Advanced in vitro exposure systems

VITROCELL®
AirTox Monitor

VITROCELL® SYSTEMS

VITROCELL® AirTox Monitor

Highest automation and reproducibility

The VITROCELL® AirTox Monitor is designed for automated exposure of lung cell cultures at the Air/Liquid Interface with full control of all relevant parameters such as temperature, humidity, exposure duration and flows.

Figure 1: The complete system with AirTox Monitor, control cabinet and water baths.

Special focus was set to minimize the needed lab space and increase reproducibility in a lab environment with frequently changing operators.

The VITROCELL® AirTox Monitor ensures this reproducibility by a user-friendly control software. All relevant process steps of the cell exposure are automatically prepared and key parameters such as temperature and humidity are controlled to target values of the recipes.

A high degree of automation and user guidance ensures reproduceable conditions day-by-day independent of the operator or location.

For increased flexibility in the experimental setup, the system can be connected to a wide range of aerosol sources. The new size-selective PM inlet offers defined ranges of particle sizes to the exposure module. Flow rates can be adapted according to the sensitivity of the cell culture system.

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User guidance

The control software is especially designed to provide an intuitive and guided operation of the AirTox Monitor.

Before starting the tests, the user is informed of the most important preparatory steps in the “Daily Check” section. These relate to process-relevant topics such as the fill level of the water baths, compressed air supply, condition of the filter units, etc., which must be checked before starting the system.

The check of these preparation steps must be acknowledged once a day.

The user can then create recipes with the process parameters or start an experiment. All process-relevant parameters are entered and saved step by step in the recipe management.

For the upcoming experiment, the operator simply selects the desired recipe from the list and starts the experiment.

During the preparation of the experiment a process wizard indicates the current process step and whether the process is completed or still in progress (Figure 3). At important stages of the preparation, the user is guided with a step-by-step instruction.

When all parameters have reached their target values, the experiment can begin. During the specified exposure duration, all process parameters are constantly controlled to the target values. The most important parameters are shown in diagrams on the Experiment Dashboard (Figure 4), which enables quick control of a stable process.

After the experiment, all relevant process parameters are stored as a CSV file for later analysis.

Further experiments can be started from postprocessing, or the system can be transferred to a safe state to end the series of experiments.

Figure 2: Industrial tablet PC for easy and intuitive operation of the AirTox Monitor

Figure 3: The process wizard indicates the current process step (humidification) and the current progress with target and actual value

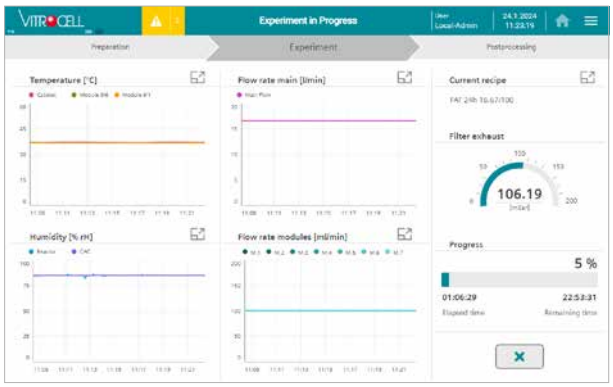


Figure 4: The Experiment Dashboard displays all important process parameters. The diagrams allow the user to quickly recognize whether all values are stable or whether deviations have occurred

Reproducibility

In order to enable a high reproducibility, the aerosol is extracted isokinetically and the experimental conditions are kept as constant as possible within the AirTox Monitor.

Isokinetic sampling is the method of choice for a reproducible and representative sampling of an aerosol. The advantages of isokinetic sampling are described standard literature (e.g. Baron/ Willeke, Hinds, VDI 2066). The new sampling unit provides an isokinetic (flow velocity of main flow and sample flow is the same) and isoaxial (flow direction of main flow and sampling flow are on the same axis) sampling, as well as the possibility to use different flow rates. The adaption is needed if main or sample flow are changing due to change in aerosol source, well format of the cell culture inserts.

To enable an easy adjustment for different flow rates VITROCELL® has developed a new isokinetic sampling unit. The standard sampling probe is threaded for mounting individual probe tips for a predefined range of flow pairings. Each tip is laser coded to ensure the secure use.

In addition to isokinetic sampling, the system enables reproducible test conditions regardless of the ambient conditions through the integrated control of all relevant process parameters. For this purpose, a new heating unit was developed that heats the entire exposure chamber evenly to the target temperature and keeps it constant over the duration of the experiment. The new humidification unit and upstream heated sampling line enable precise humidification regardless of the used aerosol source.

Figure 5: New probe tip (left) and side by side comparison of former and new sample probe (right).

	Mean value	STD
RH aerosol reactor (% r.h)	85.00	0.25
RH clean air (% r.h)	85.00	0.06
T cabinet (°C)	37.05	0.12

Table 1: Typical values over the exposure duration of four hours.

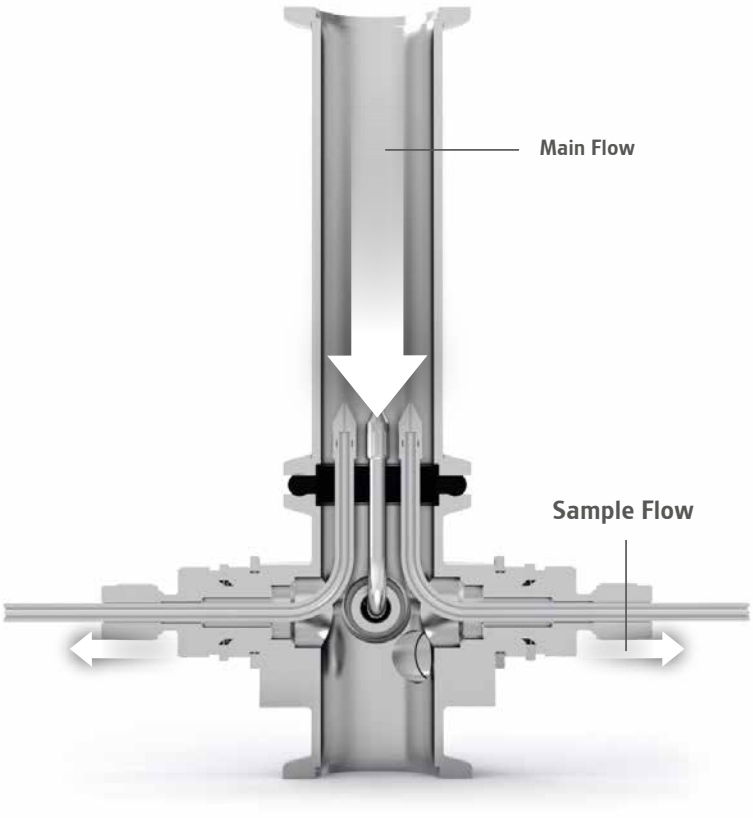


Figure 6: Illustration of function principal of the isokintec sampling unit. From the main flow individual sample flows are extracted to expose the cell cultures inside VITROCELL® exposure modules.

This temperature stability and improved humidification is key for long term exposure. Together with a separate water dosing unit, exposure durations for up to 24h become now possible.

A separate VITROCELL® 6/1 exposure module can be equipped with dosimetry tools such as QCM, TEM-Inserts, dosimetry inserts for chemical trapping and the VITROCELL® RH/T Sensor. This allows the characterisation of the aerosol within the exposure module at the same location where cells are exposed. The additional RH/T Sensor also enables real-time monitoring of the relative humidity in the exposure module if required.

Figure 7: The sample flow is guided to the exposure module, where cell cultures are exposed at the Air/Liquid Interface.

Flow pairing		Deposited mass of fluorescein sodium	
Main flow (l/min)	Sample flow (ml/min)	Mass* ($ng * cm^{-2} * h^{-1}$)	Deviation
16.67	100	74.21 +/- 1.73	2 %
8.33	50	183.73 +/- 5.80	3 %
16.67	50	54.35 +/- 3.49	6 %
8.33	25	127.19 +/- 7.69	6 %
16.67	25	50.10 +/- 3.57	7 %

* mean of 4 positions

Table 2: Deposition of fluorescein sodium for different flow pairings with the same aerosol source.

Flexibility

When investigating different aerosols or cell cultures, flexible application options are required to adapt the system to the respective framework conditions of the planned experiments.

Depending on the aerosol source, different flow rates may be available and depending on the scientific question, different particle sizes are of interest.

New cell models are also becoming increasingly complex and require adjustment in the sampling flow. If a large quantity of cell material is required for a complex analysis, a 6-well format is used; complex cell models are easier to realize in 12-well format.

All these options make it necessary to be able to adapt the system in the best possible way. For this purpose, the system is equipped with an adaptable pre-separator and an adaptable sampling unit.

With the new Adaptable PM inlet, the main flow of the system can be adapted to different flow rates without changing its separation characteristics. If the focus is on other particle fractions, the degree of separation can be adapted for a given flow rate.

PM	Flow rates l/min (m³/h)		
–	16.67 (1)	8.33 (0.5)	6 (0.36)
10	✓	✓	✓
2.5	✓	✓	✓

Table 3: Available adapter plates for common flow rates of the AirTox Monitor for PM 10 and PM 2.5

Figure 8: The adaptable PM inlet mounted by small flange quick connecotr (ISO-KF) on inlet of the AirTox Monitor

The AirTox Monitor is also equipped with the VITROCELL® Adaptable Isokinetic Sampling unit to enable a wide range pairings of main and sample flow.

The isokinetic sampling is the method of choice for a representative and reproducible sampling of aerosols according to guidline VDI 2066 and standard literature like Baron/Willeke. It ensures an isokinetic as well as isoaxial sampling.

If the sample flow needs to be adapted due to a change in well format or the cell culture system, the probes can be easily equipped with probe tips for the respective flow pairing.

Table 4 shows the flow pairings which are available and tested for the AirTox Monitor.

Main flow (l/min)	Sample flow (ml/min)		
–	100	50	25
16.67	✓	✓	✓
8.33	–	✓	✓

Table 4: shows the available and validated flow pairings for the AirTox Monitor.

Easy and swift maintenance

In designing the AirTox Monitor, particular emphasis was placed on easy access to components that need to be regularly checked and maintained. Service trays on the front and back side of the system ensure quick and easy access to filter elements, mass flow controllers or condensate tanks. Slide doors on the front and back side provide easy and quick access to the exposure modules, aerosol tubing, filter unit and aerosol reactor.

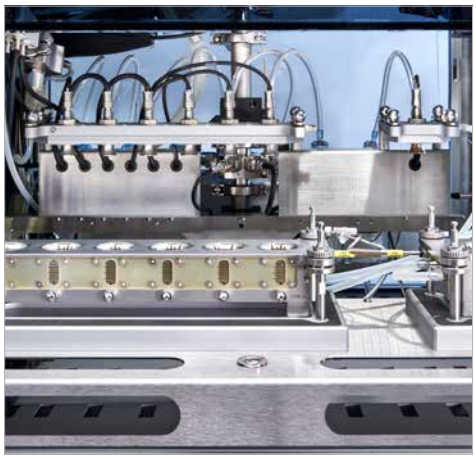
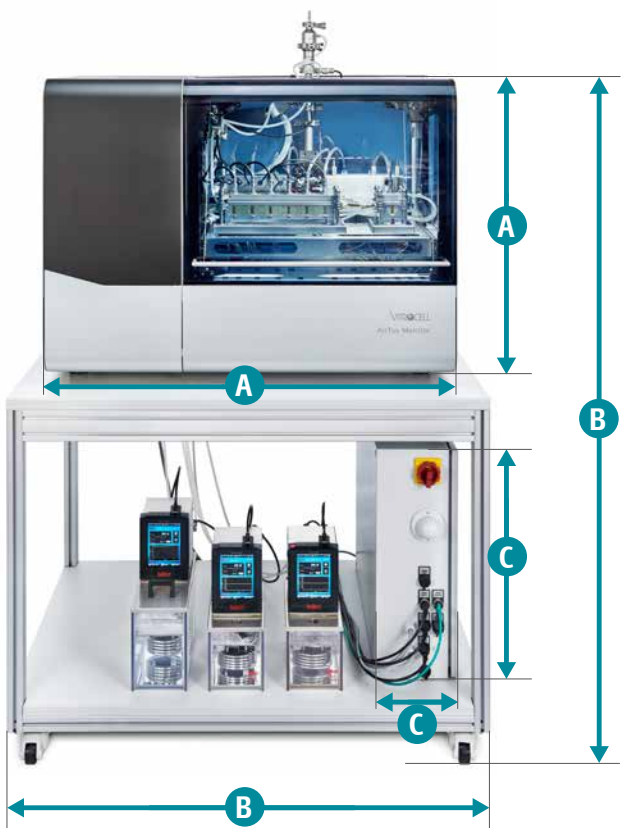


Figure 9: Easy and quick access to the exposure modules, aerosol tubing, filter unit and aerosol reactor.

Figure 10: Back side with filter unit and service tray housing the mass flow controllers.

Technical specification



Dimensions and weight:	A: 760 x 1056 x 600*, 150 kg
	B: 1720 x 1200 x 750*, 300 kg
	C: 600 x 600 x 250*, 32 kg
Power supply:	System: 230 V (0.8 kW), 50 Hz
	Water baths: 3 x 230 V (1kW), 50 Hz
	other voltages upon request
Compressed air:	working pressure 6 bar (87 psi)
	max. consumption 7 l/min

*(height x width x depth in mm)

Key Features:

- Direct aerosol sampling
- Adaptable PM Inlet
- Adaptable Isokinetic Sampling
- Exposure durations up to 24h
- Dosimetry tools (QCM, TEM-Insert, Trapping)
- Intuitive HMI with user guidance
- High day to day reproducibility
- Easy and swift maintenance
- Flow control by mass flow controller
- Compact and fully automated solution

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About VITROCELL®

VITROCELL® exclusively concentrates on the developing, producing, installing, training and servicing of advanced *in vitro* exposure systems.

The VITROCELL® Systems' team is driven by their vision for new in-vitro standards through state-of-the-art technology, highly qualified workmanship and absolute client dedication. VITROCELL® has successfully collaborated with clients from leading research institutes, contract research organizations, regulatory authorities or industrial laboratories across the world. Working with our team experts, all modules have been tailored to create durable and complete turnkey-systems for *in vitro* inhalation toxicology. Gases, environmental atmospheres, nano particles and complex mixtures are analyzed on lung cells at the air/liquid interface using these systems. VITROCELL® technologies are also applicable to solutions for skin research.

Over a decade of devotion to research in this specific field has given our team of design & precision manufacturing specialists the opportunity to mentor highly diversified and complex projects from conception to completion. We strive to become a constructive member of each research team, providing support when it is needed, advice when it is required and modules of the highest quality, which are even polished by hand before leaving here to be integrated into your workspace. Every piece of our German engineered equipment is manufactured to the highest of standards – yours.

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