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Improved traceability and reliability in mass calibration

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Abstract – Mass calibration is a labour-intensive and multi-layered process. With manual data writing and limited quality control, final results may not comply with required quality standards. Interconnected equipment enables data security, data analysis and reporting in one system. Regulatory compliance is achieved with integrated uncertainty analysis, weighing schemes and quality control tools. This paper gives an insight to common mass calibration process hurdles and new solution approaches.

Keywords**:** Importance of Software in Mass Calibration, Efficient Weight Calibration Workflow, Mass Metrology, Productivity in Mass Calibration, Improved Traceability.

1. INTRODUCTION

To enable the traceability of mass in trade and industry, reference weights that are used for the calibration of balances and scales are legally required to be accurate and conform to regulations, such as OIML R111, NIST HB 44 or JJG 99-2006 [1,2,3]. These reference weights must be traceable to the international standards by the calibration of their masses at different accuracy levels.

With the ongoing global industrialization and increased cross-border trading, the correct reading of balances is compulsory. This requires mass calibration at the highest possible accuracy levels across the globe.
Mass calibration is an elaborating process which involves highly complex calculations, demanding highly educated personnel and time. Correction of physical effects and observation of fluctuations in the environment are crucial to achieving accurate results. With today's applied technologies, this part of the calibration process is complicated and requires a high level of knowledge.

2. MANUAL MASS CALIBRATION

Weights calibration with forms and hand writing are error prone and may lead to wrong data within the traceability chain. Due to the fact that mostly a repetitive measurement has to be performed, there is a potentially higher risk of incorporating faulty data in complex analysis, resulting in incorrect final calibrations.

The selection of reference standards and calibration process strongly influence the combined uncertainty of the final result, which shall suffice regulatory limits. Establishment of quality control is elaborated and requires a great deal of labour and skills. Post-process or inappropriate quality control system may lead to additional labour and intransparent traceability.
Transcription from hand-written forms to the computer for calculations with following certificate creation leads to higher data risk resulting in challenging traceability (figure 1).

Figure 1. Mass calibration process with independent technologies.

3. PHYSICAL EFFECTS

Due to laboratory altitude and air density fluctuation, physical factors such as air buoyancy effects affect the mass calibration in significant extent. Not correcting these influences leads to deviations in the final results affecting later calibration of balances or reference weights.

Temperature changes within the laboratory generate convection of the weights under test, resulting in deviation and instable comparator reading. Measurement of the laboratory temperature stability and reducing convectional effects is crucial to enable stable and reliable data.

4. QUALITY ASSURANCE

Measurement reference standards and comparators shall be controlled on a frequent base to ensure high data quality. Maintaining quality control requires extensive testing of equipment and reference standards to detect outliers immediately, allowing time effective corrections. Including check standards measurements within the calibration process allows on-time control of the system. Evaluation is done post process. The acceptance of the calibration results is dependent on the outcome of the check standard results.

5. CALIBRATION CERTIFICATION

Measurement results are to be reported in documents with regulatory requirements. Results are to be documented in specific formats including added information's of applied equipment, reference standards and processes. This data is to be collected manually and implemented in the report.

Uncertainty calculations are to be performed as well as collecting climatic data and which needs to be transferred to the certificate.

6. SYSTEM INDEPENDENT MASS CALIBRATION

The previously discussed factors are intense in labour and are prone to human errors due to transcription and calculation errors. Physical factors are often neglected which often result in faulty data. In addition the implementation of all collected data into the calibration certificate is intense in labour.

The data reliability is not granted and faulty calibration results might be implemented in the official calibration certificates, resulting in use of non-reliable data in the succeeding calibration of standards and balances.

7. TODAY'S CALIBRATION NEEDS

To enable high data security and reliable calibration results, automatic data reading is required. To ensure users follow the defined process and results are under control all time, visual process control combined with process guidance and automated results calculation are desirable.

With statistical quality control, the mass calibration quality shall be granted at all times and certificates should be available with little efforts whilst comply with regulations.

Reference standards data entered in systems or calculations shall be protected. The calibration process should be seamless and without human data entry to ensure full data security.

8. SOLUTION APPROACH

With the integration of digital data acquisition from comparator and climatic sensors, the calculation of results through predefined processes and fully automatic certificate generation, a reliable and traceable workflow is enabled.

METTLER TOLEDO incorporated these fundamental requirements in one comprehensive software system, interacting with communication standards already integrated in comparators and climate sensors.

With the use of barcode reading technology and reuse of data within the system for following process steps, data manipulation is reduced to a minimum increasing the data security.

With protected process and reference standard settings, human errors are reduced. With visual user guidance and background data control, labor is concentrated on the core calibration process (figure 2).

Figure 2. Mass calibration process with MC Link technology.

9. DATA SECURITY

Data acquisition is an important factor to increase data security and process efficiency. By networking existing equipment to PC software, automated data reading gets established, resulting in a mature data security.

Data transcription errors are eliminated, enabling fully traceable data acquisition and calculations throughout the process. The incorporation of the measurements into sophisticated mathematical equations ensures uninterrupted traceability while eliminating external or user depending errors.

10. NETWORK SYSTEM

Networking all sensors and comparators is realized by established technologies such as RS232 serial, Ethernet or USB interfaces to interconnect data sources to the PC. Hardwired communication ensures an uninterrupted communication between the process software and the connected instruments.

Mass calibration process guidance and visual process control are enabled for tablets or laptops by wireless LAN, enabling reduction of thermal influences to the laboratory (figure 3).

Figure 3. Mass laboratory network system for highest data security.

11. CUSTOMER ADMINISTRATION

Customer's data is defined and weight sets are assigned to. All information is stored in one database enabling full traceability and a fast and reliable generation of calibration certificates.

The creation of weight sets is based on predefined templates reducing labour significantly. These weight set templates are generated with high flexibility allowing combination of various structures and materials and shapes.

Reoccurring calibrations do not require data manipulation as they get executed directly in the laboratory.

12. MASS CALIBRATION PROCESS

Within the laboratory, the HTML based laboratory client is used to perform mass calibration as well as comparator testing. The multilingual user interface ensures no interpretational errors occur while performing calibrations.

Entering the weight set ID on the tablet manually or by barcode reader identifies the appropriate process and reference weights to be used.

During the process, the user is informed in real time about data collected, intermediate results, tolerance testing and statistical testing. This enables immediate intervention if required. The results are verified versus tolerance and uncertainty requirement. The final results are only released for certificate printing, if results in function of uncertainty comply with the assigned method and tolerances (figure 4).

Figure 4. User interface mass calibration on tablet.

13. CERTIFICATE PRINTING

By entering the weight set ID and the selection of one predefined certificate template, the calibration report is generated fully automatically. Measurement data of comparators and climatic sensors, calibration results and uncertainty analysis data is incorporated and is ready to print.

14. WEIGHING PROCESS

To suffice the various requirements of international regulations such as OIML R111 [1], NIST HB 44 [2] and JJG 99-2006 contribution factors are implemented and selectable. This allows customizable weighing process to comply with local requirements and international regulations (figure 5).

Figure 5. Process definition by selection of schemes.

15. UNCERTAINTY ANALYSIS

Uncertainty factor calculations are implemented for selection of pre validated calculations.
Regulation such as OIML R111, NIST HB 44 or JJG 99-2006 [1,2,3] are fully covered. Reliable calculations and regulatory conformance are included.

16. STATISTICAL TESTING

Based on check standard measurements, statistical data is generated for quality control of the comparator and reference standards as well as establishment of process variance for uncertainty analysis. With control chart, F, T and En test, quality is under control during the entire measurement.

17. CONCLUSIONS

With the use of most recent software technologies, the mass calibration process can be improved in data security, efficiency and quality significantly. Physical effects are corrected for full compliance without added labor.

With METTLER TOLEDO MC Link software installed as an extension to existing equipment, laboratories may improve the daily work in regards of traceability, efficiency, data security and ease of use.

REFERENCES

[1] OIML R111 - TC 9/SC 3, (2004).
[2] NIST Handbook 44, 2014 edition
[3] JJG 99-2006, China Institute of Metrology (2007)