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**Structural timber — Machine strength  
grading — Basic principles**

*Bois de structure — Classement par machine selon la résistance —  
Principes de base*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 165, *Timber structures*.

This second edition cancels and replaces the first edition (ISO 13912:2005), which has been technically revised.

The main changes compared to the previous edition are as follows:

- Annexes C and D have been added;
- Clauses 5 and 7 have been technically revised.

## Introduction

The general principle of this document is that any type of machine strength-grading procedure is acceptable, provided it is defined, controlled, and documented to the extent required to reflect the degree of reliability intended for the structural application of the product.

The body of this document specifies the essential features common to all machine strength-grading operations. The requirements are minimal so as to ensure maximum scope and flexibility in the application of this document to the machine strength-grading process as applied to timber.

[Annex A](#) provides an example of a conformance standard reflecting the requirements of this document.

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# Structural timber — Machine strength grading — Basic principles

## 1 Scope

This document establishes the basic principles for rules and procedures governing the machine sorting of timber for use in structural applications. This applies to conventional bending type strength-grading machines as well as more recent machines that use other properties for strength-grading purposes.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12122-1, *Timber structures — Determination of characteristic values — Part 1: Basic requirements*

ISO 12122-2, *Timber structures — Determination of characteristic values — Part 2: Sawn timber*

ISO 13910, *Timber structures — Strength graded timber — Test methods for structural properties*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13910 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

## 4 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviated terms given in ISO 13910 apply.

## 5 General

### 5.1 Machine strength-graded timber

Machine strength-graded timber is sawn wood that has been machine sorted according to selected criteria allowing for classification into structural grades. The machine criteria shall identify mechanical and/or physical properties that reflect the timber strength and can affect the utility of the product.

### 5.2 Machine strength-grading operations

A typical machine strength-grading operation shall be comprised of a grading machine that sorts an input resource into one or more grades (see [Figure 1](#)).

The data recorded by the machine shall be processed so as to produce a sorting criterion, and this sorting criterion shall be used as a basis for assigning a grade of machine strength timber.

Where applicable, visual requirements for the total piece of timber, the unscanned end portions, or both shall be specified to supplement the information obtained by the machine.

NOTE 1 The “grading machine” comprises one or more devices that can measure properties along the length of a piece of timber as it passes through the machine. For some machines, properties along the length of a piece of timber are not measured, but rather properties are measured that relate to the piece of timber considered in total as a single unit.

NOTE 2 Within the context of this document, the term “scanner” is used to denote the device used to measure a property of the timber, and the term “scanned length” is used to denote that portion of the timber for which measurements are made by the scanning device if it measures properties along the length of a piece of timber. For conventional bending type strength-grading machines, end portions of the timber are not scanned [see [Figure 2 a\)](#)].

NOTE 3 In the use of the conventional bending type of strength-grading machine, the only parameter that is measured (mechanically) along the length of each piece of timber (except for the unscanned end lengths) is the local modulus of elasticity on flat.

NOTE 4 For a machine using single or multiple scanners, the data obtained is commonly used to produce a prediction of strength along the length of a piece of timber [see [Figure 2 b\)](#)]. For this case, the minimum predicted strength value within the piece is usually taken to be the grade control criterion.

### 5.3 Machine strength-grading quality procedures

Machine strength-grading quality procedures include both qualification and ongoing quality control operations. The quality procedures related to the machine grading operation shall be undertaken by placing checks on the four components of the strength-grading operation: 1) the resource and sawn timber inputs; 2) the machine operation; 3) the visual requirements (when specified); and 4) the graded timber output (see [Figure 1](#)).

The qualification and quality control procedures shall establish that the production is in compliance with expected performance, taking into account the normal temporal variation of the input, as well as the machine, the machine settings, and any other procedure added to define the population.<sup>1)</sup>

#### 5.3.1 Machine-controlled system

Where quality is controlled through the resource inputs and machine operation, monitoring shall be done to ensure that the resource is similar to that initially used to establish the machine settings.

#### 5.3.2 Output-controlled system

Where quality is controlled through output, the initial evaluation (see [8.2](#)) shall involve sample sizes larger than those normally used for daily evaluation (see [8.3](#)) to ensure that the 5th-percentile strength requirements are met.

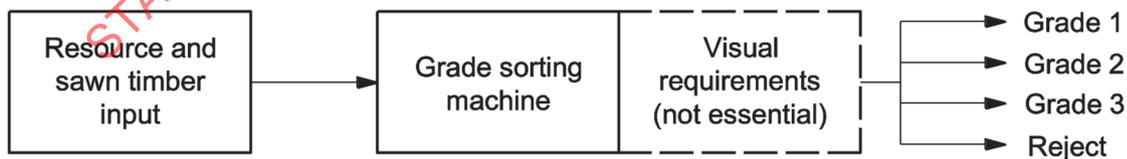
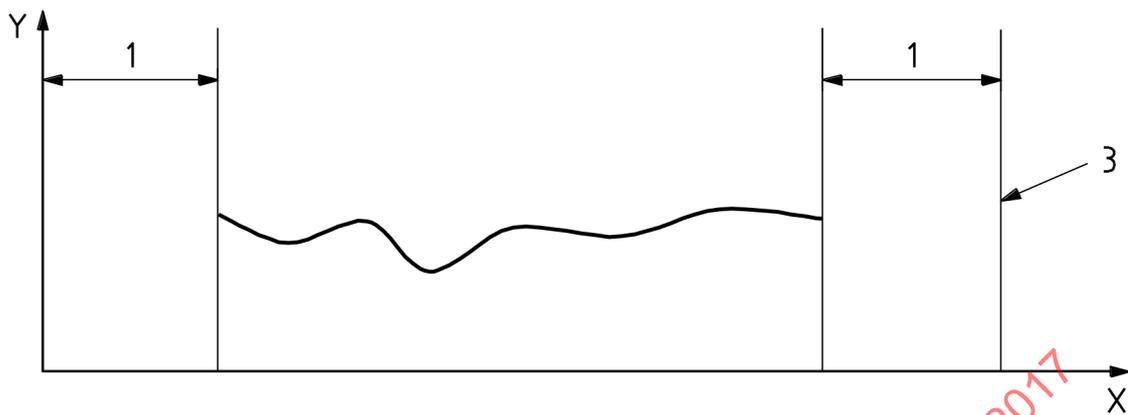
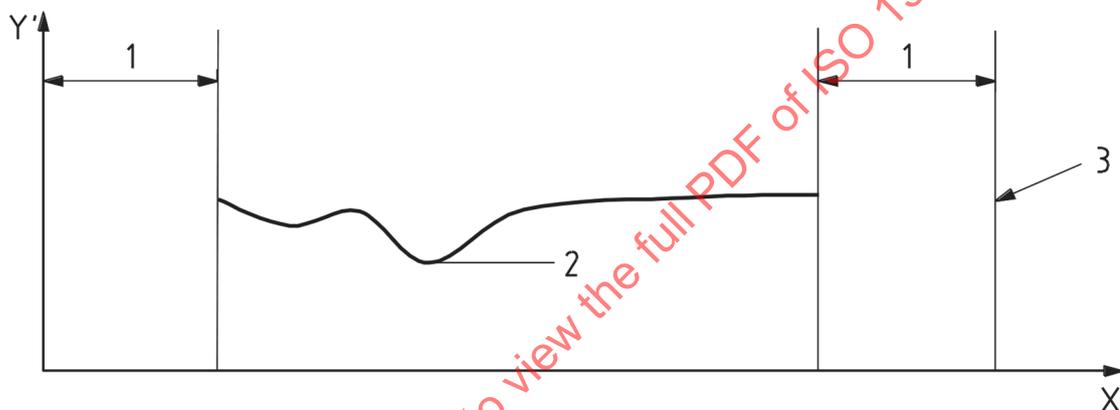


Figure 1 — Schematic of machine strength-grading operation

1) Quality control for products conforming to this document will include programmes for training, supervision and oversight of grading (see Annex D for further explanation).



a) Typical output of a scanner



b) Typical form of processed output

**Key**

- X distance from start of piece
- Y scanner output
- Y' parameter used to predict strength
- 1 unscanned length (if applicable)
- 2 value used to classify piece (e.g. low-point parameter as shown in figure)
- 3 end of piece

Figure 2 — Measurements made by a strength-grading machine

## 6 Resource and sawn timber input requirements

### 6.1 General

The input resources shall be identified in terms of all parameters that can affect the output of the machine grade sorting operation.

## 6.2 Input requirements

### 6.2.1 Resource

The parameter that shall be identified is the timber species or mixture of species.

Other parameters that shall be considered are

- a) silvicultural practices used,
- b) log source,
- c) log size,
- d) cutting pattern used to manufacture sawn timber from logs, and
- e) any other parameters deemed to be important.

### 6.2.2 Sawn timber

Parameters that shall be specified are

- a) condition (such as seasoned, unseasoned, etc.),
- b) moisture content, and
- c) any other parameters deemed to be important.

## 6.3 Control of inputs

A periodic check on the resource and sawn timber inputs shall be defined and specified.

## 6.4 Reprocessing of previously graded material

If reprocessing of previously graded material is permitted, then any requirements for re-grading of the material shall be specified.

## 7 Machine strength-grading requirements

### 7.1 Machine checking requirements

In addition to verification of the calibration of the scanner, all machine checks specified by the machine manufacturer shall be undertaken.

### 7.2 Machine acceptance criteria

The introduction of new machine strength-grading processes shall be supported by testing of samples from at least two reference grades containing a random selection of the permitted features, resulting in data on the mean modulus of elasticity and the 5th percentile of at least one strength property. This data shall be permitted to be used to formulate the structural grade model including other grades and sizes, provided it shows a consistent relationship to the reference grades.

The framework for the grading system shall be supported by evidence that it can provide a stable basis for delivering graded products that achieve key characteristic properties.

**NOTE** The intent is to select reference grades and sample sizes that will serve best to represent the grades in the system, reflecting both the range and frequency of features that can appear in these grades and demonstrating that the grading system is robust enough to differentiate properties for the timber population. [Annex C](#) provides an example of grading machine acceptance considerations.

### 7.3 Machine strength-grading requirements

The machine grading process shall specify, at regular intervals, checks to ensure:

- a) **repeatability** – within prescribed limits, the scanners shall provide the same readings for repeated passes of the same piece of timber;
- b) **calibration** – within prescribed limits, scanners shall reproduce the original readings made on special pieces of timber set aside for calibration purposes or on non-timber calibration bars;
- c) **consistency** – within prescribed limits and where scanners provide readings along the length of timber, the data from scanners shall indicate a consistent calibration all along the length of a piece of timber.

Grading machines that use the same types of scanners shall be calibrated against the same check procedure.

NOTE Grading machines that are not identical but use the same types of scanners include a number of conventional strength-grading machines. This clause refers to the use of a common standard test method (e.g. ISO 13910) in such cases for calibration purposes.

### 7.4 Visual grading requirements

#### 7.4.1 General

Where visual grading requirements are deemed to be important then rules to satisfy the strength requirements shall be specified and rules to satisfy relevant utility requirements shall be specified.

For the visual grading requirements that are specified, then a periodic check shall be made to assess the accuracy of the grading process. If a check indicates that the process is inadequate, then appropriate measures shall be specified to modify the process so that the process is adequate.

#### 7.4.2 Automated visual grading

For visual-grading machines that are used to replace visual grading people, the repeatability and reproducibility identified in 7.3 shall be met.

NOTE An example of visual strength-grading requirements, as applied to rectangular timber for structural applications, is given in [Annex A](#).

## 8 Machine strength-graded timber structural properties

### 8.1 General

The structural properties shall be as defined and measured as specified in the test methods defined in ISO 13910.

The structural design properties shall be determined from tests on timber having a defined moisture content. If the tests are conducted on timber having a moisture content that differs from that specified by the procedure conforming to this document, the properties resulting from the tests shall be adjusted (using sound engineering principles) so that the structural design properties reflect the intent of these basic requirements and/or the applicable associated design codes.

### 8.2 Initial evaluation

Once the grading operation has been selected, evidence shall be provided that the resultant output grades have the structural properties stated for the material.

For cases where such evidence is not available or it is not appropriate to link the evidence to other mills, an initial test programme shall be specified. The requirements for this test programme shall be based on sound sampling principles and the tests for the structural properties shall be based on the test procedures specified in 8.1.

NOTE The objective is to involve multiple independent data sets when qualifying a machine for machine controlled operations. Alternatively, the test sample can be a sample representative of the global population that will be graded using the machine; in such cases, the evidence can be linked to other mills carrying out equivalent sorting procedures.

### 8.3 Daily evaluation

When specified in the quality control documentation, one or more structural properties shall be measured for each production shift on a limited sample of timber. The data obtained shall be applied to a statistical process control procedure and the results used to monitor the control of the strength-grading operation.

## 9 Product identification

A product identification mark shall be placed on the timber to indicate the standard on which the sorting is based, the grade and/or strength class, and the producer responsible. The product identification mark shall also include any other relevant information required to show suitability for end use.

Each piece of timber shall be marked except for high quality strength-graded timber intended for structural and appearance purposes. For this high quality appearance timber, each shipment shall be accompanied by documentation containing the product identification requirements specified in the standard.

## 10 Documentation

Documentation requirements shall include:

- a) the standard on which the machine strength-grading process is based;
- b) specifications for the timber grade criteria;
- c) specifications and control checks of the resource input where applicable to machine control operations;
- d) specifications and control checks for the machine grade sorting process;
- e) where applicable, specifications and control checks for the visual requirements;
- f) specifications and control checks of the structural properties;
- g) specifications for the identification of the product;
- h) methods for assigning and confirming a grade; and
- i) any other specifications or materials deemed to be important.

## Annex A (informative)

### Example of a machine strength-grading timber standard

This is a practical implementation of the machine strength-grading principles defined in the main body of ISO 13912, as applied to the following case:

- conventional bending type strength-grading machine;
- rectangular cross-section timber;
- for structural applications;
- requiring strength characteristic values with a moderate to high degree of engineering reliability.

The layout corresponds to that of an International Standard (not a normal annex) to clearly show how an International Standard in this domain should look. It includes

- elements mandatory in all International Standards (Scope, Normative references, and Terms and definitions),
- conditional elements, i.e. those present depending on the provisions of a particular document (Symbols and abbreviated terms, Requirements, Sampling, Test methods and Bibliography).

Informative annexes (like this annex) and normative annexes can also form part of an International Standard. Although some of this annex is written in mandatory language for illustration purposes, it is not a normative part of this document.

**NOTE** The Scope does not usually form part of an annex, but is included in this example for completeness purposes.

#### A.1 Scope

This annex specifies the grading procedures for producing machine-sorted strength and stiffness graded rectangular timber for structural applications where a moderate to high degree of engineering reliability is required.

It is applicable for timber that is graded in the seasoned state.

For timber that is graded in the unseasoned state, there is greater uncertainty about effects on the grading evaluation, and so the structural design properties for the timber might need to be modified to reflect the intent of this standard and/or the associated design codes.

#### A.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12122-1, *Timber structures — Determination of characteristic values — Part 1: Basic requirements*

ISO 12122-2, *Timber structures — Determination of characteristic values — Part 2: Sawn timber*

ISO 13910, *Timber structures — Strength graded timber — Test methods for structural properties*

ISO 13912, *Structural timber — Machine strength grading — Basic principles*

### A.3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

#### A.3.1

##### **grade**

population of timber derived from a specified resource and by applying a specified sorting procedure

#### A.3.2

##### **CUSUM**

cumulative summation procedure for assessing structural quality trends from data sampled at intervals of time

#### A.3.3

##### **knot**

portion of a branch or limb that has become incorporated into a piece of sawn timber

#### A.3.4

##### **machine strength-grading**

strength-grading through mechanically measuring the modulus of elasticity on flat along a piece of timber

#### A.3.5

##### **seasoned timber**

timber with moisture content of 19 % or less

#### A.3.6

##### **split**

separation of the wood at the end of the piece that runs from one surface to an opposite or adjacent face

#### A.3.7

##### **structural requirements**

grade requirements that affect the structural properties of the timber

#### A.3.8

##### **shake**

lengthwise separation of the wood which occurs between or through the annual growth rings

#### A.3.9

##### **thickness**

lesser dimension perpendicular to the longitudinal axis of a piece of timber

#### A.3.10

##### **unseasoned timber**

timber with moisture content greater than 19 %

**A.3.11****utility requirements**

grade requirements that do not affect the structural properties of the timber and/or to an amount which threatens the serviceability of the piece

**A.3.12****visual requirements**

visual grading requirements that are additional to machine sorting necessary to attain required structural and utility properties within a grade of timber

**A.3.13****width**

greater dimension perpendicular to the longitudinal axis of a piece of timber

Other features such as bow, cup, spring (or crook), twist and wane should be defined in the appropriate subclauses and by referencing the feature to an illustration.

**A.4 Symbols and abbreviated terms****A.4.1 General notation**

<i>E</i>	modulus of elasticity
<i>f</i>	strength
<i>N</i>	sample size
CV	coefficient of variation

**A.4.2 Subscripts**

0,05	5-percentile value
data	value measured on data sample
mean	mean value
m	bending
target	target or specified value for the grade

**A.5 General****A.5.1 Machine strength-grading operations**

The machine strength-grading operation shall be comprised of a strength-grading machine and a visual grader or visual grading machine sorting an input resource and sawn timber into output grades. Some of the timber might not meet the requirements of the minimum grade.

Structural and utility requirements are specified for the machine strength-graded timber.

**A.5.2 Principles of quality control**

The machine strength-grading is one element of the quality control operations. This document requires that the quality control be undertaken by placing checks on the four components of the strength-grading

operation: the resource and sawn timber inputs, the machine operation, the structural and utility requirements, and the graded timber output.

## **A.6 Resource sawn timber input requirements**

### **A.6.1 General**

The input resources shall be identified in terms of all parameters that can affect the output of the machine grade sorting operation.

### **A.6.2 Input requirements**

#### **A.6.2.1 Resource**

Parameters that shall be identified are

- a) timber species or mixture of species,
- b) log source,
- c) log size,
- d) silvicultural practices used,
- e) cutting pattern used to manufacture sawn timber from logs, and
- f) other parameters deemed to be important.

#### **A.6.2.2 Sawn timber**

Parameters that shall be specified are

- a) seasoning condition at the time of machine and visual grade sorting,
- b) moisture content: 10 % to 19 %,
- c) width and thickness: 0 to +2 mm,
- d) bow: 6 mm per metre,
- e) spring (or crook): 3 mm per metre,
- f) twist: 1 mm per 25 mm of width per metre of length, and
- g) other parameters deemed to be important.

### **A.6.3 Control of inputs**

A periodic check on the resource and sawn timber inputs shall be defined and specified.

### **A.6.4 Reprocessing of previously graded material**

If reprocessing of previously graded material is undertaken that can reduce the structural design properties or lower the machine and/or visual (utility) grade, then re-grading of the material shall be required.

## A.7 Machine strength-grading requirements

### A.7.1 Machine requirements

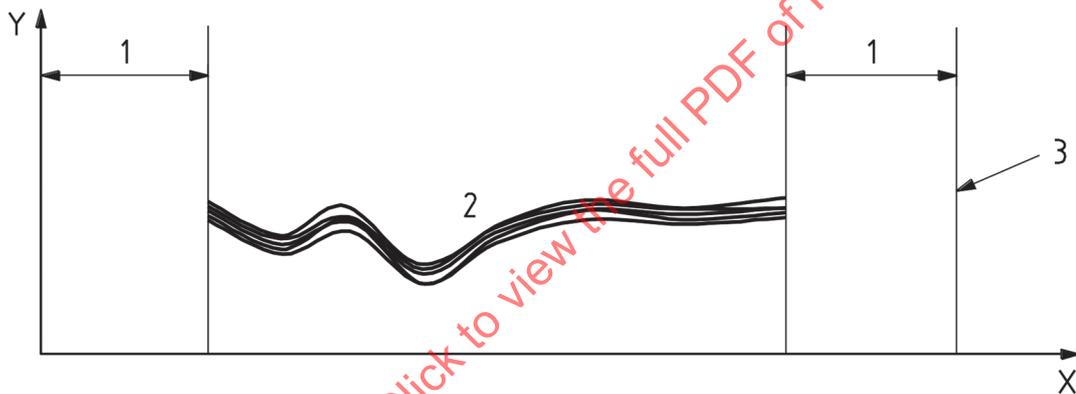
All machine checks, and the frequency of such checks, as specified by the machine manufacturer, shall be followed.

### A.7.2 Machine strength-grading processes

Machine strength-grading checks shall be based on the following principles.

#### A.7.2.1 Repeatability

At the start of each shift, one or more pieces of timber shall be sent through the machine five times (with the same leading edge and face directions). The criterion for acceptance shall be specified; for example, five overall individual pass scanner readings shall be measured at each data point and averaged along the whole piece of timber and the variation shall not exceed 10 % of the grading modulus (see [Figure A.1](#)).



#### Key

- X distance from start of piece
- Y measured modulus of elasticity on flat
- 1 unscanned length
- 2 readings from 5 passes
- 3 end of piece

**Figure A.1 — Repeatability check for conventional bending type machine**

#### A.7.2.2 Calibration

The criterion shall also be specified for calibration purposes; for example, five pieces of timber shall be selected from the range of the timber to be graded. The timber shall be reasonably straight and shall have strength-reducing defects as defined in this standard.

First, each piece of timber shall be sent through the machine four times (with a different leading edge and face configuration [see [Figure A.2 a](#)]). For a conventional bending type machine, the criterion for acceptance shall be that the range of machine readings, measured at each data point and averaged along the whole piece of timber, shall not exceed 20 % of the grading modulus for the strength grade under consideration.

Next, the four scanner readings shall be averaged at each data point and this averaged set of values shall be compared with an independent calibration at a few critical points [see [Figure A.2 b](#)]). For a

conventional bending type machine, the calibration shall be made by comparison with a static measurement of the modulus of elasticity on flat (that is, with centre point loading over a 900 mm span) at locations near the points of minimum grading moduli. The criterion for acceptance shall be that the minimum values obtained by the machine and by the static test shall not differ by more than 2 % of the static value.

The above calibration procedure shall be done at least every three months. Once the calibration sticks have been used to ensure that the machine calibration is accurate, they shall be passed through the machine at the commencement of each shift (see [Figure A.3](#)).

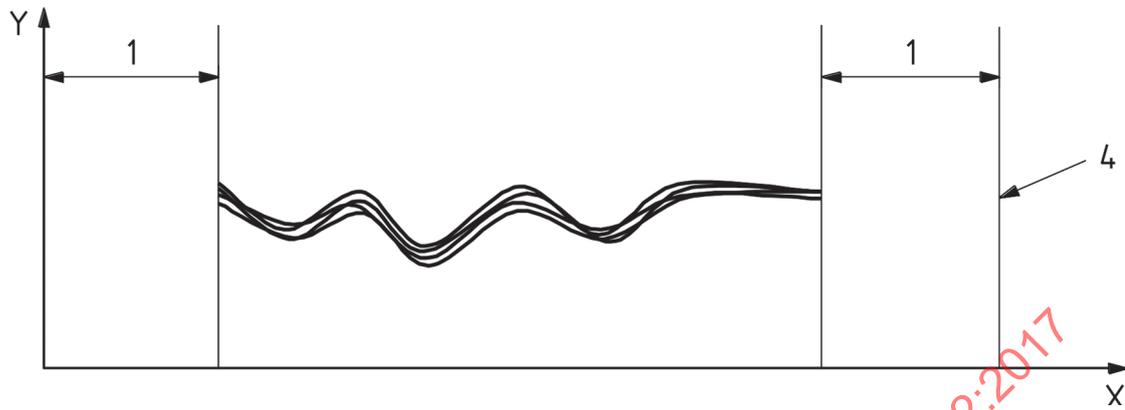
For the in-service calibration check, the data obtained with the calibration sticks at each shift shall be compared with the data obtained from the pass with the same leading edge and face configuration in the initial calibration check. The criterion for acceptance of the “in-service” calibration run shall be that the measured difference between the two sets of data at each point, averaged over the whole piece of timber, shall not differ by more than 15 % of the minimum modulus of the stick.

### A.7.2.3 Consistency check

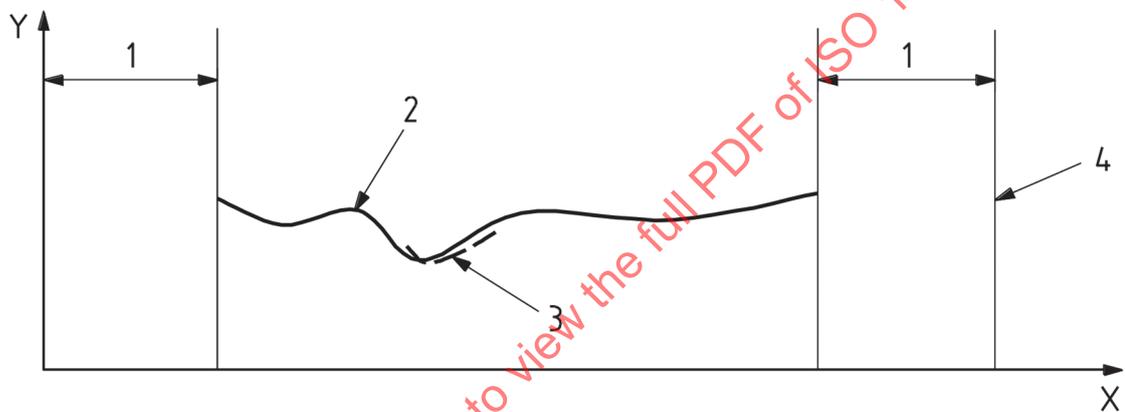
The procedure for undertaking a consistency check shall be specified; for example, to store the data obtained for 500 pieces of timber during a normal production run. For a conventional bending type machine, the data from these 500 pieces shall be averaged as an ensemble, i.e. they are averaged for each location at a specified distance from the leading end (see [Figure A.4](#)). The criterion for acceptance of the consistency check shall be the value obtained by averaging the ensemble averages for all locations; the range shall not be more than 20 % of the average value.

Sometimes the criterion of acceptance of the “on flat output” of the consistency check cannot be obtained, even with a perfect machine, due to a bias in the input resource.

**EXAMPLE** This can occur if timber from butt logs is fed into the machine with the butt end entering first. Where such a bias exists then the effect of this particular bias can be overcome by choosing a random end of timber to enter the machine during the consistency check.



a) Output from 4-way scan

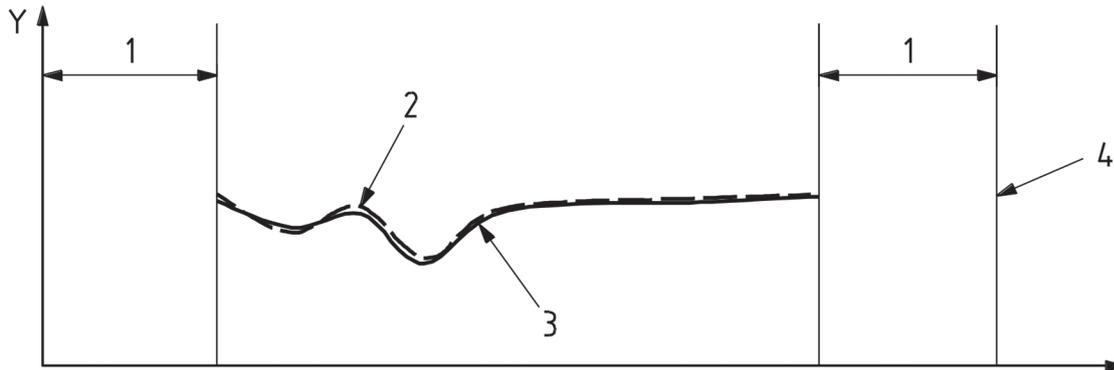


b) Calibration of scanner output

**Key**

- X distance from end A
- Y measured modulus of elasticity on flat
- 1 unscanned length
- 2 mean of a 4-way scan
- 3 independent calibration check
- 4 end of piece

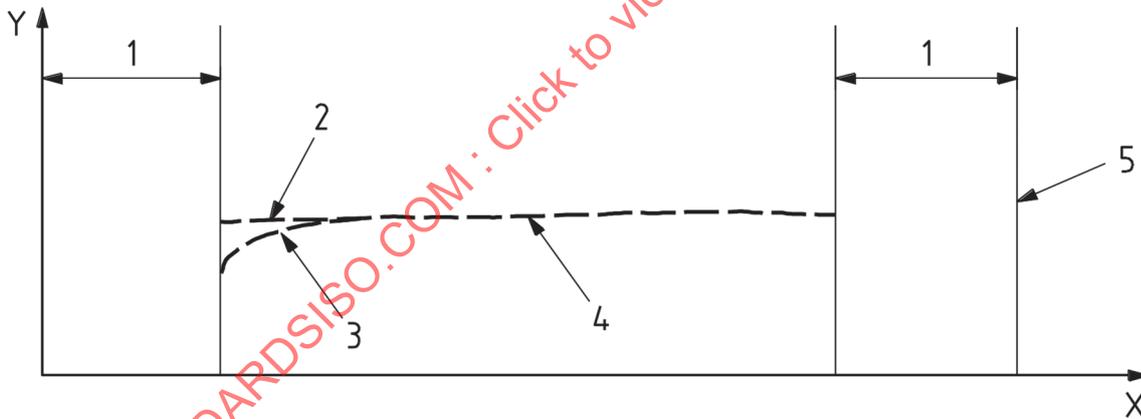
**Figure A.2 — Calibration of the scanner for conventional bending type machines**



**Key**

- X distance from end A
- Y measured modulus of elasticity on flat
- 1 unscanned length
- 2 in-service mill run
- 3 initial calibration run
- 4 end of piece

**Figure A.3 — Calibration check for conventional bending type machine during an in-service mill run**



**Key**

- X distance from start of piece
- Y measured modulus of elasticity on flat
- 1 unscanned length
- 2 machine in control
- 3 machine out of control
- 4 ensemble average of 500 pieces of timber
- 5 end of piece

**Figure A.4 — Consistency check for conventional bending type machine**

### A.7.3 Visual strength-grading requirements

#### A.7.3.1 Along the full length

The following limitations shall be applied to meet the visual requirements affecting strength along the full length:

- a) edge knots appearing on the wide face shall not exceed  $1/3$  the width of the piece, and
- b) through splits shall not exceed  $1 \frac{1}{2}$  times the width of the piece.

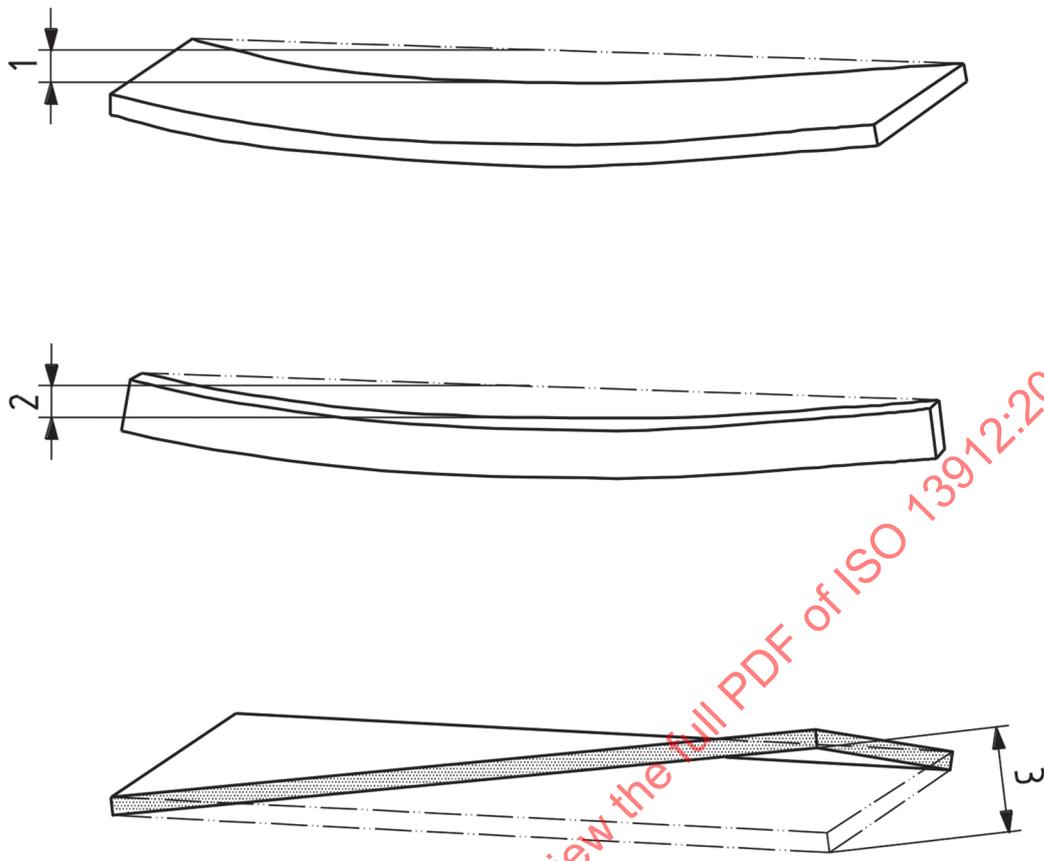
#### A.7.3.2 Within the unscanned end lengths (for conventional bending type machine)

The following limitations shall be applied to meet the visual requirements affecting strength within the unscanned end lengths:

- any strength-reducing feature shall not exceed the maximum feature of that type in the scanned part of the timber, and
- any strength-reducing features shall not exceed the requirements given for the visual utility grading requirements in this document.

The following limitations shall be applied to meet the visual requirements affecting utility:

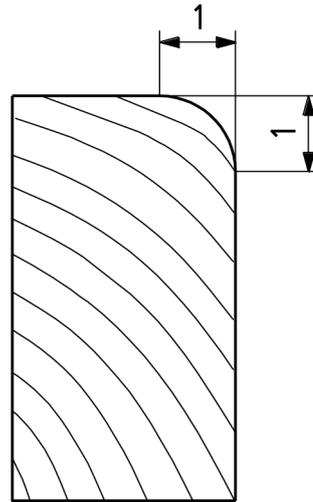
- |    |   |  |
|----|---|--|
| a) | knot on wide face                                   | maximum $1/2$ width;                                 |
| b) | width and thickness                                 | 0 mm to +2 mm;                                       |
| c) | squareness  | $\pm 2^\circ$ ;                                      |
| d) | bow (see <a href="#">Figure A.5</a> )               | maximum 5 mm per metre of length;                    |
| e) | spring (or crook) (see <a href="#">Figure A.5</a> ) | maximum 4 mm per metre of length;                    |
| f) | twist (see <a href="#">Figure A.5</a> )             | maximum 1 mm per 25 mm of width per metre of length; |
| g) | wane (see <a href="#">Figure A.6</a> )              | maximum $1/3$ width of either face; and              |
| h) | cup (see <a href="#">Figure A.7</a> )               | maximum 1 mm per 50 mm of width.                     |



**Key**

- 1 bow
- 2 spring (or crook)
- 3 twist

**Figure A.5 — Measurement of bow, spring (or crook), and twist**

**Key**

1 wane

**Figure A.6 — Measurement of wane****Key**

1 cup

**Figure A.7 — Measurement of cup****A.7.4 Check on visual strength and utility grading process**

During each production shift a check shall be made to assess the accuracy of the visual grading process. This shall be done by regrading a sample of graded timber. The pass criterion shall be that not more than 5 % of the pieces fall below the visual strength limitations and that not more than 20 % of the pieces fail the utility limitations.

If the checks indicate that the process is inadequate, then appropriate measures shall be undertaken to modify the process.

**A.8 Structural properties****A.8.1 General**

The structural properties are defined and measured as specified in the test methods defined in ISO 13910, in accordance with the principles of ISO 12122-1 and ISO 12122-2.

## A.8.2 Initial evaluation

Once the machine grading operation has been selected, evidence shall be provided that the resultant output grades have the required structural properties. This evidence shall be through direct measurement of structural properties of full-size timber (see [A.8.1](#)) or through the equivalent data from other similar grading operations.

For the case where a strength-grading operation in a mill commences with a grade sorting procedure and input resource that are equivalent to those already existing in other mills, no special initial evaluation is required as the evaluation data obtained from the other mills can be cited as initial evidence of properties of the graded timber.

For the case where the machine is similar to those that are used in existing mills, the species of timber graded is the same, but the source of timber and/or the cutting patterns used differ, then a limited check is required. A check shall be obtained by measuring the bending strength and modulus of elasticity for at least two sizes and two grades. The sample used for each size/grade should be  $N = 200$ .

If an existing machine is applied to a new species, then measurements of the graded material shall be made for at least the bending and tension strength and modulus of elasticity. All grades shall be evaluated and at least two sizes spanning the range of strength-graded timber to be produced.

For the case of a new machine, all specified grade properties and all grades shall be assessed. A minimum of three widths and two thicknesses, spanning the range of strength-graded timber to be produced, shall be assessed.

## A.8.3 Daily evaluation

At each shift, one or more structural properties shall be measured on a limited sample of timber. The data obtained shall be applied to an appropriate statistical process control procedure and the results used to monitor the control of the strength-grading operation.

NOTE The CUSUM procedure described in [Annex B](#) is one example of a statistical process control method that can be used. For general information about CUSUM charts, see [B.1](#). It should be noted that the use of the attributes chart to control 5-percentile strength values is not effective for the case of high variability in strength coupled with sudden changes in the characteristic value of strength. Attribute charts for strength are typically used alongside variables charts for stiffness and applied to lumber grades where there is a positive correlation between strength and stiffness. Visual grade limits are also applied.

## A.9 Product identification

Except for exceptional circumstances where the end use of the timber can require marking to be omitted for aesthetic reasons and where the customer specifically requests/orders timber to be free of marks, timber shall be marked to identify:

- a) reference to this document, i.e. ISO XXXX;
- b) producer responsible;
- c) grade and/or strength class;
- d) certification body;
- e) timber condition (moisture content at the time of grading); and
- f) species or species mixture (group).

For those cases where the customer specifically requests/orders timber free of marks, each parcel/package of timber of a single grade/strength class shall be dispatched under the cover of a certificate of compliance stating the following information:

- g) serial name and date of the certificate;

- h) customer's name and address;
- i) customer's purchase or order number;
- j) species or species mixture (species group), grade, and dimensions and quantities, grade;
- k) reference to this document, timber condition (moisture content at the time of grading), and date the timber was graded; and
- l) signature of the operator or of the grader.

### **A.10 Documentation**

A quality manual shall include the following:

- a) specifications of the resource and sawn timber input;
- b) this document, i.e. ISO XXXX;
- c) definition of the grade sorting process;
- d) specifications of the machine and visual structural and utility requirements;
- e) specifications of the controls for the grade sorting process;
- f) specifications of the methods used to initially and periodically evaluate the properties of the timber;
- g) specifications of the control checks of graded timber;
- h) specifications of the information marked on the timber or, where applicable for timber ordered free of marks, specifications for the certificate of compliance accompanying each parcel/package of timber;
- i) allocation of responsibilities for quality control operations; and
- j) specifications used by the certification body.

## Annex B (informative)

### Use of the CUSUM procedure for daily evaluation

#### B.1 General

CUSUM<sup>2)</sup> is one example of a procedure used by some machine strength-graded timber producers to detect changes affecting structural properties. CUSUM is a control chart tool used in conjunction with rules and interpretations to make it applicable to the process under evaluation. For example, the statistical distribution of the structural property data can play an important role in chart interpretation. Together, the control chart and the interpretation rules form the statistical control procedure for evaluating the process.

The two types of CUSUM charts are: 1) a *variables* chart; and 2) an *attributes* chart. The variables chart is used to assist in the control of a mean value and the attributes chart is used to assist in the control of a characteristic strength, in this case taken to be the lower 5-percentile value.

#### B.2 Control constants

Normally, the *variables* chart is used to control the modulus of elasticity, and the *attributes* chart is used to control strength. However, there is no reason why both charts should not be applied to all properties and in fact this is recommended. Small sample sizes are used in the application of these charts; a typical sample size would be  $N = 5$ ; hence the attributes chart is not very sensitive or can be slow to indicate a sudden change in 5-percentile strength. The attributes chart is most helpful when it is acceptable to detect the change after a number of samples. For example, taking multiple 5-piece samples in close succession following a change in the process is one way of confirming the 5-percentile strength (see [B.5](#)).

First a sample size,  $N$ , is chosen. Using the chosen sample size and the coefficient of variation of the structural property, control constants  $K$ ,  $Y$  and  $Z$  are derived from [Tables B.1](#) and [B.2](#).

#### B.3 Incremental SUM

Usually one sample is taken at each shift, the specimens being selected at random at specified intervals of time. Immediately after collection of the total sample, the specimens are tested to measure their structural properties; the results are then used to compute an incremental SUM which in turn is used to evaluate the next step of a CUSUM control chart for that particular size and grade of timber. If only one sample is collected at each shift, it is usually tested to evaluate the bending strength and modulus of elasticity of the graded timber.

For the  $i$ -th step on a variables chart, a mean value  $M_i$  is computed and the corresponding  $X_{SUM,i}$  is given by

$$X_{SUM,i} = X_{CUSUM,i-1} + (K - M_i) \quad (\text{B.1})$$

where  $X_{CUSUM,i-1}$  denotes the value of CUSUM at the previous step.

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2) CUSUM cumulative summation procedure for assessing structural quality trends from data sampled at intervals of time.

For the  $i$ -th step on an attributes chart, the value of  $SUM_i$  is given by

$$X_{SUM,i} = X_{CUSUM,i-1} + (d_i - K) \quad (B.2)$$

where  $d_i$  denotes the number of samples that failed to meet the target 3-percentile values.

For strength properties in the absence of other information, the target 3-percentile value, denoted by  $f_{0,03,target}$ , can be taken to be given by

$$f_{0,03,target} = 0,9 f_{0,05,target} \quad (B.3)$$

where  $f_{0,05,target}$  denotes the target 5-percentile value.

#### B.4 Control chart

The control chart commences with a value of  $X_{CUSUM} = 0$ . Thereafter the  $X_{CUSUM}$  is incremented according to the following rules.

- a) If  $X_{SUM,i} \leq 0$ , then  $X_{CUSUM,i} = 0$ .
- b) If  $0 < X_{SUM,i} < Y$  and  $X_{CUSUM,i-1} \leq Y$ , then  $X_{CUSUM,i} = X_{SUM,i}$ .
- c) If  $0 < X_{SUM,i} < Y$  and  $X_{CUSUM,i-1} > Y$ , then  $X_{CUSUM,i} = 0$ .
- d) If  $X_{SUM,i} = Y$  and  $X_{CUSUM,i-1} < Y$ , then  $X_{CUSUM,i} = Z$ .
- e) If  $X_{SUM,i} = Y$  and  $X_{CUSUM,i-1} \geq Y$ , then  $X_{CUSUM,i} = 0$ .
- f) If  $Y < X_{SUM,i} < Z$  and  $X_{CUSUM,i-1} < Y$ , then  $X_{CUSUM,i} = Z$ .
- g) If  $Y < X_{SUM,i} < Z$  and  $X_{CUSUM,i-1} \geq Y$ , then  $X_{CUSUM,i} = X_{SUM,i}$ .
- h) If  $X_{SUM,i} \geq Z$ , then  $X_{CUSUM,i} = Z$ .

These rules are summarised in [Table B.3](#).

If the CUSUM is greater than  $Y$ , the process is deemed to be “out of control”; otherwise it is deemed to be “in control”. An illustration of a typical CUSUM chart is shown in [Figure B.1](#).