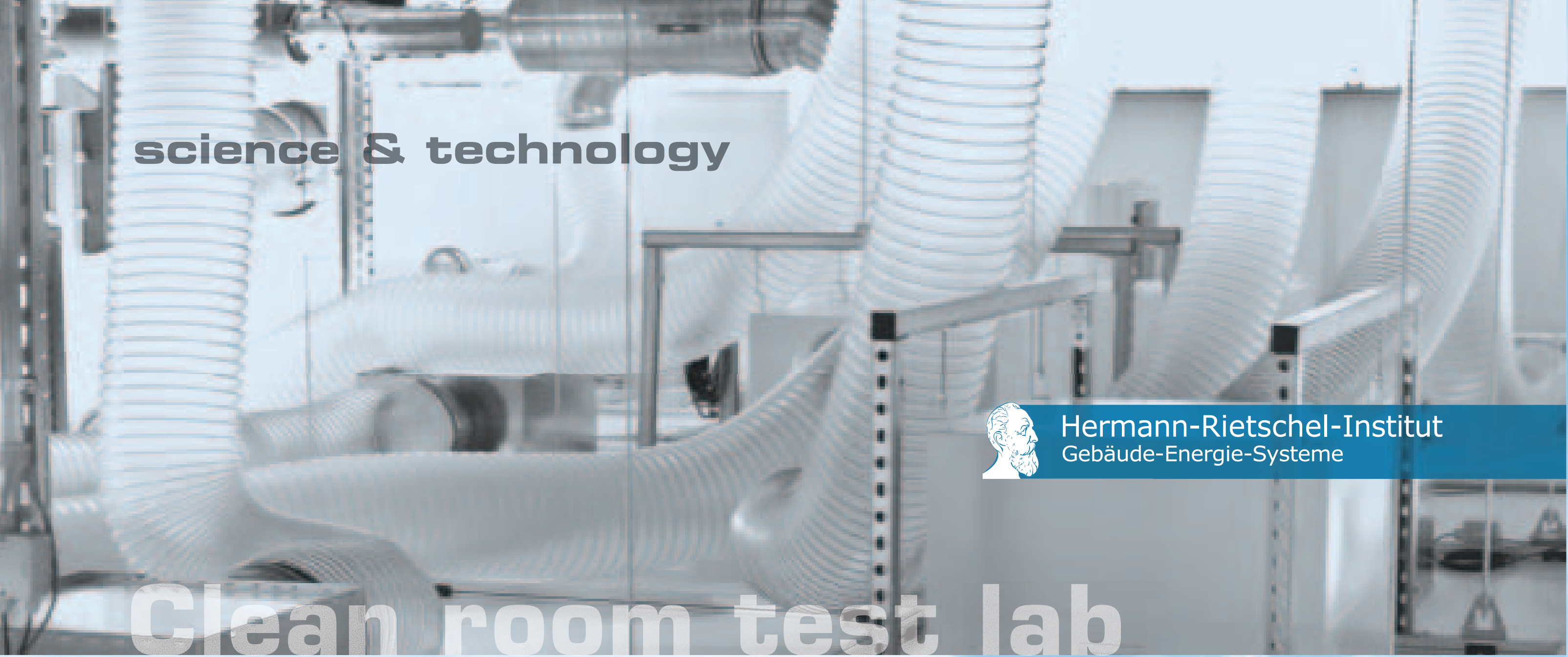
Prof. Dr.-Ing. Martin Kriegel
Leader of the 'EnEff: Clean Rooms' research project

** 1 TWh = 1 billion kWh*

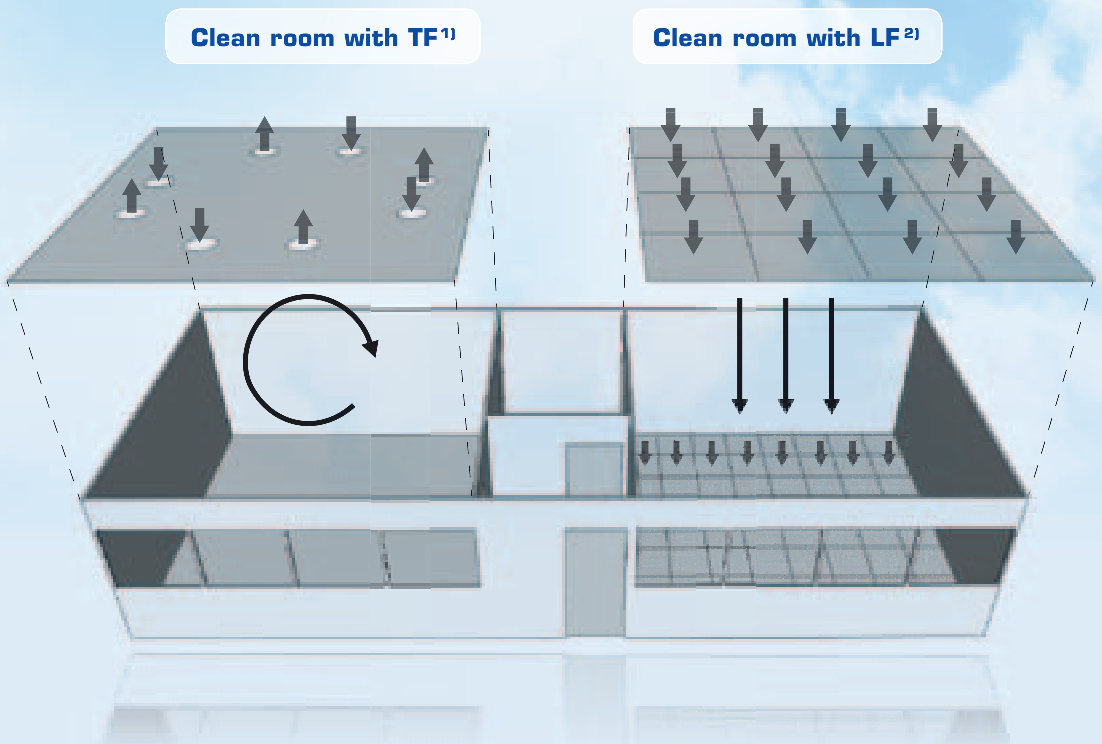
Yet the ongoing research project considers only room ventilation. Other measures such as the dissipation of thermal loads with energy-efficient air-water systems, the exploitation of renewable energy sources, or innovative thermal component activation, e.g. with phase change materials, are not dealt with, even though they cannot only optimise airflows but also help to minimise energy consumption.

Demand-based ventilation and air conditioning with stationary and intermittent airflows are, however, included in the research and tested for their effectiveness.

In the clean room test lab in Berlin the ***TROX X-CUBE air handling unit*** *is used to supply conditioned fresh air.*



Clean room test lab



1) **TF:** turbulent flow
2) **LF:** low-turbulence laminar flow

TECHNICAL DATA

Area:		75 m²
Volume flow rates:		2500 m³/h fresh air
Air conditioning system:		13000 m³/h supply air
Temperature:		16 to 24 °C (± 0.1 K)
Humidity:		40 to 60 % (± 10 %)
Pressure:	Airlock 1	15 Pa
	Airlock 2	45 Pa
Pressure cascade (clean room airlock)		15 Pa ± 5 Pa
Clean room with TF 1):		25 m² H14 filter 3000 m³/h 30 Pa
Clean room with LF 2):		25 m² U15 filter 40500 m³/h (600 room air changes per hour) 60 Pa

Supported by:

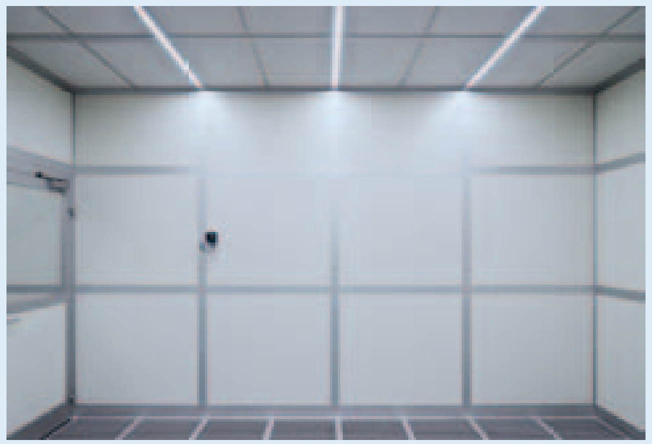
FKZ: 03ET1206A

Clean room test lab.

At the Hermann Rietschel Institute (HRI), a research lab has been installed which covers approximately 90 % of all types of real clean room situations. The team of scientists is going to examine all known types of ventilation (mixed flow, displacement flow, displacement flow with discharge near the floor, and free jet). Their goal is to generate stable airflows that ensure cleanliness at the workplace with considerably lower volume flow rates. According to Prof. Kriegel, displacement flow ventilation, or in fact any type of 'upward' ventilation, has decisive advantages when compared to conventional 'downward' ventilation since airflows need not overcome the thermal buoyancy, which would result in unnecessarily high volume flow rates.

As things are, existing standards and guidelines define only the maximum acceptable particle concentration for the different classes of clean rooms. As a consequence, research will not only focus on particle concentrations for entire rooms but for individual zones where people and/or products need to be protected. The Berlin researchers want to prove that innovative diffusers can supply steady airflows which allow for local ventilation and hence increase the local ventilation efficiency. In the end it would no longer be necessary to have a homogeneous airflow across the room but only in protection zones; volume flow rates in the room could thus be drastically decreased. The outcome of the Berlin research project could also have an effect on existing guidelines insofar as they should be more specific and include new ventilation methods.

Research lab with a low-turbulence laminar flow



Research lab with a turbulent flow

State-of-the-art measurement techniques.

The scientists of the Hermann Rietschel Institute use state-of-the-art software tools that require an enormous computing capacity, e.g. for high-tech numerical computational fluid dynamics, or CFD. For these simulations, the HRI team uses the HPC cluster of Berlin Technical University. That cluster includes 400 processors with more than 1 TB RAM and a hard drive capacity of approximately 10 TB.

Particle concentrations are usually measured by means of permanent particle monitoring. This is only possible, however, if the particle concentration in a room is homogeneous. As the research project considers only individual zones, the scientists have to calculate the correlation between a particle measurement point and the clean zone because it is rare that the measurement point can be established inside the zone that is to be protected.

Ventilation comfort in the work area.

Ventilation efficiency is just one focus of the research of Prof. Kriegel's team; the other focus is on ventilation comfort in the occupied zone. Room occupants only accept energy-efficient solutions that do not reduce the thermal comfort. Different classes of clean rooms require different dress codes – this is yet another aspect that needs to be considered by the Berlin researchers.

The art of handling clean air.

Clean room projects around the globe.

Follow the way of the airflow from A to X through a clean room production facility. From air terminal units to the X-CUBE air handling unit. We show you an example of a production facility equipped with TROX systems and components, highlighting the special features of our air management systems, filter systems and ventilation units.

One-stop shop

TROX. The clean room air managers.

The reliability and safety of an air conditioning system for clean rooms depend on an intelligent air management system combined with efficient air filtration. The individual ventilation components must complement each other perfectly.

Ventilation and air conditioning in clean rooms means, first and foremost, controlling undesired airborne particles. These are dust particles in the 'fresh' air but also micro-organisms and gases. They are usually brought in by people, or released in work processes.

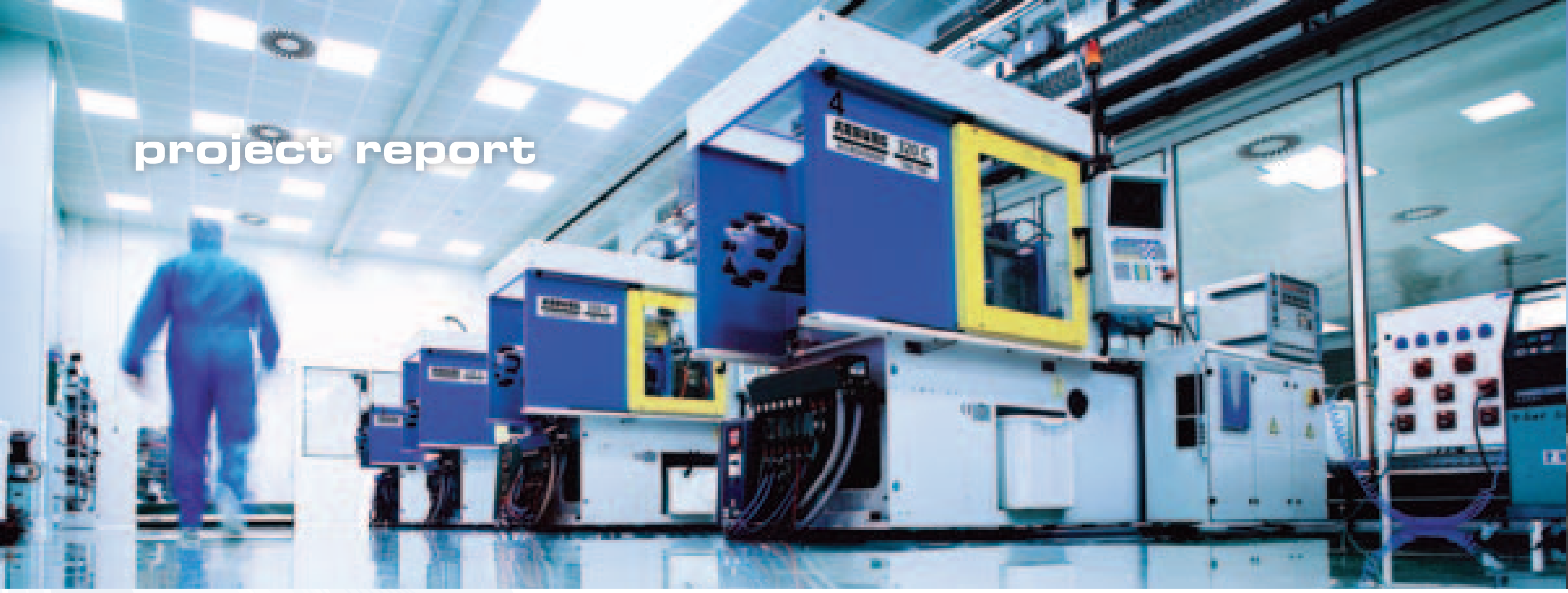
For decades, TROX has been looking into the measures that are required to prevent the contamination of people, products and the environment, and has developed appropriate, comprehensive solutions.

TROX room air management for clean rooms:

1. *X-CUBE air handling units*
2. *X-CUBE CROFCU Clean Room Fan Coil Unit*
3. *TROX room air management systems*
4. *M5 filters*
5. *F7 fine dust filters*
6. *H14 particulate filters*
7. *Ceiling mounted particulate filters*
8. *Wall mounted particulate filters*
9. *Single ventilation grilles and continuous horizontal runs*
10. *TROXNETCOM*
11. *Fire dampers*
12. *X-FANS smoke exhaust fans*
13. *External weather louvres*
14. *Multileaf dampers*

A - D *Clean room classes*

project report



Frank plastic AG

Nestle AG

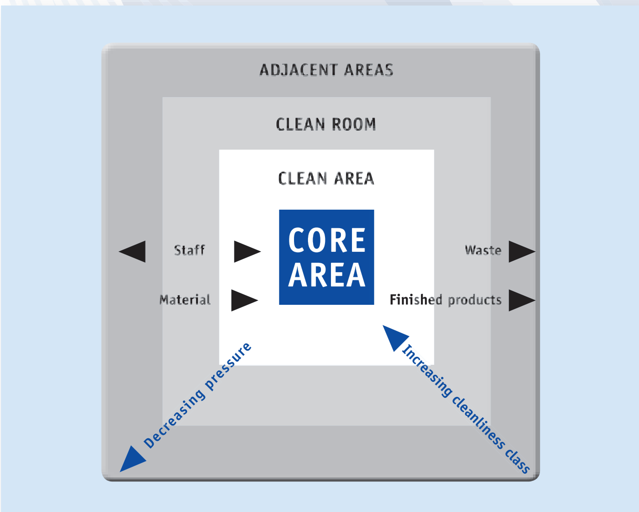
TROX high efficiency filter

Room air conditioning creates ultra-clean room conditions.

Controlling the diverse, interdependent factors which influence air cleanliness and safety has led to the development of extremely reliable and energy-efficient clean room systems that address the following aspects:

- **Air treatment, transport, filtration and discharge:** Ensuring a high level of air cleanliness and a good room air quality.
- **Air management:** Protecting products, processes, people (highest quality standards for production) and the environment from contaminated air by maintaining the required volume flow rates.
- **Fire protection and smoke extract:** Preventing the spread of contaminated air and of fire and smoke through ducting in the event of a fire. Systematic removal of toxic fire gases with a separate mechanical smoke extract system.

Contamination control with a multi-layer system



Very demanding hygiene requirements, the increasing miniaturisation and the resulting increasing vulnerability of products and processes due to airborne particles also lead to increasing and more diverse requirements for clean room protection. Even nano particles, i.e. as tiny as one millionth of a millimetre, pose a hazard to the functionality of many products. One such particle on the sensitive crystal of an LC display appears as black spots.

Demand-based ventilation saves energy.

It should be possible to operate air conditioning systems effectively but also flexibly, and not necessarily with full power for 24 hours a day. Air distribution systems provide intelligent, demand-based volume flow rate control and consequently ensure a high level of energy efficiency. Full power is really only required when workplaces are fully staffed. At other times a lower room air change rate will be sufficient. This offers a considerable savings potential over time.

Energy savings potential in existing systems.

When it comes to energy efficiency, ventilation and air conditioning systems have come a long way. This is why a considerable energy savings potential lies dormant in older systems. The modernisation of ventilation and air conditioning systems by suitable measures, e.g. by fitting air handling units with frequency converters or installing VAV terminal units, may reduce the energy requirement of these systems by as much as 40 %. Such investments pay off, often within only two years.

Tailored solutions for control and monitoring.

Ventilation and air conditioning components must communicate with each other, only then can they also work together perfectly. This is even more important when the safety of people and equipment is at stake. Intelligent communication systems allow for data to be retrieved, collected, displayed and monitored via the central BMS.

Positive pressure is one way to physically prevent contamination in clean room production facilities. Positive pressure prevents undesired airflows or undesired particles from entering a room. TROX has developed bespoke solutions for the special requirements of clean rooms. Proven plug and play communication and connection to the central BMS via LON, BACnet or Modbus, or IP-based Ethernet communication allow for easy and efficient system integration.

High-tech room air conditioning.

In highly sensitive areas, more than anywhere else, an air handling unit must meet particularly stringent hygiene requirements. The TROX X-CUBE is an air handling unit with unlimited configuration options, and even the basic version has set a new standard for safety, reliability and quality. It takes only a few small steps to arrive from the top-of-class construction for various applications to an air handling unit which meets particularly high hygiene requirements:

- Use of damper blades that comply with closed blade leakage class 4 to EN 1751
- Powder-coated attenuator splitters
- Stainless steel floor panels inside

Innovative heat recovery, high-efficiency fans and optimised components such as filters and attenuator splitters make the X-CUBE units extremely energy efficient.

The intelligent interconnection of all TROX components, devices and the air handling unit ensures reliable overall communication and central control of the system components, which complement each other perfectly.

Secondary air systems – the economical alternative.

Most clean rooms are characterised by very high air change rates, sometimes up to 600 per hour. On the other hand, only a few people may be working in the production rooms or labs at any one time. This means

Max Planck Institute for Molecular Biomedicine, Münster, Germany

X-CUBE CROFCU installed in a suspended ceiling at Solopharm in Russia

Functions:

- Particulate filters on the pressure side help to maintain air cleanliness classes
- The volume flow rate is kept at a constant level, independent of filter class or filter contamination
- Variable volume flow rate: 0 to 6000 m³/h
- Nominal volume flow rate: 4200 m³/h
- Dissipation of thermal loads and room temperature control
- Fresh air on demand; volume flow rates from 50 to 2000 m³/h can be set
- Control of exhaust air volume flow rate and room pressure
- Monitoring of the contamination level of filters downstream

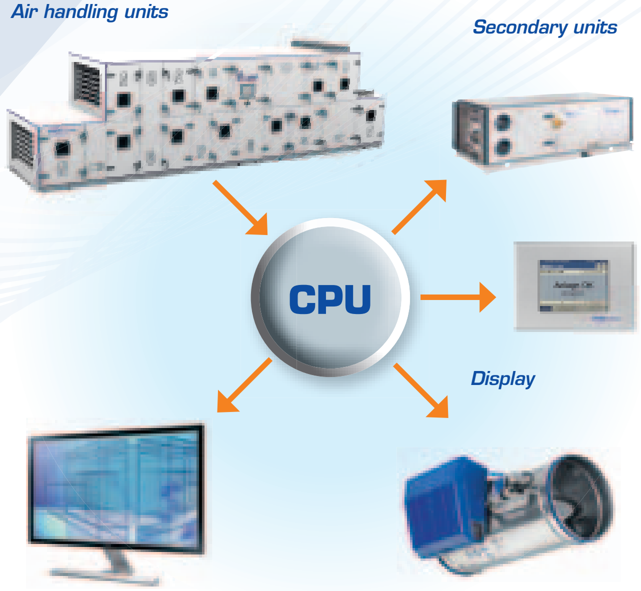
Advantages:

- Space-saving installation in suspended ceilings above clean rooms
- Very short commissioning times, no wiring on site required due to factory set parameters
- Low pressure losses due to energy-optimised system
- Suitable for 1.2 m ceiling grids
- FAT – Factory Acceptance Test

The X-CUBE CROFCU secondary air unit ensures and maintains the essential values for all classes of clean rooms. It includes the necessary components, arranged to ensure the most efficient airflow, and allows for the direct removal of exhaust air while fresh air is supplied to the room; no mixing takes place.

The fresh air is conditioned in an X-CUBE air handling unit with a highly efficient heat recovery system that can be variably sized based on the fresh air requirement of the building, the components installed, and individual factors.

TROX air management



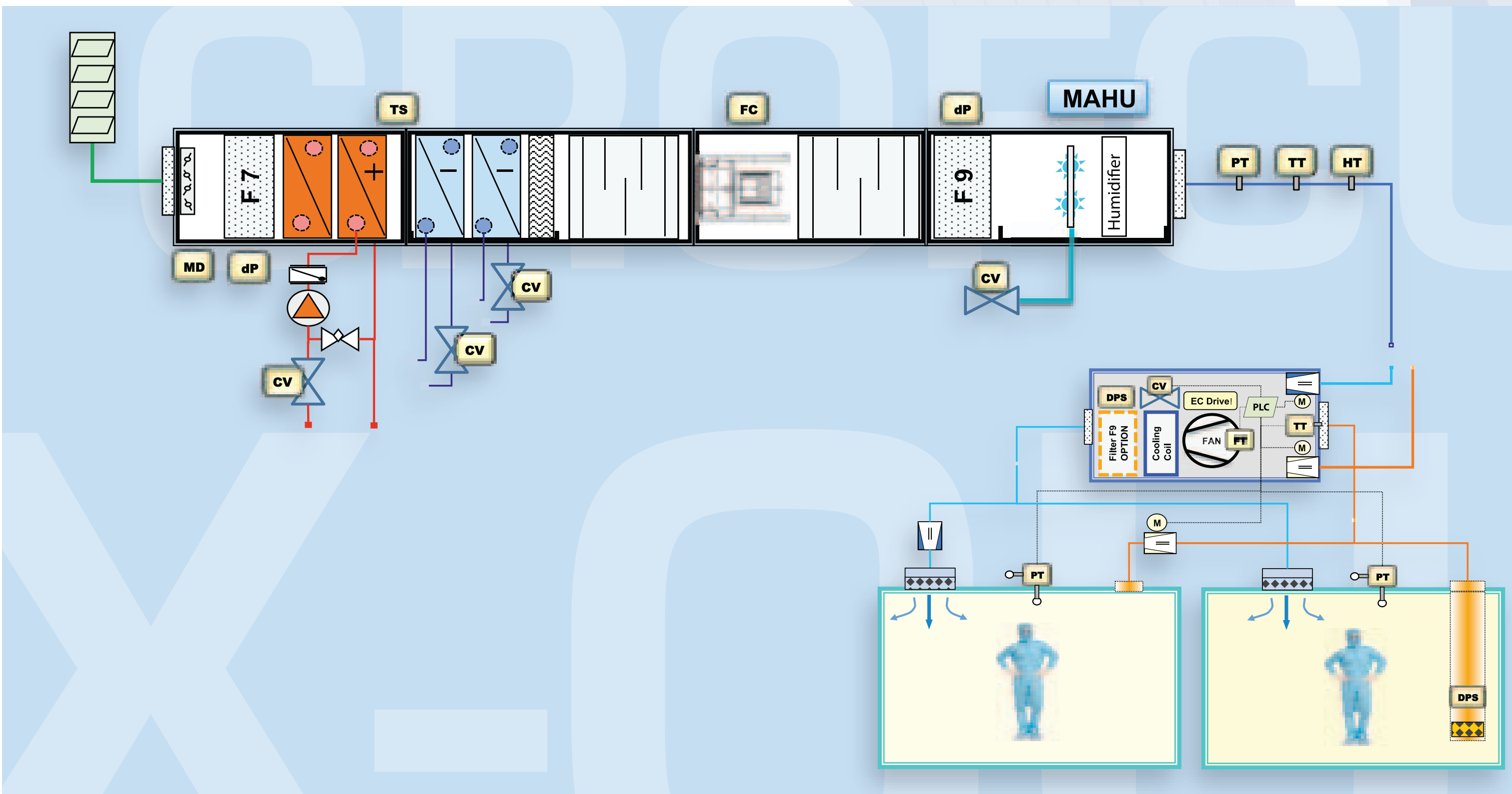
Intelligent room air management and secondary air systems minimise energy consumption

that only a small quantity of air is 'consumed' and hence only a low fresh air flow rate is required. A similar case are thermal loads, which need to be dissipated only in selected spots. It is not always necessary to supply air only in the form of fresh air. Fresh air conditioning by an air handling unit leads to a higher volume flow rate, increased energy consumption, a longer distance over which the air has to flow, and hence a higher pressure loss. This is why in many cases a secondary air system combined with a smaller air handling unit is the more economical solution.

Decentralised solution sets a new standard.

Enter Daldrop + Dr. Ing. Huber engineers, a global leader in the construction of clean room systems, whose experience and the systematic consideration of all requirements for clean rooms have led to the development of the X-CUBE CROFCU, a ventilation unit that sets a new standard in functional diversity and potential applications.

Schematic illustration of a ***CROFCU*** *unit combined with an* ***X-CUBE*** *for fresh air conditioning.*



project report

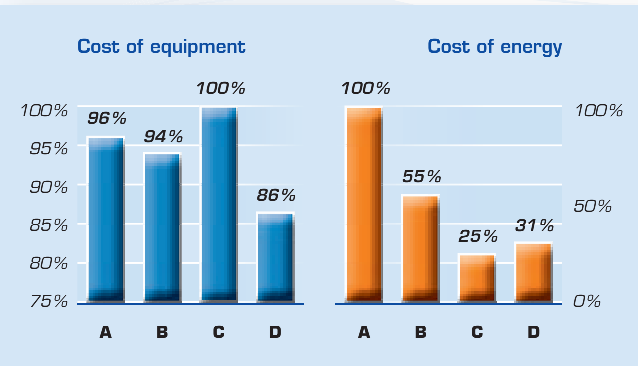
Clean room at the Max Planck Institute, with ***TROX particulate filter air terminal devices***

Proven energy-efficient secondary system.

A comparison of several projects in the pharmaceutical and biotechnology industries has revealed that the X-CUBE CROFCU is the most energy-efficient variant – in particular for air cleanliness classes 7 and 8 to ISO 14644, or classes C and D to EU-GMP.

Practical applications have shown that the X-CUBE CROFCU secondary unit considerably reduces the organisation effort for specialist consultants and HVAC contractors, and that it provides users with a flexible and extraordinarily economical system.

Equipment and energy costs



A Supply air and extract air combinations for defined zones
B Separate fresh air conditioning and secondary air units for definied zones
C Separate fresh air conditioning and fan filter units with zone cooling
D Separate fresh air conditioning and X-CUBE CROFCU in the clean room

Filtration for maximum cleanliness.

In many production areas the environment must be ultra clean, for example in life sciences, the production of pharmaceuticals, or food processing. Or in semiconductor production. In the electronics industry it is necessary to control not only submicrometre particles but also gases, i.e. atoms and molecules of certain substances, in order to avoid contamination and hence adverse effects on the product.

TROX filters meet critical and very critical hygiene requirements in the sensitive and very sensitive areas of medicine, biology, pharmaceuticals and food processing:

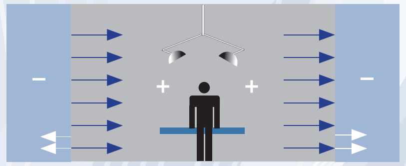
- They meet the hygiene requirements of VDI 6022
- For air cleanliness classes 5 to 8 according to ISO 14644-1
- Particulate filter air terminal devices as final filters, with Mini Pleat filter panels for the separation of suspended particles
- Easy, time-saving and secure filter change due to special press-in frame
- Various diffusers to ideally meet individual requirements

Max Planck Institute for Solar System Research, Göttingen, Germany

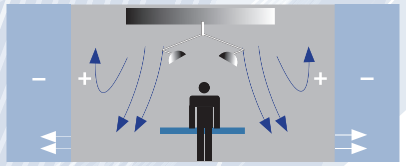
Ideal flow behaviour.

The construction of air terminal devices and their combination and installation position determine the ventilation flow behaviour and hence the effectiveness and efficiency of a clean room strategy. Depending on the air cleanliness class, different types of ventilation may be suitable for clean rooms: low-turbulence laminar flow (LF), turbulent flow (TF), mixed flow (LF and TF), or displacement flow with air discharge near the ground.

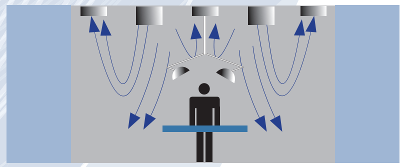
Where the requirements for hygienic air are particularly high, a low-turbulence laminar flow can ensure the removal of contaminated air. Its homogeneous velocity profile and almost parallel flow lines over the entire cross section of the clean area will displace any airborne particles.



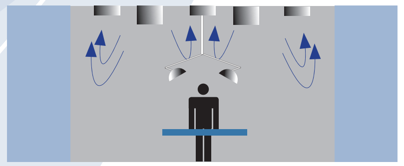
Low-turbulence laminar flow #1



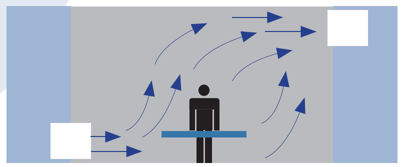
Low-turbulence laminar flow #2



Turbulent flow



Mixed flow



Displacement flow

Depending on the air cleanliness class and other requirements, different types of ventilation can protect the end product from contamination and ensure its quality.

One-stop shop. Complete solutions from a single source.

TROX provides bespoke comprehensive air conditioning solutions that cover each stage of the airflow and hence avoid interface problems: from the air handling unit and fans to measurement and control systems, and to a unique range of aerodynamic air terminal devices, filters, and fire protection and smoke extract components – TROX means that customers can get everything from a single source. Air conditioning systems that are perfectly complementary to each other considerably reduce the effort required from specialist consultants and HVAC contractors.

Important standards and guidelines relating to ventilation and air conditioning

- **EN 779** Particulate air filters for general ventilation – filtration efficiency
- **EN 1822-1** (all parts) Particulate filters (HEPA and ULPA)
- **EN 13779** Ventilation for non-residential buildings – Performance requirements for ventilation and room-conditioning systems
- **EN 16798-3 Draft:** Energy efficiency of buildings; part 3: Requirements for ventilation systems, air conditioning systems and refrigeration systems
- **EN ISO 14644-3** Clean rooms and related clean room areas – test methods
- **EN 12469** Microbiological filters
- **EN ISO 14698** Biocontamination control
- **VDI 2083** parts 1-18
- **VDI 6022 part 1** Hygiene requirements on air handling units and systems
- **DIN 1946-4**
- **SWKI Guideline 99-3**
- **ANSI/ASHRAE Standard 170** Ventilation of health care facilities
- **VMP**
- **EC GMP 2003/94/EC** (Annex 1, 11, 15)

The history of a clean environment.

The Greek word asepsis, meaning "without decay" or "purity", describes the state of sterility. From this, we get the word antisepsis. This does not mean complete sterility, but rather a reduction in the number of germs. The following measures are described as antiseptic.

Aseptic and antiseptic measures include:

Sterilisation:

Germs are eliminated from all medical instruments and clothing, and disposable instruments and clothing packed in sterile conditions are used. Generally, this is a physical process and does not require a chemical biocide.

Water sterilisation:

This is the process of rinsing with highly purified filtered water and the biocide hydrogen peroxide in order to achieve a chemical-physical and ultimately residue-free level of sterility in drinks bottling plants, for example.

Room disinfection:

Here, a chemical biocide and, if necessary, an additional physical process are used. With room disinfection, you can only reach a certain level of sterility (antisepsis), as rooms where people work can never stay completely free from germs.

Room air sterilisation:

A turbulence-free airflow with filtered air is to prevent new germs from entering sterile areas and to displace contaminated air (e.g. from patients or medical staff in operating theatres) from the immediate clean room area.

The discovery of asepsis.

The doctors **Semmelweis** and **Lister** were the first to recognise the significance of controlled, clean environments. The implementation of their hygiene measures in hospitals and operating theatres led to a drastically lower mortality rate among patients.

At the time, it was not yet known that impurities and germs could also be transported through the air. Later on, Robert **Koch** and Louis **Pasteur** were pioneers in the field of **microbiology.** They compiled important findings about how pathogens are transferred. Pasteurisation is based on the discovery that bacteria is killed when it is heated up to between 65 °C and 80 °C.

"Invisible" contamination was then investigated further in order to develop specific ways to combat it. This ultimately led to the development of the concept of **clean room technology**.

The founding fathers of air filtration.

Even back in Hippocratic times, doctors were aware that cleanliness is an absolute must when it comes to fighting diseases. More than **2000 years ago**, the Romans recognised that dust particles in the air could be separated using cloths. In principle, they discovered the filter.

In **1814**, Brisé Fradin developed a filter box filled with cotton wool, which was used to provide respiratory protection to miners.

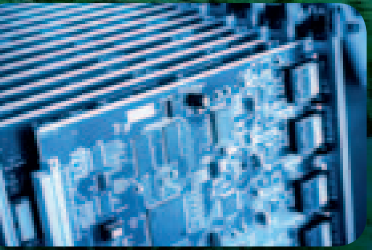
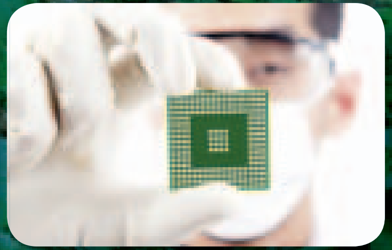
In **1861**, Louis Pasteur tried to separate airborne microorganisms for the first time using a glass test tube filled with cotton wool.

Joseph Lister, (1827–1912)
1. Baron Lister, OM (Order of Merit)
British doctor known as the " father of antiseptic surgery".

The first filling process under clean room conditions.

However, the topic of sterility initially grabbed the attention of the scientific community at the start of the **19th century**. And it was introduced to the manufacturing world by the French confectioner and inventor, François Nicolas Appert, who developed an aseptic filling method for foods such as meat broth, beans and peas in **1810** – conserving by boiling. You could say that his groundbreaking work with the first sterile product filling methods was the precursor to **clean room production.**

Clean rooms.
Production and nature.

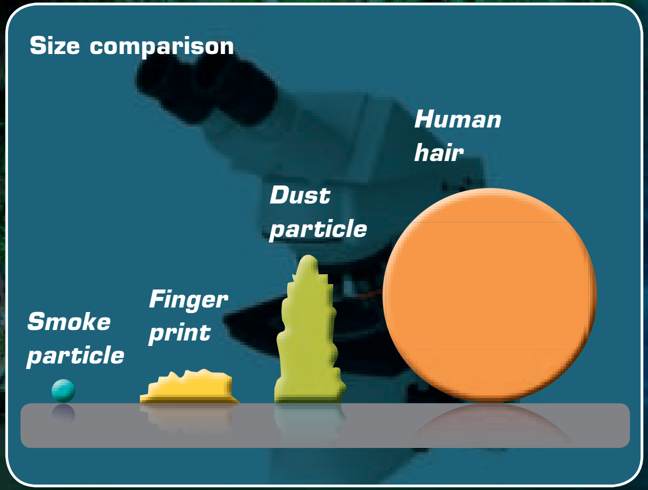
Clean room production.

Miniaturisation requires the cleanest conditions.

Production under clean room conditions was first used after World War II by the American air and space travel, and nuclear industries. For this purpose, new filter systems were developed. With components getting smaller and smaller, experts discovered that integrated micro electronics only functioned when they were manufactured and used under clean room conditions. They found that when you took miniaturisation to a certain level, the particles from the ambient air were becoming the biggest problem when it came to the error rate during production.

Other milestones in the field of clean room technology include the development of the HEPA particulate filter in the 1950s and then the ULPA filter later on.

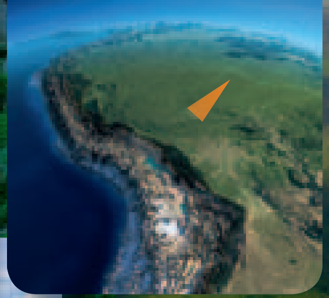
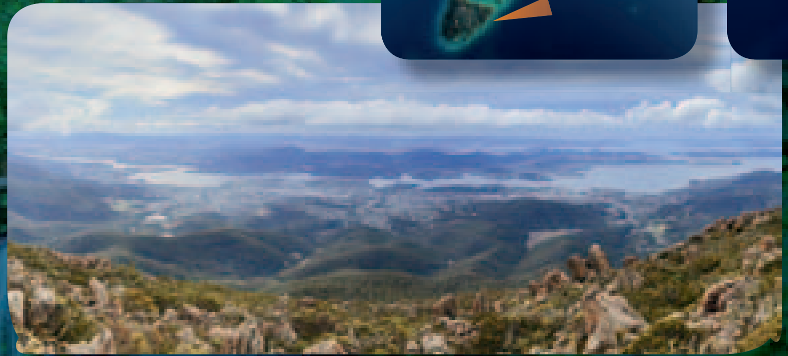
Conventional clean rooms – air-conditioned rooms with high pressure or negative pressure that are accessible through airlocks – have therefore been the norm since the 1960s in many pharmaceutical, medical, precision mechanics and electronics facilities.



If you can imagine that the width of an electronic trace on a modern-day microchip is around 30–250 nanometres, or around 300 times thinner than a human hair, then you get some idea of the enormous demands on clean room technology nowadays.

* Sources: Wikipedia; Reinraumtechnik, published by Lothar Gail, Udo Gommel, Hans-Peter Hortig; Medizintechnik - Life Science Engineering by Erich Wintermantel, Suk-Woo Ha; Clean Room Technology - High-Tech im Wandel der Zeit by Prof. Gernot Dittel

Left: Tasmania, an island on the eastern edge of the Indian Ocean, approximately 240 km south of the Australian mainland; below: panoramic view of Hobart; right: Amazon region, Bolivia, Peru, Brazil


The cleanest air in the world.

Tasmania in eastern Australia claims to have the cleanest air in the world. This is thanks to a natural displacement current: westerly winds which blow across from the Pacific Ocean to the edge of the world – the "roaring forties".

The next mainland on this line of latitude is more than 15,000 kilometres away – South America. With the Antarctic another 2000 km further south and Africa too far north, there is nothing to get in the way of these blustery winds. The westerly winds bring an enormous gust of "clean air" to the island, which replaces the polluted air already there. And the result is really quite pleasant: with low levels of methane, carbon dioxide and nitrous oxide, the "edge of the world", as it is known to the natives, really is home to the cleanest air on Earth.

Natural filtration in the rainforest.

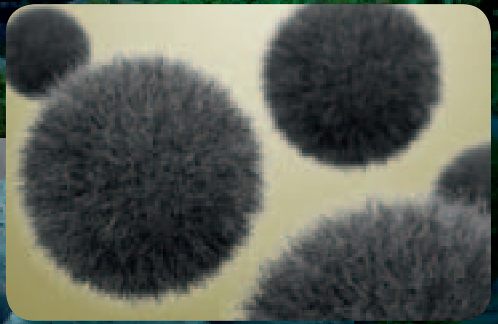
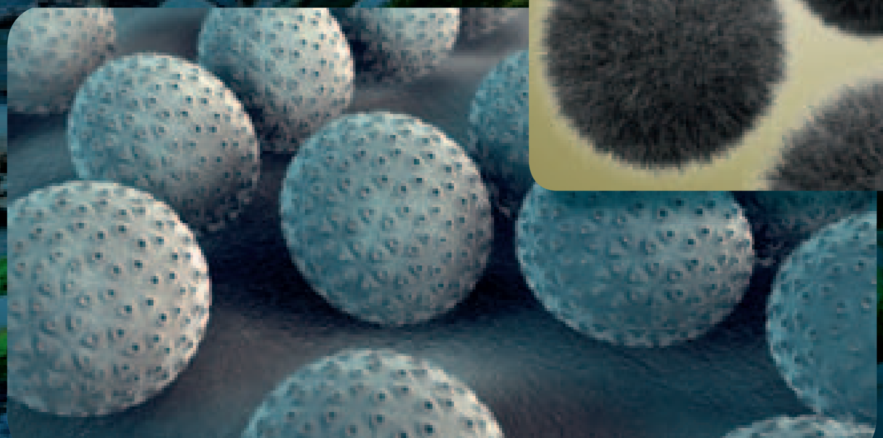
Very few places on Earth are further from the industrialised world than the Amazon rainforest. The Max Planck Institute for Chemistry (Max-Planck-Institut für Chemie) in Mainz, Germany discovered almost "virgin" air here. In other words, air just like it was before cars, factories and power stations took over.

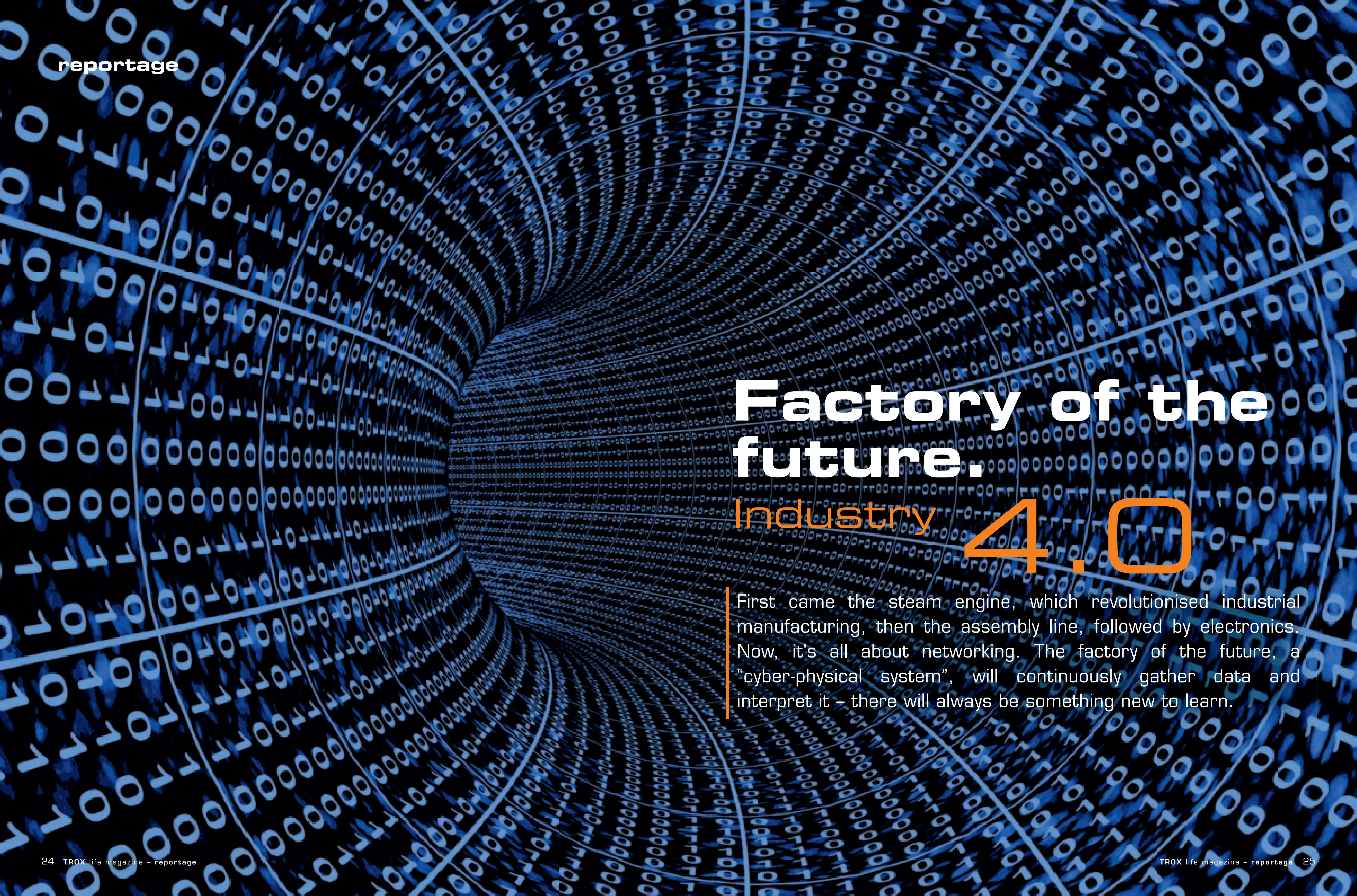
The researchers measured the particles and the concentrations of these that flow through the atmosphere over the rainforest. North easterly airflows from the Atlantic travel around 1600 kilometres over the almost completely unspoilt rainforest and clear away as many dirt particles as possible as they go. The vegetation therefore acts as a natural filter.

Above the towns and cities, you can normally find tens of thousands of particles per cubic centimetre of air, whereas above the jungle, there are just a few hundred – this is mostly particulate matter less than a thousandth of a millimetre in size which has been emitted by the vegetation. You could call this ultrafiltration. The air is nearly completely clean.

The rainforest creates its own climate by releasing pollen, fungal spores and lots of smaller particles on which droplets and ice crystals condense. These condensation nuclei form clouds and then eventually return to the Earth as rain. This is the key to the constantly damp climate found in the rainforest.

Right: dust particles under a microscope; below: pollen enlarged

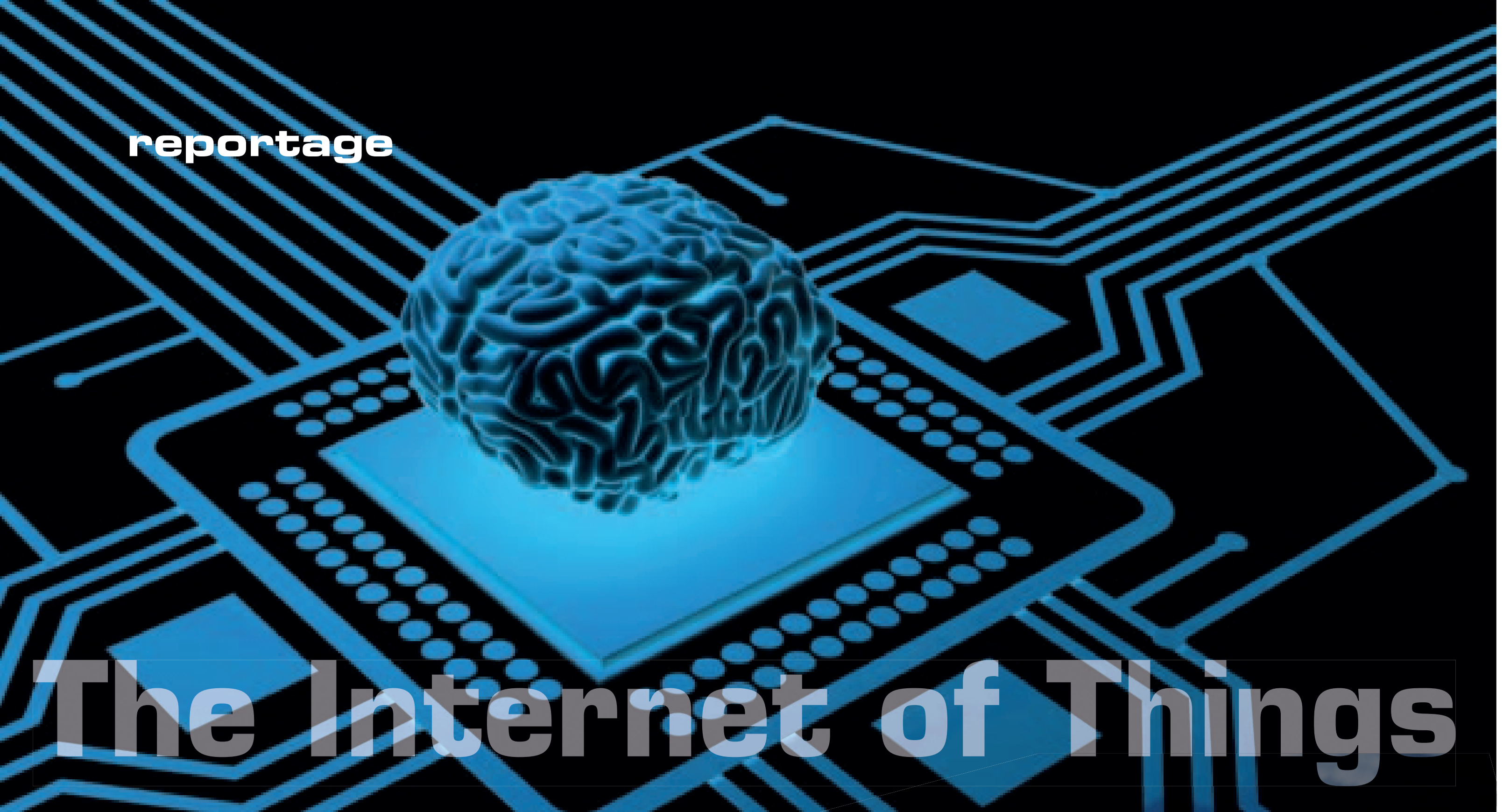





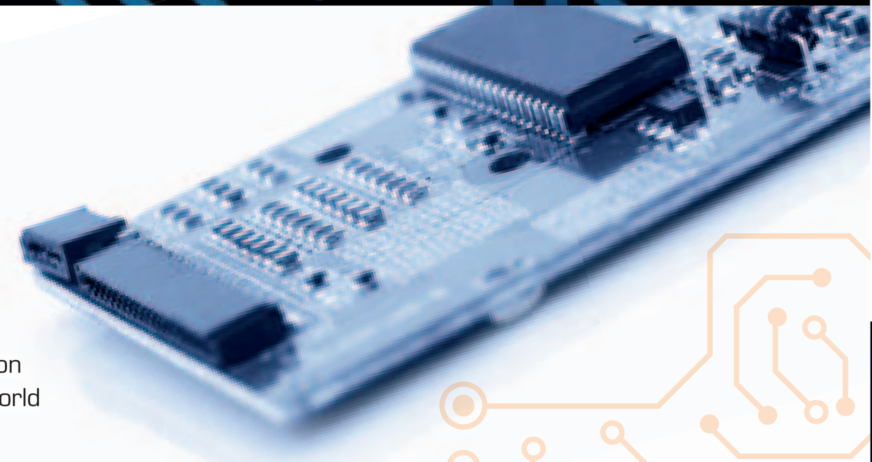
Factory of the future.

Industry 4.0

First came the steam engine, which revolutionised industrial manufacturing, then the assembly line, followed by electronics. Now, it's all about networking. The factory of the future, a "cyber-physical system", will continuously gather data and interpret it – there will always be something new to learn.



The Internet of Things



The Internet of Things.

The term "internet" comes from Kevin Ashton, a British technology pioneer. As the head of the Auto-ID Center at the Massachusetts Institute of Technology (MIT), he coined term “the Internet of Things” in 1999. In the Internet of Things, objects are equipped with artificial intelligence. They can exchange information with one another over the Internet, fusing the real world and the virtual world together.

New, groundbreaking developments have paved the way for this technology. Today, you can find everyday items fitted with miniature computers at a reasonable price. Not only can products acquire their own identity thanks to RFID (radio-frequency identification) but they can also record conditions with the help of sensors and actuators and even react to these: washing machines can wash independently without human input. And they can switch themselves on precisely when power is at its cheapest.

Cars will soon control themselves. Fridges will order more butter and milk when you have used them up. However, there is much more to the Internet of Things than simply creating a “smart home” or easing and improving everyday tasks. It is set to influence industrial manufacturing to a much greater extent. We are talking, of course, about the 4th industrial revolution, known as Industry 4.0. Experts predict that 50 billion objects will be networked by 2020.

The 4th industrial revolution.
Machines and the web growing together.

More and more objects are being fitted with artificial intelligence (embedded systems). With these being increasingly interconnected to cyber-physical systems and interacting with the Internet, the real world of tangible items and the virtual world of cyberspace are growing together more and more rapidly. The Internet of Things will trigger a radical change.

In logistics, automated processes are already being used. Containers are equipped with a chip which contains information about the product and its destination. When they go through the sorting machine, they transmit their destination. The package is then sorted accordingly and forwarded on to the correct location. These processes run quickly, autonomously and on-site.

Cyber factory.
Automating means of production.

The Internet of Things is opening up unprecedented opportunities, which will help to make manufacturing more flexible. The data required for controlling production is transported with and transmitted by the components themselves. As a result, product processes are becoming better, more precise and quicker to control without the need for a complicated central control system.

Products and devices with their own sensors are already able to record and process data from their surroundings, for example, blood bags independently measure the storage temperature and storage time. If one of these parameters is exceeded, it informs the storage system to ensure a replacement is provided immediately.

Logic components, which are embedded into devices, systems and products, can measure, regulate and control. Components in the factory are conveyed autonomously to the next free machine, where they can be processed. What's more, machines with embedded systems can also measure and pass on information about power consumption, tool wear and much more. This data is vital for maintenance tasks and can now be gathered much more efficiently and cost-effectively.

TROXNETCOM
to carry out automated functional tests for fire dampers and smoke control dampers

Control and regulation components at all levels of industrial processes enable much more significant levels of variation. This means that resource management and processes can be optimised, designs can be made more varied and factories can react more easily to the specific requirements of their customers.

Now, Swedish researchers have even developed electronic labels which can be printed using a standard printer and can connect to the mobile phone network. If these can prove themselves in practice, they would really revolutionise the manufacture of logic components. They could be produced more simply and cost-effectively, and could further the development of the Internet of Things.

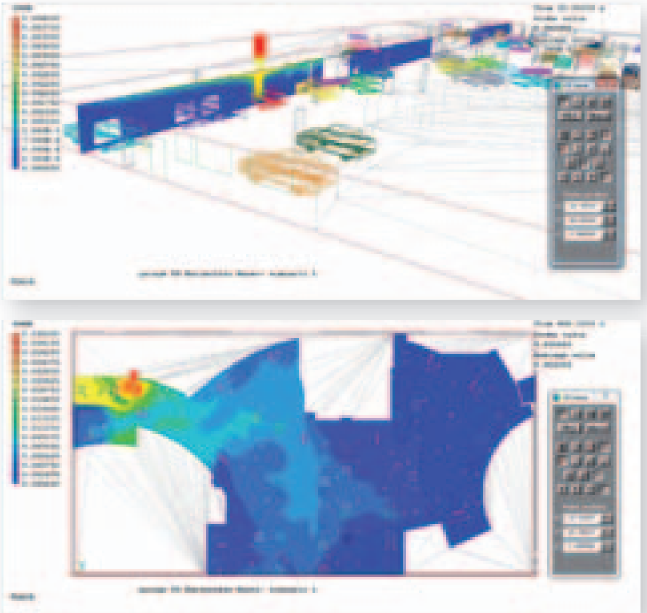
TROX 4.0

At TROX TLT, Industry 4.0 has already begun with our automated diagnosis systems. The intelligent fan diagnosis system is always on hand to investigate the condition of the fans, particularly the motors. This allows the operator to assess the condition of the components on an individual basis and therefore put measures in place immediately to carry out maintenance on the motor and ensure safe operation. With smoke exhaust fans in particular, this is a marked improvement on the previous practice of periodic inspections as the costs are considerably lower. There's also the TROXNETCOM system, which enables automated functional tests for fire dampers and smoke control dampers to be carried out. At TROX, we provide intelligent monitoring systems which ensure that the fire protection of a building is at the very highest safety level.

The intelligent TROX TLT fan checks the condition of its components independently

Virtual reality.

Another pioneering cyber technology, which is often used when constructing industrial plants, is design aided by "virtual reality" – often abbreviated as VR. Machines, systems and also entire buildings are simulated using high-performance computers. This means that mock-ups can be made in a virtual reality. In the room air conditioning and mechanical smoke extraction sectors, VR visualisation is already used as an advanced analysis tool. For example, mock-ups make it possible to visualise how smoke would spread in the event of a fire. This makes it easier to assess potential risks and means that planners can use concrete data to help plan emergency exits.

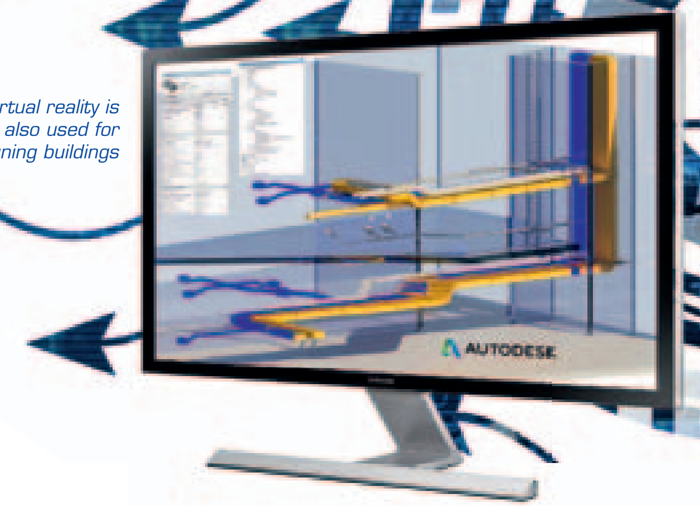


Computer simulations show the path of the smoke in the event of a fire.

The automotive industry* is already working hard to virtually model manufacturing steps, industrial robots and even entire factories. The aim is to be able to plan the construction of a new type of car precisely. In an ideal world, we would also be able to reorganise entire factories at the touch of a button. To do this, robots and their workflow must be simulated on the computer in a way that is as realistic as possible so that they can be programmed remotely. When upgrading to a new model, there is no need for costly downtime as the machines are no longer set manually.

[* DIE WELT 21.02.14 BMW plant sich selbst abstimmende Maschinen [BMW designs self-tuning machines].]

Intelligent robots also increase productivity when manufacturing TROX fire dampers.



Virtual reality is also used for designing buildings

BIM: virtual reality in buildings.

In the building sector, one virtual design method is coming out on top – Building Information Modelling. All important data for the building is digitally recorded, combined and visually represented in a building model. This means that the workflows for all those involved, such as architects, designers and building owners, are integrated into the model at the very start. Interface problems are eliminated from the beginning, which guarantees a smooth workflow and good communication.

Clean room industry 4.0

The future has already arrived in the field of clean room technology. Flow simulations combined with geometric VR models are already being used successfully in the clean room air conditioning sector to increase the efficiency of the systems even further. As a result, the characteristics of the airflow in the building can be observed at an early design stage, which is crucial for a clean room project. Architects and designers can track how scattered particles spread out and where there could be unfavourable airflow conditions in a visualised production hall on the computer. Using this data, ventilation components can be arranged in an optimum manner and energy consumption can be reduced.

With surface and circuit structures gradually getting smaller and smaller, there is a great deal of demand for even more intensive clean room technology – nowadays, microchips are already produced with structures measuring 30 nanometres in width, a dimension much smaller than the wavelength of light. The last thing anyone wants is for any particles to get in the way. Because of this, production conditions are edging closer towards an almost unthinkable requirement – zero tolerance. Deviations in the chip structure are only permissible at a size of one to ten billion. That is the equivalent of a tiny pothole one tenth of a millimetre deep on the road from Flensburg, one of the most northerly towns in Germany to Füssen, one of the most southerly.

As a complete contrast to this, some production plants have now reached unfathomable dimensions. A plant making liquid-crystal displays in Korea measures between 150 and 180,000 square metres. That's the same as all of the football pitches in the German Bundesliga. And that's nothing compared to the 1.3 million square metre factory for LCD TVs built by Foxconn Electronics and Sony in China. From this factory, a whole new area has been created where 500,000 people will be able to work and where 30 million LCD TVs will be manufactured.

Clean rooms.

Growing air conditioning segment.

The demand for clean room products is growing continuously. This can be attributed to many factors, including strict hygiene rules and increasing requirements for the protection and quality of products, the strong momentum of the pharmaceutical industry, the public health sector, biotechnology and the constant miniaturisation in the semiconductor and nano industries. Clean room technology is finding more and more areas of application.

The clean room sector is part of the technology industry along with air conditioning systems and filters, as well as protective clothing and cleaning agents. It has a global market volume worth over $10 billion. Nearly 40 % of this comes from the construction sector. The majority comes from consumables. Experts predict that the market for technical equipment for clean rooms will grow by 5% each year for the next five years.

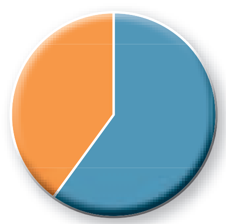
Asia will be at the heart of the action. It's hardly surprising as this is where most of the microchip industries are currently based. From a regional point of view, Asia is leading the way and will most likely be home to the sharpest growth, both in terms of hardware and consumables. China is the fastest growing producer of semiconductors and nearly all component manufacturers for displays and screens are based in Asia. Here, you can now find a 1.3 million square metre area dedicated to the production of LCDs. That's about a third of the size of Central Park.

If you use consumables as an indicator, around two thirds of the market volume comes from Asia with this trend increasing rapidly, then comes America with around 20% and Europe lags behind with just 15%.

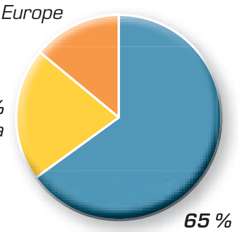
According to the German Clean Room Institute (DRRI), the German clean room technology sector, which has around 15,000 employees, generates an annual turnover of around €2.5 billion (around $3.5 billion) and really contributes to the success of Germany as a technological and manufacturing location.

The figures say it all: there is momentum in the market for clean room products and the ventilation and air conditioning technology sector will also be able to benefit from this.

Clean room products: worldwide market distribution



Regional distribution of the sales of consumables



Sources: Cleanroom World-market, Cleanroom Technology Market Report, 2014

The purity of German beer.

In 1516 and now.

Even today, German beer must be brewed using just malt, hops, yeast and water in accordance with the legislation. This purity law is the oldest food law that is still valid today. Next year, the German purity law will celebrate its 500th anniversary. It dates back to William IV, the Duke of Bavaria. After it came into force, only barley, hops and water were allowed to be used to make beer. The important role of yeast was not known at the time. This came along later.

The aim of the purity law was to prevent imitations or the use of harmful additives as a wide range of herbs or other mixtures were added to the mixture to make it last longer. Certain herbs failed to do this and it was not uncommon for a glass of beer to be fatal.

Yeast came into play more or less by accident. Much later on, it was proven that it was the actual reason for the shelf life of the barley drink. In the Middle Ages, it was usually the women who brewed the beer. Many of them were bakers and these were the ones who turned out to be the best master brewers. Why? Legend has it that they stored the beer mixture in containers where they had previously kneaded bread dough. The yeast remnants in the barrels increased the shelf life of the beer.

When a woman was less fortunate and her beer perished because she didn't have yeast remnants in her container, people would say **"hops and malt are wasted on her."** She could try to brew no less than ten separate batches of beer but, on average, only two would be successful.

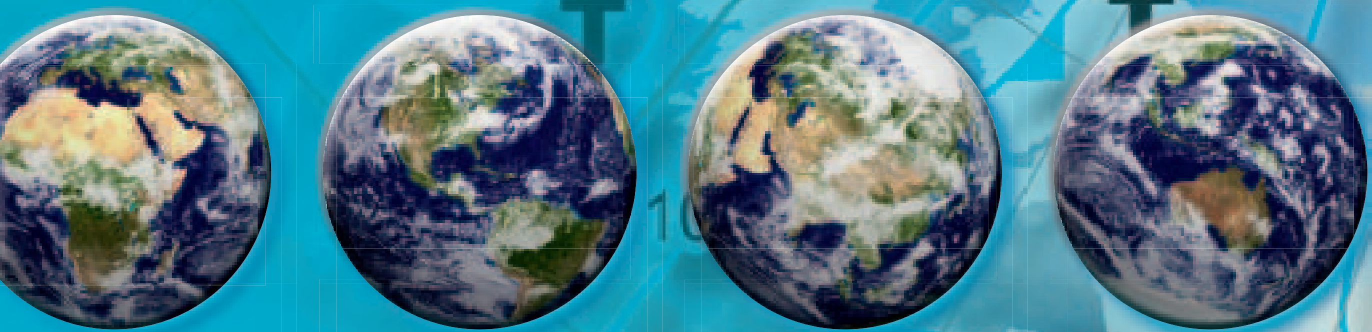
In the mid 16th century, the magic formula was discovered: alcoholic fermentation. Since then we have known that yeast combined with sugar was responsible for this reaction. About 200 years later in 1789, the researcher Lavoisier discovered that the combination of yeast and sugar had a huge impact on the product: the alcohol content, the longer shelf life associated with this and the sparkling character of the beer. By adding yeast, the malt sugar in the wort is converted into alcohol and carbon dioxide.

Cheers!

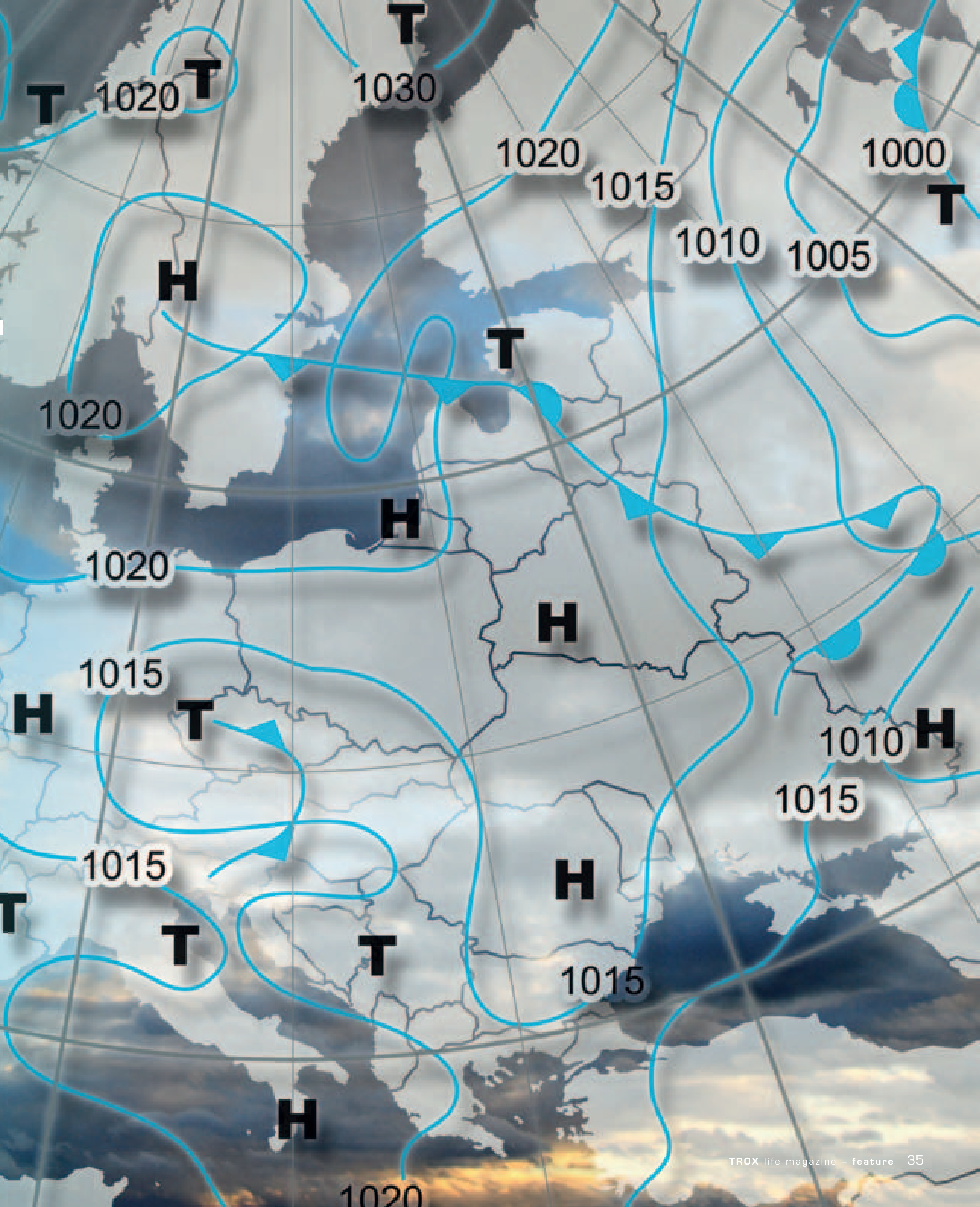
feature

Clean rooms and the weather.

Atmospheric conditions and pressure systems.



Clean rooms and the weather have so much in common. After all, air pressure, airflows and air balances are crucial factors for both.



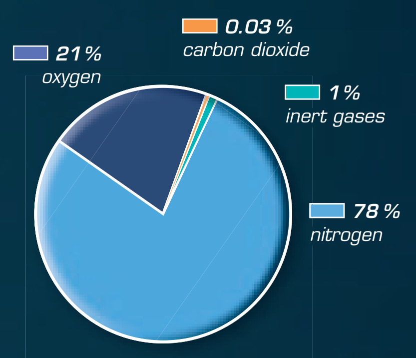
feature

The Earth and a clean room. A comparison.

Let's look at the Earth as if it were a room – a room filled with air. This air makes up the Earth's atmosphere, which exhibits different air pressure conditions. And we have the same in the clean room. Put simply, the clean room is a sealed-off space through which highly purified, and therefore clean, air flows. It is how the Earth would have been if humans had not caused air pollution.

In clean room systems, the different air pressure conditions provide the boundary between different clean areas. On Earth, they influence the weather. And the airflows provide the climatic conditions for both.

Composition of our air

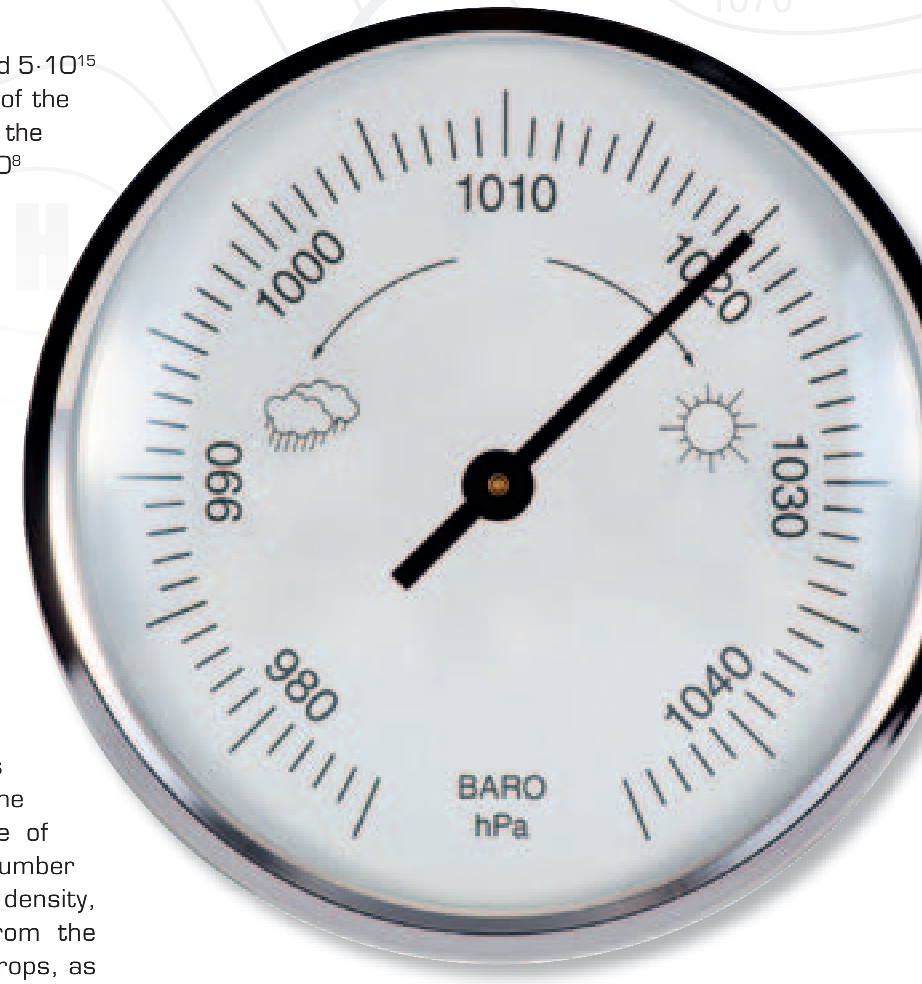


Element air.

Our air is a gas mixture of the Earth's atmosphere. It is mostly made up of the elements nitrogen and oxygen. Alongside these, the air also contains components such as argon, carbon dioxide, other trace gases and water vapour. Air particles naturally have some weight and are drawn by the Earth. This causes pressure to develop.

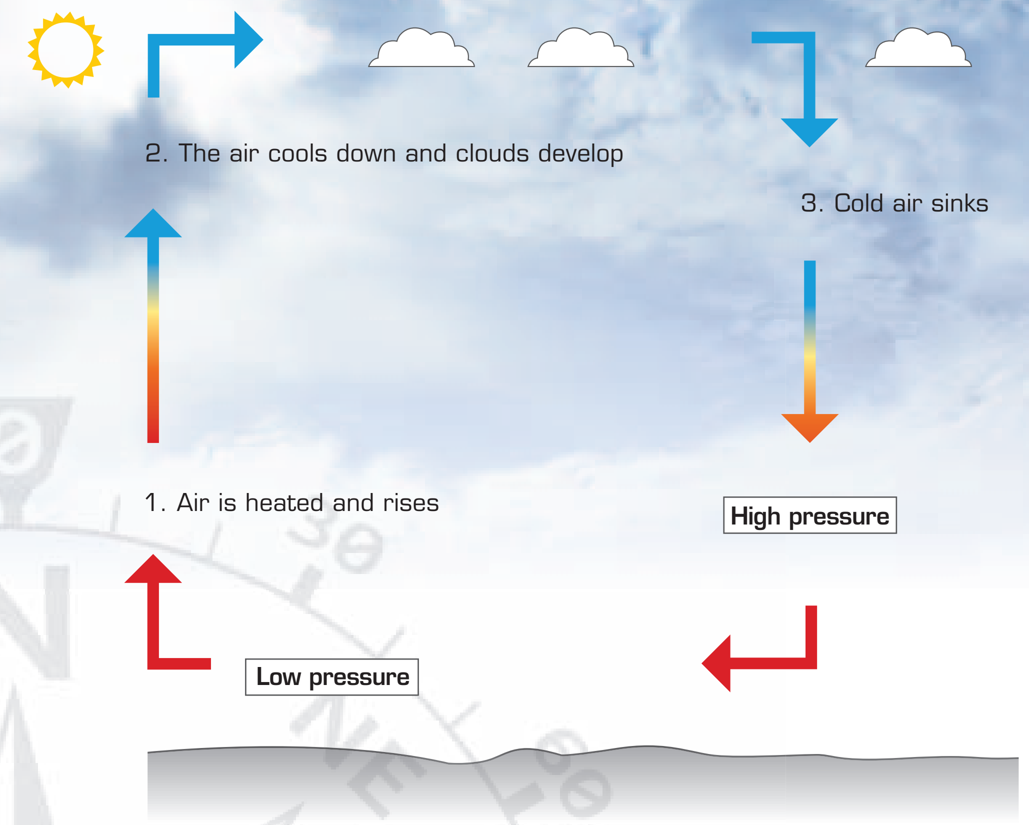
The hydrostatic pressure of air.

The Earth's atmosphere has a mass of around $5 \cdot 10^{15}$ tons. This means that each square kilometre of the Earth's surface has around 10 tons of the atmosphere weighing down on it (around $5 \cdot 10^{8}$ km² or $5 \cdot 10^{14}$ m²). The pressure, or force, exerted on each square surface unit is 10^{5} N/m² (100,000 N/m²) at sea level. As the air density is so low at the Earth's surface (around 1.2 kg/m³) and the changes in pressure around our bodies are only very small, we humans do not feel this force. In water, on the other hand, where the density is 1000 greater, the differences in pressure on our bodies make us noticeably buoyant, i.e. they make us feel lighter.



Pressure, temperature and density are directly correlated.

If the temperature increases, the particles move quicker, and collide and bounce off one another with increased momentum. Because of this, they separate from one another. The number of atoms (mass) in the air, and therefore the density, decreases. The further you move away from the Earth's surface, the more the air pressure drops, as there are fewer air masses the further up you go.



Airflows determine the weather.

Our weather is closely linked to the varying air pressure within the atmosphere. If the sun warms the air at ground level, it expands, becomes lighter and rises. In the mountain air, there are fewer air particles. The air has a lower density and the air pressure is lower. This creates an area of low pressure. The rising warm air carries humidity, and as air cools the higher it rises, it then forms clouds. Cooled air is heavy and sinks back to the area of low pressure. On its way down, the cool air heats up, absorbs the water vapour and the cloud disappears – resulting in pleasant weather. As the sinking air masses push down on the air underneath, we call this an area of high pressure.

To compensate for the different air pressure at ground level, the air from the areas of high pressure flows into the areas of low pressure. This is where wind comes from.

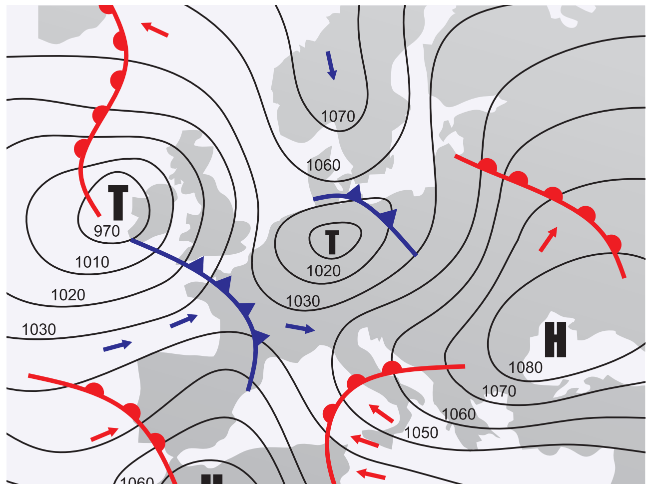
WEATHER SERVICE

Weather forecasts.

Stable air pressure.
Usually, you will find stable air pressure during an extended period of high pressure. This is normally a sign of consistently and continuously good weather conditions. In most cases, during high pressure weather conditions, the pressure remains constant for days or even weeks.

Rising air pressure.
A slow and constant increase indicates that the weather will improve in the long term while a sharp increase, noticeably above 1 hPa/hour, signals that the weather will improve temporarily. This can point to an upcoming high pressure storm.

Falling air pressure.
A slow and steady drop indicates a change in the weather conditions. Most of the time, it means that a period of good weather is coming to an end. When the air pressure drops sharply, this is a sign that an area of low pressure, which will bring poor weather conditions with it, is approaching. Depending on the degree of the pressure drop, a storm might be expected.



Air pressure and sensitivity to weather conditions.

Eva Wanka, an environmental epidemiologist from Munich, found that low frequency fluctuations in the air pressure can make people sensitive to changes in weather conditions. This is caused by the pressure receptors found in the carotid artery, which regulate heart rate and blood pressure.

"The peripheral blood vessels expand when they get warm and the body therefore releases more heat. The reverse is true in cold conditions. This can cause problems for people with high or low blood pressure."

Clean room air handling technology reacts to the weather.

As well as the air hygiene level, other important parameters in clean room air handling technology include humidity and air temperature, which must be controlled by the central air handling unit in accordance with the requirements and production environment. For this, you need a reliable sensor that continuously checks the condition of the air.

An intelligent air management system must not only measure cold, hard facts but must also take into account less concrete factors. As a result, forecasting models for the weather play a key role as parameters such as temperature and relative humidity are influenced by the atmospheric conditions.

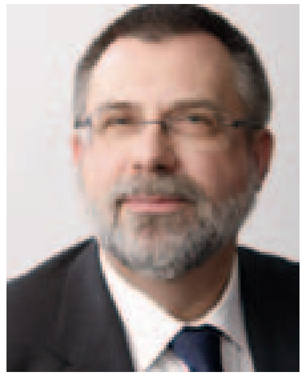
Therefore, the more accurate the forecast for the natural surroundings and the more prepared the air handling system is to react to these, the more energy-efficient the system will be.

For example: To dehumidify the air, cold conditions are required. Moist air must be cooled down to 6 °C. When the temperature is dropping significantly, the system switches to free cooling, which saves a considerable amount of energy.

Or: On a hot summer's day, the forecast is for the temperature to drop considerably the next day. The system will then react by "cooling less" during the night rather than "heating up" the next day.

Clean room expert.

An interview with Prof. Dr. Weißsieker.



Prof. Dr. Horst Weißsieker
ICTP Director Germany at Deerns
Publically appointed and sworn expert on the clean room technology sector for the Cologne Chamber of Commerce and Industry (IHK)
Honorary professor of project management at the Ilia State University in Tbilisi, Georgia

Professor Weißsieker, we read that you wanted to be an astronaut as a child?

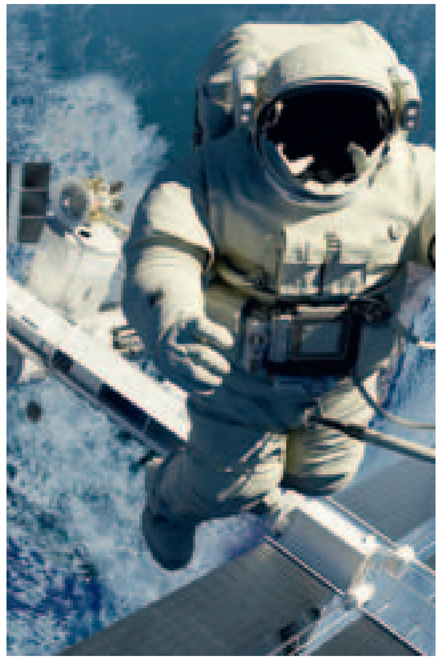
Oh yes I did, but I eventually ended up in the field of physics, although my specialism is astrophysics.

And how did you get from space to clean rooms?

As with many things in life, that happened by chance. As a student, I worked as a taxi driver and met Wolf Ziemer (editor's note: at Fläkt Lufttechnik at the time). He sparked my interest in particle physics and clean room technology. For my doctoral thesis, I wrote about clean room monitoring and active clean room control.

Incidentally, the jump from space to clean rooms is not really that big. After all, the foundations of modern clean room production lie in space travel and satellite manufacturing. Clean room technology also plays a crucial role in space flight as it is used to avoid contamination to or from space.

interview



Last year, Alexander Gerst spent half a year on the ISS. Wouldn't you like to have gone to the ISS and wouldn't clean room technology also be an interesting research project for the universe?
You're right, going to the Space Station is a long-standing dream of mine. I'm dying to go but I'm not getting any younger…

For those of us who aren't experts on air, how are astronauts even supplied with air on the ISS? Can clean room conditions also be created out in space?
On the International Space Station, oxygen is created through the electrolysis of water. The excess hydrogen is released into the universe. When the oxygen is used by the astronauts, carbon dioxide is released, which is chemically bonded and removed from the process accordingly. As a result, relatively large quantities of water must be transported to the ISS on a regular basis.

Of course, the air in the space stations is also filtered, circulated and enriched with oxygen. Good air filtration is crucial so that particulate matter cannot accumulate in critical areas. With zero gravity, particulate matter of all sizes remains airborne.

We have already successfully completed a number of clean room experiments in the various space stations. The applications ranged from pharmaceuticals and medical technology right up to micro electronics and biotechnology. Many of the production steps for clean rooms take place in a vacuum. And where else are you going to find more of a vacuum than space?

Do you have any ideas for possible space-related clean room research topics?
Under zero gravity conditions, more uniform layers develop – this is something you need for nearly all applications. Some clean room technology processes may only be possible under zero gravity conditions.

As part of your job as a clean room expert, you have visited more than 50 countries. Can you conclude from this that Germany plays a leading role in the global clean room technology sector?
Germany is, in fact, the leader in this sector in terms of guidelines, innovations and plant engineering. I am so pleased and a little bit proud to have been able to make a contribution to this over my 30-year career.

Not only do you teach about and design clean rooms, you are also one of the most acclaimed consultants on the business side of clean rooms. Without going into too much detail, can you tell us what clean room consultancy is all about?
My first consulting job involved a clean room that had been constructed ten years previously. So the case had already been going on for quite some time. After about 1 ½ years, the case came to an end with a compromise. In my projects, I often find that the parties are not aware of or do not know who has to provide what, or who has to deliver what. I can usually help to try and find a compromise as early on as possible in the dispute.

You are the chairman of the Green Hospital panel of experts for the Association of German of Engineers (VDI). It appears to be generating a great deal of momentum in the health sector.
Just like during the energy revolution, Germany is generating a great deal of momentum in the energy sector. The expertise of our engineers and our innovative edge in the field of renewable energy means that we have a real competitive advantage when it comes to green technologies.

In hospitals, as well as the quality of the air, we are paying a great deal of attention to efficiency in many different areas: building equipment, medical technology and workflows. The consumption of electrical energy in hospitals amounts nowadays to 20 % of their total energy consumption, and to around 50 % of their energy costs. As we know, the best energy is the energy that is not wasted. We now build hospitals in many countries that have the passive house standard. This relieves the strain hugely for health establishments wich are usually under severe cost pressure. As a result, Green Hospital has become a globally recognised brand.

Professor Weißsieker, thank you very much for talking to us.

TROX at the
ISH
2015

The entire world of air conditioning.

With the presentation of its one-stop shop strategy at the ISH/Aircontec in Frankfurt, Germany, TROX came full circle. We have rounded off our portfolio and are able to provide the ventilation and air conditioning equipment for every application. What is more, our air conditioning solutions are fitted with dedicated, intelligent measurement and control systems that enables the widest possible range of functions and maximum energy efficiency for ventilation and air conditioning.

Comfort air conditioning system with room and zone control X-AIRCONTROL.

TROX sets a new standard in residential construction with its whisper-quiet, compact residential ventilation units.

New hydraulic unit for high-efficiency run around coil systems for diverse applications.

NFC allows for quick diagnosis using a smartphone.

From components to systems.

TROX at the ISH/Aircontec 2015 was not just about individual components or units but also about complete system solutions for each type of building. To allow visitors to not only see, but actually experience what we are committed to, the TROX booth was divided into four sections:

- **Comfort air conditioning system**
- **Smoke extract systems**
- **Demand-controlled residential ventilation systems**
- **Decentralised ventilation systems**

Whether airport or office building, school, hospital or clean room, individual flat or block of flats – TROX is in a favourable position to provide not only components and units but complete solutions for each type of building, and then from a single source. The advantages cannot be underestimated: fewer interfaces, shorter installation time, maximum range of functions, sustainability, and internationally certified components that are ideally complementary to each other.

To allow visitors to not only see, but actually experience what we are committed to, a complete comfort air conditioning system was installed at the TROX booth. Plus innovative smoke extract systems, energy-efficient central and decentralised air-water systems, and new products for residential ventilation.

Innovations, made by TROX.

Read on and learn about the latest innovations that TROX presented at the ISH, and about the special features and advantages of technology from TROX.

Intelligence built into the system.

A new overall control system with a unique range of functions ensures energy-efficient air management combined with unparalleled comfort: X-CUBE-CONTROL, the X-CUBE control system; X-AIRCONTROL, for room and zone control based on room temperature, air quality and occupancy; and TROXNETCOM, the proven solution for fire protection and smoke extract systems. All three control systems complement each other perfectly, can be integrated with each other, and allow for operation from a smartphone with an app.

TROX actually controls and monitors the entire ventilation and air conditioning system, particularly for small and medium-sized applications, and with or without connection to the central BMS.

X-CUBE CONTROL

Hygienic circulation for highly sensitive areas.

In the high-efficiency run around coil system the optional heat exchangers for supply and extract air are connected hydraulically but are otherwise completely separate. This is why the system recommends itself for highly sensitive areas. The high-efficiency run around coil system, or HE-RCS, can be easily integrated with the TROX X-CUBE with its unlimited configuration options. The HE-RCS safely prevents the spread of odorous or otherwise undesired substances. The internal control system can be integrated with X-CUBE-CONTROL.

Volume flow rates: Everything under control.

Thanks to Near Field Communication (NFC), the new TROX Compact controllers can be read out with an Android smartphone while in operation; all it requires is the TROX FlowCheck app.

Safety first. Certified safety systems.

TROX aims to be the pacemaker in the fire protection and smoke extract industry. At the ISH, TROX demonstrated sophisticated smoke extract strategies with components that complement each other, such as jet exhaust fans, axial fire gas roof fans, mechanical smoke extract systems or duct smoke detectors. TROX links these components with TROXNETCOM to achieve an intelligent fire protection and smoke extract system.

Modular and multifunctional.

The duct smoke detector RM-O-M, with integral airflow and contamination monitoring, is a modular system and can be integrated with every fire protection system. The unique removable display unit facilitates diagnosis and operation even in case of unfavourable installation situations.

Handy: The mobile display and control panel for the RM-O-M duct smoke detector.

TROX fire dampers: CE-certified for installation with a flexible ceiling joint, flange-to-flange, mortar-based or with a fire batt, to name but a few installation types; TROXNETCOM ensures the safe connection to the air conditioning system.

Saving energy the safe way: the new TROX TLT axial fire gas roof fan of Type DAX.

Fire protection systems certified for use across Europe.

Modern architecture requires ever increasing application flexibility and more and more practical, proven installation solutions. Specialist consultants, HVAC contractors, and operators can rely on the European CE certification according to the Construction Products Regulation (CPR) and on the extensive declaration of performance; the declaration lists the essential characteristics relevant to each installation situation, thereby providing an overview of the performance of a product.

The TROX portfolio of fire protection and smoke extract components that are certified for use everywhere in Europe provides the utmost safety.

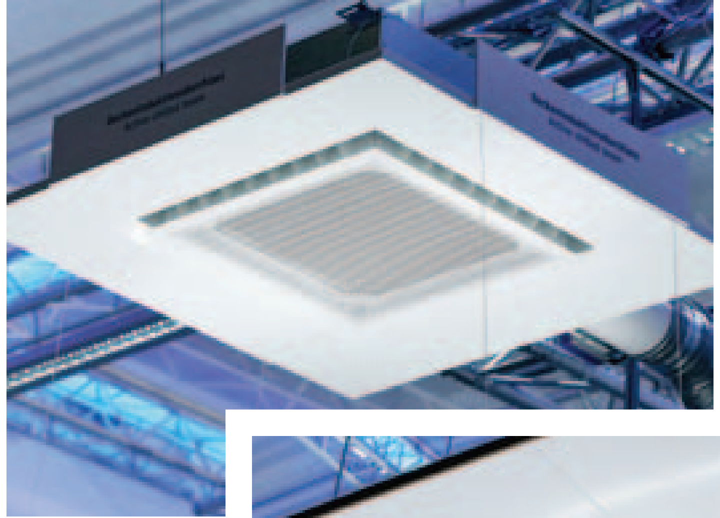
CE-compliant smoke extract systems for maximum safety.

The EK-EU smoke control damper sets a new standard in the building sector. It is provided with CE certificate and general building inspectorate licence and meets the highest requirements for safety.

Smoke extract according to the German Energy Saving Ordinance (EnEV).

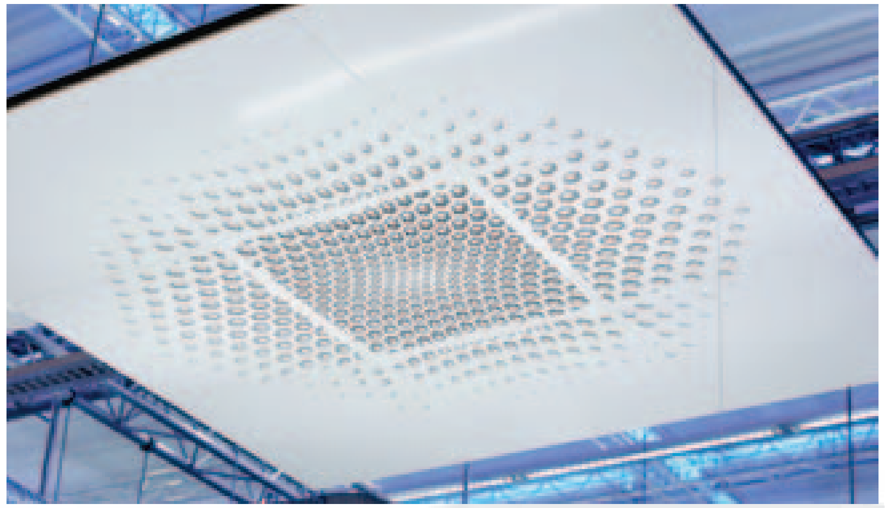
The new axial fire gas roof fan (BV AX) of Type DAX has a casing with complete thermal insulation and hence seals the building envelope. With its double skin casing and two fixed extract air dampers it meets the requirements of the German Energy Saving Ordinance (EnEV).

Test rig for long-term functional testing of actuators according to test standard EN 1366-10, for smoke control dampers in a duct.



The Type DID 614 active chilled beam with four-way air discharge offers a choice of five nozzle variants and various water connections such that it can be ideally adapted to project-specific requirements. The removable induced air grille is held in place by magnets and has an aesthetic perforation with decreasing apertures towards the edges.

Maintenance and cleaning of the decentralised under floor ventilation unit FSL-U-ZAS are easy after simply removing the grille. Operation is completely condensation-free due to a new control strategy.



Focus Design: A diffuser front of a futuristic design conceals the functional unit and blends in nicely with the ceiling.

Ideal airflow.

The aerodynamic optimisation of air terminal devices, ventilation units and filters is an ongoing process at TROX and an important aspect of energy efficiency. While technical improvement is important, the design must not be neglected – only then will it be possible to find the best solutions also for architects.

The DID 642 active chilled beam is impressive because of its slim construction. The new nozzles cause fewer pressure losses and allow for a broader range of applications. The unit can be installed freely suspended, in plasterboard ceilings or in open cell ceilings.

Air for the people, water for the loads.

Air-water systems are ideal for refurbishments because they require neither a ventilation plant room, nor a duct system, and can be integrated with the existing architecture. They can be installed in a floor, ceiling, wall or façade.

Progressive design for air management solutions.

Technical function and design of the XARTO are independent of each other, which opens up new perspectives of interior decoration. This has been proven by the Focus Design competition, which was initiated by TROX. Renowned architecture offices and specialist consultants designed diffuser fronts that blend in perfectly with the ceiling and constitute an attractive design element in their own right. Another new product: The RFD ceiling diffuser, which is covered by a finely perforated ceiling tile, i.e. not visible, and the decentralised under floor ventilation unit FSL-U-ZAS.

The Swabian Kehrwoche.

A clean staircase is the pride of a Swabian housewife.

Kehrwoche *Part of speech:* noun; *Usage:* south Germany, particularly Swabia; *Meaning:* week during which one tenant of a building is obliged to clean the steps [the pavement or similar].

When "*Reigschmeckte*", the Swabian term for people from outside the Swabian metropolis of Stuttgart, arrive in the area, they are confronted with a unique clean room measure: the Swabian Kehrwoche.

A duke imposes cleanliness on his subjects.

The Kehrwoche (literally translated as "sweep week") is a tradition in south-west Germany that dates back to Duke Eberhard Ludwig of Württemberg, who passed the "street cleaning ordinance" in 1714 in Stuttgart. To date, this is considered to be how the Kehrwoche came into being. Its original aim was to improve the unhygienic conditions on the streets and down the alleyways in the Württemberg region. To this very day, it is celebrated week-on-week – with a great deal of care and enthusiasm.

In his ordinance, Duke Eberhard reminded his subjects about the importance of cleanliness: "To keep the city clean, everyone must throw out their rubbish every week, (...) clean their street corner every 14 days, but only at night, and never leave their rubbish on the street. Those who do not have their own WC must take their waste to the stream every night."

For those outside Baden-Württemberg, it is hard to believe. Anna Hunger, a journalist, even wrote her Master's thesis on the topic. The bottom line: "Only those who clean properly are considered to be proper people in the eyes of their neighbours."

You can never change a first impression.

With the Kehrwoche, a new resident has just one chance to prove that they are a proper person. But be careful not to overdo it. It's best to strike a balance, otherwise relations with neighbours who have lived there for years may turn sour. The most important unwritten rule is that you should perform your Kehrwoche duty on a Saturday if possible. After all, on a Saturday, you have a greater chance of your neighbours seeing you carrying out your duties and noticing this. And that brings us on to rule number 2: you should make sure and carry out jobs with a bucket, dustpan and brush as loudly as possible.

Kehrwoche – cleanliness is a serious matter.

The Swabians take the Kehrwoche very seriously – it is not meant to be fun. When Manfred Rommel, Lord Mayor of Stuttgart at the time, abolished the Kehrwoche for public streets and pavements in 1988, there were protests. The residents of south-west Germany insisted that cleanliness should be anchored in law. What's more, the Kehrwoche is part of Swabian culture, just like lentils and Spätzle (a type of noodle) or roast meat, Trollinger wine and Maultaschen (filled pasta squares). The task of sweeping at least once a week was seen as a matter of honour. Those who did not comply with the law could find themselves faced with fine of between 5 and 1000 Deutschmarks. The Kehrwoche is still going strong in Stuttgart – in fact, it is stipulated in clauses in tenancy agreements.

A clean sweep!
Air ducts also included in the specifications for guideline VDI 6022.

"The mayor in me did not agree with the Kehrwoche duties," Rommel was quoted as saying. "The Kehrwoche-faithfuls have won."

Kehrwoche – no laughing matter.

Despite being the butt of everyone's jokes, the Kehrwoche has really taken hold. On 1st April, 1999, the TV broadcaster BTV reported about an alleged Kehrwoche ban. The reaction? A flood of protests. The editing team was inundated with phone calls.

A tongue-in-cheek advert for the adult education centre in Calw really shows just how seriously people take the Kehrwoche. The college offered an intensive course on the Kehrwoche on 1st April. The programme included classes on the socio-historical significance of the Kehrwoche, material science (brush, mob, dustpan) as well as practical exercises (basic grip, hold, swing and scrubbing techniques). Given the date, they expected no reaction whatsoever. They could not be more wrong – more than 100 people signed up.

Kehrwoche – a tidy little earner.

In 1995, a student decided to boost his pocket money by offering to take on Kehrwoche duties for a week. Just half a year later, he already had 180 employees. Just a short while later, he found himself with 300 employees and quit his studies. They're clever, those Swabians. As the saying goes, they know everything – except High German.

TROX® TECHNIK
The art of handling air

About this magazine:

Publisher:
TROX GmbH
Heinrich-Trox-Platz
D-47506 Neukirchen-Vluyn
Tel.: +49 (0)2845 2020
Fax: +49 (0)2845 202265
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Limberg-Druck GmbH
Industriestr. 17
41564 Kaarst, Germany

Artwork editor:
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Image sources:
Title: Fotolia
Page 4/5: Fotolia
Page 6/7: Hermann-Rietschel-Institut/TU Berlin, TROX GmbH, Fotolia
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