

► Clean Air ►►

Intelligent climate and ventilation management for highly sensitive areas.





► The art of handling air ►►

TROX understands the art of competently handling air like no other company. Since its foundation in 1951, TROX has been developing and manufacturing sophisticated components, units and systems for ventilation and air conditioning as well as for fire protection and smoke control. Dedicated research and development have made TROX a global leader of innovation in these fields.

Application-oriented clean room solutions.

In highly sensitive areas ventilation and air conditioning have to meet specific and extremely stringent requirements. TROX clean room technology meets the highest protection and safety standards, and it is found in many highly sensitive areas such as:

- Research facilities, laboratories with fume cupboards, livestock facilities
- Ultra clean production environments in the area of life sciences, optics and laser technology, nano technology, and semiconductor production
- Operating theatres and sterile areas in hospitals and health care facilities (see TROX application brochure for hospitals)
- Rooms that require a special volume flow rate and pressure control, e.g. control rooms and meeting rooms

► Comprehensive system solutions ►►

This application brochure deals primarily with the air distribution and air handling in clean rooms. The reliability and safety of a ventilation and air conditioning system depend on effective airflow management, i.e. on the coordinated interaction of all components.

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

TROX offers bespoke, complete ventilation and air conditioning solutions from a single source: Air handling units and fans, measurement and control components, and a unique range of aerodynamically optimised air terminal devices, filters, and fire protection and smoke control components all deal with the various stages of the airflow.

Where work safety and the protection of valuable products, people and the environment are priorities, it is of paramount importance that all components of a clean air system complement each other perfectly.

Fewer interfaces, less coordination effort.

The advantages for specialist consultants and HVAC contractors are obvious: one face to the customer – for efficient ventilation and air conditioning systems. The result is a drastic reduction of the usual interface or coordination problems. All ventilation and air conditioning components from TROX are engineered in Germany.

TROX has both the know-how and the necessary expertise to set the highest standards in the field of air distribution for clean rooms. Since 1998 our clean room experts have been members of the standards committees for the EN 1822, EN 14175, DIN 1946 Part 7, and other guidelines and have provided valuable input to these bodies.

The following application brochures are also available:

- Hotels
- Airports
- Office buildings
- Hospitals



Bayer, Leverkusen; Altana, Wesel; Jägermeister, Braunschweig (Germany)

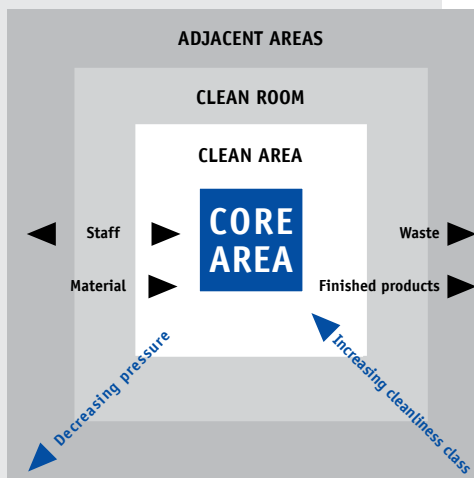
► Safety for products and processes ►►

Ventilation and air conditioning in clean rooms means, first and foremost, controlling undesired airborne particles. This is why we at TROX have thoroughly examined the measures that reduce or minimise adverse effects on people, products and the environment in order to develop complete solutions. 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 and balances
- **Fire protection:** Preventing the spread of contaminated air and of fire and smoke through ducting in the event of a fire

Contamination control with a multi-layer system:

In order to protect clean rooms and devices from contaminants that may be present in adjacent areas with lower levels of air cleanliness, the static pressure in clean rooms should always be higher than the pressure in those adjacent areas.



Lanxess, Singapore; Max Planck Institute, Göttingen (Germany)
L'Oréal, Paris (France)





► Energy efficiency ►►

Demand-based optimisation saves energy.

In most companies today, work does not end at 5 p.m. sharp. This is why many systems are running 24 hours a day, 365 days a year, even though they are really needed only about 50 % of the time. It should, hence, be possible to operate building services effectively but also flexibly, and not necessarily with full power for 24 hours a day.

Air distribution systems from TROX provide intelligent, demand-based volume flow rate control and consequently ensure a high level of energy efficiency. The systems run with full power only when people are working in the factory or in the lab. When a space is not occupied, the air change rate is reduced. 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.

Increasing efficiency with filters and air handling units.

Filters are supposed to separate particles in the air – and they are an obstacle to the airflow. As the differential pressure increases, the energy efficiency decreases. The goal is minimising the loss. TROX has developed filters that reduce the unavoidable differential pressure increase and hence increase energy efficiency. TROX offers filter media with extremely fine pleats and aerodynamically optimised filter units that help to save up to 50 % energy.

TROX air handling units are very energy efficient because they are equipped with state-of-the-art heat recovery systems and innovative high-efficiency fans.



Max Planck Institute, Göttingen (Germany)



From top to bottom: Bayer, Wuppertal (D)
Nestlé, Orbe (CH)
MDC – Max Delbrück Centre
for Molecular Medicine, Berlin (D)
Technopole Kilometro Rosso, Bergamo (I)
Novartis, Basel (CH)

► Strategies for clean rooms ►►

► Close cooperation leads to innovative room air strategies ►►

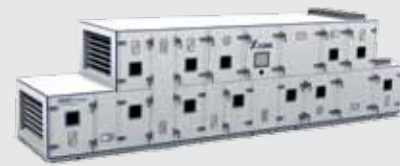
Developing and implementing a comprehensive room air conditioning strategy that meets the most critical safety and comfort requirements is only possible through the close cooperation of specialist consultants, HVAC contractors, users and manufacturers, and then from the beginning, i.e. from the design stage onwards. The know-how and the complete TROX product portfolio is, however, also ideally suited for refurbishment projects.

The illustration on the fold-out page shows you how a clean room production facility can be equipped with innovative TROX products and systems.



Our service – your benefit:

- *Expert consultancy and support throughout all stages of a project: from the design stage to handing over the system, and also after installation*
- *Comprehensive service support: commissioning, system integration, maintenance, modernisation planning*
- *Easy connection to higher-level systems due to standard interfaces*
- *Maximum data transparency due to open systems such as LonWorks®, Modbus and BACnet*
- *Air management system solutions from a single source reduce the number of interfaces required*
- *Bus systems that require considerably reduced wiring*
- *Fewer cables hence reduced fire load*
- *Support of flexible building usage: systems can easily be adapted to meet new requirements*
- *Rapid amortisation of investment costs due to reduced operating costs*
- *Energy savings due to optimised systems operation*
- *High level of operational reliability due to system self-monitoring*
- *Bus systems allow for remote diagnosis or modification*



1 X-CUBE air handling units
handle volume flow rates of up to 86,000 m³/h (24,000 l/s) for the ventilation and air conditioning of rooms – including filtration, heating, cooling, heat recovery, and humidifying and dehumidifying.



2 X-CUBE CROFCU Clean Room Fan Coil Unit
is a compact secondary ventilation unit that offers a multitude of features to meet the ventilation requirements of class C and class D clean rooms.



3 TROX room air management systems
provide demand-based volume flow rate control to ensure the best possible room air quality and temperature while they help to save energy at the same time. They maintain the correct pressure in clean rooms and prevent the transfer of air between different rooms or through air locks.



4 Filters M5
are used in ventilation and air conditioning systems to separate contaminants from the air.



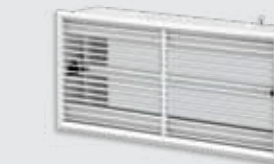
5 Fine dust filters F7
are used for the separation of fine dust in ventilation systems that must meet demanding requirements. TROX filters of filter classes M5 to F9 are tested to EN 779 and certified by EUROVENT.



6 Particulate filters H14
with Mini Pleat filter panels are used as final filters for the separation of suspended particles in industrial, research, medical, and pharmaceutical applications.



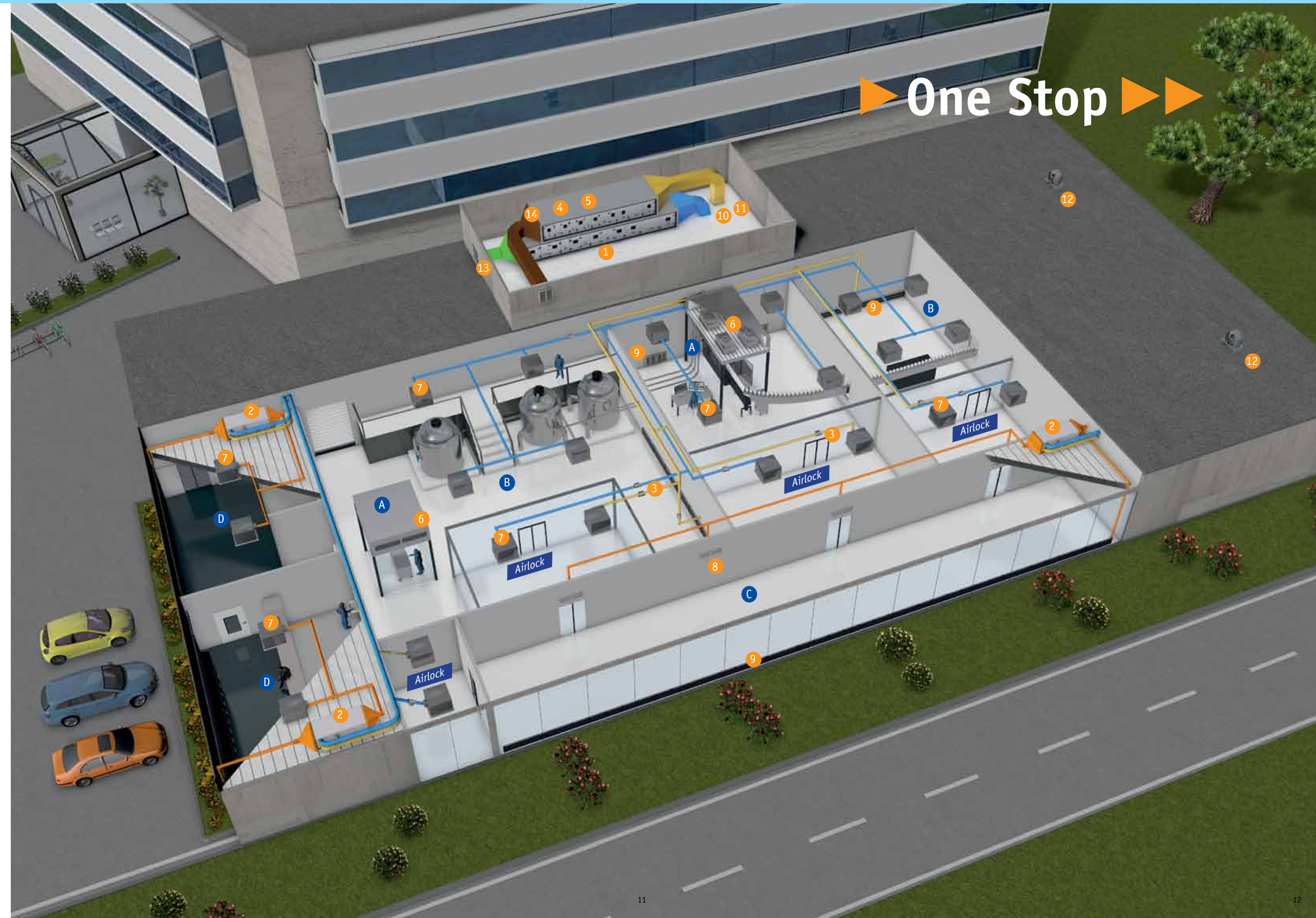
7 Ceiling mounted particulate filters
with Mini Pleat filter panels are used as final filter stage and are acoustically and aerodynamically optimised; they are available in many designs and constructions and provide a solution for all architectural requirements.



8 Wall mounted particulate filters
come with a sealing integrity test facility, a pressure measurement point, and a clamping mechanism for fixing Mini Pleat filter panels.



9 Single ventilation grilles and continuous horizontal runs
with adjustable front blades can be installed in walls and in circular and rectangular ducts.



TROXNETCOM
makes use of advanced, decentralised and open communication systems, and hence allows for economical fire protection systems that can be integrated into the central building management system with very little wiring.

Fire dampers
are certified for all European countries and prevent fire and smoke from spreading through ventilation ducting. The fire area is consequently isolated from other parts of the building.

X-FANS smoke exhaust fans
remove the hazardous fire gases in the event of a fire. Escape routes are kept free from smoke such that the building can be evacuated without any problems.

External weather louvres
protect air conditioning systems against the direct ingress of rain, leaves and birds into fresh air and exhaust air openings.

Multileaf dampers
provide a means for shut-off, and they prevent air from flowing against the intended airflow direction. Combinations of external weather louvres and multileaf dampers or non-return dampers have a dual function.

One-stop shop.
In addition to the products shown here, TROX offers many more and in fact covers the entire range of components and systems for ventilation and air conditioning:

- Mixed flow and displacement flow diffusers; diffusers for ceiling, wall and floor installation
- Air-water systems
- Decentralised ventilation systems
- Splitter attenuators and circular silencers
- X-FANS ventilation fans
- X-FANS smoke exhaust fans
- X-FANS jet fans for underground car park ventilation and smoke exhaust



▶ TROX solutions for clean rooms ▶▶

▶ Clean solutions start with planning ▶▶

Comprehensive and flexible solutions for every requirement.

On the following pages we present innovative clean room systems made by TROX. Our goal is to give you ideas for the design and implementation of ventilation and air conditioning systems for clean rooms and to show you options for different ventilation requirements.

The table on the fold-out page lists the relevant standards and guidelines and offers practical design advice with regard to the ventilation and air conditioning of clean rooms. You are then invited to follow the way of the air from the air handling unit to the air terminal devices.



► Designing a clean room always requires the assistance of a specialist consultant ►►

Air cleanliness classes to ...

Nomenclature		Max. allowable number of particles per m ³					
ISO 14644-1 ^{a)}	EU GMP Guideline ^{a)}	≥ 0.1 μm	≥ 0.2 μm	≥ 0.3 μm	≥ 0.5 μm	≥ 1.0 μm	≥ 5.0 μm
1		10	2				
2		100	24	10	4		
3		1,000	237	102	35	8	
4		10,000	2,370	1,020	352	83	
	A / B				3,500		0
5		100,000	23,700	10,200	3,520	832	29
6		1,000,000	237,000	102,000	35,200	8,320	293
	C				350,000		2,000
7					352,000	83,200	2,930
	D				3,500,000		20,000
8					3,520,000	832,000	29,300
9					35,200,000	8,320,000	293,000

Types of ventilation and filters (ISO 14644)

ISO classification ^{b)}	8	7	6	5	4	3
Typical type of ventilation	Turbulent flow TF or mixed flow M (combination of low-turbulence laminar flow LF and turbulent flow TF)			Low-turbulence laminar flow LF		
Typical prefilters, 1st stage	M5	M5	M5	M5 / F7	M5 / F9	M5 / F9
Typical secondary filters, 2nd stage	F7	F9	F9	E11	H13	H13
Typical final filters	E11 / H13	H13	H13	H14	U15	U16
Max. number of months allowed between tests to prove continued compliance with the allowable particle concentration	12	12	12	6	6	6
Recommended max. number of months between standard tests to carry out optional tests – leakage of installed filters	24	24	24	24	24	24

Examples of clean rooms in microelectronics (ISO 14644-4)

ISO classification ^{b)}	8	7	6	5	4	3
Type of ventilation	TF or M	TF or M	TF or M ^{e)}	LF	LF	LF
Average airflow velocity ^{d)}	not given	not given	not given	0.2 to 0.5	0.3 to 0.5	0.3 to 0.5
Air changes per hour ^{e)}	10 to 20	30 to 70	10 to 160	not given	not given	not given

a) Note operating states (shown: idle operation)

b) For the best results, operating states in connection with ISO classification should be determined before starting the design process.

c) With an effective barrier between the source of contamination and areas that are to be protected. This can be a mechanical system barrier or an aerodynamic barrier.

d) Low-turbulence laminar flow in a clean room usually depends on the mean airflow velocity. The required low-turbulence airflow velocity depends on local characteristics such as geometry and thermal conditions. This is not necessarily the face velocity for the filter.

e) Turbulent flow and mixed flow are determined by the air change rate (air changes per hour). The suggested air change rates apply to 3.0 m high rooms.



▶ Air handling ▶▶▶

Innovative systems are extremely reliable.

The highest requirements of safety and hygiene apply to air handling units for clean rooms. The seamless integration of ventilation and air conditioning with the central BMS is ensured by control and monitoring systems that provide comprehensive communication and configuration functions and hence a high level of flexibility.

▶ High-tech room air conditioning ▶▶

In highly sensitive areas, more than anywhere else, an air handling unit must meet particularly stringent requirements. The TROX X-CUBE is an air handling unit with unlimited configuration options of which even the basic version has set a new standard for hygiene and quality. It takes only a few measures 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 floors even inside

TROX X-CUBE units are very versatile. They can be individually configured and are hence suitable for a wide spectrum of applications. More than 70 sizes are available, and they are designed for volume flow rates of 600 to 86,000 m³/h at an airflow velocity of 2 m/s. X-CUBE units are available as supply or extract air units or as a combination of both. The units can be arranged side by side or on top of each other, depending on the installation site.

Thanks to lifting eyes at the top the cubes can be easily moved and lifted with a crane. This simplifies installation and reduces the installation time considerably. 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.

X-CUBE air handling units

- Special materials, smooth surfaces on the inside and outside due to high-quality duplex powder coating (corrosion protection class C4)
- With unlimited configuration options, allowing for project-specific adjustments
- Fast and simple installation due to modular construction
- Complete condensate drainage due to stainless steel condensate drip tray, sloped in all directions
- Components are easily accessible for maintenance and cleaning
- Construction variant with measurement and control system is easily connected to the central BMS
- High-quality TROX filters
- Heat recovery systems and innovative fans ensure excellent energy efficiency
- Also available as a weather-resistant variant with drip edge and intake hood for rain water elimination (lab tested)



X-CUBE air handling units comply with AHU Guideline 01 and are certified by Eurovent. They meet the requirements of all relevant standards and guidelines:

- VDI 6022
- ÖNORM H 6020 and 6021
- SWKI Standard VA 104-01
- DIN 1946-4
- EN 1751
- EN 13053
- EN 1886
- EN 13779



For more solutions and products please visit www.trox-cleanroom-air.com



Stainless steel condensate drip tray, sloped in all directions, conforming to VDI 6022.



Rotary heat exchanger: This heat recovery unit is a regenerative system.

► For the highest levels of hygiene and safety ►►

We expect a lot – particularly from ourselves. The X-CUBE air handling unit is a textbook example of German engineering at its best. Our R&D has paid close attention even to details, which may be small but decisive. It was the developers' goal to create a unit that provides room air of the best quality, air which meets the hygiene and safety requirements for highly sensitive areas.

Large selection of energy-efficient heat recovery systems.

Depending on the application and site it may be possible to choose among different heat recovery systems. For example, plate heat exchangers can, because of their function, only be used in combined supply air and extract air units. The same is true for rotary heat exchangers, which achieve a heat recovery efficiency of up to 80 %. For very demanding requirements on hygiene, e.g. in cases where the transfer of odorous substances or germs must be prevented, a high-efficiency run around coil system is recommended in which the supply air flow and the extract air flow are completely separate.

Ultimate hygiene.

A smooth exterior, powder-coated surfaces on the inside, stainless steel floors, and a stainless steel condensate drip tray, which is sloped in all directions, meet the most stringent hygiene requirements and withstand commercially available disinfectants. The integral cable duct, which is included in the construction variant with measurement and control system, also meets the highest hygiene requirements.

Easy maintenance and service.

Almost unlimited configuration options with regard to the arrangement of the individual components and inspection access doors with inspection windows facilitate maintenance of the TROX air handling units to a very high degree. The internal illumination provided by energy-efficient LEDs is yet another example for the high standards we set for our products when it comes to the conservation of resources and to sustainability.

TROX quality through and through.

If we produce it ourselves, we can ensure the best quality. This is our philosophy. And this is why we manufacture as many products as possible in our own facilities: From multileaf dampers with leakage class L2 or L4 (to EN 1751) to sound attenuators with glass fibre fabric and with powder-coated surfaces and to filter elements that comply with the relevant standards: It's all made in Germany.



Made by TROX: from filters to multileaf dampers and sound attenuators.



Inspection window and doors for easy inspection access.





X-CUBE CROFCU

X-CUBE CROFCU – The advantages at a glance.

- Suitable for all clean room strategies
- Suitable for all classes of clean rooms (ISO 14644-1) when combined with particulate filters
- Pumped chilled water cooling system (up to 8 kWh) with room temperature control
- Variable recirculated air volume flow rates of up to 6,000 m³/h
- Increased flexibility if several units are connected
- Energy-efficient plug fan with EC motor
- Addition of fresh air from 50 m³/h to 2000 m³/h
- Monitoring of filters downstream
- Contamination check by means of pressure zone control
- Space-saving since only smaller ducts are required when compared to conventional recirculation systems
- Simple and quick commissioning due to plug and play



► **X-CUBE CROFCU reduces energy costs** ►►

Most clean rooms are characterised by a very high air change rate. Depending on the situation, it may be necessary to change the air volume in a room up to 40 times 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 that only a small quantity of air is 'used' 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.

Enter the X-CUBE CROFCU – and with it a completely new design concept for clean rooms. The compact, factory tested secondary unit for use with centralised ventilation and air conditioning systems is typically installed in false ceilings.

With its unique features it meets the essential requirements on the ventilation and air conditioning of class C and class D clean rooms.

- Dissipation of high thermal loads
- Addition of fresh air as required
- Maintenance of room pressure by integral volume flow rate control

Filters that can be adapted as required are the perfect addition to the product.

X-CUBE CROFCU increases the efficiency.

The quasi plug-in construction of the X-CUBE CROFCU reduces the installation time on site considerably. More savings potential results from the easy and straightforward maintenance since all components are easily accessible.

Fresh air is added based on demand such that no energy is wasted. A factory acceptance test ensures that each unit complies with the applicable standards and meets the requirements of the customer. All required parameters are factory set. As a consequence, only a minimum amount of time is required for commissioning and on-site tests.

Straightforward installation of the X-CUBE CROFCU.

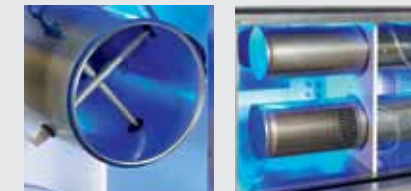
The X-CUBE CROFCU is delivered ready to operate. Transport is easy as holes are provided for the insertion of transportation rods such that the unit can be lifted with a crane. The dimensions fit the usual grid sizes of clean room ceilings. Due to its rigid base the unit can be safely installed on ceilings or set up on the floor. Any wiring inside the CROFCU is already complete and need not be performed on site.

X-CUBE CROFCU is flexible.

It is possible to use the X-CUBE CROFCU as a single unit or to combine several units. In conjunction with the TROX software this results in a flexible ventilation solution for clean rooms. The X-CUBE CROFCU allows for stand-alone operation as well as for integration with modern building management systems.



Centrifugal fan: High efficiency due to a fan with EC motor and without impeller housing.



Integral volume flow rate control with high accuracy. The primary air system allows for the direct removal of exhaust air while fresh air is supplied to the room.



Optional: Compact fine dust filter of filter class 9, energy class A, with high dust holding capacity.

▶ Air management ▶▶

Increased safety due to coordinated systems.

Intelligent components communicate with each other, they monitor and control parameters for clean rooms and ensure that these parameters are maintained.



▶ Intelligent communication systems ▶▶

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 they should ensure the safety of people and equipment. Intelligent communication systems allow for data to be retrieved, collected, displayed and monitored via the central BMS. Systems are constantly being monitored to ensure their functional reliability.

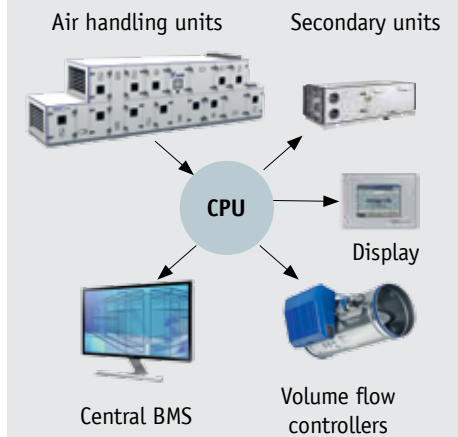
The TROX TLT fan diagnosis system is a special tool for smoke exhaust systems and allows for analysing the condition of a fan with regard to wear and performance via a remote function. Maintenance intervals can be extended as a consequence, a fan need not be replaced before its time: this saves costs.

For fire protection and smoke control, TROX relies with its TROXNETCOM system on AS-i communication at the field level. AS-i uses a two-wire cable for data and energy and ensures interference-free transmission. Due to the free network topology the system can be ideally adapted to different buildings. With up to 1736 participants in an AS-i network, TROXNETCOM is suitable for projects of every size. The combination of voltage supply and data communication with a single cable reduces not only the wiring effort; fewer cables mean also a reduced fire load.

Room balancing, room pressure control, room temperature control, and intelligent monitoring.

To maintain stable room conditions including the required air change rate, room pressure and room temperature, all extract air and supply air flow rates must be measured and communicated between the system components.

In laboratories but also in production processes where hazardous substances are handled, it is important that the building automation system is provided with the actual room air values. The TROX room management system allows for linking all network participants via an integral communication line and by using plug and play such that a continuous data exchange between these participants is ensured. The system can easily be connected to the central BMS using the standard communication interfaces LON, BACnet, or Modbus; IP-based communication with Ethernet is also possible.



TROX air management system

- **Room management function:** All parameters and functions for a room can be configured with one controller
- **BMS interfaces:** LON, BACnet, Modbus, IP-based webservice
- **Plug and play:** Automatic data exchange between the controllers; no addressing required; interactive commissioning
- **Easy maintenance, room diagnosis and room configuration**
- **Rapid and precise control** to maintain setpoint values
- **Modular hardware**

Differential pressure transducer with static differential pressure measurement, for volume flow rate measuring units. With sensors that can be validated to GMP (upon request).



Room management system

The integral control logic allows for displaying and controlling different room situations precisely.



► **Stable pressure** ►►

Air can easily overcome barriers and can, hence, not be locked out. With the air management system it is possible to precisely control pressures in the clean room and adjoining areas and to isolate rooms with particularly critical requirements of air cleanliness from those with less critical requirements.

The control system provides a tailored solution for safe and energy-efficient airflow control in sensitive areas such as clean rooms, hospitals and laboratories. Quick-response control loops are suitable for the volume flow control in fume cupboards and for room pressure control, e.g. in clean room production facilities, in operating theatres and in ICUs. Complex room balancing functions and room monitoring functions are likewise possible.

The room air management system has been optimised for conditions as they prevail in clean rooms. It includes VAV terminal units, electronic controllers, monitoring systems, sensors and control panels. The integral control logic allows for displaying and controlling different room situations precisely. Another advantage of the TROX air control system is the independent room management function. Critical room functions are controlled locally. For example, the room pressure can be maintained without any delays. Even an uninterruptible power supply (UPS) can be included. The system is extremely flexible and provides different interfaces for the connection to the central BMS (e.g. BACnet, Modbus, LON, or IP-based via Ethernet).



VAV terminal unit TVR with EASYLAB control components for room pressure control in critical areas

- ▣ V: 10 – 1,680 l/s
- V: 36 – 6,048 m³/h
- ☉ Δp: 20 – 1,500 Pa
- Ø 100 – 400 mm

Closed blade air leakage to EN 1751, class 4
Casing air leakage to EN 1751, class C



EASYLAB

- **Room management function:** All room related data and configurations stored in one controller
- **BMS interfaces:** Analog, digital, LON, Modbus, BACnet and Ethernet
- **Plug and play:** Automatic data exchange between the controllers; no addressing required; interactive commissioning
- **Easy maintenance, room diagnosis and room configuration**
- **Only one communication line** between controllers; no addressing
- **Rapid and precise control** to maintain setpoint values
- **Static measurement**
- **Modular structure** of the hardware, with numerous options for expansion

► Room balancing ►►

The safety net.

Positive pressure is a simple way to physically prevent contamination in clean room production facilities. Positive pressure prevents undesired airflows or undesired particles from entering a room. TROX provides systems which ensure that the correct positive pressure is maintained.

Advanced technical equipment and software and the wide range of VAV terminal units mean that electronic control is now an option for nearly all room pressure scenarios. The more critical leakage levels are, the more important is it to plan the pressure control accordingly. While pneumatic solutions are still an option, it is nowadays also possible to achieve precise pressure levels with an electronic system, e.g. with a bypass controller. Electronic control has clear advantages: less coordination effort, no requirement for pressurised air as with pneumatic control, and easy integration with the central BMS.

Proven plug and play communication and integration into the central BMS with LON, BACnet or Modbus, or IP-based communication with Ethernet allow for easy and efficient system integration.

Demand-based solutions.

Flexible building usage plays an immensely important role in the planning of clean room production facilities.

It must be possible to change and extend buildings at a later stage and at minimum cost. TROX air distribution technology and the TROX measurement and control system are ready for the challenge. Our air management systems have a modular structure such that they can be expanded or adapted to changing conditions flexibly and easily.



Critical areas can be isolated by means of precise pressure control and volume flow control.



▶ Air filtration ▶▶

Achieving air cleanliness.

Air cleanliness is ensured by very effective high-efficiency filters. Innovative materials of a high quality, the most exact pleats and aerodynamically optimised filter units all provide a level of efficiency that is hard to match.



▶ Protecting products and people ▶▶

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.

Internationally, the GMP guidelines are nowadays considered standard for clean room production. These and other guidelines are listed in the table on page 17.

GMP clean room classes: Example of production steps for sterile products.		airborne CFU/m ²
A	Bottling products with an unusual risk; production within microbiological safety or cytostatic work area	< 1
B	Environment of class A	10
C	Producing solutions with an unusual risk; bottling products	100
D	Producing solutions and preparing components immediately before bottling	200

Source: Christian Ernst et al., Systeme und Konzepte der Reinraumtechnik [Systems and concepts of clean room technology]

Smooth filter change.

Regular filter changes are a must, not only with regard to filtration efficiency but also with regard to energy efficiency. This is why TROX has developed various solutions to facilitate filter changes and make them hygienically safe. Different filter frames and filter units are available for different applications and with the filter medium being accessible more or less easily. Special packaging protects our filters perfectly and avoids any damage during transport or installation.

Particulate filters of filter class U16 to EN 1822: Only one particle permeates the filter.

When a U16 filter with an efficiency of 99.99995 % is exposed to 2 million particles, only one particle will not be filtered out. By comparison, an H13 filter (99.95 % efficiency) will be permeated by 1000 particles, and an M6 filter (50% efficiency) by one million particles.

Particulate filters are subject to efficiency tests before shipping. The overall efficiency is calculated from the measured local filtration efficiencies. When a filter is leak-free and fulfils the criteria of the overall efficiency, it is assigned an individual filter number.



M5/6



F7/9



H13/14



U15/16

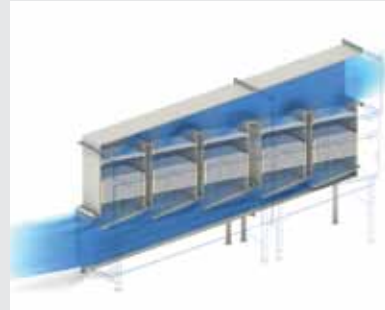


For more solutions and products please visit www.trox-cleanroom-air.com



KSFS ducted particulate filters
for Mini Pleat filter panels, Mini Pleat filter cells, and activated carbon filter cells

- Contamination-free filter change



Spigots
for more safety, a longer filter life and higher energy efficiency: The new patented connecting spigots for ducted particulate filters (KSFS) have been developed in cooperation with RWTH Aachen university, Germany. A sophisticated air distribution system ensures a uniform airflow through all filter elements. Because of this even exposure the service life of the filter elements is significantly increased. And moreover, a lower differential pressure saves energy.

► TROX air filtration systems ►►

In addition to the separation of dust in air handling units, HEPA and ULPA filters are used as high-efficiency particulate filters for the separation of the smallest particles in clean room systems. They ensure a particularly high level of air cleanliness and can separate even submicrometre germs and particles. High-efficiency filters are either ceiling mounted and have a diffuser face or they are used as final filter stage in filter ceilings.

TROX high efficiency filters.

TROX offers an extensive filter programme for technically and economically sound solutions: Filter units are available for different installation locations, e.g. walls, ducts or ceilings, and suitable filter elements meet every application requirement.

TROX fine dust filters of filter classes M5 to F9 are tested to EN 779 and certified by EUROVENT.

Each TROX filter of filter class H14, U15 or U16 is tested for leakage and overall efficiency.

TROX manufactures all parts of filter units in-house, from the casing and filter elements to the diffusers; the TROX filter production facilities in Germany are equipped with the most advanced machinery. In addition, customers can make use of the intelligent Easy Product Finder design programme.

TROX filter production: State-of-the-art production equipment and advanced test procedures carried out on the TROX test rig ensure high efficiency and maximum safety.



Air distribution



Ideal flow behaviour.

The construction of air inlets and outlets and their combination and installation position determine the ventilation flow behaviour and hence the effectiveness and efficiency of a clean room strategy.

In the occupied zone the ideal air distribution can be achieved with high induction levels that lead to a rapid reduction of airflow velocities and of the temperature differences between room air and supply air. If the goal is a laminar flow, the airflow velocity and a constant airflow must be maintained.

Air distribution strategies for clean rooms

Low-turbulence laminar flow.

A low-turbulence laminar flow is characterised by a homogeneous velocity profile and almost parallel flow lines across the entire cross section of the clean area. Contaminated air and hence airborne particles are consequently displaced or 'swamped out' of the clean area. With a low-turbulence laminar flow, airborne particles remain in the zone for only a short time, and if larger quantities of particles are suddenly set free, the air 'recovers' within a short period. The supply air is usually discharged through particulate filter elements (HEPA, ULPA) as final filters.

The highest air cleanliness classes can be achieved with a low-turbulence laminar flow, even in large clean room areas. The average airflow velocities are usually between 0.2 and 0.5 m/s. In other words: The air in the clean room zone is exchanged more than one hundred times per hour. This consumes a high amount of energy.

Turbulent flow.

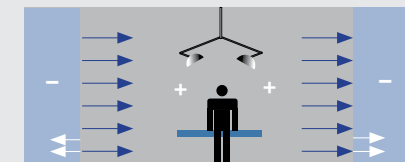
Turbulent flow means that the primary air mixes with the induced room air. Clean air is not supplied across the entire room but only at selected points, typically through ceiling swirl diffusers. High induction levels ensure a good mixing of the supply air and the room air across the clean room.

Mixed flow.

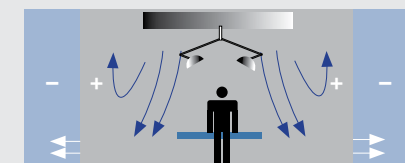
Mixed flow means a combination of low-turbulent flow and turbulent flow. It is used to reduce the number of ultra clean zones for which originally a more costly low-turbulent laminar flow system had been installed. Mixed flow ventilation allows for different zones within a clean room: for occupied areas and unoccupied areas. Zones with the highest air cleanliness, i.e. with the highest requirements of safety, are called 'white zones'. Depending on the structure of the clean room system and on the process requirements, a white zone can refer to just one part of a clean room or to a complete clean room area including all installations.

Displacement flow.

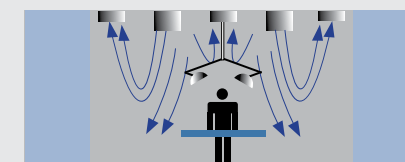
The low-turbulence airflow is supplied to the room near the floor. This creates a pool of cooler supply air and the actual source of the ventilation. The convection from people and other heat sources causes the air in this supply air pool to rise. In other words, people breathe fresh air. Contaminants in the air rise together with the fresh air (convection) and away from the occupied zone.



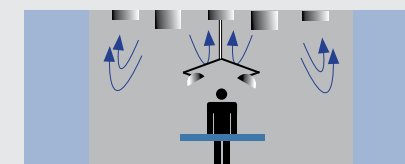
Low-turbulence laminar flow



Turbulent flow



Mixed flow



Displacement flow

TFC ceiling mounted particulate filters
with Mini Pleat filter panels as final filter stage

- Compact construction, suitable for low ceilings
- Can be combined with all clean room ceiling systems of various manufacturers



TFM particulate filter modules
with Mini Pleat filter panels as final filter stage

- Individual modules can be combined into larger ceiling sections



TFP pharmaceutical clean room terminal filters

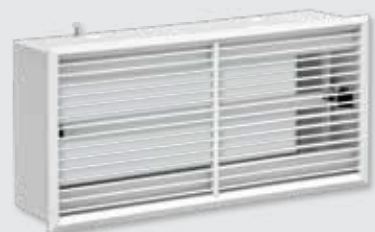
for Mini Pleat filter panels with downstream fluid seals that meet the highest hygiene requirements

- Diffuser face is held in place by magnets and can be hinged down
- Easy cleaning and validation; filter change without tools



TFW wall mounted particulate filter
with Mini Pleat filter panels as final filter stage for the separation of suspended particles

- Different constructions for filter elements with different frame depths



► Air terminal devices ►►

Aerodynamically optimised air terminal devices are extremely important to TROX. Perfect aerodynamic properties ensure maximum safety and thermal comfort.

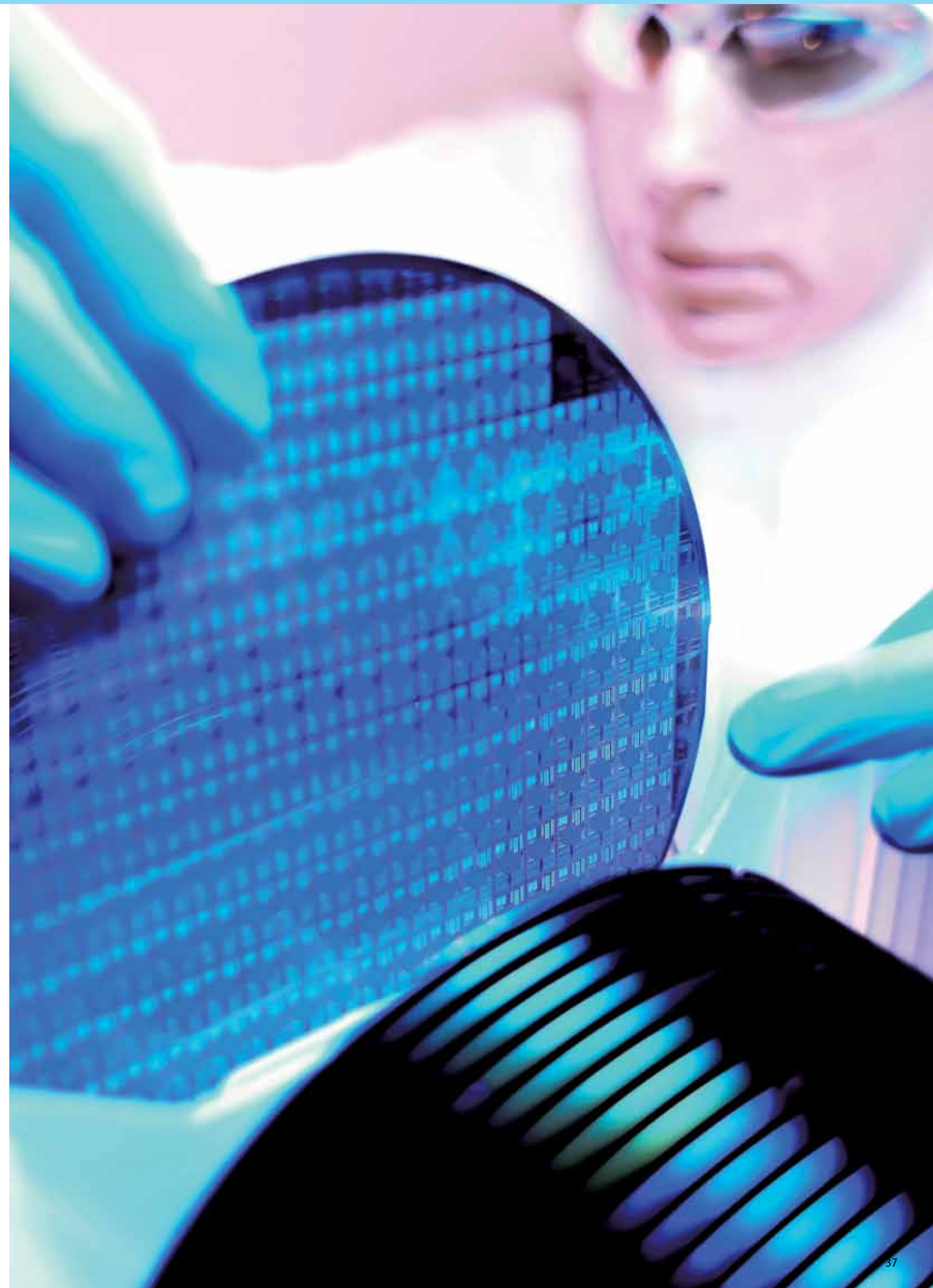
Selecting air terminal devices.

When selecting a supply air diffuser, the point of discharge and the room height are as important as the cooling loads. If one compares a room air conditioning system to a chain, air terminal devices would be the most critical link for thermal comfort. They are supposed to ensure that the occupied zone meets the most demanding requirements of thermal comfort: Room air conditioning is most comfortable if you cannot see it, hear it or feel it.

There is hardly another manufacturer who offers such a wide range of different air terminal devices. Whether installed freely suspended or flush with the ceiling, they always blend in perfectly with the room architecture, due to a multitude of construction variants and attractive surfaces.

TROX has developed bespoke solutions for the special requirements of clean rooms. These apply to the highest air cleanliness, i.e. for 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



► Clean air with TROX ►►

TROX has fitted production facilities, hospitals and laboratories all over the world with innovative components:

AACHEN University Hospital • ATHENS Oncological Children's Hospital • BERLIN Charité • CARTAGENA Hospital •
BELO HORIZONTE Unimed Hospital de Santa Bárbara • DURBAN Albert Luthuli Hospital • DÜSSELDORF Sana Hospitals •
ENSCHDEDE Medisch Spectrum Twente (MZT) • ESSEN Essen-Süd Hospitals • GREENSBORO Moses H. Cone Memorial Hospital •
HAMBURG Eppendorf University Hospital • KRAPINSKE TOPLICE Hospital Magdalena • LODZ Kopernik Hospital • MELBOURNE
The Royal Children's Hospital • MELBOURNE The Royal Women's Hospital • MOSCOW Clinical Centre of Paediatrics • RENNES
Centre Hospitalier Universitaire Pontchaillou • WESEL Evangelical Hospital • BASF LUDWIGSHAFEN • Bayer AG WUPPERTAL and
LEVERKUSEN • BMW MÜNCHEN-DINGOLFING • Merck DARMSTADT • Roche PENZBERG • VW Research WOLFSBURG • AFSI Forensic
Science Institute ALGIER • Australian Nuclear Power Science and Technology Organisation (ANSTO) LUCAS HEIGHTS • 3M
SHANGHAI • Henkel SHANGHAI • SHANGHAI University • Dynamicum University ODENSE • Finnish Metereological Institute
and Finnish Institute of Marine Research HELSINKI • Evira, Finnish Food Safety Authority HELSINKI • ARK Therapeutics
KUOPIO • Laboratoire Galderma Sophia ANTIPOLIS • Aventis LYON • CAMBRIDGE Science Park • Moorefields Eye Hospital
LONDON • OXFORD University • Biological E. Limited/MERCK & CO. Inc. HYDERABAD • CAVANESE BIO Industry Park •
Eli Lilly FLORENCE • CATANIA University • High School OSLO • Campus 02 GRAZ •
Amphiagon Pharma PAMPLONA • BASF TARRAGONA •
Sabancı University ISTANBUL ...



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