Metals and Minerals Bulletin

Precision and Tolerance of Different Weighing Systems	Bulletin 22-01 Rev. 0 - 0

Introduction and scope

The purpose of this bulletin is to explain the presence of uncertainty in the precision and accuracy of dry bulk cargoes' weight determination. This bulletin also aims at providing guidance on the decisions to be made on the suitability of different weighing systems and methods, identifying the risks involved in the quantity determination part of a trade.

This bulletin is meant to be an introduction to this topic, and provides information on calibration certificates, vessel documentation used for weight determination by draught survey, typical details on errors of different weight determination methods, and the responsibilities and limitations of TIC Council member companies.

Calibration certificates

Weighing systems are regularly used for the calculation of the value of a commodity. A weighing system 'as manufactured' is often precise; however, the accuracy depends on the quality and validity of the presiding calibrations, and on the maintenance and operating conditions of the weighing system. This section aims to set out the minimum requirements for a Certificate of Calibration for a weighing system.

Calibration is essential to ensure the reported weight is within the range of the certified calibration. It is important to note that error due to calibration ranges is additive.

The calibration certificate assumes that there have been no changes to the weighing system since calibration. Any adjustments to the settings, positioning or construction or any damage would render the calibration unrepresentative.

A 'Certificate of Calibration' and its contents can vary depending on the weighing device, applicable metrological standard and national metrological requirements. This bulletin identifies the minimum information expected in Annex 1, it not being an exhaustive list covering all weighing systems and standards.

Certificates of Calibration must be made available to the involved contractual parties and their representatives upon request.

Draught Survey and Vessel documentation (hydrostatics and ballast tables)

Draught survey is a mass determination technique based on visual estimations of draught marks, measurement of ballast level in the tanks, reading of the apparent density in air of the dock water and ballast, and performing a series of calculations using the ship's documentation.

Revisions/Reaffirmations

Rev. 0 September 2022

One of the elements to consider when trying to estimate the margin of error for draught survey method is the ship's "Tonnes Per Centimetre" (TPC) value, which is similar to a scale's division.

It is usually perceived that a ship's documentation is equivalent to a scale's calibration certificate, but it is not. The main downfalls of ship's documentations are the fact that they are based on theoretical values for ideal conditions and the values are not traceable to the reference international standard kg unit. An approved ship's documentation is not a certification attesting to the accuracy of its values. While the tests for checking the repeatability and accuracy are crucial for evaluating the performance of any weighing system, they are not conducted for ships. Therefore, the method's margin of error/tolerance cannot be measured accurately.

The results from draught survey should be used with some reserve in comparison to results from verified and certified weighing systems.

Conducting the measuring and reading with the highest possible accuracy, while using the minimum set of corrections applicable from the ship's documentation properly certified by a classification organisation (hydrostatic tables and ballast sounding tables), is all a draught surveyor can do to demonstrate that a correct draught survey was performed.

Measurement of uncertainty/precision/accuracy of weighing devices and examples of external factors influencing precision (non-exhaustive list)

The precision and accuracy of weighing devices vary from device to device, accuracy class, state of maintenance and operation, and external influences such as weather conditions.

Various standards provide figures that can be interpreted as guidelines for expectation on the maximum permissible errors for different weighing methods and devices that can occur within typical operating conditions. The table below is an overview and interpretation of such maximum permissible errors [See Annex 2 for an example of the impact of permissible errors].

Methods of Weighing, Standards, Typical details and Errors for Metals and Minerals shipments

Type of Mass Determination	Standard	OIML		NIST		ISO 12745	
		Accuracy Class	MPE	Accuracy Class	MPE	Min. C_v	Max. C_v
Draught survey	United Nations ECE Draught Survey Code	–	–	–	–	0.5%	2.5%
Barge survey	API Manual Chapter 17 Section 14	–	–	–	–	0.5%	2.0%
Conveyor Belt	OIML R050 / NIST Handbook 44 - 2.21	0.2 0.5 1 2	0.2% 0.5% 1.0% 2.0%	–	0.5%	0.4%	>3.5%
Weighbridges	OIML R076 / NIST Handbook 44 - 2.20	III	±5 e	III or III L	≥5 e	0.1%*	0.5%*

Hopper Scales (totalizing)	OIML R107 / NIST Handbook 44 - 2.22	0.2 0.5 1 2	0.2% 0.5% 1.0% 2.0%	III or III L	±4 e	0.1%*	0.25%*
Crane Scales (totalizing)	OIML R107 / NIST Handbook 44 - 2.22	0.5 1 2	0.5% 1.0% 2.0%	III or III L	≥4 e	0.15%*	0.4%*
Platform Scales	OIML R076 / NIST Handbook 44 - 2.20	III	±3 e	III	±3 e	0.05%*	0.2%*

** at gross loads; the variance for the net wet mass of a single transportation unit is equal to the sum of the variances at gross and tare loads*

MPE - Maximum Permissible Error (OIML R107): Extreme values of an error permitted by specifications, regulations, etc. for a given instrument.

e – Verification Scale Division (NIST Handbook 44): A value, expressed in units of weight (mass) and specified by the manufacturer of a device, by which the tolerance values and the accuracy class applicable to the device are determined.

C_v – Coefficient of Variation (ISO 12745): measure for random variations in a mass measurement technique, numerically equal to the standard deviation as a percentage of the observed mass.

Responsibilities and limitations of member companies

In nominations involving weight determination, TIC Council members shall perform services as defined and agreed with the principal in the scope of works. When weight determination, or the supervision thereof, is part of the scope of works, the principal is responsible for the choice of the exact method to be applied.

In nominations where mass is determined using loadcells such as weighbridges, truck scales and dynamic belt weighing systems, the weighing device is typically operated by its owner/operator, not by the TIC Council member itself. TIC Council members shall supervise the correct execution of the weighing procedures as defined in the scope of works. Some typical aspects (depending on scope of works) checked during supervision of weighing are (non-exhaustive list):

- Recording of details of weighing device such as the make, model, serial number, maximum and minimum load capacity, division, and readability;
- Recording date of last calibration according to calibration certificate and/or calibration sticker to check if within the agreed period of calibration;
- Recording of the general appearance of the weight determination device;
- Zero reading prior to commencement of weighing operations;
- Supervising and recording details of internal verification procedures;
- Supervising the execution of mass determinations, including tare weight determination if applicable.

Any irregularities need to be reported to the principal as soon as possible.

The owner/operator of the weighing device needs to ensure it is in good working order and bears responsibility for:

- The metrological soundness of the system;
- The accuracy of the system;
- Timely calibrations and internal verifications;
- The correct execution of the internal verification;
- Executing the mass determinations procedure.

When draught survey of vessels or barges is the agreed method for weight determination, the actual weight is determined by the TIC Council member, often in conjunction with the chief officer. The TIC Council member is responsible for the correct execution of the draught survey procedures, but is not responsible for the suitability of the vessel and the data provided by the ship such as the hydrostatic and ballast sounding tables.

Please refer to the Chapter 9 of the Minerals Committee Code of Practice* for further information on Quality Inspections.

* https://www.tic-council.org/application/files/9315/5714/3016/IFIA_Minerals_Committee_Code_of_Practice.pdf

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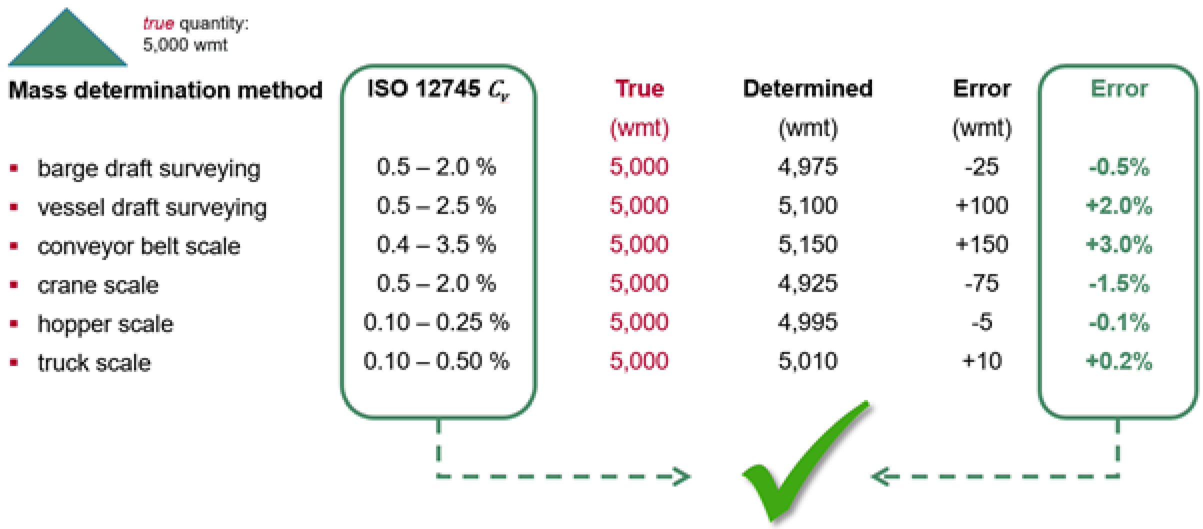
Annex 1: Minimum requirements for a Certificate of Calibration

1. General Owner Information
    a. Name of Scale Owner
    b. Location
    c. Country
2. Calibration Provider
    a. Calibration Company Name
    b. Country of Operation
    c. Contact Details
    d. List or Emblem of National Accreditations
    e. List or Emblem of Accredited Quality Systems
    f. Reference Number of Calibration
    g. Reference to Terms and Conditions of Calibration Appointment
3. Scale Information
    a. Scale Type / Description of Scale
    b. Scale Reference
    c. Scale Manufacturer
    d. Scale Model
    e. If Separate, Totaliser / Indicator Manufacturer/Model
    f. Scale Serial Number(s)
    g. Calibration Date
    h. Calibration validity expiry date
    i. Any limitations to the calibration, such as calibration validity range
4. Scale Characteristics
    a. Metrological Society (e.g., OIML, NIST)
    b. Metrological Standard Applied (I.e. R-50, Handbook 44)
    c. Scale Class, or Calibration Accuracy (i.e. Class I, or +/- 0.1%)
    d. Unit(s) of Measurement
    e. Maximum Capacity (Max)
    f. Minimum Capacity (Min)
    g. Minimum Division / Interval (d)
    h. Number of scale intervals (n)
    i. Scale Error (if Applicable for Standard) (e)
    j. Maximum Load Limit
    k. Scale type-specific details, such as size, speed, construction, flow rate
5. Calibration Test Details
    a. Time, Date and Location of test
    b. Any applicable constant(s) before and after calibration
    c. Temperature and Humidity conditions at Time, Date and Place of calibration
    d. Details of Calibration method, referencing the requirements of the applicable standards
        i. Typically, calibration standards require the following as a minimum:
            1. Testing of scale Tare
            2. Testing of scale Accuracy for a range of weights between the Min and Max values
            3. Testing of individual scale components, such as weights loaded on each loadcell (Platform Scale), or verification of belt speed indicator (Belt Scale)
    e. Details of each test and repeats made during calibration
        i. The certified weight of the standard weights
        ii. The weight range tested must be disclosed
        iii. The 'Verification' and 'In Service' thresholds for the calibration
        iv. Details of each weighing result and deviation from the standard weight

f. Traceability of Standard Weights, such as reference to the certification of the standard weight from a National Body that is traceable to a universally accepted standard weight
g. Name of Tester
h. Title, Rank or Qualification of Tester
i. Signature of Tester
j. Limitations of Calibration, such as tested range, operating conditions, location
k. Details of tamper-evident seal that stops adjustment of scale properties by an unauthorized party

Annex 2: Impact of permissible errors for different weighing methods and devices.

To illustrate the possible impact of permissible errors for different weighing methods and devices, we use an example of a mineral commodity having a true mass of exactly 5,000 metric tons that is weighed by different methods. The below table and graphs show that all of these weighing methods resulted in a mass estimation that is within the maximum permissible errors. All these weighing methods were thus operating correctly.



Mass determination method	ISO 12745 C_v	True (wmt)	Determined (wmt)	Error (wmt)	Error
barge draft surveying	0.5 – 2.0 %	5,000	4,975	-25	-0.5%
vessel draft surveying	0.5 – 2.5 %	5,000	5,100	+100	+2.0%
conveyor belt scale	0.4 – 3.5 %	5,000	5,150	+150	+3.0%
crane scale	0.5 – 2.0 %	5,000	4,925	-75	-1.5%
hopper scale	0.10 – 0.25 %	5,000	4,995	-5	-0.1%
truck scale	0.10 – 0.50 %	5,000	5,010	+10	+0.2%