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THE REQUIREMENTS AND USE OF WOOD-BASED PANELS IN FURNITURE MANUFACTURE 1/

prepared by
the secretariat of UNIDO

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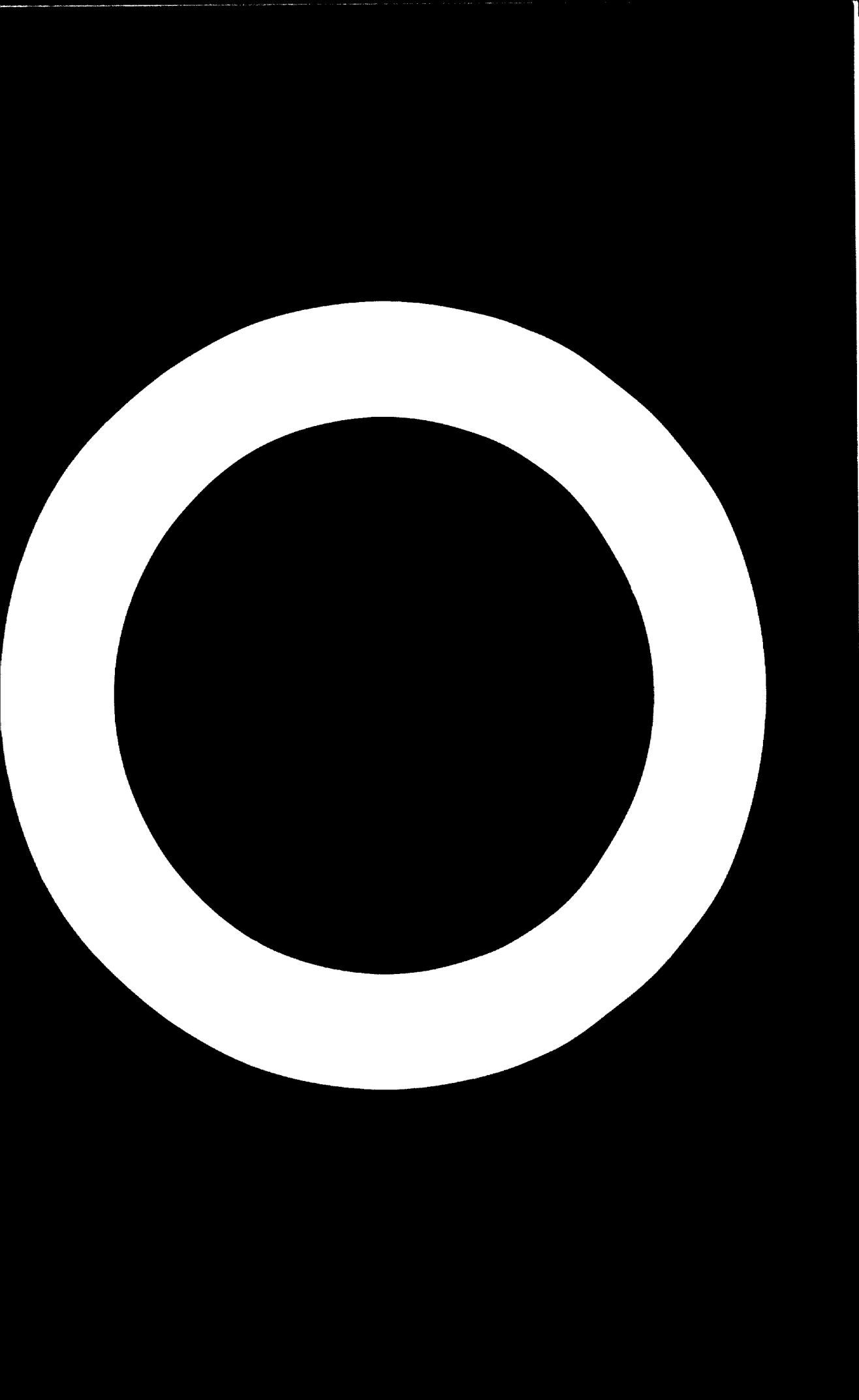
C O N T E N T S



I. [illegible]

This paper has identified some of the advantages and disadvantages of the various panel products used in the furniture industry. It is, perhaps, worthwhile reiterating that there is no one perfect product. Actual utilization will depend on a balance of advantages and disadvantages both technical and economic in deciding on the appropriate product to make use of in any specific case and varies from country to country.

A. Trends

The demand for wood-based panel products has existed ever since flat surfaces became a requirement for furniture. This is an over-simplification but it is intended to emphasize the natural affinity between this class of product and almost all kinds of domestic and institutional furniture.

Technological improvements have permitted the manufacture of panels having not only flat surfaces but also many of the other rather exacting requirements of the furniture industry, such as dimensional stability and accuracy, an appropriate surface and good strength properties. While solid wood or glued-up panels of solid wood may be considered to offer good standard qualities, the various wood-based panel products available today offer particular improvements which make them more suited than planed wood for a wide variety of applications. In short, the processing methods have been improved and specialized by the introduction of large serial industrial production.

Many of these improvements in panel qualitites and varieties have been brought about by pressures from the furniture industry. The qualities making panels suitable for building and packaging are usually related to rigidity, racking and impact resistance and durability, fire, insect and mould resistance, however of special importance to the furniture industry are dimensional accuracy and stability, high strength perpendicular to the surface, screw withdrawal resistance and surface characteristics allowing high quality coating, films and laminates to be applied. Development has gone hand in hand with the needs of these major user industries.

[illegible] trends towards rapidly increased consumption of all panel types, [illegible] furniture differ by type. Particle board has become, in many countries, the prime panel material for most kinds of furniture, but hardboard has maintained a strong position in [illegible] specific uses. Plywood was considered as a relatively ideal product for furniture but, in countries that have established a particle board industry, it has been replaced by the latter in lower cost items. It is still used as a speciality material in modern, solid designs. Another factor which accelerated the acceptance of particle board is that the large size of the panels result in a smaller waste factor in serial production.

One reason for generally expanding use in the furniture industry is higher cost of solid sawnwood, higher labour costs, and lowering of quality of sawnwood. The processing of flat components on a mass-production basis has been facilitated through the development of special high capacity, automated lines to machine and surface coat them.

A general shortage of good quality solid wood and the accent on efficient utilization of residues has been a strong influence in promoting the greater use of panels in furniture. However, in developing countries this influence has been lessened by the generally high cost of resins and, to some extent, by the rather high initial investment required for mills and the technological level of the processes.

The interrelationship between economies of scale, limited local demand and short economic transport distance are difficult to quantify but, in general, local markets within delivery range are too often insufficient to warrant production. One major hindrance to more widespread acceptance of panels has often been their inconsistent quality during early stages of local production. Small plants cannot manufacture a complete range of panels not only in thicknesses and densities, but also in sanded - non-sanded, various glues, etc. This limits demand because panels are often used incorrectly.

B. Prices

Since quality standards have been attained that have enabled panels to be successfully coated, overlaid or veneered, their availability in large custom-ordered sizes has resulted in considerable raw material cost savings for furniture manufacturers. Not raw material cost savings, but in the lack of large investment costs, which the smaller units could not afford, have been borne by the panel manufacturers. Waste from trimming to size and from the normal operations of lumber defecting has been reduced through use of custom-ordered panels.

Other cost advantages are due to smaller demands for dry kilning or air drying lumber, although in most cases these facilities must be maintained for the smaller amount of solid wood used. Storage under controlled humidity conditions is more important for panel materials than for solid wood, and this cost must be more than offset by savings in material and labour cost to justify panel use.

The tendency of firms to specialize in making only certain types of furniture, and to become assemblers rather than processers is supported by more widespread use of panels and continuous improvement in their quality. This allows and, in fact, encourages the growth of specialized component producers with a concomitant increase in efficiency and reduction in unit cost. Once again, long production runs for drawer sides, turned parts and flat pieces to fill standing orders of large furniture makers bring the opportunity to plan and schedule machine and manpower use and hence reduce costs.

A long-term effect of inflation is to make forest management a more expensive proposition unless great attention is paid to proper utilization of wood residues from sawmilling, veneer peeling and secondary manufacture. The profitability of plantations and managed woodlots is extremely sensitive to even small changes in interest rates, and this will make residue utilization (for panels) increasingly rational as higher and higher yields from the exploited timber are sought.

[illegible] will no doubt be an increase in the [illegible] complexes. The relationship between [illegible] products may no longer be [illegible] mill to market supply and demand as by the internal [illegible] used by the complexes themselves. Furthermore, it is [illegible] that complexes will develop which will bring together several mills in a region and utilize one another's mix of by-products to [illegible] material and energy more efficiently, reduce internal [illegible] and raw material costs and cut down on the amount of [illegible] effluents released into the biosystem.

3. Principal Uses for Panels in Furniture

As brought out in the introduction, the need for low cost flat homogeneous, easily decorated surfaces has been largely responsible for the growth of panel application in the furniture industry. The qualities of precision flatness, dimensional stability, equal strength along the two axes and acceptable strength have made particle board especially suitable for table and desk tops, ends of buffets, commodes and dressers, and sides, tops and shelves of bookcases. Fibreboard has found most common application in "backing" roles where its rigidity and light weight contribute to the solidity of desks, built-in closets and kitchen cupboards, and dressers, commodes and buffet types of home furniture. Drawer bottoms are also very commonly made of fibreboard: however, moulded plastic drawers are replacing this use to some extent in the low to medium-price range of furniture.

The use of plywood in furniture seems to be diminishing, but its role is also changing. Whereas it used to be considered primarily as cheap structural wood and used in carcassing and hidden places of upholstered furniture, it is now taking on a glamour role with clear or brightly coloured stained finishes making no attempt to hide the plys. Better quality, primarily hardwood plywood, must therefore be used for this purpose.

The advantages of particle board and fibreboard particularly can be greatly enhanced with overlays either applied at the mill or in the user's factory. In fact, most particle board for the furniture industry is now delivered with an overlay with the edge banding left to be done by the user following cutting to size.

It is becoming increasingly realized that technical after-sales service and advice must be provided to ensure that panel products are used to their fullest appropriate extent and that processing and application of hardware is carried out properly. Otherwise consumer acceptance will fall after discouraging attempts to use traditional (wood) techniques. This service has also been extended to include maintenance of the carbide-tipped cutting tools generally recommended for particle board, particularly for the smaller industrial user, and stocking of the special hardware used with it.

II. PLYWOOD

Most plywood used in furniture is 3- or 5-ply hardwood and from 3 to 9 mm thick. It is stronger than the other panel types and can thus reduce the weight of some items or add to their strength. Softwood plywood is used to some extent (in the U.S.A. and Canada) in structural applications.

Screwholding ability is better and hardware and fixtures are easier to apply than for particle board or fibreboard. Furthermore, specialized machines are now available which overcome these problems, provided the machines can be used to their capacity and thus justify their purchase.

Special plywood has been made by glueing curved veneers together with their grain all in the same direction. Many new and interesting designs have evolved from this technique, most notably in chairs.

[illegible] usually better not [illegible] when used [illegible] [illegible], [illegible] or stair. It [illegible], and plywood is more [illegible] than [illegible] plywood, [illegible] and is [illegible] used. Plywood can, [illegible], [illegible] already [illegible] higher value species.

[illegible] [illegible], except that the [illegible] than with normal wood [illegible], thus [illegible] versatility.

[illegible] in developed countries, plywood is used [illegible], shelving and in do-it-yourself (d-i-y) projects. In all, [illegible] U.S.A. hardwood plywood production went into furniture use in [illegible]. Some 90% - 95% million ft² - of total softwood plywood was used by home owners for such purposes as shelving (although it is not ideally suited for this), cabinets, furniture and work benches, and 90% of this was "do-it-yourself" (d-i-y). Altogether over 6 million families used plywood for this end use, mostly sanded and veneered grades. "Products made for sale" took 490 million ft² (3/8" basis) in 1972 for furniture, which represents a 69% increase since 1969, largely due to increased use in upholstered furniture. In the U.K., 11[illegible] tons of plywood were used in furniture (estimated) in 1973, which is [illegible] 14% of woodbased raw materials used in furniture. In Japan only 13% of plywood was used in furniture compared to 45% and 28% in construction and joinery in 1964 (according to an estimate made by the Tuolumne Corporation for FAO in July 1971).

It would seem that plywood use in developing countries should expand considerably in the coming years due to its ease of working, nailing, screwing and its strength coupled with its relatively good resistance in humid climates. It should be a particularly promising use for plantation softwoods in specifications suitable for furniture.

III. BLOCKBOARD

Blockboard is usually produced in conjunction with a veneer mill and preferably with a solid wood products factory as well to utilize wood which would otherwise be considered as waste, trim strips and veneer cores. The process is simpler than for other composition boards, yet provides a utilitarian panel which finds many uses in the furniture industry. Shelves and table tops which require greater strength and better screw holding characteristics are prime uses. The commonest thickness is 25 mm, but 19, 22 and 28 mm boards are also used.

Laminboard is stronger and more exacting than blockboard and is made from strips of plywood, edge glued top to bottom and surfaced with veneers.

Since blockboard is essentially solid wood, no special skills or tools are needed to work it, nor are special fasteners or hardware required. Its production should definitely be considered in developing countries as an adjunct to veneer and wood products production, since the process is not capital-intensive, nor do economies of scale play a large role.

IV. PARTICLE BOARD

The two characteristic of particle board which make it superior to plywood, blockboard and solid wood cores for underlying veneers are its lack of grain direction and its stability. Although particle board has, or can have, the same density as the medium-weight hardwoods normally used in making furniture (600 - 700 kg/m^3), its lack of grain direction means that differential swelling is almost non-existent. However, without protective coatings, thickness swelling can be a problem. Its major drawbacks are low rigidity and low resistance to tension perpendicular to the surface.

[illegible] are shown compared to birch [illegible]:

Strength property	Particle board ([illegible] kg/m³)	Birch
Bending	18[illegible] kp/cm²	[illegible]00 - 1600 kp/cm²
Tensile parallel to surface	8[illegible]-1[illegible]0 "	1[illegible]00 - 1500 "
Tensile perpendicular to surface	[illegible]	[illegible]0 - [illegible]

[illegible] bending strength is important (such as shelving, [illegible] surfaces greatly increase strength.

[illegible] surface is uneven, it must first be filled before painting or lacquering. The surface must be of a high quality for overlays not to show unevenness or "show through" of particles. Care must be taken not to sand away too much of one surface as the stability of the board may thus be impaired - especially in multi-layer boards.

Multi-layered boards have been developed, and even boards with densified edges can be produced that improve surface and edge qualities with respect to screw-holding and edge banding, and which allow machining with greatly reduced tear-out and chipping. The commonest is a 3-layer board. Flat-pressed boards are by far the more common. [illegible] are preferred by the furniture industry while extrusion types are used more in building.

The introduction of particle board into traditional wooden furniture-making areas requires a changeover in manufacturing methods. Instead of a normal wooden frame being built up (for case goods and cabinets) using glues, nails and screws, fibreboard or plywood backing, followed by any overlays being applied in the case of particle board, precision-cut, pre-veneered or overlaid particle board pieces are assembled using glue lines almost exclusively and nails or pins only for locating and holding until the glue is set. Not only must methods change as above, but the means of producing precision-cut components must be developed.

The suppliers of particle board should be able to provide technical advice to users as well as in some areas to maintain stocks of special hardware. Different designs of hinges, slides and knock-down fasteners must be available, as well as screws with deeper pitch threaded all the way to the head. Some hinges for example rely on special boring or mortising machines for application. The following services should therefore be considered by suppliers of board for the furniture industry, at least until it has attained its own capabilities:

a) precision cutting to specific sizes;

b) surfacing with melamine impregnated foils, wood veneers and other overlays;

c) edge lipping;

d) maintenance of carbide-tipped cutting tools;

e) technical design assistance.

V. FIBREBOARD

The furniture (and joinery) industries uses fibreboard primarily of the medium and hard types; that is, with specific gravities in the 0.65 to 1.20 range. The greatest demand comes from the building trades, but kitchen cupboards, backs and floors of furniture and drawer bottoms are among the major uses in furniture. Profile-pressed and punched hard and medium boards are much used by the radio, television and furniture industries - especially as TV tubes surrounds and loudspeaker grilles.

Recent developments have seen the use of double hardboard skins bonded to both sides of solid wood frames with a supporting centre of lightweight paper cores (as in flush door construction) for furniture, especially for kitchen and built-in storage furniture, and as doors in large wardrobes.

Fibreboard can be produced with finely ground particles comprising the surface, making it compact and able to be sanded to a very smooth surface. It works very little parallel to the surface and when impregnated with a glue or drying oil, fine sanding followed by painting results in excellent flush door panels. It can readily be:

a) covered with ivory pulp (with groundwood pulp);
b) primed (puttied or filled);
c) painted or lacquered;
d) printed (roller coated or by silk screen);
e) impregnated with monomers and cured by radiation;
f) laminated with melamine, urea, phenol, polyester, plastic veneer or polyvinyl chloride (PVC) either soft, hard or semi-hard.

Types a) - d) are used commonly for the backs of closets, drawer and bed bottoms, baseboards in cupboards and closets and for the backs of desks, dressers and commodes. It can be produced to a very close tolerance ($\pm$ 0.2 mm is standard) - a very important criterion for furniture manufacturers who order cut-to-size pieces.

It has been noted that workability, although difficult to define numerically, depends not so much on density of fibreboard, but on the evenness of manufacture or variations in quality that occur with changes in the properties of the raw material in pulp refining, glueing and heat tempering. A low specific gravity does, however, mean less warping. Good quality boards can be easily worked. They can be sawn, planed, bored, perforated, milled and cut and they do not crack, split or become fluffy when being worked with hard metal cutters under normal conditions. It is not advisable to drive screws into the edges of even thick fibreboard, and since framings are generally used with hinges. V-grooving is commonly used to produce corners in cabinet work.

When fibreboards are covered with hard, shrinking overlays, the tensile strength perpendicular to the surface must be observed carefully (minimum is 0.8 N/mm^2), otherwise the film can crack and split. A balancing film is often necessary on the obverse side. If fibreboard is correctly heat treated, moisture changes cause negligible dimensional changes under normal joinery uses.

Its potential for use in most developing countries will no doubt depend on the demand from the building industry. The investment required for minimum economical production at the world market level is larger than for either plywood or particle board and so local production usually follows these other panels.

The manner in which fibreboard is normally used and the usually advanced (i.e. laminated or coated) state of processing when delivered reduces the need for special skills in use. Tools must be carefully selected and well maintained to avoid furring of the board itself and cracking of hard laminates, but generally staples, nails and adhesives are all that is required. Fibreboard is not usually used where hinges, slides and specialized hardware need to be attached.

VI. TECHNICAL REQUIREMENTS OF, AND USE OF PANELS BY, THE FURNITURE INDUSTRY

The furniture industry has quite exacting requirements for panels. The building industry specifications are concerned with characteristics of weathering, durability, fire, insect and mould resistance and such strength properties as racking resistance, rigidity, impact resistance (specially for doors) and partitions whereas, if any generalization can be made, panels intended for furniture must, in particular, be dimensionally accurate and stable, flat with surface properties which allow high quality coatings, laminates and films to be applied, have good strength perpendicular to the surface and also have suitable edge characteristics, screw withdrawal resistance and other specific properties. Density alone does not sufficiently specify quality in particle board.

Plywood and blockboard are less susceptible to the high quality requirements of particle board since they are more usually used in structural or hidden applications. Fibreboard, when coated or covered, is usually done so in the factory and the main problem confronting users is in machinery, since edge chipping is very common unless great care is taken.

Particle board is the one panel which can be readily covered or coated in the furniture plant or can be bought pre-finished. For [illegible] budget, however, the questions of (a) whether to make one's own or use ready-made [illegible] and (b) whether to buy unfinished board [illegible] coating or overlay or buy pre-finished [illegible] general terms. They depend, inter alia, on [illegible], availability and cost of [illegible] methods of furniture construction, with [illegible] and finishes, have only been made [illegible] particle board quality.

[illegible] are one example with very heavy [illegible] particle board and fibre board - are an ideal [illegible] construction. Standardized size and style could well be produced in certain developing countries [illegible] popular.

Plywood appears to be becoming too expensive to use in anything but "de luxe" furniture (often moulded), in Europe at least, and its use in developing countries will depend largely on whether local plywood is made in a variety of grades and the availability and comparative cost of other wood-based panels. It is, however, a relatively low consumer of energy and the F.E.I.C. has estimated 916,200 k/cal are required per m^3 produced. These energy requirements may be broken down as follows:

Electric power	-	15%	-	160 kwh/m^3
Heavy fuel oil	-	75%	-	0.070 t/m^3
Waste wood	-	10%	-	0.030 t/m^3

This aspect will become increasingly important as energy will probably continue to command premium prices and those developing countries which must import energy will be even more conscious of this factor in the future.

The use of significant quantities of any panel in furniture making requires additional investments in handling and converting equipment. This applies right down the line from new or different storage areas and facilities for incoming panels, modified internal transportation means (and perhaps more space between machines), special panel trim saws for initial cutting to size, to specialized edge-banding machinery, presses to apply surface overlays, wide-belt sanders, curtain coating equipment and driers. Double-end tenoners in tandem are also common in larger modern plants. These requirements shed a different kind of light on the decision to use panels in furniture in developing countries. It is no longer enough to add a few extra or higher quality planers, drill presses, hand saws or such "standard" woodworking machinery, re-organize production and adopt modern serial production techniques to expand in this direction. An entrepreneur willing to produce the type of furniture made possible by the ever-improving characteristics of panel products (especially particle board) must contemplate a near total re-organization of his plant or the erection of a new one.

Among others, the glueing department must be strengthened since most panel furniture joints are made with adhesives. Designs must be adapted to the "new" materials and craftmen accustomed to working with solid wood will have to be re-oriented towards the particular strengths and weaknesses of panels. For example, joints which would tend to cause delamination failure must be avoided (due to the low strength perpendicular to the surface of particle board particularly).1/

1/ For articles on particle board conversion, see the following chapters (pages 121-137) from Particle Board Manufacture and Application edited by Lee Mitlin, Promasidia Ltd., U.K.: 1 - Machining of Board Materials by A. Smith, PIRA; 2 - Particle Board Lipping by J. Pound, Pye Thermal Builders Ltd., U.K.; 3 - Wood Chipboard Joints by D.G. Hunt, Formica Ltd., U.K.

A recent UK estimate indicated that "about 90%" of domestic furniture and a high proportion of office and contract furniture were already being made from chipboard"[1] and concluded that any increased demand (for particle board) would arise from increased production of furniture rather than increase per unit. These figures can be used by developing countries as targets and can be held up as examples of how much particle board can be used in furniture. Table I shows the proportions of furniture using various types of panels. Although somewhat out of date, they do point out the considerable variation in practice between countries, and also the fact that panel products as a whole are widely accepted by the furniture industry. Table II shows a recent (1974) breakdown of particle board in Australia.[2] Total consumption was some 1 million m³ (16 mm basis) in 1973 with a forecasted consumption of over 4 million m³ in 1985.

End-use patterns for developing countries will continue to vary widely since geographical and historical influences play such an important role in determining which panels are used for what products. As an example, Nigeria began using plywood because it was available when the plywood mills were established and thus cornered the market. It is veneered locally, but often with imported veneers, since indigenous face veneers command export prices as exports. Some 16 mm particle board is produced as core board, but production of thicker boards suitable for veneering (as used by the furniture industry) has been proposed and will certainly take over a fair share of the furniture market. Fibreboard is little used because it is not made locally.

This would indicate that the use of panels has less to do with the characteristics of the panels or boards themselves, and more with their availability at reasonable prices. The local users (furniture makers) are probably able to adapt their designs to use whatever materials are at hand, provided, of course, that the quality is acceptable. Greater usage can naturally be obtained through the provision of appropriate technical help with cutting, machining and the fitting of hardware and connectors.

1/ From an article by Mr. Tony Sparkes, FIRA, in Timber Trades Journal Supplement, 4 May 1974, pp. 12, 13.

2/ From correspondence with Pyneboard Pty. Limited, Sydney, Australia.

There has been much controversy over minimum economic plant size for developing countries, but it can be said that the varying requirements for board sizes and thicknesses, types (multi-layered, densified edges, etc.) and densities for the furniture and building industries make it very difficult for a small plant to compete with imported boards. It is important that developing countries define a rational policy with respect to these products since it is surely self-defeating to impose tariffs on both imported panels and adhesives, and at the same time try to build up a modern furniture industry. Many countries have banned the export of logs and have legislated very helpful incentives to encourage wood processing industries. This is a healthy step but must be accompanied by sustained efforts aimed at promoting the more widespread and efficient local use of panels (including in furniture manufacturing).

	Austria													
Plywood														
Blockboard	36	30	-											
Hardboard	69	1	1											
Particle Board (flat pressed)	71	70												
(extruded)	-	-												

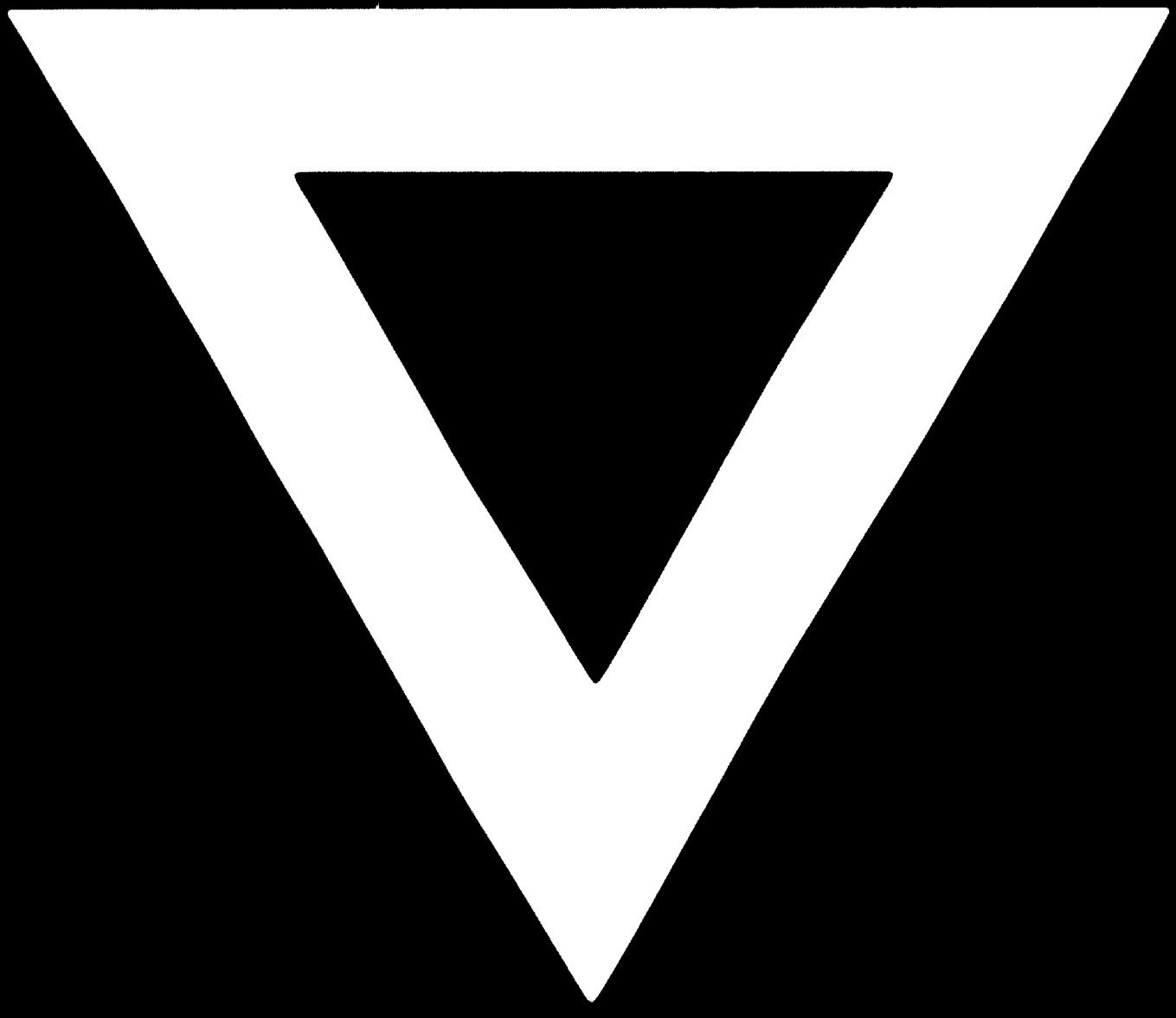
Source:

TABLE II

AUSTRALIAN MARKET CONSUMPTION
PARTICLE BOARD USAGE - PERCENT

Furniture and Fittings:		
Domestic Furniture	31	
Domestic Fixtures	17	
Commercial Furniture and Shopfitting	10	58
Appliances:		
Cabinets	8	
Partitions	4	
Vehicles and Other Industry	8	
Retail D-I-Y	6	26
Building:		
Flooring	4	
Formwork	2	
Fittings	9	
Other	•	15
Sub-Total		99
Government		1
TOTAL MARKET (%)		100

• Less than 0.5%



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