

Firmwood Defects and Conventions

7

7.1 Firmwood Deductions

While the Gross Measurement Procedures chapter of this manual deals with the more objective concepts of scaling, Firmwood Deductions introduces many subjective concepts.

Objective results are based on fact. That is, it is possible to perform most measurements and record the gross dimensions of a typical log by following standard procedures which do not vary and are quite objective. Firmwood defects, on the other hand, can be subjective or based on ideas and opinions gathered through experience. A reasonable estimation of the affects of internal rots where there are few indications of its presence and no possibility of measurement is quite subjective. Through study, training, observation, and support from the scaling community in both industry and government new scalers will gain enough experience to make judgements which are unbiased and within tolerances. There are two provincially approved methods of deduction:

- Gross/Net method, and
- Net Dimensions method.

7.2 Firmwood Deduction Principles

The following sections discuss the concepts of firmwood deduction and outlines methods for determining the net firmwood content of logs containing defects. For each defect example there is one or more volumetric calculations shown.

The Gross/Net calculation can be thought of as the method a computer would use when presented with the required measurements and shapes. Apart from their inclusion in handheld scaling computer software, these calculations are used when analyzing theoretical logs in a classroom setting, when dealing with particularly challenging or borderline logs or when arithmetic skills are strong. They are expressed in full detail for each defect example.

The field methods are based upon field experience and are provided for when not using a scaling computer. Although the results often approximate those of the gross/net calculations, experience has shown that differences can be significant enough to be of concern. The field methods typically rely on reducing one or more of the gross dimensions of a log so that the recorded net dimensions closely reflect the net firmwood volume.

7.3 Geometric Shapes

The approach taken for determining the net firmwood volume of a log is based on the standard geometric shape as illustrated below that most closely approximates the form of a log and its defect. From careful study of the *Gross Measurements Procedures* chapter it becomes clear that no new volumetric concepts are introduced; the shapes of logs, sectors, segments and slabs described earlier are able to be duplicated in virtually every defect shape by applying the standard shapes alone or in combination with others.

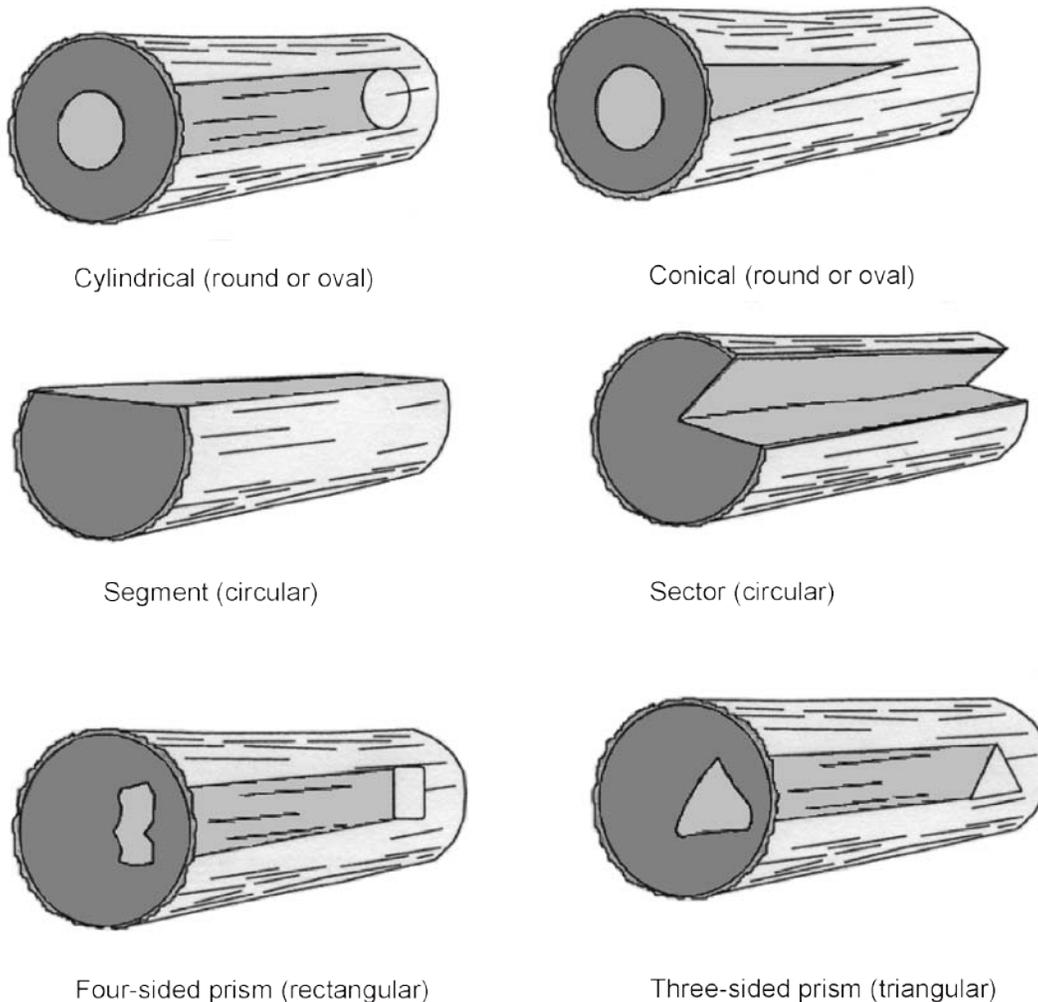


Figure 7.1 *The Geometric Shapes Used in Scaling and Firmwood Deductions.*

The shapes illustrated in this figure are either round or oval in profile (cylindrical, conical, sectors, segments) or angular (three and four sided prism). The defect deduction formulae are based on four geometric forms; the cylinder, the cone, the four sided (quadrilateral) prism and the three sided (triangular) prism.

7.4 Deduction Methods

The firmwood volume of timber excludes all rot, hole, missing wood, and charred wood. Although the current *Scaling Regulation* does not refer to missing wood as a separate entity from hole, missing wood has been added to scaling terminology to further define a hole. In scaling, a hole is a cavity or opening, such as a knot hole, an advanced heart rot, or an advanced butt rot. Missing wood refers to areas where wood is absent from a log that otherwise would be regarded as complete, such as sniped ends, equipment damage, and burn saddles. Deductions are made from the gross volume of a log for these defects as they occur. A deduction is made by subtracting the volume of the defect(s) from the gross volume of the log.

No firmwood deduction is made for discoloration or stain (incipient decay). Stained wood can be a variety of colours including blue, orange, brown, red or black. It will not have the fleck associated with some varieties of rot. Until sufficient field experience is gained, the scaler may have difficulty determining the difference between stain and genuine rot. In scaling, rot is defined to be that level of decay where wood begins to lose its strength and fibre integrity and rotted fibre may display a variety of shades.

Refer to [*Book of Common Tree Diseases in British Columbia*](#) for a more complete discussion of fungal action and tree diseases.

The degree of deterioration is sometimes determined by using the tine of the scale stick, (or spud if so attached), to remove some wood from the suspect area. Test it for strength and fibre integrity by attempting to break and pull it apart with the fingers. If it is sound it should retain the long strands of fibre that hold it together. If it crumbles or comes apart easily it may be rotten. It may be beneficial to remove another sample of wood from a sound area of the log adjacent to the area suspected of being rotten. The two samples can be compared for relative strength and integrity.

No firmwood deduction is made for twist, sweep, crook, checks, stain, large knots or other quality considerations, even though these may indicate a grade consideration. A condition which may be considered a defect in a grade reduction is not necessarily considered to be a firmwood defect in a volume deduction. Firmwood scaling is concerned with determining the volume of sound or firmwood fibre in a log. Timber grading, on the other hand, is concerned with the potential quantity and quality of end product available from that log.

For the purposes of grading, the same formulae and methods described in this chapter may be used to calculate the portion of a log that can be manufactured into an end product (grading is discussed in the following chapter of this manual, *Timber Grading*).

Depending on the tools available to the scaler, two methods may be used as described below:

7.4.1 Gross/Net Method

If using a scaling computer it will produce a detailed log listing showing the gross volumes, defect types, defect volumes, and net firmwood volumes.

To obtain the net volume of a log with defect(s) using a scaling computer, follow these steps:

- enter the dimensions of the log,
- enter the type and required dimensions of the defect(s), and
- compute the net volume.

If not using a computer equipped with scaling software:

- calculate the gross volume of the log,
- calculate the volume of the defect(s), and
- subtract the defect volume from the gross volume to get the net volume of the log.

7.4.2 Net Dimensions Method

The net dimensions method may be used when recording the scale on a paper form and consists of reducing the measured dimensions of the log so that the recorded net dimensions will calculate the correct firmwood volume.

Net dimensions equivalent to net volumes are available to the scaler by calculating:

- a length deduction,
- a diameter deduction, or
- a combination of both.

7.4.2.1 Length Deduction

Although this method requires more arithmetic, length deduction can be used for all defects and can accommodate a smaller defect than the diameter deduction method in smaller diameter and longer logs. To perform a length deduction the scaler must:

- first determine the volume of rot,
- determine the average unit volume of the log then,

- divide the rot volume by the average unit volume of the log to find the required length deduction, and
- subtract the length deduction from the gross log length.

The result is the net length of the log to be recorded.

7.4.2.2 Average Unit Volumes

References to unit volumes (UV) and average unit volumes (AUV) are made in this manual. A unit volume is simply the volume in dm³ of a one metre length of a log with the same diameter at each end. It is directly proportional to the end area, which in dm² is always 1/10 of the unit volume (or the area times 1 m). Unit volumes are read directly off the scale stick and because of their relation to end area, form the basis of comparison of defect proportion to firmwood proportion in the observation of a log. An average unit volume is the average, for one metre of log length, of the unit volume of each end of a log.

Different terminology is used from region to region when discussing unit volumes, such as the unit volume per metre (UVM), the factor, the one metre unit volume, the two metre half volume or one tenth of the ten metre volume. These terms are derived from regional differences and the various approaches to finding a unit volume or an average unit volume on a scale stick and should not be misinterpreted as something else; they are all in the same unit.

There are two simple ways to derive an average unit volume from the scale stick. Both are commonly used by scalers according to individual preference:

- in the first method, measure both ends of the log. Add the two corresponding unit volumes for the measured ends and divide by 2,
- in the second method, measure both ends of the log. Add the 10 m half volumes corresponding to the log ends and divide by 10, and
- rounding will often result in a difference of 1 dm³ between the two methods. This difference is of no significance in unit volume calculations.

Please see the Scaling Tools chapter of this manual for information about unit volumes and the scale stick.

The rounding convention relates directly to computing devices and advises that a given number will round up on the exact 0.5. The use of a scale stick for average diameters or average unit volumes, or a tape for length, will round up or down to the nearest even number on the exact 0.5. Scalers must rely on one rounding convention which eliminates the possibility of bias (one up, one down). Although the two conventions appear to be in conflict, computers work in a different domain. For example, a hand held data capture unit is never required to average diameters or lengths. They are first averaged by the scaler, and then entered into the unit.

7.4.2.3 Diameter Deduction or Radius Reduction Method

Diameter deduction or radius reduction as it is often called is the easiest and quickest of the basic deduction procedures for a through running defect or a defect which is estimated to run half way through a log. If a scaler does not consider log length and diameter when making diameter deductions for defects which do not affect the full length or exactly half the length of a log there is a risk of over-deducting. For this reason diameter deductions are limited to defects which travel the full length, or are estimated to travel exactly half the length of the log.

To obtain a net diameter equivalent to the net volume for a log follow these steps:

- measure the diameter of the log at the defect end and obtain the unit volume of that end of the log from the scale stick,
- measure the diameter of the defect and obtain the unit volume of the defect from the scale stick,
- subtract the defect volume from the unit volume of that end of the log to obtain a net unit volume, and
- locate a diameter on the scale stick with a unit volume closest to the net unit volume.

The result is the net diameter in rads or the radius in centimetres to be recorded.

The gross/net deduction method is preferred as its result is the closest reflection of a log's true net volume.

7.5 Conventions for Estimating Rot

When a defect affects the heart of a log, scalers cannot usually see how far it penetrates its length. If indicators are present rot penetration may be accurately estimated, but where there are none conventions may be employed. Basic conventions are outlined in this section to help the scaler in producing uniform and accurate results when unable to determine the actual size and/or length of the defect(s). In making volume deductions for defect, the scaler must pay close attention to any defect indicators, the ratio of the rot to the end, and the stage of the rot development. Conventions may be developed to suit changing conditions and should be tested regularly to ensure that they are still applicable. Scalers working in a new area should discuss local conditions with an experienced District scaling representative.

Ministry and Industry scalers must work together to ensure a complete and accurate scale and where the Regional Executive Director, District Manager or Forest Officer (scaling) determines that a convention does not apply, that person may order that its use be stopped.

7.5.1 Scaling Conventions versus Local Knowledge

The ultimate objective of scaling is to accurately determine the net firmwood volume and grade of each log scaled. To achieve consistent results and facilitate timely scaling most scaling is conducted with some reliance on the use of conventions. Conventions are based on historic relationships between external log characteristics and their impacts on firmwood content and product recovery.

While scaling conventions help the pace of scaling and help scalers achieve consistency, strict adherence to them fails to recognize that the trees from which logs are cut are often variable because of their inherent genetic blue print, their physical growing conditions and their history. Because of this diversity logs often do not conform to established conventions, therefore strict adherence to some conventions will not always yield the most accurate scale. Conventions must be tested regularly to ensure their continued applicability.

7.6 Formulas and Their Terms

Formulas are expressed in the next section in standard algebraic form. The example below shows the formula that is used to find the area of a rectangle:

Area (A) is equal to the length (L) times the width (W), or

$$A = LW$$

All measurements, excluding length measurements, used in the calculations are in rads. It is important to remember that when measuring the diameter of a circle in rads, the resulting value is equal to the radius in centimetres.

Table 7-1 Chart of Terms Used in Scaling Formulas

Term	Definition
L	Length of log measured in metres.
T	Top or small end diameter of a log measured in rads.
B	Butt or large end diameter of the log measured in rads.
DL	Length of defect measured in metres.
DT	Top or small end diameter of a cylindrical defect measured in rads.
DB	Butt or large end diameter of a cylindrical defect measured in rads.
H	Height of a rectangular or triangular shape measured in rads.
W	Width of a rectangular or triangular shape measured in rads.
DHT	Top height of a rectangular or triangular defect measured in rads.
DWT	Top width of a rectangular or triangular defect measured in rads.
DHB	Butt height of a rectangular or triangular defect measured in rads.
DWB	Butt width of a rectangular or triangular defect measured in rads.
IDT	Inside diameter, top, or small end of a ring defect measured in rads.
IDB	Inside diameter, butt, or large end of a ring defect measured in rads.
ODT	Outside diameter, top, or small end of a ring defect measured in rads.
ODB	Outside diameter, butt, or large end of a ring defect measured in rads.
NDT	Net top or small end diameter of a log measured in rads.
NDB	Net butt or large end diameter of a log measured in rads.
F	Factor of 0.0001570796 (the constant used in shortened Smalian's formula).
UV	One metre unit volume, expressed as dm ³ /m. A ten metre volume may be divided by 10 to obtain the one (1) metre unit volume.
AUV	The average of the unit volumes of both ends of a log or defect.
V	Volume in cubic metres or cubic decimetres.

7.7 Defect Conventions and Examples

7.7.1 Conical Defects

Measurements for Defect Volume:

- the estimated defect length in metres to the nearest tenth of a metre, and
- the defect diameter visible at log end in rads.

7.7.2 Butt Rot Conventions

Butt logs are usually identified by observing the large end for flare, fluting, and/or felling signs such as an undercut or hinge in hand felled trees, or the characteristic face left by a harvesting machine. It is important not to confuse heart rot and butt rot. Although heart rot may show in a butt cut log, and butt rot may show in a second cut log, the rot can usually be identified by its nature. For example, brown cubical butt rot is recognizable by the way the wood fibres are affected. As its name implies, the rot is brown, crumbly, and breaks easily into cubes. The following basic conventions apply to butt rot:

- Where rot appears only in the large end of a butt log with butt qualities, treat it as butt rot unless other indicators are present, such as conk knots or conk rot.
- Butt rot visible at the butt end only will be assumed to be conical in shape, with the same basal diameter as the visible end section of the rot.
- Conical butt rot that extends the full length of a log may be treated as though it is through running heart rot. However, if the rot diameter at the butt is greater than 1.5 times the rot diameter at the top, the cylinder (Smalian's) formula will tend to over deduct the volume of rot, and averaging the diameters will understate the volume of rot. If bucking is impossible, adjustments are required. There are two ways to do this; if using the cylinder formula, the rot diameter at the butt may be reduced to the difference between the callipered butt diameter and twice the average collar thickness. If averaging the diameters, the result will be closer to true defect volume of the neiloid or "golf tee" shape typical of logs with a high degree of flare. By adding 1 rad to the average, the result will be closer when the defect is a frustum of a cone. The cylinder formula is suitable for rot shapes which are parabolic (bullet shape). Section 7.6.3.1 provides example calculations to demonstrate the two concepts.
- The diameter of butt rot used for deduction calculations must not exceed that of the recorded butt measurement where the actual measurement of butt rot exceeds the line of normal taper. This is a common occurrence in decadent logs with a great deal of butt flare.

There are many factors which affect the distance butt rot runs up from the stump: species, flare, taper, size, and age all contribute. Without indicators to establish rot penetration, it

becomes necessary to estimate the length of the rot. Through decay studies, mill studies, and experience, the following conventions have been found to be reliable in most cases:

- In the British Columbia interior, the average distance which butt rot travels in most logs is approximately 15 times the radius of the rot in centimetres, if there are no indicators to the contrary. For example, if the radius is 25 cm (same as the diameter in rads), $25 \times 15 = 375$ centimetres, or 3.75 m. The penetration is therefore 3.8 m (rounded).
- In coastal areas of British Columbia, butt rot, butt shake and related butt defects have the length of defect estimate based on the relation between the defect diameter and the recorded butt diameter of the log.

Where rot measures	It often penetrates
1/4 of the recorded butt dia.	1.8 - 2.4 m
1/2 of the recorded butt dia.	3.6 - 4.2 m
3/4 of the recorded butt dia.	5.4 - 6.0 m
4/4 of the recorded butt dia.	7.2 - 7.8 m

These figures may be adjusted slightly up or down depending on the species and visible butt flare. Douglas fir and spruce, having pronounced butt flare may use the lower figure mentioned as butt rot in these species usually does not run far past the flare. In hemlock, balsam, and sometimes red cedar, where butt flare is minimal, rot may run further into the log and a larger estimate is required. These are general guidelines only.

The Ministry may endorse other conventions which are applicable to regional conditions. All conventions should be reviewed regularly to ensure continued applicability.

7.7.3 Butt Defect - Butt Rot (Conical) Partial Length of Log

This method of calculation is usually used for defects found in and confined to the butt end of a first cut or butt (flared) log. This method may also be used for all defects that have a geometrical shape of a cone or portion of a cone, such as catface.

7.7.3.1 Example and Illustration - Butt Rot Visible at Butt End of Log

Figure 7.2 depicts a typical log harvested from an interior region of British Columbia with conical butt rot measuring 25 rads in diameter and estimated to penetrate 15 times the radius, or 3.8 m.

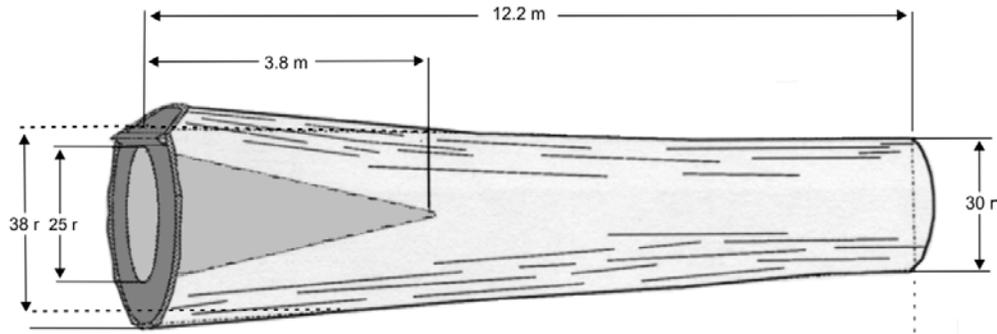


Figure 7.2 A Log with Butt Rot – One End Visible.

7.7.3.1 The Gross/Net Calculation- Butt Rot

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:

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

Where the following values are substituted for the variables:

- T = 30 rads,
- B = 38 rads,
- L = 12.2 m,
- F = 0.0001570796,
- DB = 25 rads,
- DL = 3.8 m,

$$V = [(30^2 + 38^2) \times 12.2 \times 0.0001570796] - \left[\frac{(25^2 \times 25^2) \times 3.8 \times 0.0001570796}{3} \right],$$

$$V = [2344 \times 12.2 \times 0.0001570796] - \left[\frac{1250 \times 3.8 \times 0.0001570796}{3} \right],$$

$$V = 4.492 - 0.249,$$

$$V = 4.243 \text{ m}^3.$$

7.7.3.2 The Net Dimensions Calculation – Butt Rot

Using the net method of the defect deduction with the cone formula, the log is calculated as follows:

$$\text{Average unit volume of 30/38} = 368 \text{ dm}^3 \text{ (AUV)}$$

$$\text{Defect volume 3.8/25} = 745 \text{ dm}^3 \text{ divided by 3}$$

$$\text{Total defect volume} = 249 \text{ dm}^3$$

$$\text{Rot volume: } \frac{249}{368} = 0.677 \text{ m length deduction}$$

$$\text{AUV: } \frac{249}{368}$$

$$12.2 - 0.7 = 11.5 \text{ m Net length}$$

Record the net dimensions 11.5 30/38

Net Volume – 4.234 m³

7.7.3.3 Example and Illustration - Butt Rot Visible at Both Ends of Log

Measurements for Defect Volume:

- the defect length in metres to the nearest tenth of a metre (the same as the measured log length), and
- both defect end diameters in rads.

Figure 7.3 depicts a typical log with conical butt rot measuring 30 rads and 6 rads in diameter and penetrating the full length of the log. Because the rot diameter at the butt is more than 1.5 times the rot diameter at the top, and the shape is the frustum of a cone,

($30/6 = 5$ times), an overstatement of the defect volume will result from summing the half volumes or from finding the average unit volume, and an understatement of the defect volume will result from averaging the diameters. It is possible to arrive at the volume of rot using a formula for the frustum of a cone in these cases.

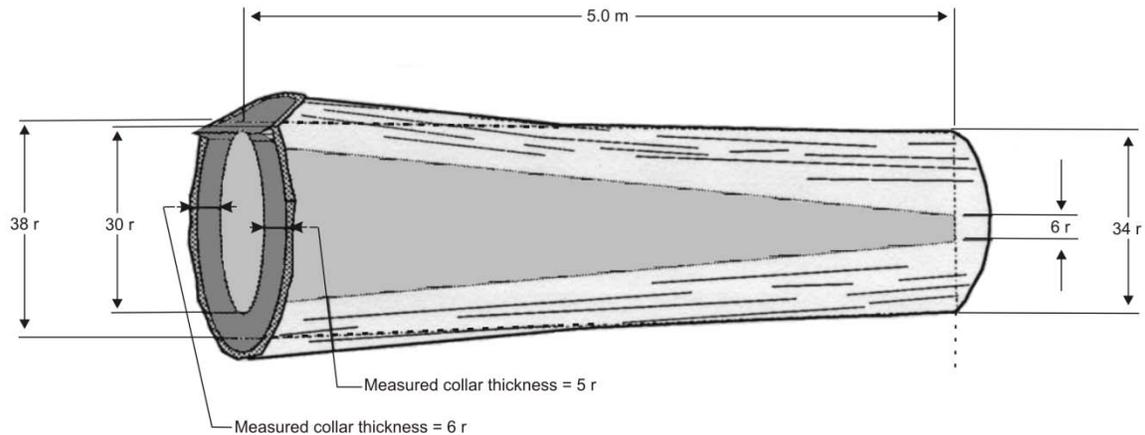


Figure 7.3 A Log with Butt Rot – Through Running.

7.7.3.3.1 Calculations - Butt Rot Visible at Both Ends of Log

It is the general convention to treat butt defect as conical, and in many geographical areas, no other treatment is used. However, experience with certain species and growth conditions may indicate that a neiloid (golf tee) shape or a parabolic (bullet) shape is valid. See Section 4.2 for an explanation of log and rot shapes. In these cases, different field approaches may be used for through running defects with extreme taper. The ability to use the following methods is governed by local conditions:

1. If the shape is assumed to be neiloid, average the diameters.
2. If the shape is assumed to be parabolic, use the average of the end areas.

When conical butt rot projects through to the top end of a log it becomes a frustum of a cone.

Method 1 shows the Gross/Net calculation that is used with a scaling computer using the formula for the shape of a frustum of a cone.

For Net Dimensions scale, if the shape is assumed to be the frustum of a cone, use Method 2 or Method 3 of the following.

Method 1 Gross/Net Deduction - Through Running Butt Rot

This is the method that a scaling computer would use for finding the net volume of a log with a defect in the shape of a frustum of a cone:

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

Where the following values are substituted for the variables:

$$T = 34 \text{ rads,}$$

$$B = 38 \text{ rads,}$$

$$L = 5.0 \text{ m,}$$

$$F = 0.0001570796,$$

$$DT = 06 \text{ rads,}$$

$$DB = 30 \text{ rads,}$$

$$DL = 5.0 \text{ m,}$$

$$V = \left[\left(34^2 + 38^2 \right) x 5.0 x 0.0001570796 \right] - \left[\frac{\left(\left(06^2 + 30^2 \right) + (06 x 30) \right) x 5.0 x 0.0001570796 x 2}{3} \right]$$

$$V = \left[2600 x 5.0 x 0.0001570796 \right] - \left[\frac{1116 x 5.0 x 0.0001570796 x 2}{3} \right]$$

$$V = 2.042 - 0.584,$$

$$V = 1.458 \text{ m}^3.$$

Method 2 Net Dimensions Calculation – Through Running Butt Rot

Determine the difference between the callipered butt diameter and twice the average collar thickness to obtain a reduced rot diameter at the butt (collar measurements are required at the butt to determine average collar thickness).

$$\begin{aligned}
 \text{AUV of 34/38} &= 408 \text{ dm}^3 \\
 \text{Callipered butt diameter} &= 38 \text{ rads} \\
 \text{(Measured rot diameter} &= 30 \text{ rads)} \\
 \text{Average collar thicknesses} &= \frac{5+6}{2} = 5.5 \text{ rads} \\
 \text{Twice av. collar thickness} &= 5.5 \times 2 = 11 \text{ rads} \\
 \text{Reduced butt rot diameter} &= 38 - 11 = 27 \text{ rads}
 \end{aligned}$$

Defect volume:

$$\begin{aligned}
 \text{Half volume of 5.0/06} &= 28 \text{ dm}^3 \\
 \text{Half volume of 5.0/27} &= + \underline{573 \text{ dm}^3} \\
 \text{Full volume of 5.0/06/27} &= 601 \text{ dm}^3
 \end{aligned}$$

Defect volume:

$$\begin{aligned}
 \text{Defect Volume: } \frac{601}{408} &= 1.47 \text{ m Length deduction} \\
 5.0 - 1.5 &= 3.5 \text{ m Net length} \\
 \text{Net dimensions} &= 3.5 \text{ 34/38}
 \end{aligned}$$

Net Volume – 1.430 m³

Method 3 Net Calculation – Through Running Butt Rot

In this example average the top and butt defect diameters. But because the rot is conic and taper is extreme, add 2 rads to the average of the defect diameters. For example, where the defect diameter at the butt exceeds the defect diameter at the top by:

< = 1.5 times, use the average

> 1.5 times and = < 2 times, use the average plus 1 rad

≥ 2 times, use the average plus 2 rads.

$$\text{Average defect diameter} = \frac{6+30}{2} = 18 \text{ rads}$$

$$\text{Adjusted defect diameter} = 18 + 2 = 20 \text{ rads}$$

Defect volume:

$$\text{Half volume of } 5.0/20 = 314 \text{ dm}^3$$

$$\text{Half volume of } 5.0/20 = + \underline{314 \text{ dm}^3}$$

$$\text{Full volume of } 5.0/20/20 = 628 \text{ dm}^3$$

$$\text{Average Unit Volume of } 34/38 = 408 \text{ dm}^3$$

$$\text{Defect volume: } \frac{628}{408} = 1.53 \text{ m Length deduction}$$

$$\text{Net dimensions} = 3.5 \text{ } 34/38$$

$$\text{Net volume} - 1.430 \text{ m}^3$$

7.7.4 The Catface (Conical)

Measurements for Defect Volume:

- the defect length in metres to the nearest tenth of a metre, and
- the width and height (big end) of the defect in rads.

7.7.4.1 Example and Illustration - Single Catface

In the example illustrated below, a portion of the tree's circumference has been scarred. As a result, it does not form a cylinder for part of its length. Where the catface tapers out as illustrated, the defect approximates the shape of a segment of a cone.

This log is 7 m long with a 20 rad top and a 24 rad butt. The conical catface is 4.8 m long and is 18 rads wide by 10 rads deep at the butt face.

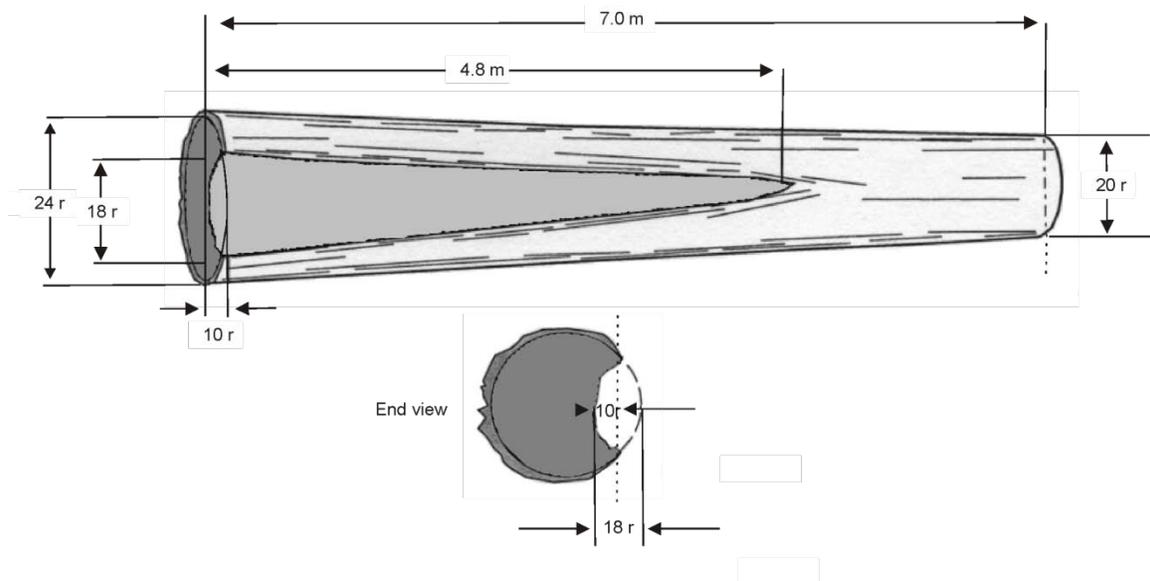


Figure 7.4 A Log with Conical Catface.

7.7.4.2 The Gross/Net Calculation – Single Catface

Using the formula for finding the net volume of a log with a conical defect:

$$V = \left[(T^2 + B^2) \times L \times F \right] - \left[\frac{(DB^2 + DB'^2) \times DL \times F}{3} \right]$$

Where the following values are substituted for the variables:

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

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

$$L = 7 \text{ m,}$$

$$F = 0.0001570796,$$

$$DB = 14 \text{ rads,}$$

$$DL = 4.8 \text{ m,}$$

$$V = [(20^2 + 24^2) \times 7.0 \times 0.0001570796] - \left[\frac{(14^2 + 14^2) \times 4.8 \times 0.0001570796}{3} \right]$$

$$V = [976 \times 7.0 \times 0.0001570796] - \left[\frac{392 \times 4.8 \times 0.0001570796}{3} \right],$$

$$V = 1.073 - \frac{0.295561}{3},$$

$$V = 1.073 - 0.099,$$

$$V = 0.974 \text{ m}^3 \text{ net volume}$$

7.7.4.3 Net Dimensions Calculation - Single Catface

Using the cone deduction formula the net volume of the log is calculated as follows:

Calculate an end defect measurement in rads by dividing the sum of the width and height by 2.

$$\frac{10 + 18}{2} = 14 \text{ rads}$$

Calculate the defect volume by first looking up the half volume for 4.8 m 14 rads.

$$\text{Half volume of 4.0/14} = 123 \text{ dm}^3$$

$$\text{Half volume of 0.8/14} = + 25 \text{ dm}^3$$

$$\text{Half volume of 4.8/14} = 148 \text{ dm}^3$$

Next calculate the full volume by multiplying the half volume by two.

$$148 \times 2 = 296 \text{ dm}^3$$

Finally calculate the volume of the cone by dividing the cylinder volume by three.

$$\frac{296}{3} = 99$$

$$\text{Defect volume} = 99 \text{ dm}^3$$

Divide the defect volume by the AUV to calculate the length deduction.

$$\begin{array}{l} \text{Defect volume: } \frac{99}{153.5} = 0.645 \text{ m Length deduction} \\ \text{AUV:} \end{array}$$

$$7.0 - 0.6 = 6.4 \text{ m Net length}$$

$$\text{Net dimensions } 6.4 \text{ } 20/24$$

$$\text{Net volume} - 0.981 \text{ m}^3$$

7.7.5 The Catface (Double Conical)

Measurements for Defect Volume:

- the defect length in metres to the nearest tenth of a metre, and
- the width and height at the largest point (usually near the middle) of the defect in rads.

7.7.5.1 Example and Illustration - Double Catface

In Figure 7.5 a full double conical catface affects a 7 m log. A portion of the tree's stem has been scarred and does not form a cylinder for part of its length. Where the catface tapers out on both ends as illustrated, the defect approximates the shape of two cones attached at the base.

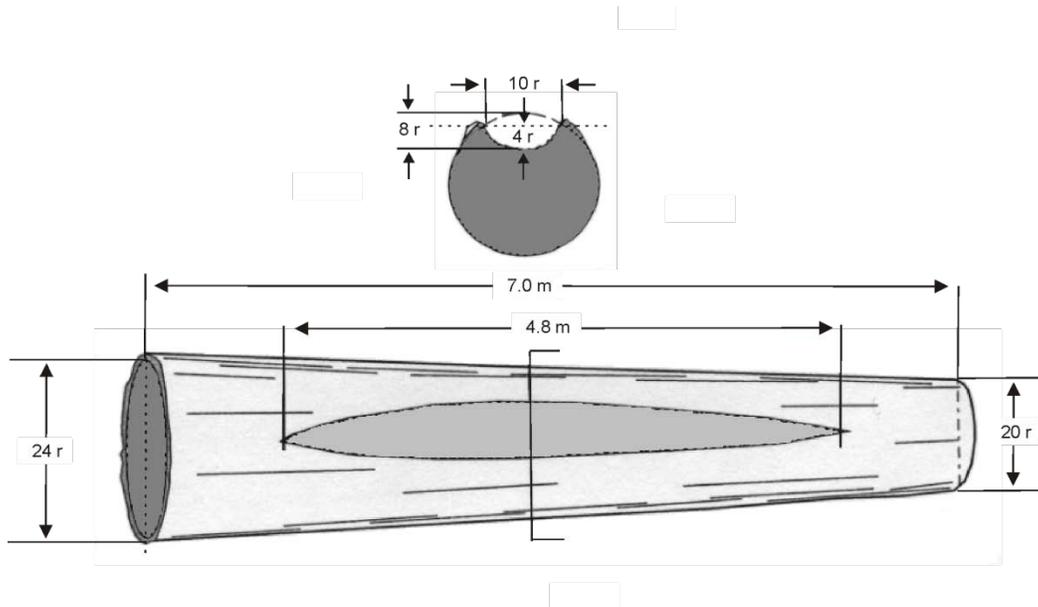


Figure 7.5 A Log with a Double Conical Catface.

7.7.5.2 The Gross/Net Calculation – Double Catface

Using the formula for finding the net volume of a log with a conical defect:

$$V = \left[(T^2 + B^2) \times L \times F \right] - \left[\frac{(DB^2 + DB'^2) \times DL \times F}{3} \right]$$

Where the following values are substituted for the variables:

$$\begin{aligned} T &= 20 \text{ rads,} \\ B &= 24 \text{ rads,} \\ L &= 7 \text{ m,} \\ F &= 0.0001570796, \\ DB &= 9 \text{ rads,} \end{aligned}$$

$$DL = 4.8 \text{ m,}$$

$$V = \left[(20^2 + 24^2) \times 7.0 \times 0.0001570796 \right] \frac{(9^2 + 9^2) \times 4.8 \times 0.0001570796}{3},$$

$$V = \left[976 \times 7.0 \times 0.0001570796 \right] \frac{162 \times 4.8 \times 0.0001570796}{3},$$

$$V = 1.07317 \frac{0.122}{3},$$

$$V = 1.07317 - 0.041,$$

$$V = 1.032 \text{ m}^3 \text{ net volume}$$

7.7.5.3 Net Dimensions Calculation - Double Catface

Using the cone deduction formula the net volume of the log is calculated as follows:

Calculate a centre defect measurement in rads by dividing the sum of the width and height by two.

$$\frac{8 + 10}{2} = 9 \text{ rads}$$

Calculate the defect volume by looking up the half volume for the length of the defect, or 4.8 m and 9 rads.

$$\text{Half volume of } 4.8/09 = 61 \text{ dm}^3$$

$$\text{Full volume of } 4.8/09/09 = 122 \text{ dm}^3 \text{ (2 x half volume)}$$

$$\text{Volume of cone } 4.8/09 = \frac{122}{3} = 41 \text{ dm}^3$$

$$\text{Defect volume: } \frac{41}{153.5} = 0.267 \text{ m Length deduction}$$

$$\text{AUV: } 153.5$$

$$7.0 - 0.3 = 6.7 \text{ m Net length}$$

$$\text{Net dimensions - } 6.7 \text{ } 20/24$$

$$\text{Net Volume - } 1.027 \text{ m}^3$$

7.7.6 Standard Heart Rot Conventions

Whereas the *Species Identification and Defects* chapter of this manual provides a general view of rot fungi, the following sections describe the treatment of rots in making firmwood deductions. The *Timber Grading* chapter gives instruction on the treatment of heart rots for grading purposes.

- Decayed heart wood may be visible at one or both ends of a log and will usually be circular or semicircular in shape. Its presence may only be indicated by rotten knots, or “conk.”
- If heart rot appearing at the end of a log is scattered or sporadic in nature, the cylinder of rot must be reduced in diameter to accommodate the firmwood scattered within the rot.

7.7.6.1 Cylindrical Defects

This method of calculation can be used for defects that have the geometrical shape of a cylinder.

This formula or combinations of this formula can be used for calculating volumes of the following defects: through running heart defect, heart defect running partial length of a log, conk defect, sapwood defect, dead side, missing wood, ring defect, ring shake, outside checks and portions of collars.

7.7.6.1.1 Heart Rot Visible at Both Ends

1. If rot is visible at both ends of the log, scale out the cylinder of rot as if it were a log inside the first log. The volume of the inner cylinder is the volume of the rot.
2. If rot is visible at both ends of a short log, they may be presumed to be connected unless there are indications to the contrary. For example, if a different species of rot shows at each end of the log they may not be connected.

7.7.6.1.2 Example and Illustration - Heart Rot, Full Length

Measurements for Defect Volume:

- the defect length in metres to the nearest tenth of a metre, (the same as the measured log length), and
- both defect end diameters in rads.

Heart rot extends completely through the log in Figure 7.6 and is measurable at both ends. The gross volume of this log is 0.763 m³

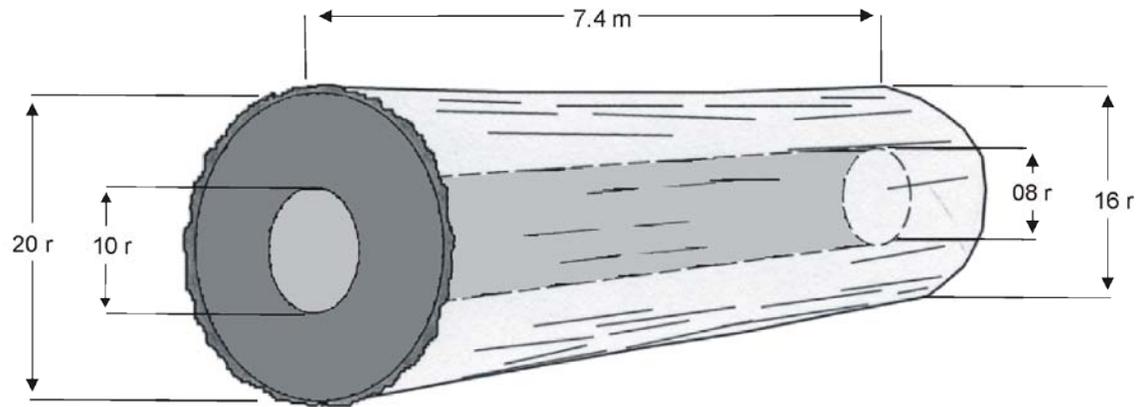


Figure 7.6 A Log with Through-running Heart Rot.

7.7.6.1.3 The Gross/Net Calculation – Heart Rot, Full Length

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

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

Where the following values are substituted for the variables:

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

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

$$L = 7.4 \text{ m,}$$

$$F = 0.0001570796,$$

$$DT = 8 \text{ rads,}$$

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

$$DL = 7.4 \text{ m,}$$

$$V = [(16^2 + 20^2) \times 7.4 \times 0.0001570796] - [(8^2 + 10^2) \times 7.4 \times 0.0001570796],$$

$$V = [656 \times 7.4 \times 0.0001570796] - [164 \times 7.4 \times 0.0001570796],$$

$$V = 0.763 - 0.191 = 0.572 \text{ m}^3$$

7.7.6.1.4 Net Dimensions Calculation - Heart Rot, Full Length

Using the cylinder deduction formula the net volume of the log is calculated as follows:

$$\text{Average Unit Volume of 16/20} = 103 \text{ dm}^3$$

With the scale stick, look up the volume of a cylinder of the diameter and length of the defect by adding the:

Top defect half volume:

$$\text{Half volume of 7.4/08} = 74 \text{ dm}^3$$

To the butt defect half volume:

$$\text{Half volume of 7.4/10} = 116 \text{ dm}^3$$

$$\text{Full defect volume of 7.4/08/10} = (74 + 116) = 190 \text{ dm}^3$$

$$\text{Defect volume: } \frac{190}{103} = 1.844 \text{ m Length deduction}$$

$$\text{AUV: } \frac{190}{103}$$

$$7.4 - 1.8 = 5.6 \text{ m Net length}$$

$$\text{Net Dimensions} - 5.6 \text{ 16/20}$$

$$\text{Net Volume} - 0.577 \text{ m}^3$$

7.7.6.1.5 Net Dimensions Calculation – Diameter or Radius Reduction – Heart Rot, Full Length

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

$$\text{Unit volume, top (16 r)} = 80 \text{ dm}^3$$

$$\text{Less the unit volume, top defect (8 r)} = \underline{-20 \text{ dm}^3}$$

$$\text{Net unit volume} = 60 \text{ dm}^3$$

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.

Unit volume Butt (20 r)	=	126 dm ³
Less unit volume Butt defect (10 r)	=	<u>- 31.dm³</u>
Net unit volume		95 dm ³

Find the rad class corresponding closest to the unit volume of 95 dm³, which is 17 rads.

Net Dimensions – 7.4 14/17

Net Volume – 0.564 m³

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.

7.7.6.2 Heart Defect – Conventions - Partial Length

1. Heart rot, pocket rot, ring rot, and similar defects when showing in only one end of the log are presumed to run half the length of the log to a maximum of 6 metres (coast), and 4 metres (interior) unless there is evidence to the contrary. In all cases, good judgement must be used and local experience is gained by observation of the bucking and manufacturing process. If it can be demonstrated to the local Ministry staff through proper studies that the defect effectively runs halfway to a maximum of 4 metres (interior) or 6 metres (coast), then it will be assured that the scale data provided will be more accurate.
2. In heart defects with only one end visible, the diameter of the defect at the unseen end is assumed to be the same as at the measured end where the defect penetrates 1/2 way or less. However, in logs where the rot penetrates more than 1/2 the length of the log, this assumption is less reasonable, and the Ministry may order that logs be bucked prior to scaling to improve accuracy. The ratio of the area of the rot to the area of the end which the rot occurs must be maintained at the unseen end or an over-deduction will result.

A convention should be reviewed at regular intervals to ensure that is applicable and not outdated. If it can be demonstrated through a study that the rot does in effect, run halfway to a maximum of 4 metres (interior) or 6 metres (coast), then this convention may be used. This study must be conducted in a way that is acceptable to the Regional Executive Director, District Manager, or Forest Officer (scaling). This will ensure that the scale data provided will be more accurate and complete.

7.7.6.2.1 Example and Illustration - Heart Rot, Partial Length

Measurements for Defect Volume:

- the estimated defect length in metres to the nearest tenth of a metre, and
- the defect diameter visible at the log end in rads.

The heart rot visible at the butt end of the log shown in Figure 7.7 is estimated to travel 2.7 m and the diameter of the rot is assumed to be the same at both ends (10 rads).

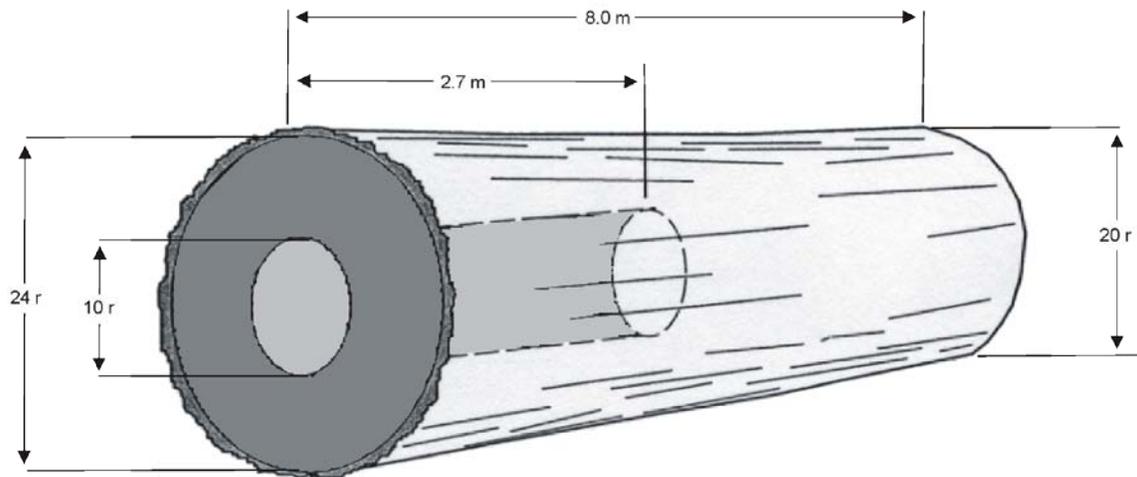


Figure 7.7 A Log with Partial Length Heart Rot.

7.7.6.2.2 The Gross/Net Calculation – Heart Rot, Partial Length

Using the cylinder formula for finding the net volume of this example which has a defect which does not project completely through the log:

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

Where the following values are substituted for the variables:

$$\begin{aligned} T &= 20 \text{ rads,} \\ B &= 24 \text{ rads,} \\ L &= 8.0 \text{ m,} \\ F &= 0.0001570796, \end{aligned}$$

$$\begin{aligned}
 DT &= 10 \text{ rads,} \\
 DL &= 2.7 \text{ m,} \\
 V &= [(20^2 + 24^2) \times 8.0 \times 0.0001570796] - [(10^2 + 10^2) \times 2.70 \times 0.0001570796] \\
 V &= [976 \times 8.0 \times 0.0001570796] - [200 \times 2.7 \times 0.0001570796], \\
 V &= 1.227 - 0.085, \\
 V &= 1.142 \text{ m}^3.
 \end{aligned}$$

7.7.6.2.3 Net Dimensions Calculation - Heart Rot, Partial Length

Using the cylinder deduction formula the net volume of the log is calculated as follows:

$$\text{Average Unit Volume of 20/24} = 153.5 \text{ dm}^3$$

Defect volume

$$\text{Half volume 2.7/10} = 42 \text{ dm}^3$$

$$\text{Full volume of 2.7/10/10} = 84 \text{ dm}^3 \text{ (2 x the half volume)}$$

$$\text{Defect volume: } \frac{84}{153.5} = 0.547 \text{ m Length deduction}$$

$$\text{AUV: } \frac{84}{153.5}$$

$$8.0 - 0.6 = 7.4 \text{ m} - \text{Net length}$$

$$\text{Net Dimensions} - 7.4 \text{ 20/24}$$

$$\text{Net Volume} - 1.135 \text{ m}^3$$

7.7.7 Assessing Conk, Indian Paint Fungus and Pin Rot

While "conk" is the name used for the mushroom-like fruiting body often seen on standing timber which indicates a fungal invasion of a tree, for scaling purposes conk refers to the types of rot which attack lignin (the glue) and leaves cellulose fibre more or

less intact. In the early stages the wood is only stained purple or light red and requires no firmwood deduction. In later stages, the wood breaks down to form a honeycomb appearance, identifiable at the end of a log by the white, yellow, orange or brown "fleck"(sometimes called "peck" and "white pocket") that distinguishes all conk rots.

During logging operations the external conk indicators are usually knocked off, leaving brown, yellowish brown, and/or orange powdery residues at the entry points. These residues are what a scaler looks for in assessing a log, because their presence indicates a very high probability of extensive conk rot. Conk knots should not be confused with rotten branch stubs, which may not indicate the presence of heart rot. Observation of the ends of logs, where they have been bucked through rotten knots, will indicate the differences in appearance.

If rot does not show at either end of the log but its presence is indicated by conk knots, the challenge is to make a reasonable determination of its range, based only on its indicators. The indicators and the assessment of them are described in the following section on conk rots. For more information on these types of rot please refer to the [Book of Common Tree Diseases in British Columbia](#).

7.7.7.1 Basic Conk Assessments

Because of the variability of the affects of conk, not only by conk species, but by the tree species and location around the province, it is very difficult to establish with conviction any conventions which will have universal application. Mill visits and experience are essential for a scaler to learn to interpret the meaning of conk indicators. In general:

1. Conk can appear in several ways on logs and the estimates for making firmwood deductions and grading are affected by the indicators present. The location of conk knots and the diameter of rot on log ends may be used to estimate the distance that rot travels. That is, the observation of these relationships will help indicate whether the rot is getting worse down the log or "running out".
2. When conk stain or conk rot shows in log end(s) carefully look for conks on the log. Use the tine of the scale stick or a spud to dig into swollen spots, punk knots, and black knots. Size of conks is sometimes helpful in determining the extent of rot in some species.
3. Where there are two or more indications of conk, they are normally presumed to be connected. It is recommended that the scaler have the log bucked to ascertain whether the conk rot has entered the heart of the log or is restricted to the knot.
4. If, among the enclosed rot, there is a substantial amount of firm wood that can be recovered in chips, then the defect diameter should be reduced proportionately for the firmwood volume determination.
5. In logs where conk shows in one or more knots and only a small amount of rot is present in the log end, that rot may not be representative of the severity of the defect.

In that case the firmwood deduction may be increased to one half the length that the conk is estimated to extend.

6. Where very large and/or numerous conks are present, an additional deduction may be required to compensate for the "funnel" affect of the path of rot from the outside of the tree into the central cylinder of rot.

7.7.7.2 Assessing Conk Rot; Visible Conk Knot(s), No Rot Visible

If the scaler observes conk knots but no rot shows at the ends of a log, the following conventions are commonly used:

1. Conk rot generally extends further down from a conk knot than up. Experience has shown that, in coastal regions of British Columbia, given no other indicators to the contrary, it may be presumed that the conk rot extends 2.4 m above the highest conk knot and 3.6 m below the lowest conk knot. In the interior regions of British Columbia, with different timber types, conk rot extends, on the average, 1 m above the highest conk knot and 2 m below the lowest conk knot. Where a conk knot is located closer to the top end or closer to the butt end than the above conventions, presume that the defect will travel one half the distance between the last knot and the log end.
2. When a conk knot is the only indication of conk and the severity of the rot is unknown, the firmwood deduction is calculated as one half the estimated length of the defect in coastal regions, and in interior regions, the diameter of the rot is assumed to be one-half the average diameter of the log for the full length of the defect.
3. Where there are conk knots and no sign of rot at the ends of a log, the scaler should, if possible, have the log bucked and/or observe the processing of the log to get a better idea of the internal affects of conks in their area.

7.7.7.3 Assessing Conk Rot; Visible Conk Knot(s), Rot Visible at One End

If a scaler observes one or more conk knots and conk rot showing in one end of a log, the following guides will serve in the assessment of the log:

1. Where conk shows in the top end of a log and there are conk knots, the rot may be run the greater distance of half the log length to a maximum of (6 m coast/4 m interior), or (3.6 m coast/2 m interior) below the last conk knot. If the last conk knot is closer to the butt end than (3.6 m coast/2 m interior), it may then be presumed to travel one-half the distance between the knot and the butt end.
2. Where conk shows in the butt end of a log and there are conk knots, the rot should be run the greater distance of half the log length to a maximum of (6 m coast/4 m interior), or (2.4 m coast/1 m interior) above the last conk knot. If the last conk knot is closer to the top end than (2.4 m coast/1 m interior), it may then be presumed to travel one-half the distance between the knot and the top end.

3. Where conk rot is visible in the butt end of a butt cut log, and there are conk knots present, the rot is treated as conk rot, not butt rot. Therefore, it is scaled as a cylinder extending from the butt end, rather than as a cone.

7.7.7.4 Assessing Conk Rot; No Visible Conk Knot(s), Rot Visible at One End

1. Where conk rot is visible in one end of a log and there are no conk knots present, the rot is presumed to travel half the length of the log to a maximum of 6 m in coastal regions and 4 m in interior regions.

7.7.8 Ring Defect

7.7.8.1 Ring Rot Conventions

Ring rot often does not form a complete circle. The volume should be calculated as if it was a full circle, and then a factor of the circumference of the ring divided by the full circle is applied to obtain the true volume. That is, if the ring travels approximately two thirds of the way around its circumference, the "unit volume" or factor of the ring area is also two thirds of what a full circle of rot would be.

If there is more than one ring of rot, the firmwood deduction is taken progressively, from the outside rings to the inside rings.

When estimating the distance that ring rot travels down a log, use the same conventions as used in the heart rots, or conk rot, if there is evidence of conk.

7.7.8.2 Ring Defect - Through Running

The simplest method of determining the volume of a ring which does not form a full circle is to:

1. Apply the methods described below as if it were a full circle.
2. Estimate the arc of the rot as a percentage of the full circle.
3. Apply this percentage factor to the full circle.

Measurements for Defect Volume:

- the defect length in metres to the nearest tenth of a metre.
- the outside diameter of the ring defect at the top end in rads and the inside diameter of the ring defect at the top end in rads, and
- the outside diameter of the ring defect at the butt end in rads, and the inside diameter of the ring defect at the butt end in rads.

7.7.8.2.1 Example and Illustration - Ring Rot, Full Length

In the example illustrated in Figure 7.8 a fungus has caused a ring shaped rot to destroy the wood fibres for the full length of the log. The rot volume may be visualised as a cylinder of rot containing another, smaller, cylinder of firm wood that is subtracted from the rot cylinder, leaving the volume of the ring.

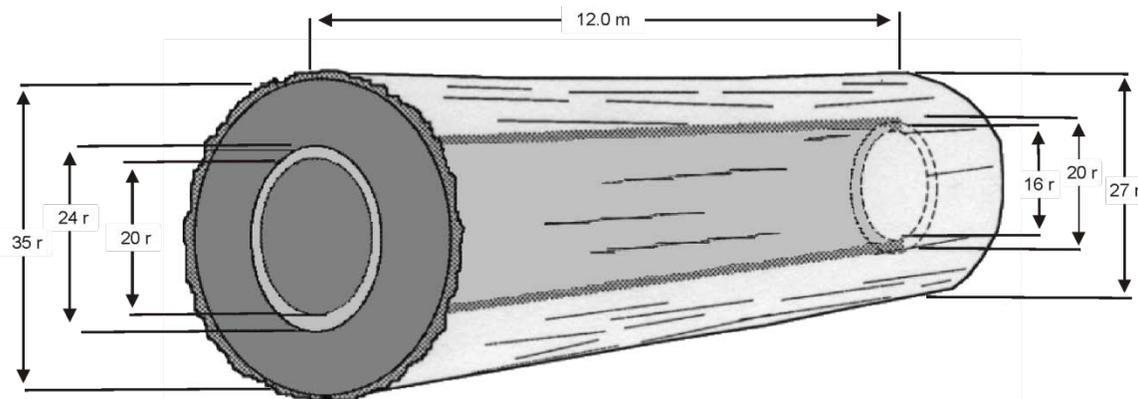


Figure 7.8 A Log with Through-running Ring Rot.

7.7.8.2.2 The Gross/Net Calculation – Ring Rot, Full Length

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 rads,
B	=	35 rads,
L	=	12 m,
F	=	0.0001570796,
ODT	=	20 rads,
ODB	=	24 rads,
IDT	=	16 rads,
IDB	=	20 rads,

$$\begin{aligned}
 DL &= 12 \text{ m}, \\
 V &= \left[(27^2 + 35^2) \times 12.0 \times F \right] - \left[(20^2 + 24^2) \times 12.0 \times F \right] - \left[(16^2 + 20^2) \times 12.0 \times F \right] \\
 V &= [1954 \times 12.0 \times 0.0001570796] - [976 \times 12.0 \times 0.0001570796] - [656 \times 12.0 \times 0.0001570796] \\
 V &= 3.683 - [1.840 - 1.237] \\
 V &= 3.683 - 0.603, \\
 V &= 3.080 \text{ m}^3.
 \end{aligned}$$

7.7.8.2.3 Net Dimensions Calculation - Ring Rot, Full Length

Using the cylinder deduction formulas the net volume of the log is calculated to be 3.080 m³.

Three steps are required for a ring defect deduction. Using the same methods as for heart rot:

1. Find a volume using the outside diameters and length of the ring.
2. Find the volume of the sound core using the inside diameters of the ring.
3. Subtract the volume of the sound core to get the volume of the outside ring (Step 2 minus Step 1).

Calculate the volume of the defect using the outside and inside diameters of the defect.

Outside diameter cylinder volume:

$$\begin{aligned}
 \text{Half volume of } 12.0/24 &= 1086 \text{ dm}^3 \\
 \text{Half volume of } 12.0/20 &= \underline{+ 754 \text{ dm}^3} \\
 \text{Full volume of } 12.0/20/24 &= 1840 \text{ dm}^3
 \end{aligned}$$

Inside diameter cylinder volume:

$$\begin{aligned}
 \text{Half volume of } 12.0/20 &= 754 \text{ dm}^3 \\
 \text{Half volume of } 12.0/16 &= \underline{+ 483 \text{ dm}^3} \\
 \text{Full volume of } 12.0/16/20 &= 1237 \text{ dm}^3
 \end{aligned}$$

Volume of defect equals outside cylinder volume minus inside cylinder volume.

$$\text{Defect volume} = 1840 - 1237 = 603 \text{ dm}^3$$

A percentage factor may be applied at this point for a partial ring defect (i.e., if the ring arc forms only one third of the circumference, multiply the above volume by 0.33 or 33 percent).

$$\begin{array}{l} \text{Defect volume: } \frac{603}{307} = 1.980 \text{ m Length deduction} \\ \text{AUV:} \end{array}$$

$$12.0 - 2.0 = 10.0 \text{ m Net length}$$

Net Dimensions – 10.0 27/35

7.7.8.3 Ring Defect - Partial Length of Log

Measurements for Defect Volume:

- the estimated defect length in metres to the nearest tenth of a metre,
- the outside diameter of the ring defect visible at the log end in rads, and
- the inside diameter of the ring defect visible at the log end in rads

7.7.8.3.1 Example and Illustration - Ring Rot, Partial Length

Ring rot is visible at only one end of the log in Figure 7.9. Because there are no other indicators, the rot is estimated to travel one half the length of the log and the ring's inner and outer diameters are presumed to be the same at both ends.

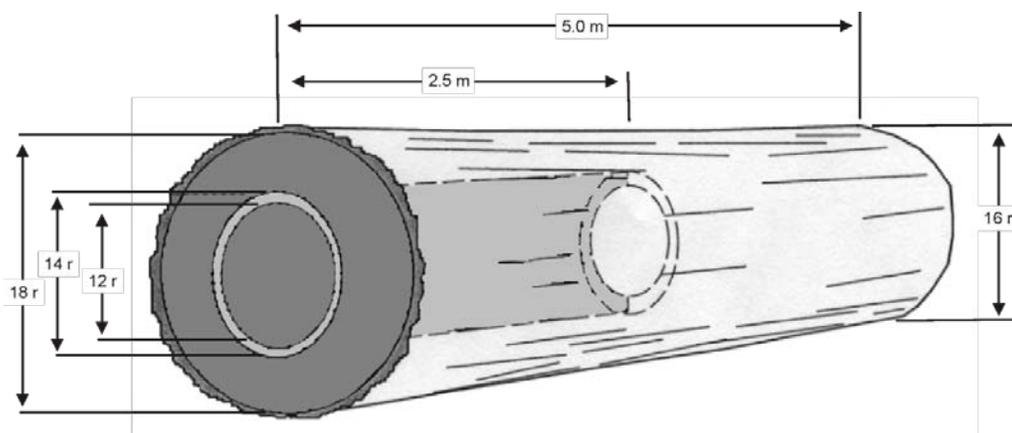


Figure 7.9 A Log with Partial Length Ring Rot.

7.7.8.3.2 The Gross/Net Calculation – Ring Rot, Partial Length

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

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

Where the following values are substituted for the variables:

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

$$B = 18 \text{ rads,}$$

$$L = 5 \text{ m,}$$

$$F = 0.0001570796,$$

$$ODB = 14 \text{ rads,}$$

$$IDB = 12 \text{ rads,}$$

$$DL = 2.5 \text{ m,}$$

$$V = [(16^2 + 18^2) \times 5.0 \times F] - [[(14^2 + 14^2) \times 2.5 \times F] - [(12^2 + 12^2) \times 2.5 \times F]]$$

$$V = [580 \times 5.0 \times 0.0001570796] - [392 \times 2.5 \times 0.0001570796] - [288 \times 2.5 \times 0.0001570796]$$

$$V = 0.456 - [0.154 - 0.113]$$

$$V = 0.456 - 0.041,$$

$$V = 0.415 \text{ m}^3.$$

7.7.8.3.3 Net Dimensions Calculation - Ring Rot, Partial Length

The net volume of the log is calculated as follows:

$$\text{AUV 16/18} = 91 \text{ dm}^3$$

Calculate the volume of the defect using the outside and inside diameters of the defect.
Outside diameter cylinder volume:

$$\text{Full volume of 025/14} = 154 \text{ dm}^3 \text{ (2 x half volume)}$$

Inside diameter cylinder volume:

$$\text{Full volume of } 025/12 = 112 \text{ dm}^3 \text{ (2 x half volume)}$$

Volume of defect equals outside diameter cylinder volume minus inside diameter cylinder volume.

$$\text{Defect volume} = 154 - 111 = 42 \text{ dm}^3$$

A factor may be applied at this point for a partial ring defect (for example, if the ring arc forms only one-half of the circumference, multiply the above volume by 0.5 or 50 percent).

$$\begin{array}{l} \text{Defect volume: } \frac{42}{91} = 0.461 \text{ m Length deduction} \\ \text{AUV:} \end{array}$$

$$5.0 - .5 = 4.5 \text{ Net length}$$

$$\text{Net Dimension} - 4.5 \text{ } 16/18$$

$$\text{Net Volume} - \mathbf{0.410 \text{ m}^3}$$

7.7.9 Pocket Defects

7.7.9.1 Pocket Rot Conventions

1. Pocket rot, unlike heart rot, is not confined to growth rings and is therefore not often circular in profile. Each segment of decay may be enclosed in an area which most resembles the shape, four-sided, triangular or circular. Section 6.3 of the *Gross Measurements Procedures* chapter define ways to enclose log segments and sectors for finding their volumes, and these same methods apply equally to irregular rot shapes. When calculating a deduction, the scaler then uses a method appropriate to the chosen shape.
2. Where multiple pockets of rot are present, and are less than 5 rads apart, experienced scalers group the individual rot volumes together visually rather than carrying out a number of discrete calculations. An example of enclosing pockets is provided in Section 7.7.10.3 (triangular defect) of this chapter.
3. When estimating the distance that pocket rot travels down a log, use the same conventions as used in the heart rots, including conk rot, if there is evidence of conk.

Measurements for Defect Volume:

- the defect length in metres to the nearest tenth of a metre (the same as the measured log length),
- if four-sided, the height and width of both defect ends in rads,
- if round or out of round, the diameters at both ends in rads,
- if triangular, the base and height at both ends in rads, and
- if multiple, the defects can be amalgamated or grouped together to form one defect.

The *Gross Measurements Procedures* chapter of this manual provides detailed information on enclosing irregular defects and determining representative dimensions.

7.7.9.1.1 Example and Illustration - Pocket Defect, Through-running

The log in the figure below is infected with a type of rot which forms in pockets rather than following the growth rings. Its shape is closer to being rectangular than circular.

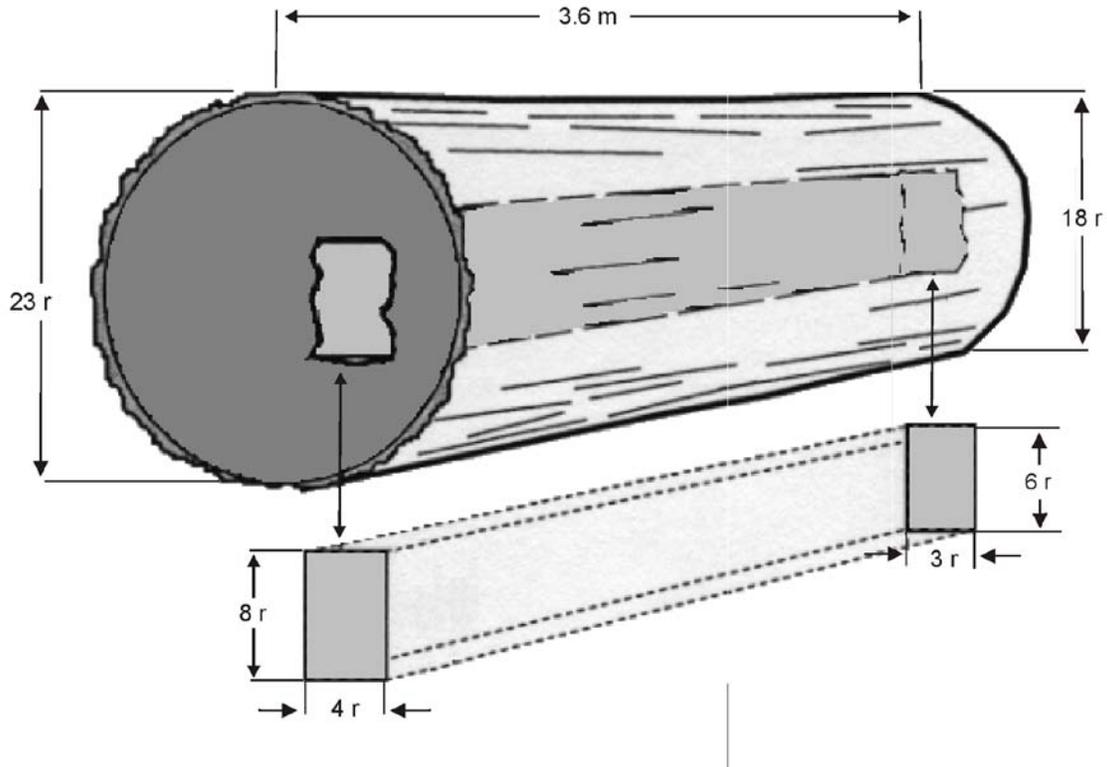


Figure 7.10 A Log with Through-running Pocket Rot.

7.7.9.1.2 The Gross/Net Calculation – Pocket Rot, Through Running

Using the formula for finding the net volume of a log with a rectangular defect which projects the full length of a log:

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

Where the following values are substituted for the variables:

$$T = 18 \text{ rads,}$$

$$B = 23 \text{ rads,}$$

$$L = 3.6 \text{ m,}$$

$$F = 0.0001570796,$$

$$DHT = 3 \text{ rads,}$$

$$DWT = 6 \text{ rads,}$$

$$DHB = 4 \text{ rads,}$$

$$DWB = 8 \text{ rads,}$$

$$DL = 3.6 \text{ m,}$$

$$V = [(18^2 + 23^2) \times 3.6 \times 0.0001570796] - \left[\frac{[(03 \times 06) + (04 \times 08)] \times DL \times 0.0004}{2} \right]$$

$$V = [853 \times 3.6 \times 0.0001570796] - \left[\frac{50 \times 3.6 \times 0.0004}{2} \right],$$

$$V = 0.482 - \left[\frac{0.072}{2} \right],$$

$$V = 0.482 - 0.036,$$

$$V = 0.446 \text{ m}^3.$$

7.7.9.1.3 Net Dimensions Calculation - Pocket Rot, Through Running

Using the four-sided prism or "rectangular box" deduction formulas the net volume of the log is calculated as follows:

The defect is enclosed in a box representing the area of the defect. The measurements section of this chapter provides detailed information on enclosing irregular defects and determining representative dimensions. An example of grouping multiple pockets into a unit is provided in Section 7.7.10.3, where three individual pockets of rot are enclosed in a triangular shape.

Calculate the unit volumes of the defect ends by multiplying the height by the width by the factor of 0.4 to convert the end area of the defect from "square rads" to unit volumes:

$$\begin{array}{rcl}
 3 \times 6 \times 0.4 & = & 7 \text{ dm}^3 \\
 4 \times 8 \times 0.4 & = & + \underline{13 \text{ dm}^3} \\
 \text{Sum of unit volumes} & = & 20 \text{ dm}^3 \\
 \text{Divided by 2} & = & 10 \text{ dm}^3, \text{ the AUV}
 \end{array}$$

Multiply the average unit volume of the defect by the length of the defect to obtain the defect volume:

$$\begin{array}{rcl}
 \text{Unit volume } 10 \text{ dm}^3 \times 3.6 \text{ m} & = & 36 \text{ dm}^3 \\
 \\
 \text{Defect volume: } \frac{36}{134} & = & 0.269 \text{ m Length deduction} \\
 \text{AUV:} & &
 \end{array}$$

$$3.6 - 0.3 = 3.3 \text{ m Net length}$$

$$\text{Net Dimensions } 3.3 \text{ } 18/23$$

$$\text{Net Volume} - 0.442 \text{ dm}^3$$

7.7.9.2 Pocket Defect - Partial Length

The log in Figure 7.11 is infected with a heart rot in the shape of a pocket, and it is estimated to travel 3.8 m.

Measurements for Defect Volume:

- the estimated defect length in metres to the nearest tenth of a metre,
- if four-sided, the height and width of the defect visible at the log end in rads,
- if round or out of round, the diameter visible at the log end in rads,
- if triangular, the base width and height visible at the log end in rads,
- if multiple, the defects are amalgamated or grouped together to form one defect, and
- in pocket defects with only one end visible, the diameter of the unseen end is assumed to be the same as at the measured end.

7.7.9.2.1 Example and Illustration - Pocket Rot, Partial Length

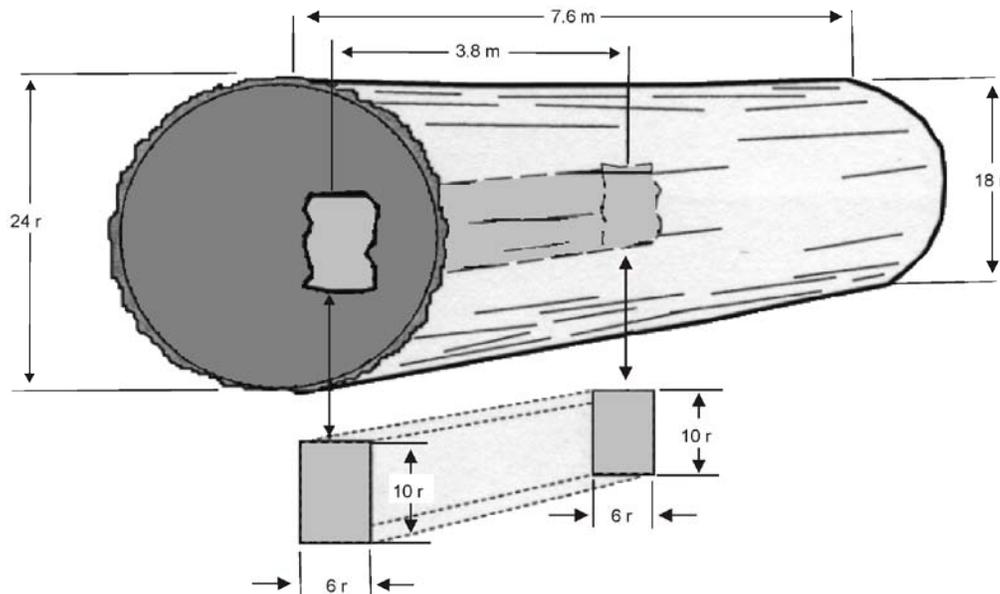


Figure 7.11 A Log with Partial-length Pocket Rot.

7.7.9.2.2 The Gross/Net Calculation – Pocket Rot, Partial Length

Using the formula for finding the net volume of a log with a rectangular defect which does not project the full length of a log:

$$V = [(T^2 + B^2) \times L \times F] - [(DHT \times DWT) \times DL \times 0.0004]$$

Where the following values are substituted for the variables:

$$T = 18 \text{ rads,}$$

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

$$L = 7.6 \text{ m,}$$

$$F = 0.0001570796,$$

$$DHT = 06 \text{ rads,}$$

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

$$DL = 3.8 \text{ m,}$$

$$V = [(18^2 + 24^2) \times 7.6 \times 0.0001570796] - [(06 \times 10) \times 3.8 \times 0.0004],$$

$$V = [900 \times 7.6 \times 0.0001570796] - [60 \times 3.8 \times 0.0004],$$

$$V = 1.074 - 0.091,$$

$$V = 0.983 \text{ m}^3.$$

7.7.9.2.3 Net Dimensions Calculation

Using the cubical or "rectangular box" deduction formulas the net volume of the log is calculated as follows:

The defect is enclosed in a box representing the area of the defect. The *Gross Measurements Procedures* chapter of this manual provides detailed information on enclosing irregular defects and determining representative dimensions.

Calculate the unit volumes of the defect ends by multiplying the height by the width by the factor of 0.4 to convert the end area of the defect from "square rads" to unit volumes, and multiply by the defect length to obtain the defect volume.

$$\text{Unit volume} = 6 \text{ R} \times 10 \text{ R} \times 0.4 = 24 \text{ dm}^3$$

Defect Volume = $24 \text{ dm}^3 \times 3.8 \text{ m} = 91 \text{ dm}^3$

Defect volume: $\frac{91}{141.5} = 0.643 \text{ m Length deduction}$

AUV: 141.5

$7.6 - 0.6 = 7.0 \text{ m Net length}$

Net Dimensions – 7.0 18/24

Net Volume – 0.989 m³

In the case of multiple scattered pockets (5 rads or more apart) or pipes, calculate the volume of each one and add them together. Where there are several small close pockets (less than 5 rads apart), visually group them together and use one measurement.

7.7.10 Triangular defects

7.7.10.1 Example and Illustration - Triangular Defect

The log in Figure 7.12 has pockets of rot. The pockets fit best into a triangle shape, and because there are no other indicators, the rot is assumed to travel half way through the log. This method may be applied to any other defect which most closely fits a triangle shape.

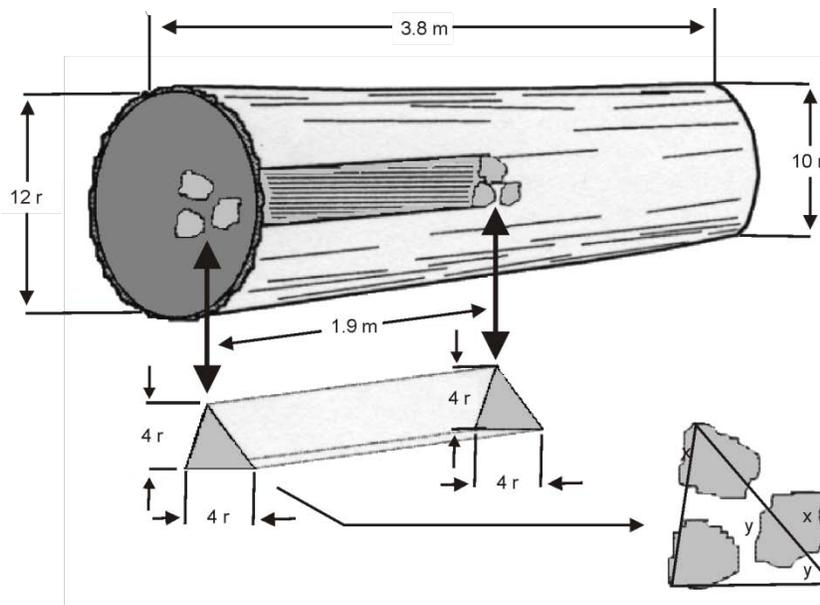


Figure 7.12 A Log with Partial-length Triangular Defect.

7.7.10.2 The Gross/Net Calculation – Triangular Defect

Using the prism formula for finding the net volume of a log with a triangular defect:

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

Where the following values are substituted for the variables:

$$\begin{aligned} T &= 10 \text{ rads,} \\ B &= 12 \text{ rads,} \\ L &= 3.8 \text{ m,} \\ F &= 0.0001570796, \\ DHT &= 4 \text{ rads,} \\ DWT &= 4 \text{ rads,} \\ DHB &= 4 \text{ rads,} \\ DWB &= 4 \text{ rads,} \\ DL &= 1.9 \text{ m,} \end{aligned}$$

$$V = \left[(10^2 + 12^2) \times 3.8 \times 0.0001570796 \right] - \left[\frac{\left(\left(4 \times \frac{4}{2} \right) + \left(4 \times \frac{4}{2} \right) \right)}{2} \times 1.9 \times 0.0004 \right]$$

$$V = [244 \times 3.8 \times 0.0001570796] - \left[\left[\frac{8+8}{2} \right] \times 1.9 \times 0.0004 \right],$$

$$V = 0.146 - [8 \times 1.9 \times 0.0004],$$

$$V = 0.146 - 0.006,$$

$$V = 0.140 \text{ m}^3$$

7.7.10.3 Net Calculation - Triangular Defects

Using Smalian's formula with factor the net volume of the log is calculated as follows:

This method of making a deduction is appropriate in cases where the shape of the defect most closely approximates that of a triangle.

In the case of multiple scattered pockets (5 rads or more apart) pockets or pipes, calculate the volume of each one and add them together. Where there are several small close pockets (less than 5 rads apart), visually group them together and use one measurement. The volume of firmwood between the pockets must be accounted for as shown in Figure 7.12. In grading, it is excluded, as explained in the Timber Grading chapter of this manual.

Whatever form a triangle may take the formula for finding its area is always one half the base times the height.

The triangle formula for scaling purposes is:

$$\text{Unit volume} = \text{BH} \times 0.2$$

For the pocket rot visible at the end of the log:

$$\text{Base} = 04 \text{ r}$$

$$\text{Height} = 04 \text{ r}$$

$$\text{Unit volume} = 04 \times 04 \times 0.2$$

$$\text{Unit volume} = 3.2 \text{ dm}^3$$

Multiply the defect unit volume by the length of the defect:

$$\text{Defect volume} = 3.2 \times 1.9 = 6 \text{ dm}^3$$

$$\text{Defect volume: } \frac{6}{36} = 0.166 \text{ m Length deduction}$$

$$\text{AUV: } 36$$

$$3.6 - 0.2 = 3.4 \text{ m Net length}$$

Net Dimensions – 3.4 m 10/12

$$\text{Net Volume} - 0.130 \text{ m}^3$$

7.7.11 Sap Rot Conventions

Logs having sap rot are scaled with the rot included in the gross scale. The difference between the gross scale of the outer scaling diameter and the net scale of the inner scaling diameter will be the deduction volume if no other defects are present.

7.7.11.1 Sap Rot Examples and Calculations

Scalers should use the "gross-net" scale method to provide additional information on the gross dimensions and volume of the log, the volume of the rot, and the net dimensions and volume.

The log in Figure 7.13 was bucked from a windfall tree and has been lying on the ground long enough for fungi to have eaten into the sap wood 2 rads deep at the butt end and between 1 and 2 rads deep at the top end.

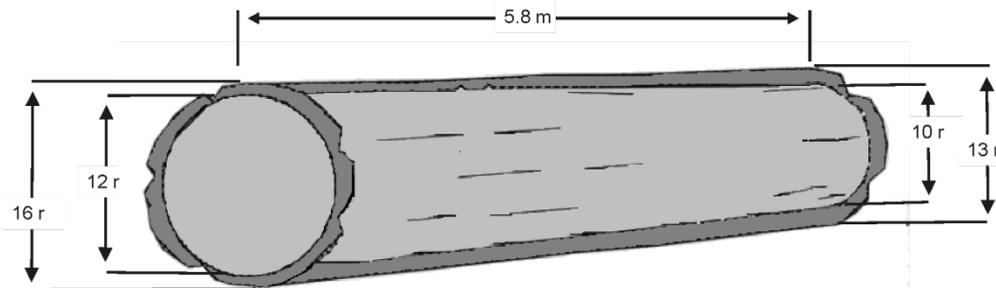


Figure 7.13 A Log with Sap Rot.

Measurements for Defect Volume:

- the defect length in metres to the nearest tenth of a metre,
- the net top end diameter (inside the defect) in rads,
- the net butt end diameter (inside the defect) in rads.

7.7.11.2 Gross/Net Calculation – Sap Rot, Full Length

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

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

Where the following values are substituted for the variables:

$$T = 13 \text{ rads,}$$

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

$$L = 5.8 \text{ m,}$$

$$F = 0.0001570796,$$

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

$$NDB = 12 \text{ rads,}$$

$$DL = 5.8 \text{ m,}$$

$$V = \left[(13^2 + 16^2) \times 5.8 \times F \right] - \left[(13^2 + 16^2) \times 5.8 \times F \right] - \left[(10^2 + 12^2) \times 5.8 \times F \right]$$

$$V = [425 \times 5.8 \times 0.0001570796] - [425 \times 5.8 \times 0.0001570796] - [244 \times 5.8 \times 0.0001570796]$$

$$V = 0.387 - [0.387 - 0.222],$$

$$V = 0.387 - 0.165,$$

$$V = 0.222 \text{ m}^3.$$

7.7.11.3 Net Dimensions Calculation-Sap Rot-Full Length

Scalers using volumetric scale will use this method rather than the diameter deduction method shown below to provide additional information on the gross dimensions and volume of the log, the volume of rot and the net dimensions and volume.

Calculate the gross top half volume of the outer cylinder:

$$\text{Half volume of } 05.8/13 = 154 \text{ dm}^3$$

Calculate the gross butt half volume of the outer cylinder:

$$\text{Half volume of } 05.8/16 = 233 \text{ dm}^3$$

Add the half volumes to find the full volume of the outer cylinder. The inner cylinder is found in the same way.

$$\begin{array}{rcl}
 \text{Full volume of 05.8/13/16} & = & 387 \text{ dm}^3 \\
 \text{Less the inner cylinder volume} & = & 223 \text{ dm}^3 \\
 \text{Equals the defect volume} & = & \underline{164 \text{ dm}^3} \\
 \\
 \text{Defect volume: } \frac{164}{66} & = & 2.484 \text{ m Length deduction} \\
 \text{AUV:} & &
 \end{array}$$

$$5.8 - 2.5 = 3.3 \text{ m Net length}$$

$$\text{Net Dimension} - 3.3 \text{ 13/16}$$

$$\text{Net Volume} - \mathbf{0.221 \text{ m}^3}$$

7.7.11.4 Net Dimensions Calculations – Diameter Deduction

This method simply ignores the sap rot and uses the diameters of the sound core of wood to find the net volume and recorded net dimensions. Although very simple to apply, it is a ‘net’ method and does not provide users of scale data with any information about the rot. Scalers using ‘net dimensions methods’ should use the length deduction method shown above to provide additional information.

Using the diameters of the firm core inside the rot, calculate the Net volume using the inner cylinder:

$$\text{Net Dimensions} - 5.8 \text{ 10/12}$$

$$\text{Net Volume} = \mathbf{0.222 \text{ m}^3}$$

7.7.12 Other Defects

Measurements for Defect Volume:

- the length of the log in metres to the nearest tenth of a metre,
- the callipered diameters of both ends of the log at the points where the log is not affected by the defect,
- a factor for the missing portion of the log, or
- the measurements required for the shape of the defect in rads.

7.7.12.1 Missing Segments

Missing wood can take many forms. This example demonstrates the use of a percentage factor to represent the missing part, but any of the other methods described previously will serve just as well if they are more representative of the shape of the defect.

7.7.12.1.1 Example and Illustration - Missing Wood

The defect shown in Figure 7.14 is typical of missing wood. Such defects as burn saddles or charred wood could also apply to this example, and in this case, the missing portion is equal to 50 percent or 1/2 the diameter of the log for 4.8 m.

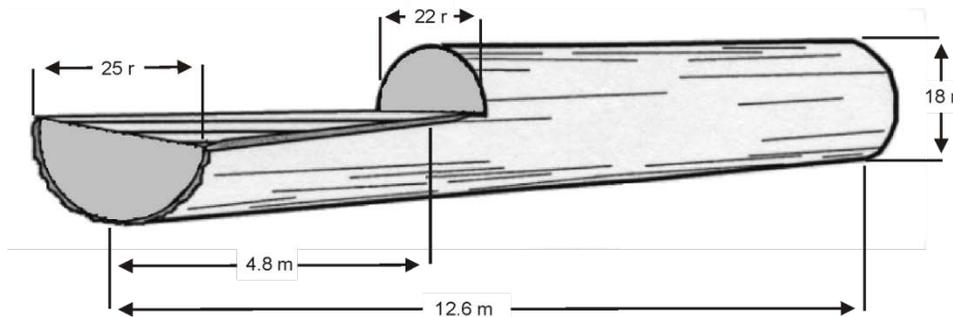


Figure 7.14 A Log with Missing Segment.

7.7.12.1.2 The Gross/Net Calculation – Missing Wood

Using the formula for finding the net volume of a log with a cylindrical defect and applying a percentage factor:

$$V = [(T^2 + B^2) \times L \times F] - \left[[(DT^2 + DB^2) \times DL \times F] \times \frac{\%f}{100} \right]$$

Where the following values are substituted for the variables:

- $T = 18$ rads,
- $B = 25$ rads,
- $L = 12.6$ m,
- $F = 0.0001570796$,
- $DT = 22$ rads,
- $DB = 25$ rads,

$$DL = 4.8 \text{ m,}$$

$$\%f = 50 \text{ percent,}$$

$$V = [(18^2 + 25^2) \times 12.6 \times 0.0001570796] - \left[[(22^2 + 25^2) \times 4.8 \times 0.0001570796] \times \frac{50}{100} \right]$$

$$V = [949 \times 12.6 \times 0.0001570796] - [[1109 \times 4.8 \times 0.0001570796] \times 0.5]$$

$$V = 1.878 - 0.418$$

$$V = 1.460 \text{ m}^3$$

7.7.12.1.3 Net Dimensions Calculation – Missing Wood

Using the cylindrical deduction formula with factor the net volume of the log is calculated as follows:

$$\text{AUV volume of } 18/25 = 149 \text{ dm}^3$$

The half volume at the upper limit of the defect:

$$\text{Half volume of } 04.8/22 = 365 \text{ dm}^3$$

Plus the half volume at the lower limit of the defect:

$$\text{Half volume of } 04.8/25 = 472 \text{ dm}^3$$

Equals the full volume of the portion of the log affected by the defect:

$$\text{Full volume of } 04.8/22/25 = (365 + 472) = 837 \text{ dm}^3$$

Multiplied by the percentage missing, is the volume of the defect:

$$\text{Volume of defect} = 837 \times 0.5 = 418.5 = 418 \text{ m}^3$$

$$\text{Defect volume: } \frac{418}{12.6} = 2.805 \text{ m Length deduction}$$

$$\text{AUV: } 149$$

$$12.6 - 2.8 = 9.8 \text{ Net length}$$

$$\text{Net Dimensions} - 9.8 \text{ } 18/25$$

$$\text{Net Volume} - 1.461 \text{ m}^3$$

It is tempting to reduce the length of the log by 1/2 the length of the defect, but it is a dangerous concept to "fold in" 1/2 of the defect. In this example, the defect is 4.8 m long, so a deduction of 2.4 m will understate the volume of the defect. If this same defect occurred at the top end of the log, the 2.4 m deduction would overstate the volume of the defect. The relationship between the defect and the average unit volume of the log must be established.

7.7.13 Missing Sectors

Measurements for Defect Volume:

- the length of the log in metres to the nearest tenth of a metre,
- the callipered diameters of both ends of the log at the points where the log is not affected by the defect,
- a factor for the missing portion of the log, or
- the measurements required for the shape of the defect in rads.

The method of applying a factor is most effective for defects which extend to the geometric centre or pith of the log because it is simpler to estimate the affected percentage of the log. This method can be used for:

- Lightning scars,
- Frost checks, or
- Dead side.

If the defect does not extend to the pith, or if it is difficult to estimate the affected percentage with certainty, apply methods for the cylinder, cone, rectangular box or prism to find the defect volume.

7.7.13.1 Example and Illustration – Missing Segment/Surface Defect

The log in Figure 7.15 has a pie-shaped sector split out of it. This sector is about 15 percent of the whole piece. Other surface defects such as lightning scars and frost checks if they contain rot are good candidates for this method of firmwood deduction. It may be used in grading too, for those types of defects which affect recovery.

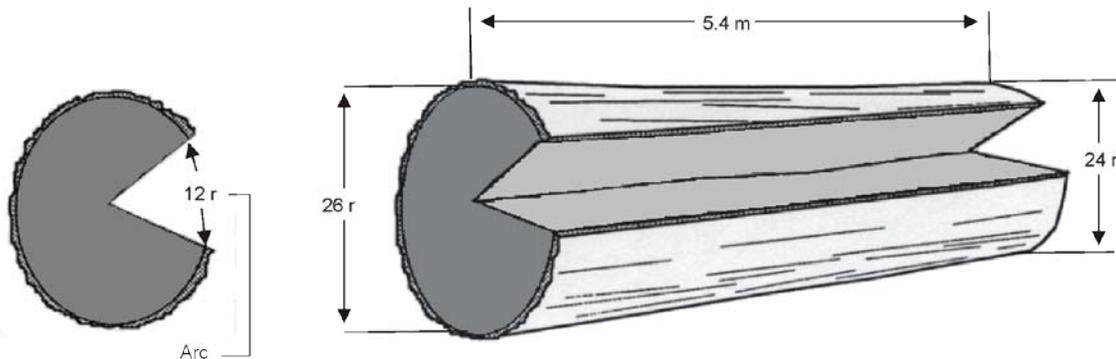


Figure 7.15 A Log with Sector Defect Extending to the Heart.

7.7.13.2 The Gross/Net Calculation – Sector Defect

Using Smalian's formula for finding the gross volume of a log with a pie-shaped defect and applying a percentage factor:

$$V = [(T^2 + B^2) \times L \times F] \times \left[\frac{(100 - \%f)}{100} \right]$$

Where the following values are substituted for the variables:

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

$$B = 26 \text{ rads,}$$

$$L = 5.4 \text{ m,}$$

$$F = 0.0001570796,$$

$$\%f = 15 \text{ percent,}$$

$$V = [(24^2 + 26^2) \times 5.4 \times 0.0001570796] \times \left[\frac{(100 - 15)}{100} \right]$$

$$V = [1252 \times 5.4 \times 0.0001570796] \times \left[\frac{85}{100} \right]$$

$$V = 1.062 \times 0.85$$

$$V = 0.903 \text{ m}^3.$$

7.7.13.3 Net Dimensions Calculation - Sector Defect

This example uses the application of a factor to determine net volume, in the same way as demonstrated in the previous example for missing wood. With pie-shaped defects which do not extend to the pith, however, it may be easier to find the volume of the defect by applying another shape as described in the measurements section of this chapter. This is because it is much more difficult to estimate the defect factor if it does not extend to the pith. That is, the volume in the outer 50% of a log's radius contains 75% of the log's volume. If a defect penetrates half way to the heart, for example, the deduction is reduced by 25 percent.

Using Smalian's formula with factor the net volume of the log is calculated as follows:

Using the scale stick, find the top end half volume:

Using the scale stick, find the gross volume of the log:

$$\text{Gross Volume: Full volume of } 5.4/24/26 = (488 + 573) = 1061 \text{ dm}^3$$

Eighty-five (85) percent of this log is sound, and the remaining 15 percent is defect, so the factor becomes 15/100 or .15. This factor may be easily visualized, if it is in simple fractions such as 1/4, 1/3, and 1/2. It can be calculated as a ratio of the circumference by multiplying the diameter by π and dividing the result into the arc of the defective sector, but finding the arc is not practical with conventional scaling tools. Degrees of arc are one option, using a watch or compass dial to learn to visualize sectors which are not obvious divisions of 360 degrees.

Factor from formal calculation:

$$\text{Radius times } \pi = 26 \times 3.14159 = 82 \text{ r circumference}$$

$$\text{Defect arc factor} = \frac{12\text{r arc}}{82} = .146 = 0.15 \text{ or } 15 \text{ percent}$$

Factor from a clock face, major divisions in 12ths (secondary divisions in 60ths (minutes) which are equal to 6 degrees):

Position of hands	=	12:00 to 9 minutes
Defect arc factor	=	9 / 60 = 0.15 or 15 percent

Factor from a compass, major divisions in 8ths or 16ths (secondary divisions in 36ths or 10 degrees):

Position from north	=	54 degrees
Defect arc factor	=	54 / 360 = 0.15 or 15 percent 100% - 15% = 85%
Factor	=	0.85

There are several incremental options available to the scaler just from these two common objects, and of course, that which is most comfortable and familiar is preferred, even a piece of paper, which may be easily and accurately folded into 16ths.

Gross Volume X Factor = Net volume

$$1.061 \text{ m}^3 \times 0.85 = 0.902 \text{ m}^3$$

7.7.14 Assessing Goitre

Goitre is a swelling or abnormal growth on the bole of a tree and rot may be associated with this defect. Internal rot seldom travels more than 1 m above and below the goitre. The volume of the rot may be assumed to be one-half of the volume of the log in the same length. For example, if the rot is estimated to travel two metres, the volume deduction will be 1 m of length. A deduction is made only when rot is present.