



Analysis of particle size of wood chips and hog fuel – ISO/TC 238

Authors: Eija Alakangas

Confidentiality: Public

Report's title		
Analysis of particle size for wood chips and hog fuel – ISO/TC 238		
Customer, contact person, address		Order reference
Finnish Forest Industry Federation		
Project name		Project number/Short name
CEN-Suomi		25217
Author(s)		Pages
Eija Alakangas		28 p.
Keywords		Report identification code
Wood chips, hog fuel, particle size distribution, standardisation		VTT-R-02834-12
<p>Summary</p> <p>This report summarizes the results of particle size analysis for 133 samples of wood chips or hog fuel. Data has been analysed according to EN 15149-1 in Finland, Denmark, Ireland and UK. In total 133 analysis results were received. VTT made a comparison for prISO 17225-1 (document N94) for particle size classes P31, P45 and P63. Used raw material were roundwood, stem wood, logging residues, whole trees, stumps and other unspecified woody biomass. Same data were used for the comparison P31 and P45 particle size classes for prISO 17225-4 (document N97), but only round wood, stem wood or whole trees were used as for raw material. Logging residues chips and stumps are not suitable for small-scale installations.</p> <p>According to the analysis carried out in different countries, proposed particle size classifications for wood chips and hog fuel are suitable in the most cases for different raw materials. The results show that requirements of proposed particles sizes in prISO 17225-1 and prISO 17255-4 can be met in class P45 by 78% and for P63 by 75%. Only every third measurement can met a particle size requirement for P31. When fine fraction is stated separately in Part 1 it helps to fulfil the requirements of fines especially for logging residue chips. It is also important to keep the main fraction wider for logging residues starting from 3.15 mm in classes P45 and P63. None of logging residues chips could met P31 requirement. For P45 requirement can be met by 77% and for P63 by 82% for logging residue chips. This classification is still quite complicated and difficult to control when chipping or crushing.</p> <p>The report also includes Finnish and Austrian proposals for size classification and new proposal agreed in WG2. Results of these new classifications (N122 and N124) have been also compared to data received. Results were almost same as for previous proposal (N 94 and N97).</p>		
Confidentiality	Public	
Jyväskylä 30.8.2012		
Written by	Reviewed by	Accepted by
Eija Alakangas Principal scientist	Jyrki Raitila, Team leader	Jouni Hämäläinen Technology manager
VTT's contact address		
P.O. Box 1603, FI-40101 Jyväskylä, Finland, eija.alakangas@vtt.fi, tel.+358 400 542454		
Distribution (customer and VTT)		
ISO/TC WG2 members		
<p><i>The use of the name of the VTT Technical Research Centre of Finland (VTT) in advertising or publication in part of this report is only permissible with written authorisation from the VTT Technical Research Centre of Finland.</i></p>		

Preface

This report is made for ISO/TC 238 for working group 2 – Fuel specification. Data of particle size analysis has been collected from Finland, Denmark, Ireland and UK. Also Holz Forschung Austria has sent their report of particle size analysis for WG2.

This report is written by principal scientist Eija Alakangas from VTT.

Jyväskylä, 30.8.2012

Eija Alakangas, convenor of WG2 of ISO/TC 238

Contents

Preface2

1 Introduction.....4

2 Goal.....5

3 Descriptions of raw materials and sieving method.....6

4 Results 10

5 Proposals for new particle size classification and conclusions25

References28

1 Introduction

Mrs Eija Alakangas, WG2 convenor of ISO/TC 238, has got feedback from fuel producers, chipper and crusher manufacturers, boiler manufacturers and researchers about the particle size classification for wood chips or hog fuel. Particle classification published in EN 14961-1:2010 and EN 14961-4:2011 has been found too demanding and not all requirements (main fraction, fine particles and coarse fraction) can be met simultaneously for most of wood chips or hog fuel. It is also very difficult for fuel producers to control the particles size. For example the following comments have been received:

- There are too many parameters, which in real chipping conditions can't be controlled (main fraction, fines (< 3.15 mm) and coarse fraction).
- When main fraction starts from 8 mm and fines are less than 3,15 mm. What is then fraction between 3.15 mm and 8 mm?
- In larger power plants (> 1 MW) fines should be less than 5 mm and maximum amount of fines should be 25 – 30 w-%. All particles should be less than 300 mm. Plants have sieving equipment so over-sized particles can be sieved and crushed.
- It is impossible to produce wood chips with particle size class P16.
- 75% main fraction is demanding especially for class P45 and P63, when it starts from 8 mm or 16 mm.

Hog fuel is defined as following: fuelwood in the form of pieces of varying size and shape, produced by crushing with blunt tools such as rollers, hammers, or flails (EN 14588:2010).

Wood chips are defined as following: chipped woody biomass in the form of pieces with a defined particle size produced by mechanical treatment with sharp tools such as knives. Wood chips have a sub-rectangular shape with a typical length 5 to 50 mm and a low thickness compared to other dimensions (EN 14588:2010).



Figure 1. Wood chips (left) and hog fuel (right).

2 Goal

The aim of this study is to find out, if new particle size proposals for ISO/TC WG2, which was agreed in telephone meeting on 17 January 2012, can be used for particle size analysis for wood chips and hog fuel. Also the aim was to analyse the new proposal from the 7 May 2012 meeting in Stockholm. Analysis was carried out by collecting data from different sieving's studies carried out in Finland, Denmark, Ireland and UK. The data analysed in this study according to the standard EN 15149-1, is unpublished.

Because particle size analysis was carried out by following sieve sizes (ISO 3310-serie) 3.15, 8, 16, 31.5, 45, 63 and 100 mm, the particle size classification was made for P31, P45 and P63 (prISO 17225-1, (Fig. 2) and P31 and P45 (prISO 17225-4, Fig. 3). VTT has received in total 133 analysis results.

Table 1. Proposal for particle size distribution for wood chips and hog fuel in prISO 17225-1 (N94).

Dimensions (mm)		
Main fraction (minimum 60 w-%), mm ^a		Coarse fraction, w-% (max. length of particle, mm) ^b
P16 small	3,15 ≤ P ≤ 16 mm	≤ 3 % > 31,5 mm and all < 45 mm, The cross sectional area of the oversized particles < 1 cm ²
P31 medium	3,15 ≤ P ≤ 31,5 mm ^b	≤ 6 % > 45 mm, ≤ 3 % > 100 mm and all < 200 mm cross sectional area of long particles ≤ 5 cm ²
P45 large	8 ≤ P ≤ 45 mm ^b	≤ 12 % > 63 mm and all < 300 mm cross sectional area of long particles ≤ 10 cm ²
P63 extra large	8 ≤ P ≤ 63 mm ^b	≤ 8 % > 100 mm and all < 300 mm cross sectional area of long particles 18 cm ²
P90 coarse	16 ≤ P ≤ 90 mm ^b	≤ 10 % > 125 mm and all < 300 mm
P300 extra coarse	3,15 ≤ P ≤ 300 mm	to be specified
Fine fraction ^c (< 3,15 mm), % of weight ISO 17826-1		
F06	≤ 6 %	
F10	≤ 10 %	
F12	≤ 12 %	
F15	≤ 15 %	
F20	≤ 20 %	
F25	≤ 25 %	
F30	≤ 30 %	
F35	≤ 35 %	
F35+	> 35 (maximum value to be stated)	
^a The numerical values (P-class) for dimension refer to the particle sizes (at least 60 w-%) passing through the mentioned round hole sieve size (ISO 17826-1).		
^b For logging residue chips, which include thin particles like needles, leaves and branches, the main fraction for P31 is 3,15 ≤ P ≤ 31,5 mm P45 is 3,15 ≤ P ≤ 45 mm, for P63 is 3,15 ≤ P ≤ 63 mm and for P90 is 3,15 ≤ P ≤ 90 mm.		
^c Amount of fines to be stated.		

Table 2. Proposal for particle size distribution for graded wood chips in prISO 17223-4.

Dimensions (mm), ISO 17826-1			
	Minimum 60 w-% in main fraction, mm ^a	Fines fraction, w-% (< 3,15 mm)	Coarse fraction, (w-%), max. length of particle (mm), max. cross sectional area (cm ²)
P16 small	$3,15 \leq P \leq 16$ mm	$\leq 12\%$	$\leq 3\% > 31,5$ mm, and all < 45 mm The cross sectional area of the oversized particles < 1 cm ²
P31 medium	$3,15 \leq P \leq 31,5$ mm	$\leq 8\%$	$\leq 6\% > 45$ mm, $\leq 3\% > 100$ mm and all < 200 mm The cross sectional area of the oversized particles < 5 cm ²
P45 large	$8 \leq P \leq 45$ mm	$\leq 8\%$	$\leq 12\% > 63$ mm and all < 300 mm The cross sectional area of the oversized particles < 10 cm ²

^a The numerical values (P-class) for dimension refer to the particle sizes passing through the mentioned round hole sieve size), ISO 17826-1.

3 Descriptions of raw materials and sieving method

Particle size analysis was carried out by using the standard EN 15149-1. Different chippers or crushers and raw materials were used in chipping or crushing studies. In Figure 2 the apparatus for sieving is presented and also requirements for P45 and P63 according to a draft N94 of prISO 17225-1 for wood chips and hog fuel are shown.

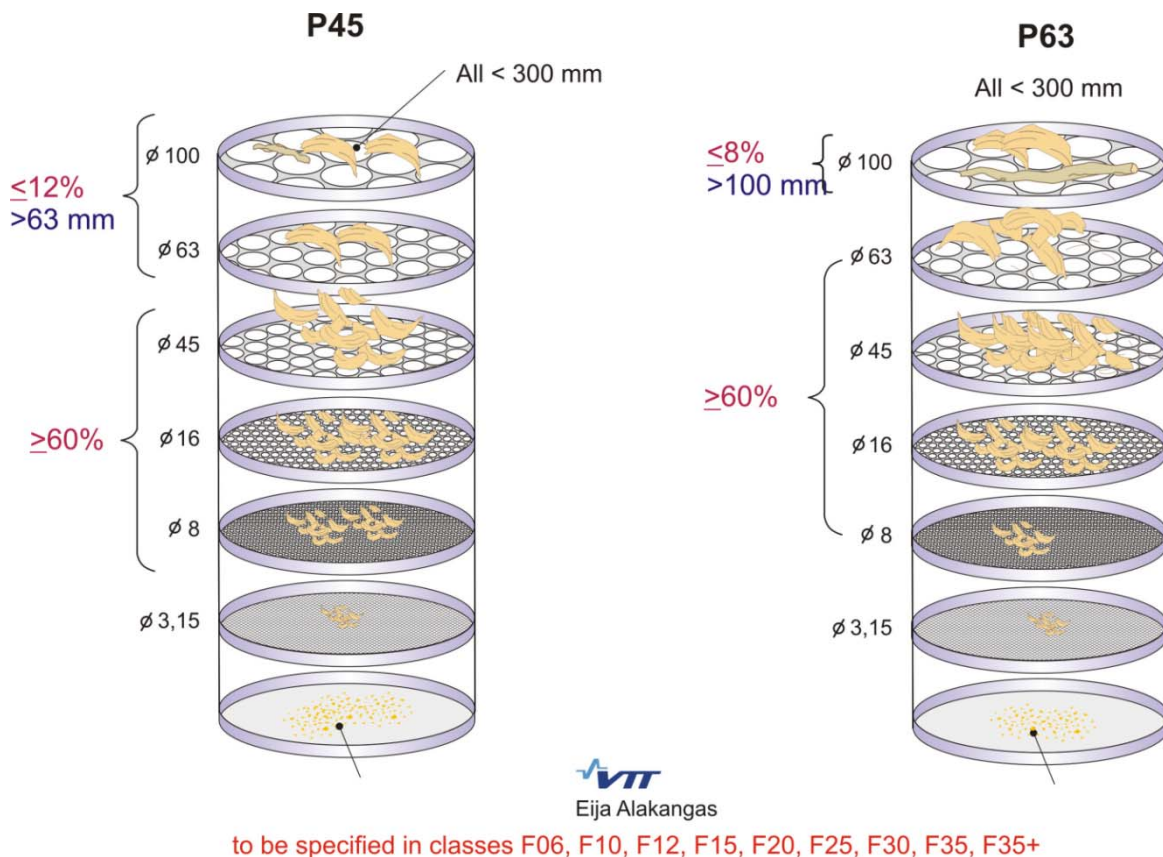


Figure 2. Apparatus and requirements for P45 and P63 according to prISO 17225-1. Note Logging residues main fraction is from 3,15 mm to 45 mm or 63 mm.

Figure 3 shows the same apparatus for particle size classes P31 and P45 according to prISO 17255-1 and 4 (N94 and N97). In the Figure 4 the photo of equipment is shown.

None of analysis included measurements of cross sectional area of oversized particles. Also particles smaller than 300 mm or 200 mm were not measured.

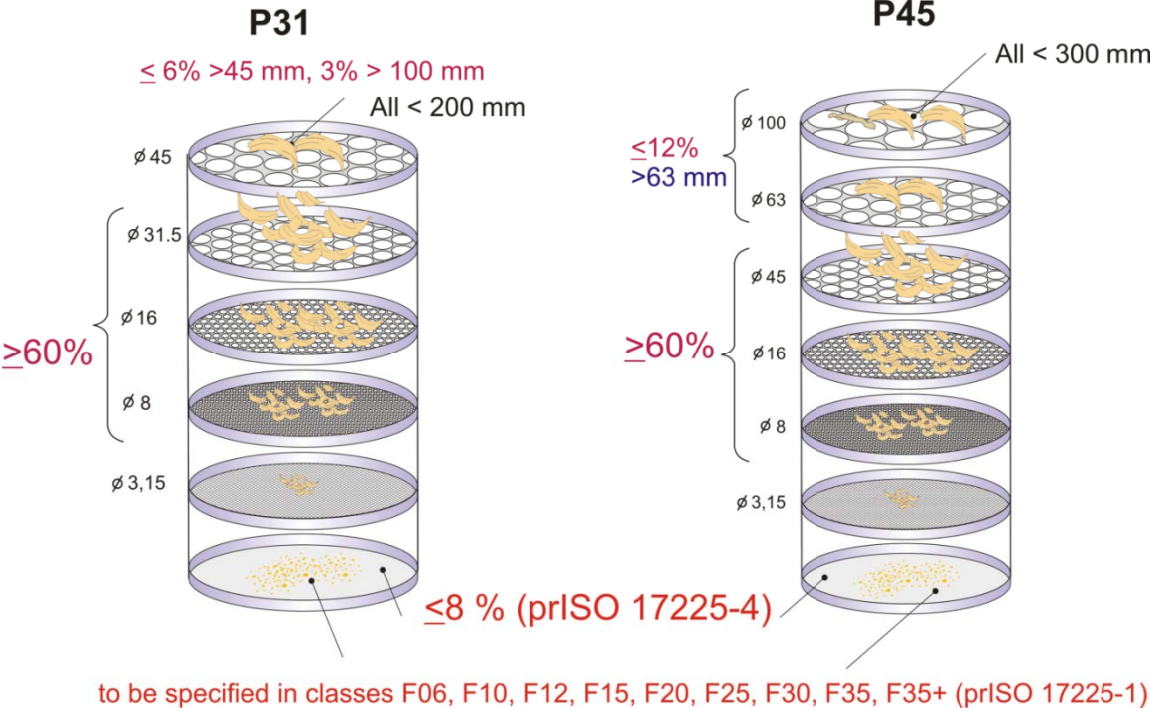


Figure 3. Apparatus and requirements for P31 and P45 according to prISO 17225-1 and 4.

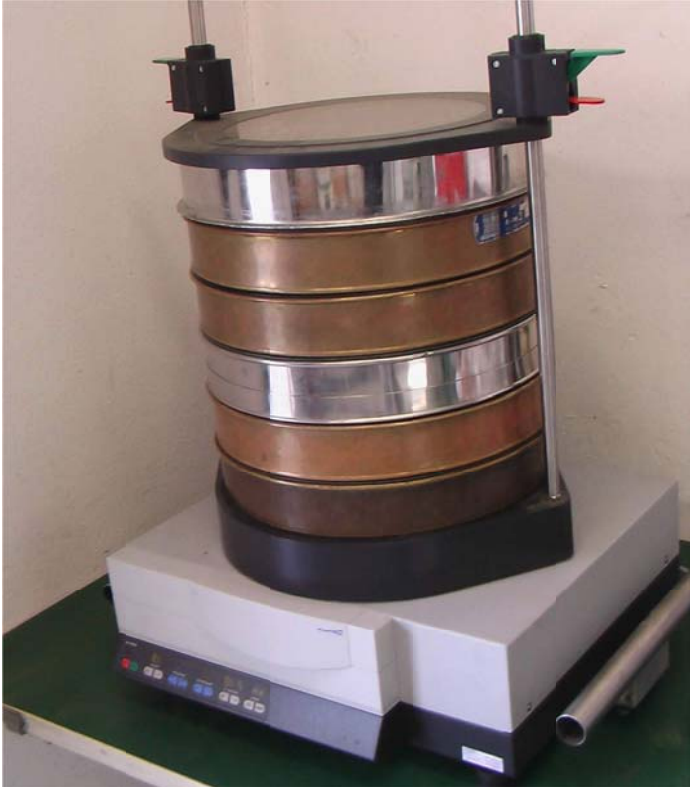


Figure 4. Photo of screening equipment. Source: TFZ

Table 3. Raw material classification

Raw material	Classification according to prISO 17225-1 Table 1
<p>Round wood and stem wood</p> 	<p>1.1.3 Stem wood</p> <p>Delimbed roundwood and pulp wood</p>
<p>Whole trees (WT)</p>  	<p>1.1.1 Whole trees without roots</p> <p>Whole trees from thinnings including also branches</p>
<p>Logging residues or logging residue bundles (LR)</p>  <p>Loose logging residues</p>	<p>1.1.4 Logging residues</p> <p>Logging residues from final cutting. Raw material includes tops and branches (thin particles).</p> <p>Logging residue bundles are usually stored and dried.</p>



Bundles

Stumps (ST)



Other raw material (OT)

1.1.5 Stumps/roots

Stumps are pulled out after final cutting, usually stored longer time to remove soil and sand (to lower ash content), produced mainly from coniferous trees

1.1 Forest, plantation and other virgin wood

Other raw material include plantation wood, or otherwise unspecified woody biomass

Following chippers or crushers (name of manufacturer or trademark) were used in studies

- Crambo
- Farmi
- Greenmech
- Heizohack
- Heinolan Sahakoneet
- Jenz
- Junkkari
- Kesla
- Laimet
- Rudnick-Enners
- Saalasti
- Schliesing
- Silvatec
- TP (different models)
- Vermeer
- VTT's two phase crusher

4 Results

Results are collected in Tables 5 – 9 according used raw material and sieve size. In the tables there are also columns, which include calculations of fines, main fraction and coarse fraction according to new proposal in prISO 17225-1 (N94). In prISO 17225-1 fine fraction can be selected separately (Fig.2, Table 1).

In the Tables 10 – 11 comparison were made for wood chips produced according to standard prISO 17225-4 (N97) and only for roundwood, stemwood and whole tree chips were compared, because stumps and logging residues are not suitable for small-scale installations (Fig. 3, Table 2).

Comparisons of requirements were made for P31, P45 and P63 for prISO 17225-1 and P31 and P45 for prISO 17225-4. Analysis of P16 was not made, but rough estimation show that requirements of main fraction can't be met. Analysis of P90 was not made, because this particle size was not measured, because in EN 14961-1 this class is P100.

Table 4. Summary of results presented in Tables 5 – 11.

Standard	Raw material	P31		P45		P63	
		Yes ¹ (%)	No ² (%)	Yes (%)	No (%)	Yes (%)	No (%)
prISO 17225-1	Round wood,	2 (28%)	5 (62%)	38 (90%)	4 (10%)	38 (90%)	4 (10%)
prISO 17225-4	stem wood	2 (28%)	5 (62%)	3 (42%)	4 (58%)	-	-
prISO 17225-1	Whole tree	8 (80%)	2 (20%)	40 (85%)	7 (15%)	40 (85%)	7 (15%)
prISO 17225-4		1 (10%)	9 (90%)	33 (70%)	14 (30%)	-	-
prISO 17225-1	Logging residues	0 (0%)	9 (100%)	17 (77%)	5 (23%)	18 (82%)	18 (18%)
prISO 17225-1	Stumps	2 (40%)	3 (60%)	2 (40%)	3 (60%)	2 (40%)	3 (60%)
	Total	15 (31%)	33 (69%)	133 (78%)	37 (22%)	96 (75%)	32(25%)

¹ yes particle size requirements were fulfilled, number (%).

²No, requirements of different fractions were not fulfilled, number (%).

The results in Tables 5 – 9 show detailed how requirements of proposed particles sizes in prISO 17225-1 (N94) and prISO 17255-4 (N97) can be met. For class P45 and for P63 requirements can be fulfilled by 78% and 75% (Table 4). Only every third measurement can met a particle size requirement for P31.

When fine fraction is stated separately in Part 1 it helps to fulfil the requirements of fines especially for logging residue chips or hog fuel. It is also important to keep the main fraction wider for logging residues starting from 3,15 mm in classes P45 and P63. None of logging residues chips could met P31 requirement. For P45 requirement can be met by 77% and for P63 by 82% for logging residue chips.

Smaller grate fired boilers need low amount of fines (< 3.15 mm) usually 6 – 8 w-%. Also long sticks (> 120 mm) can cause problems in small-scale boilers, so the large particles should be limited to 200 mm. Larger grate fired boilers (> 1 MW) can handle usually fine fractions until 25 w-%. Fluidised bed boilers can tolerate up to 25 – 30 w-% of fine particles (usually less than 5 mm). Maximum length of should be less than 300 mm for larger boilers. Gasifiers need coarse particle size, usually P90 or P100.

Table 5. Particle size analysis for stem wood and round wood compared to prISO 17225-1 (N94).

Nro	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-31,5 mm	31,5-45 mm	45-63 mm	63-100 mm	>100 mm	Fines (P31)	Main (P31, 3,15-31,5, 60%)	Coarse (P31, >45 mm 6%)	Fines (P45)	Main (P45). 8-45mm, 60%	Coarse (P45, >63 mm, 12%)	P31	P45
RW39	Stem wood	6,2	13	30,1	37,2	9,3	3	1,3		6,2	67,3	4,3	6,2	76,6	1,3	yes	yes
RW40	Stem wood, delimbed	2,1	7,3	27,4	44,5	10,8	6,1	1,7	0	2,1	71,9	7,8	2,1	82,7	1,7	no	yes
RW41	Stem wood, delimbed	2,8	9,9	27,8	40,8	12,8	5,8	0	0	2,8	68,6	5,8	2,8	81,4	0	yes	yes
RW42	Stem wood, large	4,7	15,3	20,9	25,7	9,3	6,3	0	17,8	4,7	46,6	24,1	4,7	55,9	17,8	no	no
RW44	Stem wood, small	11,9	26,8	30,1	22,7	2,5	2,3	3,7		11,9	52,8	6	11,9	55,3	3,7	no	no
RW45	Stem wood, large	13,7	17,7	21,6	12,8	6,3	3,5	0	24,5	13,7	34,4	28	13,7	40,7	24,5	no	no
RW46	Stemwood	17,9	22,5	31,5	22,5	5,5	0	0		17,9	54	0	17,9	59,5	0	no	no

Table 5. Particle size analysis for stem wood and round wood (continued) compared to prISO 17225-1 (N94).

Sample	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-45 mm	45-63 mm	63-100 mm	>100 mm	Fines (P45)	Main (P45, 8 – 45 mm, 60%)	Coarse (P45, >63, 12%)	Fines (P63)	Main (P63, 60% 8-63)	Coarse (P63, >100 mm, 6%)	P45	P63
RW1	Round wood	1,6	3,8	12,7	75,5	5,8	0,3	0,2	1,6	88,2	0,5	1,6	94	0,2	yes	yes
RW2	Round wood	1,8	6,8	37,6	51,5	1,5	0,1	0,6	1,8	89,1	0,7	1,8	90,6	0,6	yes	yes
RW3	Round wood	1,1	3,3	16,3	74,1	3,1	0,2	1,9	1,1	90,4	2,1	1,1	93,5	1,9	yes	yes
RW4	Round wood, birch	11,5	81,5		7		0	0	11,5	81,5	0	11,5	88,5	0	yes	yes
RW5	Round wood, birch	1	17,6		80		0,9	0,5	1	17,6	1,4	1	97,6	0,5	yes	yes
RW6	Round wood, birch	19,6	66,4		13,3		0	0	19,6	66,4	0	19,6	79,7	0	yes	yes
RW7	Round wood, birch	9,9	83,3		6,8		0	0	9,9	83,3	0	9,9	90,1	0	yes	yes
RW8	Round wood, birch	9,3	62,6		27,6		0,4	0,1	9,3	62,6	0,5	9,3	90,2	0,1	yes	yes
RW9	Round wood, birch	10,6	82,2		3,4		3,7	0	10,6	82,2	3,7	10,6	85,6	0	yes	yes
RW10	Round wood, birch	6,2	90,1		3,6		0	0	6,2	90,1	0	6,2	93,7	0	yes	yes
RW11	Round wood, birch	5	74,3		20,7		0	0	5	74,3	0	5	95	0	yes	yes
RW12	Round wood, birch	5,3	71,7		23		0	0	5,3	71,7	0	5,3	94,7	0	yes	yes
RW13	Round wood, birch	11,1	77,9		11,1		0	0	11,1	77,9	0	11,1	89	0	yes	yes
RW14	Round wood, confireous	1,3	4,6	21,2	65,3	4,4	2,8	0,4	1,3	86,5	3,2	1,3	90,9	0,4	yes	yes
RW15	Round wood, confireous	5,1	8,1	13,6	63,8	5,7	1,9	1,8	5,1	77,4	3,7	5,1	83,1	1,8	yes	yes
RW16	Round wood, confireous	5,8	7,9	27,6	55,4	1,9	0	1,5	5,8	83	1,5	5,8	84,9	1,5	yes	yes
RW17	Round wood, pine	11,8	81		7,1		0	0	11,8	81	0	11,8	88,1	0	yes	yes
RW18	Round wood, pine	0,3	9,9		84,3		4,8	0,8	0,3	9,9	5,6	0,3	94,2	0,8	yes	yes
RW19	Round wood, pine	19,2	63,4		16,9		0,5	0	19,2	63,4	0,5	19,2	80,3	0	yes	yes
RW20	Round wood, pine	7,9	83,4		8,7		0	0	7,9	83,4	0	7,9	92,1	0	yes	yes
RW21	Round wood, pine	7,3	71,8		20,8		0,1	0	7,3	71,8	0,1	7,3	92,6	0	yes	yes
RW22	Round wood, pine	7,7	86,5		5,6		0,3	0	7,7	86,5	0,3	7,7	92,1	0	yes	yes
RW23	Round wood, pine	4,3	90,9		4,8		0	0	4,3	90,9	0	4,3	95,7	0	yes	yes
RW24	Round wood, pine	3,3	69		26,8		0,9	0	3,3	69	0,9	3,3	95,8	0	yes	yes

Table 5. Particle size analysis for stem wood and round wood compared to prISO 17225-1 (N94) (continued).

Sample	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-45 mm	45-63 mm	63-100 mm	>100 mm	Fines (P45)	Main (P45, 8 – 45 mm, 60%)	Coarse (P45, >63, 12%)	Fines (P63)	Main (P63, 60% 8-63)	Coarse (P63, >100 mm, 6%)	P45	P63
RW25	Round wood, pine	6,3		61,2		32,5	0	0	6,3	61,2	0	6,3	93,7	0	yes	yes
RW26	Round wood, pine	8,2		78,6		14,2	0	0	8,2	78,6	0	8,2	92,8	0	yes	yes
RW27	Roundwood, coniferous	8,6	20,7	58,6	9,7	1,4	0,4	0,6	8,6	68,3	1	8,6	69,7	0,6	yes	yes
RW28	Sitka, birch	3,4	5	13,6	68,4	5,1	2	2,5	3,4	82	4,5	3,4	87,1	2,5	yes	yes
RW29	Stem	2,1	11,5	34,8	47,2	0	2,9	1,5	2,1	82	4,4	2,1	82	1,5	yes	yes
RW30	stem	2,8	18,2	39,4	37,1	2,5	0	0	2,8	76,5	0	2,8	79	0	yes	yes
RW31	stem	12,8	23,4	33,7	28,8	1,6	0	0	12,8	62,5	0	12,8	64,1	0	yes	yes
RW32	Stem	3,1	10	32	51,6	0	0	3,2	3,1	83,6	3,2	3,1	83,6	3,2	yes	yes
RW33	Stem	7,3	18,8	38	35,3	0,6	0	0	7,3	73,3	0	7,3	73,9	0	yes	yes
RW34	Stem	5,8	14,8	32,2	43,2	2,4	0	1,5	5,8	75,4	1,5	5,8	77,8	1,5	yes	yes
RW35	stem wood, rotten large	1,5	13,4	41,8	43,4	0	0	0	1,5	85,2	0	1,5	85,2	0	yes	yes
RW36	Stem wood, small	3,6		12,7	57,2	15,6	9,3	1,5	3,6	69,9	10,8	3,6	85,5	1,5	yes	yes
RW37	Stem, coniferous	1,3	3,8	10,3	66,8	10,2	4,1	3,4	1,3	77,1	7,5	1,3	87,3	3,4	yes	yes
RW38	Stem, coniferous	1,1	2,9	7,2	63,9	18,8	5,3	0,8	1,1	71,1	6,1	1,1	89,9	0,8	yes	yes

Table 6. Particle size analysis of whole trees compared to prISO 17225-1 (N94)

Report	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-31,5 mm	31,5-45mm	45-63mm	63-100mm	>100 mm	Fines (P31)	Main (P31, 3,15-31,5, 60%)	Coarce (P31, >45 mm 6%,)	Fines (P45)	Main (P45). 8-45mm, 60%	Coarce (P45, >63 mm 12%)	P31	P45
WT39	Whole tree	5,1	12,7	26,9	38,4	13,3	3,5	0,1	0	5,1	78	3,6	5,1	78,6	0,1	yes	yes
WT40	Whole tree	8,9	11,7	25,7	39,4	13,3	0,9	0	0	8,9	76,8	0,9	8,9	78,4	0	yes	yes
WT41	Whole tree	10,8	13	22,8	40	8,2	5,1	0	0	10,8	75,8	5,1	10,8	71	0	yes	yes
WT42	Whole tree	8,9	11,7	25,7	39,4	13,3	0,9	0	0	8,9	76,8	0,9	8,9	78,4	0	yes	yes
WT43	Whole tree	23,5	25,9	23,8	13,8	2,7	1,9	0,3	8,1	23,5	63,5	10,3	23,5	40,3	8,4	yes	no
WT44	Whole tree	45,6	22,9	17,7	10,1	1,2	0	2,5	0	45,6	50,7	2,5	45,6	29	2,5	no	no
WT45	Whole tree	8,1	11	14,4	19,3	12,4	25,4	9,5	0	8,1	44,7	34,9	8,1	46,1	9,5	no	no
WT46	Whole tree	16	39	41	4	0	0	0	0	16	84	0	16	45	0	yes	no
WT47	Whole tree	13	21	37	26	3	0	0	0	13	84	0	13	66	0	yes	yes
WT48	Whole tree	10	17	30	35	6	2	0	0	10	82	2	10	71	0	yes	yes

Table 6. Particle size analysis of whole trees compared to prISO 17225-1(N94) (continued)

No	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-45 mm	45-63 mm	63-100 mm	>100 mm	Fines (P45)	Main (P45, 8 - 45mm, 60%)	Coarse (P45, >63, 12%)	Fines (P63)	Main (P63, 60% 8-63)	Coarse (P63, >100 mm, 6%)	P45	P63
WT1	Whole tree	8,8	21,2	38,7	31,3	0	0	0	8,8	70	0	8,8	70	0	yes	yes
WT2	Whole tree	10,8	21,4	32,2	35,6	0	0	0	10,8	67,8	0	10,8	67,8	0	yes	yes
WT3	Whole tree	1,6	3,4	9,8	68,5	5,9	0,7	10	1,6	78,3	10,7	1,6	84,2	10	yes	no
WT4	Whole tree	3,5	9,2	38	47,2	0,5	0	1,7	3,5	85,2	1,7	3,5	85,7	1,7	yes	yes
WT5	Whole tree	2,2	4,2	14	70,3	4,4	0,4	4,4	2,2	84,3	4,8	2,2	88,7	4,4	yes	yes
WT6	Whole tree	1,2	2,1	9,1	70	10	0,7	6,9	1,2	79,1	7,6	1,2	89,1	6,9	yes	yes
WT7	Whole tree	1,6	4,7	34,8	52,2	0,8	0,1	5,9	1,6	87	6	1,6	87,8	5,9	yes	yes
WT8	Whole tree	1,8	3,4	11,9	67,2	4,3	0,1	11,3	1,8	79,1	11,4	1,8	83,4	11,3	yes	no
WT9	Whole tree	4,6	6,9	13	67,1	4,7	0,1	3,7	4,6	80,1	3,8	4,6	84,8	3,7	yes	yes
WT10	Whole tree	1,9	5,1	33,4	57,2	0,5	0	1,8	1,9	90,6	1,8	1,9	91,1	1,8	yes	yes
WT11	Whole tree	6,7	7,1	16,2	63,3	2,3	0	4,4	6,7	79,5	4,4	6,7	81,8	4,4	yes	yes
WT12	Whole tree	2,1	2,7	10,5	72,7	7,3	0,4	4,4	2,1	83,2	4,8	2,1	90,5	4,4	yes	yes
WT13	Whole tree	2,2	6,5	36,5	49,3	0,5	0	5,1	2,2	85,8	5,1	2,2	86,3	5,1	yes	yes
WT14	Whole tree	2,2	3,1	15,4	72,3	3,9	0	3	2,2	87,7	3	2,2	91,6	3	yes	yes
WT15	Whole tree, con.chem	2,1	4,8	12,4	71,8	6,6	0,9	1,6	2,1	84,2	2,5	2,1	90,8	1,6	yes	yes
WT16	Whole tree, coniferous	2	3,1	10,4	71,2	11,4	0	1,9	2	81,6	1,9	2	93	1,9	yes	yes
WT17	Whole tree, coniferous	2,1	2,3	7,3	55,4	18	9,4	5,5	2,1	62,7	14,9	2,1	80,7	5,5	no	yes
WT18	Whole tree, coniferous	5,1	8,1	13,6	63,8	5,7	1,9	1,8	5,1	77,4	3,7	5,1	83,1	1,8	yes	yes
WT19	Whole tree, coniferous	3,6	6,4	11,3	60,7	11,2	3,9	2,9	3,6	72	6,8	3,6	83,2	2,9	yes	yes
WT20	Whole tree, coniferous	2,7	4,1	8,1	61	15,3	5	3,7	2,7	69,1	8,7	2,7	84,4	3,7	yes	yes
WT21	Whole tree, coniferous	2,5	5,9	24,8	63,9	1,6	0,6	0,7	2,5	88,7	1,3	2,5	90,3	0,7	yes	yes
WT22	Whole tree, coniferous	3	5	23,2	54,5	7,8	2,1	4,6	3	77,7	6,7	3	85,5	4,6	yes	yes
WT23	Whole tree, coniferous	4,4	9,2	29	51,5	2,6	1,3	2	4,4	80,5	3,3	4,4	83,1	2	yes	yes
WT24	Whole tree, first thinning, broadleaf	1,8	7,5	23,7	62,8	2,9	0,5	0,8	1,8	86,5	1,3	1,8	89,4	0,8	yes	yes
WT25	Whole tree, first thinning, broadleaf	3,2	7,2	24,7	62,8	0,6	0,1	0,4	3,2	87,5	0,5	3,2	88,1	0,4	yes	yes

No	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-45 mm	45-63 mm	63-100 mm	>100 mm	Fines (P45)	Main (P45, 8 - 45mm, 60%)	Coarce (P45, >63, 12%)	Fines (P63)	Main (P63, 60% 8-63)	Coarce (P63, >100 mm, 6%)	P45	P63
WT26	Whole tree, first thinning, broadleaf	0,9	2	7,5	71,4	13	2,8	2,5	0,9	78,9	5,3	0,9	91,9	2,5	yes	yes
WT27	Whole tree, first thinning, broadleaf	1,2	4,9	23,3	67,5	1,6	0	1,5	1,2	90,8	1,5	1,2	92,4	1,5	yes	yes
WT28	Whole tree, first thinning, broadleaf	0,8	2,8	8,5	67,6	17,9	1,3	1,1	0,8	76,1	2,4	0,8	94	1,1	yes	yes
WT29	Whole tree, thinning, birch-pine	1,9	3,8	18,2	67,4	5,2	0	3,5	1,9	85,6	3,5	1,9	90,8	3,5	yes	yes
WT30	Whole tree, thinnings	4,1	9,5	19	60,4	5,5	0	1,5	4,1	79,4	1,5	4,1	84,9	1,5	yes	yes
WT31	Whole tree, thinnings	1,9	3,8	18,1	67,2	5,2	0	3,9	1,9	85,3	3,9	1,9	90,5	3,9	yes	yes
WT32	Whole tree, thinnings	0,9	10,1	36,4	46,1	2,3	0	4,2	0,9	82,5	4,2	0,9	84,8	4,2	yes	yes
WT33	Whole tree, thinnings	2,6	4,8	13,9	65,3	6,1	0	7,3	2,6	79,2	7,3	2,6	85,3	7,3	yes	yes
WT34	Whole tree, thinnings	1,2	2,5	15,5	74,5	2,1	0	4,2	1,2	90	4,2	1,2	92,1	4,2	yes	yes
WT35	Whole tree, thinnings	1,3	5,1	25,5	52,4	5,9	0	9,8	1,3	77,9	9,8	1,3	83,8	9,8	yes	no
WT36	Whole tree, thinnings	2,8	9,3	26,4	56,5	3,2	0	1,9	2,8	82,9	1,9	2,8	86,1	1,9	yes	yes
WT37	Whole trees	3,6		20,8	47,8	10,8	11,2	5,8	3,6	68,6	17	3,6	79,4	5,8	no	yes
WT38	Whole trees, first thinnings	16,1	18,5	28,2	31,1	3,4	2,8		16,1	59,3	2,8	16,1	62,7	0	no	yes

Table 7. Particles size analysis of logging residues compared to prISO 17225-1 (N94).

No	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-31,5 mm	31,5-45mm	45-63 mm	63-100 mm	>100 mm	Fines (P31)	Main (P31. 3,15-31,5, 60%)	Course (P31, >45 mm 6%,)	Fines (P45)	Main (P45). 3,15-45mm, 60%	Coarce (P45, 12%)	P31	P45
LR14	Logging residue	19,5	11,2	12	13,4	10,5	6,3	1,9	25,2	19,5	36,6	33,4	19,5	47,1	33,4	no	no
LR15	Logging residue	24,2	34,2	29,8	8,3	0,7	2,8	0		24,2	72,3	2,8	24,2	73	2,8	no	yes
LR16	Logging residue	25,1	27,9	24,4	16,8	3,4	2,3	0,1		25,1	69,1	2,4	25,1	72,5	2,4	no	yes
LR17	Logging residue	32,8	24,4	21,8	12,2	4,7	0	4,1		32,8	58,4	4,1	32,8	63,1	4,1	no	yes
LR18	Logging residue	25,6	21,4	18,8	25,7	4,8	3,7	0,1	0	25,6	65,9	3,8	25,6	70,7	3,8	no	yes
LR19	Logging residue	28,3	21,6	26	17,2	1,7	5,2	0		28,3	64,8	5,2	28,3	66,5	5,2	no	yes
LR20	Logging residue	33,7	18	22	17,2	2,9	1,7	4,6		33,7	57,2	6,3	33,7	60,1	6,3	no	yes
LR21	Logging residue bundle	30	17,6	12,3	10,5	7,4	0	0,1	22,2	30	40,4	22,3	30	47,8	22,3	no	no
LR22	Logging residue bundle	20,7	11,8	12	21,3	8,4	15,2	1,7	8,8	20,7	45,1	25,7	20,7	53,5	25,7	no	no

Table 7. Particles size analysis of logging residues compared to prISO 17225-1(N94) (continued)

No	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-45 mm	45-63 mm	63-100 mm	>100 mm	Fines (P45)	Main (P45, 3,15-45, 60%)	Coarce (P45, >63mm 12%)	Fines (P63)	Main (P63, 3,15-63, 60%)	Coarce (P63, > 100 mm, 8%)	P45	P63
LR1	Logging residue	4,9	7,2	14,2	61,1	5,1	0,5	6,9	4,9	82,5	12	4,9	87,6	7,4	yes	yes
LR2	Logging residue	7,2	13	36,9	38,3	1,1	0	3,4	7,2	88,2	4,5	7,2	89,3	3,4	yes	yes
LR3	Logging residue	5,3	7,5	17,8	57,9	3,5	0	7,9	5,3	83,2	11,4	5,3	86,7	7,9	yes	yes
LR4	Logging residue	3,1	5,6	15,2	60,5	4,9	0,5	10,2	3,1	81,3	15,1	3,1	86,2	10,7	no	no
LR5	Logging residue	6,5	11,6	31,9	42,6	0,2	0	7,2	6,5	86,1	7,4	6,5	86,3	7,2	yes	yes
LR6	Logging residue	7,7	8,6	20	53,1	2,8	0,1	7,8	7,7	81,7	10,6	7,7	84,5	7,9	yes	yes
LR7	Logging residue, dry brown	35,4	34,2	22,3	7,7	0,5	0	0	35,4	64,2	0	35,4	64,7	0	yes	yes
LR8	Logging residues, dry	30,5	18,1	23,1	26,4	0	1,8	0	30,5	67,6	0	30,5	67,6	1,8	yes	yes
LR9	Logging residues, dry, brown	22,4	32,6	29,7	15	0,4	0	0	22,4	77,3	0,5	22,4	77,7	0	yes	yes
LR10	Logging residues,dry brown	20,4	31,4	31,3	16,1	0,4	0,5	0	20,4	78,8	0,4	20,4	79,2	0,5	yes	yes
LR11	Logging residues,dry brown	41,9	30,9	17,3	7,8	0,2	0,2	1,5	41,9	56	2,9	41,9	56,2	1,7	no	yes
LR12	Tree sections, coniferous	11,6	12,1	25,7	46,7	1,9	0	1,9	11,6	84,5	6,8	11,6	86,4	1,9	yes	yes
LR13	Tree sections, coniferous	2,9	6,4	20,1	62	5,7	1,2	1,7	2,9	88,5	7,5	2,9	94,2	2,9	yes	yes

Table 8. Particles analysis of stumps compared to prISO 17225-1 (N94)

No	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-31,5 mm	31,5-45mm	45-63mm	63-100mm	>100 mm	Fines (P31)	Main (P31, 3,15-31,5, 60%)	Coarce (P31, >45 mm 6%)	Fines (P45)	Main (P45). 8-45mm, 60%	Coarce (P45, >63 mm 12%)	P 31,5	P45
ST2	Stumps	5,3	5,7	11,7	21,5	10,3	11,5	5,4	28,6	5,3	38,9	45,5	5,3	43,5	34	no	no
ST3	Stumps	9	10,5	15,8	16,7	11,3	5	4,6	27,1	9	43	36,7	9	43,8	31,7	no	no
ST4	Stumps	9,7	25,8	34	23,8	3,4	1,4	2		9,7	83,6	3,4	9,7	61,2	2	yes	yes
ST5	Stumps	11	18	31	28,5	10,9	0,6	0		11	77,5	0,6	11	70,4	0	yes	yes
ST6	Stumps, precrushed	24,4	14	16,1	15,3	17,1	7,2	0	5,8	24,4	45,4	13	24,4	48,5	5,8	no	no

Table 9. Particle size analysis of other (unspecified sources) compared to prISO 17225-1 (N94).

No	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-31,5 mm	31,5-45mm	45-63mm	63-100mm	>100 mm	Fines (P31)	Main (P31, 3,15-31,5, 60%)	Coarce (P31, >45 mm 6%)	Fines (P45)	Main (P45). 8-45mm, 60%	Coarce (P45, >63 mm 12%)	P31	P45
OT7	unknown	1,5	1,8	4,2	7,6	6,8	5,2	11,8	61	1,5	13,6	78	1,5	18,6	72,8	no	no
OT8	Unknown	5,2	13,3	23,5	28,7	7,9	10,4	10,9	0,1	5,2	65,5	21,4	5,2	60,1	11	no	yes
OT9	unknown	12,7	24	27,6	21,2	5,7	0,6	8,3		12,7	72,8	8,9	12,7	54,5	8,3	no	yes
OT10	unknown,	10,1	14,5	25,2	30,6	9,6	2,1	7,9		10,1	70,3	10	10,1	65,4	7,9	no	yes
OT11	unknown	13,2	10,1	22,6	22,7	11,6	8,9	10,9	0	13,2	55,4	19,8	13,2	56,9	10,9	no	no

Table 9. Particle size analysis of other (unspecified sources) compared to prISO 17225-1 (N94) (continued)

No	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-45 mm	45-63 mm	63-100 mm	>100 mm	Fines (P45)	Main (P45, 8 – 45, 60%)	Coarce (P45, >63, 12%)	Fines (P63)	Main (P63, 60% 8-63)	Coarce (P63, >100 mm, 6%)	P45	P63
OT1	Energy wood, coniferous	3,2	8,1	30	56,4	1,4	0,1	0,8	3,2	86,4	2,3	3,2	87,8	0,9	yes	yes
OT2	Energy wood, coniferous	4,3	8,9	25,9	57,2	2,6	0	1,1	4,3	83,1	3,7	4,3	85,7	1,1	yes	yes
OT3	Lodgepole pine	7,5	16,2	25,8	44,1	1,3	1,2	3,8	7,5	69,9	6,3	7,5	71,2	5	yes	yes
OT4	Lodgepole pine	3,7	8,9	12,9	57,7	9,1	3	4,6	3,7	70,6	16,7	3,7	79,7	7,6	no	no
OT5	Naturally regenerated pine	3,8	7,4	29,5	57,9	0,7	0,1	0,6	3,8	87,4	1,4	3,8	88,1	0,7	yes	yes
OT6	Planted birch	2,6	8,8	28,1	54,8	2,9	0,1	2,6	2,6	82,9	5,6	2,6	85,8	2,7	yes	yes

Table 10. Particle size analysis for stem wood and round wood compared to prISO 17225-4 (N97).

Nro	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-31,5 mm	31,5-45mm	45-63mm	63-100mm	>100 mm	Fines (P31) 8%	Main (P31, 3,15-31,5, 60%)	Coarce (P31, >45 mm 6%,)	Fines (P45) 8%	Main (P45). 8-45mm, 60%	Coarce (P45, >63 mm, 6%, all 200 mm)	P31	P45
RW39	Stem wood	6,2	13	30,1	37,2	9,3	3	1,3		6,2	67,3	4,3	6,2	76,6	1,3	yes	yes
RW40	Stem wood, delimited	2,1	7,3	27,4	44,5	10,8	6,1	1,7	0	2,1	71,9	7,8	2,1	82,7	1,7	no	yes
RW41	Stem wood, delimited	2,8	9,9	27,8	40,8	12,8	5,8	0	0	2,8	68,6	5,8	2,8	81,4	0	yes	yes
RW42	Stem wood, large	4,7	15,3	20,9	25,7	9,3	6,3	0	17,8	4,7	46,6	24,1	4,7	55,9	17,8	no	no
RW44	Stem wood, small	11,9	26,8	30,1	22,7	2,5	2,3	3,7		11,9	52,8	6	11,9	55,3	3,7	no	no
RW45	Stem wood, large	13,7	17,7	21,6	12,8	6,3	3,5	0	24,5	13,7	34,4	28	13,7	40,7	24,5	no	no
RW46	Stemwood	17,9	22,5	31,5	22,5	5,5	0	0		17,9	54	0	17,9	59,5	0	no	no

Table 10. Particle size analysis for stem wood and round wood compared to prISO 17225-4 (N97) (continued)

Sample	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-45 mm	45-63 mm	63-100 mm	>100 mm	Fines (P45) 8%	Main (P45, 8 - 45mm, 60%)	Coarse (P45, >63, 12%)	P45
RW1	Round wood	1,6	3,8	12,7	75,5	5,8	0,3	0,2	1,6	88,2	0,5	yes
RW2	Round wood	1,8	6,8	37,6	51,5	1,5	0,1	0,6	1,8	89,1	0,7	yes
RW3	Round wood	1,1	3,3	16,3	74,1	3,1	0,2	1,9	1,1	90,4	2,1	yes
RW14	Round wood, confireous	1,3	4,6	21,2	65,3	4,4	2,8	0,4	1,3	86,5	3,2	yes
RW15	Round wood, confireous	5,1	8,1	13,6	63,8	5,7	1,9	1,8	5,1	77,4	3,7	yes
RW16	Round wood, confireous	5,8	7,9	27,6	55,4	1,9	0	1,5	5,8	83	1,5	yes
RW25	Round wood, pine	6,3		61,2		32,5	0	0	6,3	61,2	0	yes
RW26	Round wood, pine	8,2		78,6		14,2	0	0	8,2	78,6	0	no
RW27	Roundwood, coniferous	8,6	20,7	58,6	9,7	1,4	0,4	0,6	8,6	68,3	1	no
RW28	Sitka,birch	3,4	5	13,6	68,4	5,1	2	2,5	3,4	82	4,5	yes
RW29	Stem	2,1	11,5	34,8	47,2	0	2,9	1,5	2,1	82	4,4	yes
RW30	stem	2,8	18,2	39,4	37,1	2,5	0	0	2,8	76,5	0	yes
RW31	stem	12,8	23,4	33,7	28,8	1,6	0	0	12,8	62,5	0	no
RW32	Stem	3,1	10	32	51,6	0	0	3,2	3,1	83,6	3,2	yes
RW33	Stem	7,3	18,8	38	35,3	0,6	0	0	7,3	73,3	0	yes
RW34	Stem	5,8	14,8	32,2	43,2	2,4	0	1,5	5,8	75,4	1,5	yes
RW35	stem wood,rotten large	1,5	13,4	41,8	43,4	0	0	0	1,5	85,2	0	yes
RW36	Stem wood,small	3,6		12,7	57,2	15,6	9,3	1,5	3,6	69,9	10,8	yes
RW37	Stem, confireous	1,3	3,8	10,3	66,8	10,2	4,1	3,4	1,3	77,1	7,5	yes
RW38	Stem, confireous	1,1	2,9	7,2	63,9	18,8	5,3	0,8	1,1	71,1	6,1	yes

Table 11. Particle size analysis of whole trees compared to prISO 17225-4 (N97).

Report	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-31,5 mm	31,5-45mm	45-63mm	63-100mm	>100 mm	Fines (P31) 8%	Main (P31, 3,15-31,5, 60%)	Coarse (P31, >45 mm 6%)	Fines (P45) 8%	Main (P45). 8-45mm, 60%	Coarse (P45, >63 mm 12%)	P31	P45
WT39	Whole tree	5,1	12,7	26,9	38,4	13,3	3,5	0,1	0	5,1	78	3,6	5,1	78,6	0,1	yes	yes
WT40	Whole tree	8,9	11,7	25,7	39,4	13,3	0,9	0	0	8,9	76,8	0,9	8,9	78,4	0	no	no
WT41	Whole tree	10,8	13	22,8	40	8,2	5,1	0	0	10,8	75,8	5,1	10,8	71	0	no	no
WT42	Whole tree	8,9	11,7	25,7	39,4	13,3	0,9	0	0	8,9	76,8	0,9	8,9	78,4	0	yes	yes
WT43	Whole tree	23,5	25,9	23,8	13,8	2,7	1,9	0,3	8,1	23,5	63,5	10,3	23,5	40,3	8,4	no	no
WT44	Whole tree	45,6	22,9	17,7	10,1	1,2	0	2,5	0	45,6	50,7	2,5	45,6	29	2,5	no	no
WT45	Whole tree	8,1	11	14,4	19,3	12,4	25,4	9,5	0	8,1	44,7	34,9	8,1	46,1	9,5	no	no
WT46	Whole tree	16	39	41	4	0	0	0	0	16	84	0	16	45	0	no	no
WT47	Whole tree	13	21	37	26	3	0	0	0	13	84	0	13	66	0	no	no
WT48	Whole tree	10	17	30	35	6	2	0	0	10	82	2	10	71	0	no	no

Table 11. Particle size analysis of whole trees compared to prISO 17225-4 (N94) (continued).

No	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-45 mm	45-63 mm	63-100 mm	>100 mm	Fines (P45) 8%	Main (P45, 8 - 45mm, 60%)	Coarse (P45, >63, 12%)	P45
WT1	Whole tree	8,8	21,2	38,7	31,3	0	0	0	8,8	70	0	no
WT2	Whole tree	10,8	21,4	32,2	35,6	0	0	0	10,8	67,8	0	no
WT3	Whole tree	1,6	3,4	9,8	68,5	5,9	0,7	10	1,6	78,3	10,7	yes
WT4	Whole tree	3,5	9,2	38	47,2	0,5	0	1,7	3,5	85,2	1,7	yes
WT5	Whole tree	2,2	4,2	14	70,3	4,4	0,4	4,4	2,2	84,3	4,8	yes
WT6	Whole tree	1,2	2,1	9,1	70	10	0,7	6,9	1,2	79,1	7,6	yes
WT7	Whole tree	1,6	4,7	34,8	52,2	0,8	0,1	5,9	1,6	87	6	yes
WT8	Whole tree	1,8	3,4	11,9	67,2	4,3	0,1	11,3	1,8	79,1	11,4	yes
WT9	Whole tree	4,6	6,9	13	67,1	4,7	0,1	3,7	4,6	80,1	3,8	yes
WT10	Whole tree	1,9	5,1	33,4	57,2	0,5	0	1,8	1,9	90,6	1,8	yes
WT11	Whole tree	6,7	7,1	16,2	63,3	2,3	0	4,4	6,7	79,5	4,4	yes
WT12	Whole tree	2,1	2,7	10,5	72,7	7,3	0,4	4,4	2,1	83,2	4,8	yes
WT13	Whole tree	2,2	6,5	36,5	49,3	0,5	0	5,1	2,2	85,8	5,1	yes
WT14	Whole tree	2,2	3,1	15,4	72,3	3,9	0	3	2,2	87,7	3	yes
WT15	Whole tree, con.chem	2,1	4,8	12,4	71,8	6,6	0,9	1,6	2,1	84,2	2,5	yes
WT16	Whole tree, coniferous	2	3,1	10,4	71,2	11,4	0	1,9	2	81,6	1,9	yes
WT17	Whole tree, coniferous	2,1	2,3	7,3	55,4	18	9,4	5,5	2,1	62,7	14,9	no
WT18	Whole tree, coniferous	5,1	8,1	13,6	63,8	5,7	1,9	1,8	5,1	77,4	3,7	yes
WT19	Whole tree, coniferous	3,6	6,4	11,3	60,7	11,2	3,9	2,9	3,6	72	6,8	yes
WT20	Whole tree, coniferous	2,7	4,1	8,1	61	15,3	5	3,7	2,7	69,1	8,7	yes
WT21	Whole tree, coniferous	2,5	5,9	24,8	63,9	1,6	0,6	0,7	2,5	88,7	1,3	yes
WT22	Whole tree, coniferous	3	5	23,2	54,5	7,8	2,1	4,6	3	77,7	6,7	yes
WT23	Whole tree, coniferous	4,4	9,2	29	51,5	2,6	1,3	2	4,4	80,5	3,3	yes
WT24	Whole tree, first thinning, broadleaf	1,8	7,5	23,7	62,8	2,9	0,5	0,8	1,8	86,5	1,3	yes
WT25	Whole tree, first thinning, broadleaf	3,2	7,2	24,7	62,8	0,6	0,1	0,4	3,2	87,5	0,5	yes

Table 11. Particle size analysis of whole trees compared to prISO 17225-4 (N94) (continued).

No	Raw material	< 3,15 mm	3,15-8 mm	8-16 mm	16-45 mm	45-63 mm	63-100 mm	>100 mm	Fines (P45) 8%	Main (P45, 8 - 45mm, 60%)	Coarce (P45, >63, 12%)	P45
WT26	Whole tree, first thinning, broadleaf	0,9	2	7,5	71,4	13	2,8	2,5	0,9	78,9	5,3	yes
WT27	Whole tree, first thinning, broadleaf	1,2	4,9	23,3	67,5	1,6	0	1,5	1,2	90,8	1,5	yes
WT28	Whole tree, first thinning, broadleaf	0,8	2,8	8,5	67,6	17,9	1,3	1,1	0,8	76,1	2,4	yes
WT29	Whole tree, thinning, birch-pine	1,9	3,8	18,2	67,4	5,2	0	3,5	1,9	85,6	3,5	yes
WT30	Whole tree, thinnings	4,1	9,5	19	60,4	5,5	0	1,5	4,1	79,4	1,5	yes
WT31	Whole tree, thinnings	1,9	3,8	18,1	67,2	5,2	0	3,9	1,9	85,3	3,9	yes
WT32	Whole tree, thinnings	0,9	10,1	36,4	46,1	2,3	0	4,2	0,9	82,5	4,2	yes
WT33	Whole tree, thinnings	2,6	4,8	13,9	65,3	6,1	0	7,3	2,6	79,2	7,3	yes
WT34	Whole tree, thinnings	1,2	2,5	15,5	74,5	2,1	0	4,2	1,2	90	4,2	yes
WT35	Whole tree, thinnings	1,3	5,1	25,5	52,4	5,9	0	9,8	1,3	77,9	9,8	yes
WT36	Whole tree, thinnings	2,8	9,3	26,4	56,5	3,2	0	1,9	2,8	82,9	1,9	yes
WT37	Whole trees	3,6		20,8	47,8	10,8	11,2	5,8	3,6	68,6	17	no
WT38	Whole trees, first thinnings	16,1	18,5	28,2	31,1	3,4	2,8		16,1	59,3	2,8	no

5 Proposals for new particle size classification and conclusions

According to the analysis carried out in different countries, proposed particle size classifications for wood chips and hog fuel are suitable in the most cases for different raw materials. The results show that requirements of proposed particles sizes in prISO 17225-1 (N94) and prISO 17255-4 (N97) can be met in class P45 by 78% and for P63 by 75%. Only every third measurement can met a particle size requirement for P31.

When fine fraction is stated separately in Part 1 it helps to fulfil the requirements of fines especially for logging residue chips. It is also important to keep the main fraction wider for logging residues starting from 3.15 mm in classes P45 and P63. None of logging residues chips could met P31 requirement. For P45 requirement can be met by 77% and for P63 by 82% for logging residue chips.

This classification is still quite complicated and difficult to control, when chipping or crushing. There is still doubt, where fraction 3.15 to 8 mm or 3.15 to 8 mm belongs, when main fraction starts from 8 mm or 16 mm and fines are defined particles smaller than 3.15 mm. There should be a note under tables for P45 and P63 stating the fraction 3.15 to 8 mm belongs to main fraction, if the requirement of main fraction (60%, starting from 8 mm) is fulfilled in P45 and P63. Same note for P90: Fraction 3.15 to 16 mm belongs to main fraction, if the requirement of main fraction (60%, starting from 16 mm) is fulfilled in P90.

Finnish proposal of size dimensions shall be based on four things (see Figure 5):

- the main fraction = 100% - the allowed amount coarse fraction %. There shall be no lower limit for the particle size.
- the coarse fraction shall be all particles larger than the upper particle size limit of the main fraction
- the max dimensions of the oversized particles are given as in Table 1 in prISO 17225-1 and the amount is included in the amount of the coarse fraction.
- the allowed amount % of fines (< 3,15 mm) is inside in the main fraction

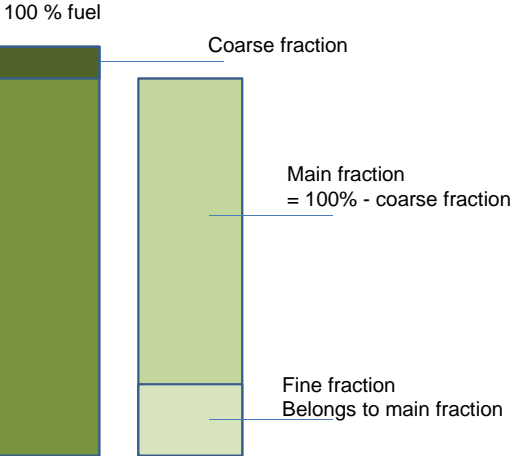


Figure 5. Schematic presentation of the proposal for simplified size classification.

HolzForschung Austria has carried out a study of forest chips particle size distribution (Steiner et al. 2012) and a report was disseminated to WG2 members before the Stockholm meeting. Austrian proposals for particle size classifications are shown in Tables 12 and 13.

Table 12. Austrian proposal for particle size classification for prISO 17225-1

Class	Main fraction (minimum 60 w-%, mm)	Coarse fraction, w-% max. length of particle, mm	Cross sectional area, cm ²
P16	$3,15 \leq P \leq 16$	$\leq 6\% > 31,5$ mm, all ≤ 45 mm	≤ 1
P31	$3,15 \leq P \leq 31,5$	$\leq 6\% > 45$ mm, $\leq 3\% > 100$ mm, all ≤ 200 mm	≤ 5
P45	$3,15 \leq P \leq 45$	$\leq 10\% > 63$ mm, all ≤ 350	≤ 10
P63	$3,15 \leq P \leq 63$	$\leq 10\% > 100$ mm, all ≤ 350	≤ 18
P100	$3,15 \leq P \leq 100$	$\leq 10\% > 125$ mm, all ≤ 350	-
P300	$3,15 \leq P \leq 300$	To be specified	-

Austria also proposed to have F40 class for fines.

Table 13. Austrian proposal for particle size classification for prISO 17225-4

Class	Main fraction (minimum 60 w-%, mm)	Coarse fraction, w-% max. length of particle, mm	Fire fraction, w-% (< 3,15 mm)	Cross sectional area, cm ²
P16	$3,15 \leq P \leq 16$	$\leq 6\% > 31,5$ mm, all ≤ 45 mm	≤ 12	≤ 1
P31	$3,15 \leq P \leq 31,5$	$\leq 6\% > 45$ mm, $\leq 3\% > 100$ mm, all ≤ 120 mm	≤ 8	≤ 5
P45	$3,15 \leq P \leq 45$	$\leq 10\% > 63$ mm, all ≤ 120	≤ 8	≤ 10

The WG2 meeting of ISO/TC 238 was held on 7 May 2012 in Stockholm. WG2 discussed and decided to use the Austrian proposal as a basic. Also WG4 expert was consulted during the meeting and less sieve sizes were selected for classification. I was decided to propose the new size classification (Table 14 and Table 15) for Draft International Standards (DIS).

Table 14. Particle size proposal for draft international standard prISO 17225-1 for wood chips and hog fuel (N129).

Dimensions (mm) ISO 17827-1					
Main fraction (minimum 60 w-%), mm ^a		Coarse fraction, w-% (max. length of particle, mm)	Oversized particles (mm)	All (mm)	The cross sectional area of the oversized particles, cm ²
P16S	$3,15 \leq P \leq 16$ mm	$\leq 6\% > 31,5$ mm		≤ 45	
P16	$3,15 \leq P \leq 16$ mm	$\leq 6\% > 31,5$ mm	$\leq 1\% > 45$	≤ 150	≤ 1
P31S	$3,15 \leq P \leq 31,5$ mm	$\leq 6\% > 45$ mm		≤ 150	≤ 2
P31	$3,15 \leq P \leq 31,5$ mm	$\leq 6\% > 45$ mm	$\leq 3\% > 45$	≤ 200	≤ 2
P45S	$3,15 \leq P \leq 45$ mm	$\leq 10\% > 63$ mm		≤ 200	≤ 2
P45	$3,15 \leq P \leq 45$ mm	$\leq 10\% > 63$ mm		≤ 350	≤ 10
P63	$3,15 \leq P \leq 63$ mm	$\leq 10\% > 100$ mm		≤ 350	≤ 18
P100	$3,15 \leq P \leq 100$ mm ^b	$\leq 10\% > 150$ mm		≤ 350	
P300	$3,15 \leq P \leq 300$ mm	to be specified	to be specified		
Fine fraction, F (< 3,15 mm w-%), ISO 17826-1					
F06	$\leq 6\%$				
F10	$\leq 10\%$				
F12	$\leq 12\%$				
F15	$\leq 15\%$				
F20	$\leq 20\%$				
F25	$\leq 25\%$				
F30	$\leq 30\%$				
F35	$\leq 35\%$				
F35+	> 35 (maximum value to be stated)				

Only one class shall be specified for wood chips or hog fuel and lowest possible class should be stated (N132). S in table means for small scale use. Only S-classes were selected for prISO 17225-4.

Table 15. Particle size proposal for draft international standard prISO 17225-4 for wood chips (N132)

Dimensions (mm), ISO 17827-1					
	Minimum 60 w-% in main fraction, mm ^a	Fines fraction, w-% (< 3,15 mm)	Coarse fraction, (w-%),	All (mm)	Max. cross sectional area of the oversized particles (cm ²)
P16S	$3,15 \leq P \leq 16$ mm	≤ 12 %	≤ 3 % > 31,5	< 45 mm	Not to be specified
P31S	$3,15 \leq P \leq 31,5$ mm	≤ 8 %	≤ 6 % > 45	< 150 mm	< 2
P45S	$3,15 \leq P \leq 45$ mm	≤ 8 %	≤ 10 % > 63	< 200 mm	< 5

^a The numerical values (P-class) for dimension refer to the particle sizes passing through the mentioned round hole sieve size (ISO 17827-1). The lowest possible class should be stated. Only one class shall be specified for wood chips

Table 16 shows how the new classification proposal complies with the existing data.

Table 16. Summary of results presented in Tables 5 – 11 based on new proposals (N129 and N132).

Standard	Raw material	P31		P45		P63	
		Yes ¹ (%)	No ² (%)	Yes (%)	No (%)	Yes (%)	No (%)
prISO 17225-1	Round wood,	5 (72%)	2 (28%)	39 (88%)	5 (12%)	37 (100%)	0 (0%)
prISO 17225-4	stem wood	5 (72%)	2 (28%)	3 (43%)	4 (57%)	-	-
prISO 17225-1	Whole tree	5 (72%)	2 (28%)	39 (88%)	5 (12%)	36 (95%)	2 (5%)
prISO 17225-4		5 (72%)	2 (28%)	5 (72%)	2 (28%)	-	-
prISO 17225-1	Logging residues	0 (0%)	9 (100%)	14 (64%)	8 (26%)	12 (92%)	1 (8%)
prISO 17225-1	Stumps	2 (40%)	3 (60%)	3 (50%)	3 (50%)	1 (100%)	0 (0%)
	Total	22 (42%)	30 (58%)	103 (79%)	27 (21%)	86 (97%)	3 (3%)

¹ yes particle size requirements were fulfilled, number (%).

²No, requirements of different fractions were not fulfilled, number (%).

Results are little better than in the previous proposal. Especially requirement of P31 can be better met with this new proposal.

References

N94: prISO 17225-1, Solid biofuels – Fuel specification and classes, Part 1 – General requirements, Committee draft, January 2012

N97: prISO 17225-4, Solid biofuels – Fuel specification and classes, Part 4 – Graded wood chips, Committee draft. January 2012

N129: prISO 17225-1, Solid biofuels – Fuel specification and classes, Part 1 – General requirements, Draft international standard, July 2012.

N132: prISO 17225-4, Solid biofuels – Fuel specification and classes, Part 4 – Graded wood chips. Draft international standard, July 2012.

EN 15149-1:2011, Solid biofuels – Determination of particle size distribution - Part 1: Oscillating screen method using sieve apertures of 1 mm and above.

Steiner, M., Pichler, W. & Denzler, J. Evaluation of different particle size classification schemes, Vienna April 2012, 12 p.