Client Report :

Stickering, Stacking and Loading Best Practice Guide

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Executive Summary

This best practice guidance document has been drafted as part of the European CRAFT project (BE-S2-53 60), DRYCON : Improved Control Methods and Systems for the Consistent Drying of Wood, as a deliverable under Task 1: Baseline Drying Quality, the Effect of Stack Design on Drying Quality.

The main objectives of task 1 were:

- To determine a basis for assessing timber quality improvement during subsequent tasks
- To determine the effect of stacking, stickering and loading on air flow and quality of dried timber

This best practice guidance document deals with the second objective. The first will be dealt with in a separate report. The stacking, stickering and loading methods used by individual sawmills were assessed and evaluated in 8 commercial kiln trials around the UK. This enabled the 'best practices' from each sawmill to be included in this guidance document. The sawmill site assessments have identified a number of areas where improvements could be made. However in general, the working procedures of the eight sawmills assessed were of high quality and none exhibited any serious kiln drying procedural problems.

The main recommendations of this study are that:

- Dunnage or bearers should be as small in cross-section as possible, whilst still allowing easy entry of forks for loading and un-loading
- Stickers should be of adequate length to support the timber, but not excessively long to hinder close loading
- Sticker spacing should be in the region of 500 mm to 600 mm
- Parcels of battens should be made up of timber containing all the same lengths and dimensions
- Spaces between parcels should be reduced and excessively large gaps between the timber load and kiln frame blocked, to direct air through the kiln load
- Saw blades and chipper canter blades should be changed regularly to produce a smooth surface finish on battens, thus ensuring a uniform and constant air flow through the load
- All baffles, curtains and flaps should be well maintained and regularly checked for correct working
- Kiln operators should have appropriate training and guidance
- Operatives should be allocated an adequate amount of time with which to correctly load the kiln, so as to ensure consistent and uniform drying of the load

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1. Introduction

This best practice guidance document has been undertaken as part of the European project programme, Brite/EuRam BE-S2-5360: Improved Control Methods and Systems for the Consistent Drying of Wood (DRYCON) under Task 1: Baseline Drying Quality, and the Effect of Stack Design on Drying Quality.

The information and practices reviewed have been compiled after completion of kiln drying trials at 8 major UK sawmilling companies. Best practices relating to the stickering and stacking and loading of timber for kiln drying were assessed at each of the participating sawmills.

The majority of stacking and stickering systems used at participating sawmills have automated or semi-automated processes. Very few mills rely on manual stacking. This is mainly due to economic considerations (expensive labour) and the large volume of timber being processed. The machinery used for the stickering process often regulates the size of parcel, and the distance that can be set between stickers. This can also be influenced by the length of timber being stacked. Both parameters are important, to support the battens, and to reduce the likelihood of distortion occurring during the drying process due to bad stickering.

This best practice guide also provides guidelines on kiln loading. This procedure is carried out primarily by forklift or side loader, with the quality of the whole process governed by the operator's knowledge, skill and the time allocated to the task.

2. Description of the project

This project consisted of 8 sawmill visits to quantify the levels of distortion (pre- and post-kilning) and the moisture distribution in a typical kiln load of dried timber. During these trials the air temperature and humidity present within the kiln were monitored throughout the schedule, as was wood temperature and moisture content. Air velocity was also measured to assess the distribution of air within the kiln, thus allowing an assessment of the interactions between air velocity, distortion and moisture content.

During these kiln trials, detailed information was recorded concerning the stacking, stickering and kiln loading of timber prior to kiln drying. The recommendations concerning each of these aspects are set out in the relevant sections.

3. The Kiln Drying Process

A wood drying kiln is basically an insulated box with the facility to produce heat and to humidify and circulate air. These three variables (heat, humidity and airflow) are essential elements of the drying process and are controlled via sensors within the kiln to optimise the removal of moisture from wet timber at a controlled rate.

Most kilns assessed during the trials had the fans and heat exchangers positioned in the roof space, above a false ceiling, situated above the kiln load. Top and side flaps or rubber partitions reduce the size of gaps around the parcels, ensuring the heated air was directed through the load as efficiently as possible. Several of the kilns had forced air extraction units to remove moisture laden air, whilst louvered vents introduced fresh air. All the kilns assessed had their operation and schedules controlled by computer.

Stacking, stickering and loading are an important part of the kiln drying procedure, and play an important role in optimising the drying process and minimising distortion. Timber which is stacked neatly, loaded uniformly and supported adequately along its length will dry with a consistently higher quality than that with widely spaced supports and randomly stacked lengths. The roughness of the cut surface and dimensional uniformity will also affect the drying process by disrupting the flow of air over the timber and causing un-even drying. Chippers, bandsaws and circular saws should therefore be adequately maintained to ensure a good surface finish, with good dimensional accuracy.

4. Stacking, Stickering and Loading

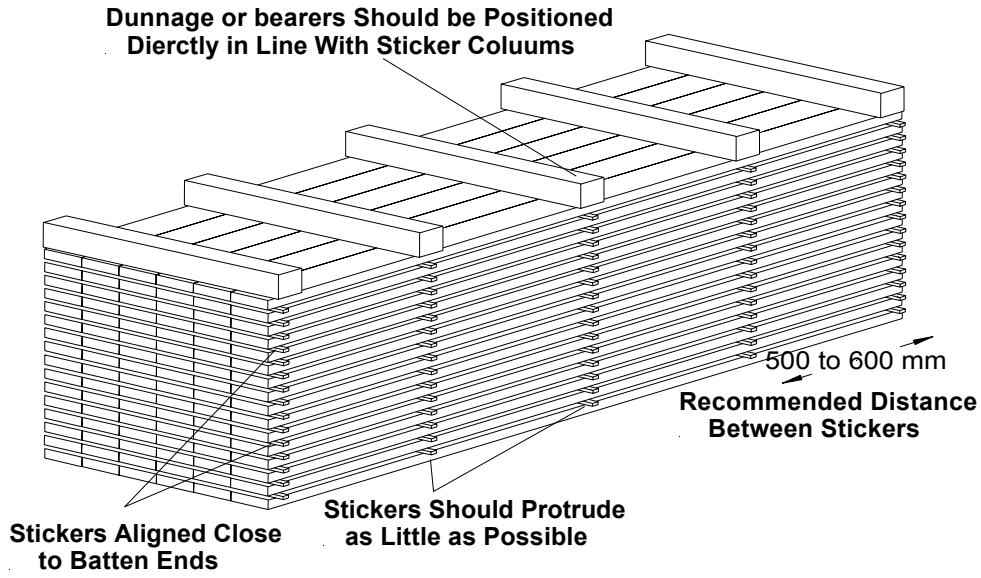
4.1 Parcel or Pack Design

Pack design is a fundamental part of the kiln drying process. Correct stacking of parcels will enhance the overall drying process and to help produce a high quality product, dried to a uniform moisture content, with very little or no distortion thus making the product visually acceptable to the buyer.

Where possible it is advisable that all parcels contain battens of the same length, and the kiln load is made up of timber of all the same dimension. Initial analysis of moisture content variation undertaken on material from the kiln trials indicated significant variation of moisture content and distortion between mixed batches of wide (50 x 200 mm) and narrow (50 x 100 mm) battens. Generally, wider battens dry to a higher final moisture content than narrow battens contained within the same load. It is therefore recommended that a kiln load be made up of parcels containing battens with all the same dimension. If this is not possible then, wider battens should be monitored for the desired moisture content, even if this means over-drying narrower pieces.

Parcels of timber containing battens of different lengths may also cause problems relating to moisture content and stacking. Although differences in moisture content between battens of differing lengths could not be identified, the parcels were difficult to stack correctly and were often un-supported at various points along their length, which created distortional problems. If it is not possible to make up parcels containing the same length battens, extra stickers should be incorporated to ensure each layer of battens are adequately supported and the ends of the parcel are square.

Figure 1. Good Stacking



To minimise distortion developing during the drying process, the stickers must be positioned at regular intervals across each layer of battens thus providing support to each successive layer. Battens within a parcel are therefore supported by those stickers above and below each layer as shown in figure 1. In turn each parcel is supported by dunnage positioned below each column of stickers, which is supported by the kiln floor or bogie.

Where stickers and dunnage are correctly positioned, the battens within a load are supported and to some extent restrained by the overall weight of the load. If stickers or dunnage are positioned in a non-uniform pattern, the weight of those parcels above can cause distortion to occur in battens within parcels which are out of alignment or poorly stickered (fig 2b, appendix 2).

The automatic stacking and stickering machine is an important part of the wood processing chain. It automates what was once a particularly labour intensive operation and speeds up the transfer of timber from the end of the saw line to the kiln area. It ensures a consistency in the sticker spacing, thereby reducing the chance of miss-placed stickers. Even so, the sticker placement chutes occasionally jam or partially jam, dropping rectangular dimension stickers edge down fig 2a, appendix 2). This effectively inserts a wider section sticker between two battens. If this is not rectified before drying commences, the timber may set with induced distortion causing battens above and below to become excessively bowed. Close supervision of the stacking and stickering machine and correctly dimensioned or even square dimension stickers may reduce or even eliminate this problem.

During the kiln trials it was noticed that large variations occur between sticker spacing. At different sawmills, it was found that the distance between stickers could be as large as 1200 mm or as low as 550 mm. It is recommended that the distance between stickers should be in the region of 500 to 600 mm in order to reduce the likelihood of distortion and provide adequate support over the batten length. Stickers positioned at the end of the parcel should be within 50 mm of the parcel end, preferably less. The minimum sticker frequency will be determined by the longest sawn length produced and the number of chutes on the stickering machine.

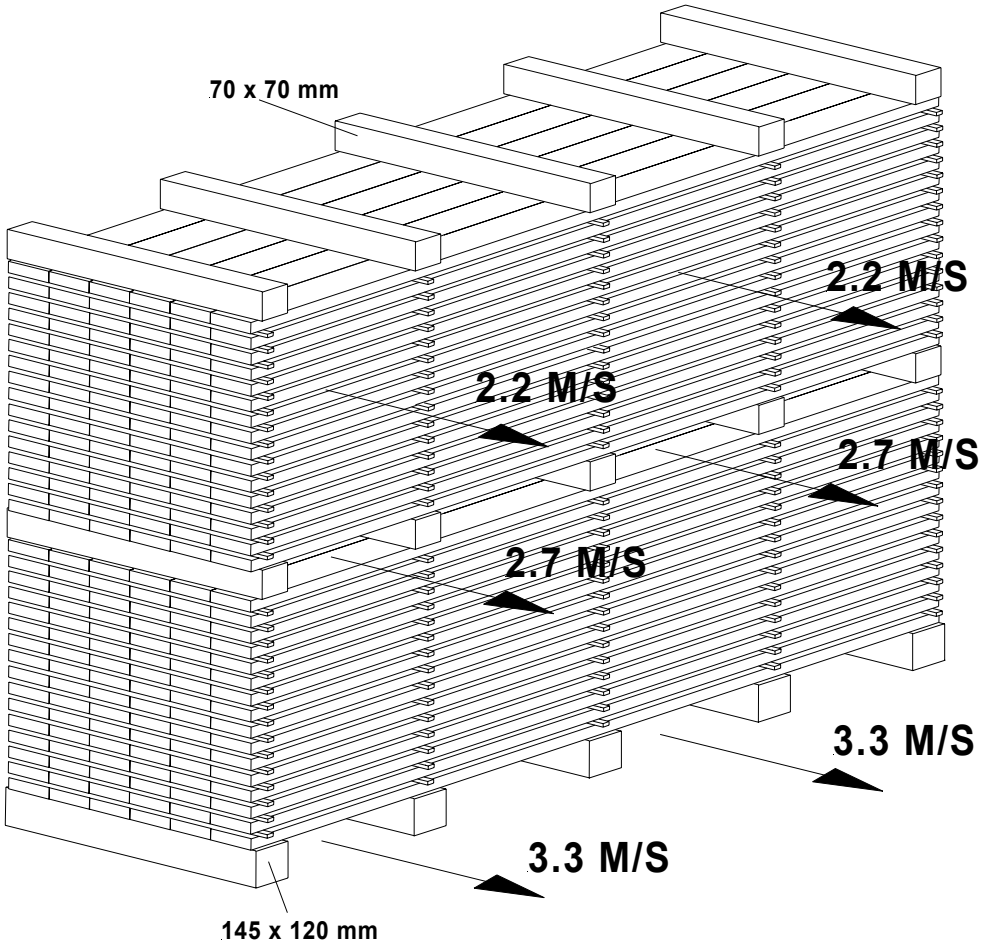
Recommendations

- Where possible, parcels of battens should be made up of timber containing all the same lengths and dimensions
- Where this is not possible, extra stickers should be inserted to provide adequate support to the battens below and above the different length battens. This will provide continuity of support to adjacent parcels
- Care should be taken when rectangular stickers are used (22 x 50 mm). This will eliminate ‘rogue’ stickers being inserted ‘thin edge down’
- Sticker spacing is important; it provides support to battens throughout the drying process and reduces the development of distortion. It is recommended that sticker spacing should be in the region of 500 to 600 mm
- Stickers should be positioned as close to the end of the parcel as possible (within 50 mm, preferably less) to ensure little or no overhang of battens

4.2 Dunnage and Sticker Dimensions

During the 8 kiln trials, air velocity was measured entering, and exiting the kiln load, both through the stickers and the dunnage. Figure 2 shows the air velocity measured exiting the kiln load in one of the participating sawmill's kilns. This figure clearly shows the difference in air velocity between that measured through the sticker spaces and that through the dunnage. There can be a considerable variation between air velocity readings from different areas of the kiln load. The larger spaces afforded by wider sections of dunnage allow passage of a greater volume of air, thus reducing the velocity and volume of air passing through the stickered parcels. It is therefore recommended that dunnage dimensions should be as small as possible, whilst still allowing easy fork lift access.

Figure 2. Air Velocity Variations Between Dunnage and Stickers



During the kiln trials, it was noticed that bearers or dunnage situated at the base of the load were often of a larger dimension than that used to separate the remainder of the stack. This practice, although common, has no direct benefit to the drying or loading process and only allows a larger volume of air to divert beneath the load rather than through the stack. As previously stated, bearers or dunnage should be as small a dimension as possible whilst still allowing easy fork lift access. If larger section dunnage must be used, an L-shaped baffle can be constructed to restrict the movement of air under the parcels.

A small-scale kiln trial undertaken at BRE has shown that air velocity increases, as sticker size becomes larger. However, this does not necessarily prove that the drying rate also increases as a result of increased sticker thickness, especially if the volume of air is sufficient to remove the moisture released by the wood. Drying rate is also influenced by temperature, relative humidity and wood moisture content.

It is therefore recommended that sticker dimensions remain the same until there is evidence that improvements in drying procedures can be made by altering sticker thickness.

Stickers and bearers are subjected to an extremely hard working life. Both are subjected to constant wear and damage, eventually becoming unsuitable for their chosen purpose. Stickers and bearers, which are worn or damaged, should be replaced. If possible, old and new stickers should not be mixed, as dimensional changes caused by compression damage and shrinkage can result in a mixture of different dimension stickers being used throughout a parcel.

Sticker length is another important consideration. Over length stickers form a physical barrier between parcels when they are being loaded into the kiln. This prevents close stacking of parcels and often results in stickers being broken or moved as loading progresses fig 2b, appendix 2). Sticker length should be optimised to provide adequate support to each layer of battens without excessive protrusion from the edges.

Recommendations

- Dunnage or bearers should be as narrow as possible, whilst still allowing easy entry of forks for loading and un-loading
- Bearers and stickers should be machined square, to the correct dimensions.
- Stickers should be of adequate length to support the timber, but not excessively long to hinder loading
- Damaged bearers and stickers should be replaced
- Where possible new and old stickers should not be mixed

4.3 Wood Surface Finish

A small-scale kiln trial undertaken at BRE monitored the air velocity through a parcel of timber to assess how different surface finishes affect air velocity. Results from this trial indicate that air velocity was markedly reduced over battens with band-sawn surfaces in comparison to battens with planed surfaces. This indicates that worn chipper teeth or saw blades can have a significant effect on the drying process by reducing or disrupting the air velocity. It is recommended that saw blades and chipper teeth be kept as sharp as possible and saws well maintained, to ensure the surface finish of processed battens is consistently smooth. The large number of battens received from individual trials, which had obviously been through a chipper canter, prompted this small experiment. In many cases, the surface finish was extremely rough or pitted, indicating worn or badly maintained chipper blades or teeth.

Recommendations

- Saw blades and chipper canter blades should be changed regularly to produce a smooth surface finish on battens, thus ensuring a uniform and constant air flow through the load

4.4 Loading the Kiln (Load Design)

The eight kilns assessed consisted of 4 drive-in and 4 trolley loaded kilns, seven of which utilised different loading regimes. In general, most kiln loads filled all available space. This is an important consideration when assessing the economics of drying and to ensure the maximum airflow through the stickered parcels of timber.

In most cases, only one operative carried out the loading process. These individuals exhibited a high degree of skill and precision, completing the task quickly and efficiently. It was not unusual for an operative to intersperse kiln loading with loading delivery vehicles, and removing timber from the end of the saw line into storage areas. Operatives are under constant pressure to un-load and re-load the kilns as quickly as possible in order to speed up the turnaround of timber for kiln drying. This pressure can compromise the neat and uniform loading of timber for kiln drying.

Each loader also appeared to use a predetermined pattern concerning bearer position and number. The bearers were generally, but not always, placed beneath a line of stickers at regular intervals along a parcel. However, they were not necessarily directly beneath all columns of stickers. It was frequently noticed that the centre of a parcel was left clear of dunnage for easy entry of the forklift blades. Protruding stickers also caused problems when attempting to load the parcels in the kiln (see section 4.2).

Kiln loading is one area where the operative can have a significant influence on the drying process. The kiln must be loaded correctly i.e. stickers should align through each successive parcel, dunnage should be positioned in line with each column of stickers and parcels should be loaded as close as possible. Adequate time should therefore be

allocated to this task, to ensure it is carried out correctly and external pressure to complete the task is kept to a minimum.

It is recommended that bearers should be positioned beneath each column of stickers throughout the kiln load, not more at the base and less further up the load, as was frequently seen. This ensures adequate support is given to the whole load, thereby minimising distortion caused by irregular growth patterns and the drying process.

The kilns and surrounding area should always be kept clear of un-wanted debris such as old stickers and dunnage. A clean and tidy kiln area ensures that a uniform airflow is achieved through the stack, reducing turbulence, by the elimination of obstacles. It also provides a safe working environment.

Recommendations

- Where possible the kiln load should fill all the available kiln space
- Bearers should be positioned directly beneath each line of stickers to provide adequate support to all parcels, thus minimising drying distortion
- Parcels of timber should be loaded in a manner which reduces the number, and size of gaps between alternate parcels
- The kiln area should always be kept clean and tidy

4.5 Control of Air through the Stack

Most kilns encountered during this study have some form of side and top flaps to reduce the size and number of large gaps between kiln walls, ceiling and timber. Any large open spaces or gaps will always be the preferred route of the heated air, considerably reducing the efficiency of the drying process. Flaps and curtains should be well maintained and used for the process they were designed for, ensuring that the flow of high cost air is maximised through the stickered timber.

The top flaps can, in some kilns, overhang the top parcels by several batten thicknesses. This problem is often caused by over wide flaps or slightly oversize stickers, bearers or parcels. Where this problem occurs, battens covered by the flaps will dry at a much slower rate than the majority of un-covered battens in the kiln. This causes the covered battens to have higher final moisture content, which may be out of specification for its intended end use.

Recommendations

- Where possible, all large gaps or spaces i.e. those spaces at the stack ends (between door and stack) the base (floor and stack) and top (ceiling and stack) should be adequately blocked to ensure air is forced through the stickered battens (air will take the line of least resistance)
- Ensure that all baffles, curtains and flaps are well maintained and work correctly
- Ensure that top flaps do not overhang the front or rear top parcels

5. Conclusion and recommendations

Assessments have been completed at eight commercial kiln installations at participating UK sawmills. During the trials, the stacking, stickering and loading methods used by each individual sawmill were monitored and evaluated. In general, the procedures used by the sawmills have been of high quality, however, improvement opportunities have been identified and are discussed in this report.

The main conclusions identified in this Report are the need for good practices to be performed throughout the stacking, stickering and loading process. Attention to detail is an important principle of the kiln drying process and is one area where significant improvements in the drying process can be achieved. Aspects requiring attention include:

- Correct sticker spacing and alignment
- Reduction of bearer dimension
- Standardisation of batten dimensions per kiln load
- Minimising protrusion of stickers outside each parcel
- Adequate time to load the kiln correctly
- Training and guidance for kiln operators

Additional areas for consideration, not included in this report, but relevant to improving quality, concern the packaging, sawmill storage, transportation and final storage of timber of kiln dry material. Poor wrapping and storage before distribution can adversely affect the quality of kiln dried timber. Problems created in these areas may be inadvertently attributed to the sawing or drying process. It is therefore important that improvements in the quality of processing and kiln drying are not compromised by practices further down the production/delivery chain.

By incorporating a combination of basic improvements and the reinforcement of good practice in stickering, stacking and loading, a significant increase in the quality of dried timber can be obtained. An assessment of the stacking, stickering and loading regimes by sawmill staff utilising this document may identify areas needing attention. This would allow standardisation of common procedures, thus ensuring uniformity of working practices between staff and different shifts. Guidelines could also be implemented to identify good practice, and ensure the various tasks outlined in this document are carried out to written specifications. This would ensure that the quality and uniformity of each given task was attained and adhered too.

Annexe 1.

Terminology

Recent changes, over the past 3-4 years, in the softwood kiln drying process necessitates a revision of the terminology used to describe the loading, stacking and stickering of timber prior to kiln drying. Current kilns have been designed to accommodate large volumes of timber comprising of a large number of packs, each automatically stacked and stickered. This differs considerably from older kiln practices, where kilns were smaller and one large pack or quantity of battens were loaded by hand.

The terminology used within this document is as follows:

- **Stickers** – A square or rectangular section length of timber used to separate layers of battens within a parcel (the species is generally the same as that being dried)
- **Stickering** – The process of inserting stickers between individual battens in a parcel
- **Dunnage or Bearers** – Square or rectangular section lengths of timber used to separate individual parcels of battens.
- **Stacking** - The process used to form a parcel of timber; i.e. battens are '**stacked**' in a pre-determined order to form a parcel or pack.
- **Packs or Parcels** - A kiln is loaded or filled with '**Packs**' or '**Parcels**' of timber, i.e. a parcel is made up of a specific number of battens, (the size and number of which is dependant on batten dimension and sawmill policy) stickered in layers, the final size and weight of which, is easily manoeuvred by mechanical means.
- The kiln can then be '**loaded**' or '**filled**' with parcels of timber, either onto a trolley or directly into the kiln to form a '**kiln load**'.

Annexe 2.

Annexe 2

Figure 2a. Incorrect Sticker Alignment & Placement

Figure 2b. Sticker Displacement & Alignment Inducing Distortion