Measurement of Log Volume Under Bark

Swedish Regulations for Timber Measurement

Version 2021-04-01

BIOMETRIA

Contents

1 Introduction

1.1 Swedish regulations for timber measurement – timber measurement legislation

Swedish Regulations for Timber Measurement are adopted by the Biometria Board on the basis of recommendations from RMR (Council for Measurement and Reporting). The documentation for RMR is prepared by the Biometria department for development and IT. In certain cases, the Swedish regulations are supplemented with business-related regulations.

Regulations and instructions concerning checks and follow-up are briefly described in each measurement regulations document and in separate documents. Current versions of measurement regulations and measurement inspection documents can be retrieved from www.biometria.se.

Timber measurement in Sweden is regulated by special legislation, the Swedish Timber Measurement Act. This Act and the regulations of the Swedish Forest Agency (SKSFS 2014:11) on timber measurement form a fundamental regulatory framework for timber measurement and timber reporting in Sweden.

One of the regulations concerns requirements for accuracy when measuring logs. The requirements concern gross volume.

- Systematic errors: only insignificant systematic errors are allowed in measurement.
- Batchwise deviation: for timber batches greater than 10 m³ the maximum permitted deviation is stated as a function of the batch size. As the batch size increases, the permitted deviation decreases. A batch of timber is defined as follows: *A clearly defined quantity of timber agreed by the seller and buyer that is measured using the same method. The specifications regarding timber properties are identical for the entire quantity. The timber is usually delivered on a single occasion or within a short interval of time.*

1.2 Area of application for these regulations

Log measurement according to the methods described in these regulations applies to all tree species and applies regardless of the intended use of the timber. Limits regarding log length and diameter are stated under each measurement method. Provisions relating to quality are described in assortment-specific documents.

Logs may be measured manually or automatically in scanners. Section measurement is primarily applicable in automatic measurement in a scanner. The scanner must be approved by VMK (Timber Measurement Control) for the application(s) concerned. Scanners include:

- 3D scanners
- Shadow scanners with one or more measurement directions
- X-ray scanners

1.3 Measurement units for log volume

The volume of the log under bark is determined either as gross or net volume. Net volume refers to volume after any deductions for diameter and/or length. There are two measurement units for log volume: top cylinder volume ($m^3$to) and form-adjusted solid volume (m^3sub), Figure 1.

Top cylinder volume – $m^3$to

The top cylinder volume is calculated as the volume of a cylinder with a diameter equal to the top diameter of the log, measured under bark, and with a length equal to the log length. The top cylinder volume is determined according to the method known as top measurement. The volume is expressed in $m^3$to.

Form-adjusted solid volume – m^3sub

Form-adjusted solid volume comprises the solid volume of the log after deductions for any bulges. Form-adjusted solid volume is expressed in m^3sub, and is determined using any of the following measurement methods:

- Mid-point measurement: The solid volume of the log is found by measuring the diameter at the mid-point of the log length and measuring the length of the log.
- Top-butt measurement: The solid volume of the log is found by measuring the diameter of the top and butt and measuring the length of the log.
- Top form conversion factor matrix: This is used to calculate the solid volume of the log. Top measurement and matrices of conversion factors are used for each combination of length and top diameter.
- Section measurement The solid volume of the stem or log is found by dividing the stem or log into sections; the volume of each section is calculated according to mid-point measurement, after which the results are totalled.

Manual top-butt measurement is used as a standardised method in checks and follow-up of form-adjusted solid volume. When necessary, other measurement methods are adjusted so that, when applied over an imaginary large batch of timber, the same total volume as that shown by top-butt measurement is obtained.

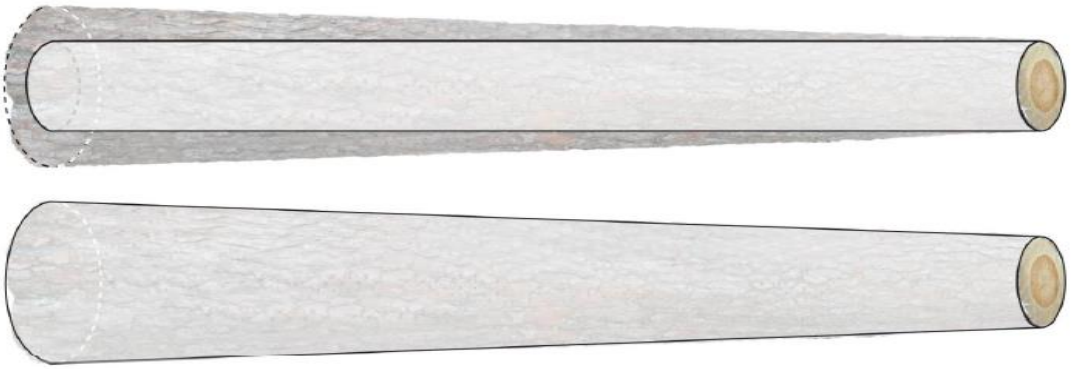

Figure 1. Top cylinder volume ($m^3$to) and form-adjusted solid volume (m^3sub).

1.4 Basic requirements for measurement – delivery check

The timber must be measured accurately and according to the regulations applicable to the measurement. If local conditions do not allow the measurement to be carried out in this way, the timber must not be measured. The timber must be measured as seen, but damage that has occurred during or after delivery to the measuring site is to be disregarded.

On agreement, the timber consignment in question may be inspected before it is unloaded from the vehicle. The inspection examines whether the timber properties, and the conditions for measurement, comply with applicable regulations and agreements. If this is not the case, measurement is refused. If measurement is refused, both seller and buyer of the timber are to be informed immediately, and notified of the reason for the refusal.

2 Log length and diameter

In log measurement, length and diameter are recorded. Where there is deduction for diameter and/or length, both gross and net measurements are recorded.

2.1 Log length

Log length is the shortest distance between the centres of each end of the log. Felling comb or other irregularity in the log-end is excluded from the length measurement. If there are several saw cuts, length is measured from the one affecting the entre of the end surface. The centre at the end of the log is the geometric centre of the end surface. In section measurement, this straight line forms the basis for dividing the log into sections. The largest permitted measurement unit for length is 1 cm. Figures are rounded off to the nearest cm according to Swedish Standard.

For assortments that may include thin stems, such as pulp wood and energy wood, the log length is measured in relation to the minimum diameter of the assortment, such as 30 or 50 mm under bark. Any tolerance for a protruding thinner part of the log is described in assortment-specific regulations on quality. For wood mechanical assortments, such as sawlogs, the entire length of the log is measured, even if the top diameter is smaller than the minimum merchantable diameter.

If the log has a fork, the length is measured along the thickest fork limb. See diagrams in section 2.2.3.

Figure 2. Log length is the shortest distance between the centres of each end of the log. The centre is the geometric centre of the end surface.

Certain regulations for determining quality class (grading) include a length deduction. Length deduction means that the measured log length is reduced to increase the quality of the log; the volume of a defective part of the log is deducted when determining the volume for a commercial transaction. For length deduction, both gross and net length are to be calculated.

When the price relates to certain module lengths, e.g. 3-dm modules, the excess is calculated, i.e. the difference between the net length of the log and the length on which the price is based.

The following lengths may then need to be measured or calculated:

- Gross length: the full length of the log.
- Net length: The length of the log after any length deduction.
- Length on which price is based: based on the module length in the pricelist that is the exact length, or the one below the log's net length, and that gives the quantity forming the basis of payment according to the price list.
- Excess: difference between the net length and the length on which the price is based; this is a measure of the quantity that is not paid for according to the price list.

Where payment is made for excess length, the quantity on which the price is based equals the net quantity, so the excess is always zero.

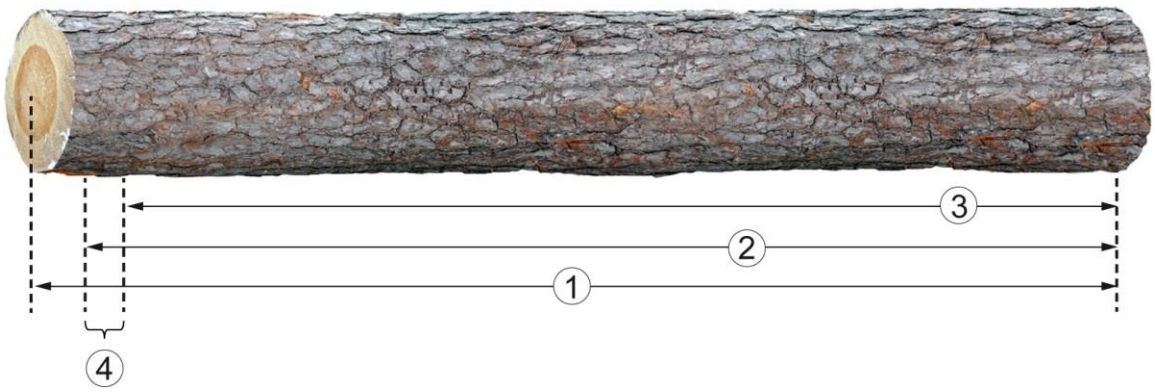

Figure 3. Gross length (1), net length (2), length on which price is based (3), and excess (4).

2.2 Log diameter

2.2.1 Measurement directions, diameter deduction, and measurement units

Diameter is measured under bark, perpendicular to the mid-line of the log. Measurement points for different measurement methods are described in chapter 3. If the measurement point is covered with snow, ice, soil or similar, affecting the log measurements, a reasonable correction must be made. Where mechanical damage has occurred, such as through skidding, the diameter is measured in an orientation not affected by the damage. Diameter can be measured in one or more directions.

When measurement is in one direction, this direction must be chosen randomly, such as by choosing the same direction for logs placed on a hoist or measurement bench (also called 'convenient diameter measure'). If the log is distinctly oval at the measurement point, i.e. the

log's largest diameter exceeds the smallest diameter by more than 10%, manual measurement[1] must be carried out using cross-callipering.

Where measurement is in two directions (cross-callipering), the first direction must be chosen as for a one-direction measurement. The second direction must be perpendicular to the first. An exception is made for a clearly oval measuring point, where cross-callipering measures the largest and smallest diameter. The diameter is then the mean of the two measurement directions.

For measurement in a 3D scanner, any number of measurement directions can be used.

In manual checks of measurements, cross-callipering is used.

Certain regulations for determining quality class (grading) include a diameter deduction. This means that the log diameter is reduced to increase the quality, because the volume of a defective part of the log is deducted when determining the volume on which the price is based. All measurement points on the log must be allocated the same diameter deduction. For diameter deduction, both gross and net diameter are to be calculated.

The largest permitted measurement unit for diameter is 1 cm. When the measurement unit is 1 cm, the class bottom is recorded, and the volume is calculated using the middle of the measurement class. When the measurement unit is 1 mm, the figure is rounded to the nearest mm according to Swedish Standard.

2.2.2 Adjustment for bulges

The diameter measurement must be adjusted at bulges, for example at whorls or closed forks. Measured from the butt end, the diameter must not increase along the log. At a bulge (*burl* or *burr*), the log is given the smallest diameter occurring between the bulge and within 50 cm towards the butt end of the log, counted from the point of the biggest diameter of the bulge.

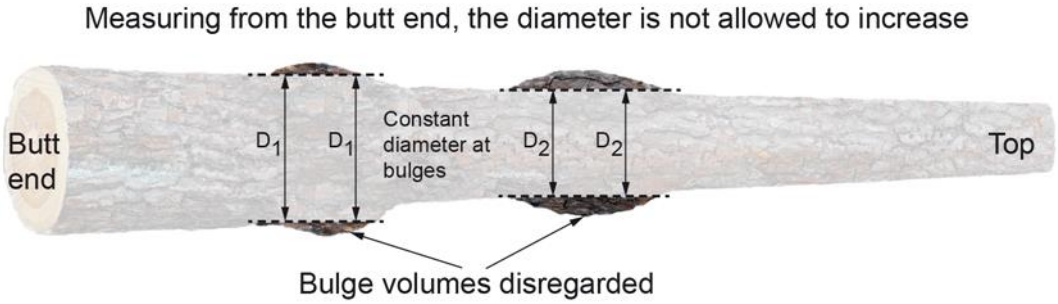

Figure4. The diameter is adjusted at bulges. Measuring from the thick end of the log, diameter measurements must not increase along the log. Of practical reasons, thinner diameters are searched within 50 cm from the top of the bulge.

[1] Manual callipering must be performed with a moderate and constant pressure between the jaws. When diameter is measured over bark, the pressure of the jaws must not be so great that the bark is squeezed, or so slight that lichen or bark flakes affect the measurement.

2.2.3 Diameter measurement of logs with open or closed forks

A log is defined as having a fork if the fork limb's diameter (d) under bark is at least half of the main stem's diameter (D) and is at least 30 mm under bark (see Figure 5). If these conditions are not fulfilled, the thinner stem section is regarded as a branch.

A fork is open if there is air between the fork limbs, and closed if there is no air between the fork limbs. Logs with sudden large diameter changes (> 30 mm) caused by a fork limb being cut off are regarded as logs with a closed fork.

Figure 5. A limb is defined as a fork if its diameter (d) is at least half of the main stem's diameter (D), measured at the base of the fork. A fork can be either open or closed.

An open/closed fork that does not reach the upper half the log length is not included in the volume measurement. If the open/closed fork affects the top half of the log, the log's top diameter is recorded as the measured top diameter increased by one-third of the top diameter of the thickest fork limb (Figure 6). D + D/3 can be greater than the butt diameter. If the log has a closed fork at the measurement point, the log's diameter is measured by cross-callipering.

Corresponding regulations apply for determining the butt diameter of a forked log in cases where the fork begins below the butt measurement point.

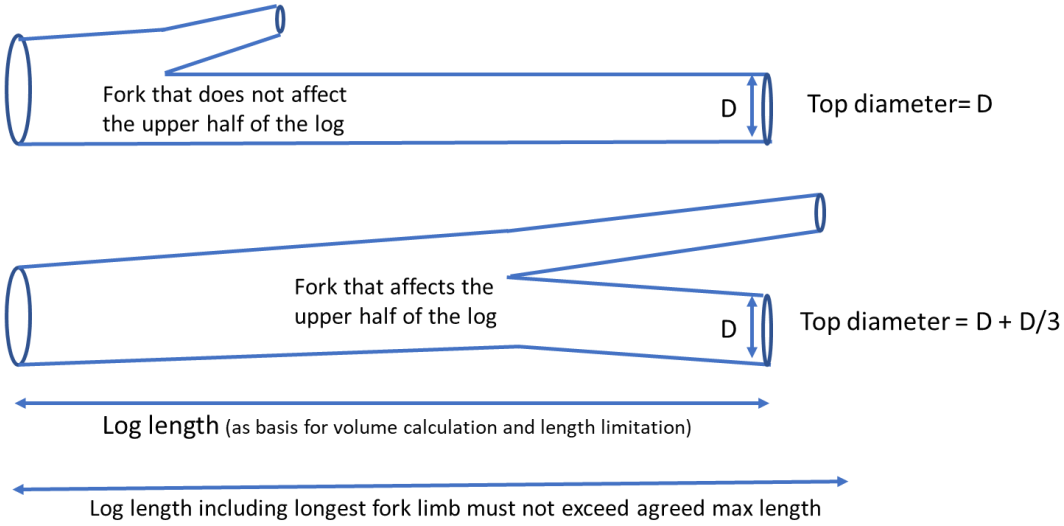

Figure 6. Measurement of log with fork. In the upper diagram, the fork limb does not reach the upper half of the log, so the top diameter of the log is D. In the lower diagram, the fork limb affects the upper half of the log, so the top diameter of the log is D+D/3. Log length is measured at the thickest fork limb. Log length including the longest fork limb must not exceed agreed max length.

2.3 Manually assessed deduction for bark – bark functions

When diameter is measured over bark, the measurement under bark is obtained by deducting double bark thickness (bark deduction). When the diameter is measured manually, the bark deduction is determined by assessing bark thickness.

When the diameter is measured automatically in scanners, assessments in combination with bark functions are used. In section measurement of butt logs of pine and spruce, bark functions according to Appendix 1 or Appendix 3 are used. In other cases involving pine and spruce, regional bark functions according to Appendix 1 are used. For pine, the bark is divided into thin, medium, or thick types in the functions. For spruce, the bark is divided into thin and thick types. Where a measurement site handles wood from a large geographical area, the bark functions must be adapted in relation to the estimated geographical distribution of the sawlogs.

The bark type is assessed at the measurement point. Because bark abrasion can affect the diameter recorded at the measurement point, this is assessed 0-20 cm from the measurement point in the direction towards the butt end of the log.

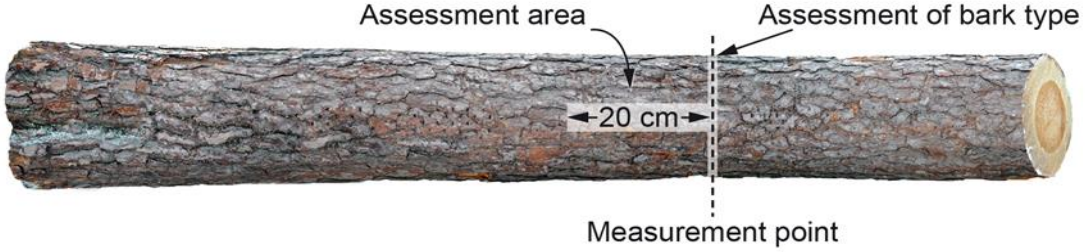

Figure 7. In automatic measurement of diameter, the bark type is assessed at the measurement point. Bark abrasion is assessed in the area 0-20 cm from the measurement point in the direction towards the butt end of the log.

Automatic measurement of diameter in 3D scanner.

For automatic measurement of diameter in a 3D scanner, Table 1 is used to determine which bark function is to be used. The table concerns pine and spruce.

Table 1. Relationship between bark type (bark thickness class), percentage of bark remaining on the stem, and bark functions (bark code). This information is to be used in automatic measurement of diameter over bark in a 3D scanner. The table concerns pine and spruce.

Bark type	**Bark code**			
	0	1	2	3
	Percentage of bark remaining			
None	0	-	-	-
Thin	-50	50 -	-	-
Medium	-25	25-75	75.	-
Thick	-25	25-75	75-90	90-

Automatic measurement of diameter with one measurement direction

If the log's rotational position is not changed between assessment and diameter measurement (e.g. measurement on lengthwise conveyors), bark abrasion is assessed at the point of contact between the measurement direction and the log. If there is so much bark abrasion that the equipment is assessed to measure the diameter on bare wood, 'no bark' is recorded. In assessment of logs on crosswise conveyors, 'no bark' is recorded if the bark is abraded on more than half the circumference (see figure 8). If there is bark at the point of contact (lengthwise conveyor) or covers more than 50% of the cross-section (crosswise conveyor), the bark type is classified as thin, medium, or thick.

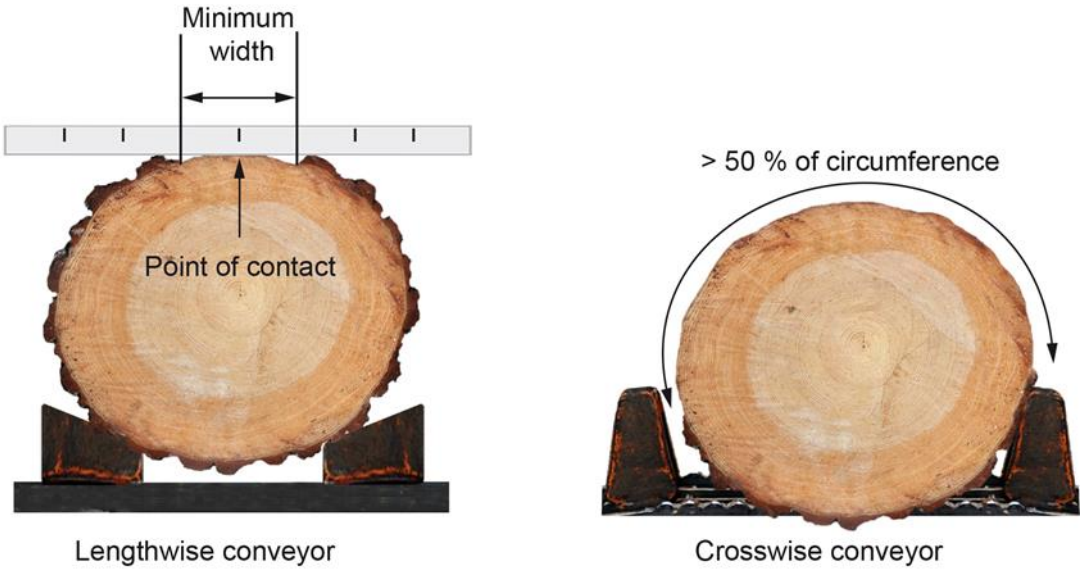

Figure 8. Principles for assessing bark abrasion when measuring logs on lengthwise conveyors (left) and crosswise conveyors (right).

2.4 Automatic measurement of diameter under bark

Measurement of diameter under bark on logs without bark may be carried out automatically if the equipment has type approval from VMK. Examples of technologies/methods are the tracheid method, X-rays, or image analysis.

2.4.1 Diameter measurement under bark using the tracheid method

Certain 3D scanners are based on laser triangulation, in which a camera, mounted at an angle to the hoist track, records where a laser beam meets the log. In these types of scanner, the tracheid method can distinguish whether the measurement is on bark or on wood. If the logs have sufficient bark abrasion, the bark can be excluded and the diameter under bark obtained.

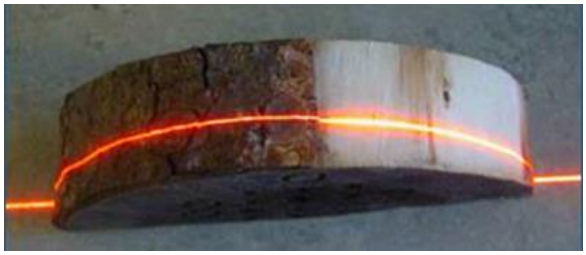

Figure 9. Principle of diameter measurement under bark using the tracheid method The laser beam used in the scanner is more dispersed on wood than on bark. Image analysis measures the width and intensity of the laser beam, distinguishing between wood and bark.

Standard procedure

The standard procedure is based on the bark being abraded on at least 4% of the log's mantle surface. The limit applies regardless of where on the log the bark is abraded. Diameter under bark is calculated using interpolation or extrapolation from adjacent bark abrasion. Bark code 4 indicates that diameter under bark is calculated automatically.

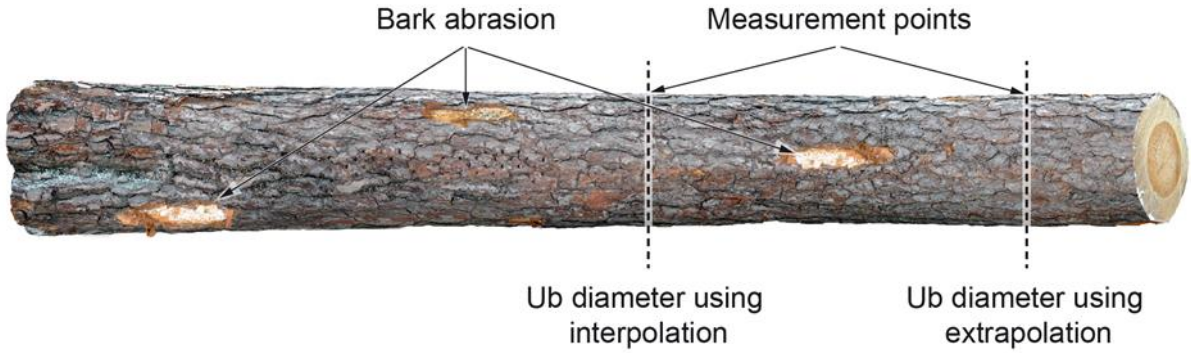

Figure 10. The tracheid method can only be used for diameter measurement if bark is abraded on at least 4% of the log's mantle area. The limit applies regardless of where on the log the bark is abraded.

Procedure where bark abrasion is less than 4%

When the measurement system establishes that bark is abraded on less than 4% of the mantle area of the log, i.e. the bark on the log is almost intact, the bark thickness is determined

instead by using bark functions (Appendix 1 and Appendix 3). For spruce that has not been divided into bark types, bark code 5 is used. For pine, and spruce if it is divided into bark types, bark type (bark thickness class) is assessed manually if the scaler can see the log after the bark abrasion has been determined. In other cases, default codes are used: bark code 6 = thin bark; bark code 7 = medium bark; bark code 8 = thick bark.

Procedure when the tracheid method cannot be used

If there is a lot of snow or ice on the log, if there is blue stain, or if the log has blackened after a long period of watering, the tracheid method cannot be used to distinguish between wood and bark. In such cases, the procedure described in Section 2.3 must be used.

Table 2. Bark codes for 'automatic' measurement of diameter under bark.

Bark codes when equipment for 'automatic' measurement of diameter under bark is used.	**Description**
4	Used when the equipment has automatically calculated a diameter under bark.
5	Used when the equipment shows that the log has intact bark, and the bark has not been allocated a type. The bark function is used, and the result is an automatically calculated diameter under bark.
6-8	Used when the equipment shows that the log has intact bark, and there are different bark functions depending on bark type. The bark type is assessed manually or set automatically dependent on diameter: bark code 6 = thin bark; 7 = medium bark; 8 = thick bark.

2.4.2 Diameter measurement under bark using X-ray equipment

X-ray equipment can be used to detect density differences between wood and bark. The X-ray method may be, but is not necessarily, used in combination with other scanners, where the X-ray measurement gives a bark thickness that is used in the other scanner to calculate diameter under bark. Bark code 4 indicates that diameter under bark is calculated automatically. When the measurement system determines that the density difference between wood and bark is insufficient, e.g. if the logs have dried or have been watered, the procedure described in Section 2.3 must be applied.

2.4.3 Diameter measurement under bark using image analysis

Image analysis can be used to distinguish between wood and bark. The method has many similarities with the tracheid method. In certain cases, bark functions may need to be used in the same way as when the tracheid method is used.

3 Measurement methods to determine log volume under bark

When the log volume is determined using any of the methods described below, the volume is given in cubic metres to at least three decimal places. The volume of timber batch is given in cubic metres to at least two decimal places.

3.1 Top measurement – m³to

In top measurement, the top cylinder volume is calculated, i.e. the volume of a cylinder with the same length as the log and with a diameter equal to the top diameter of the log under bark. The diameter is corrected for any bulging as described in Section 2.2.2. Top measurement may be used on all tree species, regardless of diameter and length. The top diameter is measured 10 cm from the top end of the log. The volume of the log is calculated using the following formula:

Top-measured volume: $V = \frac{\pi}{4} \cdot L \cdot D_t^2 \cdot 10^{-8}$

where V is the log volume in m³to, L is the log length (cm), and D_t is the top diameter (mm).

Figure 11. Measurement point for diameter in top measurement.

3.2 Mid-point measurement – m³sub

Calculating log volume using mid-point measurement involves using a cylinder with the same length as the log and with a diameter equal to the mid-point diameter of the log under bark. The diameter is corrected for any bulging as described in Section 2.2.2. Mid-point measurement may be used on all tree species, regardless of diameter and length. The volume of the log is calculated using the following formula:

Mid-point volume: $V = \frac{\pi}{4} \cdot L \cdot D_{mi}^2 \cdot 10^{-8}$

where V is the log volume in m³sub, L is the log length (cm), and D_{mi} is the mid-point diameter (mm).

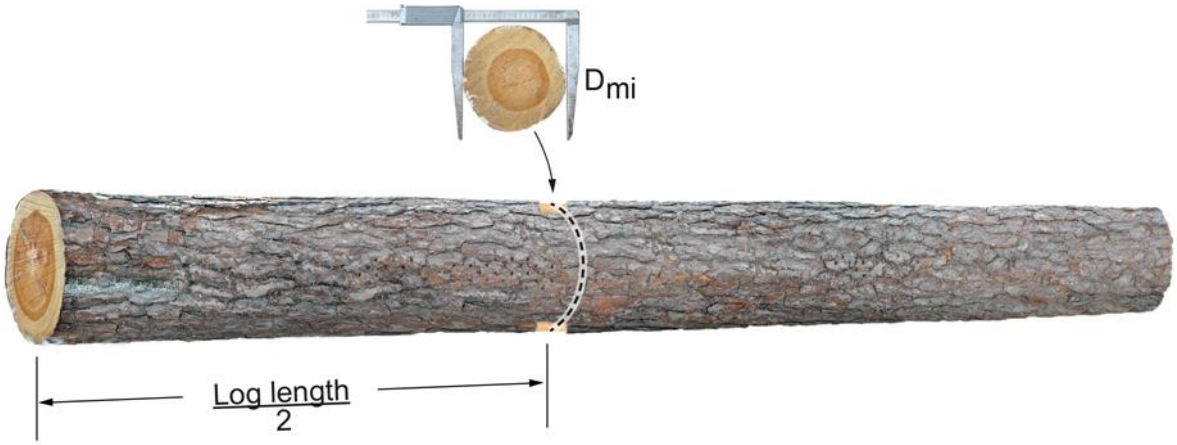

Figure 12. Measurement point for diameter in mid-point measurement.

3.3 Top-butt measurement for pine and spruce assortments for sawing – m³sub

In top-butt measurement, the log volume is determined using two diameter measurements, one from the butt end and one from the top end. This type of top-butt measurement is used for pine and spruce assortments suitable for sawing, and is expressed in m³sub[2]. The measurement is based on the diameter 130 cm from the butt on butt log types, and 10 cm from the butt on other log types, and the diameter 10 cm from the top and log length in the volume calculations. The diameter values are corrected for any bulging as described in Section 2.2.2. The measurement method has different functions for tree species (pine and spruce) and log type, and is adapted for assortments suitable for sawing.

The log type is divided into butt log and other log types, and is determined objectively through the tapering at the butt end. All logs where the difference in diameters over bark 10 cm from the butt compared with 50 cm from the butt exceeds 13 mm are defined as *butt log types*, and all logs with up to 13 mm difference are defined as *other log types*.

Top-butt measured volume for pine and spruce assortments suitable for sawing is calculated using the following formulas.

Butt log type:

$$V_b = a_1 + \frac{(\alpha_2 \cdot D_t^2 + \alpha_3 \cdot D_{r130}^2)}{4} \cdot \pi \cdot L \cdot 10^{-8} + \alpha_4 \cdot D_{r130}$$

Other log type:

$$V_b = \frac{(\alpha_2 \cdot D_t^2 + \alpha_3 \cdot D_{r10}^2)}{4} \cdot \pi \cdot L \cdot 10^{-8}$$

where V_b is the log volume in m³sub, L is the log length (cm), and D_{r10}, D_{r130} and D_t are the respective butt and top diameters (mm). The values for the constants α_1 - α_4 used in the formula are obtained from the table below.

[2] The method applies for log measurement from 1 January 2020.

Table 3. Constants used in the formula for top-butt measurement of pine and spruce assortments suitable for sawing.

Tree species	Log type	α_1	α_2	α_3	α_4
Pine	Butt log	-0.0136	0.314	0.637	0.0001149
	Other		0.524	0.473	
Spruce	Butt log	-0.0180	0.340	0.604	0.0001589
	Other		0.606	0.410	

3.4 Top-butt measurement of other assortments – m³sub

This type of top-butt measurement is used for all assortments apart from pine and spruce assortments suitable for sawing. The diameter is measured 10 cm from each end of the log, with the exception of the butt end of a butt log, where the measurement is taken 50 cm from the end. The diameter values are corrected for any bulging as described in Section 2.2.2. Top-butt measurement may be used for all tree species on logs with a top diameter of ≥ 3 cm and length ≤ 6.5 m. The volume of the log is calculated using the following formula:

Top-butt-measured volume: $V = \frac{\pi}{4} \cdot L \cdot (\alpha D_r^2 + (1-\alpha) D_t^2) \cdot 10^{-8}$

where V is the log volume in m³sub, L is the log length (cm), and D_r and D_t its butt and top diameter respectively (mm). The value for the constant α in the formula is obtained from Table 44.

Table 4. The constant α in the formula for calculating top-butt-measured volume.

Top diameter mm	Length class, cm -349	350-449	450+
		α	
-149	0.485	0.485	0.485
150-249	0.465	0.460	0.455
250 -	0.440	0.430	0.420

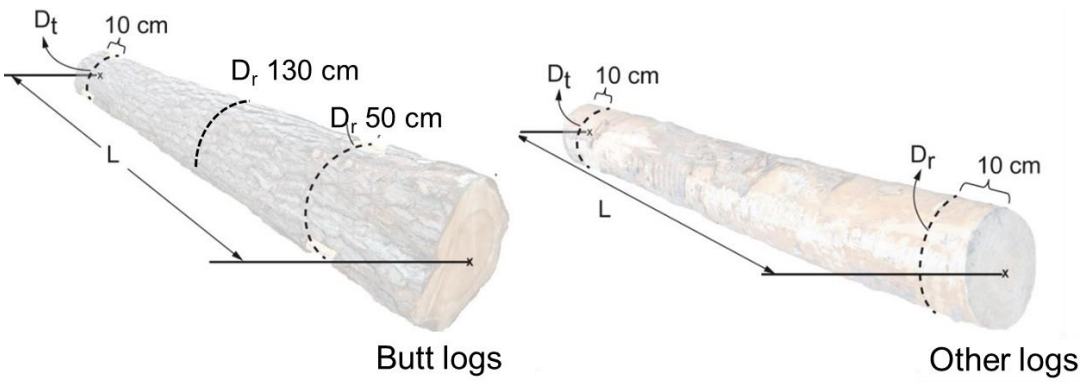

Figure 13. Measurement point for diameter in top-butt measurement. For assortments of pine and spruce suitable for sawing the butt end diameter of butt logs is measured 130 cm from the butt end. For other assortments it is measured 50 cm from the butt end

3.5 Solid volume via top form conversion factor matrix – m³sub

When top form matrices are used, the log volume (equivalent to form-adjusted solid volume) is determined as the product of the top-measured volume and a conversion factor. The method should only be used to calculate volumes for statistical purposes.

Table 5. Schematic example of structure of a top form factor matrix.

Top diameter		**Log length in cm**			
mm	**etc.**	**400-429**	**430-459**	**460-489**	**etc.**
etc.					
150-169					
170-189		*Conversion factor from m^3 to m³sub*			
190-209		*for each square in the matrix*			
etc.					

The top form conversion factor matrices must be well documented and based on relevant data. Solid volume may only be determined using the top form conversion factor matrix for the tree species and the length and diameter intervals covered by the matrix.

3.6 Section measurement – m³sub

Section measurement may be used on all tree species, regardless of log length and diameter. Because a large number of diameters are measured, section measurement is primarily applicable for automatic measurement in a scanner. If snow or ice is present on such a scale that the section-based diameter measurement may be affected in an uncertain way, section measurement may not be used.

3.6.1 Diameters

Diameter measurement points in section measurement

In section measurement, the log is divided into sections no longer than 50 cm. The measurement begins from the butt end of the log (thick end). The length of the final section includes any remaining part-section, i.e. the length of the final section is between one and two section lengths. Every section is measured at the mid-point. The diameter values are corrected for any bulging as described in Section 2.2.2.

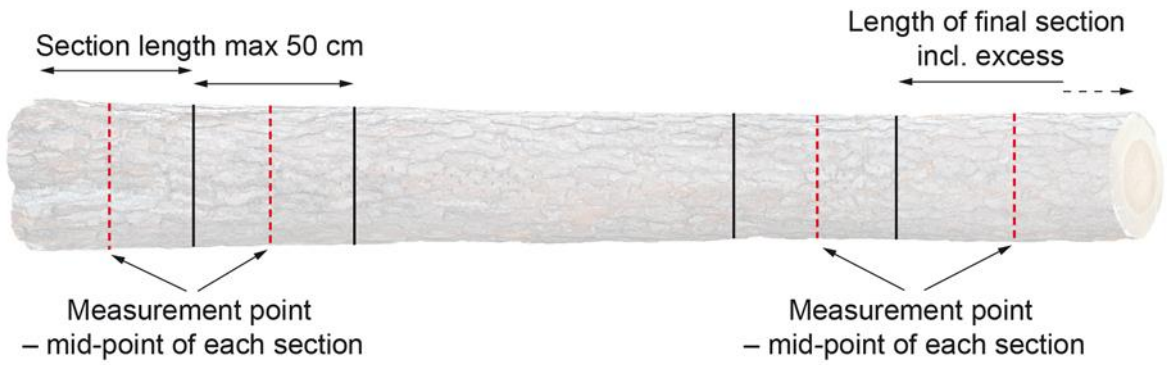

Figure 14. Positions for measuring diameter in section measurement.

Diameters in butt section of butt log – butt function

Compared to the rest of the stem, the butt section in a butt log can have an irregular-shaped cross-section and varying bark thickness. These factors make automatic measurement of diameter under bark difficult, and some mills apply butt reduction before measurement.

Consequently, where butt reduction is a requirement, the diameters of the first 130 cm of the butt log's butt end may be calculated using the functions presented in Appendix 2. The functions are based on the diameter at 130 cm, which is interpolated from the nearest section diameters. The functions give the diameter over bark. Diameter under bark is calculated using the bark function shown in Appendix 3. The butt part function can be used for pine and spruce. When the butt part function is used, all logs must be divided into either butt logs or other logs by the scanner.

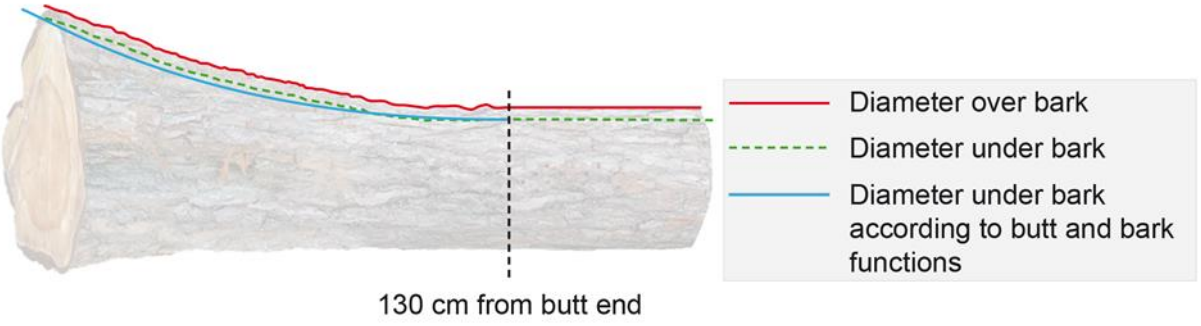

Figure 15. At the butt end of the butt log, the diameters may be determined using the butt function. The function is based on the diameter 130 cm from the butt end.

3.6.2 Volume calculation

For each section, a cylinder volume is calculated based on the mid-point diameter and length of each section. The volume of the log is calculated as the total of the section volumes.

Where diameter deduction is applied (for example, in quality classification of pine, 1 cm for scars and butt crevices), both gross and net volume are to be calculated. When calculating net volume, deductions are made on all diameter measurements before the volume is calculated.

4 Checks of original measurements

Log measurement must be checked by manually measuring randomly selected logs:

- Top measurement in the unit top cylinder volume – $m^3$to
- Top-butt measurement in the unit form-adjusted solid volume – m^3sub

The control unit is the log, and the result from the control measurement is expressed as deviations (ratios) between the original measurement and control with regard to volume, length, and diameter at the desired aggregation level (measurement site, time period, batch, etc).

Control and follow-up includes comparison with top-butt measured volume. Measurement points for control and follow-up of diameter measurements are therefore as follows:

- Butt log: 50 or 130 cm from the butt end and 10 cm from the top end.
- Other logs: 10 cm from the butt and top ends.

5 Revision history

Date	Description
1 January 2014	The instruction may be applied in accordance with the decision of the SDC Board. The instruction replaced the section *Quantity determination – volume measurement of logs* in Measurement Instructions VMR 1-99.
1 August 2016	Title changed from *SDC Instructions* to *Swedish Instructions*. Section 2.4.3 added.
1 April 2017	Table 1 in Section 2.3 changed.
1 January 2018	Section 2.2.1 The sentence *Diameter refers to the diameter equivalent to the cross-sectional area of the log under bark at the measurement point in question* removed.
1 January 2019	VMF Syd, VMF Qbera, VMF Nord and SDC merged to form Biometria
1 October 2020	Top-butt measurement for assortments suitable for sawing added. Title changed to *Swedish regulations...*
1 April 2021	Chapter 2. If there are several saw cuts, length is measured from the one affecting the centre of the end surface. If the log has a fork, the length is measured along the thickest fork limb. A log is defined as having a fork if the fork limb's diameter (d) under bark is at least half of the main stem's diameter. Chapter 3.5. The method should only be used to calculate volumes for statistical purposes.

Appendices

Appendix 1. Functions for calculating the size of bark deduction in automatic measurement of diameter

Report R 90, 1974 from the Royal College of Forestry, Department of Wood Technology (Peter Zacco, Bark Thickness in Sawlogs) contains functions of the type Y = a + bX, where Y = double bark thickness, X = top diameter over bark, and a and b are constants. For pine, the report contains functions for 13 geographical areas and three bark type (thickness classes). For spruce, there are functions for 11 geographical areas, but no division according to bark type.

In the following functions, y corresponds to double bark thickness in mm and x is the top diameter of the log in mm. Counties are shown in bold font.

Pine

	Bark type area	Bark function	
1.	**Norrbotten**	thin bark:	y = 2.00 + 0.0153x
		medium bark:	y = 1.89 + 0.0238x
		thick bark:	y = -0.26 + 0.0458x
2.	**Västerbotten**	thin bark:	y = 2.82 + 0.0151x
		medium bark:	y = 3.21 + 0.0215x
		thick bark:	y = 3.03 + 0.0383x
3.	**Västernorrland**, **Jämtland**, except the municipalities in Area 4.	thin bark:	y = 2.81 + 0.0156x
		medium bark:	y = 2.50 + 0.0270x
		thick bark:	y = 2.77 + 0.0406x
4.	Härjedalen municipality in **Jämtland**, **Gävleborg**, except the municipalities in Area 5	thin bark:	y = 2.73 + 0.0157x
		medium bark:	y = 2.72 + 0.0260x
		thick bark:	y = 2.72 + 0.0430x
5.	Ockelbo, Gävle, Sandviken and Hofors municipalities in **Gävleborg**, **Dalarna**, Torsby municipality and northern part of Hagfors municipality in **Värmland**	thin bark:	y = 2.23 + 0.0161x
		medium bark:	y = 4.39 + 0.0167x
		thick bark:	y = 3.12 + 0.0394x
6.	**Värmland**, except the municipalities in Area 5, **Örebro**, **Västmanland**	thin bark:	y = 3.33 + 0.0147x
		medium bark:	y = 3.83 + 0.0236x
		thick bark:	y = 2.40 + 0.0487x
7.	**Uppsala**, **Stockholm**, **Södermanland**	thin bark:	y = 2.46 + 0.0172x
		medium bark:	y = 1.36 + 0.0329x
		thick bark:	y = -3.15 + 0.0744x
8.	Bengtsfors, Åmål, Mellerud, Färjelanda and Vänersborg municipalities in **Älvsborg**,	thin bark:	y = 3.41 + 0.0166x
		medium bark:	y = 2.81 + 0.0373x

	former county of **Skaraborg**, **Östergötland** except municipalities in Area 12	thick bark:	y = 5.27 + 0.0494x
9.	Former county of **Göteborg-Bohus**	thin bark: medium bark: thick bark:	y = 1.85 + 0.0281x y = 1.63 + 0.0507x y = 4.36 + 0.0625x
10.	**Halland**	thin bark: medium bark: thick bark:	y = 2.90 + 0.0176x y = 3.84 + 0.0287x y = 0.27 + 0.0625x
11.	**Älvsborg**, except the municipalities in Area 8, **Jönköping**, **Kronoborg**	thin bark: medium bark: thick bark:	y = 4.07 + 0.0102x y = 4.91 + 0.0241x y = -0.18 + 0.0728x
12.	Eastern parts of Norrköping and Åtvidaberg municipalities and Söderköping and Valdemarsvik municipalities in **Östergötland**, **Kalmar**	thin bark: medium bark: thick bark:	y = 2.50 + 0.0231x y = 4.17 + 0.0344x y = 1.71 + 0.0671x
13.	**Blekinge** and **Skåne**	thin bark: medium bark: thick bark:	y = 2.91 + 0.0144x y = 4.86 + 0.0278x y = 4.82 + 0.0547x

	Spruce **Bark type area**	**Bark function**
1.	**Norrbotten** and **Västerbotten** northwest of the Pajala-Arvidsjaur-Dorotea line (= Inland Line)	y = 3.10 + 0.0496x
2.	**Norrbotten** and **Västerbotten,** except parts in Areas 1 and 3	y = 2.54 + 0.0475x
3.	**Västerbotten** coastal area, i.e. the area southeast of the Skellefteå-Medle-Norrfors line (= Coastal Line)	y = 4.60 + 0.0342x
4.	**Jämtland** northwest of the line Dorotea-Strömsund- Östersund-Svenstavik-Rätansbyn (= Inland Line) except Härjedalen municipality	y = -0.11+ 0.0540x
5.	**Västernorrland**, **Jämtland**, **Gävleborg**, **Kopparberg**, **Örebro**, **Västmanland**, **Uppsala**, **Stockholm**, **Södermanland**, **Östergötland**, **Jönköping**, **Kronoberg**, **Älvsborg** and the former **Göteborg-Bohus**, except the parts in Areas 4, 6, 7, 8 and 10	y = 3.28 + 0.0370x
6.	**Västernorrland** and **Gävleborg** coastal area, i.e. the area east of the Norrfors-Bollstabruk-Stöde-Delsbo-Arbrå-Jädraås-Hofors line	y = 2.47 + 0.0368x
7.	Härjedalen municipality in **Jämtland**	y = -0.92 + 0.0647x

8.	Älvdalen and Malung municipalities, and western and northern parts of Mora municipality in **Dalarna**	y = 4.09 + 0.0426x
9.	**Värmland** and the former county of **Skaraborg**	y = 4.08 + 0.0294x
10.	Eastern parts of Norrköping and Åtvidabergs municipalities and Söderköping and Valdemarsvik municipalities in **Östergötland**, **Kalmar**	y = 3.18 + 0.0420x
11.	**Halland**, **Blekinge**, **Skåne**	y = 3.38 + 0.0323x

Where a measurement site receives timber from different geographical areas, the bark functions applied must be adjusted in relation to the estimated geographical distribution of the sawlogs.

Appendix 2. Functions for calculating diameter over bark at the butt end of the butt log

The following functions are part of the Finnish Ministry of Agriculture and Forestry's *Ordinance on measurement of volume of timber that has been felled by machine using the machine's measurement device* (Ordinance no. 15/06, Helsinki, Finland, 2006).

When determining the diameters over bark for the butt end of the butt log (0.0-1.3 m), the following formula is used:

$$D_L = \left[1 + \left(a_0 * (1{,}3 - L) + a_1 * (1{,}3 - L)^{a_2} \right) / 100 \right] * D_{1,3} \qquad \text{(Formula 1)}$$

where

D_L = diameter at a distance of L from the logging cut (cm)
$a_0..a_2$ = parameters according to tree species, obtained using formulas 2-4
L = distance from logging cut (m)
$D_{1,3}$ = diameter at a distance of 1.3 m from logging cut (cm)

Factors such as tree species and the thickness of the tree affect the shape of the butt end. Parameters for the butt end ($a_0..a_2$) are established on the basis of models for the tree species, where the diameter of the tree 1.3 m from the logging cut is the independent variable. The following formulas include the models for the parameters:

$$a_0 = a_{00} + a_{01} * D_{1,3} + a_{02} * D_{1,3}^{\ 2} + a_{03} * D_{1,3}^{\ 3} + a_{04} * D_{1,3}^{\ 4} \qquad \text{(Formula 2)}$$

$$a_1 = a_{10} + a_{11} * D_{1,3} + a_{12} * D_{1,3}^{\ 2} + a_{13} * D_{1,3}^{\ 3} \qquad \text{(Formula 3)}$$

$$a_2 = a_{20} + a_{21} * D_{1,3} + a_{22} * D_{1,3}^{\ 2} \qquad \text{(Formula 4)}$$

where

$D_{1.3}$ = min (45;$D_{1.3}$) *
$a_{00}..a_{22}$ = coefficients for different tree species in Table 1

* When large trees are involved ($d_{1.3}$ > 45 cm) the butt end's relative shape is assumed to be the same as on 45-cm stems. This is calculated so that the maximum value of Formulas 2-4 is limited to 45 (cm).

Table 1. Coefficients by tree species.

Tree species	**a_{00}**	**a_{01}**	**a_{02}**	**a_{03}**	**a_{04}**
Pine	24.30	- 1.324	0.039372	- 0.0003850	0
Spruce	30.46	- 3.399	0.181337	- 0.0043459	0.00003908
	a_{10}	**a_{11}**	**a_{12}**	**a_{13}**	
Pine	1.00	0.381	- 0.006291	0	

Spruce	- 0.35	0.143	0.016430	- 0.0003800	
	a_{20}	a_{21}	a_{22}		
Pine	7.70	- 0.233	0.003056		
Spruce	12.65	- 0.556	0.008019		

Appendix 3. Functions for estimating bark thickness in harvester-felled pine and spruce

(Björn Hannrup, 2004, Arbetsrapport 575, Skogforsk, Uppsala)

PRAKTISK TILLÄMPNING AV DEN NYA BARKFUNKTIONEN FÖR TALL

Som stöd för praktisk implementering sammanfattas den nya tallfunktionen (Sf_tall) och dess begränsningar nedan. Motsvarande sammanfattning återfinns i Arbetsrapporten (nr. 575) som beskriver framtagningen av barkfunktionerna. De förändringar av texten (ändrad övre brösthöjdsdiameter) som är gjorda jämfört med Arbetsrapporten är markerade med fet, kursiv stil.

dbh_b=min(dbh,***480***) /* Sätter brösthöjdsdiametrar överstigande ***480*** mm till ***480*** mm. Den nya variabeln ges namnet dbh_b för att hållas separat och inte orsaka fel vid volymsberäkningarna. */

h_{tg}=-ln(0.12/(72.1814+0.0789*dbh_b-0.9868*lat))/(0.0078557-0.0000132*dbh_b) /* Beräknar brytpunkten för funktionen i cm */

db=3.5808+0.0109*dbh_b+(72.1814+0.0789*dbh_b-0.9868*lat)*exp(-(0.0078557-0.0000132*dbh_b)*h) /* Beräknar dubbla barktjockleken nedan brytpunkten i mm */

if h>h_{tg} then db=3.5808+0.0109*dbh_b+0.12-0.005*(h-h_{tg}) /*Beräknar dubbla barktjockleken ovan brytpunkten i mm */

db=max(db, 2) /* Sätter beräknade dubbla barktjocklekar under 2 mm till 2 mm */

PRAKTISK TILLÄMPNING AV DEN NYA BARKFUNKTIONEN FÖR GRAN

Den nya granfunktionen (Sf_gran) sammanfattas nedan.

reldia=dia/dbh /* Relativa diametern beräknas som aktuell diameter genom brösthöjdsdiametern */

```
db=0.46146+0.01386*dbh+0.03571*dbh*reldia    /* Beräknar dubbla barktjockleken i mm */
```

db=max(db, 2) /* Sätter beräknade dubbla barktjocklekar under 2 mm till 2 mm */

Swedish Regulations for Timber Measurement are adopted by the Biometria Board on the basis of recommendations from RMR (Council for Measurement and Reporting). The documentation for RMR is prepared by the Biometria department for development and IT.

The regulations are published on www.biometria.se.

Postal address
Biometria ek för
Box 89
751 03 UPPSALA

W: www.biometria.se

E: info@biometria.se

T: 010-228 50 00