

Radioactivity in Air Monitoring



RADIATION PROTECTION



Berthold Technologies has more than 60 years experience in manufacturing radiation protection measuring systems. We provide a comprehensive range of measurement and control systems for radiation protection in air monitoring applications such as room air and stack emission systems.

Continuous measurement of gaseous, aerosol particulate, Iodine radioisotopes.

On-line systems with detectors built into ventilation ducts and stacks are available together with air sampling systems including isokinetic extraction to ISO standards.

High sensitivity with low detection limits.

Radon/Thoron compensation.

A number of data acquisition systems are available depending on the requirements of the facility.



Tritium in Air Monitoring

- Proportional flow-through detector system with discrimination between Tritium or C^{14} and Noble Gas
- Ionisation Chamber version

Fixed Filter Alpha/Beta Particulate Monitors

- High sample volume 200 mm diameter fixed filter system
- 50/60 mm fixed filter systems for standard applications
- Simultaneous Alpha and Beta measurements
- Gamma particulate options
- Natural activity (Radon/Thoron) compensation

Moving Filter Particulate Monitors

- Continuous moving filter or step filter options
- Autonomous operation for up to 1 year, depending on filter speed/dust loading
- Second delayed measuring detector
- Radon/Thoron compensation
- Ambient Gamma compensation
- Versions for harsh environments (exposed parts in high grade stainless)
- IP65 versions for outdoor environmental monitoring

Iodine Monitors

- Systems for I-131 and I-125
- Iodine cartridge sample changer for unattended operation
- PIN-Particulate Iodine & Noble Gas systems

PET Facility Air Monitoring

- Positron sensitive detectors mounted on duct/stack walls

Data Acquisition, Visualisation, Archiving & Reporting

- Centralised data station, PC or SCADA options
- Local and distributed alarm beacons
- Reporting software for stack emissions

Installation, Calibration and Service

- Full service support from factory trained engineers
- Sample extraction, including Isokinetic to ISO Standards
- Shrouded probe extraction



Tritium In Air

Typical applications include monitoring tritium activity in room air and exhaust stacks. This is necessary in facilities handling or storing tritium or tritium containing materials. Facilities such as those in biomedical research, synthesis laboratories, pharmaceutical laboratories, neutron generators, accelerators and fusion research reactors.

The **LB 110** provides the measurement of tritium activity concentration in air directly. Discrimination between Tritium and other radio isotopes is possible in a second measurement channel using a pulse rise time technique.

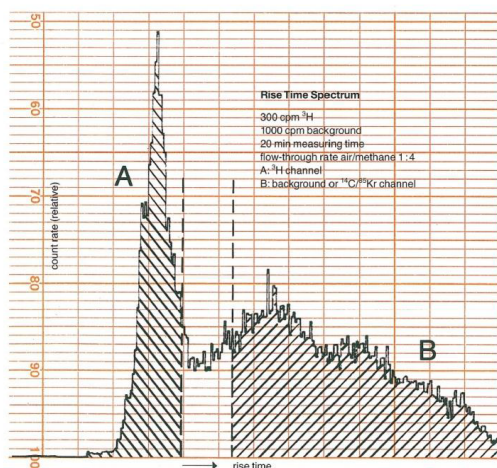
LB 671 ion chamber Tritium in Air system for higher activities and without the need for counting gas.

Detection limits (averaging time 10mins): LB 110 <1 kBq/m³

LB 671 approx. 300 kBq/m³

LB 110 Tritium in Air Monitor

- Proportional flow through detector system with discrimination between Tritium or C¹⁴ and Noble Gas
- Measurement Air and Counting Gas flow regulation
- Virtual Cathode wire to limit memory effect due to deposition of tritium on the detector walls
- Detector heating option to eliminate condensation



Rise Time Spectrum analysis to discriminate between Tritium and other isotopes (eg ³H or ¹⁴C/⁸⁵Kr)

LB 110

Efficiency for ³ H	60%
Spillover ⁸⁵ Kr into ³ H channel	5 to 7%
Background in ³ H Channel	1 to 3 cps
Measuring volume	0.325 litre
Air sampling flow rate	0.25 L/min



LB 671 Tritium in Air Monitor

- Cylindrical Ionisation chamber with two concentric cylinders
- Ion trap for charged particles between cylinders
- All parts in contact with sample air are or in Stainless Steel
- Heating of inner cylinder to eliminate condensation

LB 671

Efficiency for ³ H	0.2%
Spillover	n/a
Background	zero point cal
Measuring volume	2 litre
Air sampling flow rate	set at 4 lpm

Fixed Filter Alpha/Beta Particulate Monitors & Samplers

Berthold offers fixed filter monitors for alpha, beta and gamma particulates. All our systems include efficient sampling pumps and can be supplied with active flow control for isokinetic sampling of stacks. For alpha particulate the systems have the capability of measuring both natural and artificial alpha with compensation for radon and thoron series nuclides.

The exposed sampling parts of the monitors are available in high grade stainless steel or, in the case of the **LB 150 D-R**, an optional Teflon coated dust collection unit.



**200 mm diameter
filter of LB 150 D-R**

LB 150 D-R Alpha-Beta Particulate Monitor

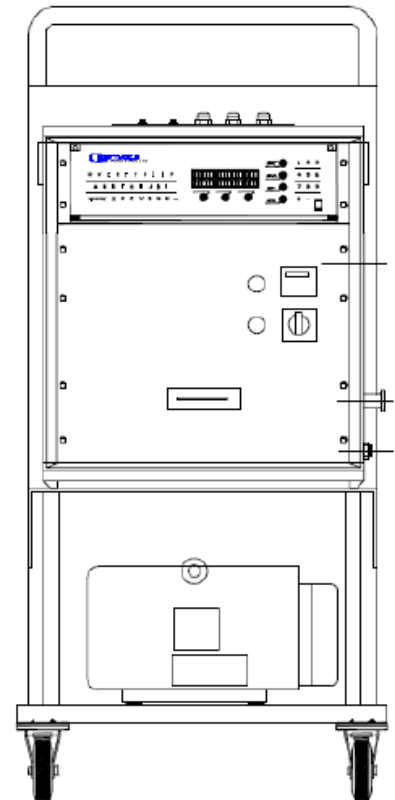
- 200 mm diameter glass fibre filter
- Triple detector for alpha & beta, gamma (guard) discrimination
- High sampling rates, typically 40 m³/h flow rate
- Discrimination of naturally occurring alpha contribution by energy range discrimination (AERD) and pseudo coincidence method (ABPD)
- Low detection limits, <0.01 Bq/m³ artificial alpha (60min averaging time, natural activity in equilibrium at concentration of 0.1 Bq/m³)
- Applications include requirement for very low detection limits in stack emission or where high temperature air needs to be diluted for cooling purposes before sampling.

LB 152-1 Alpha-Beta Particulate Monitor

- Available as Alpha only, Beta only or Alpha/Beta versions
- Mobile versions with sampling pump, sampling rate up to 6 m³/h
- 40 mm lead shield
- 60 mm diameter glass fibre filter
- Pseudo coincidence (ABPD) compensation for natural activity nuclides with Alpha/Beta version
- Detection limit :
Alpha <0.2 Bq/m³ 10min averaging time
Beta <2 Bq/m³ 10min averaging time

LB 9124-1/NaI Gamma Particulate Monitor

- 2" NaI detector, energy range 50 keV to 2.5 MeV
- 50 mm lead shielding
- 60 mm diameter glass fibre filter
- Nominal sampling flow rate of 5 m³/h
- Temperature control option
- Detection limit <0.15 Bq/m³ (60 min averaging time, Co-60)



**Fig 1: Monitor on Mobile
chassis**

Moving Filter Alpha-Beta Particulate Monitors

Systems for monitoring airborne radioactive Alpha and Beta particulates in rooms, ducts and stacks. The continuously or step moving filter provides autonomous operation over months. This has particular advantages in areas where access is minimised to limit potential exposure to hostile environments or where the monitors are deployed in remote networks as, for example in environmental monitoring networks.

A particular advantage of the systems is the possibility to provide corrosion resistant materials for all the wetted parts and that the air sampling module has IP65 rating thereby protecting the user from potential exposure to sampled air.

LB 9128 Series Moving Filter Alpha/Beta Particulate Monitors

- Filter Tape monitor cassette, dust collection area $25 \times 25 \text{ mm}^2$
- Filter speed from 5 mm/h to 500 mm/h
- Sampling head for $3\text{--}5 \text{ m}^3/\text{h}$ flow rates
- Si-CAM Detector, optional compensation for high ambient dose rate
- Radon Thoron compensation by pseudo coincidence (ABPD) & AERD
- Instrumental Detection limit alpha 0.006 Bq/m^3 , beta 0.039 Bq/m^3 (60 min averaging time, rate proportional)

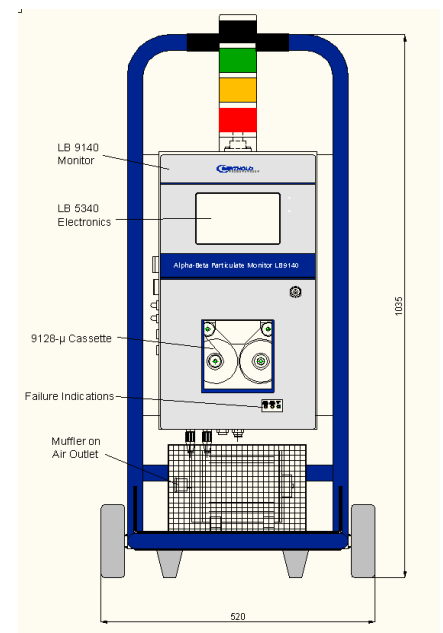


LB 9100 Series Moving Filter Alpha/Beta Particulate Monitor

- Filter tape, dust collection area $50 \times 50 \text{ mm}^2$
- Wide range filter speeds or step control
- High sampling rates to $25 \text{ m}^3/\text{h}$ and isokinetic sampling option
- Alpha/Beta scintillation detector
- Optional stainless steel/ruggedized versions for hostile environments
- Radon Thoron compensation by pseudo coincidence (ABPD)
- Optional delayed detector (120 hours) to eliminate radon influence
- Combination with Iodine and/or Noble gas monitor in same cabinet
- IP68 protection for sampling module
- Instrumental Detection limit alpha 0.001 Bq/m^3 , beta 0.021 Bq/m^3 (600s averaging time, rate proportional)

LB9140 Transportable Moving Filter Alpha/Beta Particulate Monitors

- Filter Tape monitor cassette, dust collection area $25 \times 25 \text{ mm}^2$
- Filter speed from 5 mm/h to 15 mm/h
- Typical $3.3 \text{ m}^3/\text{h}$ sampling flow rate
- Si-CAM Detector, optional compensation for high ambient dose rate
- Wetted parts Ni plated brass to MIL standard, IP65 enclosure.
- Small Footprint, Transportable.
- Radon Thoron compensation by pseudo coincidence (ABPD) & Alpha energy (AERD)
- Silent Low maintenance pump
- Instrumental Detection limit alpha 0.02 Bq/m^3 , beta 0.08 Bq/m^3 (60 min averaging time)



Radon Thoron Compensation Techniques

In order to maintain the lowest detection limits for transuranic alphas such as from uranium, plutonium, americium and curium, compensation for alphas derived from radon, thoron and their progeny needs to be employed. Fluctuating and elevated levels of radon/thoron/progeny can lead to elevated DAC values and false alarms.

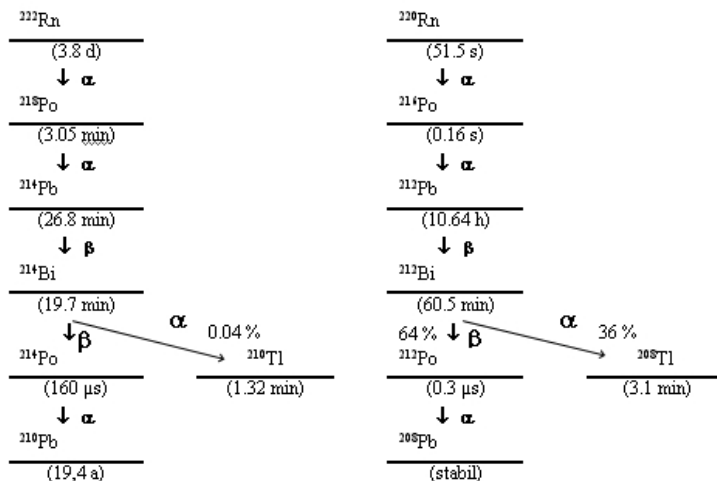
All Berthold alpha/beta filter counting systems have the ability to compensate for radon/thoron/progeny alphas present on the filter. By using pseudo coincidence and, in some cases, energy discrimination the compensation provides excellent measurement of transuranic alphas. As the pseudo coincidence technique is based on the specific decay characteristics of radon/thoron, it is independent of temperature/pressure and dust loading, which is a problem when using spectral and/or energy discrimination.

Pseudo coincidence (ABPD)

This technique utilises the fact that an alpha emission occurs within 160 μ s of a beta emission in the radon/thoron decay chain. By time gating the alpha and beta channels an accurate measurement of natural alphas is possible allowing for compensation. The method is further improved by measurement of the random occurrence of an alpha followed by a beta since this will occur at the same frequency as a beta followed by an alpha.

Energy Range Discrimination (AERD)

By using multiple alpha detectors and the fact that radon/thoron/progeny have alpha energies between 6.0 and 8.78 MeV a further compensation method can be used together with the ABPD method.



Iodine in Air

The measurement of Iodine (I-131 and I-125) radioactivity concentrations in air cannot be achieved on a glass fibre filter/detector arrangement. Instead a special activated charcoal "TEDA" filter is used within a suitable lead shielding/detector arrangement.

Berthold provides systems for both I-125 and I-131 measurements for room, stack and environmental applications.

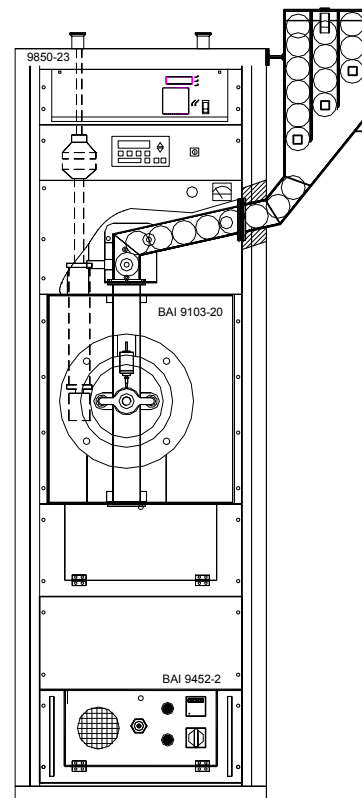
LB 9122/9123 Mobile Iodine in Air Monitors

- I-131 and I-125 versions
- 25 mm or 50 mm lead shielding options
- Noble gas compensation
- Heated option to eliminate temperature effects of iodine capture and PM tube drift
- Nominal 3 m^3/h sampling rate
- Detection limits: I-125, 0.3 Bq/m^3 (3600s averaging time)
I-131, 2 Bq/m^3 (3600s averaging time)

LB 9103 Stationary Iodine Monitors

(Additional features to above)

- Sample flow rate measurement
- Optional TEDA cartridge sample changer LB 9103-21
- Optional auto source check actuator
- Detection limit I-131 1.2 Bq/m^3 (3600s averaging time)



LB9103-21 with optional TEDA cartridge sample changer

Data Acquisition, Visualisation, Archiving and Reporting

A number of data acquisition, alarm and control systems are available depending on the requirements of each facility. The **LB 112** can provide individual measuring stations for a pair of detectors with display of instantaneous radiation levels together with multiple local and/or alarm outputs. The alarm relays can also be used for hot cell interlock purposes.

A multichannel data logger, **LB 9000** provides a central station connected to multiple probes within the facility. The multichannel system provides trend graphics for all of the connected probes together with daily release values from a stack detector. For smaller installations the 6 radiometric channel **LB 5340** can be used.

For long term data archiving the above systems can be linked to the Windows based MEVIS PC software. MEVIS provides a full database of all the radiological measurements, historical and active alarms together with flexible reporting which is especially important for stack release data. Multiple systems can be linked via RS232/485 or Ethernet. WLAN is available too with appropriate interfaces (Ethernet to WLAN; RS485 to WLAN).

For an even greater degree of facility monitoring we offer a full System Control and Data Acquisition (SCADA) system. This system provides full data collection from all the measurement detectors and integrates other building signals such as cyclotron status, vault door interlocking, hot cell interlocks, ventilation status of each room/hot cell. Each room of the facility is graphically shown, together with the detector values and alarm status. A number of remote touch screen displays located throughout the building allows personnel to view activity levels and various building status signals from remote locations.



The **LB 112** allows connection of two detectors (eg LB 6535 Activity in Air probe) and provides a visual display of the live measurement.

The alarm beacon can be mounted on the enclosure, as shown, or remote as required.

A number of LB 112s can be networked with a central archiving software (MEVIS or SCADA).

Multiple alarm relays are provided for each measuring channel allowing the unit to directly activate interlock signals.

The **LB 9000** allows multiple monitoring systems to be connected directly to a central location.

The system is modular allowing configuration for the required number of detectors and alarm/control relays as the facility requires.

The built-in display allows graphic representation of the radiometric data.

Reports can be generated automatically such as daily stack release data.

For data archiving the system can be interfaced directly with MEVIS.

The LB 9000 offers an intermediate solution to a full SCADA system but can also be incorporated into a SCADA network.



Data Acquisition, Visualisation, Archiving and Reporting

MEVIS provides a Windows PC based software for visualisation of the radiological data in real time and from a historical database. Alarm status is also archived allowing a full history of the facility status to be recalled.

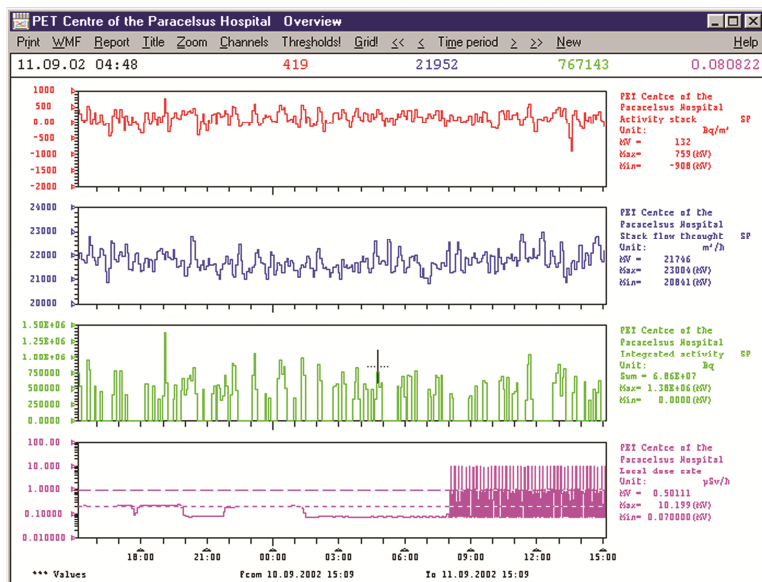
A single page graphic of the building is provided with a summary overview of the dose rates and activity in air status for the facility. Individual detector time trend graphics are provided together with accumulated release values and air flow rates from the stack release monitor.

Alarms can be defined within MEVIS to alert the user of an accidental release of activity or if they are approaching the daily authorisation activity limit. Full reporting of the released activity is provided.

Multiple users can consult their own subset of measurement data via webpage publishing and MEVIS visualisation software. System redundancy can be achieved by a Master/Slave setup of the MEVIS package on 2 PC platforms.

Berthold also offers a full System Control and Data Acquisition (SCADA) for facilities. By using a SCADA system Berthold can provide a fully integrated solution for radiation monitoring application.

The SCADA system allows multiple input and output signals to be combined with the radiological measurement data. All probes are directly connected to either one or multiple "Nodes" located in the building, the Nodes are then connected via Ethernet to a central SCADA PC running industry standard application software specifically configured for the application. Additional signals can be integrated with the measurement, such as the status of ventilation extract system, pressure, temperature, etc. Having all this information correlated in a single database provides greater insight into the facility's operation.



MEVIS central station screen display of radiometric data from four monitors within a facility.

Displays include building graphic summary, trend displays, alarm status (both live and historical), accumulated stack release activity as an amount and as a percentage of daily authorisation.

Alarms can be provided locally or at the central MEVIS station.

The **LB 5340** data logger is the normal device incorporated into the air monitor cabinet and provides local display and calculation of activity in air concentration and activity released per unit time.

The system can be networked with the central data station MEVIS or SCADA PC as required.



LB5340 Data Logger (19"-rack, 3 HE)

SCADA

Using an industry standard SCADA provides for the integration of many of the facilities status inputs which can directly relate to the radiation monitoring system. For example release abatement systems can be completely controlled by the SCADA system and alarms distributed throughout the facility.

Ventilation status signals can also be integrated allowing the user to correlate activity release events to ventilation failure. The SCADA system can be configured for multiple input and output signals of all types such as: 4-20 mA analogue, contact closure event signals, TTL pulse signals, Ethernet, RS232/485.

16 channel I/O modules can be multiplexed to provide the required number of input and output signals such as alarm beacons or interlock relays.

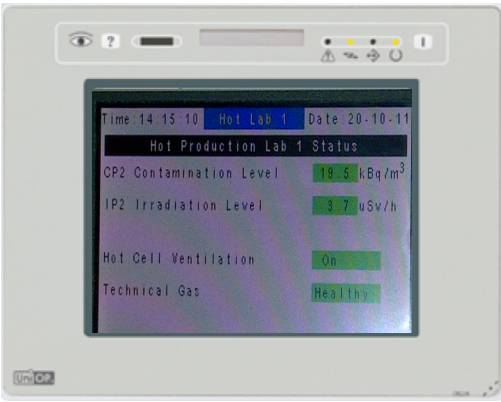
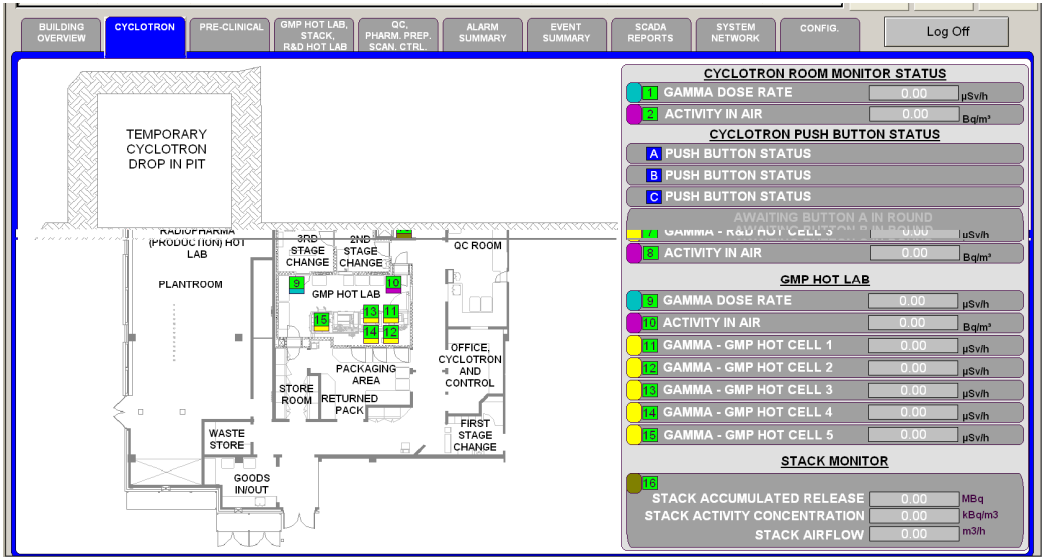
Data recording is provided by the PC together with graphic displays of the room layout, activity trend graphs, alarm status etc. If required multiple PCs can be configured to run in a dual redundant mode.

Information can be disseminated to other locations by connecting remote touch screen displays as required.

Building graphics can be configured for each area of the facility with the real time activity in air and dose rate shown for each location.

Clicking on the probe icon provides the historical trend displays of the activity vs time.

All alarms are immediately displayed on the screen and alarm beacons triggered in the desired remote and/or local rooms.



Remote colour touch screens are available to distribute the current Activity in Air and Dose Rate values for each location. The user can select the required area of the facility and immediately see the actual Bq/m³ or uSv/h values in that area.

The values are highlighted in green/orange or red background depending on the activity level and defined alarm thresholds.

High visibility alarm beacons are typically installed in key locations providing an emergency audio visual indication of a



Stack Monitoring, Sample Extraction and Flow Measurement

For effective stack monitoring or sampling the flow rate has to be determined within the required accuracy and a representative sample extracted from the air stream with minimal particulate losses.

Flow rate measurement and sample extraction techniques are well described and need to conform to a number of international regulations such as ISO2889 and equivalent local standards.

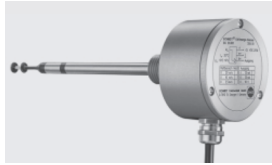
Berthold has many years experience in providing air monitoring solutions compliant with the required standards.

In applications where the stack flow rate varies and isokinetic sample extraction is required specialised sample probes are provided with the capability of adjusting the sampling rate automatically.

Stack or Duct Flow Measurements

Thermal anemometer

- Simple to install
- Virtually maintenance free
- Accuracy >5%
- May not be representative for large ducts with turbulent flow



Flow Meter Location

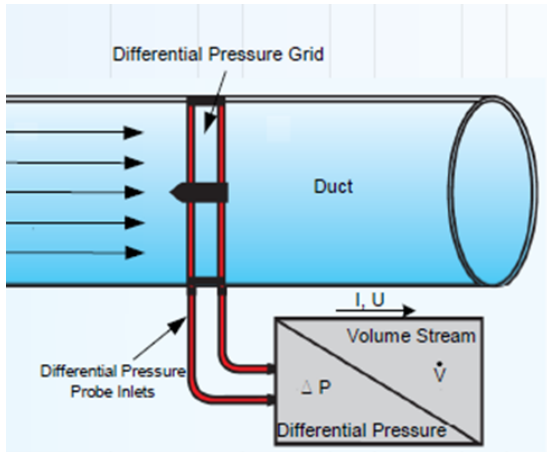
In order to achieve an accurate measurement of the air flow it is extremely important to install the sensor in the optimum location.

A measurement in a well mixed air stream is required which is normally 5-10 diameters from the last bend or junction of the duct work.

It is therefore very important to include the requirement of the flow measurement in the design of the stack at an early stage.

Wilson Grid/X-Y grid

- Array of Pitot tubes
- Averages flow across whole cross section of duct
- Accuracy <3% with in-situ calibration
- Virtually maintenance free

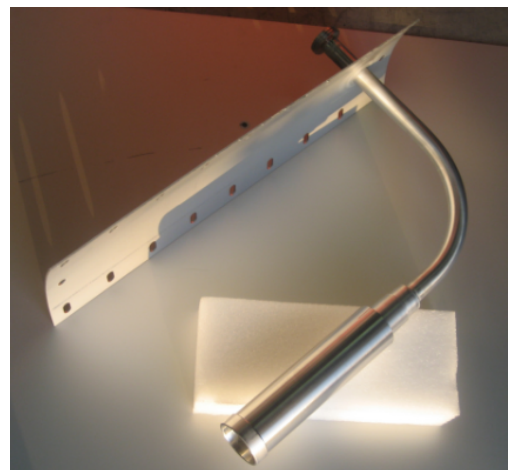


Sample Extraction

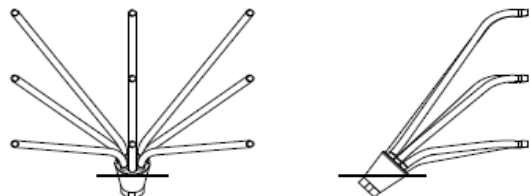
The location and construction of the sample probe is critical and must be optimised to ensure representative sampling. Considerations include:

- Isokinetic Sample Probes. Custom designed to ensure velocity entering the sample tube is the same as that in the stack. For varying flow rates the sampling pump has to be regulated to maintain the equal flow
- Typically, in a well mixed airflow, successful sample probe locations are in the range of 5 to 10 hydraulic diameters downstream of a flow disturbance and 3 or more hydraulic diameters upstream of a flow disturbance
- Shrouded Probe design
- Customised multi point air sampling rake
- Polished Stainless Steel with minimum 5D bend radius
- Plastic tubing, for example in iodine sampling
- Minimal sampling tube lengths
- Trace heating to minimise condensation in the sample lines

Shrouded Probe



Multi point air sampling rake



Installation and Calibration

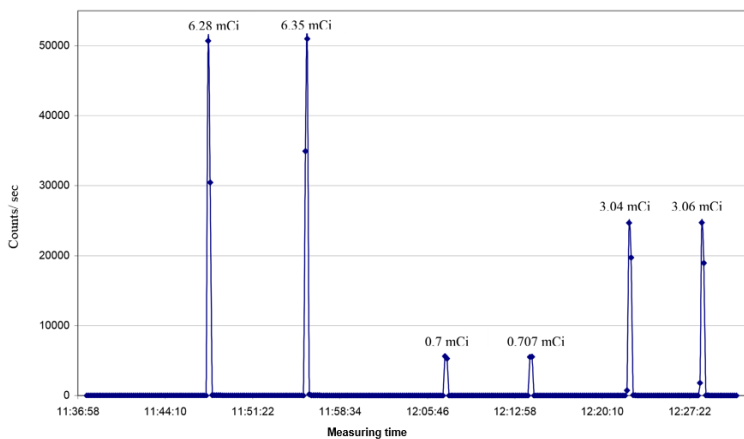
Berthold provides full design and configuration of a turnkey solution for air monitoring applications tailored to the customer's specific needs.

An installation is provided, followed by on site testing and validation. Berthold has experience working with many industrial applications in the nuclear industry and with sample extraction techniques.

All Berthold detectors have factory test data against traceable sources to confirm the required calibration factors.

If on-site calibration of the stack monitors is required Berthold has many years experience providing assistance to scores of facilities around the world.

Detector failure is automatically alarmed and the Central Station PC provides a permanent log of the alarms and events. Detector failure and other "trouble" signals can be accommodated by the other data logger options. In the event of any system failure Berthold engineers are available to provide on site service.



Controlled release of known activities of gaseous isotopes can be used to provide a "live" calibration check of the air monitoring probes including the stack release monitor.

Particulate sampling is more demanding but Berthold has collaborated with testing laboratories to characterise the performance of our systems using well defined aerosols of known activity.

Service

Berthold provides full design and configuration of a turnkey solution for radioactivity in air measurements tailored to the customer's specific needs.

A number of standard air monitoring system modules can be combined to provide the specific measurement solution for the application.

In line monitors for gaseous isotopes avoid the need for sample extraction but where the latter is required Berthold is able to offer systems to meet the various international standards including isokinetic sampling.

Remote software support can be provided by installations that are connected to the internet and if required on-site service supported by a local inventory of spare parts to ensure minimum downtime.

Should the user wish to undertake first line service themselves Berthold can provide the appropriate training and telephone support whenever necessary.

Calibration Of An Alpha-Beta Moving Filter
Particulates Monitor
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