OPTIMIZING CALIBRATION INTERVALS FOR SPECIFIC APPLICATIONS TO REDUCE MAINTENANCE COSTS[1]

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Abstract

The introduction of the Servomex MultiExact 5400 analyzer has presented an opportunity to review the cost of ownership and how improvements to an analyzer's performance may be used to reduce this. Until now, gas analyzer manufacturers have taken a conservative approach to calibration intervals based on site practices and experience covering a wide range of applications. However, if specific applications are considered, then there is an opportunity to reduce costs by increasing calibration intervals. This paper demonstrates how maintenance costs may be reduced by increasing calibration intervals for those gas analyzers used for monitoring Air Separation Units (ASUs) without detracting from their performance.

Key words: Calibration; Gas analyzer; Air separation; Maintenance.

OTIMIZAÇÃO DE INTERVALOS DE CALIBRAÇÃO EM APLICAÇÕES ESPECÍFICAS REDUZINDO CUSTOS DE MANUTENÇÃO

Resumo

O lançamento do analisador Servomex MultiExact 5400 analyzer apresentou-se uma oportunidade para rever o custo de propriedade e como melhorias na performance do analisador pode ser utilizada com este intuito. Até este momento, fabricantes de analisadores de gases tem utilizado uma abordagem conservadora ao recomendar intervalos de calibração baseado em práticas de campo e experiências cobrindo um grande número de aplicações. Entretanto, se aplicações específicas são consideradas, existe então uma oportunidade de reduzir custos através do aumento do intervalo de calibrações. Este trabalho demonstrará como custos de manutenção podem ser reduzidos pelo aumento do intervalo de calibração destes analisadores de gases utilizados em plantas de separação do ar (ASUs) sem comprometer sua performance.

Palavras-chave: Calibração; Analisador de gás; Separação do ar; Manutenção.

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1 INTRODUCTION

1.1 Discussion of Calibration Intervals

Calibration intervals can be realistically set by examining the factors which contribute towards measurement uncertainty and comparison of this with the maximum uncertainty tolerated by the user.

A number of influencing factors, such as temperature coefficient and output fluctuation are not time dependent. However drift is time dependent and hence is normally the primary influence in determining calibration intervals.

Air Separation generally produces a clean dry sample gas so there should be no significant effects from the process which will prematurely age or contribute to drift in the analyzer. It is assumed that the analyzers are located in temperature controlled environments, which is typical for installations in this application, and that the analyzers have been powered on for at least 4 weeks. It is also assumed that the analyzer is installed and maintained strictly in accordance to the manufacturer's recommendations.

It is important to be aware that drift can be in a negative direction as well as in a positive direction. However, it is generally monotonic, and it is this characteristic that can be exploited.

In instances where the change in the concentration of the target species is the inverse of the drift caused by the sensor, then the situation arises whereby the analyser performance actually 'masks' a degradation in performance of the cryogenic stack. This is one of the reasons that validation is required. In setting tolerance limits for the validation sequence, if the drift of the analyser is creating a hazardous or undesirable situation, then a maintenance required status is raised and a calibration routine can be performed.

Validation is normally defined as the act of passing calibration gases through the analyser to confirm the readings given but, unlike calibration, the reference points used in the calculation of concentration remains unchanged. As validation does not involve a change in the measurement function of an analyser, it is often considered unnecesary for as senior or experienced operator to undertake this activity. Furthermore the risks associated with incorrect process or calibration gas will not invalidate the instrument's performance.

It is for this reason that validation may often be undertaken automatically whereas calibration is not.

2 MATERIALS AND METHODS

2.1 Application Specific Calibration Intervals

We now examine some examples of the applications. In these the typical drift rates, output fluctuations and temperature coefficients have been assessed and compared to some examples of customers' needs in order to give an indication of specific calibration intervals that are appropriate for each application.

Application 1: Trace CO_2 (Compressed Air to Coldbox)

The concentration of CO_2 in this process is usually less than 1 ppm with the analyzer range set at 0 to 10 ppm. The alarm limit is typically between 1 and 3 ppm CO_2. The purpose of the measurement is to check that the CO_2 impurity is near zero and thus, it can be seen, that the zero stability of the analyzer is critical for this analysis.

The analysis of trace levels of CO_2 is commonly determined using Infra-Red Gas Filter Correlation (GFx) technology. The data obtained during the type testing and site trials of the new MultiExact analyzer, which utilizes the latest generation of Servomex's GFx technology is used in the following calculations.

In this example negative drift creates a situation where an increase in the levels of CO_2 are not detected even though the concentration exceeds the alarm levels. If negative drift is occuring in the analyser then this can be identified when the mA output reaches it's underrange cutoff, which should be set close to zero. When this occurs a zero calibration should be performed.

Positive drift, however, will cause the alarm to be triggered when CO_2 levels are actually lower than the alarm limit set. This is therefore a safer scenario.

Typical Reading

For the purpose of this calculation we will assume that the nominal concentration of CO_2 in the sample stream is 0.1ppm.

Drift

For GFx instruments it has been demonstrated that zero drift decreases exponentially over time and that the published drift specification of 0.2 ppm per week can be achieved within hours of the analyzer being commisioned.

Hence for this calculation it is assumed that the zero drift per week is +0.2 ppm. (Negative drift will cause an underrange cutoff.)

Temperature Coefficient

The specification for temperature coefficient is 0.15 ppm / 10°C

When used in an environmentally controlled room it is reasonable to assume that the maximum ambient temperature change is 3°C. Hence the the temperature coefficient measurement uncertainty is ±0.045 ppm.

Output fluctuation

The specification for output fluctuation is 0.1 ppm. Thus it is assumed that the output fluctuation measurement uncertainty is ±0.1 ppm.

Calibration interval

In this specific application the concentration is near zero and hence it is the zero calibration which is of most significance and will determine the calibration interval for the analyzer

The maximum non time dependent measurement uncertainty is the sum of the temperature coefficient and output fluctuation i.e.

0.045 ppm + 0.1 ppm = ±0.145 ppm

The maximum drift uncertainty to avoid false alarms will be the difference between the alarm limit and the maximum non time dependant measurement uncertainty e.g. for an alarm limit of 3 ppm.

(3 ppm – 0.1ppm) – 0.145 ppm = 2.755 ppm

The calibration interval, in weeks, specific to this application is the maximum drift uncertainty divided by the rate of drift per week i.e.

2.755 ppm / 0.2 ppm = 13.5 weeks approx.

The following table indicates the calculated zero calibration intervals for different process alarm limits. Also shown are the associated percentage reduction in calibration costs when compared to those incurred using typical calibration intervals.

Table 1. Calibration Interval comparison – ppm CO2

	CO_2 Alarm Levels		
	1 ppm	**2 ppm**	**3 ppm**
ASU specific low calibration interval in weeks (from above calculations)	3.5	8.5	13.5
Typical low calibration interval in weeks (from manufacturers' published specification)	1	1	1
Reduction in calibration costs in % (in comparison to the typical)	71	88	92

- Assumes validation is performed remotely

Application 2: O_2 purity (Gaseous O_2 to Pipeline)

The concentration of O_2 in this process is very close to 100% and the analyzer range may be 98 to 100%. The purity of the gas is usually better than 99.8%. The analysis of O_2 purity levels is determined using paramagnetic technology. The data obtained during the type testing and site trials of Servomex's new MultiExact analyzer is used in the following analysis.

The Servomex MultiExact utilizes a null torsion balance paramag sensor which undertakes all signal processing in the digital domain. This effectively means that the span drift of these analyzers is equal to the zero drift and hence it is only necessary to consider the span drift quoted as this incorporates any zero drift error. As a caution to the reader this assumption can only be made for analyzers based on the same technical principals.

In this example positive drift of the analyser creates a situation where a reduction in the levels of O_2 are not detected even though the O_2 concentration falls below the alarm levels. If positive drift is occuring in the analyser then this can be identified when the mA output reaches it's upper range cutoff which should be set close to 100%. In this instance a span calibration can be performed.

Negative drift, however, will cause the alarm to be triggered when O_2 levels are actually higher than the alarm limit set. This is therefore a more desirable scenario.

Typical Reading

For the purpose of this calculation we will assume that the typical concentration of O_2 in the sample stream is 99.99%.

Drift

The specification for span drift is less than 0.02 % per week.

From this the drift rate is assumed to be ±0.02% / week for this specific application.

Temperature Coefficient

With a sample of 100% oxygen the published specification for temperature coefficient is 0.1 % / 10ºC.

Again it can be assumed that the maximum ambient temperature change is 3°C, therefore, the temperature coefficient measurement uncertainty is ±0.03%

Output fluctuation

The published specification for output fluctuation is 0.01 %.

Based on this a measurement uncertainty of ±0.01% is assumed.

Calibration interval

In this specific application the concentration is near span and hence it is the span calibration which is of most significance.

The maximum non time dependent measurement uncertainty is the sum of the temperature coefficient and output fluctuation i.e.

0.03 % + 0.01 % = ±0.04 %

The maximum drift uncertainty to avoid poor product quality will be the tolerance allowed for product quality and the maximum non time dependent measurement uncertainty e.g. for an alarm level of 99.8%.

(99.99 - 99.8) % – 0.04% = 0.15 %

The calibration interval, in weeks, specific to this application is the maximum drift uncertainty divided by the rate of drift per week i.e.

0.15 % / 0.02 % = 7.5 weeks

The following table indicates the calculated zero calibration intervals for different process alarm limits. Also shown are the associated percentage reduction in calibration costs when compared to those incurred using typical calibration intervals.

Table 2. Calibration Interval comparison – Purity O2

	O_2 Alarm Levels		
	99.7 %	**99.8 %**	**99.9 %**
ASU specific calibration interval in weeks (from above calculations)	12.5	7.5	2.5
Typical span calibration interval in weeks (from manufacturers' published specification)	1	1	1
Reduction in calibration costs in % (in comparison to the typical)	92	87	60

3 RESULTS AND DISCUSSION

It should be considered that the published drift data for measurements is often the upper limit of the expected drift performance. Due to variances in the quality of the installation and the complex interactions that cause drift, the actual drift performance of the measurement can be significantly different.

Site trials of the new MultiExact Analyzer have shown better drift performance than the published specifications. It is therefore useful to determine the true drift performance of the analyzer. By using the MultiExact's AutoVal feature, the performance can be logged by the analyzer. The last 100 calibrations or validations are stored on the analyzer's database. By interrogating the validation history, it is easy to track the analyzer output against actual calibration gas values.

In addition, the ability to perform a 'Remote Calibrate / Validate' or 'Automatic Calibrate or Validate' procedure will mean that the requirement for manual calibrations is further reduced.

4 CONCLUSIONS

It has been shown that it is important to consider both positive and negative drift scenarios when determining the best calibration schedule for any measuring process. In reality actual calibration intervals will vary with circumstance, however, it can be seen that it is practical to significantly extend the period between calibrations through analysis of analyser performance and the correct use of validation methodology.

The following table summarizes the calibration cost and estimates the potential savings if application specific calibration intervals are used.

Table 3. Calibration Cost comparison – ppm CO2 & Purity O2

	ASU Analysis	
	ppm CO_2	**% O_2**
Typical calibration costs based on generic recomendations in $ per annum	6000	4000
Average calibration costs for specific ASU application in $ per annum	700	500
Savings in $ per annum	5300	3500

- Costs are rounded to nearest $100
- Labour costs assumed at $75 / hour

From the analysis it can be seen that if ASU application specific calibration intervals are employed then the annual savings per analysis are in excess of $5000 for the ppm CO_2 application and $3000 for the % O_2 application. Furthermore, by using the datalogging capabilities of the MultiExact analyzer even greater savings may be obtained.

The savings outlined in this paper are achievable when a stable, high performance analyzer such as the Servomex MultiExact is used, and they can make a real impact on the customers' bottom line.