TELEDYNE
INSTRUMENTS
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"THE INTEGRITY AND RELIABILITY OF ON LINE PROCESS ANALYZERS IS CRUCIALLY RELATED TO THE DESIGN OF THE SUPPORTING SAMPLE HANDLING SYSTEM"

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TELEDYNE ANALYTICAL INSTRUMENTS

Introduction:

Although a considerable amount of attention is normally given to the selection of the most suitable type of analyzer to perform the desired analytical task, a similar amount of attention is all too often not extended to the sample conditioning system. This may be due to a lack of understanding of the importance of this part of the complete system. A well-designed, properly applied measuring system can do no better than give a correct analysis of the sample being supplied to it. If the sample is not representative of the process, there is nothing an analyzer can do to correct the situation, and the analytical data can not be used for control purposes. The results of poorly designed sample conditioning vary from the analyzer not operating at all to an analyzer operating only with extremely high maintenance requirements and/or giving erroneous or poor data.

One should have a clear “definition of process analyzers” as being environmentally suitable automatic devices that continuousy or periodically measure one or more chemical or physical parameters in a process and present the results in a usable form.
A process analyzers’ “sample handling system” is a device or combination of devices which transfer a sample (usually either in gas or liquid phase) from a process stream to a process analyzer in such a way as to minimize maintenance and to preserve or enhance the analytical information contained in the sample.

Close attention must be paid to the design of the analyzer and sample system because of the unattended operation of the process analyzer(s) and the potential cost of an incorrect analysis.

The sample handling systems provided with many of the analyzers manufactured by Teledyne Analytical Instruments (TAI) is that portion of the overall system that modifies the sample gas or liquid flow from the process conditions to conditions suitable for the analyzer. For all intentional purposes, gas/vapor applications are mainly considered here, although many liquid applications are also within the scope of TAI sample handling systems and will be presented in the near future.

With the exception of ambient or in-situ type analyzers, all analyzers require at least a minimum amount of sample handling. Many of the standard instruments incorporate sample systems designed to cover the most common applications. In addition to providing proven standard sample systems, TAI has over 35 years of unique custom sample system design and application experience.

Sample System Design Criteria:

When designing an extractive sample handling system for a specific application, you are attempting to optimize a remote analyzer(s) for monitoring a process as close to real time as possible. Several major instrument functions or parameters and sample handling system requirements need to be considered to keep a customer happy. Many of the inquiries TAI receives pose questions (many of which are listed below) for the design engineer or customer to solve in order to create a quality working system.

Those "instrument requirements" to be considered are:

Flow:

What is the maximum and minimum flow rate the instrument(s) will tolerate? Will changes in flow rate affect the performance of the analyzer?

Temperature:

What is the maximum and minimum sample temperature the instrument(s) will tolerate? What effect will rapid and /or slow temperature changes have?

A phase change is usually not acceptable for most sensing technologies. A phase change should be absolutely avoided especially when corrosion can occur. A vapor to a liquid phase change, for example, can exhibit rigorous attack on contact material system components especially if ppm moisture is present and the liquid formed has an unacceptable corrosive chemistry. Also leaks into enclosures can occur during extreme temperature changes, so proper sealing techniques should be employed. Improperly chosen or incompatible contact materials (tubing, valves, regulators, o'rings, gaskets, to name a few) can be attacked by process sample chemicals very quickly causing instrument or system component damage or a toxic or unsafe hazardous condition.

Pressure:

What are the maximum and minimum pressure requirements for the instrument? What effect will a change in sample pressure have on an analyzer such as phase change, leaking/corrosion, toxic or flammability conditons, pump or other component damage, sensor contamination?. Consider also these changes as additive errors on the instrument(s) accuracy and drift.

Particulate Loading:

What is the maximum level of particulates an analyzer will tolerate before requiring "excessive maintenance"?

The major "process conditions" that need to be considered are:

Temperature:

Do we need to heat up, cool down, or maintain the sample temperature? Will a change in temperature have an effect on sample chemistry? Will temperature cause or stop a reaction, or cause condensables (water or other solvents) to drop out. Should

condensation to a liquid phase occur, will it create undesirerable corrosives that can attack materials constructed in the sample system? Did we cause wet versus dry basis readings to give larger than anticipated analyte readings at the analyzer, because we had to change the volume percents to rid excessive water from the sample which would otherwise contaminate or interfere with the analyzer sensing technology?

Pressure:

Do we need to pump up or educt (aspirate) the sample to provide flow through the analyzer? Will a change in process pressure have effects on the sample chemistry, response time to the analyzer, material handling capability, accuracy of the analyzer or create a leak into the enclosure(s)? Is it necessary to provide a pumping force to return the sample to process or a safe vent? Will the outlet require an atmospheric vent, flare return or process return that is not stable in pressure? Will special pressure controls be required for the outlet return(s)? Will the sample return require heating or cooling similar to the inlet sample to maintain its physical state? What are the cost implications if the sample cannot be returned to the process?

What happens should a leak occur within the sample handling system? Should it be detected by incorporating a toxic or specific gas leak detector within the analyzers' enclosure. How will the leak affect the integrity of the exposed electronics, sampling components and internal control unit enclosures. Should or can the internal parts be purged with an inert gas to minimize a hazardous nature (toxic/flammable) or corrosive condition? What are the purge gases available at the site? Is purging cost justified?

Particulates:

What is the particulate loading? How much sample filtering or washing is required prior to introduction to the analzyer? What is an acceptable maintenance schedule on filters? Can the design incorporate ease of change-out without disturbing the process flow to the analzyer (i.e., incorporate dual filters within a valving arrangement)?

What is the toxic nature of the sample from a filter changing standpoint? How do you dispose of the filtrate? Can a self-cleaning filter be used based upon sample kinetics using the inertial mass of the particles? What self-cleaning filter systems are available in the market? Consider using cyclones, brush-like filters or in-situ sintered type of filters at the takeoff with a high pressure shocking blowback cleaning function that can also be performed.

Dew Point:

What is the dew point of the sample? What will be the effect of heating, cooling, pumping or aspirating (by creating a positive or negative pressure) the sample? Is it acceptable to remove condensibles from the sample? How might doing this affect the volume or weight percent of the component(s) being measured? These condensibles might be water vapor or even low boiling hydrocarbons or vapors that sublime (those that go from vapor to solid upon cooling). Many analyses of stacks, for example, report analyses on a dry basis. Consider the wet to dry basis errors encountered upon removing excessive water vapor from a stack gas containing 20% water vapor. Perhaps the analyzer cannot withstand the high temperatures necessary to keep the water in vapor phase completely through the sampling train and sensor and therefore, the water must be removed by a dryer in order to measure the gas of interest. The most accurate number will be the one corrected for the loss of water vapor removed. Consider then just one of the analytes such as 3% Oxygen (O2) with 20% water vapor removed. The

O2 reading after the dryer, as indicated by the analyzer, would be 3.75% O2. The correct reading is 3% O2 on a wet basis in the process. To arrive at the accurate value for O2, a correction must be applied by continuously measuring the water vapor and inputing its variable to the dry basis O2 analyzer reading. TAI has a dedicated error correction measuring system that can monitor the wet/dry basis amounts for any analyses that require true weight amounts, for example, that are emitted out of a stack.

Corrosivity:

Strongly consider what sample wetted materials are compatible with the sample. Besides metals like 316ss, monel, nickel and hastelloy, many special plastics are commonly used like various grades of fluorocarbon resins of viton, teflon, kalrez, chemraz and kynar. There are also many sealing materials fabricated of these special materials such as elastomeric o'rings, diaphrams, valves, regulators, flowmeters, and gaskets. Many of these components are available with surface coatings by special processes that improve life, corrosion resistance and performance substantially.

In addition to the physical parameters above, there are several analytical considerations that must be taken into account.

Response time:

From the time that the sample leaves the sampling point to the time the sample exits the sensor, how long will it take to get an accurate measurement? Is a high flow rate "bypass loop" required to minimize lag time? Consider the correct volumes (line sizes vs distances traversed) that are needed by the bypass vs sample loops and also the available pressures at the takeoff vs at the inlet to the analzyer system. If pressure must be reduced at the takeoff to reduce the volume of gas needed to move quickly through the sample train, will conditioning at the takeoff also be required? Is a blowback, probe and filtration also needed in front of the pressure reduction stage? What happens when pressure is changed? Will the sample condense due to gas expansion and cooling? Could it condense from over-pressurization upon pumping? As one can imagine, many scenarios can occur and must be considered to keep the takeoff sample matched close to the process variable being measured at the analyzer.

Background Composition:

Are there any compounds in the sample that will interfere with the analysis of the component of interest? Can these compounds be separated (using membranes) washed or chemically scrubbed out of the sample? Will variations in background composition have an effect on the analysis? If the interferants are removed, how are they disposed of? Can they be safely removed, vented or scrubbed without exhausting the scrubbing media too quickly? Is the media specific to the interferant being removed? What else is taken out? What is the life of the scrubbing media? What is the maintenance cycle? Is it reasonable to not have to change it out frequently? What are the cost implications of the washing process vs scrubbing media? How much wash water is used. What quality does it have to be?

Sensor Poisoning:

Are there any compounds in the sample that will poison the sensor? Can these be easily, safely, efficiently removed by washing or chemically scrubbing or converted to a safe, inert form in the sample?

Sample Solubility:

If it is necessary to water wash the sample or cool the sample down and remove condensables? Will any of the components of interest be removed? What effect will this have on the analytical accuracy?

Specal Concerns of Sampling Systems

Frequently, there are additonal components or conditions that require special design consideration within sample handling system. These considerations involve gas to liquid or liquid to vapor applications. The majority fo these special problems are 1) corrosion, 2) excessive water phase containment or removal of it, 3) thermal degradation, 4) extreme dust, 5) contaminants of tars, gums, resins, oil or solids that plug or can polymerize within the sampling train or analyzer sensor. Although a general set of guidelines have been mentioned here, the ultimate system can only be achieved by considering each problem stream as an individual problem concern.

Conclusion:

The most important consideration is to remember that the goal is to condition the stream so that it may be continuously analyzed “without” changing the original stream composition. This may not always be the case or possible but the questioning guidelines here serve to educate the user in the intricacies and problems that must be considered and overcome to render an accurate, quality designed sample handling system that offers efficient payback on the total system package. The intention is to choose the correct analyzer(s) and to design an integrous sampling handling system with as much simplicity as possible to render meaningful information that can assist the user in fulfilling their process control, monitoring needs reliably.

An important part of designing and building a quality sample handling system matched to the best analytical instrumentation for the customers application is the gathering of the basic information needed by the system design engineer. TAI has quite accurately addressed this problem by formatting a one-page worksheet for the user to fill out and forward to the Teledyne Representative or Teledyne Sales Engineer **that truly speeds up the proposal process** since most of the common **needed information** can be simply filled in on the form and emailed or fax’d to the appropriate contact mentioned above.

Due to the importance of this paper to the user and the much needed gathering of the application data sheet, we have included it here as part of this mini-paper. This paper and data sheet can be downloaded by accessing the Teledyne Analytical Instruments web-site at: http://www.teledyne-ai.com.

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APPLICATION INFORMATION SUMMARY

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Rep Reference Quote #			
Customer:			
Address:			
Contact Name | Title | Dept:			
Customer FAX | Phone:			

QUOTE SPECIFICATIONS

*Component(s) of Interest	Ranges:	%	PPM	Other

*Background: (list all background components):

Component:	Concentration (min|max|normal)			%	PPM	Other

*Sample Phase:	Gas:		Liquid:								
*Sample System:	By TAI		By Customer (attach piping diagram)								
Preferred Materials of Construction:											
*Inlet Sample Pressure (min|max|normal) (indicate Gauge or Absolute)				PSIG		ATM		Other Bar, Kg/cm2 kPa			
*Outlet Sample Pressure (min|max|normal) (indicate Gauge or Absolute)				PSIG		ATM		Other Bar, Kg/cm2 kPa			
*Sample Temperature (min|max|normal)				^{0}F		^{0}C		Other			
Sample Dewpoint (min|max|normal)				^{0}F		^{0}C		Other			
*Particulate Loading	NO				MG/M^3			Other			
*Particulate Loading	GRAINS/FT^3										
*Area Classification:											

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	*If Div. II hazardous, is Z-purge acceptable?	YES		NO		Other											
	Control Unit: GENERAL	INTEGRAL		REMOTE @ APPROX. DISTANCE													
	*Control Unit: LOCATION	INDOORS		OUTDOORS		Other											
	Control Unit: SIGNAL OUTPUT	SPECIFY:															
	Control Unit: ALARMS	HI, FS		LO, FS		HI, NON/FS		LO, NON/FS									
	*Analyzer/Enclosure Mounting:	FREESTANDING		WALL		RACK		PANEL									
	Enclosure Dimensions: (MAXIMUM)	WIDTH		HEIGHT		DEPTH		CM		INCHES							
	*Ambient Temperature: (min|max|normal)				^{0}F		^{0}C		Other								
	Relative Humidity																
	Utilities:	Cooling Water	YES		TEMP.					NO							
		STEAM	YES		TYPE		TEMP.			NO							
	Instrument Air:	YES		PRESSURE													
	*Power:	110V, 60HZ		220V, 50HZ		Other											
	Additional Comments:																
	PURPOSE OF INQUIRY:	FEASIBILITY		BUDGETARY		COMPETITIVE BID											
		IMMEDIATE PURCHASE		Other													

* Required For Feasibility Form: ASI_W97.doc, 02-08-02

NOTE: Please be accurate:

For Example:

A miss-applied check-off of 100 ^{O}F versus 100 ^{O}C can make a significant difference in the accuracy of a proposal.