| Forestry Commission Job Report 058 - Extended summary |
| **Solid Timber:Woodchip Volume Ratio** |

Introduction

This report summarises published data on the ratio between solid timber volume and chip volume.

The solid timber:woodchip volume ratio is a measure of the ratio of solid volume content to overall bulk chip volume. The value is important as it is a fundamental assumption used in storage and energy value calculations. Chip cost and price is also often calculated on a volume basis. Knowledge of the ratio can help estimate chip tonnage and calorific value.

Factors effecting solid timber:woodchip volume ratio

Review of published literature found that the ratio between woodchip volume and its solid timber volume varies with a number of factors. The type of chipper used, its condition and screens will interact with the feedstock material to alter chip shape and particle size distribution. Moisture content of feedstock material and temperature will also cause variation in chip character. In addition, loading and transport will influence the amount of pile compaction and settling.

Table 1: Factors influenceing solid timber:woodchip ratio

Factor	Impact on Ratio
Particle Shape	Ratio decreases with increasing diagonal-to-thickness ratio
Particle Size Distribution	Ratio decreases with increasing particle homogeneity
Tree Species	Low density and/or brittle species produce more fines, increasing heterogeneity, increasing ratio
Branch Content	Fresh branches and twigs can avoid full chipping, producing more slivers and decreasing ratio
Storage	Good storage can decrease MC%, leading to material becoming more brittle and less dense, increasing ratio
Season	In extreme cold, biomass can freeze and become brittle, increasing ratio
Loading Method	Ratio will vary with compression effects from loading e.g. blowing from a chipper spout will increase ratio compared to chips falling from a conveyor etc.
Settling	Increase in ratio during transit will be dependent on a number of factors: initial ratio, particle size distribution, duration of transit, vibration during transit. The greatest settling occurs within the first 10-20 km. Settling may not occur with frozen chips.

Published values for solid timber:woodchip volume ratio

Published figures for solid to chip volume ratio were found to vary mostly between 0.30 and 0.45, the most commonly quoted figure being 0.40.

Table 2: Summary of published solid timber:woodchip volume ratios

Chip Specification	Solid:Woodchip Volume Content	Source
Generic	0.38-0.44	Nylander and Törnmarck, 1986
Generic	0.40	Hakkila and Parikka, 2002
G30	0.40	Francescato et al., 2008
G50	0.33	Francescato et al., 2008
Hog Fuel	0.30	Folkema, 1989
Pulp Chip	0.25	Folkema, 1989
Chunkwood chip	0.35	Folkema, 1989
Generic	0.35-0.45	Johnson, 1989
Generic	0.44	Kofman, 2010
Generic	0.40	Lindblad et al., 2010
Generic	0.40	Savolainen and Berggren, 2000

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Technical Development (TD) woodchip studies

Studies were conducted by TD in 1998 to compare chip production from a range of chipper types fed with broadleaved species. The proportion of solid volume within chip piles can be seen have varied between 0.30 and 0.44 whilst loose.

Chipper Type	Material	MC% (w.b.)	Roundwood Density (t/m3)	Pile Solid Volume Content	
				Loose	Settled
Cone	Oak	38	0.96	0.37	0.39
Cone	Oak	43	1.05	0.38	0.40
Cone	Oak	42	1.05	-	-
Disc	Oak	38	0.96	0.40	0.43
Disc	Oak	43	1.06	0.44	0.51
Disc	Oak	42	1.06	-	-
Disc	Oak	41	0.87	0.37	0.39
Disc	Oak	42	1.01	0.38	0.39
Drum	Oak	25	0.91	0.40	-
Drum	Chestnut	32	0.86	0.30	-
Drum	Lime	48	0.83	0.33	-
Drum	Chestnut	32	0.86	0.31	-

Settling

The effect of settling can be seen to be small, the ratio generally increasing by 1-3%. These figures agree well with overall volume reduction values of up to 10% on settling quoted by Kofman (2007).

Conclusions

- Solid timber:woodchip volume ratio will alter with feedstock material qualities, chipper type and setup, and chip storage.

- The range of solid timber:woodchip volume ratio is likely to be between 0.30 and 0.44 from chipping in British conditions.

- Settling is likely to increase solid timber:woodchip volume ratio by in the order of 1-3%.

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