

Stack Monitoring and Sampling



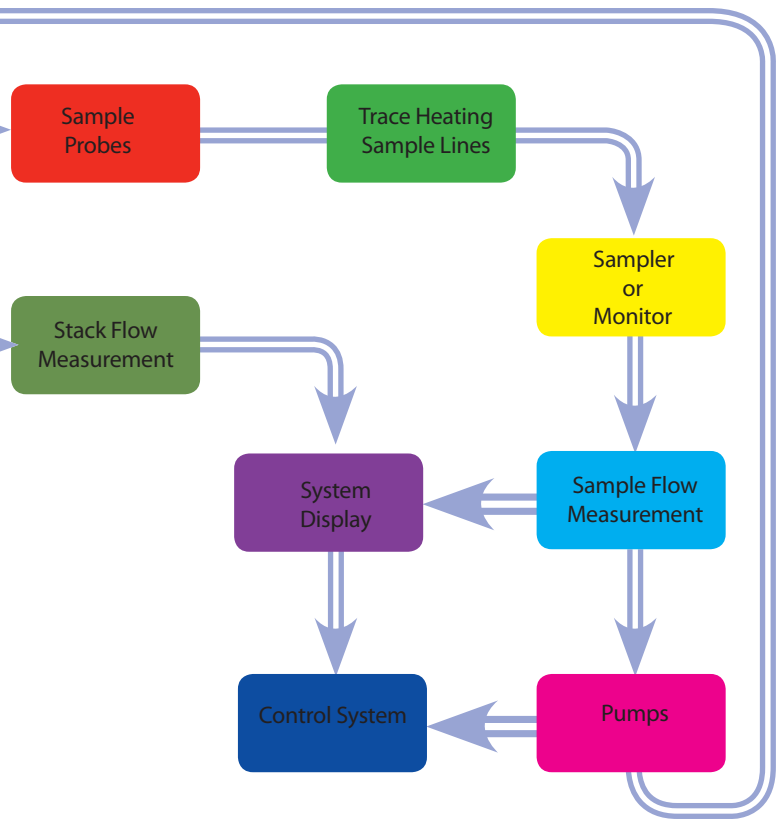
Stack Systems

The philosophy for any stack monitoring system is based so that the complete system can comprise of all or some of the modules of equipment described in this document.

The exact requirement will depend upon many factors, the need to either perform SAMPLING or MONITORING, the location of the equipment, the type of contaminant in the air stream, the data required by the site and regulatory Health Physics personnel.

Lab Impex can assist with design at early stages of a project to ensure that the equipment can be sited in the optimum location. This ensures that the measurements provide the most accurate results possible.

It has been found that an early design of discharge measurement equipment provides the most cost effective and efficient system.



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| 4 | Stack Systems | The stack measurement system may be designed to measure particulate or gaseous discharges. Depending upon the nuclide ,differing methods are incorporated to collect the contaminant. |
| 5 | Sample Probes | The sample is removed from the stack or duct via a sampling probe. For particulate sampling an Isokinetic or Shrouded probe would be used. Gas sampling would use a simple gas sample probe, the position of the probe to collect both particulate and gaseous contaminants is critical in both cases. |
| 6 | Trace Heating Sample Lines | The sample transport line is a very important feature in the sampling loop, this is one of the main areas whereby losses may occur in the transport system. Careful understanding must be applied to this aspect of the design and in some cases Trace Heating of the sample/return lines should be considered. |
| 7 | Samplers | The sample collector may be a filter paper for particulate measurements or liquid traps for some forms of gases. Gases may use a charcoal filter as a collection medium, which would then be removed for subsequent counting . |
| 8 | Monitors | LIS offers a range of detection systems for the continuous measurement of radioactive material |
| 10 | Stack Flow Measurement | The measurement of the air stream in the stack or the duct is a crucial element in any sampling or monitoring system. Low velocity air flow measurement is a difficult process and Lab Impex prefer to use an Averaging Pitot type device. The requirements for accurate flow measure are well defined and we can advise as to their location and operation. |
| 12 | Sample Flow Measurement | The amount of sample flowing through a collector should be measured to ensure that the correct sample flow rate is maintained and in many instances this device will also be required to totalise the flow over a known time period. This device will also provide a Hi or Lo alarm if the flow rate varies from set parameters. |
| 13 | Pumps & Control System | The sample needs to be removed from the stack or duct by a vacuum system, after the sample has travelled through the collector, it will be returned to the stack/duct. The vacuum may be produced by a vacuum pump or an ejector, which requires a compressed air source to provide its motive power. |
| 14 | On Site Support | LIS offer a range of on site services including consultancy, feasibility studies, installation, flow tests, calibration and maintenance. |



Stack Systems

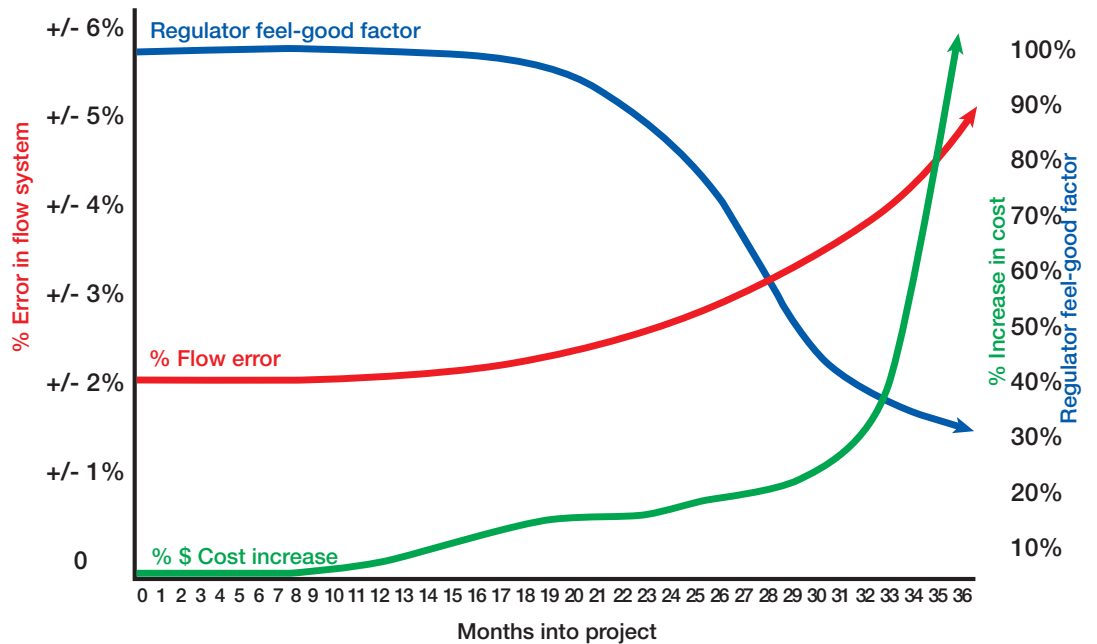
There are basic differences between SAMPLING and MONITORING systems, a sampling system collects a sample removed from the stack or duct, and this sample is removed from the system and retrospectively counted in a laboratory. A monitoring system draws the sample into a detector which measures the activity in real time. A sampler would be used for regulatory purposes whereas a monitor would be used for instantaneous measurements and the trigger mechanism for alarms.

For collecting particulate for either sampling or monitoring systems, the sample would be collected onto a filter paper, whereas Tritium would be sampled by collecting it in a liquid trap, which would be retrospectively counted. For monitoring purposes the gas sampler would be passed through an Ion chamber.

The air stream in the stack or duct would need to be measured, there are many various air flow meters available, but the Lab Impex preferred option is to use an Averaging Pitot type device. There are several reasons for this, the first being that the working principles of a Pitot are well proven, tried and tested, well documented and covered by many UK and international standards. They can be easily tested and calibrated in-situ, without the need for expensive removal and return to external testing laboratories.

The aerial discharge sampling and monitoring equipment maybe a small part of a nuclear facility, but it is extremely important that the system works efficiently and correctly. To ensure that the equipment is located in the optimum location, early consideration as to its position increases accuracy, reduces cost and generates a "Feel Good" impression of a good engineering solution.

Factors affected by early or late design



Where systems have to be retrospectively installed into existing installations and facilities; where the conditions are not ideal, Lab Impex can supply advise as to the best location to position equipment and design bespoke solutions to overcome the limitations of the site conditions.

Sample Probes

There are three main types of stack sample probes used by Lab Impex, Isokinetic and Shrouded probes are used to extract particulate samples from stacks and ducts and simple gas probes for gases.

The location of the sample probe is critical, to ensure representative sampling together with the positioning of the collecting device. Lab Impex Systems can offer a service to advise as to the optimum sample train design, this would cover the complete sample transport system, which includes the sample probe (design and location), sample transport line and the type and location of the collecting device (Monitor or Sampler).

Isokinetic Sample Probes

Isokinetic Sample Probes are designed to extract a sample from the stack with the velocity of the air entering the nozzle flowing at the same velocity as the free gas stream in the stack. With the two velocities being equal this ensures that there is no over or under sampling of the particulate in the gas stream. With the stack flow being at a fixed flow, and the sample flow being fixed the diameter of the nozzle bore is the limiting factor to determine that the sample probe is operating under isokinetic conditions.



Oversampling

If the flowing velocity into the nozzle is greater than the free stream velocity, the system will over sample the amount of particulate in the stack.

Undersampling

If the flowing velocity into the nozzle is less than the free stream velocity, the system will under sample the amount of particulate in the stack.

Isokinetic sampling

When the two velocities are exactly the same, the nozzle collects a true representative sample of the particulate which is entrained in the stack flow stream.

Shrouded Probes

The shrouded probe can offer some benefits over an isokinetic sample probe, where as the isokinetic sample probe has work within a defined set of flowing parameters, a shrouded probe can operate over a range of stack flow conditions.

The outer shroud captures an intermediate sample from the main stack flow stream and the internal sample nozzle collects particulate from this smaller sample. The shrouded probe has been tested to determine the collection

Gas Sample Probes

The gas sample probe assumes that the stack flow is a homogenous fully mixed volume of gas in the stack. The maximum length of sample pipe is not so important as for particulate sample lines where sample losses could occur due to plate-out within the transport system. However, care should be taken with the choice of pipe line material, to ensure that there is no reaction between the gas being sampled and the material of construction.

Trace Heating/ Sample Lines

Trace heating

The sample gas which reaches the collector, should be dry to avoid and moisture damaging the detector or collection media.

Condensation may occur if the sample transport line travels through areas which have differing temperatures and if the stack gas temperature is greater than the surrounding temperatures.

A common reason for these conditions occurring is when the sample is being removed from an external stack and then running through cooler exterior sections and back into a warm building.

If the stack temperature is greater than the cooler external air, any moisture in the sample gas could condense in the sample line, after which the liquid would be drawn into the building and onto the collector.

Information concerning the RH (relative humidity) for the stack gas and any temperature gradients along the transport route should be considered to determine if condensation problems could arise. Trace heating the sample transport lines can eliminate potential moisture problems.

Sample transport lines

When considering transport lines for sampling particulate the length of the pipe run should be kept as short as possible. The inside of the particulate transport system should be clean, smooth and free from debris, to this end schedule pipe should not be used, cold drawn tube is the preferred material used by Lab Impex Systems.

Horizontal straight tubing sections should be kept as short as possible and there should be no inwardly steps at the tube connections which reduce the tube diameter by more than 1%.

There will be some losses in the transport system, but careful design and consideration will optimise the overall efficiency of the system. For 10mm AD particles the penetration from the free air stream to the collector should be less than 10%. The early design of the sample transport system can greatly increase the efficiency and reduce cost of the overall system.

The same criteria regarding condensation, and maintaining the sampled gas above its dew-point should be applied when sampling gaseous effluents.



Samplers

Tritium and C14 Samplers

Tritium and C14 samplers collect the sample by passing the sample gas through liquid traps, the liquid is subsequently removed to a laboratory for counting. The collection medium for Tritium can be either demin-water or glycol whereas sodium hydroxide would be used to collect C14.

Depending upon in which form the isotope is - organic or inorganic a furnace and catalyst may be incorporated.

The flow of the free air stream in the duct or duct together with the sample flow through the collectors are both displayed in the sampler enclosure.



Particulate Samplers

The sample is withdrawn from the duct or stack by means of either an Isokinetic or Shrouded sample probe, with the sample transport line being kept as short as possible (see section on sample lines).

The sample is collected on filter papers which can either be card mounted or loose, these are removed and retrospectively counted in a laboratory. The size of the collection medium will depend upon the type of counters being used. As the record sampler is to be used for regulatory purposes, dual vacuum pumps are normally supplied, these pumps can be controlled either manually or with automatic changeover.

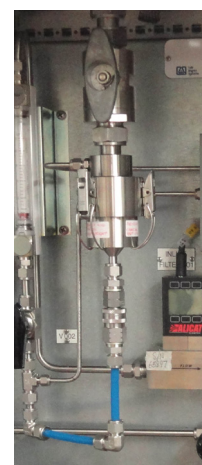
Both the totalised stack and sample flows are recorded over the sampling period, with alarms to warn of flow rates which are outside a pre-defined level.

If the sample is being collected by means of Isokinetic Sample Probes it is important that the stack and sample flows remain constant, however if there is a possibility that the stack flows could vary over time (during dark hours for instance) it may be necessary to modulate the sample flow, to maintain a stable sampling fraction. If a shrouded probe is used this problem is overcome, as a shrouded probe can operate over a range of stack flows.



Iodine Samplers

In many ways Iodine Sampler is similar to Particulate samplers in their physical construction and operation. However wherein particulate is collected on a membrane filter, iodine is collected on a tedia or charcoal cartridge. Care should be taken with the choice of the routing of the sampling transport line, to avoid temperature gradients etc.



Monitors

Alpha-Beta Particulate

For continuous measurement of radioactive particulate in stacks and ducts, nuclear facilities will often incorporate a Continuous Air Monitor (CAM) in their stack monitoring program. Due to the need to provide a result in real time, a CAM offers a less sensitive result compared to laboratory analysis of a record sample, however the system offers the advantage of providing early warning to a failure of the process or filtration mechanisms.

The LIS SmartCAM is a next generation alpha-beta CAM that provides the user with unparalleled performance in terms of detectable limit, sensitivity and speed to alarm.

The SmartCAM utilizes state-of-the-art Spectral Measurement Analysis in Real Time (SMART) Technology, which provides real advances in alpha measurement techniques. Using an isotope peak fitting algorithm proven to be more accurate than regions-of-interest or tail-fitting methods, results are faster, more accurate and more reliable than ever.

Key points of performance include:

Measurement of alpha and/or beta particulate

Allows the user to identify air concentration by isotope or as gross alpha

Full alpha spectral analysis with unique radon-thoron peak fitting algorithm

Improved measurement quality as a result of alpha spectrum stabilization, by means of continuous air pressure and temperature measurement.

Fixed filter or moving filter configurations available



The SmartCAM is recognized as a leading solution for fast and accurate detection of radioactive particulate. Over 600 devices have been supplied around the world in the past three years.

Iodine

Continuous measurement of radioiodine species within stack effluent is a common requirement for nuclear power and fuel cycle facilities.

The LIS monitor is available in isotopic specific configurations including I-124, I-125, I-129 and I-131, and offers real time measurement of both molecular and organic forms of iodine.

The sensor element of the Iodine Monitor is a patented detector called the CGADC (Continuous Gas Analysis and Detection Chamber). The CGADC combines a sensitive scintillation detector with a stainless steel measurement chamber housing a radioiodine filtration cartridge. The CGADC is packaged as an integrated device, with shielding, pump, flow sensor and CMS (Continuous Monitoring Station) processor, and is available in either a fixed or transportable configuration.

Key points of performance include:

Filtration mechanism captures all forms of radioiodine

Achieves low MDLs through unique detector design with Brehmstrahlung shield

Automatic background compensation

Temperature spectrum stabilization reduces inaccurate measurement due to spectrum drift

CMS analysis algorithm provides a low stable measurement at background, but ensures a fast response to rising concentration levels



Monitors

Noble Gases

The LIS Noble Gas Monitor is an integrated solution for the measurement of the airborne concentration of radioactive (beta emitting) noble gases. The monitor is suitable for stack applications, and comprises detector, shielding, pump, flow sensor and CMS (Continuous Monitoring Station) processor.

The heart of the system is the BG-10 scintillation detector. Offering unparalleled sensitivity to noble gases, the BG-10 uses a specially designed plastic scintillation sensor mounted in a flow through measurement chamber.

The LIS Noble Gas Monitor is available in a standard configuration with a six decade range of measurement, or alternatively as a dual detector configuration offering a wider, extended measurement range .

Key points of performance include

- Excellent MDL resulting from minimal detector response to external sources of gamma
- Low response to NORM such as radon and thoron
- CMS analysis algorithm provides a low stable measurement at background, but ensures a fast response to rising concentration levels
- Optional gamma dose-rate detector for dynamic gamma background compensation



System Configuration Options

The LIS Stack Monitoring Stations for alpha/beta aerosol, iodine and noble gas are available as either independent stand-alone devices, or as integrated systems comprising all three or any two of the monitoring stations.

Central Data Logging of Effluent Discharge

Nuclear facility license requirements stipulate the need for continuous recording and management of effluent data.

Typically, this can be achieved through the use of data loggers such as chart recorders and other panel mount hardware, but increasingly facilities are implementing the use of PC loggers and supervisory control and data acquisition (SCADA) networks.

The LIS Stack Monitoring Stations are compatible with many industrial SCADA packages such as LabVIEW, but for clients who require a more application specific solution, LIS offer a bespoke radiation monitoring SCADA called the 9205EMS.

The 9205EMS collects real-time alarm status and result data from a network of the radiation detection instruments and stack monitoring equipment.. Key points of performance include

- Facility Floor plan view allows fast recognition of any alarm or status event
- Effluent data presented for stack releases on a daily, weekly, monthly and annual basis
- Automatic effluent release reports generated at a user defined frequency
- To provide instant data access, the 9205EMS internet client allows an operator to review 9205EMS data from any network access point
- Graphical display of historic measurement (trend and tabular)
- Compatible with any network architecture (TCPIP, RS485, Wireless)



From the systems' inception in the early 1990's, the 9205EMS has been adopted at hundreds of nuclear facilities around the World.

Stack Flow Measurement

Type of Flow meter

The choice of flow meter is dependant upon many factors, the flow rate, the geometry of the stack/ducting and the location at which the flow meter can be installed.

There are many designs and principles of measuring air flow, and the type of device favoured by Lab Impex are flow meters based on the Pitot Tube. There are several reasons for this. The first being that the working principles of the Pitot are well documented and covered in many UK and International Standards and directives.

They can be easily proved and calibrated in situ, without the need for expensive removal and return to test laboratories.

There are several basic formats of the Pitot device which have been enhanced by Lab Impex Systems to cover the wide range of installation requirements which are found today in the nuclear industry.

When combined with our DP2001 Low Range Differential Pressure Transmitter, it offers a simple solution for measuring a very difficult parameter – AIR FLOW. With increased accuracy, the amount of emissions into the environment can be controlled to a higher level than ever before, and when used in conjunction with our range of monitoring and sampling equipment, even the smallest amounts of allowable discharge can be detected.

We are dealing with fairly large conduits through which the flowing medium (discharge air) is moving at a relatively slow velocity i.e. less than 12-14 m/sec.

In a perfect installation, the length of duct into which the flow meter is to be installed would be at least 10 hydraulic diameters long.

Under these conditions the position of the flow meter would be at a point 70% along the duct. At this point the velocity profile would be fairly regular and flat, but as stated above, this is a perfect installation, and in the real world things may not be as simple.

There are many types of flow meters, and within these types there are different configuration.

- Single point measurements.
- Averaging flow meters in one plane.
- Averaging flow meters in two planes.

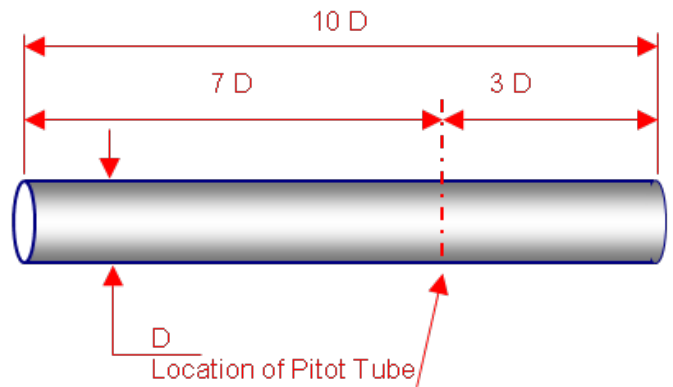
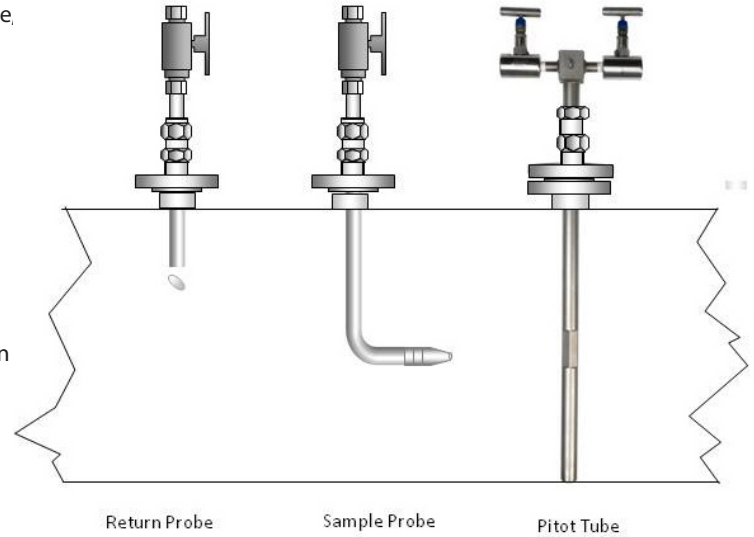
We can say that at LIS our preferred type of flow meter is the Pitot Tube. The reason is due to the fact that this form of flow meter has the following benefits :

Simple construction with no moving or electrical parts in the flow stream.

Well documented performance data.

Can be calibrated in-situ.

When used with a LIS differential pressure transmitter DP2001 can give output in Actual, Standard or Normal m^3/sec etc. m/sec and kg/sec .



Stack Flow Measurement

Pitot Arrays

If there are ten or more straight lengths of ducting a single Insertable Averaging Pitot tube can be used.

As the straight duct length decreases there are many solutions to achieve the same amount of flow metering accuracy, but as the straight length decreases the cost of the solution increases.

Pitot tubes can be multiplexed together.

A Pitot Array can be designed to fit into new or existing sections of ductwork. An array is a number of separate Pitot heads, with each one enclosed within a shroud. All the heads are interconnected by means of a common manifold system. Pitot Arrays can be designed and built to suit any size of duct or stack. This type of device is particularly useful where the available length of straight duct is restricted.

Pitot Arrays can be built into complete duct sections, which would contain not only the Pitot Array but also a section of flow straightener. The flow straightener conditions the flow immediately in front of the Pitot heads. This design of flow meter can operate at high accuracy in very short lengths of ducting. As each instrument is designed and built to meet the parameters of each individual installation, they should always be calibrated under the flowing conditions which will prevail under normal usage.

The calibration can be performed in-situ on site, after the instrument has been installed or at the Lab Impex flow facility. The most effective choice of flow test will depend upon the flow rates and size of the duct/stack.

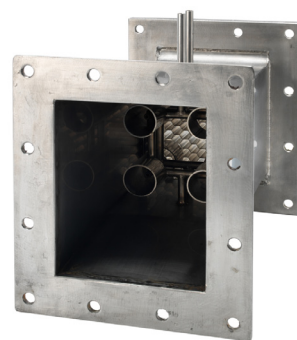
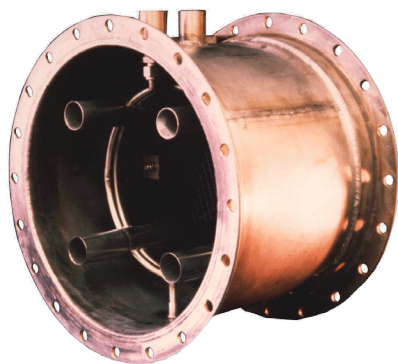
When a Pitot Array is supplied as a complete duct section, sampling probes, temperature sensors and tapping points for static pressure measurements can also be included into the design.

DP2001 Transmitter

When monitoring the airflow in ducts and stacks by means of a DP generating device (Pitot tube, venturi etc) the differential pressure to be measured tends to be less than 300 Pascals. For measuring these low ranges a transmitter designed for just this application needs to be used, the DP2001 range of instruments meets this specification. As changes in process temperature can introduce significant errors in measurements, this source of inaccuracy is removed by including temperature input.

Applications

The Lab Impex Systems DP2001 Differential pressure Transmitter has been designed for use on extract and ventilation monitoring systems. The DP2001 electronics incorporates the latest digital technology and when used in conjunction with the well tried and tested Pitot tube, it produces an accurate and traceable flow measurement. The use of a process temperature input permits mass flow computation, which can enhance the accuracy of flow measurement.



Sample Flow Measurement

Sample flow measurement and system transport

The measurement of the sample flow is as important as the stack flow. The amount of sample which has passed through the collector (sampler or monitor) is crucial to accurate measurements. The sample flow rate is dependant upon the function of the equipment, for instance for particulate sampling or monitoring the sample flow rate could be 37Lt/min or 2cfm, where as for noble gas samplers the flow rate could be 10 Lt/min and Tritium sampler may require only 400cc/min.

There are several methods of measuring these relatively small flow rates. Due to the importance of these flow measurements, on some applications two separate flow meters employing differing technologies are required. In these instances a thermal mass meter and a variable area (VA / rotameter) would be used. The VA meter would be used to measure the flow rate, but this would be a visual measurement only, the thermal mass meter would measure the rate of flow and provide a totalised reading also, which would be reset after each sampling period. In addition to the local displays, the electrical output from this instrument could be used for remote monitoring of the sample flow conditions.

The transport system should be kept as short as possible, and this is critical when considering particulate sample systems.

The sample pipe work should be constructed from cold drawn tube and never schedule pipe, this is to ensure a smooth internal surface. Bends and horizontal pipes should be kept to a minimum. The efficiency of the transport system may be checked by computer modelling or by in-situ testing after the system has been installed. Lab Impex can advise as to the best location for equipment, which should be undertaken as early in the project as possible, please see the graph in the "Stack System" section which is entitled "Factors affected by early or late design".

Sample transport lines for gaseous sampling are not affected as much as particulate sample lines, but care should be taken so as not to have excessive lengths or route paths through differing temperature regions, as this could aggravate potential condensation problems.

Another option is to include a differential pressure transmitter or differential pressure gauge across the collection medium. This will provide important condition signals, it will provide alarm signals if the collector becomes "blinded" where the differential pressure will increase or if the collector is broken or damaged, when the differential will become low.



Pumps

The motive power to draw the sample air through the sampler or monitor can be provided by various vacuum pumps or air ejectors.

The type of pump chosen will depend upon a number of factors which will be unique to each installation, these factors include, sample flow rate, total pressure drop through the system, flowing temperature and the ambient atmospheric conditions at the site location.

For a bubbler type of sampler (Tritium / C14) a diaphragm would be used, when sampling particulate a dry running self-lubricating rotary vane pump would be required. What ever the size and design of pump needed a significant consideration is the importance of the sampling or monitoring function. If the service required is for a monitor, a single vacuum pump is sufficient, although the area from which the sample is being taken must be a consideration. In general terms when specifying the number of vacuum pumps to be installed on a sampling system, because this equipment is being used for historic accountancy purposes two pumps would be used, one run, and one standby. In the event of loss of vacuum an alarm would alert an operator that the run pump had failed and the standby pump should takeover. If the equipment is located in an unmanned area the pump changeover should be automatic.

To overcome the requirement of dual vacuum pumps, if the facility has an installed compressed air supply, an air ejector could be used as an alternative to electrical vacuum pumps. These have the advantage of having no moving parts, and as the air compressor on many sites are supplied from a UPS this means that the system would remain in sampling mode, even in the event of a power failure.

All the pump control signal can be sent to control room or other monitoring systems. The system also contains soft-start devices to eliminate high in-rush currents as the pumps start.



Control System

Pump Control Systems

The pump control system can be as simple as a single on/off switch to a fully automated control system. Often the sampling system is the equipment used to record discharge for regulatory purposes, and therefore it is important to maintain sampling during operation of the plant. To ensure continuous sampling in the event of a pump failure, dual vacuum pumps are incorporate into the design of the system.

The are several considerations which are covered by the Lab Impex design:

- Selection of which pump is designated "Run" and "Standby"
- Indication of which pump is running
- Indication of pump failure
- Reset pump failure alarm
- Pump manual stop/start
- Individual pump run timer

On site support

Annual Flow Testing

It is becoming evermore important to be able to prove that a site, building or process is complying with all the relevant legislation regarding emissions into the environment. Lab Impex Systems work with their customers to meet these requirements, for example under BS140011996 with respect to emissions to air (Section A.3 Planning sub-section A.3.1 Environmental aspects). We assist our clients to achieve their goals covered by their EMS aims:

- Comply and prove their authorised site discharges.
- Comply with the relevant national & local environmental laws.
- Prevent or mitigate the effects of environmental incidents.
- Help promote environmental monitoring awareness to staff.

It is well documented that Gaseous Discharges are very difficult to quantify. We employ tried and trusted flow measurement methods, based on the Pitot Tube principle used in conjunction with state of the art monitoring systems to produce traceable and reliable data, to the accuracies now demanded of Industrial, Chemical, Pharmaceutical and Governmental sites and installations.

The tests are conducted in accordance with detailed documented data/procedures as covered by relevant British Standards publications. Not only can the actual flow be measured, but Characterisation Tests of the stack, can determine that the location of any sampling equipment, is producing a representative example of the discharge via the main stack.

As the legislation concerning emissions into the atmosphere becomes even tighter, Lab Impex Systems offer the full range of their expertise to help you meet your legal requirements for environmental monitoring.

Duct Characterisation Tests

These tests are carried out to determine two factors concerning a duct/stack flow system, the first is to establish the velocity profile at the point at which any sampling of the air stream is performed, and the second is to produce an accurate and traceable measurement of the flow rate, against which any permanently fitted flow meter can be referenced.

These tests results can be used as an annual check to determine that extract systems are still working to their design specifications.

These results can then be used to show trends in fan efficiency, discharge rates etc

The second reason for undertaking these tests is to establish the velocity profile within the duct, so that the nozzle position of a sample probe can be determined. The velocity at the exact location position will then be used to calculate the diameter of the isokinetic sample probe nozzle bore.

There are several National Standards and directives covering dust/stack flow measurements and sampling, in Europe the relevant standard is ISO 2889 and in USA it is ANSI N13.1 .



Positively Supporting Safety

Laboratory Impex Systems is a global leader in the development and supply of radiation detection equipment and integrated nucleonic systems.



PRODUCTS

Detailed overview of each product and it's features



Stack and Duct Sampling and Real Time Monitoring

Lab Impex Systems have the capability to survey, design, supply, install and commission complete isokinetic sampling and stack flow monitoring systems > [read more](#)



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www.labimpex.com

Lab Impex Systems Ltd

Company Profile

Lab Impex Systems is a global leader in the development and supply of radiation detection equipment and integrated systems.

The company is enriched with 36 years of experience in catering to the high technology needs of Defence, Nuclear, Medical and Industrial customers all over the world. We take pride on being able to respond to our customers needs; whether a nuclear power station (operating or decommissioning), a nuclear fuel cycle facility, or a nuclear medicine establishment handling radioisotopes.

LIS are an international supplier of equipment and systems, and are active in every major market around the World.

Our services include:

- Radiation detection instrument supplies
- Consultation on design
- Provision of complete systems
- Installation, commissioning and service support.

Our areas of expertise:

- Technical knowledge and experience
- Quality management system
 - ISO 9001:2008
 - ASME NQA-1
- Post installation service support
- Custom solutions



positively supporting safety

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