

BS 1133-8:2011+A1:2016



BSI Standards Publication

Packaging code

**Part 8: Guidance on wooden boxes,
cases and crates**



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Published by BSI Standards Limited 2016

ISBN 978 0 580 95095 7

ICS 55.160

The following BSI references relate to the work on this document:

Committee reference PKW/0

Drafts for comment 11/30197409 DC, 16/30345602 DC

Publication history

First published December 1943

Second edition, December 1950

Third edition, April 1981

Fourth edition, November 1991

Fifth (present) edition, December 2011

Amendments issued since publication

Date	Text affected
November 2016	A1 - See Foreword

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to vi, pages 1 to 116, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 December 2011. It was prepared by Subcommittee PKW/0/-/11, *Packaging – Wood*, under the authority of Technical Committee PKW/0, *Packaging*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This part of BS 1133 supersedes BS 1133-8:2011, which is withdrawn.

Information about this document

The start and finish of text introduced or altered by Amendment No. 1 is indicated in the text by tags **A1** **A1**. Minor editorial changes are not tagged.

BS 1133-8:2011 was a full revision of the standard, and introduced the following principal changes:

- a change of status from code of practice to guidance document;
- the introduction of a new Annex A on health and safety issues;
- the introduction of a new Annex B on tables of sizes for skids sills and rails.

Relationship with other publications

The packaging code now consists of the following parts:

- *Part 7.6: Paper and board wrappers, bags and containers – Moulded pulp packaging;*
- *Part 10.1: Metal containers – Tins and cans;*
- *Part 10.2: Metal containers – Metal drums;*
- *Part 15: Tensional strapping;*
- *Part 18: Packaging in glass;*
- *Part 19: Use of dessicants in packaging;*
- *Part 22: Packaging in plastics containers.*

Entry and dimensional requirements for pallet bases in cases and crates are covered worldwide by BS ISO 6780 and for Europe by BS EN 13382. The two do not conflict with each other but BS ISO 6780 allows additional pallet sizes which are used across Europe since there are few compatibility issues. However, individual local commercial contracts might not permit certain pallet types, materials or sizes.

Use of this document

As a guide, this part of BS 1133 takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

Presentational conventions

The guidance in this standard is presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This part of BS 1133 provides guidance for manufacturers, users and specifiers of wooden boxes, cases and crates for industrial, defence and other commercial applications.

This document contains guidance on wood species, sheet materials and fastenings likely to be encountered by UK manufacturers or export packers and gives guidance on the design of:

- a) industrial, defence and commercial cases and crates;
- b) ranges of smaller sawn wood boxes for general use;
- c) ranges of plywood and wood-based sheet boxes and cases;
- d) plywood cases of metal edge construction;
- e) wirebound boxes, crates and cases;
- f) warehouse storage containers.

This British Standard also gives brief guidance on sustainability and recycling.

Annex A contains health and safety information.

Annex B contains tables of sizes for skids sills and rails.

NOTE 1 Knowledge of engineering principles is needed to produce a design specification from the information given in certain tables, particularly in relation to large cases and crates.

NOTE 2 Much of the information in this British Standard might also be of value in other areas where wood is used in packaging and distribution, e.g. agricultural boxes and pallets.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN 12246, *Quality classification of timber used in pallets and packaging*

BS EN 13183-2, *Moisture content of a piece of sawn timber – Part 2: Estimation by electrical resistance method*

BS EN 13246, *Packaging – Specification for tensional steel strapping*

BS EN 13427, *Packaging – Requirements for the use of European standards in the field of packaging and packaging waste*

BS EN 22872, *Complete, filled transport packages – Method for determination of resistance to compression*

BS EN 22874, *Complete, filled transport packages – Method of test for stacking using compression tester*

BS EN ISO 2234, *Packaging – Complete, filled transport packages and unit loads – Stacking tests using a static load*

BS EN ISO 4180, *Packaging – Complete, filled transport packages – General rules for the compilation of performance test schedules*

BS EN ISO 15867, *Intermediate bulk containers (IBCs) for non-dangerous goods – Terminology*

BS ISO 6780, *Flat pallets for intercontinental materials handling – Principal dimensions and tolerances*

3 Terms and definitions

For the purposes of this part of BS 1133, the following terms and definitions apply.

3.1 **batten**

length of wood added to a wooden case or crate to hold the boards together and to strengthen and protect it

NOTE Girth battens are fitted externally and run fully top to bottom and across the case top.

3.2 **blocking**

any block, strip, packing or distance piece, usually of wood, fastened to the inside of a case to mount or hold the contents in position against vertical or horizontal movement

3.3 **box**

lightweight case, of close-boarded or sheet material, not normally fitted with girth battens, sometimes with open-top bulk storage

NOTE Specialist boxes such as open-top potato boxes may hold up to 1 t.

3.4 **case**

assembly of skids, headers and cross members, fully covered with sheathing so that goods cannot be viewed and are therefore protected from pilferage, weather and impact damage

3.5 **corner post**

vertical batten forming all or half of a single case corner on to which sheathing is nailed

3.6 **crate**

assembly of skids, posts, headers and cross members with skeletonized outer sheathing which permit goods to be viewed

3.7 **cripple**

failure by bending, while only partly driven, of a nail or staple during insertion into timber

3.8 **cross member**

connecting, horizontal structural member of the base perpendicular to skids, positioned between the headers

NOTE Heavy goods are often fixed by bolting to these.

3.9 **crush batten**

structural member fitted horizontally inside the top of the shorter case dimension running parallel with the headers with the function of preventing slings from crush-damaging the goods

3.10 **diagonal braces**

multiple components of a case or crate nailed internally or externally between 30° and 60° and positioned between frame members to prevent distortion of the structure

3.11 **dunnage**

loose wood members of varying size that are part of stevedores' moving, slinging and stacking equipment for distributing load, levelling, holding sling gaps and reducing stress in critical members

- 3.12 duration of transport**
period of time from delivery of the package to the carrier to its arrival with the recipient
- 3.13 export packaging**
packaging sufficient to protect goods for shipment, allowing for multiple transshipment, specific climatic conditions in transit and duration of transport
- 3.14 freight container**
standardized modular international system of shipping containers for export and import of large volume of goods
NOTE Freight containers are covered for BS ISO 1496 (all parts).
- 3.15 goods for packing**
merchandise to be rendered transportable and storable by packaging
- 3.16 header**
connecting horizontal structural member perpendicular to skids or sills, placed at the two ends of each skid or sill and held by nailing or bolting
- 3.17 heavy good**
item requiring special packaging due to its bulk and/or construction and measurements
- 3.18 kiln drying (KD)**
use of controlled airflow, heat and humidity in a large drive-in insulated oven for a period varying from hours to days, to quickly and safely remove water from wood without degrade
NOTE 1 Kiln drying is also used to sterilize timber, e.g. in international export phytosanitary treatment under ISPM 15 [1].
NOTE 2 Oven dried content is taken as being nominally 0%, dry wood as 12%, air dried as 15%, and green wood (fibre saturation point) as 28%, unless otherwise stated. ^{A1}
- 3.19 load-bearing package**
package constructed in such a way that it can bear the full weight of the packed goods in the process of loading and unloading whatever equipment is used for lifting
NOTE The loading gear (ship's tackle) is applied to the package.
- 3.20 means of packaging**
system and type of packing material used to contain goods to be packaged in order to make them fit for transport and storage
- 3.21 multiple-use package**
package intended for multiple use, possibly collapsible or folding
- 3.22 package**
packed goods ready for transport
- 3.23 packaging**
material used to pack goods and also the process of using it
- 3.24 packing**
generic terms for all means and auxiliary means of packaging

- 3.25 rail**
wood member, at right angles to sawn boarded sheathing, which both supports and acts as assembly jig during the construction of sheathing panels
NOTE For plywood sheathing panels rails are fitted to stiffen and aid nailed connection to adjacent components.
- 3.26 rubbing strip**
strip applied to the bottom of a large case under the skids to permit slings to enter from the ends and then stop at a pre-determined point
NOTE Rubbing strips only need compressive strength to withstand stacking.
- 3.27 sheathing**
weatherproof covering of plywood, waferboard, MDF or water-resistant tri-wall
- 3.28 sill**
longitudinal timber beam placed internally as an alternative to skids when a machine's mounting points are not its lowest part, i.e. if it has projections below its base
- 3.29 sill-based case**
case built with sills running lengthwise and boards running across the width of the base
- 3.30 skid**
longest structural member of a case or crate placed horizontally below flooring boards and running from end to end of the base
- 3.31 skid-base case**
case built with skids running lengthwise and flooring boards running across and above the width of the base
- 3.32 sling point**
essential strengthened lifting position and clear marking for slings to be placed to assist lifting
- 3.33 sling spreader base**
part of stevedores' sling lifting equipment to separate slings and hold clear of a crate or case to serve the same purpose as crush battens, but fitted externally and temporarily
- 3.34 spliced**
joining of multiple shorter pieces of timber by means of overlapping sections to achieve a strong full-length component
- 3.35 vertically built case**
case built with a substantial base and vertically boarded sides and ends
NOTE Such a design is commonly used for shipping heavy machinery.
- 3.36 warehouse storage container**
stackable storage container from sawn or wood sheet material used in storage and shipping
- 3.37 wirebound**
case or crate or entirely very largely held together and fastened with thin ductile steel wire, enabling flat packing after use for storage or return to sender

3.38 wooden packaging

item (e.g. boxes, punnets, trays, cases, crates, pallets, stillages, collars and bins) made exclusively or primarily of wood

4 Wood for packaging

4.1 Sawn wood – Species suitable for packaging uses

Wood is a natural material and it is not possible to control its quality by methods appropriate for manufactured packaging materials such as plastics or metal. BS EN 12246 lists two packaging grades. The species and grade of wood should be selected to suit the particular end use.

Wood is classified as “softwood” (the conventional term for both the timber and the trees belonging to the botanical group gymnosperms) or “hardwood” (from deciduous trees), irrespective of whether it is actually physically hard or soft. As far as commercial timbers are concerned, softwoods are all conifers. Most wood used for packaging applications is softwood, but hardwood can also be used.

The heaviest (denser) species of timber are usually stronger, although they are often more difficult to work and fasten.

Where the properties of a timber species are not known, the strength and the ease with which nails can be driven into the wood (commonly referred to as “nailability”) should be checked before use.

Nailability is particularly relevant when improved nails, such as annularly threaded nails, are used because these are more difficult to drive and might bend on entry into very dense species. See **8.2.4** for more information about nails with poor resistance to bending.

Some timbers are also particularly liable to cause acidic corrosion of metallic objects with which they are in contact and this hazard should also be considered.

NOTE BS 7195 deals with metal goods packed within proximity of corrosive wood species.

Sapwood (the outer layer of the tree trunk which, in the growing tree, contains living cells and reserve materials, e.g. starch) is often lighter in colour than the inner heartwood, but might not be distinguishable. Sapwood contains starches and is more susceptible to insect and fungal attack than heartwood, but it is not practicable to specify heartwood for wooden box, case or crate construction nor is it necessary for the short life of the average wooden container.

4.2 British grown species

4.2.1 Softwoods

4.2.1.1 Pines

Pines are among the strongest of the softwoods used for packaging. The heartwood of the timber is often a reddish brown in colour and is usually resinous. Knots are large and scattered, with a tendency to loosen on drying.

Pines have a greater susceptibility to sapstain (bluestain) than other species and close piling after sawmill conversion should be avoided while still at a high moisture content.

NOTE Sapstain is a stain in softwood sapwood resulting from the growth of certain fungi which derive their nourishment from wood cell contents, but do not cause decomposition of the wood cells themselves. The stain is greyish blue in colour and hence is also referred to as bluestain.

The following pines are used for packaging purposes.

- a) Corsican pine, one of the strongest species.
- b) Lodgepole pine, similar in strength to European redwood.
- c) Maritime pine, imported from France and Portugal. This has the highest bending strength of any commercially available softwood packaging species.
- d) Scots pine, known as European redwood when grown and imported from Scandinavia, Baltic countries and Russia. The different geographical origins cause a variation in the texture, density and size of knots, resulting in separate listings in reference tables.

4.2.1.2 Spruces

Spruces are the lightest of the main packaging timbers listed, lighter in colour and less resinous than the pines, the knots tend to be small, tight and concentrated in nodes.

Norway spruce is widely planted throughout the UK and has the advantage of a good stiffness to weight ratio.

The British-grown wood is generally lower in strength properties than the same species imported from Scandinavia, which is known as whitewood.

Sitka spruce is the most widely planted species in the UK, and should be used where light weight is essential, having a good strength to weight ratio.

NOTE The knots of the sitka spruce tend to be small.

4.2.1.3 Other conifers

This group includes the strongest softwoods which should be used for specialist purposes rather than for general use. Examples of other conifers are:

- a) douglas fir, widely planted in the British Isles and the strongest and stiffest of the UK softwoods listed;

NOTE 1 Some splitting might be experienced when Douglas fir is nailed but increasing the distances of the nail from the edge, or the use of a blunt nail, can reduce this to acceptable levels.

- b) larch; three varieties are available throughout Britain (see Table 1), although European larch is less likely to be encountered. The larches are stronger in bending, and harder and tougher than most softwoods.

NOTE 2 Splitting could be troublesome where nails are driven near the edge of boards, but this can be reduced by the same means indicated for Douglas fir.

Table 1 British grown softwoods and hardwoods suitable for packaging

Standard name	Other names	Botanical name	Density ^{A)} kg/m ³
fir, Douglas ^{B)}	Columbian pine	<i>pseudotsuga menziesii</i>	530
larch, Dunkeld ^{B)}	hybrid larch	<i>larix eurolepis</i>	530
larch, European ^{B)}	—	<i>larix decidua</i>	590
larch, Japanese ^{B)}	—	<i>larix kaempferi</i>	560
pine, Corsican ^{B)}	—	<i>pinus nigra maritima</i>	520
pine, lodgepole ^{B)}	contorta pine	<i>pinus contorta</i>	470
pine, maritime ^{B)}	—	<i>pinus pinaster</i>	530
pine, Scots ^{B)}	Redwood	<i>pinus sylvestris</i>	520
spruce, Norway ^{B)}	European whitewood	<i>picea abies</i>	420
spruce, Sitka ^{B)}	silver spruce	<i>picea sitchensis</i>	400
ash, European	English ash	<i>fraxinus excelsior</i>	710
aspen, European	English aspen	<i>populus tremula</i>	450
beech, European	English beech	<i>fagus sylvatica</i>	690
alder	—	<i>alnus glutinosa</i>	530
birch, European	English or silver birch	<i>betula spp.</i>	670
chestnut, European	horse chestnut	<i>aesculus hippocastanum</i>	520
elm, Dutch	—	<i>ulmus hollandica</i>	580
elm, English	—	<i>ulmus procera</i>	560
oak, European	English oak	<i>quercus spp.</i>	720
plane, European	English plane	<i>platanus spp.</i>	640
poplar, black	robusta, European blackpoplar	<i>populus spp.</i>	450
poplar grey	—	<i>populus canescens</i>	480
poplar, white	abele	<i>populus alba</i>	450
willow, white	crack willow	<i>salix spp.</i>	450
lime	—	<i>tilia spp.</i>	610

^{A)} Density values are averages for the species air dried to 15% to 18% moisture content.

^{B)} Denotes a softwood.

4.2.2 Hardwoods

Hardwoods vary in colour, strength, weight and other properties and include the strongest UK timbers. There is only a low volume of hardwoods used in packaging, except for specialized functions, largely due to limited availability, higher cost, and the fact that some species are difficult to nail.

In general, UK hardwoods should be used in distance blocking and heavy-duty skids where high compression or scuffing strength are required.

Hardwoods are frequently supplied in an undried, and therefore weaker, state.

The following are some examples of hardwoods and their associated features.

- Aspen. [See item h).]
- Ash and beech. Possessing excellent strength properties, these species are well suited to top-quality box and case members. Care should be taken as longer nails can bend on entry when hand-driving is undertaken. The difference between radial and tangential shrinkage is greater than in most other species and this can lead to greater distortion after drying.
- Birch, a species with high strength properties very similar to oak, although availability is limited and dependent on locality. Some difficulties might arise

due to splitting, therefore persons should consider pre-boring or the use of pointless or reduced diameter nails to avoid this.

- d) Elm, a difficult timber to work, but with exceptional nail-holding properties. When available, this timber should be used for distance blocking or for short lengths. Elms are typically around 30% weaker than oak in bending but considerably better than softwoods with regard to nail holding.
- e) Horse-chestnut, a soft, easily worked timber with strength characteristics similar to those of softwoods. This species is not to be confused with sweet chestnut, which is an acidic timber, liable to corrode steel fastenings, and not recommended for packaging.
- f) Oak. This species occurs throughout Britain and Europe. It is difficult to nail, and pre-boring or the use of pointless nails might be necessary. This timber is acidic and likely to promote corrosion of steel fastenings in damp conditions. Oak is often thought of as being much stronger than softwoods, but the difference in bending strength is quite small.
- g) Plane. Of limited availability, this should be used for decorative work. It has high resistance to cleavage and indentation; other strength properties are similar to those of pines.
- h) Poplar, both UK and European. With this species, the effects of shrinkage and distortion on drying can be excessive.

NOTE Aspen is from the same botanic species group as poplar.

- i) Willow, whose strength properties in general are similar to poplar, but is suitable for blocks where bending strength is unimportant. Crack willow can suffer from splitting during conversion and nailing, white willow being superior in this respect.

4.2.3 European grown species

4.2.3.1 General

This category includes those species grown in Russia which are widely imported into Europe. The most important species are described in 4.2.3.2 and 4.2.3.3.

4.2.3.2 Softwoods

The following softwoods can be used for packaging purposes.

- a) Whitewood, widely imported from Scandinavia, Baltic area and Russia for the construction, joinery and packaging industries. It has good working properties and a high stiffness to weight ratio. One of the lightest of the species used in packaging, the timber can vary in strength according to its geographic origin, the more northerly grown timber tending to be stronger due to its slower growth.

NOTE 1 This is commonly known as European whitewood/European or Norway spruce.

- b) Maritime pine. An important UK packaging species imported from France and Portugal where the plantation grown timber tends to be heavier and generally stronger than that grown in Britain, although strength can vary widely with plantation location. It has a tendency towards large knots and knot clusters which can reduce strength. The species has outstanding nail-holding properties.
- c) Redwood, widely distributed in Europe and Northern Asia and an important packaging species in the UK. The sapwood band is creamy white to yellow in colour, narrow in northern growing areas, but becoming wider in southerly areas. The heartwood is pale yellowish brown to red brown, resinous and usually distinct from the sapwood. The timber is easily worked

and takes nails well, although resin can be a problem. When grown in the UK, it is customary to refer to this species as Scots pine.

NOTE 2 This is commonly known as European redwood.

- d) Douglas fir. [See 4.2.1.3a)]
- e) Larch. [See 4.2.1.3b)]
- f) Norway spruce. (See 4.2.1.2)

NOTE 3 Table 2 shows European-grown softwoods and hardwoods suitable for packaging.

4.2.3.3 Hardwoods

The following hardwoods can be used for packaging purposes.

- a) Poplar. Six main types including aspen are found in Europe, but the most common commercial species are the black Italian poplar and, when plantation grown, the hybrid *Populus × euramericana*. Density or specific gravity are a good measure of strength and poplar from Turkey, as generally imported for packaging, has the lowest density of all the species likely to be used in British case making.

NOTE 1 For their low weight, poplar timbers are relatively strong and tough, but while the species traditionally seen in the UK, the black Italian poplar, falls between maritime pine and spruce in strength, the faster-grown Southern European hybrids are weaker than spruce.

*NOTE 2 Poplars of the *Populus × euramericana* hybrids imported from Turkey could be up to 35% weaker than Portuguese maritime pine, or up to 20% weaker than sitka spruce. These values are based upon breaking strength in the well-dried condition. Turkish poplar takes nails well and is less likely to splinter than the spruces.*

NOTE 3 The poplar hybrids dry and shrink rapidly, but tend to retain moisture in pockets. There is also a tendency for some knots to split.

- b) Elm and horse-chestnut. [See 4.2.2d) and e)]
- c) Beech. Southern and Mid-European beech is a very strong timber with properties similar to UK grown beech. There might be a slight reduction in density, reducing strength by a small amount.

Table 2 Imported species suitable for packaging (1 of 2)

Standard name	Origin	Other names	Botanical name	Density ^{A)} kg/m ³
Alder	Europe, Baltic	—	<i>Populus canescens</i>	390
Aspen, European	Europe	poplar, balsam	<i>Populus tremula</i>	450
Beech, European	Europe	Slavonian beech	<i>Fagus sylvatica</i>	690
Birch	Canada, USA, Baltic, Russia	American birch, white birch, yellow birch	<i>Betula spp.</i>	610–710
elm, Dutch	Europe	—	<i>Ulmus hollandica</i>	580
fir, balsam ^{B)}	widely distributed	balsam	<i>Abies balsamea</i>	400
fir, Douglas ^{B)}	Canada, Europe	Columbian pine	<i>Pseudotsuga menziesii</i>	530
fir, silver ^{B)}	Central and Southern Europe	European silver pine	<i>Abies alba</i>	480
hemlock, eastern ^{B)}	East Canada, East USA	white hemlock	<i>Tsuga Canadensis</i>	470
hemlock, western ^{B)}	North-western USA	Pacific hemlock	<i>Tsuga heterophylla</i>	500
larch, Dunkeld ^{B)}	widely distributed	hybrid larch	<i>Larix × eurolepis</i>	530
larch, European ^{B)}	widely distributed	—	<i>Larix decidua</i>	590
larch, Japanese ^{B)}	widely distributed	—	<i>Larix kaempferi</i>	560
larch, tamarack ^{B)}	Canada and Northern USA	eastern larch	<i>Larix laricina</i>	580
pine, elliotis ^{B)}	Brazil	—	<i>Pinus elliottii</i>	490
pine, Austrian	Central Europe	Bosnian pitch pine	<i>Pinus nigra var nigra</i>	800
pine, Corsican ^{B)}	UK and Southern Europe	Bosnian pitch pine	<i>Pinus nigra maritime</i>	520
pine, jack ^{B)}	Canada	princess pine	<i>Pinus banksiana</i>	500
pine, lodgepole ^{B)}	Europe, Western Canada	contorta pine	<i>Pinus contorta</i>	470
pine, maritime	SW France	—	<i>Pinus pinaster</i>	520
pine, maritime ^{B)}	Portugal	Portuguese pine	<i>Pinus pinaster</i>	530
pine, radiata ^{B)}	Chile, New Zealand South Africa	Insignis pine, Monterey pine	<i>Pinus radiata</i>	480
pine, southern ^{B)}	Southern USA	loblolly pine, shortleaf, longleaf pine, slash pine	<i>Pinus taeda, Pinus echinata, Pinus palustris, Pinus elliottii</i>	670–490
pine, yellow ^{B)}	Eastern Canada, Eastern USA	eastern white pine, northern pine	<i>Pinus strobus</i>	420
poplar, black	France, Belgium, Turkey	robusta, black Italian poplar	<i>Populus nigra, Populus eur 'serotina'</i>	450
poplar, grey	Europe	—	<i>Populus canescens</i>	480
poplar, hybrid ^{C)}	Southern Europe	Turkish poplar	<i>Populus euramericana</i>	370

Table 2 Imported species suitable for packaging (2 of 2)

Standard name	Origin	Other names	Botanical name	Density ^{A)} kg/m ³
redwood, European ^{B)}	Russia, Finland, Sweden, Poland	Baltic redwood	<i>Pinus sylvestris</i>	520
rubberwood	Malaysia	—	<i>hevea brasilliesis</i>	610
spruce, black ^{B)}	Eastern Canada	water spruce	<i>Picea mariana</i>	480
spruce, Engelmann ^{B)}	Canada/USA mountains	mountain spruce	<i>Picea engelmannii</i>	450
spruce, red ^{B)}	Canada	yellow spruce	<i>Picea rubens</i>	450
spruce, Sitka ^{B)}	Western coastal areas	silver spruce	<i>Picea sitchensis</i>	450
spruce, white ^{B)}	widely distributed	eastern Canadian spruce	<i>Picea glauca</i>	420
whitewood, European ^{B)}	Russia, Finland, Sweden, Poland	Baltic whitewood	<i>Picea abies</i>	450

^{A)} Density values are averages for the species air dried to 15% to 18% moisture content.

^{B)} Denotes a softwood.

^{C)} Not given as a standard name in BS 7359.

4.2.4 North American grown species

4.2.4.1 General

Timber from Canada and the USA is used for packaging in the UK. The timber in Canada and Alaska is predominantly coniferous, with approximately 90% softwood and 10% temperate hardwood, while that in the USA is approximately 70% softwood and 30% temperate hardwood.

The main softwood species imported into the UK for packaging are described in 4.2.4.2.

NOTE Table 2 includes other species for reference purposes, although they are not as widely used.

4.2.4.2 North American softwoods

The following softwoods can be used for packaging purposes.

- Balsam fir. The timber is very similar to spruce in colour and general appearance, but is coarser and less lustrous. There is practically no difference in colour between sapwood and heartwood, but the ends of logs usually show a wide sapwood band and a darker core, although this is not really noticeable once the log is converted. The wood is fairly light in weight, softer than spruce and the timber is easily worked and takes nails well.
- Jack pine. A timber of the hard-pine class, with a sapwood about 40 mm wide, yellowish in colour and a heartwood varying in colour from pale to reddish brown. It is not unlike European redwood (*pinus sylvestris*) in appearance, but is more resinous and coarser in texture. It has similar strength to European redwood and Portuguese maritime pine.
- Black spruce. A slow-growing tree, also known as swamp or water spruce, comparatively small, sometimes no more than 12 m high. It is similar to white spruce in appearance, but heavier, harder and stronger.
- Douglas fir. A strong timber with similar properties to the same species grown in the UK.

- e) Hemlock. Western hemlock is similar to European redwood in strength, but can suffer from splitting when nailed. Eastern hemlock has a tendency to warp and twist during drying and is considerably less strong than western hemlock.
- f) White spruce. The wood is almost white to pale yellowish brown in colour, closely resembling a European whitewood. It is straight-grained, lustrous and slightly resinous. The wood weighs approximately 420 kg/m³ when dried, but, since a proportion of other species might be included in shipments, this weight is conservative and the average weight could be a little higher. It takes nails well. The timber is generally marketed as Canadian spruce and, while the bulk of shipments contain mostly timber of *Picea glauca*, they might contain some red spruce, black spruce and balsam fir.
- g) Red spruce. Similar to white spruce in appearance, but the prominent late wood bands give a more sharply defined annual growth ring and greater density.
- h) Southern pine. A commercial mixture of four species from the southern states of the USA as listed in Table 2, also called southern yellow pine. Each species varies individually from a medium to a high strength.

NOTE Table 2 lists the density values of North American softwoods.

4.2.4.3 Hardwoods

Imported hardwoods are often used for shorter lengths and blocking.

The main species of hardwood are:

- a) ash – black ash is the primary packaging species among the ashes and has good all-round strength properties;
- b) birch – its characteristics are not dissimilar to ash, but paper birch (as packaging grades commonly are) is somewhat weaker; it takes nails well;
- c) maple – for packaging, the variety exported is usually soft or silver maple; its strength is similar to that of many average softwoods. It is easily worked, but slow drying;
- d) poplar – it has low strength properties but is easily nailed. It is of low density and might distort during drying.

Other overseas grown species suitable for packaging are:

- a) kapur/keruing – imported from South-east Asia, these are among the strongest of the species included in this standard. Their availability might be limited because of competition from other end uses. Some resin exudation might occur with keruing, while kapur could promote corrosion of fastenings due to its slightly acidic nature;
- b) radiata pine – the backbone of the southern hemisphere softwood industry in Chile, South Africa and New Zealand, although it is not native to those parts. It is indigenous to only a small area around Monterey in the state of California, USA, where it is also known as insignis or Monterey pine and where it is a relatively unimportant species;
- c) eliottis pine – one of the heavier and stronger of the four species comprising southern yellow pine as commercially grouped and exported by the USA. It is commonly known as slash pine or longleaf pine in the USA. It is included in this section to cover Brazilian eliottis pine. When grown in Brazil, the species is normally plantation grown and, since it grows faster in Brazil than in the USA, it would be expected to be weaker and the existing USA strength data would probably not be relevant.

4.2.5 Special considerations – Nasal or skin irritants

Although dust problems are particularly associated with certain species, it should be noted that airborne wood dust can cause irritation due to its physical characteristics. This is a basic problem which should be dealt with in the same way as dust arising from any material.

Where irritation occurs due to a particular species, it has been shown that, in many instances, it is related to specific chemical constituents in the wood. The response of an individual to a particular irritant species depends entirely on that individual.

NOTE A list of irritant softwood and hardwood species is shown in Annex A.

4.3 Strength of sawn wood and factors affecting strength

4.3.1 General

Manufacturers and specifiers of wood packaging should refer to BS EN 12246 for their sawn timber purchases. Both the aesthetics and the strength of wood play a part in producing acceptable packaging.

There are three factors that should be taken into account at the time of purchase:

- basic strength of a species;
- visual appearance grading; and
- effects of moisture.

4.3.2 Basic strength

4.3.2.1 General

Unlike timber for building purposes, typical sizes of packaging timber cannot be purchased in guaranteed minimum strengths. Relevant mean strengths are listed in Table 3 and $\overline{A_1}$ Tables 4a and 4b $\overline{A_1}$.

The values of bending strength in Table 3 and $\overline{A_1}$ Tables 4a and 4b $\overline{A_1}$ are not working stresses but the mean breaking strengths, which means that, at best, 50% of a given species is likely to be weaker than the listed values, at worst (and in fact in almost every practical usage of the timber), the average strength is likely to be substantially less than given values as the tests are on perfect, defect-free wood specimens. Table 3 and $\overline{A_1}$ Tables 4a and 4b $\overline{A_1}$ are primarily intended for comparison between species and should not be used for design purposes. Table 3 and $\overline{A_1}$ Tables 4a and 4b $\overline{A_1}$ should not be used for basic case and crate design unless safety factors are introduced; such factors typically allow for the weakening incidence of knots, wane and slope of grain.

The main use of Table 3 and $\overline{A_1}$ Tables 4a and 4b $\overline{A_1}$ should be to make valid comparisons between species so that a case manufacturer or specifier can evaluate a species and determine whether special allowances or extra thicknesses should be taken due to it possibly being weaker than a tried-and-tested species.

Table 3 Strength properties of clear ^{A)} softwoods

Standard name	Origin	Botanical name	Moisture content		
			green	20%	12%
			Mean bending strength (N/mm²)		
fir, balsam	Canada	<i>Abies balsamea</i>	43	53.1	74.5
fir, Douglas	Canada	<i>Pseudotsuga menziesii</i>	54	66.6	93
fir, Douglas	UK	<i>Pseudotsuga menziesii</i>	53.1	65.3	91
fir, silver	Central and Southern Europe	<i>Abies alba</i>	41	52.2	77
fir, silver	UK	<i>Abies alba</i>	43	54.3	79
hemlock, western	Alaska to North-western USA	<i>Tsuga heterophyllia</i>	52	66.1	97
larch, Dunkeld	UK	<i>Larix × eurolepis</i>	43	55.3	82.6
larch, European	UK	<i>Laris decidua</i>	53	66.7	96.3
larch, Japanese	UK	<i>Laris kaempferi</i>	48	60	85.6
pine, Corsican	UK	<i>Pinus nigra maritima</i>	41	53.3	81
pine, jack	Eastern Canada	<i>Pinus banksiana</i>	45	57.4	84.7
pine, lodgepole	UK	<i>Pinus contorta</i>	41	54.3	85
pine, maritime	Portugal	<i>Pinus pinaster</i>	47.4	59.8	86.8
pine, maritime	UK	<i>Pinus pinaster</i>	36	48.2	77
pine, radiata	Chile	<i>Pinus radiata</i>	38.1	49	73.2
pine, radiata	Kenya	<i>Pinus radiata</i>	41	54.3	85
pine, radiata	New Zealand	<i>Pinus radiata</i>	38	53.3	91.6
pine, Scots	UK	<i>Pinus sylvestris</i>	46.2	59.4	88.9
pine, yellow	Canada	<i>Pinus strobus</i>	42	53.8	80
redwood	Russia, Finland, Sweden, Poland	<i>Pinus sylvestris</i>	44	57.1	86.5
spruce, black	Eastern Canada	<i>Picea marina</i>	38	48.1	70
spruce, Norway	UK, Republic of Ireland	<i>Picea abies</i>	36	46.7	71
spruce, sitka	Canada	<i>Picea sitchensis</i>	39	49.9	74
spruce, sitka	UK, Republic of Ireland	<i>Picea sitchensis</i>	35	44.9	67
spruce, white	Eastern Canada	<i>Picea glauca</i>	36	40.8	49.7
whitewood	Russia, Finland, Sweden, Poland	<i>Picea abies</i>	39	51.3	79.5

^{A)} Clear means that data are obtained from small specimens of knot-free, straight-grained timber tested in accordance with BS 373. Commercial timber is not likely to be clear and therefore is weaker than the values given.

Table 4a – Strength properties of clear ^{A)} hardwoods ^{A1}

Standard name	Origin	Botanical name	Mean bending strength (N/mm ²)		
			green	20%	12%
ash, European	UK	<i>Fraxinus excelsior</i>	66	82	—
beech, European	UK, Northern and Central Europe	<i>Fagus sylvatica</i>	65	81.8	118
birch	Europe	<i>Betula spp.</i>	63	81	123
elm, Dutch	UK, Europe	<i>Ulmus x hollandica</i>	44	53.7	—
elm, English	UK	<i>Ulmus procera</i>	40	49.1	—
kapur	Sabah	<i>Dryobalanops spp.</i>	81	92.4	—
keruing	Malaysia, Sabah	<i>Dipterocarpus spp.</i>	70	83.3	—
mengkulang	Malaysia, Sabah	<i>Heritiera spp.</i>	81	91.8	—
oak, European	UK	<i>Quercus petraea</i>	59	71.4	126
plane, European	UK	<i>Platanus x hybrida</i>	54	—	—
poplar, Italian black	UK, Europe	<i>Platanus x euramericana</i>	41	50.9	—
poplar, grey	Europe	<i>Populus canescens</i>	44	54.3	—
poplar, Turkish	Southern Europe	<i>Populus euramericana</i>	32	39	—
willow, white	UK	<i>Salix alba</i>	36	44.6	—

^{A)} Clear means that data is obtained from small specimens of knot-free, straight-grained timber tested in accordance with BS 373. Commercial timber is not likely to be clear and therefore is weaker than the values given.

Table 4b – Compression strengths of main species

	Compression strength perpendicular to side grain green wood [over 28% mc] [N/mm ²]	Compression strength perpendicular to side grain dry wood [at 12% mc] [N/mm ²]	Hardness or resistance to indentation on side grain green wood [N]	Hardness or resistance to indentation on side grain dry wood [N]
alder, European	2.83	3.82	2 200	2 940
birch, European	4.81	7.29	3 200	5 470
European redwood, <i>Baltic origin</i>	2.48	4.90	1 960	2 580
European whitewood, <i>Baltic origin</i>	1.86	4.25	1 510	2 140
ash, European	5.64	10.13	4 270	6 140
beech, European	5.64	10.53	4 271	6 410
larch, <i>UK grown</i>	3.15	6.47	2 450	3 650
oak, European	6.19	7.29	4 670	5 470
pine, radiata, <i>New Zealand grown</i>	2.29	3.45	1 820	2 670
pine, maritime, <i>French grown</i>	2.11	3.45	1 690	2 671
pine, Scots, <i>UK grown</i>	2.83	3.88	2 220	2 980
poplar, European black	2.16	3.03	1 730	2 360
spruce, Norway, <i>UK grown</i>	1.74	2.53	1 420	2 000
spruce, Sitka, <i>UK and Irish grown</i>	1.93	2.72	1 560	2 140

NOTE For green wood the correlation coefficient between compression perpendicular to the grain y (N/mm²) and hardness x (N) is 0.907 and the corresponding equation is $y = 0.00137x - 0.207$; at 12% moisture content the figures are 0.902 and $y = 0.00147 \times 1.103$. On the basis of these equations the compression strength perpendicular to the grain (N/mm²) is generally calculated from the hardness (N) force test results thus avoiding a special test. These values were extracted from Building Research Establishment 'Bulletin 50 - The Strength Properties of Timber'. ^(A1)

4.3.2.2 Softwoods

Two sets of bending strength values are given in Tables 3 and 4: the green or fresh cut strength, which applies to most softwood upon assembly, and the 20% strength, which applies to some imported species, such as European redwood or Canadian white spruce, because of their drier state upon import to the UK.

Green moisture content should normally be taken as a level above 28% (fibre saturation point), the point at which a further increase of moisture does not affect wood strength.

After a period in use, most packing case softwood dries to 20% moisture level and strength comparisons should be made at this level.

NOTE Where values for timber tested to BS 373 are not available, species have not been included in Tables 4 and 5.

4.3.2.3 Hardwoods

Hardwoods are used in UK packaging, where compression strength, abrasion resistance and nail-holding strength are of greater importance (blocks, short bearers etc.). The bending strength of packaging grades of hardwoods is far less than given in Table 4, since the wood qualities sold into the packaging market have a large proportion of grain slope, knots and wane.

NOTE 1 Details of the effects these naturally occurring features have upon sawn wood strength are given in BS 4978.

Hardwoods dry more slowly than softwoods and should be used in thicker sections. They remain nearer to the green strength values for much of the lifetime of a typical case and only these values are relevant (see Table 4).

NOTE 2 This might not apply to Far Eastern hardwoods which are imported in a drier state.

4.3.3 Appearance grading

Appearance grading is important in the sale of commercial timber today. This system is not concerned with strength but with outward appearance. For the selection of packaging grades of timber, with the exception of very large cases and crates, there is no alternative, since the stress grading system does not extend down to small sizes (the minimum is 35 mm thick).

Appearance grades are not necessarily inferior to stress grades, e.g. redwood sold as "Scandinavian 5th appearance grade" might be both stronger and more attractive in appearance than redwood sold as "SC1 stress grade".

NOTE Table 5 lists the equivalent appearance grades of wood for packaging.

Table 5 Equivalent appearance grades of wood for packaging

Name	Country of origin	Acceptable packaging grade	Higher packaging grade
Douglas fir-larch	Canada	No. 3 common	No. 2
hem fir	Canada	No. 3 common	No. 2
redwood	Russia, Sweden, Finland, Poland	Russian 5th, Scandinavian 6th	Russian 4th, Scandinavian 5th
spruce-pine-fir ^{A)}	Canada	No. 3 common	No. 2
whitewood	Russia, Sweden, Finland, Poland	Russian 5th, Scandinavian 6th	Russian 4th, Scandinavian 5th

^{A)} Spruce-pine-fir imported from Canada comprises the four major species mixed at random (balsam, fir, jack pine, black and white spruce).

4.4 Basic sizes of sawn softwoods and hardwoods

4.4.1 General

The UK imports timber from many parts of the world in addition to producing its own, which results in a wide choice of species available to the user but, since there is as yet no effective international standardization of sizing, it also results in a relatively wide range of basic sizes.

NOTE BS EN 1313-1 covers the sizes of softwoods available from supplying countries with details of acceptable tolerances and further machining which might be carried out for particular end uses.

Although some logs are still available "in the round", most hardwoods are now imported as sawn sections, cut to specific thicknesses. Parcels of hardwood consist of three product groups:

- a) specified widths, square edged;
- b) random widths, square edged;
- c) random widths, waney edged.

4.4.2 Softwood and hardwood

The methods of measurement of hardwoods are more complex than the measurement of softwood.

Surfaced (planed) softwoods are imported from Canada and the USA known as CLS (Canadian Lumber Standards) or ALS (American Lumber Standards) respectively.

Most hardwoods are imported in specific thicknesses but random widths which are within an agreed and accepted range. They might also be imported as cut-to-size dimension stock or as logs sawn through and through and cut to size on order.

NOTE Through-and-through sawing results in planks of uniform thickness which can be tapered along their length with waney edges.

5 Wood-based sheet materials

5.1 Plywood

Plywood is an ideal packaging material, limited only by its higher cost than sawn wood of the same thickness. It has superior performance under arduous conditions while retaining comparatively high strength/low weight properties.

Plywood for packaging can have three, four, five or seven plies; the larger the number of plies, the higher the quality and the lower the chance of distortion due to moisture, or high load (see 5.3) which can occur in packaging applications.

During manufacture, synthetic resin adhesive should be applied to plywood by roller spreaders, sprayers or coaters and the veneers should be assembled with the grain of each at 90° to the adjacent veneer.

In certain circumstances this practice of bonding at right angles may be varied in order to produce plywood with special characteristics. The resultant assembly is known as a “lay-up”, and is then subjected to pressure and heat.

After cooling, the panels should be trimmed, usually to 2 400 mm × 1 200 mm, although other sizes such as 2 440 mm × 1 220 mm and 1 525 mm × 1 525 mm are available from certain countries.

The international harmonization of plywood specifications has made extremely slow progress over the years and even now a comprehensive international standard does not exist. This is largely due to plywood’s complex mixture of variables including:

- a) adhesive type;
- b) veneer type;
- c) thickness and grade of veneer;
- d) veneer lay-up;
- e) surface finish;
- f) overall panel thickness.

For packaging applications this lack of standardization has had less effect than in industries such as the building industry where requirements can be more specialized.

The critical three variables in packaging are:

- adhesive type (moisture resistance);
- veneer species (avoidance of surface decay);
- overall panel thickness (strength).

5.2 Plywood adhesives

5.2.1 General

The export packer should be aware of the type of adhesive that has been used in plywood manufacture in order to avoid problems with the finished package and because incorrect adhesive can lead to problems with delamination and loss of integrity.

The purchaser should be aware that the selection of an interior grade of adhesive when cases are to be stored externally can lead to delamination.

The purchase of plywood from a source which has not been subject to quality controls should be avoided, since it could result in an inadequate quantity of adhesive or the use of an interior grade of adhesive with no warning of lack of moisture resistance.

5.2.2 Adhesive classification

5.2.2.1 General

The two main types of plywood available are urea formaldehyde bonded and phenol formaldehyde bonded. Phenol formaldehyde bonded should be selected for packaging purposes where enhanced moisture resistance is required.

5.2.2.2 Urea formaldehyde (UF) bonded

This type of bond should be used in moisture resistant (MR) or interior type (INT) plywood.

Moisture-resistant plywoods survive full exposure to weather for limited periods only. They can withstand cold water and hot water for a limited time, but fail when exposed to boiling water.

Interior plywood is strong and durable in dry conditions and resistant to cold water.

5.2.2.3 Phenol formaldehyde (PF) bonded

This type of bond is used in weather- and boil-proof (WBP), Exterior or Exposure 1 type plywoods. PF bonds are highly resistant to weather, micro-organisms, cold and boiling water and both wet and dry heat.

5.2.2.4 Melamine urea formaldehyde (MUF) bonded

A third type of adhesive, urea formaldehyde fortified with melamine and known as MUF, is used in some types of plywood manufactured in the Far East. MUF bonds are more resistant to moisture and weather than UF bonds, but not as resistant as PF ones. MUF is sometimes designated CBR or cyclic boil resistant, which is a grade slightly below WBP.

NOTE Different countries have different designations for the adhesive classes and these might be marked on the face of the plywood.

5.3 Plywood grade and thickness

Short-term strength and water resistance should be the main criteria for design due to the typically short life and lack of need for aesthetics in packing case design.

For most plywoods the visual quality of plywood veneers are characterized by letter designations, e.g. CD Exterior has one side veneer of a higher quality (C) than the other side (D). For wood packaging applications, veneer appearance of C or D should be deemed adequate for most purchasers.

The type of adhesive used (see 5.2.2.2), and whether the veneer characteristics restrict external exposure to weather, should be important considerations for export packers.

The timber veneers of plywood should be durable, and bonded according to the guidance given in 5.2.2.2, 5.2.2.3 and 5.2.2.4. With thinner grades of plywood, the imbalance caused when the outer veneer becomes saturated (thereby expanding) and the inner veneer remains dry can cause an outward bowing of sheathing if not tied at sufficient centres to maintain rigidity.

5.4 Veneer species

There are certain types of degradation which look unattractive, e.g. surface moulds and stains, and certain hardwood plywoods might be particularly badly affected, with moulds occurring within a few weeks in adverse conditions of high humidity.

6 Other wood-based products used in packaging

6.1 General

A growing interest in using timber waste as economically as possible has led to the development of sheet materials of a lower cost than plywood such as fibreboard and wood chipboard. Although these products use wood as the raw material, unlike sawn wood, their quality can be controlled.

NOTE Table 6 lists types of wood-based sheet materials.

6.2 Wood chipboard

Wood chipboard is particle board made exclusively from small particles of wood together with a binder, the particles being larger than in fibreboard and the binder normally being synthetic resin. Boards are available from 3 mm to 50 mm thick and can be of uniform construction through their thickness, of graded density, or of distinct three- or five-layer construction to give enhanced bending strength properties without excessive weight.

Wood chipboard has progressively superseded blockboard and laminboard and uses wood wastes, including forest thinnings, planer shavings and other joinery shop residue.

Wood chipboard in sheet form has a low strength to weight ratio and is difficult to nail due to a combination of high density (500 kg/m³ to 700 kg/m³) and thickness (12 mm to 20 mm) in excess of most fibreboard or plywood.

NOTE 1 The thinner boards are easier to work, but have low impact resistance.

Processed wood should be used for moulded blocks since its performance equals that of most sawn softwoods in terms of fastener retention but exceeds it in terms of dimensional stability under changing humidity.

The wood chips and cutter shavings should be mixed with a glue-wax suspension during manufacture and this mixture should be placed in a mould which is then pressed under high pressure and heated to cure.

NOTE 2 Moulded chipboard distance blocks provide pallet-based case manufacturers with an alternative method of production with more uniform quality. The extremely small dimensional variations facilitate automatic feeding of blocks where this operation is important.

6.3 Flakeboard

6.3.1 General

There are two types of flakeboard: waferboard and orientated strandboard.

6.3.2 Waferboard

Waferboard is a flakeboard made of specially prepared flakes, predominantly from small particles of wood, and a binder. It is normally made from wood wafers or flakes at least 32 mm in length, randomly orientated.

6.3.3 Orientated strandboard (OSB)

OSB is a three-layer flakeboard in which the grain of the flakes in each of the layers is aligned, the orientation in the centre layer being across the board, while the grain of the flakes in the surface layers lies parallel to the long axis of the board. The description orientated structural board is also used for this material.

The method of producing waferboard and orientated strandboard is that used to produce wood chipboard but with some differences, for example only small roundwood logs are used, and wood waste is not.

For this method, the logs should have their bark removed, be cut to length and then should be put into a waferizer which reduces them to wafers (waferboard) or strands (OSB), after which the wafers or strands should be dried. After drying to a moisture content of between 3% and 8%, the majority of fine particles should be removed from the finish. The dry wafers or strands should be stored to await further processing and blended with phenol formaldehyde (PF) adhesive with a proportion of either paraffin slack wax or wax emulsion. A waferboard mat is then formed by random distribution of wafers.

NOTE 1 The mat-forming section of an OSB production line orients the strands of the first layer mainly in one direction. The second layer is then oriented at right angles to the first, and so on. It is the orientation process which gives the panel properties more akin to plywood.

Flakeboards are comparable with, or replacements for, plywood, since their properties and handling qualities are more akin to those of plywood rather than fibreboard or wood chipboard.

NOTE 2 Waferboards are of greater interest to the packing case maker because they tend to be light and easier to nail.

6.4 Fibreboard (fibre building board)

Fibreboard, more correctly termed fibre building board, is defined as sheet material, usually over 1.5 mm thick, made from fibres of ligno-cellulosic material. It is sold as hardboard, medium board and softboard (insulating board). The wet process is the most common technique for manufacturing hardboard, medium board and softboard. Certain packaging applications make use of fibreboard where moisture resistance is not critical. Particular applications are fruit and vegetable trays strengthened by wood battens.

Hardboard and medium board, which are produced between 3.2 mm and 12 mm thick, should be used for packaging applications.

NOTE In packaging, the term "fibreboard" is also used to refer to cases made of solid or corrugated fibreboard.

Solid fibreboard is made from recycled paper and typically is less than 2.5 mm in thickness, while corrugated fibreboard consists of one or more sheets of fluted paper ("fluting") glued to two or more liners. Both solid and corrugated fibreboard can be used in conjunction with wood in some packaging applications and the actual material required should be specified.

Table 6 Types of wood-based sheet materials (1 of 3)

Type	Use	Class and condition	Relevant standards
OSB (orientated strand board)			
EN OSB/1	General purpose boards for interior for use in dry conditions or low relative humidity	Dry conditions or up to 65% RH	BS EN 300
EN OSB/2	Load bearing packing case sheathing and smaller boxes in dry conditions	Load bearing for use in dry conditions or up to 65% RH	BS EN 300
EN OSB/3	Load-bearing Packing case sheathing and smaller boxes for use in short term humid conditions	Exposed with occasional wetting	BS EN 300
EN OSB/4	Heavy duty load-bearing packing case sheathing for use in short-term humid conditions and flat top packing case lids liable to occasional wetting	Heavy duty, exposed with occasional wetting	BS EN 300
Chipboard			
EN Type P1	Standard grade, low strength to weight ratio, general purpose small packaging, poor structurally, for dry interior use	Moisture Class 1	BS EN 312
EN Type P2	Furniture grade with finer surface, still a low strength-weight ratio, dry interior use, not structural	Moisture Class 1	BS EN 312
EN Type P3	Same as P1 and P2 but moisture resistant, uses similar to above low strength-weight ratio, for occasional short term wetting	Moisture Class 2	BS EN 312
EN Type P4	Higher strength-weight ratio, domestic flooring applications so can be used for packing case flooring, shelving and dry interior use	Moisture Class 1	BS EN 312

Table 6 Types of wood-based sheet materials (2 of 3)

Type	Use	Class and condition	Relevant standards
EN Type P5	Moisture resistant, higher strength-weight ratio, resists short-term wetting as case flooring, for use in more humid structural conditions but not long term wetting.	Moisture Class 2	BS EN 312
Plywood			
EN 636 Class 1	General purpose plywood, non-durable large packing case sheathing and smaller boxes	Class 1 – internal – dry conditions	BS EN 636
EN 636 Class 2	Short-term exposure weather resistant plywood for packing case sheathing and smaller boxes	Class 2 – humid conditions with risk of wetting	BS EN 636
EN 636 Class 3	Long-term exposure packing case sheathing, pallet collars, flat-top packing case lids, waterproof glue line but take into account durability of surface veneer species	Class 3 – exterior plywood – moisture level frequently above 20% emc	BS EN 636 and BS EN 314-2:1993, Class 3 for glueline
MDF (medium density fibreboard)			
Type MDF	General purpose sheathing small cases, interior dry use, not structural	EN 622-5 Class 1	BS EN 622-5
Type MDF H	General purpose sheathing small cases, limited humid conditions, not structural	EN 622-5 Very limited wetting Class 1 and 2	BS EN 622-5
Type MDF Exterior	General purpose sheathing small cases, limited exterior conditions but not fully exposed	EN 622-5 Occasional wetting Class 1, 2 and 3	BS EN 622-5
Hardboard			
EN 622-2 Service grade	Thinnest material, limited to lightest duty smaller box sheathing for use in dry conditions	Use in dry conditions	BS EN 622-2
EN 622-2 Standard grade	Slightly stronger duty thin material smaller box sheathing for use in dry conditions	Use in dry conditions	BS EN 622-2

Table 6 Types of wood-based sheet materials (3 of 3)

Type	Use	Class and condition	Relevant standards
EN 622-2 Tempered grade	Strongest hardboard for smaller box sheathing for use in dry conditions	Use in dry conditions	BS EN 622-2
Blockboard and laminboard			
EN 636 Class 2	Short-term exposure weather resistant for packing case sheathing and smaller boxes, often veneered, can also be good structurally if grain direction is allowed for	Class 2	Glueline to BS EN 314-2:1993 Class 2 or 3

7 Moisture in wood and the avoidance of problems in storage and use

7.1 Sawn wood

Before wood is stored or used to construct boxes or cases, a percentage of the water it contains should be removed. The target should be for wood to have 20% moisture content or less. Timber should be dried prior to storage because it can decay if kept at a high moisture content for long periods, and certain species cannot safely be stored even for a few days in the close piling that is normal in packaging timber yards.

The development of unsightly moulds (light surface growths which can be brushed off) or sapstain/bluestain, which penetrates throughout the sapwood causing permanent staining, should be avoided by the following actions.

- Stacking with thin spacers between each board or batten to allow free passage of air and dispersal of humidity until the timber is at, or below, 20% moisture content when close piling under cover creates less risk.
- Kiln drying to 20% moisture content and storing under cover.

Immersion in fungicidal solutions (which provide short-term protection from sapstain and mould) should not be carried out.

Below 20% moisture content, known as the decay safety line, timber is generally safe from discoloration or damage.

NOTE 1 Placing wood packaging in freight containers can present special problems due to high humidity and high temperature. Substantially lower wood moisture contents are needed in such cases.

Timber should be dried to a level appropriate to its end use and all sheet materials should be stored in such a way that moisture ingress is minimal.

NOTE 2 Wood, provided that it is at 20% moisture content or below, can be close piled, but only if protection from rain is available in order to avoid damage caused by increased changes in moisture content.

Softwoods and permeable hardwoods of very low moisture content take up moisture more quickly than the less permeable hardwoods so that storage and temporary exposure to weather should be adjusted accordingly.

NOTE 3 The abbreviation "emc", which stands for equilibrium moisture content, occurs frequently in relation to timber being dried and timber in service.

Wood is hygroscopic, that is, its moisture can change to levels which are related to the temperature and humidity of the surrounding air. An emc value is the moisture content which a piece of timber achieves when exposed for a long period to air at a particular relative humidity (RH) and temperature (although temperature has the lesser effect).

NOTE 4 The approximate relationship between the RH and emc of sawn wood is given in Table 7.

Much packaging timber is machined and assembled at a high moisture content, often at 30% to 40%, but, although this timber is easier to nail and easier to machine at these high moisture contents, shrinkage is more marked than if assembly had taken place at 20%.

When the cell cavities are empty of water, but their walls are still holding water to their maximum capacity, the wood is said to be at fibre saturation point. Water over and above the fibre saturation point level fills, or partially fills, the cavities of the wood fibres. Its removal during the drying of the wet wood reduces only the mass of the wood, not its dimensions. For most common timbers, this fibre saturation point falls between 25% and 30% moisture content. Further drying below fibre saturation point can result in shrinkage as the fibre walls contract. This process happens in reverse if dried wood is put into a wet environment and absorbs water.

7.2 Degradation of wood by corroding metal

7.2.1 General

Wood can corrode metals, but corroding steel also degrades wood. Alkalies produced in the localities of cathodic reactions and iron salts at local anodic areas both cause degradation of wood and loss of wood strength. Iron stains on wood around steel fasteners are produced by interaction between iron salts and tannins and related substances in the wood; they indicate that corrosion and degradation are starting. Iron stains are not always associated with fastenings and new corrosion; they can be caused by traces of iron salts left behind from woodworking and machining operations.

If the wood is always wet, the acid in it, aided by salt if immersion is in seawater, acts as a bulk electrolyte in which various electrochemical cells can be formed, which can be more vigorous than the micro-cells set up in atmospheric corrosion; in particular, the wood can be degraded by alkalies formed at a cathode as well as by iron salts formed at a rusting iron anode.

7.2.2 Oxygen concentration cells

The shank of a fastener inserted into wood becomes starved of oxygen and anodic, and the exposed head becomes cathodic. The cathodic alkali gives negligible protection to the head as it is soon washed away, but could cause alkaline degradation of the wood at the area of emergence.

7.2.3 Other concentration cells

A cell might be set up when a single piece of metal passes through two different woods, caused by differences between the contents of acid, salt and oxygen in the two woods.

7.2.4 Bimetallic corrosion cells

Wet wood, especially salty wood, is an electrolyte, and bimetallic cells are set up between two different metals in contact with one another and embedded in wood.

NOTE A common case is where copper-base fasteners are used to attach wooden planking to a steel framework, where the corrosion of the steel can occur.

The new copper preservative solutions can have this effect too.

7.3 Plywood

Plywood uses identical species to sawn wood, yet, when subjected to moisture changes, plywood's cross-spliced construction provides superior dimensional stability in the plane of the panel. The swelling or shrinkage of wood along the grain with changes in moisture content is small, being only about 1% of that across the grain. In plywood, therefore, the tendency of individual veneers to swell or shrink crosswise is greatly restricted by the relative longitudinal stability of the adjacent plies (veneers). The vastly superior strength of wood along its grain can easily counteract the small forces set up by the wood across its grain due to moisture movement.

Moisture expansion of a plywood panel that is free to move consists of a uniform restrained swelling across the full width or length, and a less restrained swelling at the edges. Edge swelling is independent of panel size, varies with the thickness of veneers having grain perpendicular to the direction of expansion and, for the same veneer thickness, is about twice as great for face plies as for inner plies.

In package assembly, under UK conditions, relative humidity might vary between 30% and 70%, with corresponding moisture contents ranging from 6% to 13%. Total dimensional changes of a 1 200 mm × 2 400 mm standard plywood panel exposed to this change in conditions could be expected to average about 1 mm across the width and 2 mm along the length, showing substantial improvement upon the performance of sawn woods.

7.4 Measurement of moisture content

There are two methods of measuring moisture content in general use. The most common method, using an electrical moisture meter, consists of a non-destructive reading surface which is based upon the fact that the electrical properties of timber vary with its moisture content. This method, covered in BS EN 13183-2, should be used for packaging work. The electric moisture meter gives an instant reading which can be repeated many times with little effort to give an overall picture of moisture content and its distribution.

NOTE 1 A skilled user of a resistive type meter can obtain results within 2% of the true moisture content.

The most common and accurate moisture meters are of the electrical resistance type. These work on the principle that, as the moisture content of a piece of timber increases, its electrical resistance decreases; conversely, timber with a low moisture content has a high resistance.

Conductivity should be measured between two pin-like electrodes which are pushed or hammered into the timber to be tested. Corrections should be applied with varying species to improve the accuracy of the results.

NOTE 2 The portability of these battery-powered instruments is also a major advantage and moisture meters have gained wide acceptance in determining moisture content during the processing, storage, transportation, installation and in-service checking of timber and timber products.

The range over which the better meters are accurate is 9% to 28%, but the meter should be periodically calibrated to traceable standards.

It should be noted that the readings given by moisture meters are sometimes influenced by the presence of salts such as those from waterborne preservatives, e.g. the very common copper-based preservatives, and from contamination by sea water. Such salts increase the conductivity of the wood, particularly at higher moisture contents, and give falsely high readings of moisture content. The magnitude of this effect is variable and it is not possible to correct the readings, but when the presence of salts is suspected, higher than expected moisture readings should be examined further, e.g. by the use of a hammer electrode with insulated pin shanks.

NOTE 3 The alternative method of measuring moisture content, the oven drying method, is destructive in that it involves taking the piece of timber (or a sample of it), weighing it to determine the mass of wood plus the water it contains, drying it to obtain the dry mass and using the formula given in BS 373 to calculate the moisture content.

When measuring plywood with an electric meter, it should be regarded as a separate material and not treated merely as the timber species from which it is made. The moisture content readings obtained with a resistance-type meter on plywood are often misleading and they should not be regarded with confidence, since the presence of soluble chemicals in the gluelines of certain types of plywood affects the reading obtained.

Resistance-type meters might, in extreme cases, indicate moisture values of approximately double those obtained by the more accurate oven drying methods.

NOTE 4 BS EN 13183-3 covers a third method of measurement. However, tests against the most accurate oven-drying method show that this is the less accurate the resistive meters covered in BS EN 13183-2.

7.5 Kiln-dried timber – Problems with development of moulds after drying

Kiln-dried softwood pallet boards occasionally present problems because after a few weeks in stock or in use they can develop a white/grey mould. The moisture content they were dried to is critical to prevent this from happening, e.g. 20% moisture content is known as the “decay safety limit” and any timber above this level should be considered at risk.

The purchaser should specify that timber should be kilned to 20% or less and users should check the wood with a moisture meter on arrival.

Freshly felled softwood straight from the sawmill might have from 35% up to 60% moisture content. The amount of water in the wood depends on time of year, species, time at the sawmill, etc. Pallet and box makers accept timber with 25% to 30% moisture on delivery.

Kiln-dried pallet wood from suppliers can have a moisture content of 24% (still quite wet) down to a very dry 12% for pallets for the paper industry. To kiln dry thin pallet boards to a low level takes between 15 h and 60 h in a drying kiln, depending on their wetness, thickness of the boards, their species and the drying temperature and humidity in the kiln.

NOTE 1 “Kiln dried” does not automatically mean that wood is very dry, for example fencing makers routinely ask sawmills to kiln their wood down to 27–28% because it is ideal for chemical pressure treatment.

Any commercial order for kiln-dried wood should always state the required moisture content.

NOTE 2 A range of 15–18% contains a good margin of error in order to stay below the “decay safety limit”.

On delivery, a few boards should be measured for moisture content using a moisture meter.

There are several reasons why white or grey moulds or bluestain can start on clean and apparently dry boards.

- a) The moisture content in some of the timber might be above the decay safety limit of 20%.
- b) There might be lack of air movement in a closed, unheated store.

NOTE 3 A lower store temperature at night or over the weekend without good ventilation can automatically raise RH. Normal indoor RH values are between 30% and 55%. Values above 70% RH could be the cause of the problem.

- c) Airborne spores settling on apparently dry boards.

NOTE 4 A high relative humidity can be measured with a battery-operated hygrometer. The right type can measure in seconds, though some models take several minutes to obtain an accurate reading.

7.6 The causes of bluestain in packaging timber

7.6.1 General

Bluestain (also called sapstain) is a discolouration of timber caused by deeply penetrating fungi that have dark coloured threads (hyphae). Bluestain varies in colour but is usually greyish blue in appearance. Bluestain is permanent and, due to its depth of penetration, cannot be cleaned off, thus giving rise to customer complaints.

Staining does not only affect the surface but can also penetrate throughout the entire depth of sapwood, showing up as staining on the side or as end grain.

In certain species, sapstain can also invade the heartwood.

7.6.2 Free or restricted ventilation

Timber should be dried to 20% moisture content using either air or kiln drying to prevent discolouration damage and it should then stored under well-ventilated cover to protect it from rain. If not freely ventilated, the timber needs to be dried to the levels given in Table 7 in order to protect from mould and stain.

Table 7 Wood equilibrium moisture content (emc) in humid air

Degrees C	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°
RH%										
30%	6.3	6.3	6.3	6.3	6.2	6.1	6.0	5.9	5.7	5.6
35%	7.1	7.1	7.1	7.0	7.0	6.9	6.7	6.6	6.4	6.3
40%	7.9	7.9	7.9	7.8	7.7	7.6	7.5	7.3	7.2	7.0
45%	8.7	8.7	8.7	8.6	8.5	8.4	8.2	8.0	7.9	7.7
50%	9.5	9.5	9.5	9.4	9.3	9.1	9.0	8.8	8.6	8.4
55%	10.4	10.4	10.3	10.2	10.1	10.0	9.8	9.6	9.4	9.1
60%	11.3	11.3	11.2	11.1	11.0	10.8	10.6	10.4	10.2	10.0
62%	11.7	11.7	11.6	11.5	11.4	11.2	11.0	10.8	10.6	10.3
65%	12.4	12.3	12.3	12.2	12.0	11.8	11.6	11.4	11.1	10.9
67%	12.8	12.8	12.7	12.6	12.4	12.2	12.0	11.8	11.5	11.3
70%	13.6	13.5	13.4	13.3	13.1	12.9	12.7	12.5	12.2	11.9
72%	14.1	14.0	13.9	13.8	13.6	13.4	13.2	12.9	12.7	12.4
75%	14.9	14.9	14.8	14.6	14.5	14.2	14.0	13.7	13.4	13.1
77%	15.5	15.5	15.4	15.2	15.1	14.8	14.6	14.3	14.0	13.7
80%	16.5	16.5	16.4	16.2	16.0	15.8	15.6	15.3	15.0	14.6
85%	18.5	18.5	18.4	18.2	18.0	17.8	17.5	17.2	16.9	16.5
90%	21.0	21.0	20.9	20.7	20.5	20.3	20.0	19.7	19.3	19.0
95%	24.4	24.4	24.3	21.1	24.0	23.7	23.4	23.1	22.7	22.3
98%	26.9	27.0	26.9	26.8	26.7	26.4	26.1	25.8	25.5	25.1

NOTE 1 Units: relative humidity percentage (RH%) versus Degrees Centigrade (°C) yielding wood equilibrium moisture content percentage (emc%).

NOTE 2 Example: a relative humidity of 60% at 20 °C results in an emc in wood of 11%.

7.6.3 Wet timber

While the fungi responsible for bluestain are not the same as those which produce fungal decay, the conditions which favour development of bluestain also favour the eventual onset of more serious fungal decay, although this takes longer to occur depending on species and conditions. Most species of wood used for pallets and packing cases in Europe are classed as perishable or non-durable.

Timber should not be left wet in poorly drained or ventilated storage or to gain water outdoors. It should not rise to a moisture level above 20% for more than a month or two or else, in addition to sapstain, irreversible decay is likely to start.

NOTE 1 This period depends on ambient temperature and the durability of the species.

NOTE 2 In the early stages bluestain does not affect timber strength.

Decay progressively reduces wood strength and should be avoided.

All the wood components for pallet and boxes should be structurally sound in order to remain safe in use.

7.7 Shrinkage and distortion of sawn timber

7.7.1 General

There are two interrelated problems associated with putting sawn timber into service at a higher moisture content than its eventual emc: shrinkage and distortion.

7.7.2 Shrinkage

If a piece of timber at 25% moisture content is put into a 13% emc environment, it can be expected to shrink at least 3% tangentially and 1.5% radially, or 2.25% on average. Although this is not much on a 25 mm × 25 mm batten, it represents a 3 mm gap on a 150 mm sheathing board.

It is unrealistic to apply high precision to matters involving moisture content and shrinkage, but a severe mismatch between the moisture content at the supply, manufacturing and end use stages can lead to serious problems.

7.7.3 Distortion

Radial shrinkage is only half tangential shrinkage and, since the grain of a piece of timber rarely runs parallel to its edge, this means that, in practice, large changes of moisture content can be accompanied by distortion. This could result in the bowing or twisting of battens or cupping of cladding boards.

NOTE 1 Figure 1 shows characteristic (though exaggerated) shrinkage even when the grain runs perfectly parallel.

Distortion should only be removed by machining, prior to assembly, but this involves considerable cost.

If in a particular design of case no shrinkage gaps should appear during transportation or end user storage, the moisture content of the timber sheathing should be reduced to a few percentage points above the expected emc.

NOTE 2 For example, drying from 40% to 18% would satisfy the most rigorous requirement.

Although the effect of drying is to increase the strength of the timber itself, the effect on nailed joints is often the reverse. This is because the initial high friction between the members of a joint created by the high-speed application of nails is gradually lost as the member components shrink away from each other during drying.

The strongest joints are those made when the timber is dried to, or very near to, the emc before assembly. The effect of drying is to increase the withdrawal resistance of individual nails, which, of course, is the reverse of the effect on the total joint.

The following single rule can be applied in relation to the effect of drying on joint strength.

- a) For joints in shear, a lowering of strength could result.
- b) For joints in tension, a raising of strength could result.

NOTE 3 Species vary considerably in their tendency to distort.

NOTE 4 Table 8 gives some examples of large and small movement timbers.

NOTE 5 A number of species have not been evaluated yet.