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BY EMAIL

To: Regional Managers

From: Bill Howard
Director
Revenue Branch

Re: *Scaling Manual*, Amendment No. 5

The purpose of this memo is notify you of the above amendment, provide you with the attached summary of the amendment, and ask that you advise all scaling staff.

For your information, the *Scaling Manual* can be found at:
<http://www.for.gov.bc.ca/hva/manuals/scaling/index.htm>

The manual may also be purchased through Crown Publications, 521 Fort Street, Victoria, British Columbia, V8W 1E7 (telephone 250-386-4636). Crown Publications will advise out of service manual holders of the amendment.

If you have any questions, please contact Jim Crover, Scaling Policy Forester, Revenue Branch at Jim.Crover@gems9.gov.bc.ca (telephone 250-356-1955) or Robert Frear, Technical Scaling Co-ordinator, Revenue Branch at Robert.Frear@gems6.gov.bc.ca (telephone 250-356-7673).



Bill Howard
Director
Revenue Branch

Attachment

pc: Ministry of Forests Subscribers, *Scaling Manual*



**BRITISH
COLUMBIA**

Ministry of
Forests



MANUAL REVISION TRANSMITTAL

<p>FOR FURTHER INFORMATION OR IF YOU HAVE A CHANGE OF ADDRESS, PLEASE CONTACT:</p> <p>Jim Crover Scaling Policy Forester Revenue Branch Ministry of Forests 6th Floor - 727 Fisgard Street Victoria, BC V8W 1R8 Phone: 356-1955 PROFS userid: Jim.Crover@gems9.gov.bc.ca FAX: 387-5670</p>	MANUAL TITLE	
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W. Howard Director, Revenue Branch		

Please make the following changes to your copy of the above Ministry manual.

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5.2.3 Smalian's Formula - Example Calculation

If the log illustrated in Figure 5.4 is given a top radius "*T*" of 9 cm (9 rads in diameter), a butt radius "*B*" of 11 cm (11 rads in diameter), and a length "*L*" of 9 m.

Fully expressed, Smalian's formula states:

$$V = \left(\frac{\frac{\pi T^2}{10\,000} + \frac{\pi B^2}{10\,000}}{2} \right) L$$

Substitute the variables "*T*", "*B*" and "*L*" with the logs dimensions:

$$V = \left(\frac{\frac{\pi 9^2}{10\,000} + \frac{\pi 11^2}{10\,000}}{2} \right) 9.0$$

Calculate the area of the two ends in square centimetres:

$$V = \left(\frac{\frac{254.468\,952}{10\,000} + \frac{380.132\,632}{10\,000}}{2} \right) 9.0$$

Divide each area by 10 000 to change square centimetres to square metres:

$$V = \left(\frac{0.025\,446\,895\,2 + 0.038\,013\,263\,2}{2} \right) 9.0$$

Sum the areas of the two ends and divide by two to average the areas:

$$V = 0.031\,730\,079\,2 \times 9.0$$

Multiply the average end area by the length in metres to yield the volume:

$$V = 0.285\,570\,712\,8\,m^3,$$

Round the volume of the log to 3 decimal places:

$$\text{Volume} = 0.286\,m^3$$

5.2.4 Smalian's Formula - Simplified for Field Use

The fully expressed Smalian's formula described in Section 5.2.3 contains three constants; " π ", 10 000, and "2". For field use, the formula may be simplified by reducing these constants to one constant, expressed as " C ". Smalian's formula is:

$$V = \left(\frac{\frac{\pi T^2}{10\,000} + \frac{\pi B^2}{10\,000}}{2} \right) L$$

By rearranging the terms to consolidate the constants, the formula becomes:

$$V = (T^2 + B^2) L \left(\frac{\pi}{20\,000} \right)$$

The value of " C " is therefore:

$$C = \frac{\pi}{20\,000}$$

$$C = 0.000\,157\,079\,6$$

Using the constant " C " provides for Smalian's simplified formula:

$$V = (T^2 + B^2) \times L \times C$$

where: V = the volume of the log in cubic metres,

T = the top radius in centimetres (or the diameter in rads),

B = the butt radius in centimetres (or the diameter in rads),

L = the length in metres, and

C = 0.000 157 079 6 (the constant).

5.2.5 Smalian's Field Formula - Example Calculation

Using the simplified Smalian's field formula developed in Section 5.2.4 and substituting the log dimensions from Figure 5.4 into the formula, the volume of the log may be calculated in fewer steps than with the long formula demonstrated in Section 5.2.3. Many pocket calculators will not carry this number of decimals, so one may use 1.570 796 and divide by 10000 after multiplication.

$$\begin{aligned}
 V &= (T^2 + B^2) \times L \times C \\
 V &= (09^2 + 11^2) \times 9.0 \times 0.000\ 157\ 079\ 6 \\
 V &= (81 + 121) \times 9.0 \times 0.000\ 157\ 079\ 6 \\
 V &= 202 \times 9.0 \times 0.000\ 157\ 079\ 6 \\
 V &= 1\ 818 \times 0.000\ 157\ 079\ 6 \\
 V &= 0.285\ 570\ 71
 \end{aligned}$$

Round the volume of the log to 3 decimal places:

$$\text{Volume} = 0.286\ m^3$$

5.2.6 The Application of Smalian's Formula

Most scalers derive log volumes from the BC Metric Scale Stick, from the FS 546 *Table of the Half Volume of Cylinders in Cubic Decimetres* or from computer software. All of these methods, while still based upon Smalian's formula, save unnecessary arithmetic, but scalers must know and be able to use the formula in situations where these tools are not available.

Scalers must be able to demonstrate their knowledge and comprehension of the principles underlying scaling by stating the full version of Smalian's formula and by calculating volumes with either the full or simplified version on the written portion of the Licenced Scaler's Exam.

All persons designing software for scaling purposes must employ Smalian's formula and have the software approved by the Ministry of Forests. Additional information on volume calculation and compilation standards is found in Chapter 7, Appendix 7B. Information on approval procedures can be obtained from a regional office of the Ministry of Forests.

5.3 Scaling Tools

All scaling computation software and measuring devices must comply with Ministry of Forests and/or CSA standards for accuracy (CSA CAN3-0302.1-M86-12.x). It is the responsibility of scalers to ensure the accuracy of their equipment.

5.3.1 Tally sheets

Tally sheets are used to record scale data. The data is then key-punched into computers which use Smalian's formula to calculate volumes, or hand-compiled from the scale stick or *FS 546 Table of the Half Volume of Cylinders in Cubic Decimetres*. The summarized information is then submitted on Ministry approved forms. Chapter 7 details the selection and use of the approved forms to be used in different types of scales.

5.3.2 Hand-held Computers

Hand-held computers and data capture units, using ministry approved scaling software are now preferred over the tally sheet and summary sheet system. After entering the data, the machine generates a detailed log listing and a summary report including volumes by species and grades automatically. These computer generated forms may be submitted in lieu of the above tally sheet system, thereby substantially reducing the time required to manually determine volumes and complete the forms.

5.3.3 Volume Tables

The *FS 546 Table of the Half Volume of Cylinders in Cubic Decimetres* contains half volumes of cylinders with lengths from 2 m to 29.9 m and radii from 1 cm to 100 cm (diameters from 1 rad to 100 rad). It is often used to assist in hand compiling log volumes.

5.3.4 Measuring Tapes

The metric steel loggers' tape, calibrated to 0.05 m (0.5 dm) increments, is used to measure log lengths.

5.8.3.1.4 Field Calculation - Diameter or Radius Deduction

Using unit volumes off the scale stick, find the unit volume for the top end measurement and subtract the unit volume of the defect.

$$\begin{array}{rcl} \text{Unit volume, top (16 r)} & = & 80 \text{ dm}^3 \\ \text{Less the unit volume, top defect (8 r)} & = & \underline{- 20 \text{ dm}^3} \\ \text{Net unit volume} & = & 60 \text{ dm}^3 \end{array}$$

Find the rad class corresponding closest to the unit volume of 60 dm^3 , which is 14 rads.

Calculate the unit volume for the butt end measurement and subtract the unit volume of the butt end defect.

$$\begin{array}{rcl} \text{Unit volume Butt (20 r)} & = & 126 \text{ dm}^3 \\ \text{Less unit volume Butt defect (10 r)} & = & \underline{- 31 \text{ dm}^3} \\ \text{Net unit volume} & = & 95 \text{ dm}^3 \end{array}$$

Find the rad class corresponding closest to the unit volume of 95 dm^3 , which is 17 rads.

The volume corresponding to the net dimensions of 7.4 m by 14 r by 17 r is 565 dm^3 .

Record the net dimensions as 074/14/17.

Use the diameter or radius deduction method only if heart defect or hole runs the full length or exactly half the length of the log.

5.8.3.2 Heart Defect - Partial Length of the Log

5.8.3.2.1 Example and Illustration - Heart Rot, Partial Length

The heart rot visible at the butt end of the log shown in Figure 5.40 is estimated to travel 4.0 m and the diameter of the rot is assumed to be the same at both ends (10 rads).

Although not demonstrated in this example, the diameter deduction method may be used if rot is assumed to travel exactly half-way or is through running.

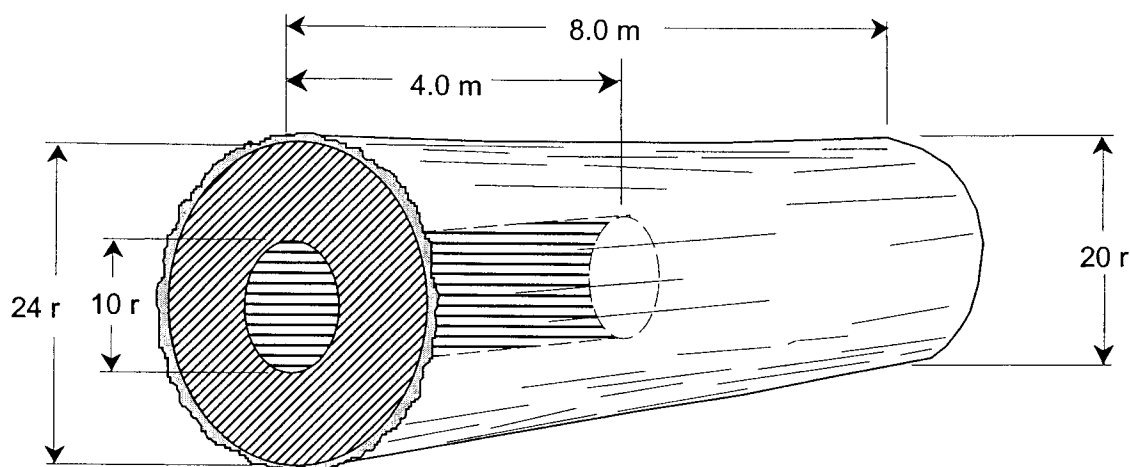


Figure 5.40 A log with partial length heart rot.

5.8.3.2.2 Formal Calculation - Heart Rot, Partial Length

Using the cylinder deduction formula described in Appendix 5B, the net volume of the log is calculated to be 1.100 m³.

5B.1.1 The Cone Formula (Volume of a Cone)

The formula that is used to find the volume of a conical defect is expressed as follows, where the volume of a cone is one third of the volume of a cylinder with the same basal diameter:

$$V = \frac{(DB^2 + DB^2) \times DL \times F}{3}$$

The complete formula for finding the net volume of a log with a conical defect is expressed as follows, where the volume of the cone of defect is subtracted from the volume of the cylinder of firm wood:

$$V = \left[(T^2 + B^2) \times L \times F \right] - \left[\frac{(DB^2 + DB^2) \times DL \times F}{3} \right]$$

5B.1.2 The Cone Formula (Volume of a Frustum of a Cone)

The formula that is used to find the volume of a conical defect is expressed as follows, where the volume of the frustum of a cone is one third of the volume of the sum of the square of the top and butt diameters plus twice the product of the top and butt diameters, times the length:

$$\blacktriangleright \quad V = \frac{\left[DT^2 + DB^2 + (DT \times DB) \right] \times DL \times F \times 2}{3}$$

The complete formula for finding the net volume of a log with a conical defect which is visible at both ends is expressed as follows, where the volume of the defect is subtracted from the volume of the cylinder of firm wood:

$$\blacktriangleright \quad V = \left[\left[T^2 + B^2 \right] \times L \times F \right] - \left[\frac{\left[DT^2 + DB^2 + (DT \times DB) \right] \times DL \times F \times 2}{3} \right]$$

5B.1.3 The Cylinder Formula (Volume of a cylinder)

The formula that is used to find the volume of a cylindrical defect is expressed as follows, using Smalian's shortened formula:

$$V = (DT^2 + DB^2) \times DL \times F$$

The complete formula for finding the net volume of a log with a cylindrical defect is expressed as follows where the volume of the cylinder of defect is subtracted from the volume of the cylinder of firm wood:

$$V = [(T^2 + B^2) \times L \times F] - [(DT^2 + DB^2) \times DL \times F]$$

A variant of the formula used for finding the net volume of a log with a ring defect and is expressed as follows, where the volume of the inner core of sound wood is subtracted from the volume determined from the outside diameters of the ring before subtracting its volume from the gross volume of the log:

$$V = [(T^2 + B^2) \times L \times F] - [(ODT^2 + ODB^2) \times DL \times F] - [(IDT^2 + IDB^2) \times DL \times F]$$

A variant of the formula used for finding the net volume of a log with a sapwood defect is structured the same as the one used above for a ring defect, except that the variables *ODT* and *ODB* are replaced with *T* and *B*, and the variables *IDT* and *IDB* are replaced with *NDT* and *NDB*.

5B.1.4 The Four-sided Prism Formula (Volume of a Rectangular Box)

The formula that is used to find the volume of a rectangular defect is expressed as follows:

$$V = \frac{[(DHT \times DWT) + (DHB \times DWB)] \times DL \times 0.0004}{2}$$

The complete formula for finding the net volume of a log with a rectangular defect is expressed as follows where the volume of the defect is subtracted from the volume of the log cylinder:

$$V = [(T^2 + B^2) \times L \times F] - \left[\frac{[(DHT \times DWT) + (DHB \times DWB)] \times DL \times 0.0004}{2} \right]$$

5B.7 The Heart Defect Calculation in Chapter 5, Figure 5.40

Using the formula for finding the net volume of a log with a cylindrical defect which does not project completely through the log:

$$V = \left[(T^2 + B^2) \times L \times F \right] - \left[(DT^2 + DT^2) \times DL \times F \right]$$

Where the following values are substituted for the variables:

$$T = 20 \text{ rads,}$$

$$B = 24 \text{ rads,}$$

$$L = 8.0 \text{ m,}$$

$$F = 0.0001570796,$$

$$DT = 10 \text{ rads,}$$

$$DL = 4.4 \text{ m,}$$

$$\blacktriangleright V = \left[(20^2 + 24^2) \times 8.0 \times 0.0001570796 \right] - \left[(10^2 + 10^2) \times 4.0 \times 0.0001570796 \right]$$

$$\blacktriangleright V = [976 \times 8.0 \times 0.0001570796] - [200 \times 4.0 \times 0.0001570796],$$

$$V = 1.226 - 0.126,$$

$$V = 1.100 \text{ m}^3.$$

5B.8 The Ring Defect Calculation in Chapter 5, Figure 5.41

Using the formula used for finding the net volume of a log with a ring defect which projects through a log:

$$V = [(T^2 + B^2) \times L \times F] - [(ODT^2 + ODB^2) \times DL \times F] - [(IDT^2 + IDB^2) \times DL \times F]$$

Where the following values are substituted for the variables:

$$T = 27 \text{ rads,}$$

$$B = 35 \text{ rads,}$$

$$L = 12 \text{ m,}$$

$$F = 0.0001570796,$$

$$ODT = 20 \text{ rads,}$$

$$ODB = 24 \text{ rads,}$$

$$IDT = 16 \text{ rads,}$$

$$IDB = 20 \text{ rads,}$$

$$DL = 12 \text{ m,}$$

$$V = [(27^2 + 35^2) \times 12.0 \times F] - [(20^2 + 24^2) \times 12.0 \times F] - [(16^2 + 20^2) \times 12.0 \times F]$$

$$V = [1954 \times 12.0 \times 0.0001570796] - [976 \times 12.0 \times 0.0001570796] - [656 \times 12.0 \times 0.0001570796]$$

$$V = 3.683 - [1.840 - 1.237]$$

$$V = 3.683 - 0.603,$$

$$V = 3.080 \text{ m}^3.$$

- where fire damaged timber is incidentally harvested from undamaged or lightly fire damaged stands, recent fire damage will normally be taken to mean any dead standing timber that is felled within one calendar year of the fire being declared out, unless the Regional Manager orders otherwise. Where fire damaged timber is harvested from moderate to heavily damaged stands (as assessed in accordance with Appendix A.7.2 of the *Cruising Manual*) that have been appraised in accordance with Section 4.4.4 of the *Interior Appraisal Manual*, the determination of what is recent fire damage will be based upon a stand-specific decision of the Regional Manager.

Specific details of the interior dead/dry grades (grade codes 3 and 5) can be found in Sections 6.6.4 and 6.6.6.

6.4.4.2 Identifying Undersized Logs in the Interior

Cutting specifications in interior cutting authorities make reference to the diameter outside bark at stump height (DSH). This diameter is important as it determines whether or not the tree has to be utilized.

When scaling interior timber, scalers must assign an undersized grade to logs which are cut from trees which are smaller than the diameter at stump height specified in the cutting authority.

The DSH is measured outside the bark at a point 30 cm (15 rads) above the highest ground at the base of the tree. Since scalers do not see the stump, but only the butt log cut from it, the DSH is measured outside the bark at a point 15 cm (7.5 rads) from the butt end on candidate logs.

To be considered for the undersized grade:

- a log must show sufficient evidence such as an undercut, butt flare, or other butt characteristics to indicate it comprises a tree and not a top cut or long butted log, and
- the outside bark measurement (averaged) at a point 15 cm from the butt face must be less than the minimum diameter at stump height specified in the cutting authority.

If there is no evidence a log was cut from an undersized tree, it must not be graded as Grade 6.

The minimum DSH is set by the *Provincial Utilization Policy* at 15 cm (7.5 rads) for lodgepole pine, and 20 cm (10 rads) for all other species. More stringent utilization requirements may be set under the cutting authority. Utilization standards on the coast do not refer to the DSH. As such, the coast schedule of grades does not have an undersized log grade.

Where timber is cut on an area where cutting specifications are not in place, scalers are to assume a DSH of 15 cm (7.5 rads) for lodgepole pine and 20 cm (10 rads) for all other species.

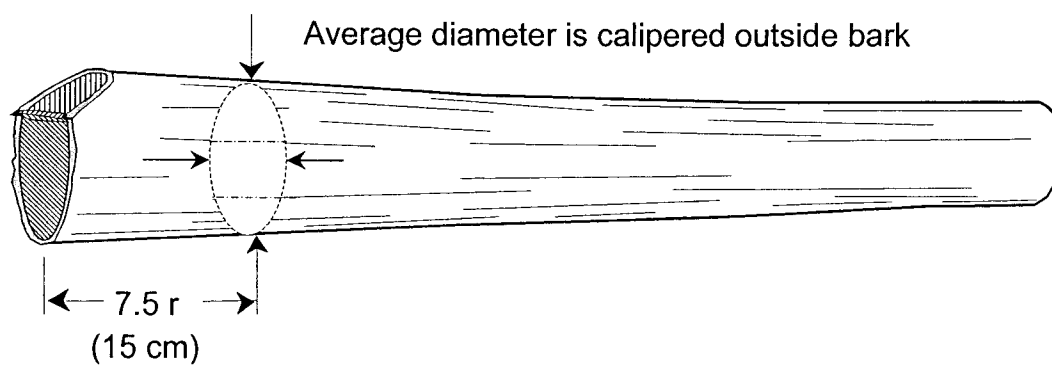


Figure 6.24 *Measuring diameter for interior undersize grade.*

Appendix 7B Scale Data Computation and Documentation Standards

1. Standard for compiling log and segregation volumes.
2. Standard for Weight Scale calculations.
3. HBS Source Document Requirements:
 - a. FS 72 - Summary of Scale, and
 - b. FS 531 - Computed Weight Scale Sample.

**Ministry of Forests
Revenue Branch**

**Version 2.0
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7B.1 Standard for Compiling Log and Segregation Volumes

7B.1.1 Calculation Standard

Steps to Compute Log Volumes		Units	Decimal	Maximum Value	Source	Example
1.	Top Radius Squared = Top Radius * Top Radius	cm ² cm cm	0 0 0	999 999 999 999	Tally Tally	5 184 72 72
2.	Top Area = 3.141592 * Top Radius Squared	cm ² cm ²	1 6 0	9 999 999.9 9.999 999 999 999	pi Step 1	16 286 3.141 592 5 184
3.	Top Area = Top Area / 10000	m ² cm ²	5 1	99.999 99 9 999 999.9	Step 2	1.628 6 162 86
4.	Butt Radius Squared = Butt Radius * Butt Radius	cm ² cm cm	0 0 0	999 999 999 999	Tally Tally	6 241 79 79
5.	Butt Area = 3.141592 * Butt Radius Squared	cm ² cm ²	1 6 0	9 999 999.9 9.999 999 999 999	pi Step 4	19 607 3.141 592 6 241
6.	Butt Area = Butt Area / 10000	m ² cm ²	5 1	99.999 99 9 999 999.9	Step 5	1.960 7 19 607
7.	Total Area = Top Area + Butt Area	m ² m ² m ²	5 5 5	99.999 99 99.999 99 99.999 99	Step 3 Step 6	3.598 3 1.628 6 1.960 7
8.	Average Area = Total Area / 2	m ² m ²	5 5	99.999 99 99.999 99	Step 7	1.794 65 3.589 3
9.	Length = Length / 10	m dm	1 0	99.9 999	Tally	6.2 62
10.	Log Volume = Average Area * Length	m ³ m ² m	3 5 1	999.999 999.999 99 99.9	Step 8 Step 9	11.127 1.794 65 6.2
11.	Log Volume Sum = Sum of Log Volumes (all logs)	m ³ m ³	3 3	99 999.999 999.999	Step 10	11.127 11.127
12.	Segregation Volume (Piece Scale) = Log Volume Sum	m ³ m ³	1 3	99 999.9 99 999.999	Step 11	11.1 11.127
13.	Segregation Volume (Weight Scale) = Log Volume Sum	m ³ m ³	2 3	99 999.99 99 999.999	Step 11	11.13 11.127

7B.1.2 Calculation Conventions

Rule:

Use only single-operation calculations, except in compound additions and subtractions where all operands have the same number of decimal places.

7B.1.2.1 Multiplication

Compute each product to a number of decimal places equal to the sum of the number of decimal places specified for the two operands, then round to the number of decimal places specified for the product. For example, the calculation to compute the product, to two decimal places, of two numbers, one with no decimal places, and the other with three decimal places, would be done as follows:

$$\begin{array}{rclcl} \text{e.g.,} & 262 & & & \\ & \times & .234 & & \\ & = & 61.308 & = & 61.31 \text{ rounded to two decimal places} \end{array}$$

7B.1.2.2 Division

Compute each quotient to a number of decimal places equal to the number of decimal places specified for the quotient plus one, then round to the number of decimal places specified for the quotient. For example, the calculation to compute the quotient, to two decimal places, of two numbers, each with zero decimal places, would be done as follows:

$$\begin{array}{rcl} \text{e.g.,} & 62.616 & = 62.62 \text{ rounded to two decimal places} \\ & 234309 \overline{)14671518} & \end{array}$$

7B.1.2.3 Addition

Compute each sum to a number of decimal places equal to the larger of the number of decimal places specified for the two operands, then round to the number of decimal places specified for the sum. For example, the calculation to compute the sum, to two decimal places, of two numbers, each with four decimal places, would be done as follows:

$$\begin{array}{rclcl} \text{e.g.,} & 13.5837 & & & \\ & + & 11.6489 & & \\ & = & 25.2326 & = & 25.23 \text{ rounded to two decimal places} \end{array}$$

7B.1.2.4 Subtraction

Compute each difference to a number of decimal places equal to the larger of the number of decimal places specified for the two operands, then round to the number of decimal places specified for the difference. For example, the calculation to compute the difference, to two decimal places, of two numbers, one with five decimal places, and the other with three decimal places, would be done as follows:

$$\begin{array}{rclcl}
 \text{e.g.,} & 12.69999 & & & \\
 & - 9.375 & & & \\
 & = 3.32499 & = & 3.32 & \text{rounded to two decimal places}
 \end{array}$$

7B.1.2.5 Rounding

There are three general rules for rounding:

Rule 1 - if the remainder *beyond the last digit* to be reported is less than 5, drop the last digit. For example, rounding to three decimal places, the number 0.102 494 439 becomes 0.102

Rule 2 - if the remainder is greater than 5, increase the final digit by 1. For example, rounding to three decimal places, the number 321.766634408 becomes 321.767.

Rule 3 - to prevent rounding bias, where the remainder is exactly 5, scalars (in the field) will round the last digit to the closest even number. Thus, the number 3.55 rounded to one decimal would be 3.6 (rounding up) and the number 6.450 rounded to one decimal would be 6.4 (rounding down). However, current programming language may not provide this <Even> function and will adopt the convention of rounding up on the exact half. The following steps will produce an acceptable result to 3 decimals:

Add 0.000 5 to the unrounded log volume

Multiply by 1000

Drop everything to the right of the decimal (i.e., <Int> or <Integer> function).

Divide by 1000

Example:

Step	Objective	Units	Decimals	Maximum Value	Source	Example
11	Log volume	m ³	11	31 321.766 456 344 08		00 000.102 494 439 00
	Add 0.000 5	Constant	11	31 321.766 956 344 08	7B.1.2.5	00 000.102 994 439 00
	Multiply by 1000	Constant	8	31 321 766.956 344 08	7B.1.2.5	102.994 439 00
	Drop the decimals	Dm ³	0	31 321 766	Int Function	102
	Divide by 1000	m ³	3	31 321.766	7B.1.2.5	00.102