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ISO 17025 Accreditation for a Standing Start Finish (SSF) Primary Flow Stand and the Application To Using Coriolis Flowmeters as Reference Standards

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Abstract: At FLOMEKO 2000 Micro Motion, Inc. (MMI) reviewed the concept of Transfer Standard Method (TSM) flow stands for the calibration of flow instruments, in particular the uncertainty analysis for calibration of Coriolis meters. This paper is an extension of the topic, discussing in depth the issues involved with ISO 17025 accreditation, maintaining calibrations, and traceability.

The company has chosen to use Coriolis flowmeters as Global Reference Meters (GRM) to maintain the traceability on the TSM stands operating worldwide. To accomplish this ISO 17025 accreditation was successfully sought for the SSF Primary Flow Stand (PFS) that is used to calibrate the GRM's.

This paper will discuss the experiences associated with accrediting the SSF Primary Flow Stand, the processes involved with creating a GRM, calibrating TSM stands worldwide and the implications to TSM stand uncertainty.

This paper includes:
- *Review of SSF Primary Flow Stand Uncertainty and Traceability*
- *Internal Proficiency Testing Methodology*
- *Practical experiences in attaining ISO 17025 accreditation*
- *Process for GRM calibrations*
- *Advantages to using the GRM process*

Keywords: Coriolis, traceability, ISO 17025, transfer standard, flow meter

INTRODUCTION

The three purposes of this paper are:

- Review the TSM stand calibration process used by the flowmeter manufacturer.
- Introduce the Global Reference Meter (GRM) process that is used to maintain traceability and calibration of the TSM stands.
- Discuss the ISO 17025 accreditation process the manufacturer went through in support of the traceability required for the TSM stands and the GRM process.

2. TSM Process

Previously, at FLOMEKO 2000, the manufacturer introduced the use of TSM stands, using Coriolis mass flowmeters as primary reference standards, to calibrate its flowmeters. The review of the process will include:

a) TSM operation
b) Traceability, as discussed at FLOMEKO 2000
c) Uncertainty of PFS gravimetric Standing Start Finish (SSF) stand and TSM stand

2a. TSM Operation

Figure 1 is a simplified P&ID (process & instrument diagram) of the TSM design. Different TSM calibration stands with different flow rate capabilities are all of a similar design. All TSM stands use pneumatically powered clamping systems, which facilitate rapid installation of the UUT (unit under test refers to the meter(s) being calibrated and adjusted). The flow meters called RM (reference meters) and QCM (quality check meter) on each TSM stand are identical in size and calibration. For some meter technologies, the UUT can be more than one sensor installed in series.

The UUT is calibrated and adjusted to the RM. When verifying a meter's performance, after determining its flow calibration factor, the TSM calibration stand with its automated programming checks the UUT's low flow performance by comparing it to that of one of the in-line reference meters smaller than itself. Each time a reading is obtained from the UUT, the RM and QCM meters are also read. This is one of the key features of the TSM stand design: The QCM provides a continuous, real time, first level check on the calibration process for the UUT and on the stability of the RM, as well as on other potentially confounding effects such as entrained air and leakage.

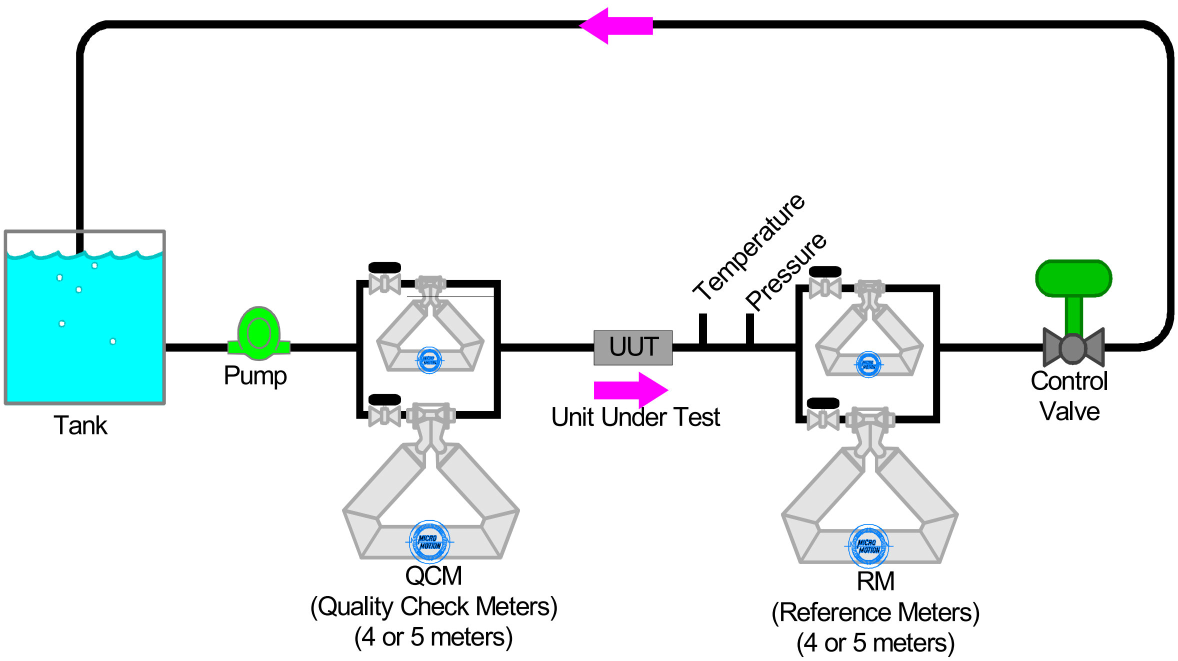


Figure 1
Simplified P &ID for a TSM Flowmeter Calibration Stand

2b. PFS and TSM UNCERTAINTY

As developed in Ref 1 the Calibration and Measurement Capability (CMC), formerly referred to as the Best Measurement Capability (BMC) for mass of the PFS was 0.012%, assuming a k value of 2 for a 95% confidence level. This result will be revisited when ISO 17025 accreditation of the PFS is discussed.

Also developed in Ref 1 the CMC for mass of the TSM stands was 0.013%, assuming k=2. This result will not be developed any further in this paper.

2c. TSM TRACEABILITY

The traceability of the TSM calibration process (figure 2) was established to national standards through a chain of successive measurements, as presented at FLOMEKO 2000 (ref 1).

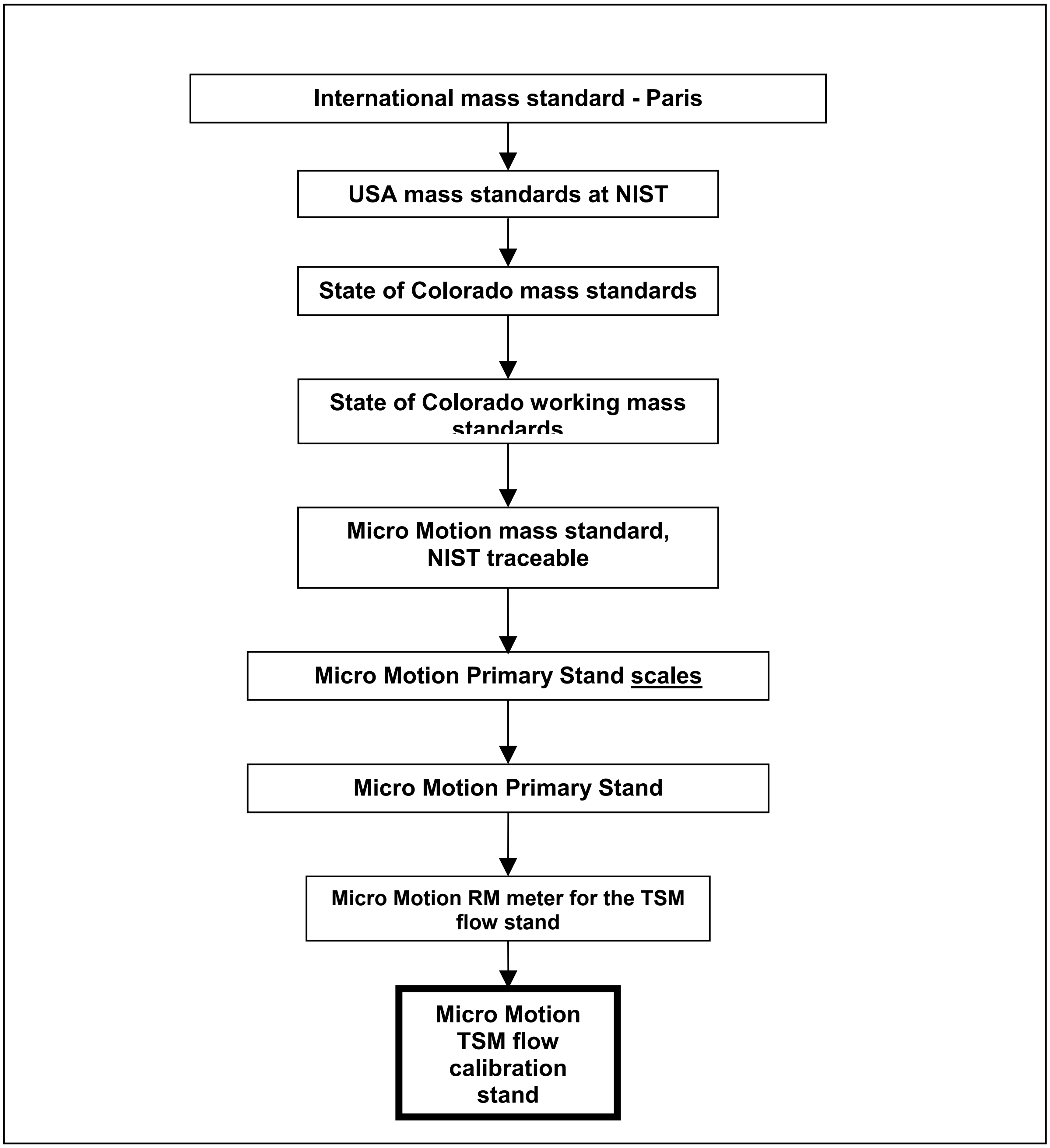


Figure 2
Original Calibration Traceability for TSM Stands

3. Global Reference Meters

3a. GRM Process

With the success of the TSM stands in MMI's USA and Asia Pacific facilities, the program was extended. TSM stands were installed and are operating at the company's Mexico manufacturing facility. Also TSM stands were installed and are in the process of being commissioned at the company's Netherlands facility.

The company now has nine stands, at four facilities, on three continents to support, figure 3. Originally the concept was to maintain calibration and traceability through reference meter (RM) replacement (see figure 2 for traceability chain).

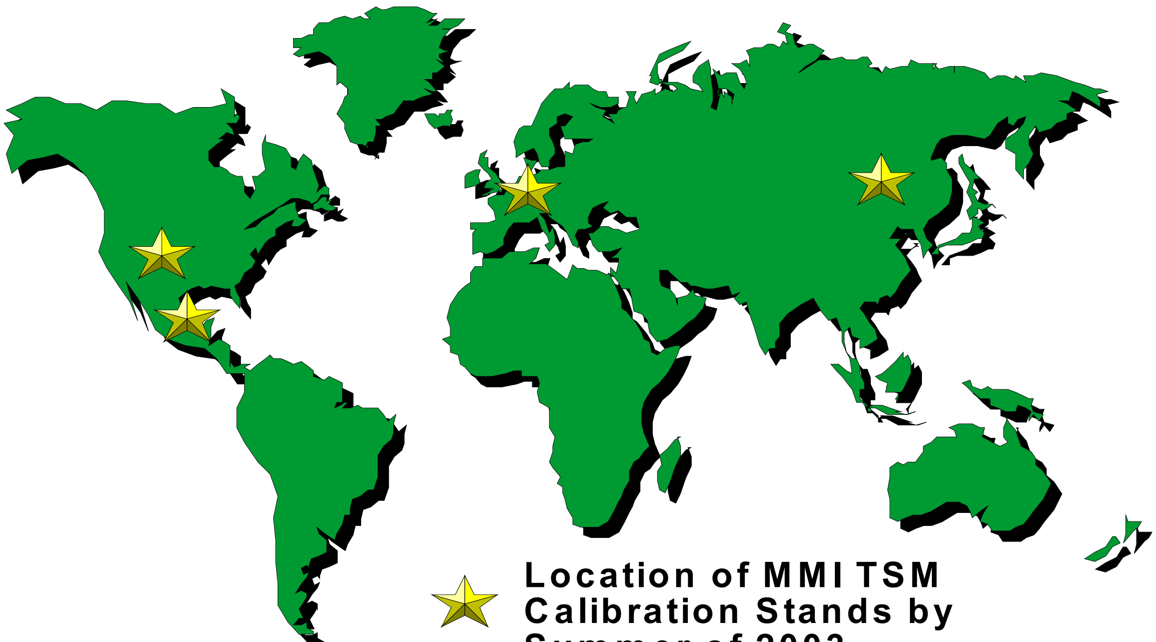


Figure 3

This methodology had several issues. First, the methodology for maintaining the calibration did not look at the "system". System integrity was maintained through secondary methods, a measurement assurance program (MAP) and on-board Quality Check Meters. Although adequate, the methods were secondary, not primary calibrations. Second, the company had originally decided to use its own Coriolis flow meters because of their long term stability, so un-installing and replacing ran counter to the underlying philosophy of the stands. Third, like all good meter installations, if the process is running as desired taking the line apart and installing a new piece of equipment is not efficient.

To overcome these issues the company developed a process based on the transfer standard methodology, using what are called Global Reference Meters (GRM). The process involves using a set of reference meters, calibrated in precisely the same manner as the TSM RM's. These meters are then installed in the UUT position on the TSM stand and used to calibrate the corresponding flow path, i.e. 1 inch meter calibrates the 1 inch meter path, of the RM. These same meters are used to calibrate all of the TSM stands globally.

The process has three advantages. First, the calibration process is performed with the GRM in the calibration position, providing a system view equivalent to a production calibration. Second, the calibration requires no alteration to the stand, therefore being less labor intensive and lowering the risk of secondary problems associated with meter replacement. Third, it provides a means of comparing the company's TSM stands globally, an internal round robin.

3b. GRM Traceability

This process would then change the previously discussed traceability chain to the new scenario shown below in figure 4. The change in the traceability path are 1) the State of Colorado is replaced by the company's mass standard supplier, Rice Lake Weighing Systems, and 2) the TSM stands traceability is now maintained by the GRM, not the RM's original calibration.

Initially the company plans on using the PFS stand in Boulder, Colorado, USA as a hub, bringing the meters back for verification calibrations between trips to the various calibration stands. Although there is no indication that this is required due to meter stability, it seems prudent initially to insure the process is operating correctly. The full primary calibration of the GRM's will be conducted annually.

The final piece to ensuring traceability chain was to get ISO 17025 accreditation on the PFS calibration stand, located within the company's Measurement Technology and Test Lab (MTTL). This would then make the GRM's fully traceable through an accredited path all the way back to the international mass standard.

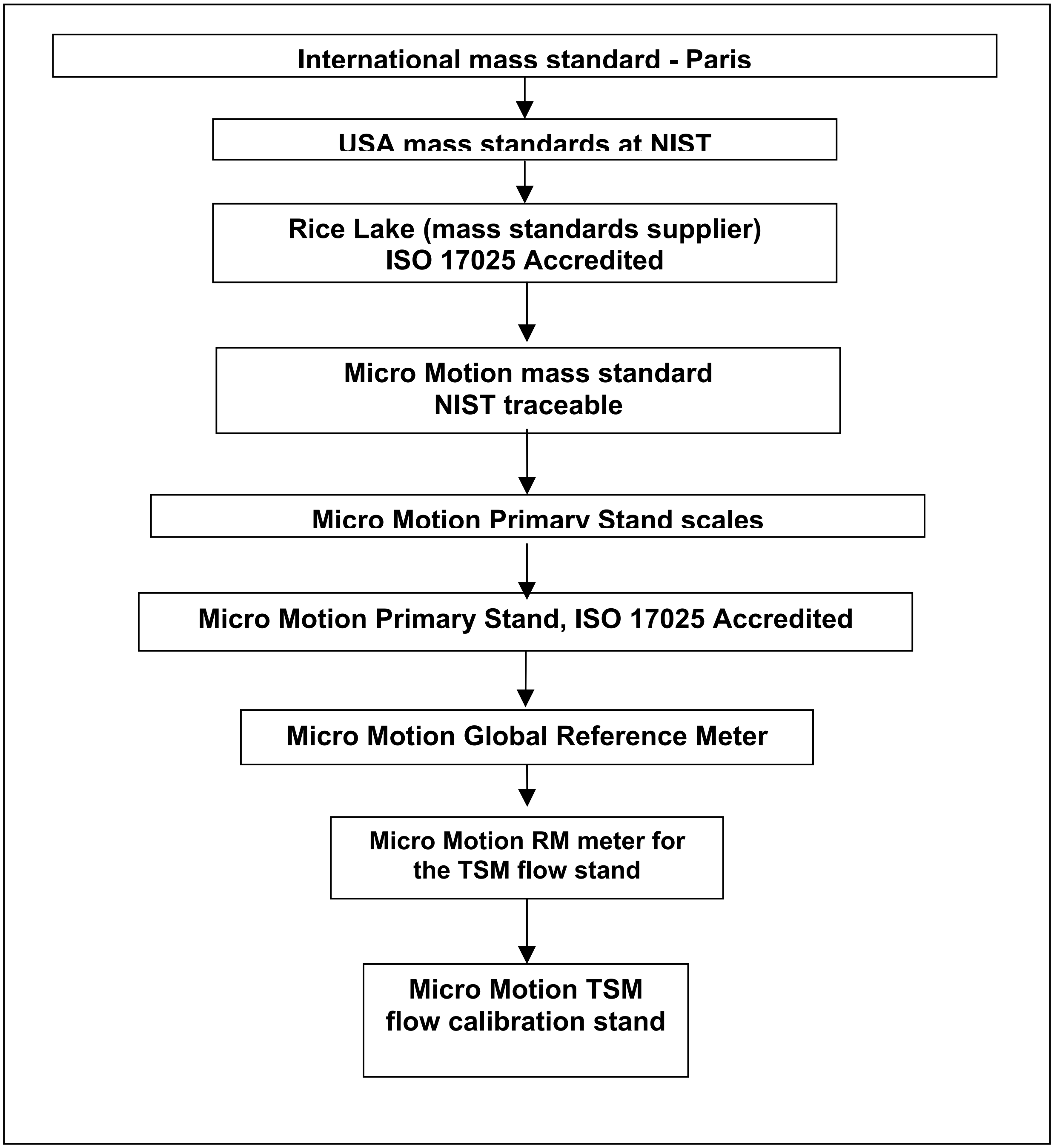


Figure 4
Revised Traceability for TSM Stands

4. 17025 Accreditation

4a. Quality System

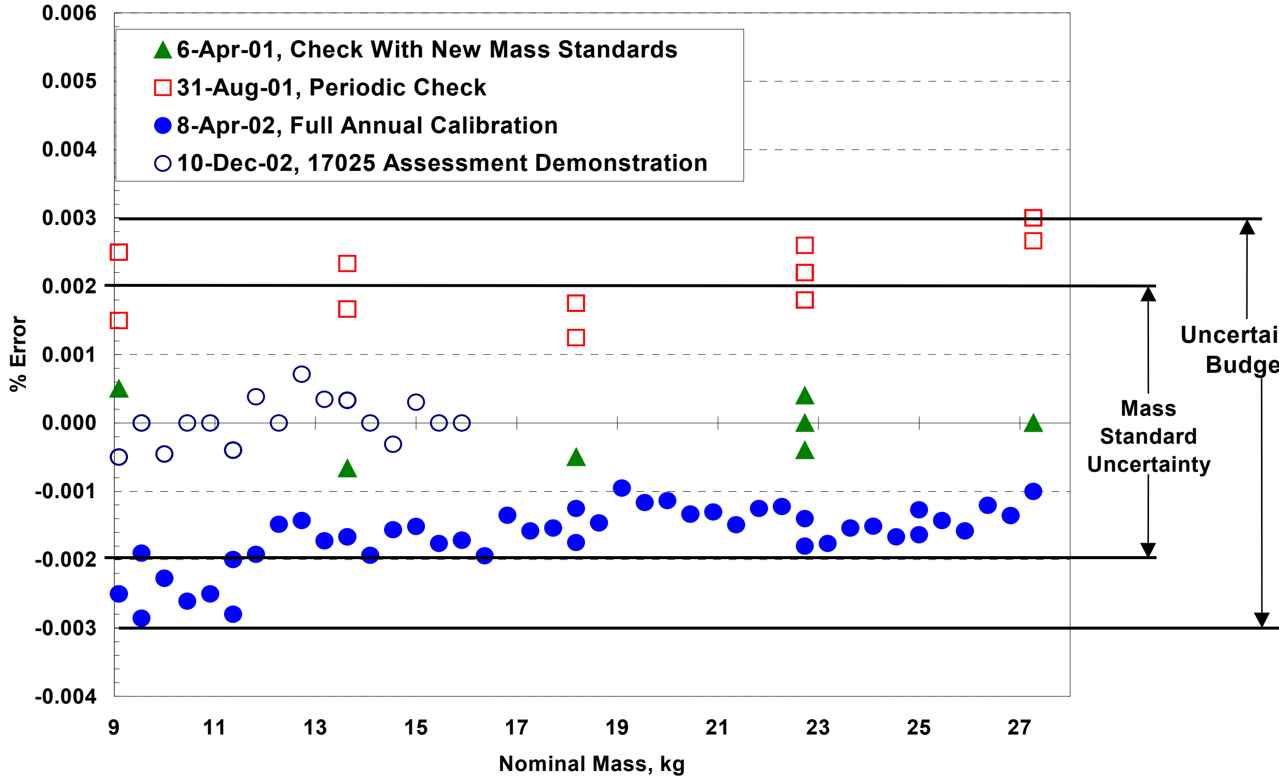
Prior to obtaining ISO 17025 accreditation the company had already attained ISO 9000:2000 certification. This certification covered the company's facilities in the USA, Mexico, The Netherlands, and China. All facilities are under the same certificate, with the same quality system. Initially, when the effort to obtain ISO 17025 was undertaken a stand-alone quality system was being developed. Given the rigorous nature of ISO 17025 the belief was that the way to assure compliance was a narrowly focused, dedicated quality system for the Measurement Technology and Test Laboratory (MTTL) Primary Flow Stand (PFS). Although very focused to the needs of the MTTL, it soon became apparent that a lot of work was being duplicated. (An example would be the creation of a Corrective/Preventative Action procedure for the MTTL when a company wide procedure already existed and was judged acceptable to ISO 9000 already.) Recognizing the fact that the needs of section 4 of the ISO 17025 standard were satisfied with the existing quality system the team was allowed to focus on the more technical aspects of accreditation, mainly section 5, technical requirements.

The activities in the technical requirements concentrated on four areas: uncertainty, traceability, lab management and proficiency.

4b. Uncertainty

The full detail of the uncertainty analysis for the PFS was previously published at FLOMEKO 2000, reference 1. We are not going to revisit the entire analysis here, rather we will talk about the main component in maintaining the levels previously published, scale stability. The stand is comprised of three scales to provide the full span of desired flow rates, 0.2 kg/min to 3200 kg/min. Procedurally the scales are required to be calibrated annually, but to build up a history of performance, calibrations were performed approximately every six months. Figure 5 below, for the small scale is representative of these periodic calibrations.

The mass standards the MMTL uses for the PFS have an uncertainty of 0.002%. This graph illustrates how the scales are essentially stable within the uncertainty of the mass standards used. Based on these results a 0.003% allowance for scale stability was figured into the uncertainty analysis for scale drift.



PFS Small Scale Calibration History
(without adjustment)
Figure 5

4c. Traceability

The reference standards that impact the uncertainty of the PFS include: mass standards, pressure transmitters, and temperature transmitters. As shown in figure 4, the company's mass standards are ISO 17025 traceable to the International mass standard in Paris. The pressure and temperature standards, used in real-time buoyancy corrections, are maintained through outside services. The pressure transmitters are calibrated on-site using an ISO 17025 accredited calibration service. The temperature calibration are a secondary calibration, where the secondary reference is sent out to the original supplier, ISO 17025 accredited, for calibration.

4d. Lab Management

The operation of the 7000 lb/min Primary Flow Stand (PFS) within Micro Motion, Inc.'s (MMI's) Measurement Technology Test Lab (MTTL), brings with it a new set of requirements in addition to those already in place for ISO 9000 requirements. Most notable of those, is that unlike the typical engineering flow stand that may be routinely modified to meet testing requirements, the PFS requires monitoring and formal revision control, for all software and hardware changes. For accreditation purposes, the PFS has both a major equipment list, and software revision documents, that are maintained by MTTL personnel. No equipment or software may be changed or modified without the approval of Quality management. The approval process for change requires that an assessment be done for the impact on the stands' performance, thus assuring that no effect adds to the stands uncertainty. Once the assessment is complete, before and after performance data is collected and analyzed for each change. If the analysis shows there is no effect, then the change is made permanent and the documentation is updated.

The formal change process highlights one of the main challenges of the accreditation process, the accreditation on a single flow stand in a lab of many flow stands. Although the company demands thorough testing and justifications before modifying flow stands, the formal review process with the quality department was a departure from historical behavior. Issues with the PFS are more than "engineering" problems to be solved. Impact on calibrations, past and present, as well as performance implications must be taken into account.

Training requirements for the PFS are different from the other flow stands as well. In addition to hands-on training, as done for all other engineering stands, test technicians that operate the PFS to perform primary calibrations must be able to competently explain the operating procedures to the MTTL manager. The MTTL manager will then quiz the technician for the proper understanding of what can affect calibration uncertainty. When satisfied, the MTTL manager will certify the test technician is competent to perform the PFS primary calibrations and place the appropriate training document in their personnel file.

4e. Proficiency Testing

For proficiency testing there were several difficulties to overcome:

- The PFS is a Coriolis-specific stand
- MMI is a commercial enterprise whose most suitable test partners from the respect of technology are competitors
- The uncertainty attained, 0.012%, was so low as to greatly reduce the number of potential partners
- Prior to receiving accreditation, MMI was not as attractive as a test partner

Currently the company is seeking suitable partners to perform proficiency testing.

To monitor ongoing system quality the company performs internal proficiency testing. This is accomplished by using three control meters, one appropriately sized meter for each scale. Prior to accreditation these meters were calibrated periodically, but not on a scheduled basis. To satisfy the ongoing needs of accreditation the control meters are now calibrated on a monthly basis. When analyzing the proficiency of independent labs or stands the proficiency testing formula shown below is used:

$$E_n = \frac{|LAB - REF|}{\sqrt{(U_{95}LAB)^2 + (U_{95}REF)^2}}$$

With: $U_{95}LAB$ representing the CMC, with k=2, of the lab under test
$U_{95}REF$ representing the CMC, with k=2, of the lab being used for reference
LAB representing the calibration of the lab under test
REF representing the calibration of the lab being used for reference

For internal proficiency testing the LAB is the current calibration and the REF is the original meter calibration. The REF value is never changed, thus yielding a measure of the stands long term stability. Because the assumption of independence cannot be made for calibrations on the same stand, the standard formula was modified as shown:

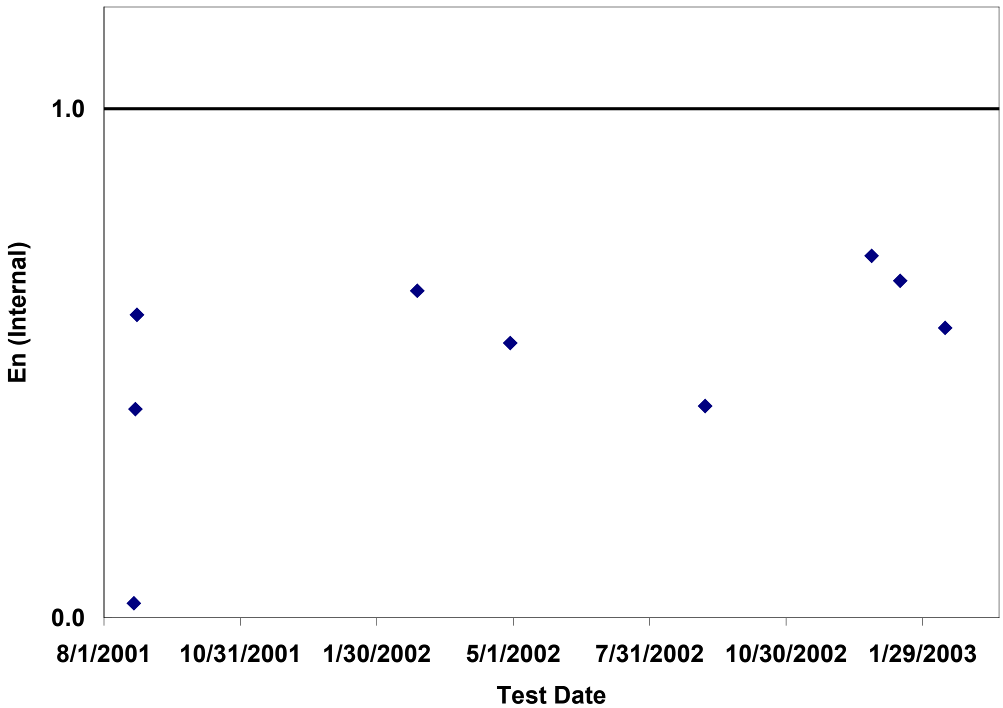
$$E_n = \frac{|LAB - REF|}{\sqrt{(U_{95}LAB)^2 + (U_{95}REF)^2 - r_{LAB,REF}(U_{95}LAB)(U_{95}REF)}}$$

where

$$r_{LAB,REF} = \frac{U_{95}(LAB, REF)}{(U_{95}LAB)(U_{95}REF)}$$

$U_{95}\,(LAB,REF)$ indicates the potential uncertainty factor for correlation effects between calibrations on the same stand
$r_{LAB,REF}$ is the correlation coefficient, assumed to be 0.5

The process is then reviewed, with En<= 1 indicating a system where differences are not statistically significant. Figure 6 below is typical of the calibration results for the control meters. The control meter shown is for the largest scale.



PFS Large Scale E_n History
Figure 6

4f. Assessment

The company went through the assessment process on December 10 and 11, 2002. The accrediting body was A2LA. Following the successful assessment and review by the accrediting body, MMI received accreditation on February 8, 2003. The scope of accreditation is for calibration of Coriolis mass flow, at flow rates of 0.2 kg/min to 3200 kg/min, with a CMC of 0.012% (Annex 1).

5. Conclusion

Micro Motion was able to develop a process for maintaining traceability on the TSM calibration stands globally. This was accomplished by extending the use of its own Coriolis flowmeters as transfer reference standards. The process is enabled by the ISO 17025 accreditation of the PFS, to a very low uncertainty (0.012%), that is used to calibrate the GRM's. The process allows in situ calibration of the TSM stands, provides a global round robin of the TSM stands and has greatly simplified the logistics of maintaining the TSM stands.

REFERENCES

1. FLOMEKO 2000, Traceability and Uncertainty Analysis for a Calibration Process for Flowmeters, Using Coriolis Flowmeters as Reference by Robert DeBoom, Marc Buttler, Andrew Kolbeck and Aart Pruysen

ANNEX

1. Certificate of Accreditation and Scope of Accereditation

AUTHORS

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Annex 1 Accreditation certificate

THE AMERICAN
ASSOCIATION
FOR LABORATORY
ACCREDITATION

ACCREDITED LABORATORY

A2LA has accredited

MICRO MOTION INC./MEASUREMENT TECHNOLOGY TEST LAB
Boulder, CO

for technical competence in the field of

Calibration

The accreditation covers the specific calibrations listed on the agreed scope of accreditation. This laboratory meets the requirements of ISO/IEC 17025 - 1999 "General Requirements for the Competence of Testing and Calibration Laboratorie." Laboratories that comply with this International Standard also operate in accordance with ISO 9001 or ISO 9002 (1994). This laboratory also meets the requirements of ANSI/NCSL Z540-1-1994 and any additional program requirements in the field of calibration.

Presented this 6th day of February 2003.

President
For the Accreditation Council
Certificate Number 2033.01
Valid to April 30, 2005

For the calibrations to which this accreditation applies, please refer to the laboratory's Calibration Scope of Accreditation.

American Association for Laboratory Accreditation

SCOPE OF ACCREDITATION TO ISO 17025-1999
& ANSI/NCSL Z540-1-1994

MICRO MOTION INC./MEASUREMENT TECHNOLOGY TEST LAB
7070 Winchester Circle
Boulder, CO 80301
Dave Calvert Phone: 303 530 8552

CALIBRATION

Valid To: April 30, 2005 Certificate Number: 2033.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations[1]:

I. Fluid Quantities

Parameter/Equipment	Range	Best Uncertainty[2] (±)	Comments
Calibration of Coriolis Flow Meters	(0.5 to 7000) lb/min	0.012 %	Standing/start-finish gravimetric flow stand

[1] This laboratory offers commercial calibration service.
[2] Best Uncertainties represent expanded uncertainties using a coverage factor of k=2 which provides a level of confidence of approximately 95 %.

(A2LA Cert. No. 2033.01) 02/06/2003

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