Setting the Standard for Automation™

Calibration Interval Analysis

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Presenter: Donald M. Rozette

- Bringing 20 + years of experience in the Instrumentation, Controls and Reliability field as an Instrument Engineer, Certified Automation Professional (CAP) and Certified Functional Safety Expert CFSE, Don is able to bring a fresh and client based viewpoint to the Product Management role. Since coming to Meridium in late 2011, his experience has helped further integrate the Asset Safety Work Process, into the overall APM solution.
- Leveraging Meridium's existing integration with Emerson's AMS Analytics, process historians, and reliability analytic tools Don has no trouble envisioning a day in the not too distant future, where risk would be measured and displayed as a dynamic rather than static property.
- Don attended West Valley College in Saratoga, California and is a U.S. Navy Veteran.

Background

- Accurate and reliable Instrumentation and control systems should be considered during any asset performance initiative.
- Meeting safety and regulatory requirements often necessitates the adoption or implementation of a calibration management program.
- In order to successfully manage an instrument calibration program several things immediately come to mind. The question most often asked is:
- How often should the device be calibrated?

Criticality Assessment

- Initially calibration interval should be based on the criticality of the device, and any applicable failure rate data that is available.
- Criticality of instrumentation is commonly defined in three categories (e.g. high, medium, low).
- Highly critical instruments, such as those that are used as part of safety systems and protective layers, and those with other regulatory requirements, These instruments will commonly account for 20% of the overall population.

Criticality Assessment

- Medium criticality instruments, such as those that are associated with "control loops" typically comprise 60% of the overall population.
- The remaining 20% of the overall population are the lowest criticality instruments, such as process indicators, status indications, and non-critical or low priority alarm

Performance Specification

- As with defining calibration intervals, acceptable performance percentages for each of those criticalities will be developed.
- For the highly critical instruments 95%of the population with an As Found error <1.1% is recommended.
- The pass ratio or the allowable error can be scaled down to 92% with a max allowable As Found error of <2.1% for medium critical instruments, and 90% with a max allowable error of <3.1% for the least critical instruments

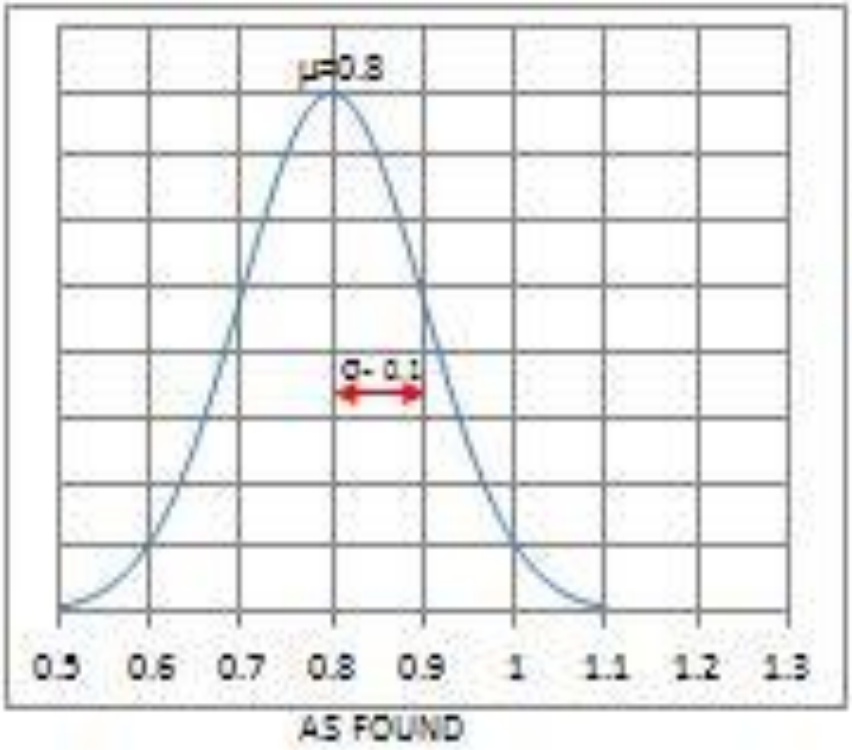
Interval Analysis

- Based on the performance of the select population of instruments (e.g highly critical level transmitters) and the results of the calibrations performed on those level transmitters, patterns will emerge that will guide the analyst to increase or decrease the calibration interval to maintain a performance criteria equal to the criteria that was predefined. Instruments can be grouped by Class, Type, Manufacturer, Application etc. The deeper into the classification, the lower the variance of data will be.
- Plot the calibration error of the population under analysis (excluding outliers) by statistical analysis.

Statistical Analysis

- Determine average As Found error and Standard Deviation of the calibration results of the population

a. The Avg. A.F. Error (μ)
b. The standard deviation (σ)



Example.

Calibration Data:

- Avg. A.F. Error (μ) = 0.8
- Standard Deviation (σ)=0.1

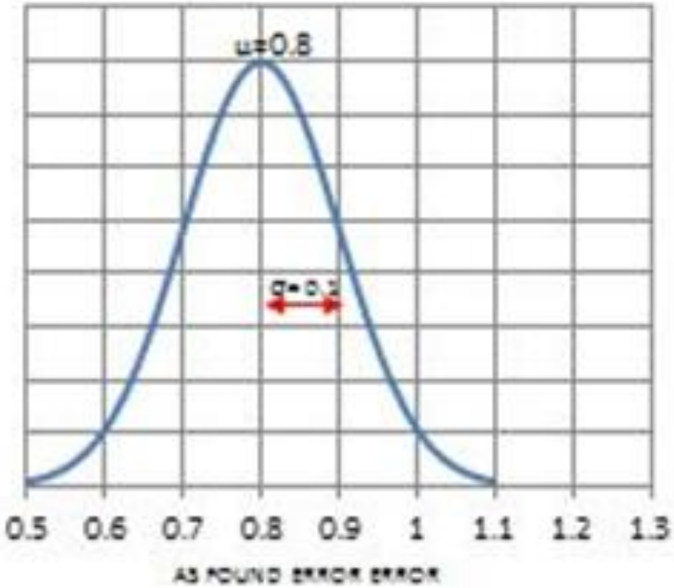
Statistical Analysis (Performance Comparison)

- Distribution Analysis is showing that the performance is exceeding the specification

Example:

Company requirements:

- Maximum Avg_A.F. Error = 1 %
- 95 % of Population with As Found error < 1.1 %

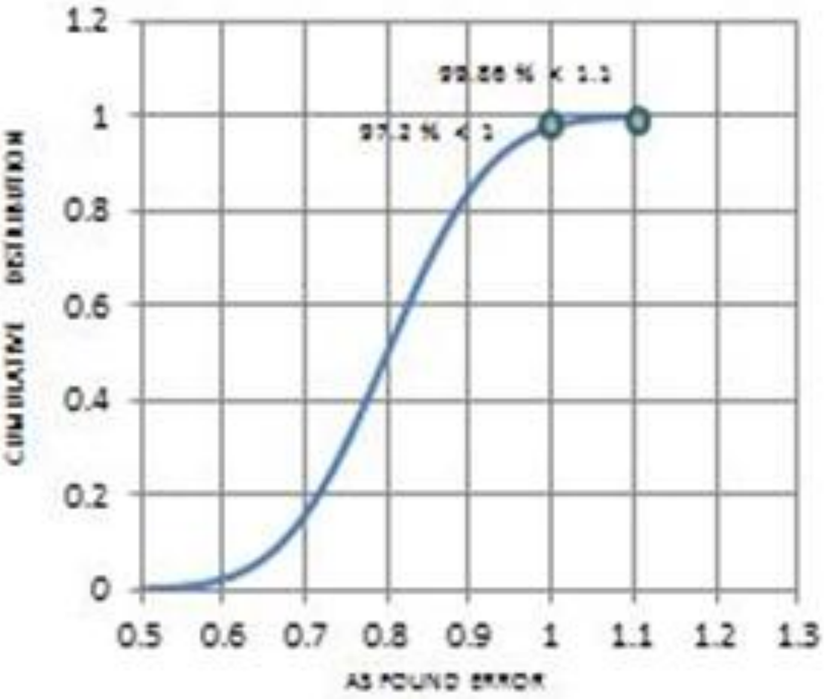


<u>CONCLUSION</u>:

- Performance exceeds Requirements:
  - Avg_A.F. Error = 0.8% vs. 1.0 %
  - 99.86% vs. 95% of Population with an Error < 1.1 %

Interval Re-Evaluation

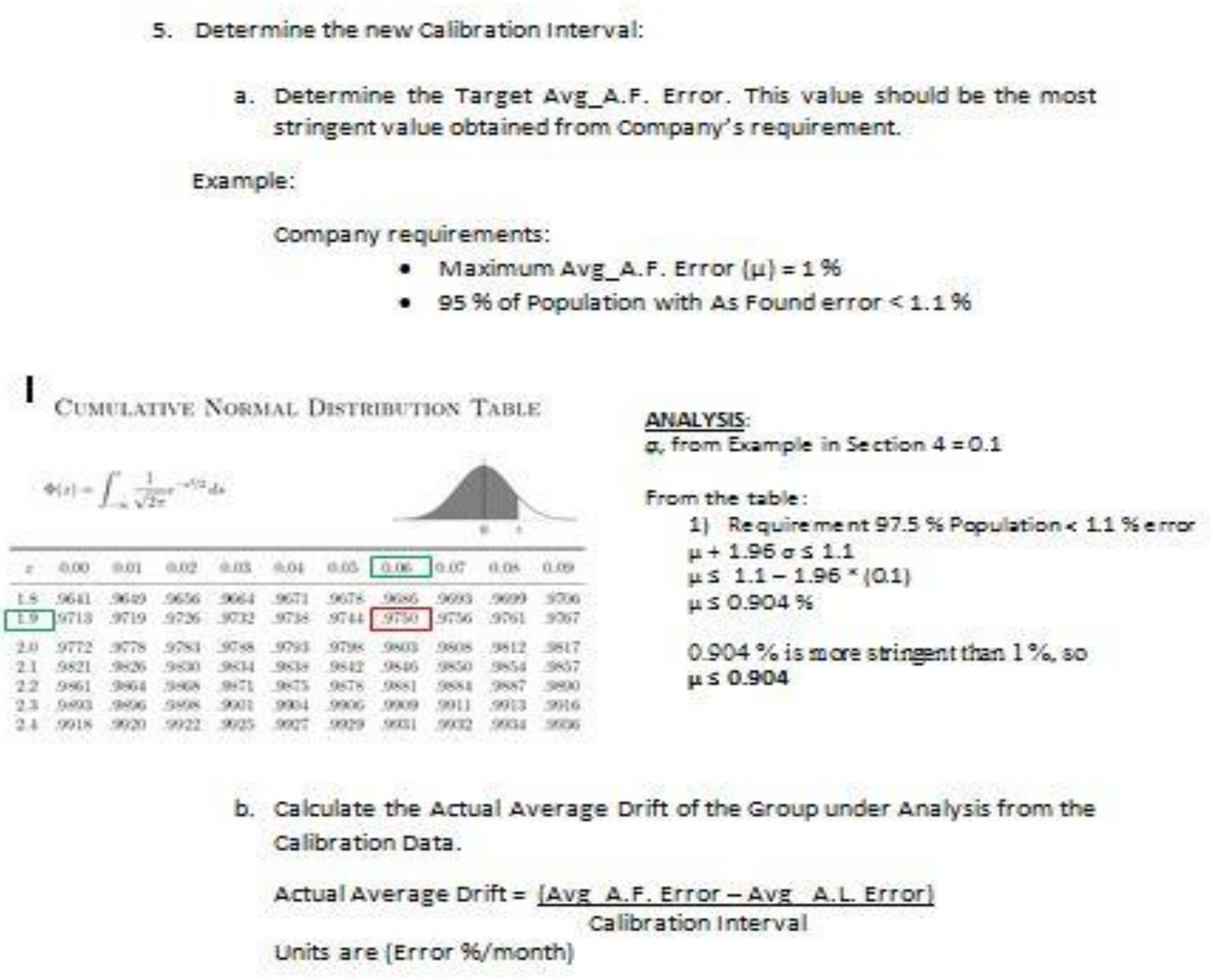
- Cumulative Distribution Analysis can be used to determine the optimum calibration interval



RECOMMENDATION:

- Evaluate to Extend the Calibration Interval

Optimum Interval Determination



5. Determine the new Calibration Interval:

   a. Determine the Target Avg_A.F. Error. This value should be the most stringent value obtained from Company's requirement.

Example:

Company requirements:

- Maximum Avg_A.F. Error (μ) = 1 %
- 95 % of Population with As Found error < 1.1 %

CUMULATIVE NORMAL DISTRIBUTION TABLE

$$\Phi(z) = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} e^{-s^2/2} ds$$

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936

ANALYSIS:

σ, from Example in Section 4 = 0.1

From the table:

1) Requirement 97.5 % Population < 1.1 % error

$\mu + 1.96\,\sigma \le 1.1$

$\mu \le 1.1 - 1.96 * (0.1)$

$\mu \le 0.904$ %

0.904 % is more stringent than 1 %, so

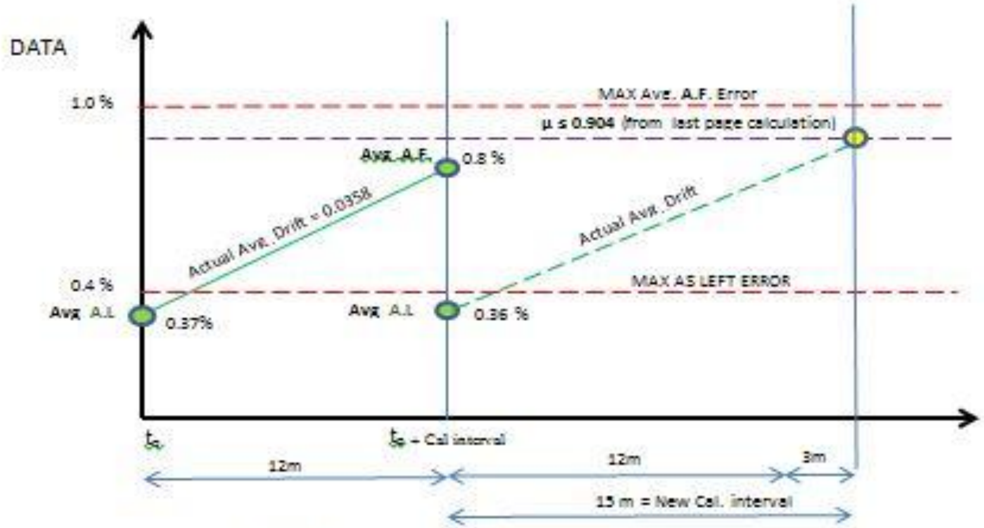
$\mu \le 0.904$

   b. Calculate the Actual Average Drift of the Group under Analysis from the Calibration Data.

$$\text{Actual Average Drift} = \frac{(\text{Avg\_A.F. Error} - \text{Avg\_A.L. Error})}{\text{Calibration Interval}}$$

Units are (Error %/month)

Optimum Interval Determination



Example.

Calibration Data:

- Avg. A.F. Error (μ) = 0.8
- Standard Deviation (σ)= 0.1
- Avg. A.L Error, at t_o = 0.37 %
- Avg. A.L. Error, at to + Cal interval = 0.36%

ANALYSIS:

Actual Avg_Drift = (Avg_A.F. - Avg_A.L) / Calibration Interval
= (0.8-0.37)/12
= 0.03583 % / month

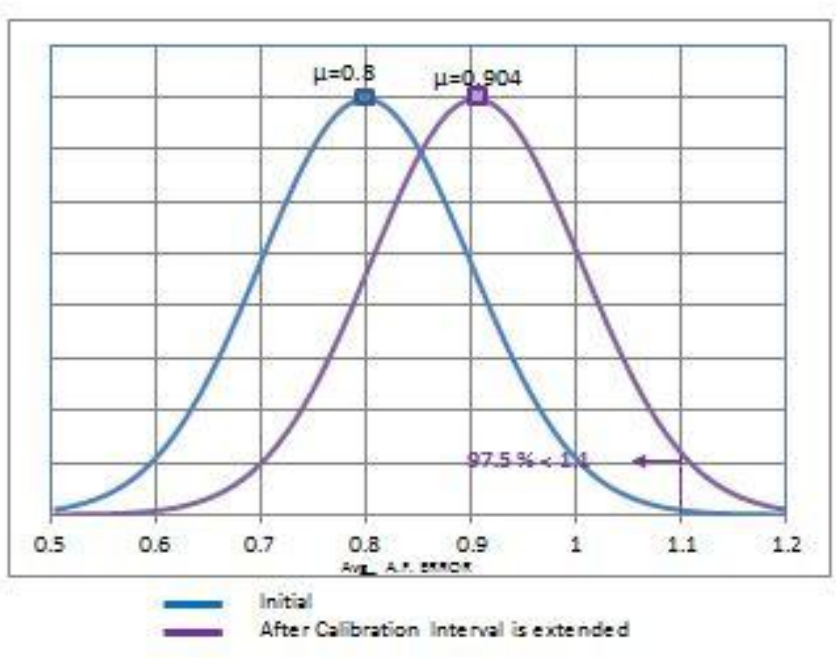
c. Calculate the New Calibration Interval

New Cal. Interval = (μ - Avg_A.L.) / Actual Avg_Drift
= (0.904 -0.36)/ 0.03583
= **15.18 months**

Optimum Interval Analysis

- As demonstrated, it is possible to optimize your calibration periodicity and still maintain the accuracy requirements of the business unit in the most cost effective means through statistical analysis of the data obtained during the calibration

d. Document Expected Results for Future Analysis of Calibration Data



The Calibration interval was extended from 12 to 15 months (20 % Cost reduction) and performance is expected to be above company requirements.