OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

D01915

United Nations Industrial Development Organization

Distr.
LIMITED
ID/WG.83/7
17 November 1970
ORIGINAL: ENGLISH

Expert Working Group Meeting
on the Production of Panels
from Agricultural Wastes

Vienna, Austria, 14 - 18 December 1970

STANDARDS AND QUALITY CONTROL FOR PANELS MADE FROM AGRICULTURAL WASTES [1]

by
H. Neusser
Austrian Wood Research Institute
Vienna, Austria

[1] The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.70-6294

Distr.
LIMITED
ID/WG.83/7 SUMMARY
11 November 1970
ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Expert Working Group Meeting
on the Production of Panels
from Agricultural Wastes

Vienna, Austria, 14 - 18 December 1970

SUMMARY

STANDARDS AND QUALITY CONTROL FOR PANELS MADE FROM AGRICULTURAL WASTES[1]

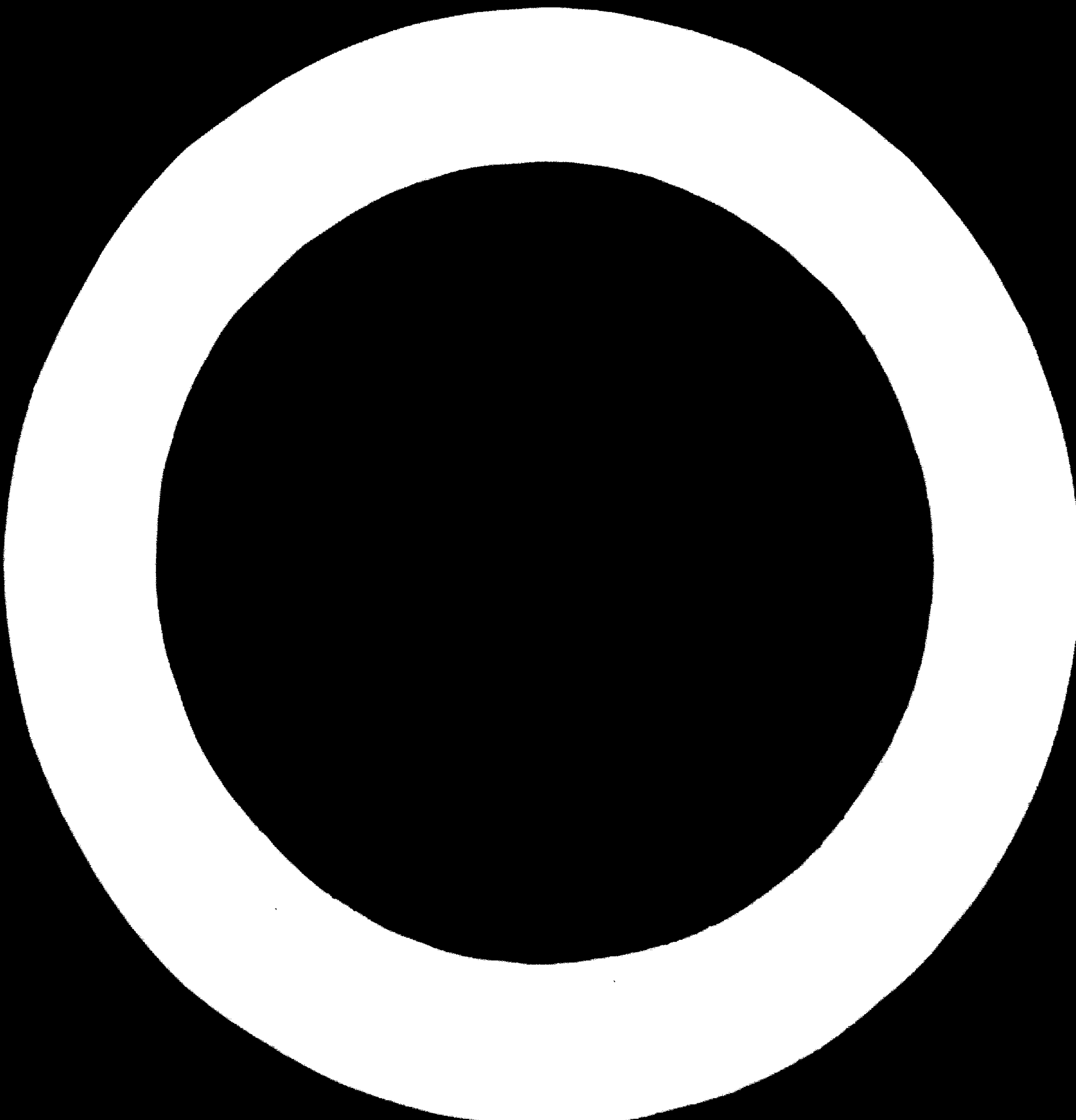
by

H. Neusser
Austrian Wood Research Institute
Vienna, Austria

In comparison with conventional (wood) materials, several particular rules have to be followed in processing agricultural wastes into building materials for interior and exterior use. First of all, the sizes of the available particles are important. Particles must be sorted and/or shredded to produce uniform particle material in order to manufacture products of larger dimensions economically. In surveying the not very ample literature in the field of annual plants, one notes the extraordinarily high harvest yields of these raw materials. Solely regarding the most important species of annual plants, this yield is calculated at 2.5 times as high as the harvest of wood fibres in the entire world. One also notes some particular properties of the annual plants which represent the main reasons why they are not yet much utilized. Besides the difficulties of transport and storage, it must be mentioned first of all that each kind of raw material

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.70-6200



and final product needs a specific processing method in order to attain the usual property limits. Based on the publications available, there is considerable evidence that this scope may be achieved. In each case it has to be determined whether the necessary investments and production costs may be kept to a level which enable agricultural wastes to compete with raw materials already used in the past.

It must not be overlooked that the available machinery and equipment has been developed especially for the conventional (wood) raw materials and that the products manufactured up till now have their own special market. Any new products must either put up with the situation or pioneer new markets. Technicians and managers must investigate the marketing conditions and produce the appropriate products according to a constant quality. From this point of view limit values cannot be rigidly adhered to.

The standards used in industrial countries should serve as a starting point. In order to make up for possible higher costs of processing raw materials which have not been utilized up till now, the limits of one property, which is of minor importance, may be lowered by about 30 %, leaving the limits of the other properties constant, or all property limits may be lowered by 10 %. To risk more than this appears to be too dangerous. Undoubtedly, the higher any commercial risk is, the more stress must be put on controls of the raw material, of the production process and of the final product.

In order not to make this article too long, and because of the great variety of botanical, climatical and technological conditions, the points to which attention has to be paid can be mentioned only briefly. First of all, the properties of the raw material during storage and during the production stage have to be taken into account, as well as the properties of the final product. Furthermore, the energy input, the amount of wages, and respectively of working hours, the service life of the tools and the yield all have to be controlled. Production control is expensive, but if it is done properly and if it is understood well, it at least pays back its costs or increases the profitability of the factories.

It is essential for production control to have the necessary equipment for testing and a well educated personnel, to use suitable testing methods and quality limits, which are reasonable from the economical point of view..

If hitherto unutilised raw materials is to be processed, it must be considered that results obtained by laboratory scale tests might not be directly applicable on a commercial scale, due to the different dimensions of the products. Before large investments are made, test results have to be checked by plant tests on a commercial production scale. This is necessary even if for this purpose great volumes of raw materials must be transported long distances.

Research on products obtained by these tests nevertheless exceeds the field of usual production control or of standardization.

In the building industry and in interior designing, architects tend to use elements which have large surface areas. Among other materials, boards from wood are used to a considerable extent. However, wood is not available everywhere in the desired quantity or quality. For this reason the use of agricultural wastes as raw materials began to be of interest a considerable time ago. In the meantime, a large number of suitable basic materials for the manufacture of boards became known, for instance: bagasse, cotton stems, hemp, flax shives, jute stems, kenaf, straw, reeds, bamboo, date palm wastes, coconut husks, maize cobs, coffee husk, groundnut shells, cashew nut shells, esparto grass, rice husks, rubber tree fibres, etc. There are several requirements for the use of such raw materials:

(i) they must be available in the immediate vicinity of the board plant, since they are bulky and otherwise high transportation costs would result;

(ii) they must be storable throughout the year without requiring too expensive preventive measures against rot;

(iii) the costs for storage and preparation should not be too high;

(iv) it must be possible to manufacture boards having the necessary properties for use in construction and interior decoration in buildings, for vehicle finishings, for packaging, etc. The distribution system must be well organised, including a sufficient storage of stock;

(v) the material involved must not cause any danger to human life, animals or plants in the proximity of the factory.

Agricultural wastes are usually available in the form of irregular pieces: usually small branches, stems, etc. Thus the only way to utilise them is to break them down and to shred them to a suitable particle size from which to form products of larger dimensions. Consequently, only some specialised products may be manufactured. These are listed in the following table according to the sizes of their contributing particles

from stalks:	braided, glued or bonded mats or boards;
from chips:	particleboards with synthetic resin bond, either flat-pressed, extruded or formed, boards and bricks bonded with concrete, shaken or pressed;
from fibres:	fibreboards flat-pressed or formed in the dry-process, bonded with synthetic resin, in the wet process, manufactured with or without synthetic resin bond.

In order to produce economically, the manufacture of such products requires more or less large equipment, which makes high investments necessary. The principle task of quality control is to ensure a minimum of delays or stoppages in production - since every wasted minute costs money - and to maintain a reasonable quality in order to keep customers satisfied. To achieve these ends, knowledge of the properties of the raw material, familiarity with the energy input, with the rate of wages per hour of production, with the service life of the tools, with the yield, etc. is imperative, and this information must be applied in relation to the quality of the final product. Often, senior personnel of a factory object to this extra work because they only consider the additional costs. In fact production control pays back and provides advantages, provided control is carried out properly and the advantages recognized and utilized. Last but not least, quality control should result in a small range of tolerance for the quality of the final product. By means of this, it becomes possible for instance to export the product or substitute imports. In cases where it seems advantageous for example for usages of minor importance, quality and price may be lowered to suit the intended purpose of the material. All these considerations are necessary, in every country and with every degree of industrialization. Production may be governed by either one of the following principles:

(i) either you produce without any proper production control, you select a quality high enough not to drop under the necessary quality standards, even if the quality decreases considerably. This method is expensive, because most of the time you produce a quality higher than that asked for. Further, this method does not keep customer's complaints at bay, because the customers get used to the unnecessarily high quality and object to any decrease in quality, even if the agreed quality limits are not violated;

(ii) or on the other hand you produce goods subjected to sufficiently accurate quality control and classify the final product into various categories which correspond to the principal usage requirements of the product, but which need not necessarily be of very high quality. Also in this case the customer gets used to the average properties of the material, and does not complain if small variations of quality occur, even if they are near the lower limit of the quality range. The most disadvantageous case for the producer is that such a product might eventually be unsuitable for some particular purpose because of too low a quality.

The importance of wood based panel products, to which in this regard the boards from agricultural wastes may be added, has increased extraordinarily during the last few decades. Thus in many countries national standards have existed for a considerable time. Within the International Organization for Standardization, the Technical Committee (ISO/TC 89) was formed, whose terms of reference are as follows:

Derived Timber Products

(Boards made from wood or other ligno-cellulose fibrous materials)

Standardization of fibre building boards, particle boards, plywood and block boards and other similar board products, either flat or moulded made from wood of ligno-cellulose fibrous materials including nomenclature specifications and test methods.

At this time the committee was subdivided into three subcommittees, these were SC 1 Fibreboards, SC 2 Particleboards and SC 3 Plywood. With regard to this paper, the work of SC 1 and SC 2 is interesting. It seems that mineral bonded boards made of ligneous fibres, chips or other particles are not yet classified by ISO. Presumambly ISO/TC 59 (Building construction) should deal with the same. The necessity to find internationally acceptable agreements is the reason why ISO-recommendations can be published only after discussing them over long periods of time. Thus it is necessary to use the national standards, which do not yet correspond to international requirements. Where no national standards exist, each factory has to make its own standards. The latter are necessary even in addition to any official standards that might exist, because the properties of the products still vary with the manufacturing process, for instance with regard to moisture content, moisture distribution, strength, behaviour when wetted, etc., facts which are true also in case of the agricultural wastes.

Since large quantities and hence high values are leaving the production line every hour, any drop in quality must therefore be determined immediately and corrected instantly. This is possible only if:

(i) simple and effective control methods are used;

(ii) the relation between the properties immediately after leaving the production line and after storage are known, and if all data obtained may currently be used in a control scheme which enables the senior personnel to make the necessary checks at any time.

The control of the raw material, of the production and of the final product form one unit. The development of new products and the after-sales service for the products have to be done separately. Such problems may not be within the scope of this paper, as it is not our intention to answer the question of how far a factory should enter into basic or technical research, both using the same methods of examination as for production control. The choice of the acceptable limits is discussed on page 26 of this paper.

The agricultural raw materials known now or that could even ually be introduced into board production in the future are available only during limited periods of the year, but in great bulk only at their harvesting times. Supplies must be stored all the year round and must be used up gradually. The problems involved herewith can only be referred to briefly in relation to the different botanical, climatical and technological conditions.

1. <u>Properties of the raw material during storage</u>

Technical properties:	Particle size (coarse and fine, separating effect); bulk weight (loose or in bales); moisture content (undried or dried, under coverings or spread in the open); mineral pollutions (content of sand or soil, especially in the lower lying areas of the storage space); botanical contamination (leaves, weeds).
Botanical-morphological properties:	Increased amount of parenchym tissue, fibrous admixtures to chips (for example flax fibres to flax chips), difference between the densitites of individual particles, unthreshed seeds (corn, maize), blends of related raw materials (rye, wheat, straw from barley and oats).
Extractives:	Ash content (silica in particular), resin and/or fat content, amount of starch and/or sugar, amount of albumen, of tannic acid, etc.

Resistance against attack by vermin and fire: Preserving measures and their efficiency.

2. Testing the raw material during the production stage

Control of production data;
Control of service life of tools;
Control of energy input;
Control of the percentage breakdown of particle sizes (coarse and fines);
Control of the blend ratio of raw materials and additives;
Control of the air exhaust containing fines and poisonous substances;
Control of the waste water (solubles may cause rot, chemical reagents may pollute the water supply).

3. Testing the additives

Control of the glues (solids content, viscosity, gelation time, respectively curing time of resins for particleboards, etc., precipitability of resins for fibreboards);
Control of the hardener with respect to its concentration and reactivity in the production of particleboard;
Control of the precipitants in the manufacture of fibreboard;
Control of the hydrophobic agents;
Control of the fresh water with respect to purity and hardening agents;
Control of added preservatives (if any) against vermin attack;
Control of other additives.

4. Testing the final products

In industry, executives ought to know that control of production and control of the quality of the final product are valuable auxiliary means of management. Furthermore it is imperative that these controls be carried out according to the laws of statistics and that an unacceptably low quality should not be hidden in a product by modifying testing procedures without justification. The methods of production control - in which the producer is interested - depend on the product. The producer as well as the customer should be interested likewise in the control of the final product. The methods of control of the final product do not only depend on the product, but also on the usual conventions of the individual countries. Depending on the property to be tested and on the tester, the following kinds of control are employed:

(a) The 100 % control. This is only applicable for non-destructive tests. There are for instance: the sorting of boards into quality classes; the stress-grading of lumber; the test for modulus of elasticity of the variations of thickness of entire boards, tested in series, etc.;

(b) Control by means of samples taken at random. This method is used for destructive tests, where usually test specimens are needed, for example for determining the moisture content, the bending strenth, the internal bond, the thickness swelling, etc. In order to keep the risk of a complaint to a minimum for the producer and the risk of a disadvantageous purchase to a minimum for the customer, the number of samples necessary depends on the amount delivered. There are different schemes for selecting samples at random, but here only one shall be mentioned, which has been worked out by the University of Columbia a considerable time ago for testing military equipment. Based on this scheme, another one is at present being developed by ISO/TC 89, especially for wood-based panel products. If it must be assumed that the producer does not use vigorous production control methods, representative sampling considerably wastes material and time;

(c) The quality seal. In this case it is assumed, that production control, including data evaluation, is carried out in the plant and that a specific official association, which controls quality in order to seal the products, only acts as an official checking agent. For example, in the Federal Republic of Germany an association exists for the control of the quality seal. It is agreed that in order to obtain and to keep the quality seal, the producer has to take, each day and from each type of board one board whose properties are tested according to DIN 68 761 (Holsspanplatten) and the results are evaluated from time to time, the evaluation being repeated for the different thickness of boards. Every six months a control officer takes at random three boards of the same thickness for checking and has them tested in an authorised institute. The regulations for introducing or deleting a quality seal are agreed on separately. If a product shows the quality seal, each board must be marked with the same, and sampling and testing by the customer is unnecessary.

For products which are composed of a number of wood-based panel products, for example furniture or prefabricated houses, it is required, that each product used is marked with the quality seal. Thus only the quality of the design and of the workmanship remains to be examined.

Since every form of control is expensive, controls must be kept to a minimum. Only those properties should be tested, which are a good measure of quality and which may be tested by simple, accurate and reliable methods. For this purpose use has to be made of recommendations of international standards, such as ISO, CEN[1], COPANT[2], etc. or of existing national standards, in the case of exports, of the standards of the receiving country. Basically with regard to wood-based panel products one has to distinguish between quality standards, testing standards and dimension standards. The first two indicate the limit values which a product has to show, the third one indicates by which testing methods the properties of a product must be determined.

At the present time, we at the Austrian Wood Research Institute are attempting to collect a list of standards which is to be as complete as possible, dealing with both wood and wood-based panel products, including those made from annual plant wastes. In this study related fields are included. At the present stage of this work - the standards of several important countries are still being investigated - the following report may be given. Until now we have found approximately:

130 standards for fibreboards in 24 countries;
60 standards for particleboards in 18 countries;
15 standards for mineral bonded products in 6 countries;
5 standards for mats and boards made from reeds, straw, etc. in 4 countries.

It is very difficult to make a complete list of standards because of the current new publications of standards and new agreements. Especially for mineral bonded boards and blocks, and for mats and boards from reeds, straw, etc. difficulties arise because these products are usually not covered by separate standards, but are included in bulky standards dealing with building

---

1/ CEN (Comité européen de normalisation)
2/ COPANT (Pan American Standards Comission)

materials in general. One can determine in which countries standards exist for testing special properties as for example resistance to nail and screw withdrawal, surface quality, dimensional stability, etc. exist in order to use them for production control or as a basis for further work in the field of standardization. Studying the list of standards one notices that in general the testing standards of most of the countries are confined to the determination of the same properties. But the limiting values for the quality standards show noticeable differences. The working groups of ISO/TC 89 are trying to eliminate these differences. This work has already proceeded well, so that within the next year new recommendations may be issued. However, these recommendations have to be incorporated into the national standards in order to put them into practice. In this regard it has to be mentioned that in different countries the law deals differently with standards. It is always advantageous to cite the standards in a commercial contract and to point out any special agreements deviating from them.

In most of the cases quality standards are formulated in such a way that they are either valid for general purposes and/or for building purposes. In this way a wide range of applications of the standard is possible on the one hand, on the other hand the quality limits must be set high enough to avoid severe mishaps in use. Thus it may happen that in some fields of application some properties of the boards are of a considerable and unnecessarily high quality, which increases costs. If within such fields of application large quantities of a product are used, it appears to be advantageous to establish special limiting values for this purpose, which would facilitate the utilisation of new raw materials, for example of agricultural wastes. Basically such considerations should be related to those quality limits which have been successful in industrial countries for decades and they should not be lowered more than 30 %. In a general standard or a standard for the building industry, only typical products may be included, for clearness. Special products should be excluded or dealt with only in special standards. Special products are:

(a) Products for unusual applications, with intentionally selected qualities and quality limits other than the usual standards. A typical example can be found in the different grades of plywood; for example plywood for furniture, for boats, for aircraft, etc. In order to mention further examples, boards for underflooring may have a lower bending strength while boards which are not intended to be wetted may have a higher thickness swelling, etc.

(b) Products containing additives which cause a considerable variation of one or more of the standardized properties. A flame-resistant treated board, the strength of which is reduced by the preservative cannot be compared with the requirements pointed out by a general standard. If it is possible by means of special processing to raise the bending strength again to the usual value, the board may correspond to the standard, but shows additionally the favourable property of being flame-resistant.

(c) Products with exceptional structure, moulded or profiled, machined, or treated in any way subsequent to production, etc. Examples of this are sandwich boards, moulded parts made of fibres or particles, prime coated, lacquered or overlaid boards, trimmed boards with commercially unusual dimensions, boards with profiled edges. If such products are manufactured in large quantities, as for example particle boards and fibreboards overlaid with synthetic resin impregnated paper, it is advantageous to agree to a special standard for these products. Such a standard should deal with the properties of the board as well as with the properties of the overlay.

A control scheme or a standard should cover all important properties of a material. Unfortunately this is not possible in every case, because the abovementioned simple and reliable test methods are not available in all cases. Further, there are properties which may be described easily in words, but which cannot be characterised easily by figures. An example for this is the surface quality, which is a complicated technological problem. Despite these difficulties, an attempt has been made to list groups of properties. All data obtained during control testing must be evaluated, resulting in an average figure and in an analysis of variance. This data must be compared with the theoretical optimum values.

Dimensions:	Length, width, thickness, if products have cavities, the dimensions of the same, if products have laminated structure, the individual thickness of the layers;
Weight:	Total weight, weight per unit of surface area, density with or without eventual cavities;

Shape:	Shape of the surface, deviations from the shape, stability of the shape under different conditions;
Moisture:	Moisture content on delivery, when being tested, and in service;
Strength:	Bending strength, modulus of elasticity, tensile strength, internal bond, compression strength (parallel and perpendicular to the surface of the boards), impression strength (force applied pointwise or over given surface), hardness, impact strength, penetration strength, resistance to nail and screw withdrawal, etc.
Behaviour when wetted:	Thickness swelling, longitudinal swelling, swelling in boiling water, water retention, etc.;
Surface quality:	Density of the surface, strength of the surface, corrugations, etc.;
Workability:	Machinability, paintability, tool wear, etc.;
Durability:	Creep of building parts under load, wheathering behaviour, resistance against fungal attack, bacteria, insects, and rodents, fire resistance.

Subsequently an attempt has been made to define quality requirements for some important products for which alternatively also annual plants might be used as raw materials.

4.1 Glued mats and boards made from stalks

Besides reeds, bamboo, papyrus, straw and similar plants may also be used, provided the stalks have the necessary length. At this time in Austria only the use of reeds (Phragmites communis) is permitted by the relevant standards. Reeds are harvested in winter, after having dried out entirely. The stalks must be healthy, ripe, straight and free from roots and leaves. If squeezed, the stalks must give a clear sound, cracks must be situated lengthwise only. Reeds which crack across the longitudinal axis, and which are dark-coloured on the cross-section are rotten and useless. The diameter of the stalks is as much as 5 - 12 mm. The reeds are sorted and delivered in bundles of 1 - 2.5 metres in length (the circumference of the bundle is as much as 30 centimetres at the lower end). If the reeds are delivered unsorted, they are usually not free from leaves, but most curved and broken stalks have been removed. For making mats or boards, the reeds must be a little longer than the width of the product, because of trimming waste. Gluing depends on the final utilisation of the mats or boards. Three products are made from reeds:

Thin reed mats: These are made from one layer of 50 to 100 stalks per meter, depending on the desired spaces between the individual stalks. They are usually bound with galvanised iron wire, but other bonds may also be advantageous. The master wire has a diameter of 0.8 mm, the binding wire 0.4 mm. The weight per unit of surface of the mats is as much as 0,5 - 1,0 kg/m^2. These mats are used in the building industry to hold mortar to walls, as curtains on building scaffoldings, for concealing interspace elements on fences, as shadow roofs for livestock, for increasing the strength of dikes, etc. The necessary properties are: light colour, easy handling, high compression strength perpendicular to the mat, stiffness across the mat (parallel to the stalks), flexibility along the mat (perpendicular to the stalks), resistance against rot.

Thick reed mats: (For example for horticultural uses). Made from bundles of stalks and bonded with sisal or plastic rope. The mats are 10 - 12 m long, about 15 mm thick, rigid against vertical pressure on the mat, stiff across the mat, and flexible across the length of the mat. All requirements are as for the above mentioned one-layer reed mats. Weight per unit 2 - 3 kg/m^2. These mats are used as covers over garden-beds for protection against low temperatures, as anti-noise covers for floors, etc. The thinner the stalks, the higher the protective effect of the mats.

Boards for buidling uses: Made from bundles of stalks, bonded with galvanised iron wire, the diameter of the master wires being 1.8 mm, of the bonding wires 1.4 mm. The boards must be stiff enough to remain even, in spite of handling. Density about 200 kg/m^3. Other requirements as for the mats mentioned above.

Standard measurements in Austria:

Panel thickness (from wire to wire along edges) 20, 30, or 50 mm, tolerance minus 1 mm, plus without limits.

The length of the boards (in the direction or production, across the stalks) 2,000 mm ± 2 %.

The width of the boards (against the direction of production, parallel to the stalks) 1,000 mm ± 2 %.

Dynamic stiffnes 2.3 kg/cm[3].

4.2 <u>Glued boards from stalks</u>

Healthy stalks are cemented to form blocks. The blocks are cut into slabs across the stalks. The slabs are used as the central layer for sandwich boards. The type of glue to be used depends on the intended end-use. The glue bond between the central layer and the outer sheets must be sufficiently strong.

4.3 <u>Herbal insulating materials for building</u>

Coconut fibres, seaweed (sestera marina), wood fibres, peat fibres, etc. are used for:

mats with unbonded fibres, glued or sewn together and faced either on one or on both sides with paper;

felts with bonded fibres without paper faces;

boards with bonded fibres without paper faces.

The requirements mentioned below must be fulfilled both by mats and boards from stalks, by insulation boards, by particle boards of low density, etc. in the case of the same end-uses.

Insulating fibrous material must be free from coarse particles, of equal thickness and density, and show straight and parallel edges.

Dimensions:	rolls	-	width	1,000 mm ± 2%
	boards	-	length	1,000 mm ± 2%
	boards	-	width	500 mm ± 2%
	nominal thickness 1/		5 - 20 mm	
			25 - 50 mm	
	allowance -1 mm, above without limits			
			-5 %, above without limits	

1/ under a load of 0.001 kp/cm²

	Thickness under the floating[2]		
	deviations from the guaranteed thickness		
	8 mm	allowance	-1 mm, + 2 mm
	8 mm		-1 mm, + 3 mm
Density:	at a load of 0.001 kp/cm^2		resp. 0.02 kp/cm^2
		30 kp/cm^3	200 kp/cm^3
Strength:	tensile strength		0.1 kp/m^3
	elongation in tension[3]		100 mm
Dynamic stiffness of pulp group	I		3 kp/cm^3
	II		12 kg/cm^3

4.4 Light building boards made from wood wool and similar raw materials

The wood wool must be sound, long-fibred and shaved longitudinally. In Europe mainly spruce (Picea excelsa) is used; it has given good results. Other species may be used as well, but their suitability must be investigated prior to use. They should show a great capillary activity and should have a low extractive content, in order to have good reception properties if it is to be "mineralized". For bonding, caustic burnt magnesite or a suitable portland cement is used. Some extractives, such as sugars, tannic acids, etc. seriously retard the setting of the concrete. Therefore the content of these substances is very important. It may vary widely with wood species and felling time. W. Sandermann has found that a sugar content of up to 0.125 % improves setting time, but that it increasingly retards it above this level. In the literature several methods for examining the wood are described. They may be applied by analogy to other raw materials from which long, slender particle elements may be obtained. In Europe at the present time the following standard boards are produced.

Measurements:								
thickness (mm)	15	25	35	50	75	100		tolerance -2, + 3 mm
width				500				-5, + 5 mm
length				2000				-10, + 5 mm
Density: (depending on thickness)	570	460	415	390	375	360	kg/m^3	-0% + 20 %
bending strength	17	10	7	5	4	4	kp/cm^2	
compressability +)	10	15	18	20	20	20	%	

2/ under a load of 0.02 kp/cm^2

3/ with 750 mm free length under a load of 0.1 kp/cm^2

+) specimen size 200 x 200 mm, measured 1 minute after application of load of 3 kp/cm^2

The test must not be made earlier than after two weeks of storage at 20°C with a relative humidity of 60 to 75 %. Each specimen must not deviate from the rectangular shape by more than 3 mm per 500 mm of length. The edges of the boards must be as sharp as possible as far as the board's structure allows. Boards with a density lower than 480 kg/m³ should have a temperature conductivity of not more than 0.08 kcal/mh°C. For boards of higher density it is of no use to establish a limit value, because of the low thickness and of the infiltration of mortar.

4.5 Light building boards and light building bricks made from particles

In general shredded chips made from wood are used. In Europe, spruce (Picea excelsa) has given good results. For bonding, portland cement is used. Regarding other wood species and their extractives what has been said above with respect to wood wool cement boards applies. Utilization of wood waste may be considered. Until now they could only be used where wood species and time of felling were reliable factors. Similar considerations have to be made with respect to agricultural wastes. The sizes of the particles should be between 3 and 30 mm.

The dimensions of the boards should be the same as those of the light building boards from wood wool. Additionally they are also manufactured in bigger dimensions, thus having thickness of 10 cm, lengths of up to 9 m and surfaces of up to 8 x 2 m. Densities are somewhat higher than those of the wood wool boards, attaining about 600 kg/m³. Bending strength is as much as 9 - 12 kp/cm², temperature conductivity is as much as 0.1 kcal/mh°C. Apparently there are not yet any related standards, neither are there any related to solid and hollow bricks. In the first instance these boards are used for industrial buildings. Only buildings with one storey may be made from solid bricks, because their supporting strength is limited. Hollow bricks are filled with concrete, thus providing a supporting core, and therefore the number of storeys built up with these can be unlimited. The Austrian Wood Research Institute has selected the following limit values for its own use:

dimensions:	(exterior) nominal measure	± 2 mm in each direction
density:	(solid)	> 630 kg/m³
strength:	compression strength 1/	> 10 kp/cm²
compressability 2/		< 10 - 20 %

1/ In the direction of normally occuring load

2/ With solid bricks in the direction of the practical load, with hollow bricks onto the wall elements of the brick, perpendicular to the usual direction of load, related to a wall size of 100 x 100 mm.

4.6 Floor overlay from wood pieces, sawdust and similar raw materials

Caustic burnt magnesite is used as adhesive. Besides inorganic fillers and colours, also organic fillers are used. Chips from hardwood are unsuitable. Besides chips from softwoods, additives in the form of by-products from the paper, cork and leather processing industries, from shreded straws from flax or hemp may be used. The moisture content of these materials must be lower than 20 %. An advantageous composition of particle sizes is essential. The overlays are made with one or two layers. Four weeks after laying, the floor overlay must have the following properties.

bending strength	> 60 kp/cm^2
compression strength	> 150 kp/cm^2
impression strength (Brinell)	> 4 kp/mm^2
variation of dimensions (over 4 weeks of curing)	< ±0,25 %

4.7 Particle boards for general purposes and for the building industry

According to ISO-Rec. 820 these are board-like products made from particles of wood or other lignocellulosic material and bonded with adhesives. Based on their density, one has to distinguish:

light-weight particle boards with a density below 450 kg/m^3;
medium-weight particle boards with a density of 450-750 kg/m^3; and
heavy particle boards with a density higher than 750 kg/m^3.

Light-weight particle boards are used as filling material or for acoustical purposes. In some cases heavy particleboards are manufactured for specialised uses. In general, both these kinds of boards are dealt with by agreements between supplier and customer. The above-mentioned ranges of density only serve to define the types of boards. Usually the commercial densities vary within narrower limits, and may be selected by the producer. The board's density is determined without making up for eventual cavities or overlay, using the exterior measurements of the boards.

Boards may be unsanded, sanded or planed, veneered or overlaid. According to the service conditions the boards will be exposed to, at least two kinds of glue bonds have to be distinguished:

(i) glue not resistant to weather, in general based on urea-formaldehyde resin;

(ii) weatherproof glue, in general based on phenol-formaldehyde resin.

For uses where the moisture content of the board is permanently higher than 18 % and where conditions are favourable for fungal attack, or where the board might be subject to insect attack, the boards must contain a recognised preservative, and the treated board must be tested. The same conditions apply with flame-retardants. Preserved boards must be specially marked. According to the method of production one has to distinguish between flat-pressed and extruded boards.

<u>Flat pressed boards</u> are composed of one or more layers. In general, a structure is obtained showing high quality fine particles in the outer layers, and coarser particles of inferior quality in the core. The particles are mainly situated with their longitudinal axis parallel to the level surface of the board. One has to distinguish boards with outer layers

(i) made from decorative particles, surface unsanded, for decorative applications;

(ii) made from ordinary particles, surfaces without particular requirements;

(iii) made from fines, surfaces for high requirements with respect to structure;

(iv) made from fines particles, the surfaces corresponding to the highest requirements with respect to structure.

Boards should show a mainly uniform surface structure, mostly free from pores. The colour of the surfaces depends on the raw materials used. Unsanded boards with decorative particles must not show any irregularities. If boards are delivered unsanded, the particles must be well bonded on the outer layer. Sanded boards may show small single irregularities on the surface. Furthermore, per 3 m^2 of board surface area, 2 patches of dust with a diameter of not more than 10 cm, 2 patches of glue with a maximum diameter of 2 cm, and unsanded or sanded-through patches up to 2 cm away from the edge are permitted. These faults are all allowed on one side only. With respect to other properties, the following requirements have to be fulfilled.

1. Allowances of the dimensions, including deviations from the rectangular shape:

length	± 5 mm
width	± 5 mm
thickness, sanded for general use	± 0,3 mm.

thickness, unsanded for decorative	± 0,75 mm
thickness, unsanded for building	–0, +2 mm
moisture content of board at time of delivery	9 % ± 3 %

2. **Strength:**

Thickness (mm)	bending strength (kp/cm^2)	internal bond (kp/cm^2) seasoned	internal bond (kp/cm^2) soaked 1/	surface lifting strength (kp/cm^2)
from 6 to 13	> 200	> 4.0	> 1.5	
from 13 to 20	180	3.5	1.5	
from 20 to 25	160	3.0	1.5	> 7.0 2/
from 25 to 40	120	2.0	1.0	
from 40 to 70	80	1.5	0.7	

3. **Thickness swelling in water** 3/ at 20° ± 2°C

after 0.5 hours	< 1 %
after 2 hours	< 6 %
after 24 hours	< 15 (< 12) %

4. **Screw and nail holding:**

Screw and nail holding is determined only infrequently, although information on this property is usually requested by the end user, because of the very few standards existing in this field. This is due to the technical and standardisation difficulties (axial withdrawal perpendicular and parallel to the

1/ Additional test for weatherproof bonded particle boards besides testing when seasoned (after 2 hours of immersion in water at 100°C and subsequent recooling).

2/ Internal bond of the surface layer of particle boards for general purposes including veneering. For overlaying a surface lifting strength of 10 kp/cm^2 is necessary.

3/ Determined using specimens of a size of 25 x 25 mm. The 0.5-hours figure is a measure of surface quality. The 2-hours figure is indicative of short term behaviour in water, the 24-hours figure for long term behaviour in water. According to Austrian standards the 2 hours figure to be determined for boards for general purposes. For building boards, the 24-hour test should be made. Thickness swelling should not exceed 15 % for exterior grades boards and 12 % for interior grade boards. If there is no condensation in the board, the influence of moist air cannot be estimated by means of these figures. It may help for purposes of estimation, that a variation of 10 % in the moisture content of the air may cause a variation of the board's moisture content of about 1.5 %. This may cause a variation in thickness of 0.6 % and a variation in length or width of as much as 0.03 %.

plane of the board, pull-through resistance of screw and nail heads, sheer strength of side of hole, (radial withdrawal parallel to the plane of the boards), the influence of the distances between the screws and nails, the influence of the distances of the screws and nails from the edge of the wood, etc.) and to the different shapes of the screws and nails. Experience shows that boards with a good bending strength and a good internal bond also have good screw and nail withdrawal properties.

5. <u>Bowing of the board:</u>

Based on conditions of manufacture particle boards are always curved to some degree. According to the opinion of the Austrian Wood Research Institute bowing $\leq$ 1 mm per 1000 mm of length may be tolerated. Boards bowing 1 - 2 mm out of the true may be regarded as slightly curved, boards bowing more than 2 mm are regarded as pronouncedly curved.

6. <u>Surface quality:</u>

One method of examination is defined in BS 1811. (Methods of test for Wood Chipboards and other Particle Boards). At present the international acceptance of this method is being discussed by ISO/TC 89. The following table shows limit values which are being used at the Austrian Wood Research Institute when applying the above-mentioned British Standard.

7. <u>Machinability:</u>

It is a basic requirement that smooth, sharp edges should be obtainable if using high quality tools. Tool wear is also of great importance. At present a test method is being discussed by ISO/TC 89 (see ISO/TC 89, SC 1, WG 8, Draft Proposal 179, Fibre building boards, determination of sand quantity). This draft deals with the determination of sand content. Furthermore, the paintability is of interest, and a suitable method is also being discussed (see ISO/TC 89, SC 1, WG 8, Draft Proposal 178, Fibre building boards: Determination of paint absorption).

<u>Extruded boards</u> consist of one layer only with or without cylindrical cavities parallel to the direction of production. The particles are situated chiefly with their longitudinal axis perpendicular to the plane of the board. Extruded board may be unsanded, or covered on both sides with veneers, plywood, hardboard or other overlays. They are glued with urea-formaldehyde resin. Veneers may be glued to the board either with urea-formaldehyde resin or with phenolic-formaldehyde resin.

1. Dimensions:

length and width, tolerance as for flat pressed boards

thickness without overlay ± 0,3 mm

thickness with overlay ± 0,5 mm

2. Strength:

Thickness (mm)	Bending strength[1] (kp/cm^2)	Tensile strength[2] (kp/cm^2)	Surface lifting strength of the overlay[3] (kp/cm^2)
boards without cavities up to 16	> 50	> 4,0	> 10
boards without cavities exceeding 16, to 25	40	3,5	
boards with cavities up to 30	40	4,0	
boards with cavities exceeding 30, to 45	25	3,0	
boards with cavities exceeding 45	10	2,0	

4.8 Fibreboards for general purposes and for building

According to ISO-Rec 818 these are board-like products from lignocellulosic fibres bonded primarily by felting of the particles and by natural bonding forces. The boards may contain adhesives and/or additives. According to their density one has to distinguish:

(i) porous wood fibreboards with a density below 350 kg/m^3 (with bitumen additions below 400 kg/m^3);

(ii) semi-hardboards with a density from 350 to 800 kg/m^3;

(iii) hardboards with a density above 800 kg/m^3.

The above-mentioned ranges of density should only show the types of board. The commercial densities vary within narrower limits and may be selected by the manufacturer. Boards may be smooth on both sides, smooth on one side and on the other showing the marking of the sieve, or sanded, or they may be sanded on both sides. Boards may have one or more layers. Where the constant moisture content of the board is more than 18 % and therefore fungal attack is possible,

1/ Perpendicular to the direction of production.

2/ Parallel to the direction of production (identical with the internal bond of flat pressed boards).

3/ Perpendicular to the plane of the board.

and where attack by insects may occur, boards must contain a preservative and must be tested separately. If the boards contain fire retardants the same necessity arises. Protected boards must be specially marked. The boards should be free from faults, and should have a regular appearances except for small dark spots and slight irregularities from the sieve markings, which are caused by occasional repairs to the sieve. The colour of the boards depends on the raw material utilized. Colour additives which are not affected by sunlight are permitted if they do not hide the fibrous structure of the board. The following requirements must be fulfilled (see table).

5. The quality obtainable by products made from annual plants

In the foregoing chapters, considerations were made regarding production control and testing of the final products. We have attempted to give an idea of the desirable limit values. Concerning the latter, it must be stressed that the list of data given has been simplified and is therefore incomplete, and in some points data deviate from the existing standards. The limit values were selected in order to correspond to the requirements of general and building uses as required in the industrial countries. They were originally selected to be easily obeyed if using suitable wood species. For judging the products - especially particle boards - in addition some properties were considered, which are not dealt with by most of the testing standards, but which appear to be essential.

Surveying the not very ample literature available in the field of annual plants, one notes the extraordinarily high harvest yields of these raw materials. R. Hesch calculates this yield at 2.5 times as high as the harvest of wood for fibreboards in the entire world. There are some particular properties of the annual plants which provide the reasons why they have not yet been utilised. Besides the difficulties of transport and storage, each raw material requires a specific method of conversion into basic products in order to attain the above-mentioned limit values. Basing on opinions on the publications available, there is no doubt that the necessary qualities may be achieved. Nevertheless in each case the necessary investment has to be considered in order to compete with the raw materials already in use. It must be mentioned that equipment is available which has been developed for each particular raw material. Furthermore the consumers prefer the well-known products. Any new products must either put up with the situation or pioneer new markets. From this point of view no limit values can be regarded as unchangeable laws.

Both technicians and managers must investigate the marketing conditions, and must produce the appropriate product in a constant quality. As mentioned above, one may lower one property of a product by about 30 %, leaving the other properties constant, in order to make up for any higher production costs. Alternately, all properties together may be lowered by 10 %. To risk more would be too dangerous. In general, the higher any commercial risk is, the more stress must be put on the control of both production and of the final product.

Nominal thickness (mm)		Tolerance: Unsanded thickness[1] (mm)	Tolerance: Sanded thickness (mm)	Width (mm)	Length (mm)	Moisture on delivery (mm)	Bending strength (kp/cm2)	Behaviour when wetted[2]: water behaviour (%)	Behaviour when wetted[2]: thickness swelling (%)
Porous	up to 7	± 0,5					> 20		
fibre boards	from 7 to 13	± 0,7	– 0,3	± 5	± 5	up to 12	> 18	-	< 8
	from 13	± 1,0					15		
Semi-hardboards	up to 7	± 0,5					> 100		
	from 7	± 0,7	± 0,3	± 5	± 5	6 ± 3	> 80[3]	-	< 15
Hardboards	up to 3	± 0,4					420		
	from 3	± 0,5	± 0,3	± 5	± 5	6 ± 3	400	< 30	< 18

1/ Also valid for incompletely sanded boards, the initial thickness differences of which remain nearly unaltered.

2/ Determined with porous boards after 2 hours, with semi-hardboards and hardboards after 24 hours of soaking in water at 20°C.

3/ Boards with a thickness of more than 13 mm are seldom manufactured. Their bending strength should be > 50 kp/cm².

TABLE 1

Programme of ISO/TC 89, drafting or agreed recommendations

	fibreboards dry and wet processed	particleboards flat pressed	particleboards extruded	boards and bricks minerally bonded
Definition - Classification -	ISO-Rec.818	820	820	+)
Terminology	.)	.)	.)	+)
Sampling - preparation - control	.)	.)	.)	+)
Determination of dimension and deviations from shape of boards	.)	.)	.)	+)
Determination of the dimensions of samples	766	821	821	+)
the density	819	822	822	+)
the moisture content	767	823	823	+)
Determination of the bending strength	768	.)	.)	+)
the internal bond	.)	.)	.)	+)
the penetration resistance	.)	.)	.)	+)
the compression strength	-)	-)	-)	+)
Determination of the water absorption	769	-)	-)	+)
the thickness swelling	.)	.)	.)	+)
the dimensional stability	.)	.)	.)	+)
Determination of the surface quality	.)	-)	.)	+)
the paintability	.)	.)	.)	+)
the machinability	.)	.)	.)	+)
Measurements and tolerances	.)	.)	.)	+)
Quality conditions	.)	.)	.)	+)

-) generally not interesting with respect to testing technique

.) presently drafting

+) not yet introduced to the programme (presumably to be discussed by ISO/TC 59)

TABLE 2

PV limit values for commercially sanded particleboards as well as for particleboards with various overlays

Quality in utilisation group 1/ 1	2	3	PV limit value, determined on the board sanded for delivery	Thickness of coarse 2/
very good			< 0,030 mm	0,20 mm
good	very good		≤ 0,060 mm	0,40 mm
less good	good	very good	≤0,120 mm	0,65 mm
bad	less good	good	≤0,240 mm	1,00 mm

1/ Utilisation group 1: overlaid with thin decorative paper, lacquer cover, etc.;
2: overlaid with veneers, thick layers of polyester, etc.;
3: overlaid for inferior utilisation.

2/ Average of 10 of the thickest particles per 5 g of surface layer grade particles.

Selected Bibliography

Literature on annual plants for board manufacture, available at the Austrian Wood Research Institute up till June 1970

1. Anonymous: Bagasse as a raw material for insulation board manufacture
FAO/ECE/BOARD/CONS/PAPER N.13
Wood-based panels meeting, 8 - 19, July 1963, Rome.

2. Anonymous: Torf, ein beachtenswerter Rohstoff der Pappenindustrie und Hartfaserplattenherstellung
Wochenblatt für Papierfabrikation N. 1, Jahrg.92, Jan.1964, p. 4-5.

3. Chapman, A. Watson: Purchasing, Handling and Storing of Bagasse,
FAO/ECE/BOARD/CONS/PAPER 4, p. 12.

4. Guha S.R.D., Singh M.M., Mukherjee V.N. and Saxena V.B.: Fibre Boards from Bagasse
Indian Pulp and Paper No. 4, Vol. 20, p. 255-256, October 1965.

5. Hesch R.: Einjahrespflanzen als Rohstoffe für die Spanplattenindustrie
Holz als Roh- und Werkstoff 4, p. 129-140, 1968.

6. H. 't Hooft: Erfahrungen bei der Herstellung von Holzfaserplatten aus Getreidestroh
DGfH-Bericht 1, Entwicklung und Herstellung von Holzfaserplatten, Sitzung am 26 April 1955/Braunschweig, p. 18-19.

7. Lampert H.: Die Herstellung von Faserplatten aus Rapsstroh
Holztechnologie 1, p. 15-22, 1960.

8. Lathrop E.C., Aronovsky S.I., Knapp S.B., O'Neil F.W., Hitchings, R.G., Ernst, A.J. and Clark R.F.: Fiber Shipping Containers from Sugarcane Bagasse
Tappi No. 10, Vol. 40, October 1957, p. 787-791.

9. Lewin M. and Lengyel A.: Papyrus as a raw material for the production of insulating and hardboard
Bulletin of the Research Council of Israel No. 3, Vol. 6C, August 1958, p. 181-196.

10. Naffziger T.R., Clark T.F. and Wolff I.A.: Structural Board from Domestic Timber Bamboo "Phyllostachys bambusoides"
Tappi No. 2, Vol. 44, February 1961, p. 108-112.

11. Nemrahl J. and Kuniak L.: Zuckerrohr als Rohstoff für die Faserplattenfertigung
Drevo 16/1961, Heft 1, p. 16-17.

12. Sano Y., Ishihara S. and Nagasawa S.: Studies of the Production of Fibreboards from Bamboo (I), manufacturing process at high temperature cooking and the atmospheric defibering from MOSOCHIKU
Bull. Gov. Forest. Exp. Stat. No. 113, p. 135-144, March 1959.

13. Sano Y. and Nagasawa S.: Studies of the Production of Fibreboards from Bamboo (II), on the manufacture of fibreboard from MOSOCHIKU by high temperature cooking and high pressure defibering process and other experiments.
Bull. Gov. Forest Exp. Stat. No. 126, p. 51-61, November 1960.

14. Sinclair G.D. and Sallans H.R.: New Saskatoon Plant Produces Insulating Board from Straw and Hardboard from Wood
Paper Trade Journal No. 50, Vol. 142, December 1958, p. 48-55.

15. Singh A.A., Jain H.C. and Sekhar A.C.: Some investigation on Pressed Boards from Bamboo
Indian Pulp and Paper No. 11 Vol. 23, p. 651-656, June 1969.

16. Skory H.: Opracowanie sposobu poprawienia niektorych wlasnosci fizycznych plyt pazdzierzowych
Przemysl drzewny No. 1, p. 12-13, 1969.

17. Ulbricht H., Francke D. and Spielmann H.: Rapsstroh, seine strukturelle und chemische Beschaffenheit und deren Veränderung bei längerer Lagerung
Holztechnologie Vol. 2, p. 117-122, 1962.

8. 10. 71