Biometria
Authorisation of Timber Measuring Companies

General document for timber measurement

Version 2026-01-01

BIOMETRIA

Contents

1 Introduction

This general document was prepared in conjunction with the merger between VMK and Biometria in June 2022, and derives from three earlier VMK documents. This document sets out regulations regarding Biometria's authorisation of timber measuring companies in other countries, such as the Baltic States. The document is adopted by RMR (Council for Measurement and Reporting), or parts thereof. Current measurement instructions and documents regarding checks are available from www.biometria.se.

A timber measuring[1] company that complies with the regulatory framework set up by the parties in Biometria's instructions for timber measurement may apply to Biometria for authorisation. The regulatory framework for the sector is based on requirements stipulated in the Swedish Timber Measurement Act (VML) and Timber Measurement Ordinance, and regulatory documents issued by the Swedish Forest Agency. By law, only insignificant systematic errors in measurement are permitted, and the requirement levels are the sector's interpretation of the Timber Measurement Act.

The aim of authorisation is to simplify measurement of timber arriving in Swedish ports. Decisions regarding authorisation and withdrawal of authorisation are made by RMR. In cases where RMR cannot reach consensus on authorisation, the decision is instead made by the Biometria board.

Authorised measuring companies must use measurement checks and other monitoring procedures to ensure consistent interpretation and application of measurement regulations, instructions regarding checks, and other measurement documents.

This English version of the authorisation document is the one that applies. (The Swedish version is simply a complementary document.)

This document comprises:

- Guidelines for authorisation of a measuring company (Chapter 2)
- Standard procedures for checking timber measurement and timber reporting for an authorised measuring company (Chapter 3)
- Information on how Biometria assesses the quality of measurements conducted by an authorised measuring company (Chapter 4)
- Description of authorisation process for timber measuring companies (Appendix 1)
- Information on how the results of check measurements are calculated (Appendix 2).

2 Guidelines for authorisation of timber measuring companies

2.1 Aim of the measurement

The timber must be measured in an objective and consistent way, in line with requirements arising from developments in forestry, the forest industry, and the biofuels sector.

[1] Often called "measuring company".

2.2 Measurement regulations

Authorisation is granted for measurement of timber according to Biometria's instructions for timber measurement. Current measurement instructions can be found on www.biometria.se. The website also includes Biometria's general documents on timber measurement, measurement instructions, and procedures regarding checks. All these documents must be followed by authorised measuring companies in applicable cases.

2.3 Measurement equipment

An authorised timber measuring company must only use type-approved measurement equipment, and procedures must comply with Biometria's measurement instructions. Type approval is issued for equipment that has undergone Biometria's type approval process.

2.4 Measurement checks

An authorised measuring company must apply the rules shown in this document for both internal checks and applicable parts of requested checks. The measurement checking procedures of the authorised measuring company must also be assessed at least annually, e.g. by participation in Biometria's harmonising check measurement exercise.

To enable satisfactory internal checks and follow-up of measurement activities, the authorised measuring company must ascertain the right to use measurement data collected on behalf of clients.

The results of the company's internal checks, compiled in accordance with this document, must be submitted to Biometria annually, no later than 14 February, and without request.

2.5 Measurement quality

Timber measurements by an authorised measuring company must be of an approved quality. See Chapter 4, "Assessment of measurement quality of authorised measuring company"[2].

2.6 Responsibility for measured quantities and timber reporting

The authorised measuring company is responsible for ensuring that measurement data is managed and processed correctly, and that information about the measured quantities is submitted to the relevant parties in the form of a measurement report. The authorised measuring company must also comply with the parts of this document relating to timber reporting.

2.7 Staff competency and ethical regulations

An authorised measuring company is responsible for ensuring that employed or commissioned measurement officials (scalers) have the necessary competency for the task.

[2] A statement regarding quality is made in one of Biometria's annual public reports.

All officials measuring timber must have given a written guarantee that they will perform their measurement tasks to the best of their ability and conscience, and with due care and impartiality, and that they will not disclose business information relating to the measurement to external parties. Conflicts of interest in relation to parties involved in the measurement procedure must be avoided. If this is not possible, a conflict of interest must be reported to the supervisory staff.

The management and supervisory staff of the authorised measuring company must have good knowledge of timber measurement, and observe the same due care and impartiality as the scalers who measure timber.

2.8 Authorisation validity

An authorised measuring company that deliberately or through negligence fails to comply with the regulations in this document may have their authorisation withdrawn with immediate effect.

2.9 Fees

Fees for authorisation are specified in agreements with the measuring company in question. Fees for new agreements are also shown on www.biometria.se.

3 Standard procedures for checking timber measurements and timber reporting

3.1 Introduction

In this section the parts of Biometria's general regulatory framework relating to checks and follow-ups of measurements by authorised measuring companies are described.

3.1.1 Types of checks

An authorised measuring company must apply the following types of internal checks:

- Checks of competency and internal calibration measurements
- Checks of measurement equipment
- Checks of original measurements
- Checks of calculations and data processing up to the point where measurement results reach the party concerned.

An authorised measuring company must also enable relevant parties to request measurement checks of individual consignments if they are affected by the consignment ('requested check' and 'requested remeasurement using photo'). See Sections 3.8 and 3.9.

3.2 Traceability

There must be an unbroken chain for calibration and adjustment to all measurement tools and equipment, both for original measurements and for check measurements. Calibration and adjustment must be based on traceable standards from national/international measurement standards[3].

3.3 Checks of competency and internal calibration measurements

3.3.1 Original measurement

Log scalers (measurement officials) who conduct measurements of timber that will form the basis of a commercial transaction must have completed a theory and practical test of competency for the assortment concerned and the measurement method, as proof of competency before they are approved to measure timber.

To maintain and improve the quality of measurement, the measuring company must continually review the ability of log scalers to apply applicable measurement procedures and regulations. This competency check involves analysis of original measurement results, and in-service training through measurement of specific timber units with verified measurement values. The competency check also includes maintenance and use of measurement equipment. Written procedures regarding competency checks must be available at the measuring company.

3.3.2 Measurement checks and internal calibration measurements

To ensure accuracy in check measurements and consistent application of measurement instructions, internal calibration measurements are performed annually for the measuring company's quality assurance manager/check scaler. The calibration measurements are to be instructive and educational exercises, and are to be comparative measurements that make it possible to identify and thereby prevent differences in the check measurement. Written procedures regarding internal calibration measurements must be available at the measuring company.

Results from internal calibration measurements are to be submitted to Biometria, and are used to ensure an appropriate method for checking measurements and for calculating the accuracy of the method used in checks. The results can also be used as a basis for changes to instructions and development of work procedures and measurement methods.

3.4 Measurement equipment checks

3.4.1 Approval of measurement equipment

Measurement equipment used by an authorised measuring company must be type approved by Biometria. Hand-held equipment without electronics is exempt from this requirement. The installation of fixed equipment must be approved.

[3] In Swedish "mätnormal"

3.4.2 Daily inspection and periodic checks

Procedures for daily inspection and periodic checks must be described in instructions for checking procedures. All measurement equipment, including equipment without electronics, must be individually marked and calibrated against traceable measurement norms, and must be checked periodically. The results must be documented and saved for at least two years. Exceptions can be made for simple equipment, for example equipment used for assessing quality properties.

3.4.3 Logbook at measurement sites

An authorised measuring company must ensure that suppliers of equipment meet specific requirements. An authorised measuring company must ensure that a service plan for the facility be drawn up, and that any actions taken concerning equipment/systems/facility are recorded in a logbook, regardless of who has conducted or ordered the action. An authorised measuring company must ensure that they have received information regarding any interventions relating to measurement equipment or the measurement facility in general, and that an impact assessment has been conducted. The logbook should preferably be online, with access authorisation for the measurement site owner, the measuring company, and the supplier of the equipment.

3.5 Checks of original measurements

3.5.1 Purpose

Original measurements are checked to:

- calculate, per population, the systematic deviation and standard deviation (temporary deviation for individual timber unit) of the original measurement;
- calculate, per measurement method and chosen aggregation level, the batchwise deviation in terms of quantity and value;
- provide data for assessing the competency of the log scaler and thereby use the data for in-service training (see section 3.3); and
- serve as an instrument for detecting errors that can affect measurement.

3.5.2 Method of checking

Biometria's Swedish measurement regulations describe how original measurements are to be checked for each measurement method. Principles for assessing the accuracy of the original measurement are:

1. Measurements must be checked using the same measurement method as was used in the original measurement, or a more accurate one.
2. If the same measurement unit can be measured with different methods and/or measurement technology, the measurement must be checked in a way that is equivalent to, and independent, of the method or technology used in the original measurement. For example, one method/technology may comprise a reference for others. In cases where a measurement unit is checked in different ways, it must be ensured that there is no systematic difference between them.

A method for checking measurements is to be accurate, stable, and consistent. Consequently, the results of a measurement check may not display systematic variation between repeated

measurements, at different times, from area to area, or between measurement sites. The accuracy of the checking method must be documented.

If the measurement includes conversion figures and/or unit conversion rates, e.g. log-by-log measurement that is converted from $m^3$to till m^3sub or stacks that are converted from gross weight to m^3sub, the check measurement must be designed as a direct check measurement of the converted/unit conversion quantity.

3.5.3 Procedure

A check of an original measurement must normally be based on a random sample of timber units, and involve the entire target population. A 'timber unit' is a unit of timber with a unique identity that is to be measured, such as a log, stack, or loose volume in a container. For these selected timber units, the results of the original measurement are compared with the results of a measurement check. Where a random sample of timber units cannot be applied, it should still be possible to assess measurement accuracy on the basis of knowledge about the sources of error in the measurement.

- The result of the check is to be reported per check population.
- 'Check populations' are created by dividing the original measurement into groups according to measurement method and assortment or assortment group.
- The check population normally comprises one assortment/assortment group with a certain tree species at each individual measurement site.

The following apply when original measurements are to be checked:

1. Check measurements are to be conducted by specially appointed persons (check scalers) with comprehensive knowledge of the measurement method and equipment to be checked.
2. If both original (first) measurement and check measurement involve elements that can be influenced by the actions of the scaler, the same person may not perform the two measurements.
3. Measurement officials tasked with checking an original measurement must participate in internal calibration measurements in accordance with Section 3.3.2.
4. An original measurement must not be influenced by the type of timber unit that will be, or has been, the subject of measurement checks. Consequently, the official who performed the original measurement must not be aware of whether the measured timber unit is part of the check population.
5. The number of timber units per check population and year is to be planned so that the systematic deviation in relation to checks can be determined with the standard error shown in Section 3.5.5. Any risk of loss of timber units or uncertainty about the volumes must be taken into account. However, the number of checked timber stacks should not be less than 30 per check population.
6. Every timber unit in a check population must have a documented probability of being selected as a timber unit. The sample may be stratified, for example in terms of quantity and quality, providing that the applied stratification is taken into account when calculating the results of checks and that there is sufficient data to estimate the accuracy by batch.
7. Any loss of timber units, and the cause, is to be recorded.
8. The check must be designed in such a way that, each year, the accuracy of measurement can be calculated at batch level for each measurement method and chosen aggregation level.
9. The check is to be performed on timber in its existing condition.

3.5.4 Minimum and target levels for measurement quality

Minimum level is the lowest level that the scaling is expected to reach, i.e. the level of acceptance. If a scaler or measurement site does not reach the minimum level, special measures must be taken to improve measurement quality. This must include an analysis of causes and an action plan.

Minimum and any target levels or levels of corrective action for scaler and measurement site are adopted by the authorised measuring company, and are based on the scaler and site satisfying the levels of requirements shown in this document.

3.5.5 Data for assessment

Assessment of minimum levels and any target levels or levels of corrective action is based on a sample of timber units where the systematic deviations can be determined within a 95% confidence interval, with the level set according to measurement method, follow-up unit, and type of deviation (Table 1). Results from temporarily manned measurement sites are reported and assessed in aggregated form.

Table 1. Maximum level with a 95% confidence interval for systematic deviation in volume and value (%) for different measurement methods.

		Confidence interval for deviation	
	Follow-up unit	**Gross volume**	**Value/Net volume**
Log-by-log measurement of check and sample stacks	Tree species per measurement site	± 1.0	± 1.5
Stack measurement	Assortment per measurement site	± 2.0	± 3.0

Here, tree species and assortment normally refer to softwood trees, birch, and aspen.

3.6 Checks of reporting

An authorised measuring company must ensure the quality of reporting, and perform the checks considered necessary to ensure accurate timber reporting.

Reporting must be checked before and after changes in software and/or hardware are implemented in measurement equipment and reporting systems. The checks must be conducted in a way that ensures the flow of a measurement through the reporting system in terms of quantity and quality of the timber.

Continual checks must be conducted at least every other month for each measurement method and assortment group.

Results of reporting checks are to be submitted to Biometria as described in Section 3.8.2.

3.7 Biometria's harmonised check measurements

The authorised measuring companies must apply Biometria's Swedish regulatory framework in a consistent manner. The authorised measuring companies must participate in Biometria's harmonised check measurements of relevant assortments (currently pulpwood). Check scalers/quality leaders from Biometria also participate in these exercises. The overall aim of the exercises is to ensure consistent checks of timber measurement and application of measurement instructions. This is to ensure that assessment of measurement quality is comparable and consistent for all authorised measuring companies and Biometria.

3.8 Reporting of results from checks

The reporting concerns all types of checks, i.e.

- Checks of competency and internal calibration measurements
- Checks of measurement equipment
- Checks of original measurements
- Requested checks and requested remeasurements using photos
- Checks of reporting

3.8.1 Processing

Deviations: value/net volume

Value deviation and net volume deviation are used to assess the measurement and to generate performance indicators comparable between authorised measuring companies and between measurement sites[4].

Analysis

Measurement checks are to be processed and reported to enable analysis of the measurement result. Systematic deviations are calculated per check population. The sampling procedure applied for the checked timber units must be taken into account in the calculations, so that every constituent part of the check population exerts an influence corresponding to its total quantity and value.

Uncertainties in measurement are to be reported as a standard deviation of the deviations, and as a standard error for the systematic deviation for both volume and value

Statistical calculations for measurement checks are described in Appendix 2 of this document (and as Appendix 2 in *Biometria's checks of timber measurement*).

3.8.2 Reporting of checks to Biometria

Authorised measuring companies must submit the results of checks to Biometria according to the specification below. The authorised measuring company decides on other reporting and distribution of the results of checks.

Continual reporting

The results of checks for each individual measurement site or group of measurement sites must be submitted to Biometria on request.

[4] The alternative would be to use relative price lists, but as reject pulpwood usually has no value, net volume deviation gives the same result as value deviation. When quality grading into Prima/Sekunda classes is introduced, Biometria's relative price list will be used to assess value deviations.

Incidents that seriously affected the measurement and/or reporting (excl. price calculation) must be reported to Biometria as soon as possible. The report is to include details of the incident, and measures taken and planned.

Annual reporting

The report is to cover the immediately preceding calendar year, and must be submitted to Biometria no later than 14 February. The report is to be in the form of a check report and must contain the following:

1. Description of the checking activities, including all applicable points in the standards for checks.
    a. Summary of the results
    b. Comments on the results
2. The authorised measuring company's own minimum targets regarding measurement accuracy.
3. Description of the improvement measures implemented during the year
4. Description of incidents that seriously affected the measurement and reporting at individual measurement sites or groups of measurement sites.

Results of checks of competency and internal calibration measurements

The report must contain: 1) A description of the scope of the activity, and
2) A summary of the results.

Results of checks of measurement equipment

The report must contain:
1) A description of the scope of the activity, and
2) A summary of the results.

Results of checks of original measurement

The results of checks for the authorised measuring company, both aggregated and divided into measurement sites or groups of measurement sites, are to be reported by main assortment (saw logs, pulpwood, energy wood, etc.) and tree species. Gross quantity, net quantity, quality value, and relative value are to be reported as follows:

1. Number of checked timber units.
2. Systematic deviation between the original measurement and check measurement, expressed as a percentage of the average quantity/value shown in the check measurement.
3. Standard deviation for the deviations and standard error for the systematic deviation, expressed as a percentage of the average quantity/value shown in the check measurement.
4. Loss of timber units: where losses exceed 6% of the total number of units, the two most common reasons for loss are to be stated.
5. Summary of results from requested checks.
6. Batchwise accuracy (gross quantity per measurement method and chosen aggregation level).

Results regarding checks of reporting

Results of checks of reporting for the authorised measuring company are to be submitted as follows:

1. Scope and description of checking procedures (according to Section 3.6) and compilation of results from these.
2. A compilation of significant errors in production concerning reporting of the quantity and/or quality of the timber.
3. Description of procedures to ensure that all parties in the transaction receive correct payment.
4. Description of how corrections have been managed in everyday production and corrections of timber reporting.

3.9 Requested check

3.9.1 Background

An authorised measuring company must offer and conduct requested checks. The procedure should broadly be as follows.

The aim of a requested check is to serve as a complaint about an original measurement.

A requested check must be conducted by person with particular responsibility and authorisation for follow-up and checks.

All parties affected by the results of ordinary measurement may request a check of measurements taken by the measuring company. The party requesting the check must state their role (supplier, seller, buyer, transporter, or harvesting contractor[5]) in the contract to which the check applies. The party submitting the request must also state the basis for the requested remeasurement (gross quantity, net quantity[6], timber value, or measurement refusal). The authorised measuring company provides a template for a requested check, available from the website.

When determining value, the price list applying to the original measurement in the first stage of the transaction is to be used.

If the requested check relates to value or net quantity, the following applies:

1. If the original measurement concerned timber loaded on a vehicle, the checked timber unit is the entire load or, in co-loading, the part of the load that comes from one supplier (*one* assortment, usually identified through *one* delivery-ID number, called the delivery).
2. In co-loading, part of the split stack or split loose volume is excluded from the checked timber unit.

If the transporter has requested a check of data used to determine transport payment, the measurement check concerns gross quantity, and the checked timber unit is the entire vehicle load.

The measuring company must have procedures in place to conduct requested checks of the measurement assignments it has undertaken. When a check is requested and performed prior to the original measurement (advance check), the measuring company and the

[5] Contractors who carry out harvesting and/or forwarding.
[6] Net quantity = Gross quantity – (rejects + deductions).

requesting party must work actively to ensure that the measurement official conducting the original measurement is unaware of the advance check request before the original measurement is completed.

One condition for a measurement check is that the timber is accessible for measurement and kept separate from other timber. A request for a check is submitted to the measuring company. The request must show who has requested the check and the load or consignment to which the check applies. If the timber is measured at a mill or under equivalent conditions (e.g. delivery check for subsequent photo-based measurement), the check must be requested before the timber is unloaded. The timber must be unloaded at or adjacent to the delivery point. From the time of the request for a check until the timber is unloaded, the timber (vehicle) must be kept under the surveillance of the measuring company.

The request for a measurement check is submitted to the authorised measuring company, which administers the check. This involves appointing the check scaler, analysing the results, and forwarding these to the parties concerned. After the requested check has been conducted, the authorised measuring company informs Biometria of the outcome.

Generally, for roundwood in a conversion population[7], a check can only be requested and conducted on scaling performed in the first stage (the simple measurement). For conversion populations where gross and net conversion figures are established in advance, the check can apply to both quantity and value. For conversion populations where the value is not established until measurements for the conversion population are completed, the check will only apply to quantity.

The above paragraph does not mean that only transporters and logging contractors can request a check; all relevant parties can request a check even if the check only applies to quantity.

3.9.2 Procedure

In a measurement check, the quantity and quality of the timber is to be assessed in its existing condition. Changes in timber properties considered to have occurred after the original measurement must be stated in the results report.

Parties affected by the requested check may attend the proceedings, in normal cases one person per party. The measuring company informs the parties involved as soon as possible about the time and place of the measurement check. The methods for checking stated in the relevant measurement instruction are to be applied.

In the check, the same measurement unit as in the original scale must be used. For example, stack-measured saw timber/standard length measured in m^3sub, should be top-/butt-measured to obtain a comparable volume. Conversion figures may not be used in a requested measurement check.

The following sections describe how the requested check is to be performed for the methods used for original scales as shown in table 2 in Section 3.9.3.

[7] Roundwood that, after harvest, is measured using a sample is regarded as a conversion population.

Check of log-by-log measurement or stack measurement (A-B in table 2)
Log-by-log or stack measurements are checked through log-by-log measurement. A requested check is performed by two check scalers working in collaboration. The principal check scaler must be from another part of the measuring company (or other authorised measuring company) and is appointed by the measuring company. The second check scaler will normally be the local check scaler, who ensures that any site-specific regulations are applied.

For timber that is sorted in connection with log-by-log measurement (the most common procedure at sawmills), the requested check must be conducted as advance measurement.

In checks of stack measurement, the stacks must be kept separate so that analyses can be performed both per stack and totalled for the consignment. For requested checks in post-measurement in conjunction with photo-based measurement. the request must be submitted before delivery or in connection with the delivery check. In this case, instructions relating to advance check in Section 3.9.1 apply.

Weighing of consignment, raw weight (C in table 2)
A requested check must concern the entire vehicle, i.e. there must only be one consignment on the vehicle. A check may be requested either after a load weight has been recorded or in the form of an advance check. A check may be requested even when the unladen weight of the vehicle is established through random weighing. Check weighing must take place on a weighbridge operated in accordance with *Guidelines for Checks and Maintenance of Static Weighbridges*, and that is placed in immediate proximity to the weighbridge on which the weighing that will form the basis of a commercial transaction takes place. No reloading is permitted between the weighing procedures.

In an advance check, the check scaler must participate. A check that is requested after the weighing that formed the basis of a commercial transaction has taken place may be performed by officials from the measuring company. The measuring company decides, in consultation with the measurement site manager, whether the requested check has been performed in accordance with given conditions.

Assessment of dry content of comminuted material (D in table 2)
A requested check of dry content assessment of cellulose chips involves taking new dry content samples. The request can concern 1) checks requested in advance of measurement[8], 2) requests made directly after the original measurement.

1) In the case of check requested in advance, the scaler (as usual) must not be aware of the request for the check. In such cases, a check scaler takes the samples for checking after the normal sampling.

2) When a request for a check is made immediately after the original measurement, the check samples may be taken by the scaler who, manually or using mechanical equipment, conducted the original measurement. This is only on condition that the scaler who conducted the original measurement is familiar with the procedure regarding requested checks. In this form of requested check, the raw weights of the samples must be sent to the measuring company together with the request for a check.

[8] At least one week in advance.

The requested check must comprise ten separate samples taken systematically and representing the entire consignment. In normal cases, the samples may be taken out of a pile tipped from a vehicle.

The dry content of the samples must be assessed separately using a drying cabinet. The dry weight of the material must be determined by the check scaler immediately after the samples have been taken. In conjunction with the weighing, the check scaler must compile the previous month's results from daily inspection of the drying cabinet in question, and include these in the report to the measuring company. Dry content is calculated as the arithmetic average of the check samples. Weights deriving from laboratory scales are to be shown to at least one decimal place.

The weight of the original measurement for the consignment is used to determine the consignment quantity, and to determine the payment obligation according to Table 2.

Fraction determination/screening (E in table 2)
Fraction determination/screening is a type of grading of comminuted material, such as cellulose chips. A requested check is performed as a new analysis of removed samples. Biometria's *Kvalitetsbestämning av cellulosaflis* stipulates how long screened samples must be stored in a sealed plastic bag or a bucket with a tightly sealing lid. In screening, removed bark and rotted wood must be stored in special plastic bags together with the sample. After a request for a check of screening, the check must be conducted as soon as possible, to minimise changes in the sample caused by drying, and because of the risk of growth of harmful mould. The sample in question is to be sent to the measuring company's reference screen, and must be screened by the official who operates the reference screen. Weights deriving from laboratory scales are to be shown to at least one decimal place.

Measurement refusal (F in table 2)
A requested check of a measurement refusal may concern, for example, a consignment of saw logs. The timber in question may then be unloaded at the measurement site/delivery terminal, so that the check scaler can inspect/measure the timber. If measurement refusal concerns freshness/blue stain, the inspection must take place within 48 hours, with the inspection confined to the timber that is the subject of the measurement refusal. In normal cases, a consignment with a different reason for measurement refusal must be checked by two check scalers. Photos of the timber ('timber unit') must be recorded.

3.9.3 Adjustment of measurement results and payment of costs

The result of the check is to be reported to the parties concerned, in a way that clearly shows the difference between original measurement and check measurement. The result of the check measurement will apply, regardless of the scale of deviation from the original measurement, and regardless of the grounds for the requested check[9]. This principle also applies when the check concerns a sample unit.

If the difference (+/-) between the results[10] according to the original measurement and the check measurement, expressed as a percentage of the check measurement, is less than the percentage figures given below for each measurement method, the party requesting the check will pay some of the cost of the check, according to the amount shown on the website

[9] In cases of, for example, measurement refusal, deviations from this may be needed.
[10] Results are shown as a percentage to one decimal place, and rounded according to Swedish Standard, rule A.

of the measuring company. If the deviation is equal to or greater than the percentage figures stated, the entire cost of the check measurement is to be paid by the measuring company. In cases where the check takes place at a terminal or close to a mill or plant, the buyer pays any costs relating to placing of timber, etc.[11]

Table 2. Limits for payment obligation for requested check

		Limits for payment obligation, % of		
	Method used in original measurement	**Gross quantity**	**Net quantity**	**Value**
A	**Log-by-log measurement**	3	4	5
B	**Stack measurement[1)]**	5	6[2]	7
C	**Weighed consignment, raw weight**	1	----	1
D	**Weighing, dry content (assessment of DC of cellulose chips)**	3	----	4
E	**Fraction determination/screening**	----	----	Correct reject[3]
F	**Measurement refusal**	----	----	Correct measurement refusal[4]

[1)] Here, stack measurement includes the methods and combinations of methods used to determine the solid volume of roundwood in stacks.
[2)] In quality grading, with no rejects extracted, the 5% limit applies.
[3)] If the request does not concern rejects, the limit is 2%.
[4)] Correct measurement refusal of all the stacks in the requested check.

For other methods, the limit for payment obligation will be one standard deviation according to the expected precision of the measurement, in terms of the quantity that the requested check concerns. In accordance with this, the authorised measuring company sets the limits that will apply. Where the measurement concerns value, two percentage points are added to the limit stated for the gross quantity.

The limit for payment obligation depends on the subject of the requested check (gross quantity, net quantity, value, reject, or measurement refusal).

3.10 Requested remeasurement using photos

3.10.1 Background

An authorised measuring company that conducts remote measurement using photos must offer and conduct requested remeasurement of stacks in photos. The procedure must be conducted as follows.

The purpose of a requested remeasurement of stacks using photos (hereinafter “requested remeasurement in photos”) is to serve as a complaint regarding an original measurement.

[11] In cases where advance checks are performed in conjunction with felling in the forest, the seller/requesting party pays any costs for placing timber, etc.

Requested remeasurement using photos is a complement to a requested check of a photo-based measurement (see section 3.9) and has certain similarities to a requested check.

A requested remeasurement can only apply to stack measurement performed at a measurement site with remote measurement equipment. All parties affected by the results of an original measurement (where a requested check has not been conducted) may subsequently submit a request for remeasurement using photos at the measuring company. The person requesting the remeasurement must state their role (supplier, seller, buyer, transporter, or harvesting contractor[12]) in the contract to which the remeasurement applies. The party submitting the request must also state the basis for the requested remeasurement (gross quantity, net quantity[13], timber value, or measurement refusal).

The request is submitted to the measuring company that performs the remeasurement using photos. The work also includes appointing the check scaler, inviting concerned parties, compiling the results, and forwarding these to the parties involved. The authorised measuring company provides a template for requesting a remeasurement. A request for remeasurement must be received no later than 45 days from the date of the original measurement.

When determining value, the price list applying for the original measurement in the first stage of the transaction is to be used.

If the requested remeasurement concerns value or net quantity, the following applies:

- If the original measurement concerned timber loaded on a vehicle, the checked timber unit is the entire load or, in co-loading, the part of the load that comes from one supplier (*one* assortment, usually identified through *one* delivery-ID, called the delivery).
- The consignment must comprise at least two whole stacks. However, if the requested remeasurement using photos relates to a measurement refusal, this may be applied to a single stack.
- In co-loading, part of the split stack or split loose volume is excluded from the checked timber unit.[14]

If the transporter has requested a remeasurement of data used for transport payment, the remeasurement relates to gross quantity and the entire vehicle load is remeasured.

For timber in a conversion population, the same conditions apply as described in Section 3.9.1.

3.10.2 Procedure

A requested remeasurement is conducted by three other scalers with good experience of the same measurement conditions (assortment, measurement equipment, and timber origin). The scalers measure the relevant stacks in the stored photos. This is done with no knowledge of the result of the original measurement. Extra care should be taken to check other factors that could influence the measurement, such as calibration settings and the recorded bank

[12] Contractors who carry out harvesting and/or forwarding.
[13] Net quantity = Gross quantity – (rejects + deductions).
[14] If the consignment does not satisfy points 2 and 3, and a party considers that clear mistakes have been made in the measurement using photos, the District Manager is contacted. The DM then ensures that an experienced quality manager investigates the photos to check that no clear mistakes have been made.

width. The result comprises the average of the three remeasurements. Where applicable, the same gross and net conversion figures should be used in requested remeasurement as in the original measurement. The measuring company appoints the scalers and immediately informs the parties concerned about the time and place of the remeasurement.

In cases where the solid volume was determined in the original measurement using approved automatic measurement equipment (e.g. laser or camera technology), the scalers remeasuring the timber may use the automatically generated solid volume and input measurement data. They should then apply that information when remeasuring the timber using photos. In cases where their assessment[15] is that the volume as shown by the original measurement deviates greatly from the volume measured using a photo, the scalers are also to measure the volume. In other cases, the scalers only reassess the quality.

3.10.3 Adjustment of measurement results and costs relating to remeasurement

The result of the remeasurement is to be reported to the parties concerned, in a way that clearly shows the difference between the original measurement and remeasurement. The result of the remeasurement will apply, regardless of the scale of deviation from the original measurement, and regardless of the grounds for the requested remeasurement.

If the difference (+/-) between the results[16] of the original measurement and the remeasurement, expressed as a percentage of the remeasurement result, is less than the percentage figures given below, the party requesting the remeasurement will pay part of the cost of this, according to the amount shown on the website of the measuring company. If the deviation for the subject of the request is equal to or greater than the percentage figures stated, the entire cost of the remeasurement is to be paid by the measuring company.

Table 3. Limits for payment obligation for requested check using photos.

Method used in original measurement	**Limit for payment obligation, % of**		
	Gross quantity	**Net quantity**	**Value**
Stack measurement[1)]	6	7	8
Measurement refusal	----	----	Correct measurement refusal[2]

1) Here, stack measurement includes the methods and combinations of methods used to determine the solid volume of roundwood in stacks.
2) Correct measurement refusal of all the stacks in the requested remeasurement.

Limits for payment obligation depend on the subject of the remeasurement (gross quantity, net quantity, value, reject, or measurement refusal).

[15] According to the same procedures as those used in the original measurement, to determine whether an override (an adjustment of the original automatic measurement) is to be performed.
[16] Results are shown as a percentage to one decimal place, and rounded according to Swedish Standard, rule A.

4 Assessment of measurement quality of authorised measuring companies

At the authorised measuring company level, requirements regarding quality in timber measurement are set by the board of each authorised measuring company. These are based on the measuring company satisfying Biometria's requirements according to this document. This section concerns log-by-log and stack measurement of pulpwood.

4.1 Aim and minimum levels

This section describes how Biometria assesses measurement quality of authorised measuring companies. The section does not consider all follow-ups conducted by Biometria, and only focuses on follow-up concerning deviations in check results at company and measurement site level. Biometria may also monitor new or particularly interesting measurement methods. It is also important to emphasise that the measuring company is always responsible for the quality of timber measurement.

In this section, the minimum requirement levels are established that apply to systematic deviations and variation (standard deviation) that Biometria uses in review and assessment of quality of timber measurement. Biometria also assesses how well the authorised measuring company meets the minimum requirement levels set out in the section 'Standards for checking timber measurement and reporting' in terms of the minimum permitted number of timber units for checking (30).

4.2 Measurement quality and deviations

In Biometria authorisation, deviations are graded as *minor*, *major* and *exceptional*. If a deviation is not rectified within one year, the deviation is normally upgraded one level. Exceptional deviations are described in Section 4.4 together with the possibility of withdrawn authorisation.

Deviations in measurement quality are often caused by factors that can take time to change, such as the ability of the log scaler and other measurement officials to correctly apply applicable measurement instructions and the technical conditions at the measurement sites. There can also be variation over the year, depending on, for example, differences in wood properties, so assessments of measurement quality for this purpose should primarily cover 12 months.

4.3 Biometria's assessment of timber measurement quality

When Biometria finds abnormal deviations in measurement quality at the authorised measuring companies, a letter is sent to the authorised measuring company in question requesting an analysis of causes and an action plan. 'Abnormal' deviation at measurement site level varies not just with the measurement method but also with assortment, properties of the raw material, etc.

In the assessment, the statistical reliability in the check data must also be considered. These factors mean that limit values for *minor*, *major* and *exceptional* deviations are applied with a

certain flexibility. Depending on the statistical base and other circumstances, Biometria/RMR can adjust the assessment of the deviation.

In assessment of quality in timber measurement, two levels are used: measuring company and measurement site. In both cases, the quality is assessed per group assortment, i.e. normally softwood, birch, and aspen pulpwood. Reports are submitted to Biometria annually in accordance with *Standard Procedures for Checking Timber Measurements and Timber Reporting* and no later than 14 February.

4.3.1 Authorised measuring company level

Requirements

At the authorised measuring company level, the following limits apply.

Table 4. Measuring company level per group assortment: systematic deviations permitted between original measurement and check/detailed measurement. Stack measurement refers only to physical measurement of the stack, i.e. not a measurement obtained through a check population. Where a check population is used, the log-by-log measurement stage is assessed.[17]

	Pulpwood	
	Log-by-log measurement of check and sample stacks	**Stack measurement**
Gross volume deviation	± 1.5 %	± 2.0 %
Value deviation	± 2.5 %	± 3.0 %

Table 5. Measuring company level and group assortment: variation (standard deviations) between original measurement and check/detailed measurement. Stack measurement refers only to physical measurement of the stack, i.e. not a measurement obtained through a check population. Where a check population is used, the log-by-log measurement stage is assessed.

		Pulpwood	
Variation gross volume	**Group assortment**	**Log-by-log measurement**	**Stack measurement**
	All	± 12.0 %	
	Softwood		± 8.0 %
	Spruce		± 8.0 %
	Birch		± 9.0 %
	Aspen		± 9.0 %

Deviations

A deviation in which a limit is exceeded by more than 0.5 percentage points for systematic deviation and 1.0 percentage points for variation and confidence interval is regarded as a major deviation; other deviations are regarded as minor. When a limit is exceeded, the measuring company is required to submit an analysis of causes and a rectification plan. When requirement limits are exceeded, a report of the check result is to be submitted to Biometria after six months.

[17] Limits will soon also be established for total systematic deviation (stack measurement stage + log-by-log measurement stage).

If a minor deviation is repeated in the subsequent year's report, it is upgraded to a major deviation. Deviations denoted as major must be rectified within one year, i.e. before the subsequent year's report to Biometria. If this is not done, the deviation is upgraded to exceptional. See Section 4.4.

4.3.2 Measurement site level

Requirements

At the level of measurement site, the following limits apply.

Table 2. Measurement site level and group assortment: systematic deviations between ordinary measurement and check/detailed measurement. Stack measurement refers only to physical measurement of the stack, i.e. not a measurement obtained through a check population. Where a check population is used, the log-by-log measurement stage is assessed.

	Pulpwood	
	Log-by-log measurement of check and sample stacks	**Stack measurement**
Gross volume deviation	± 2.0 %	± 2.5 %
Value deviation	± 3.0 %	± 5.0 %

Table 3. Measurement site level and group assortment: variation (standard deviation) between ordinary measurement and check/detailed measurement. Stack measurement refers only to physical measurement of the stack, i.e. not a measurement obtained through a check population. Where a check population is used, the log-by-log measurement stage is assessed.

		Pulpwood	
Variation gross volume	**Group assortment**	**Log-by-log measurement**	**Stack measurement**
	All	± 12.0 %	
	Softwood		± 8.0 %
	Spruce		± 8.0 %
	Birch		± 9.0 %
	Aspen		± 9.0 %

Deviations

For volume, a major deviation is when a limit is exceeded by more than 0.5 percentage points in terms of systematic deviation, and 1.0 percentage points for variation and confidence interval; smaller deviations are regarded as minor. The corresponding limit for value deviation is 1.0 percentage points. When a limit is exceeded, the authorised measuring company is required to submit an analysis of causes and a rectification plan. For measurement sites where requirement levels are exceeded, a follow-up report showing the check results is to be submitted to Biometria after six months.

If a minor deviation remains in the subsequent year's report, it is upgraded to a major deviation. Deviations denoted as major must be rectified within one year, i.e. before the subsequent year's report to Biometria. If this is not done, the deviation is upgraded to exceptional. See Section 4.4.

4.4 Exceptional deviation / Withdrawal of authorisation

According to handling of deviations as described in Section 4.3.1 at authorised measuring company level, and Section 4.3.2 at measurement site level, a deviation can be upgraded to exceptional.

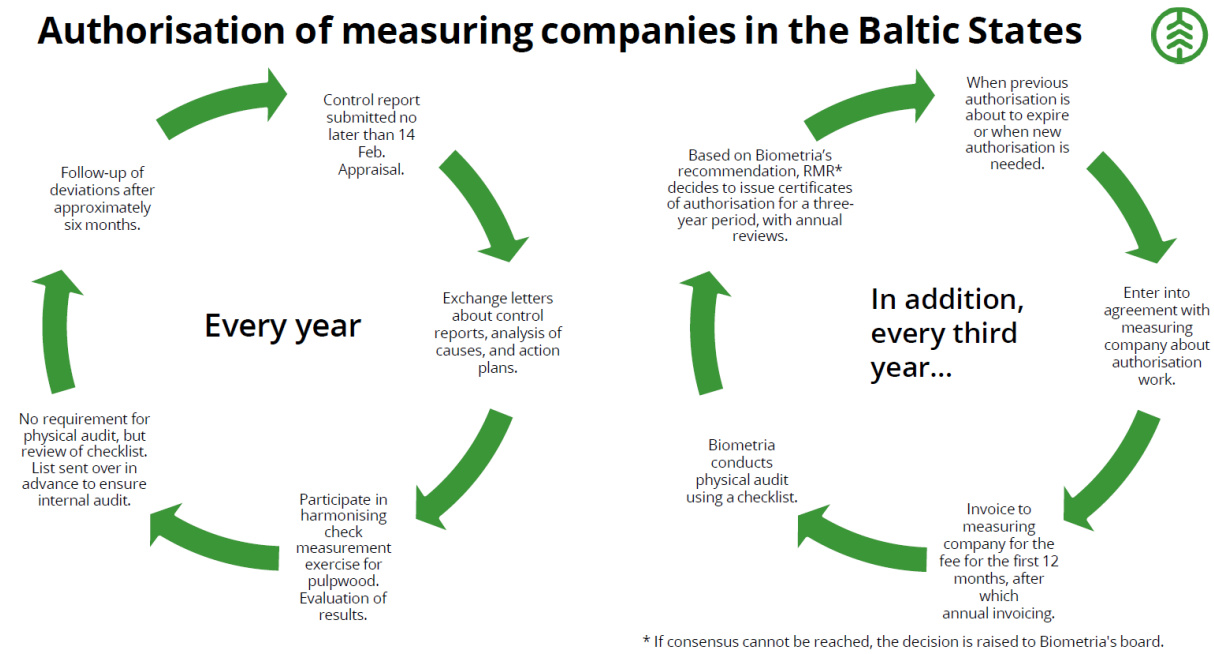
When a deviation has been upgraded to exceptional, Biometria may require that the CEO of the authorised measuring company reports to RMR, physically or via Teams, to explain the circumstances and measures taken.

If the measures are deemed insufficient, Biometria may withdraw the authorisation of the measuring company.

5 Revision history

Date	Description
11 August 2022	The document derives from three previous VMK documents, and was drawn up in connection with the merger between VMK and Biometria. The three VMK documents that are being replaced are *Standard Procedures for Checking Timber Measurements and Timber Reporting*, *Guidelines for Authorisation of Timber Measuring Companies*, and *Guidelines for VMK Assessment of Quality of Timber Measurement by VMK-Authorised Measuring Companies*. Adopted by a working group from RMR.
1 January 2023	Section 3.5.5. Data for assessment added. Standard error replaced with confidence interval. Section 3.10.1. Reporting date changed to measurement date. Section 3.10.2. Clarification of procedure for requested remeasurement of stacks using photos for cases where the volumes in the original measurement were determined using approved automatic measurement equipment. Section 4. Requirements for measurement quality for softwood sawlogs, energy wood, and cellulose chips removed. Requirements for pulpwood changed in conjunction with the merger between VMK and Biometria on 3 June 2022. The limits are now shown per group assortment. Adopted by RMR on 23 November 2022.
1 January 2024	Chapter 1. Clarification that the English version is the one that applies. Section 3.10.1. Clarification. Footnote 13 added. Appendix 1. Added.
1 January 2025	Section 3.1.1. Clarification that an actor can only request checks and remeasurement if they are affected by the consignment. Section 3.2 added, on traceability. Section 3.5.3. Clarification regarding check population. Section 3.8.2. Reporting of accuracy percentage removed.
1 January 2026	Section 3.9.1 and 3.10.1. Adaptation to VIOL 3: *reporting number* replaced by *delivery-ID*. Section 4.3. Table 5, 6 and 7, slightly stricter requirements for gross volume deviations. The new requirements are adapted from changes in "Biometrias kontroll av virkesmätning", which were established by Biometria's board on 11 December 2025. Footnotes 9 and 15. Changed rounding principle from Swedish standard rule B to rule A. Appendix 2. Calculation of results during check measurement. Slightly supplemented.

Appendix 1. Description of authorisation process for timber measurement companies



The governing document for authorisation of measuring companies in the Baltics is "Biometria's authorisation of timber measuring companies", The document is adopted by RMR or parts thereof.

Appendix 2. Calculating results in measurement checks

In this appendix, statistical concepts are described, along with how they are used in measurement checks of timber to show the degree of correspondence between the results of original measurements and check measurements. Results of a measurement can concern both quantity and value. The statistical description is for a *check population*, i.e. usually the measurement of an assortment using a specific measurement method at each individual measurement site or group of sites.

To describe the results for a check population, randomly selected *timber units* are checked, such as sawlogs, pulpwood stacks, or bushels. These form the basis of calculations of systematic deviation, for example, for volume and value, and a standard error that shows how accurately the systematic deviation can be calculated. If these timber units are selected in different ways within a check population (such as different sampling frequencies), the results must be weighted to correctly represent the entire check population.

Quantity, value, and quality value of individual timber units

Quantity
Calculation of the timber unit's **gross and net quantity** is described in the Swedish measurement regulations (www.biometria.se). Principles regarding measurement methods and measurement units are described in Section 3.4.2.

Value
The **value** of the timber unit is calculated as net volume multiplied by a relative price. This price is obtained from a relative pricelist, which is an average of pricelists from major Swedish actors in the past three years. For example, pine sawlogs, Quality Class 3, with a top diameter of 220-239 mm, have a value of 100 in the relative pricelist. All other diameter classes and quality classes are then related to this class (table 4). 'Diameter' is the top diameter of the log after any diameter deduction. Relative prices of other assortment categories are obtained in the same way.

Table 4. Example of relative pricelist for pine sawlogs. A log with a top diameter of 225 mm and Quality Class 3, with a diameter deduction of 10 mm, has a value of 97.

	Smallest diameter in the class interval (mm)																
Qual. class	< 140	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440+
1	79	93	103	114	133	143	151	158	163	165	165	165	161	161	168	168	168
2	75	90	96	101	103	104	106	110	112	115	117	119	109	109	115	115	115
3	68	79	84	93	97	100	102	105	106	108	109	110	105	105	108	108	108
4	62	74	74	75	76	76	76	76	77	77	77	77	73	73	76	76	76
0	69	80	86	95	99	102	104	107	108	110	112	112	107	107	110	110	110
9	35																

Quality value
The ***quality value***[18] of the timber unit is its value without considering any errors in measurements of quantity. For sawlogs, this means that the quality value is determined on the basis of the log diameter and length in the original scale. Any diameter deduction is

[18] Previously called treatment value or quality determination value.

regarded as an assessment of quality, so the net volume used in calculating the quality value may still differ between the original measurement and the check measurement. In stack measurement, the original measurement for gross volume is used, but the proportion of rejects and products in each measurement is applied.

NB.

1. The quality value for the original measurement is the same as its value.
2. The principles for calculating quantity (gross and net) and value are the same as in original measurement.

Example. Pine sawlogs
Pine sawlogs with a price on the relative pricelist according to table 4. Log dimensions, quality assessment and calculated volume are shown in the table below.

Parameter	Parameter	Original measurement	Check measurement
Log dimensions	Length (cm)	460	460
	Diameter (mm)	225	227
Quality assessment	Diameter deduction (mm)	0	10
	Quality class (product)	Class 4	Class 3
Volume used for calculating value (m^3 by top measurement)	Gross volume	0.183	0.188
	Deduction volume	0.000	0.016
	Net volume	0.183	0.172
Volume used in calculating quality value (m^3 by top measurement)	Gross volume	0.183	0.183
	Deduction volume	0.000	0.016
	Net volume	0.183	0.167

Original measurement:
$Value = 0.183 \cdot 76 = 13.908$
$Quality\ value = 0.183 \cdot 76 = 13.908$
The log value and quality value in the original measurement is 13.908.

Check measurement:
$Value = 0.172 \cdot 97 = 16.684$
$Quality\ value = 0.167 \cdot 97 = 16.199$

The log value in the check measurement is 16.68 and the quality value is 16.20.

Example. Deciduous pulpwood[19]

Stack of deciduous pulpwood with estimated species distribution. Relative prices are birch 100, aspen 75, and other deciduous species 40. Rejects have a relative price of zero (=0).

Parameter	Parameter	Original measurement	Check measurement
Species distribution (%)	Birch	50	55
	Aspen	30	32
	Other deciduous	20	13
Rejects (%)	Rejects	3	5
Volume used for calculating value (m^3sub)	Gross volume	14.00	14.50
	Reject volume	0.42	0.725
	Net volume	13.58	13.775
Volume used for calculating quality value (m^3sub)	Gross volume	14.00	14.00
	Reject volume	0.42	0.725
	Net volume	13.58	13.275

Original measurement:

$$Value = \frac{50}{100} \cdot 13.58 \cdot 100 + \frac{30}{100} \cdot 13.58 \cdot 75 + \frac{20}{100} \cdot 13.58 \cdot 40 = 1093.19$$

$$Quality\ value = \frac{50}{100} \cdot 13.58 \cdot 100 + \frac{30}{100} \cdot 13.58 \cdot 75 + \frac{20}{100} \cdot 13.58 \cdot 40 = 1093.19$$

The value and quality value of the stack is 1093.19.

Check measurement:

$$Value = \frac{55}{100} \cdot 13.775 \cdot 100 + \frac{32}{100} \cdot 13.775 \cdot 75 + \frac{13}{100} \cdot 13.775 \cdot 40 = 1159.855$$

$$Quality\ value = \frac{55}{100} \cdot 13.275 \cdot 100 + \frac{32}{100} \cdot 13.275 \cdot 75 + \frac{13}{100} \cdot 13.27 \cdot 40 = 1117.755$$

The stack value in the check measurement is 1159.855 and its quality value is 1117.755.

Check results for quantity and value

In calculations of check results, systematic deviation and its reliability (standard error and/or confidence interval), and standard deviation for the deviations are obtained for gross quantity, net quantity, value, and quality value The principles for calculating these results are the same, regardless of the measurement unit.

Terms and general formulas (not used for conversion populations)

Information about the timber unit	Function
y_i	Result of original measurement for timber unit i
x_i	Result of check measurement for timber unit i

[19] Calculation of value and quality value for stacks where the distribution of, for example, species or dimensions forms the basis of payment will be introduced when the appropriate IT support has been developed.

Δ_i	Deviation between the two results for timber unit i	$y_i - x_i$
n	Number of timber units	

Data calculations		**Function**
Sy_i	Total of the results of original measurement of timber unit, where i = 1 to i = n.	$y_1 + y_2 + \ldots + y_n$
Sx_i	Total of the results of check measurement of timber unit, where i = 1 to i = n.	$x_1 + x_2 + \ldots + x_n$
K	Control ratio based on totals of the results	$\frac{\sum y_i}{\sum x_i}$
$\bar{y}$	Average of results in original measurement	$\frac{\sum y_i}{n}$
$\bar{x}$	Average of results in check measurement	$\frac{\sum x_i}{n}$
$\bar{\Delta}$	Systematic deviation in absolute figures	$\frac{\sum \Delta_i}{n}$
t	t-value for a 95% confidence interval	*Can be retrieved from table. t = 2.00 if n = 60 and t = 1.96 if n = ∞*

Calculated check results		**Function**
$\bar{\Delta}_r$	Systematic deviation in original measurement in relation to check measurement (%)	$100 \cdot (K - 1) = 100 \cdot \frac{\bar{\Delta}}{\bar{x}}$
s	Standard deviation for the deviations between original measurement and check measurement in absolute figures[20]	$\sqrt{\frac{1}{n-1}\sum(\Delta_i - \bar{\Delta})^2}$
s_r	Relative standard deviation (coefficient of variation) for the deviations between original measurement and check measurement (%)21	$\frac{100 \cdot \sqrt{\frac{1}{n-1}\sum(\Delta_i - \bar{\Delta})^2}}{\bar{x}}$

[20] To simplify the calculations, the formula can also be expressed in summarised form:

$$s = \sqrt{\frac{1}{n-1}\left(\sum \Delta_i^2 - \frac{(\sum \Delta_i)^2}{n}\right)}$$

[21] To simplify the calculations, the formula can also be expressed in summarised form:

$$s_r = 100 \cdot \frac{\sqrt{\frac{1}{n-1}\left(\sum \Delta_i^2 - \frac{(\sum \Delta_i)^2}{n}\right)}}{\frac{\sum x_i}{n}}$$

e	Standard error for systematic deviation in absolute figures	$\frac{s}{\sqrt{n}}$
e_r	Relative standard error for systematic deviation (%)	$\frac{s_r}{\sqrt{n}}$
Confidence interval (95%)	95% confidence interval for systematic deviation in absolute figures	$t \cdot \frac{s}{\sqrt{n}} = t \cdot \varepsilon$
Confidence interval (95%)$_r$	95% confidence interval for systematic deviation as a percentage of the result of check scale	$t \cdot \frac{s_r}{\sqrt{n}} = t \cdot \varepsilon_r$

Systematic deviation and standard deviation
In the work to improve the accuracy of timber measurement, the aim is both low systematic deviation and low standard deviation. A systematic deviation may be corrected, which is the aim of the check measurement. Later correction of a high standard deviation is not possible (figure 1).

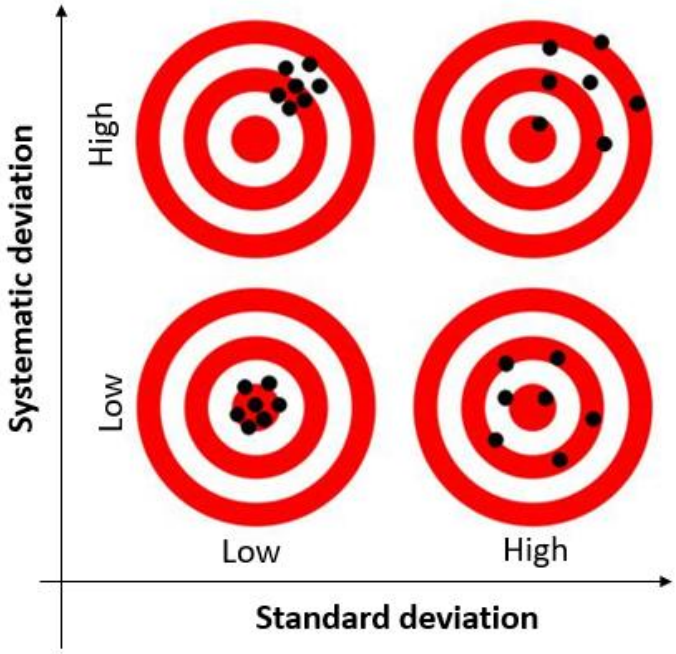


Figure 1. A high level of accuracy means both low systematic deviation and low standard deviation.

Until December 2018, a more complicated formula was used for standard deviation, based on ratio estimation. In principle, the standard deviation (and coefficient of variation) was then calculated for the deviations between the results in the original measurement (y_i) and the results in the check measurement, multiplied by the control ratio ($K \cdot x_i$), i.e. $y_i - K \cdot x_i$ (compare with $y_i - x_i$ in the table above). The more complicated function may be used in current versions of Biometria's system for following up checks, but the new function will be incorporated in VIOL 3 and in future check monitoring tools. The difference in results for the standard deviation is small or negligible, and can therefore continue to be used in comparisons over time, i.e. older results do not need to be recalculated.

Standard deviation, based on ratio estimation, has been described in many different ways (see earlier versions of this statistical appendix and the Sample System from SDC, 2015). In Orvér's report on sample measurement, it is termed ratio variation (Orvér 2002). The function can be written as:

$$s_r = \frac{100 \cdot \sqrt{\frac{1}{n-1}\sum\left(y_i - x_i \cdot \frac{\bar{y}}{\bar{x}}\right)^2}}{\bar{x}}$$

This can also be written in summarised form:

$$s_r = 100 \cdot \frac{\sqrt{\frac{1}{n-1}\left(\sum y_i^2 - 2 \cdot \frac{\sum y_i}{\sum x_i} \cdot \sum(x_i \cdot y_i) + \left(\frac{\sum y_i}{\sum x_i}\right)^2 \cdot \sum x_i^2\right)}}{\frac{\sum x_i}{n}}$$

The above standard deviation should *not* be confused with a standard deviation calculated from ratios for each timber unit measured. Ratio-based standard deviation should not be used in follow-up of checks, since the ratios calculated from individual timber units may not be normally distributed

Reliability in systematic deviation (standard error and confidence interval)
Using standard deviation, the reliability of the systematic deviation can be calculated through the standard error or confidence interval. Both are a measure of the reliability of a mean value that has been calculated from a sample.

For a population with a normal distribution, the population's true mean value will be, with 68% probability, within ±1 standard errors. This means that the true mean value will be obtained 68 times in every 100 samples.

With a 95% confidence interval, the population's true mean value will be, with 95% probability, within ±1 confidence interval. For a sample with many sample units, the standard error is approximately doubled (±2 standard errors). If a more reliable confidence interval is desirable, a 99% confidence interval can be calculated: this is 2.5 times the standard error.

The more timber units in the sample, and the smaller the standard deviation, the smaller the standard error and confidence interval, giving a more reliable calculation of the systematic deviation.

If, instead, the relative standard deviation is used, the relative standard error or a relative confidence interval can be calculated using the same principles.

Normal distribution
When calculating check results for populations, the confidence interval and normal distribution are important concepts. The deviations in quantity and value that are calculated in timber measurement normally have a normal distribution. This means that most deviations are found close to the systematic deviation and become more uncommon the greater the deviation. The distribution is bell-shaped, and 68% of the deviations are expected to lie within ±1 standard deviations (figure 2).

The probability of the true systematic deviation compared with that estimated from a sample is distributed in a similar way (figure 2). The true deviation, with 68% probability, is expected to be within ±1 standard errors, and with 95% probability within ±2 standard errors.

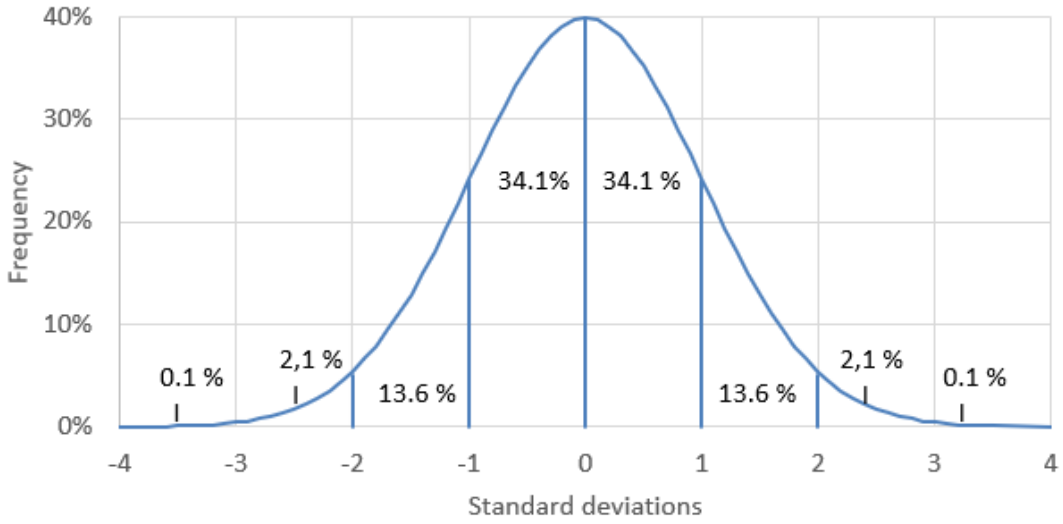


Figure 2. Distribution of a normally distributed population with a mean value of 0 and standard deviation of 1. The probability of the true systematic deviation when the calculated systematic deviation is 0 and has a standard error of 1.

Terms and general formulas used for conversion populations

In measurements of conversion populations, samples are taken for accurate measurement in one or more stages. The systematic deviation is then calculated in relation to population conversion and results from all stages in the original measurement and in the check measurement. In addition, systematic deviation, standard deviation and standard error are calculated for each measurement stage separately compared with the subsequent measurement stage. Calculation and evaluation of this method will be possible when IT support has been developed, probably when VIOL 3 is introduced.

Table 5. Example of measurements of conversion population where samples are extracted for detailed measurement in one stage (Example 1) and in two stages (Example 2).

Type of measurement	**Selection**	**Example 1**		**Example 2**	
		Measurement stage (*j*)	**Measurement**	**Measurement stage (*j*)**	**Measurement**
Original measurement	Entire population	1	Stack measurement	1	Estimation of stacks
Original measurement	Sample 1	2	Log-by-log measurement of sample stacks	2	Stack measurement of sample stacks
Original measurement	Sample 2	-	-	3	Log-by-log measurement of sample stacks

Check measurement	Check sample	3	Measurement of check log	4	Measurement of check log

Check results for the final stage in original measurement, i.e. stage 2 for example 1 and stage 3 for example 2 in the table above, are calculated in the same way as in the previous section (7.3.1). The principle for calculating systematic deviation for the other stages in the original measurement is similar, and is described below. Note that measurement in a preceding stage in original measurement is called *simple measurement*, while the subsequent measurement is called *detailed measurement*.

Input data for sample units		**Function**
q_i	Result of simple measurement for measurement stage j for sample timber unit i. Result converted to population is used for the first measurement stage (j = 1)[22]	
z_i	Result of detailed measurement of subsequent measurement stage (j + 1) for sample timber unit i	
Δ_j	Deviation between results of simple measurement and detailed measurement in subsequent measurement stage for sample timber unit i	$q_i - z_i$
n	Number of sample timber units	

Data calculations		**Function**
Sq_i	Total of results of simple measurement for measurement stage j of sample timber unit i, where i = 1 to i = n	$q_1 + q_2 + \ldots + q_n$
Sz_i	Total of results of detailed measurement in subsequent measurement stage (j + 1) for sample timber unit i where i = 1 to i = n.	$z_1 + z_2 + \ldots + z_n$
K_j	Control ratio for measurement stage j	$\frac{\sum q_i}{\sum z_i}$
$\bar{q}_j$	Mean result of simple measurement for measurement stage j	$\frac{\sum q_i}{n}$
$\bar{z}$	Mean result of detailed measurement for subsequent measurement stage (j + 1)	$\frac{\sum z_i}{n}$

[22] When calculating systematic deviation, standard deviation and standard error for individual stages for some other purpose than following up measurement of a population, the measurement result without correction for the population may have to be used. This is appropriate, for example, when the stack measurement of the original scaler is to be checked through detailed measurement of stacks whose logs are individually measured.

$\overline{\Delta}_j$	Systematic deviation in absolute figures for measurement stage *j*	$\frac{\sum \Delta_i}{n}$
t	t-value for a 95% confidence interval	*Can be taken from table. t=2.00 if n=60 and t=1.96 if n=∞*

Calculated check results		**Function**
$\Delta_{r\,.j}$	Relative systematic deviation for measurement stage *j* (%)	$100 \cdot (K_j - 1) = 100 \cdot \frac{\overline{\Delta}}{\overline{z}}$
s_j	Standard deviation for deviations between simple and detailed measurement in absolute figures in measurement stage *j*[23]	$\sqrt{\frac{1}{n-1}\sum(\Delta_i - \overline{\Delta})^2}$
$s_{r\,.j}$	Relative standard deviation (coefficient of variation) for deviations between original measurement and check measurement (%)[24]	$\frac{100 \cdot \sqrt{\frac{1}{n-1}\sum(\Delta_i - \overline{\Delta})^2}}{\overline{x}}$
e_j	Standard error of systematic deviation in absolute figures in measurement stage *j*	$\frac{s}{\sqrt{n}}$
$e_{r.j}$	Relative standard error of systematic deviation in measurement stage *j* (%)	$\frac{s_r}{\sqrt{n}}$
Confidence interval (95%)	95% confidence interval for systematic deviation in absolute numbers	$t \cdot \frac{s}{\sqrt{n}} = t \cdot \varepsilon$
Confidence interval (95%)r	95% confidence interval for systematic deviation in percentage of results	$t \cdot \frac{s_r}{\sqrt{n}} = t \cdot \varepsilon_r$

Systematic deviation for conversion population

The systematic deviation for measurement of a conversion population is calculated using the control ratios from each measurement stage in the original measurement. How the standard deviation is calculated can vary depending on the type of timber unit (e.g. log, stack) in each stage, and whether there are correlations between the measurements. For a conversion population of sawlogs, the timber is first measured as a stack in the simple measurement

[23] To simplify calculations, the formula can also be expressed in summarised form: $s_j = \sqrt{\frac{1}{n-1}\left(\sum \Delta_i^2 - \frac{(\sum \Delta_i)^2}{n}\right)}$

[24] To simplify calculations, the formula can also be expressed in summarised form: $s_{r.j} = 100 \cdot \frac{\sqrt{\frac{1}{n-1}\left(\sum \Delta_i^2 - \frac{(\sum \Delta_i)^2}{n}\right)}}{\frac{\sum x_i}{n}}$

procedure, after which sample stacks are selected for detailed log-by-log measurement. Finally, from the log-by-log measurement, sample logs are then randomly selected for check measurement. For this example, the standard deviation for the combined systematic deviation is, in principle, the same as the standard deviation in the first phase (stack measurement) (see Strömgren, 2018).

Input data		**Function**
K_j	Control ratio, measurement stage *j*, where *j* = 1 to *j* = *m*	
$\Delta_{r\,.j}$	Relative systematic deviation for measurement stage *j*, where *j* = 1 till *j* = *m* (%)	$100 \cdot (K_j - 1) = 100 \cdot \frac{\bar{\Delta}}{\bar{z}}$
m	Number of measurement stages	

Calculated results		**Function**
K_{tot}	Control ratio for all measurement stages	$K_1 \cdot K_2 \cdot \ldots \cdot K_m$
Δ_{tot}	Systematic deviation in conversion population (%)	$100 \cdot (K_{tot} - 1)$

Example
Stack measurement with extraction of samples for log-by-log measurement in original measurement. Check measurement of individual logs.

	Gross volume of sample stack (m^3sub)	
Stack	Stage 1 (Simple)[1]	Stage 2 (Detailed)
1	14.00	14.20
2	13.50	14.30
3	13.75	13.20
4	14.25	14.00
5	12.00	13.00

[1]Population-converted volume

	Gross volume of check log (m^3sub)	
Log	Stage 2	Stage 3 (Check measurement)
1	0.125	0.130
2	0.190	0.188
3	0.120	0.123
4	0.075	0.074

In the calculations below, the ellipsis after the number (…) indicates that the value should not rounded off; all available decimals should be used.

Measurement stage 1:

$$K_1 = \frac{14.00 + 13.50 + 13.75 + 14.25 + 12.00}{14.20 + 14.30 + 13.20 + 14.00 + 13.00} = 0.9825 \ldots$$

$$\Delta_1 = 100 \cdot (0.9825 \ldots - 1) = -1.75 \ldots$$

Measurement stage 2:

$$K_2 = \frac{0.125 + 0.190 + 0.120 + 0.075}{0.130 + 0.188 + 0.123 + 0.074} = 0.9902 \ldots$$

$$\Delta_2 = 100 \cdot (0.9902 \ldots - 1) = -0.98 \ldots$$

All stages:

$$K_{tot} = 0.9825 \ldots \cdot 0.9902 \ldots = 0.9729 \ldots$$

$$\Delta_{tot} = 100 \cdot (0.9729 \ldots - 1) = -2.71 \ldots$$

The systematic deviation for the first measurement stage is -1.7%, for the second stage -1.0%, and for the conversion population considering all stages, the systematic deviation is -2.7%.

Weighting of check results for quantity and value

When the check results are to be shown for several measurement sites and/or periods when the sampling frequency varied, they must be weighted according to the quantity or the value they represent. This is to ensure that a small measurement site is not weighted as heavily as a large site, or that a period of the year with higher sampling frequency is weighted more heavily than other parts of the year. The results are weighted according to an estimated total quantity or value as if everything in the original measurement had been checked.

The check results are calculated first for groups of timber units within a *smallest weighting unit*. The smallest weighting unit is a timber unit taken from a check population where each timber unit has equal probability of being randomly selected for checking. In practice, the smallest weighting unit often means a group of timber units within the same assortment category and measurement site during a period in which the selection frequency has been constant. If the selection frequency was constant for the first half of the year, and then increased for the second half, the results are calculated for each half-year separately, and then weighted together according to their respective quantity or value.

Table 6. Calculation of weighted systematic deviation for several smallest weighting units.

Abbreviation	Description	Function
Y_u	Total measured quantity or value of all timber units in original measurement, weighting unit u	
$K_{u,}$	Control ratio for weighting unit u	
X_u	Total measured quantity or value adjusted for any over- or underestimation of all timber units in original measurement for weighting unit u	Y_u/K_u
ε_u	Standard error for weighting unit u (%)	
$\bar{K}$	Weighted mean control ratio value for several weighting units	$\frac{\sum(X_u \cdot K_u)}{\sum X_u}$
$\bar{\Delta}_r$	Weighted systematic deviation (%)	$100 \cdot (\bar{K} - 1)$

$\varepsilon(\bar{\Delta}_r)$	Standard error for weighted systematic deviation (%)	$\sqrt{\frac{\sum(X_u^2 \cdot \varepsilon_u^2)}{(\sum X_u)^2}}$

Example: Calculation of weighted systematic deviation and its standard error for several measurement sites.
If we assume that we have three measurement sites (A, B and C), the weighted systematic deviation is calculated as follows:

$$\bar{\Delta}_r = 100 \cdot \left(\frac{X_A \cdot K_A + X_B \cdot K_B + X_C \cdot K_C}{X_A + X_B + X_C} - 1\right)$$

The standard error for the weighted systematic deviation is calculated as follows:

$$\varepsilon(\bar{\Delta}_r) = \sqrt{\frac{X_A^2 \cdot \varepsilon_A^2 + X_B^2 \cdot \varepsilon_B^2 + X_C^2 \cdot \varepsilon_C^2}{(X_A + X_B + X_C)^2}}$$

The weighted standard deviation shows the variation in deviations between all measured timber units at several measurement sites, scalers and/or period, calculated on the basis of the weighted systematic deviation ($\bar{\Delta}$). The standard deviation is of the same type as that described on page 26, and is weighted according to the total number of measured timber units. The calculation steps are shown in the table below.

Table 7. Calculation of weighted standard deviation for several smallest weighting units. Certain abbreviations in the functions have been shown in previous tables, so are not explained here.

Abbreviation	Description	Function
N_u	Total number of measured units in original measurement for the smallest weighting unit u	
n_u	Total number of measured timber units for weighting unit u	
s_u	Standard deviation for weighting unit u *as* if it had been a population (absolute figures) [25]	$\sqrt{\frac{\sum(\Delta_i - \bar{\Delta})^2}{n_u}}$
s_{weight}	Weighted standard deviation for several weighting units (absolute figures)	$\sqrt{\frac{\sum(N_u s_u^2)}{\sum N_u}}$
$\bar{x}_u$	Mean figure for check measurement for weighting unit u	
$\bar{x}_{weight}$	Weighted average for check scaling for several weighting units	$\frac{\sum N_j \bar{x}_j}{\sum N_j}$

[25] s_u can also be expressed as follows in summarised form:

$$\sqrt{\frac{\sum \Delta_i^2 - \frac{(\sum \Delta_i)^2}{n_u}}{n_u}}$$

$s_{r.weight}$	Weighted relative standard deviation for several weighting units (%)	$\frac{s_{weighted}}{\overline{x}_{weighted}}$

Weighting in conversion populations
Weighting of the check results for a conversion population is conducted in the same way as for check results without a conversion population. Note that the results are weighted after the simple measurement in the original measurement of all timber units. Because samples can be extracted in several phases, and also check samples can be extracted, the identification of the *smallest weighting unit* can be rather more complicated. In order to satisfy the requirements for the smallest weighting unit, the selection frequency for samples in each stage and for the timber units must be constant in each stage. If, for example, sample stacks are extracted at different frequencies from different populations, but then check logs are extracted with the same selection frequency for log measurement regardless of population, then both sample stacks and check logs within each population comprise smallest weighting units.

Accuracy percentage – randomly adjusted accuracy percentage

Accuracy percentage
Accuracy percentage shows the percentage of logs that, in original and check measurements, are assessed to be equal in terms of assortment category, tree species and quality. Accuracy percentage should be interpreted with a certain caution, because it is strongly affected by the number of quality classes and the distribution between them (see below). For example, spruce timber, where logs of Quality Class 1 often dominate, a high accuracy percentage could only be attained if they are always graded as Class 1.

Table 8. Calculation of accuracy percentage.

Abbreviation	Description	Function
n_{equal}	Number of timber units with equal quality assessment in original and check measurements.	
n_{tot}	Total number of timber units	
T	Accuracy percentage	$\frac{n_{equal}}{n_{tot}} \cdot 100$

Example
The original scaler and check scaler have made the same assessment of quality for 900 of a total of 1200 check logs.

$$T = \frac{900}{1200} \cdot 100 = 75$$

The accuracy percentage is 75%.

The accuracy percentage for several smallest weighting units is weighted according to the total number of timber units in the population from which the units were extracted.

Table 9. Calculation of weighted accuracy percentage for several smallest weighting units.

Abbreviation	Description	Function
Y_u	Total number of timber units in original grading, from which a selection of timber units were extracted and allocated to the smallest weighting unit u	
T_u	Accuracy percentage for smallest weighting unit u	
$\bar{T}$	Weighted accuracy percentage for many smallest weighting units for u = *1* to u = last weighting unit	$\frac{\sum(Y_u \cdot T_u)}{\sum Y_u}$

Example
Measurement sites A, B and C each comprise a smallest weighting unit, i.e. the selection frequency for timber units has been constant at the measurement sites during the period in question. A total of 100 000, 150 000 and 200 000 logs were graded in the original measurement at sites A, B and C, respectively. The respective accuracy percentages were 70, 75 and 80%.

$$\bar{T} = \frac{100\,000 \cdot 70 + 150\,000 \cdot 75 + 200\,000 \cdot 80}{100\,000 + 150\,000 + 200\,000} \approx 76.1$$

The weighted accuracy percentage is 76.1%.

Randomly adjusted accuracy percentage
A randomly adjusted accuracy percentage shows how much better the quality grading is compared with a completely random quality grading. The theory behind randomly adjusted accuracy percentage is that, in a grading system with few classes, and one class is clearly dominant, it is easy to attain a high accuracy percentage. The accuracy percentage is highly dependent on how the timber units are normally distributed in the different classes.

A randomly adjusted accuracy percentage is a key figure where the accuracy percentage (T) is adjusted in terms of an accuracy percentage that is random, the random accuracy percentage (T_e). If the measurement official grades the timber randomly, the accuracy percentage and the random accuracy percentage will be the same; the randomly adjusted accuracy percentage (T_{rand}) will in this case be zero. A measurement official who only grades randomly will get a randomly adjusted accuracy percentage of 0%.

Table 10. Calculation of randomly adjusted accuracy percentage.

Abbreviation	Description	Function
n_{equal}	Number of timber units with equal quality assessment in original and check grading.	
$n_{j.check}$	Number of timber units in class *j* in check grading	
$n_{j.orig}$	Number of timber units in class *j* in original grading	
n_{tot}	Total number of timber units	
T	Accuracy percentage	$\frac{n_{equal}}{n_{tot}} \cdot 100$
T_e	Random accuracy percentage	$\sum\left(\frac{n_{j.check}}{n_{tot}} \cdot \frac{n_{j.orig}}{n_{tot}}\right)$
T_{rand}	Randomly adjusted accuracy percentage	$\frac{T - T_e}{1 - T_e}$

Example of calculation of randomly adjusted accuracy percentage:

Distribution of timber units in quality classes according to table below.

			Original grading			
			Class 1	Class 2	Class 3	total
			A	B	C	D
Check grading	Class 1	1	88	2	0	90
	Class 2	2	4	2	0	6
	Class 3	3	2	1	1	4
	Total	4	94	5	1	100

$$T = \frac{88 + 2 + 1}{100} = 0.91 = 91\%$$

$$T_e = \left(\frac{90}{100} \cdot \frac{94}{100}\right) + \left(\frac{6}{100} \cdot \frac{5}{100}\right) + \left(\frac{4}{100} \cdot \frac{1}{100}\right) = 0.846 + 0.003 + 0.0004 = 0.8494 = 84.94\%$$

$$T_{random} = \frac{0.91 - 0.8494}{1 - 0.8494} \approx 0.402 = 40.2\%$$

The randomly adjusted accuracy percentage is 40.2%.

Accuracy in estimation of product proportion in stack

In stack measurement, the proportion of products in the stack can be estimated. Examples of products are tree species in deciduous pulpwood and diameter classes (thick and thin) in sawlogs. In checks of accuracy in product proportion estimates, a systematic deviation for each product proportion, and its standard deviation and standard error, are calculated.

Calculation will be performed in this way when the IT has been developed, probably when VIOL 3 is introduced.

Table 11. Calculation of systematic deviation in product proportion, and the standard deviation and standard error.

Abbreviation	Description	Function
y_i	Product proportion for stack *i* in original measurement (%)	
x_i	Product proportion for stack *i* in check measurement (%)	
Δ_i	Deviation in product proportion for stack *i* (%-points)	$y_i - x_i$
n	Number of stacks	
Δ	Systematic deviation in product proportion, where *i* = 1 to *i* = *n* (%-points)	$\frac{\sum \Delta_i}{n}$
s	Standard deviation of deviations in product proportion (%-points)	$\sqrt{\frac{\sum(\Delta_i - \Delta)^2}{n - 1}}$
ε	Standard error (%-points)	$\frac{s}{\sqrt{n}}$

Example
At a measurement site, three check stacks of pine sawlogs have been measured. The proportion of sawlogs with diameters exceeding 16 cm were estimated at 40, 50 and 60% in the original measurements, and 51, 45 and 67% in the check measurements.

$$\Delta_1 = 40 - 51 = -11$$
$$\Delta_2 = 50 - 45 = 5$$
$$\Delta_3 = 60 - 67 = -7$$

$$\Delta = \frac{-11 + 5 - 7}{3} = -4$$

$$s = \sqrt{\frac{(-11 - (-4))^2 + (5 - (-4))^2 + (-7 - (-4))^2}{3 - 1}} = \sqrt{\frac{49 + 81 + 9}{2}} = 8.33\ldots$$

$$\varepsilon = \frac{8.33\ldots}{\sqrt{3}} = 1.73\ldots$$

The systematic deviation for the proportion of sawlogs with diameters exceeding 16 cm is -4%-points and the standard error is 1.7%-points. The standard deviation for the estimates is 8.3%-points.

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