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Workshop on Wood Processing
for Developing Countries

Vienna, Austria, 1975

FIBREBOARD PRODUCTION IN DEVELOPING COUNTRIES: AN ANALYSIS OF ALTERNATIVES 1/

by

Karol Eisner*

* University College of Forestry and Wood Technology, Zvolen, CSSR

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SUMMARY

Fibreboard is manufactured by breaking down wood into its fibres and reconstituting them into boards of varying densities, using primarily pressure but also in some cases adhesive. Densities range from up to 400 kg/m3 to 800 kg/m3 and 1100 kg/m3 for insulation, medium density and hardboard respectively.

The traditional wet process uses much water but no adhesives and normally results in board which is smooth on one side only - the other having the mesh marks of the screen used in dewatering and pressing. The semi-dry process is little used, uses some adhesive and paraffin and is "smooth one side". The dry process produces "smooth two side" board and normally uses adhesive (1-3%).

Application is principally in furniture as frame construction, backs and in kitchen cupboards, in transportation, building and packaging. It competes to a large degree with plywood in furniture and partitions. Oil-tempered hardboard can be used (up to 10 times) in concrete framework where a smooth surface is required and also for exterior cladding.

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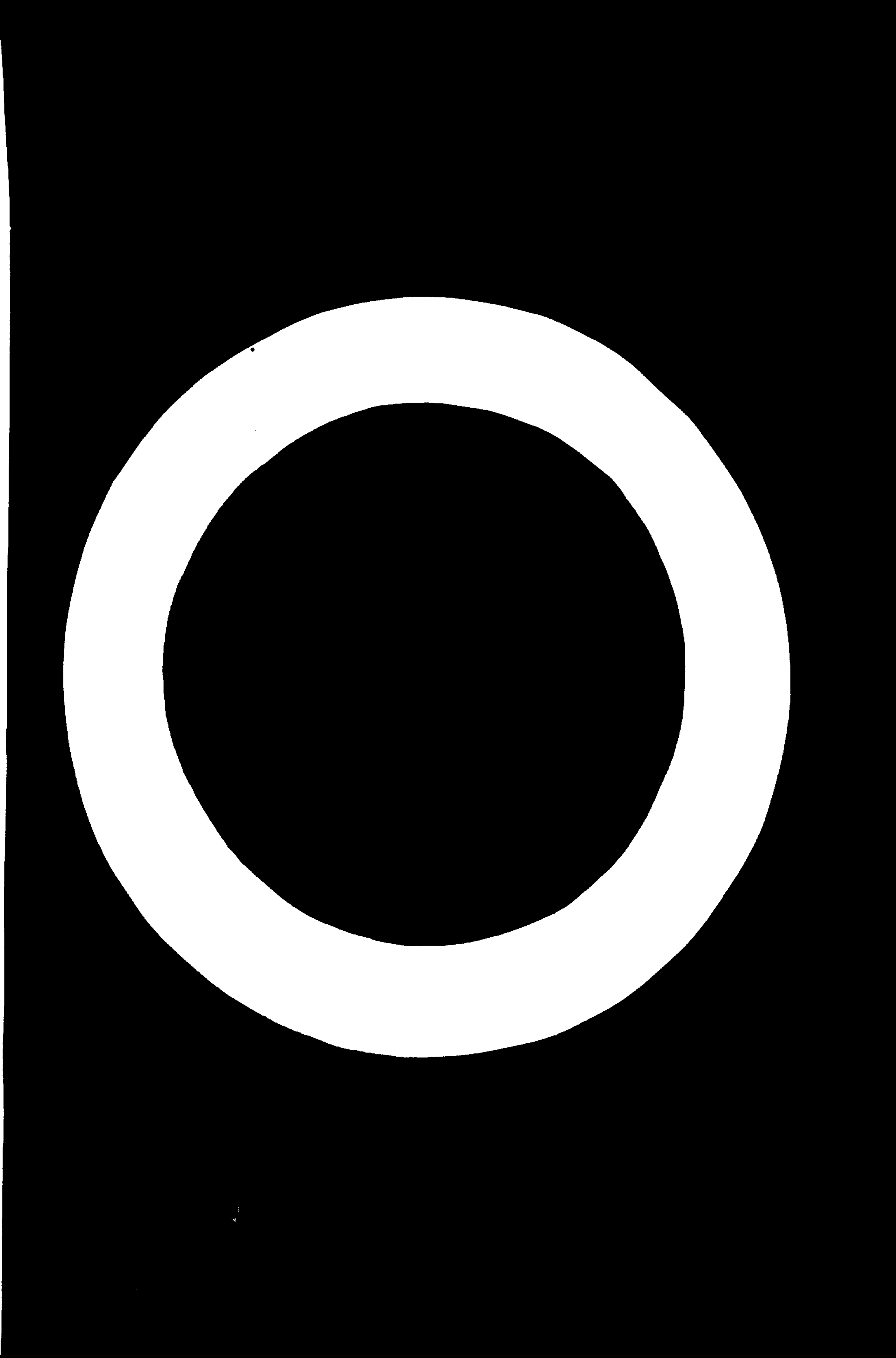
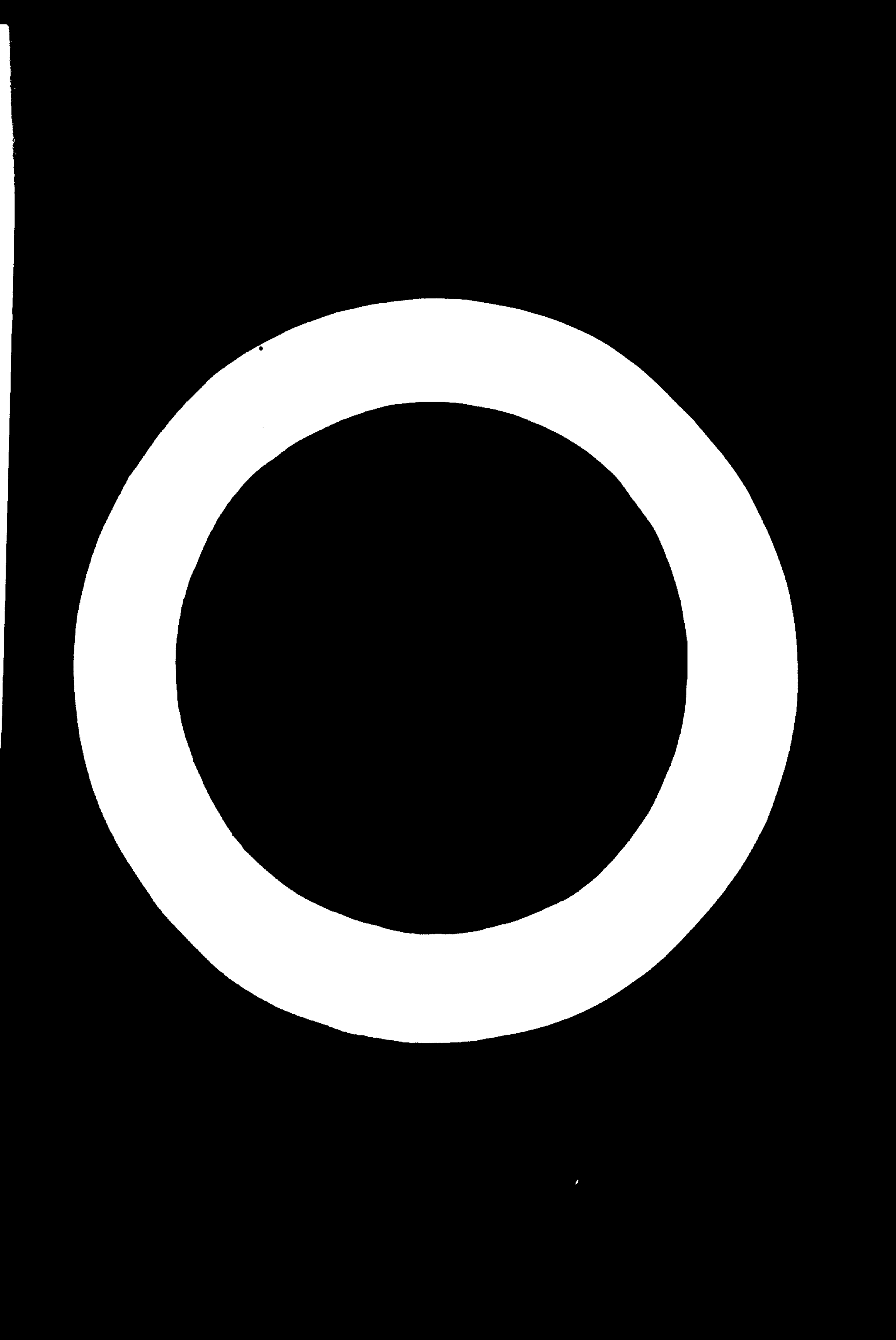


The individual operations common to both main processes are barking, chipping and defibring. The wet process includes watering, additive mixing and dewatering (mat forming), then pressing at 190 - 230°C at 50-5[illegible] kp/cm^2 and drying to about 8%. A heat treatment can follow to increase strength and moisture resistance (160 - 170°C for 4 hours). The dry process includes wax and resin addition, felting by air suspension and pressures higher than for the wet process (60 - 70 kg/cm^2).

A new product - Medium Density Fibreboard (MDB) - has found popular usage in the U.S.A., having better homogeneity, tighter edges and better dimensional stability than ordinary particle board, follows the fibreboard processing method but can use a broader range of raw materials, including some bark. Fibreboard can also be produced continuously.

The wet process is considered to be a more likely proposition for developing countries since smaller plant sizes can be economical.



Contents

INTRODUCTION

Fibre board is manufactured by breaking down the wood substance into fibre and reconstituting it into board material. Fibreboard of low density was produced at the beginning of this century from ground wood pulp. In the early 1920's the first hardboard was produced by hot pressing of wet pulpwood mat. This product proved very suitable for many purposes.

Fibreboard is classified according to its density into non-compressed and compressed board; or as soft or insulation board (density up to 400 kg/m3); as medium density board (400 - 850 kg/m3); as hardboard (850 - 1100 kg/m3); and as superhard (or oil tempered) board (density over 1100 kg/m3).

The production of hardboard was for a long time a "wet process" by using the wood in pulp form as a fibre suspension in water. After World War II the semi-dry and dry methods were developed, which require the addition of an adhesive and the introduction of new processing machinery, thereby producing a new type of hardboard.

The wet process is characterized by forming the fibre mat from the water suspension and drying or pressing the mat in a wet state. To enable moisture and steam to escape from the mat during pressing, a wire mesh is placed under the mat. This gives a characteristic "screen back" surface on one surface of the hardboard, which is then called S-1-S, or "smooth on one side". To increase some properties of the hardboard a heat treatment at a temperature of 160°C for 4 hours is generally applied, mainly if resin has not been added.

By the semi-dry process the wood fibres, after being coated with paraffine and phenolic adhesive, are dried with hot gases to about 10-50% moisture content. Then they are felted by air to a mat and pressed on a wire mesh to "side one smooth" board (S-1-S). The semi-dry process at the present time is little used and is therefore not described herein.

By the dry process the wood fibres are dried to a moisture content lower than 10% and the air felted mat pressed between caul plates without underlaying a wire mesh. In this manner a hardboard type with both faces smooth (S-2-S) is manufactured. Normally the addition of from 1-3% phenol-formaldehyde resin is involved.

According to a Czechoslovak method a dry-processed hardboard without addition of adhesive can be produced by using special press conditions.

The possibility to produce smooth both side board by the wet process exists as well, in which case the mat, after being wet felted, is dried and then hot pressed between smooth caul plates.

1. PRODUCTION, APPLICATION AND GENERAL OUTLOOK

1.1. Production

The world production of fibreboard in comparison to the situation in developing countries is shown in Table 1. According to this summary, taken from the last FAO Yearbook, the world production of fibreboard in 1971 reached the considerable quantity of 8,392 million tons, 72% of which was compressed boards and 28% non-compressed boards. The production of the developing countries in 1971 was, according to Table 1, only 5.1% of the total world figure, despite a share of world population of 47.5% (1,760,200,000 of 3,719,000,000). The annual world production increased in recent years at an average of about 5% per annum. Nevertheless, the increase in the developing countries was insignificant despite a considerable import of fibreboard during the same period, as shown in Table 2. It should be pointed out that the total production capacity of the approximately 60 mills of the world was higher than the actual production. The utilization of the world production capacity was about 75%.

Table 1: Production of Fibreboard in Developing Countries

1971 in '000 tons

Region	Compressed	Non-compressed	Total
Latin America	159.0	53.2	212.2
Africa	1.5	1.0	2.5
Near East Africa	-	-	-
Near East Asia	68.0	2.0	70.0
Far East	138.9	1.8	140.7
Oceania	-	-	-
Developing countries	367.4	58.0	425.4
in %	86.4	13.6	100
World	6,072.8	2,319.3	8,392.1
in %	72	28	100

Developing countries are states classified following the FAO standard country classification according to the UN Standard Country Code, Statistical Papers, Series MNC.49, New York 1970. The criteria adapted for distinguishing between developed and developing countries used by the UN are based on the level of per capita gross domestic product.

Table 2: Imports of Fibreboard by Developing Countries in 1971

	Compressed		Non-compressed	
Region	1,000-T	US$1,000	1,000-T	US$1,000
Latin America	8.7	1,518	[illegible]	751
Africa	64.4	[illegible]	2.7	322
Near East Africa	2.3	409	-	-
Near East Asia	11.1	[illegible]	-	-
Far East	21.9	2,139	[illegible]	1,673
Oceania	5.8	[illegible]	0.3	31
Total	114.2	14,786	11.2	2,777
Total import	[illegible] ton		US$ 17,557	

1.2. Application

The use of hardboard has developed steadily, due to its low price and suitable physical and mechanical properties. This development is characterized by an increasing use for many purposes, such as in furniture, transportation, building and packaging.

For furniture hardboard can be used in carcass construction for backsides, tops, bottoms and doors in conjunction with light framing. However, it must be admitted that hardboard in wooden frame construction has recently been replaced for certain purposes by a thicker material such as particle or medium density board. Fibreboard is suitable in many instances for replacing plywood, which is more expensive, and for many purposes of superfluous strength. Fibreboard, when painted, is suitable as furniture, kitchen cabinets, etc.

In the building industry hardboard is widely used for built-in furniture and fittings. A considerable quantity is also used for renovations due to its low cost and rigidity.

Hardboard is also extensively used by the building industry in the construction of flush doors. These doors consist of a light wooden frame, filled with a honeycomb material, which is faced on both sides with 3.2mm hardboard.

Further possibilities for the use of hardboard in buildings could be for partitions, underlay for floors from plastic sheets and in the form of perforated boards as accoustic and decorative material for ceilings. Large quantities of hardboard are used for exhibitions and shop displays, particularly when manufactured perforated and with fire-retardant properties.

Oil tempered hardboard can be used further in concrete framework mainly for facings, where a smooth concrete surface is required. For prefabricated units hardboard can be used up to 50 times.

Under relatively severe Swedish climatic conditions, hardboard has been proved successful for external cladding. Also especially durable is the heat tempered board in external conditions if painted.

A relatively new, but important, field of application for hardboard is in agricultural buildings, e.g. hen houses, machine sheds and even roof covering. Other possibilities which exist are for external cladding for grain storage buildings and lining of the frame structure of doors and silos.

The Swedish Wallboard Association has prepared standard drawings for leisure time cottages, which can serve also as patterns for low-cost housing in developing countries.

Other diversified possibilities for using hardboard would be "do-it-yourself" building activities, as reported in a publication "Information for the Handyman" issued by FIDOR (Fibre Building Board Development Organization Limited, London).

Hardboard is used frequently for the manufacture of diverse types of transport equipment such as buses, railway rolling stock and ships, etc. Besides the finished standard boards, various types of improved products are generally manufactured. Hardboard mills are increasingly applying finishing processes for improving mechanical strength, moisture resistance, resistance to bio-deterioration and fire. There are also many possibilities to create decorative effects on the surface of the board. Some of these types are:

> Oil-tempered hardboard - impregnation of hardboard with a drying oil such as linseed oil and by exposing it in a heat treatment chamber to a temperature of about 160°C for 4 hours the board obtains a higher density and improved water resistance and strength.
>
> Colour treated board - by drying the whole pulp or by overlaying the fibre mat with a surface layer of pigmented pulp.
>
> Printed board with imitation of wood grain or other pattern.
>
> Board painted with lacquer or faced with decorative melamine paper or plastic sheet, etc
>
> Perforated board with holes for accoustic insulation.
>
> Moulded or embossed board with relief type surface of various patterns.
>
> Sandwichboard of hardboard in combination with various other board material and honeycomb core.

In many developing countries hardboards are used for manufacture of boxes and containers for the transport of fruits, vegetables and other materials in substitution for imported sawn wood or corrugated paper board.

1.3. General Outlook

It is well known that the developing of the production capacity of particle board is more dynamic than that of fibreboard. The reasons for this are partly lower investment costs, relatively lower production costs and as a result a suitable profitability even for smaller production units. The constant increase of prices for synthetic resins and other chemicals in recent times should, however, cause a certain change in favour of fibreboard production in the future. Particle board requires almost 3 - 4 times more resin than hardboard. Another advantage, especially for developing countries, is the viability of using hardwoods which are less suitable for particle board because of their high densities.

According to FAO studies and reports on board conferences since 1958, prices for fibreboard dropped gradually to an extent of about 25-30%, in contrast to, for example, sawnwood prices which tended to increase. At present a considerable rise in prices for chemical commodities can be observed as a consequence of the rise in petroleum prices. In the Arab Republic of Egypt, for example, the price of phenol-formaldehyde liquid resin increased since January 1974 from 166 to 230 £ sterling/ton, representing an increase of nearly 40%. For this reason hardboard may in the future gain certain advantages over particle board, which requires 3 or 4 times the quantity of resin as is used for fibreboard production.

Prices for equipment have been increased of course as well, but at equal rates for all types of board.

The further development of hardboard production and consumption depends on its ability to compete with other sheet materials. In developing countries fibreboard production requires a certain degree of industrialization and a sufficient number of skilled workers for the production and application of these boards.

New promising possibilities have been opened up by the industrial introduction of medium density boards, which are not a competitor of, but a very valuable supplementary product for, particle board and other boards of greater thickness and lower density.

2. DESCRIPTION OF MANUFACTURE

2.1. Raw Material

For a long time coniferous wood in the form of sawmill residues, pulp-wood and forest thinnings have been used exclusively in the fibreboard industry. This raw material made it possible to manufacture by the wet process all types of fibreboard, insulation, as well as hardboard without using any resin additives due to its sufficient fibre length. With increased consumption, particularly for the pulp and paper industry in many countries, coniferous wood became deficient as compared to hardwood which is widespread, especially in developing countries. Additionally, methods have been devised for manufacturing fibreboards of standard quality from short fibre hardwood.

For plants of small capacity one possibility was the batch process with preparing the hardwood chips by pressure digesting with caustic soda, quick de-watering in a deckle-box using vacuum and pressure and hot pressing of the highly plasticised and well de-watered fibre mat in a common multi-daylight hot press.

Another process which has found much favour was the improving of strength properties by using a small quantity (1-2%) of a binder, such as phenol-formaldehyde watersoluble resin or albumin. These modifications make it possible to use for the fibreboard manufacture not only different hardwood species but also a number of plant residues. Moreover, it has been proved that hardwood is advantageous in dry production methods.

The question of wood type is nowadays without problems. Small logs, thinnings as well as industrial residues from sawmills and other woodworking plants are suitable. New experiences were achieved with the rising practice of transporting the wood to the manufacturing plant in the form of chips and storing them outdoors in large piles. Problems of biodeterioration because of too long outdoor storage of the chips may, however, be considered under certain climatic conditions.

The question as to whether wood for fibreboard is to be debarked or not cannot be clearly answered. It depends on the wood species and the bark thickness. In the wet process a high bark content causes a dark colouring of the board and increases the water absorption. One exception, however, is pine bark, which is more water resistant due to its resin content.

In the case of the dry process, there is the possibility of removing most of the bark by pneumatic separation.

In countries with little or no forest resources, such as those in North Africa and the Near East, non-wood raw material can be used, such as straw, palm branches, reeds and similar local plants and plant residues. A suitable plant residue of similar importance is bagasse. In general, these boards manufactured from plant residues are of an inferior quality when compared with those made of wood.

2.2. Description of Individual Operations

The following operations are common to both wet and dry processes:

(i) Debarking

In cases where thick bark requires its elimination, mostly single log debarkers of the dry type VK or Cambio are used. This equipment is manufactured in different sizes according to the planned plant capacity.

(ii) Chipping

To reduce larger wood assortments such as small logs, offcuts, slabs, etc. chippers mostly of the vertical disc variety with 2 or more knives and capacities of up to and even beyond 100 cu. m. of chips per hour are used. For wood residues of different sizes the tendency is to have drum chippers installed, designed for maximum efficiency. The chip size from these machines is less uniform, but they allow for greater utilization of small wood pieces which are not suitable for disc chippers. By sieving the chips over a vibrating screen coarse wood particles and fines are rejected.

In smaller plants chips are stored in vertical bins with discharging equipment. Recently more and more chips are stored in open air piles. In the latter case attention is to be paid to losses caused by biological deterioration of the chips inside the pile. The degradation of the wood quality is more significant on chips from hardwoods than from coniferous species and is influenced by the storage time, depending on climatic conditions. In order to secure sufficient long life from the de-fibring discs, metal and other non-wood impurities should be eliminated. For smaller plants a magnetic separator may be sufficient, while for larger capacities - mainly if the chips are spoiled with mineral impurities - washing equipment with flotation effect is preferred.

(iii) Defibring

Defibring is carried out in attrition mills or by an explosion process. The latter requires high pressure steam and is less suitable for developing countries. Defibring by attrition mills is possible direct or after pre-treatment. Direct defibring such as in Bauer mills requires high energy consumption. Ground wood pulp used in the beginning of board production contains inevitable damaged and short fibres which slow the drainage and reduce the board strength.

Commonly applied are certain procedures of pre-treatments such as steaming the chips under pressure or mild chemical cooking with sodium hydroxide. Steaming is carried out in order to plasticize the middle lamella by which the fibres are bound together and hence facilitate the defibrisation at a lower level of power consumption. Such equipment are, eg. Asplund defibrators manufactured by the Swedish Defibrator Company or the RT mills of the Polish Cekop Company, or of the Voith Company in the Federal Republic of Germany, or the Swedish Krima moulator. This equipment is built in different sizes, ranging from 10 to 100 tons per day. Pressurized attrition mills with continuous steaming digesters are obtainable from the Bauer Company in the U.S.A.

When using the wet process, the following operations are carried out:

(i) The fibres are diluted with water and the fibre mass after screening is reduced in a refiner machine. The refiner used has a similar design as the defibrator but with closer distance of the attrition discs and with special shape for an intensive dividing of fibre bundles. Refiners of different types are built by the same companies as mentioned for defibrators. Recently the Sprout Waldron Company has also developed machines for fibreboard.

The fibre is prepared with different freeness characteristics according to the final product. For insulation board the freeness of the pulp is higher (16°S.R.) than for hardboard (8°-12°S.R.). For refining to higher freeness continuous working hollanders with basalt inlay are often used.

(ii) Additives are introduced to the refined fibre pulp for improving the properties of the final board. These are chemicals for sizing and improving the resistance to humidity (wax or resin emulsions), chemicals for improving the strength of the board (bonding materials like resins) and finally preservatives against biodeterioration (pentachlorphenol).

The wax or resin emulsion is usually prepared at the board plant itself in a relatively simple piece of equipment, having regard to the limited stability of those emulsions. For precipitation of the hydrophobic and bonding agents on the fibres, sulphuric acid or the more suitable aluminium sulphate is added to the pulp up to the extent of pH 4-4.5.

Chemicals reducing the combustibility of the board manufactured by the wet process are applied commonly on finished boards, e.g. as additives to the wetting water of the conditioning section or on the surface as intumescent paint.

(iii) The next production step consists of dewatering, or forming of the fibre mat. In the earlier times of board production the deckle-box method was used, which may be still of some interest to developing countries for small capacity plants or for certain kinds of pulp difficult to drain.

Due to its higher working speed continuous methods of forming are generally preferred, such as cylindrical drums of the Oliver type or mostly horizontal endless wire dewatering machines (Fourdrinier). These machines are built for hardboards in widths of 1220mm up to 2135mm. The uniformity of distribution of the fibres is secured by a headbox from which the pulp flows onto the wire and is drained by gravitation, suction and cold pressing. The formed endless mat of approximately 35% dry matter is then divided into board lengths of approx approximately 5,500mm. The mat speed is adjustable from 4 up to 20 m/min, depending on mat thickness. Dewatering machines are built by firms such as Karlstads Mekaniska Werkstad (KMW), Sweden, Czech., Poland, Voith, FRG and others.

(iv) Pressing: The fibre mat is transported on a caul with a wire mesh underlayer in a multiplaten, steam or hot water heated press, and pressed at a temperature of 190 - 230°C with a pressure of 50 - 55 kp/cm2 according to a fixed pressure time diagram. By quick closing of the press the majority of free water is squeezed out and the rest, after lowering the pressure, is dried to around 8%. The pressure is then again increased and the plasticized fibres compressed and bound together to the desired density. The underlayed wire mesh allows a good drainage of water and steam, but gives the characteristic screen back surface on the reverse side, the end product being known as S-1-S board. Hot presses are built by several companies in Europe, USA and Japan.

(v) If boards are manufactured without resin glues, which is common in the case of longfibre coniferous wood, the boards after pressing are subjected to heat treatment for improving the strength and resistance to humidity. This exercise is carried out in chambers with circulating hot air of 160 - 170°C for about 6 hours. By heat treatment the boards are dried almost bone-dry and must be conditioned to a humidity equilibrium of 5 - 8% to avoid warping and buckling during its application. This operation is carried out either in conditioning chambers with air of high relative humidity during several hours or continuously by humidification rolls according to the "Masonite" method. The conditioning boards are then trimmed to the correct dimensions, using saws with hard metal teeth. Before shipping a surface finishing is sometimes applied.

Non-pressed insulation boards are dried in a continuous multi-daylight dryer of the Svenska Fläktfabriken type with hot circulating air.

Manufacture according to the dry process is in the first steps identical to the wet method. Hardwood species are principally used as raw material. Hydrophobic wax in melted form is added together with the chips into the defibrator. If phenol-formaldehyde resin is used, the addition of the solution is carried out through the hollow shaft of the defibrator. The fibre received from the defibrator is dried, either in flash or nozzle dryers to a moisture content of [illegible]%, then pneumatically classified from coarse fibre bundles and bark particles. The drying medium is flue gas from oil burners combined with burner dust. Types of dryers being used for this purpose are Kennedy[illegible], Buettner, Schilde, etc.

The fibre mass is refined in disc refiners such as those made by Defibrator, Bauer, Sprout Waldron, etc. Quick-setting resin binders are added to the fibres in separate blenders which are developed by diverse machine producers like the Bauer double disc blender, Loedige [illegible] glue blender, etc.

The fibre mat is formed by air felting devices distributing the dried and glued fibres from air suspension on a transport wire belt, whereby the mat is often densified by the application of vacuum. Dry felters are built in different types by such firms as Washington Iron Works, Schenck, etc.

The airfelted mat is very loose and is continuously pre-compressed by a [illegible] pre-press. Hot pressing is carried out in multi-[illegible] presses with higher specific pressure than for the wet process (60-[illegible] kp/cm²) and with platens for simultaneous closing.

Due to the low moisture content of the mat, the pressing time is shorter although the capacity of the press is at the same press temperature in contrast to the wet method, where the time is more than doubled. [illegible] is not necessary and the resulting board is smooth on both sides (S-2-S).

<u>Medium Density Fibreboard (MDF)</u>

A relatively recent product of the fibreboard industry is the MDB. This board is in fact more a fibre-type particle board and enjoys a [illegible] position on the [illegible] market. MDF has a thickness similar to common particle board, e.g. 12-30mm, but is more homogeneous, having good uniformity, tight edges and good dimensional stability. MDB has a relatively low density and contains mechanical and physical properties like particle board of the same thickness.

MDF from oak and mixed hardwood chips with 8% urea-formaldehyde resin and 1% wax indicates the following properties:

		[illegible]	Mixed Hardwood
Density	g/cm^3	[illegible]	0.648
Thickness	mm	[illegible]	20.3
Bending strength	kp/cm^2	[illegible]	287.0
Modulus of elasticity	kp/cm	[illegible]	25.200
Internal bond	kp/cm^2	[illegible]	7.7
Swelling /24 hrs.	%	[illegible]	3.1
Water absorption/ 24 hours	%	[illegible]	17.5
Linear expansion	%	0.17	0.18

Based on experience in North America, as reported at the Fourth Particleboard Symposium of the Washington State University, Pullman in 1970, the manufacturing process of MDB has the following characteristics:

(i) Raw materials are hardwood or softwood pulp logs, chips shavings and even sawdust. Important is the possibility of using mixed hardwoods. Vegetable fibres, such as bagasse, are suitable as well. The moisture content of the wood is not decisive. Hardwood bark has no influence on board properties to an extent of 5%. Higher content reduces strength. Softwood should be debarked.

(ii) Fibre preparation: Chips of uniform size are steamed in a digester for about 5 minutes at steam pressures of 7-10.5 kp/cm2, depending on species. The softened chips pass directly from the digester to a pressurised attrition mill (Bauer 418) and from this mill the fibre is blown into the dryer. The freeness of the fibre should not be as fine as needed for hardboard.

(iii) Drying of the fibre is carried out in a direct-fired flash or tube dryer, such as the 'Kenneburg' type, to a moisture content of 6-7%. The flue gas temperature in the dryer is approximately 300°C.

(iv) Blending of resin and additives: Fibre has a very low bulk density of about 10-20 kg/m3. For this reason the blending with resin in the usual blenders for wood particles is unsatisfactory, because fibre tends to form balls which prevent uniform distribution of resin and a proper felting. Therefore the resin is sprayed into a stream of fibre and then the fibre is passed through an attrition mill (e.g. Sprout Waldron single disc type). Another possibility is to feed the resin through the hollow shaft of a blender (e.g. Bauer 440 double disc blender). This is the procedure in the case of using heat sensitive resin such as urea-formaldehyde or melamine. Phenolic resin can be added to the chips in the digester.

(v) Felting is carried out continuously by a four-head vacuum former of the Washington Iron Works type.

FIGURE 1

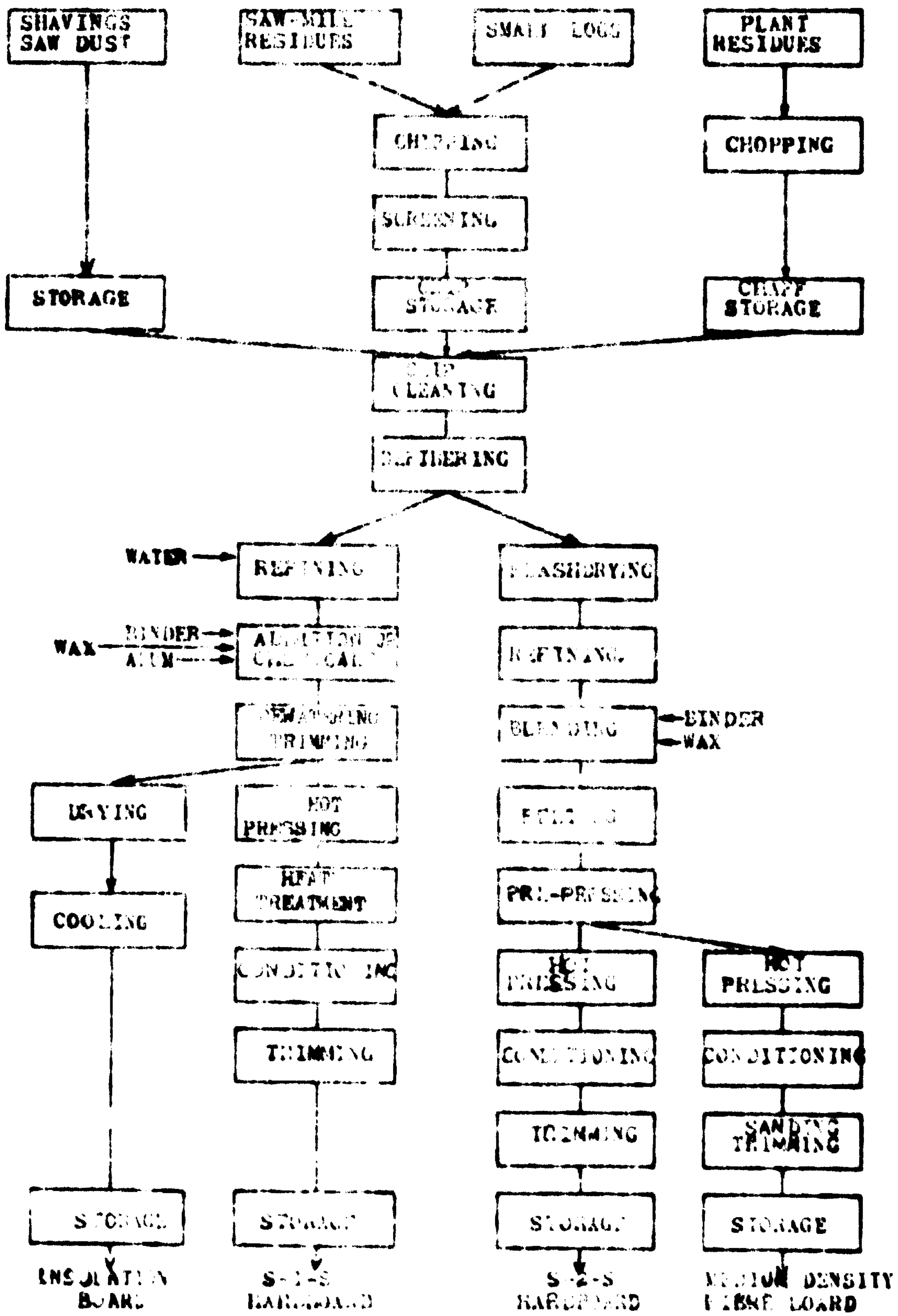


DIAGRAM OF PROCESSES FOR MANUFACTURING FIBRE BOARD IN WET AND DRY METHOD

Table 3: Basic Properties of Fibreboard

Item	Unit	Insulation Board	Medium Density Board	Hardboard	Superhard Board
Density	kg/m^3	450	450 - 850	850 - 1100	1100
Humidity	%	6-10	6 - 10	6 - 8	5 - 8
Water Absorption 24 hrs.	%	60	50	30	20
Swelling 24 hrs.	%	10	20	20	10
Bending Strength	kp/cm^2	30	150	400	500
Internal Bond Strength	kp/cm^2		[illegible]	6	
Modulus of Elasticity	kp/cm^2	3.000	15.000	30.000	50.000
Hardness	kp/mm^2		5	10	15
Thermal Conducivity	kcal/ m,h,deg	0.04	0.06	0.08-0.15	

(vi) Pre-pressing is necessary to reduce the thickness of the loose mat of from about 2[illegible]mm to [illegible]mm. A pre-pressed mat allows trimming and safer transport of the mat to the hot press by the caulless system and reduces the size of board edge trim.

(vii) Hot pressing: For MDB pressing, conventional equipment is used with simultaneous closing of the platens and a caul-less system. In a US factory (Deposit plant of the Celotex Corporation, New York) a radio-frequency curing system (Thermex) is used in connection with a four-opening press (which was produced by Washington Iron Works) of the board size 1500 x [illegible]400mm. Contrasted with the press cycle for 19mm board glued with urea-formaldehyde resin by common hot pressing of 8 minutes, in combination with radio-frequency, the curing time is reduced to 100 seconds. For phenolic resins the curing time is about 50% longer, but higher temperatures up to 180-200°C can be used and heating time substantially shortened.

The high frequency generator used has an input of 600 kW and a frequency of 10 megacycles.

Pressed boards are stored and sanded on both sides with a wide belt sander (e.g. Smithway). Finally the boards are trimmed and stored for shipment.

Basic figures characterizing the property and the production flow sheet of various types of fibreboard are shown in Table 3 and Figure 1

Continuous Hardboard Production

Though the continuous manufacture of particle board has been known and used over the past [illegible] years (Okal and Bartrev systems), fibreboard production has up to now been only in multi-daylight presses with intermittent stroke pressing. According to a recent publication of World Wood, 19[illegible], No.3, Washington Iron Works, Seattle, U.S.A. has in construction a continuous belt press for the production of endless fibre hardboard with vacuum felters, pre-heating and all necessary control equipment. The new production line is destined for hardboards of [illegible] up to [illegible].5mm thickness. At a standard thickness of 3.2mm and width of [illegible]mm, the daily production can reach 100 tons and at a width of 2400mm production can be [illegible]0 tons. More realistic data may be obtained after studying the initial output of the first full capacity plant, which is expected to be in production some time in 1976.

3. SELECTION OF PROCESSES

Among the various types of fibreboard mentioned above, hardboards are, from the standpoint of broad applicability for developing countries, of highest importance. The worldwide production of insulation board indicates a downward trend and its manufacture can be recommended only if a detailed feasibility study promises a sufficient market.

MDB is a totally new approach and it can in many cases be applied more favourably than hardboard or particle board. This type, however, requires units of higher capacity in order to guarantee acceptable prices and corresponding profits. According to American experience, units with a minimum of 300 tons per day are profitable, a capacity which is really not applicable to a country with limited markets.

For the production of hardboard 2 basic processes are viable, as shown before: a wet and a dry method.

In countries with limited water resources the dry method offers certain possibilities for the manufacture of fibreboard. The dry method undoubtedly has some notable advantages, such as:

- the elimination of the expensive purification of effluents
- a shorter press cycle and in consequence a better utilization of the hot press
- the possibility to manufacture boards smooth on both sides
- the manufacture of multi layer board

On the other hand this process has several disadvantages from the point of view of developing countries, for example:

- plants with capacity less than 300 tons per day are not economical
- the investment costs are higher than for a wet process of the same output
- the production costs for lower capacity are higher while the consumption of resin increases
- special attention must be paid to fire and explosion hazards

All equipment generating dust has to be closed tightly to prevent escape of dust and its distribution throughout the plant. Foreign materials such as metal, rock and sand must be eliminated by detectors, screening and rock traps. Overheating of rotating machines and conveyors must be prevented. It is necessary to install tools for quick detection of fires as well as to improve the safety against explosion.

The production technology is more sensitive and requires a higher technical level from operational staff.

If the water availability is not critical and the estimated demand lower than 100 tons per day, a decision in favour of the wet process would be indicated. The wet process utilizes machinery which has been well proved during many years of service, is simpler to operate, besides being easier for the staff to understand as to its overall functions. By extreme closing of water recirculation, the water consumption can be held to reasonable limits.

Concerning the choice of suitable capacity for a hardboard plant, reference is made to a 1968 paper of G. Gran of the Defibrator Company, wherein figures show costs for wet and dry felted hardboard, depending on various unit sizes. In Figure 2 machine costs are shown, in Figure 3 building costs and in Figure 4 production costs, including capital costs, depreciation, interests, etc. The costs are shown in Swedish currency and are more valid for developed countries, but may also serve as a basis for comparison for developing countries.

According to these Figures, the wet process seems to be more advantageous in units with one press than the dry process. The production output is, however, limited to 150 tons per day, but it seems to be evident that a higher output will hardly be required at present in the most developing countries.

In spite of the quick growth of population the market in the majority of developing countries is rather limited - excluding some oil producing countries - due to the modest level of industrialization and the low income per capita. The development of hardboard production should advance, therefore, only gradually and on the basis of detailed market studies. The aim of most developing countries should therefore be to purchase units as small as possible but which guarantee a sound economy. For wet felted hardboard a 50-70 ton per day unit seems to be a suitable minimum. For such a plant capacity a detailed analysis is shown in Appendix 1, which may serve as a model for further consideration.

Concerning the detailed procedure for selecting and purchasing new equipment, attention should be paid to the paper by A. Travnik entitled "General Selection Guidelines for Woodworking Machinery" (ID/WG.151/6) presented at the UNIDO Technical Meeting of November 1973.

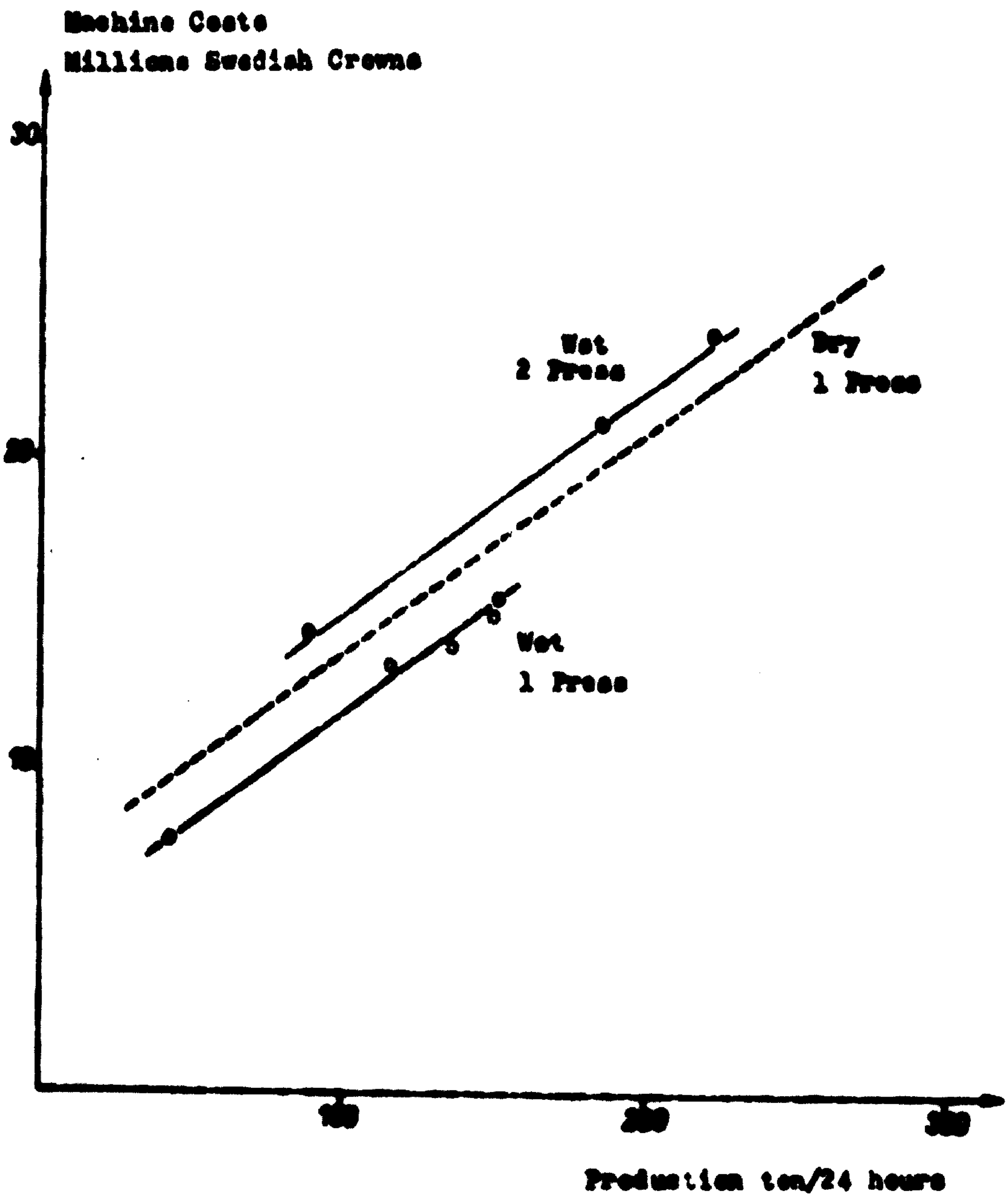


Figure No. 2. Machine Costs of 3,2 mm Hardboard by Wet and Dry Process

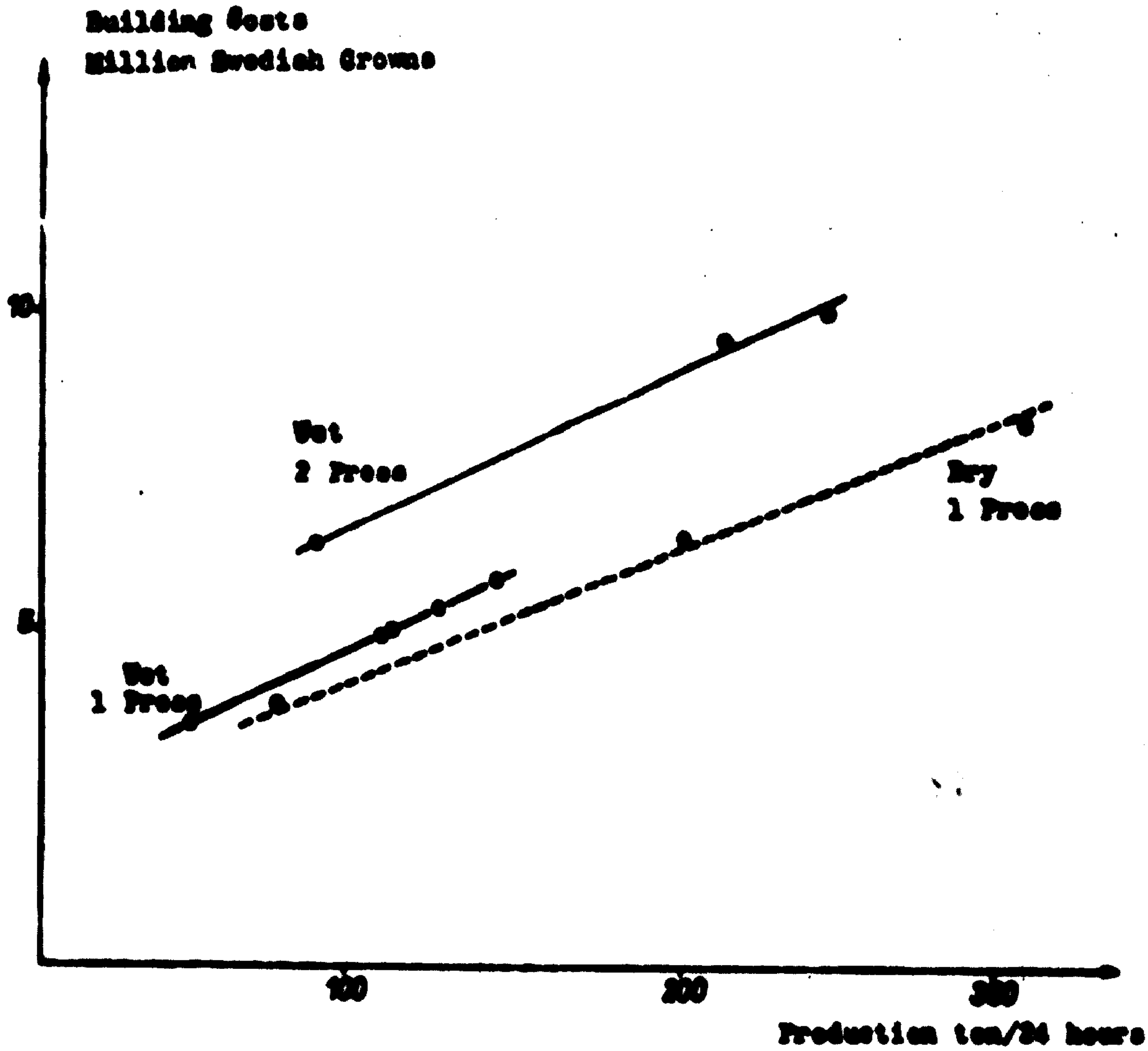


Figure No. 3. Building Costs of 3,2 mm Hardboard by Wet and Dry Processes.

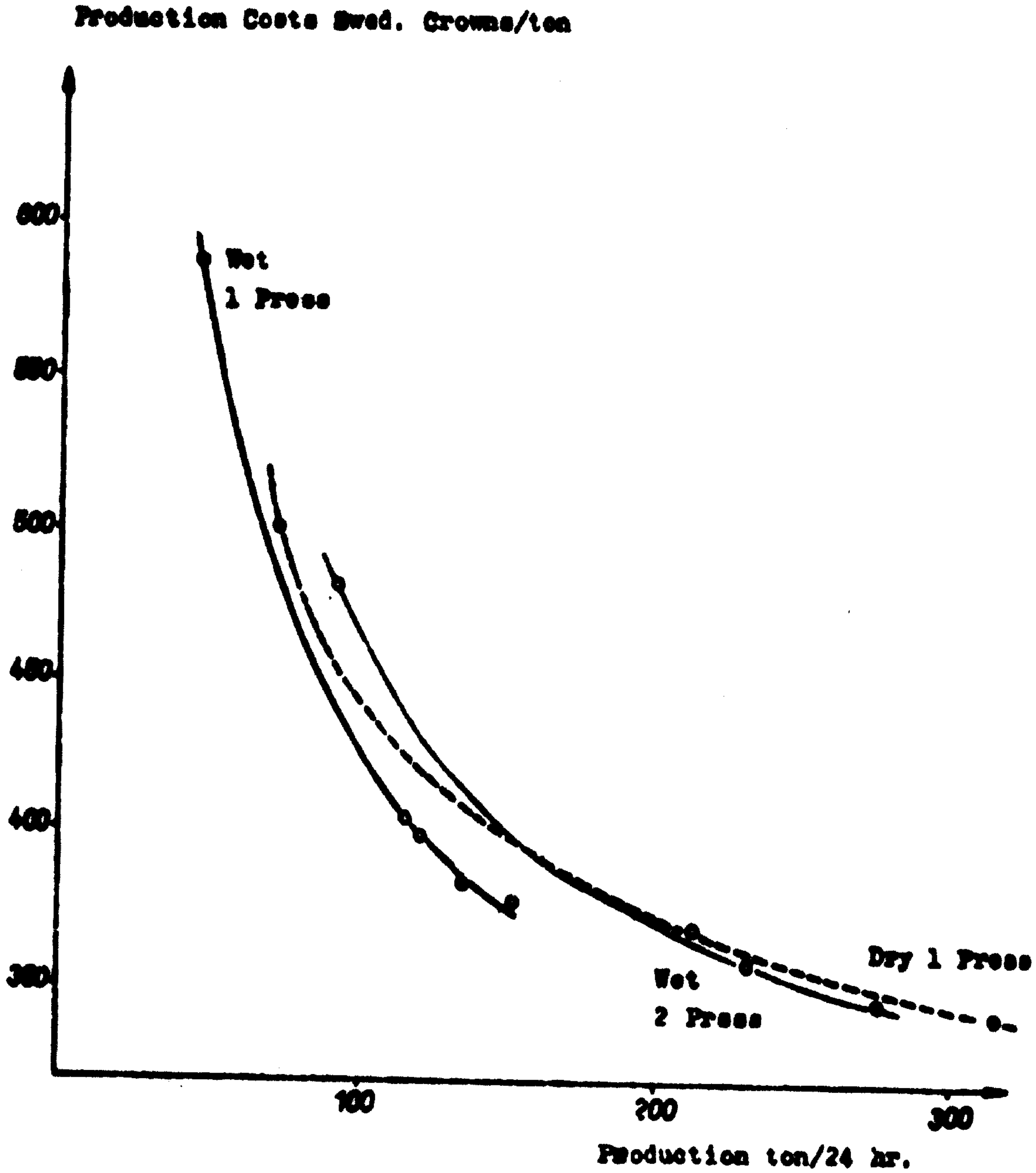


Figure No. 4. Production Costs of 3,2 mm Hardboard by Wet and Dry Process.

APPENDIX 1

ANALYSIS OF A MODEL FOR A HARDBOARD FACTORY OF 20,000 TONS PER YEAR PRODUCTION

Production days:

280 per year averaging 22 working hours

Daily production:

71.4 tons or 22.319 m^2

Size of hardboard:

1220 x 5500 x 3.2 mm

Quality:

corresponding to world standards - BS 42-1961, DIN-68750

Technology:

wet process

Raw material:

hardwood-small logs or sawmill residues

Assumption of region and year:

Near East; derived from price offers of 1970

1. Basic Equipment

a) Preparation of chips

2 Disc Chippers - type KMW
1 Screen - type KMW
1 Chipwashing equipment - type Defibrator

b) Defibring and sizing

1 Defibrator LVPB 2 - type Defibrator
1 Refiner - Asplund ROP
Sizing plant with melting, emulgating and storage tanks

c) Wet board forming

1 Endless wire machine - type Söderhamn or KMW, with suction and press section, sheet cutter

d) Hot pressing

1 20-daylight hydraulic press with feeding and discharging device, complete with surface and transport cauls, wire screens, grinding and polishing machine, for trimmed board size 1220mm x 5500mm

e) **Finishing**

3 Heat treatment chambers - type Svenska Fläktfabriken
with 12 transport wagons
3 Conditioning chambers
1 Trimming Equipment

2. **Sundry Equipment**

a) Steam boiler for 10t steam/hr.
30 atm pressure, oil firing

b) Hot water plant for 30 m^3/25 atm

c) Electrical equipment

d) Control equipment. Instrumentation

e) Piping and fittings

f) Repair shop

g) Board crating: lift truck

h) Oil impregnator for 15t/24 hr.

i) Fire protection equipment

j) Treatment of effluents

k) Control laboratory

Weight of the machinery: approximately 900 tons

Total input: approximately 4,000 kW

3. **Consumption Figures for 1 tons of Board**

Item	Unit	Quantity per 1 ton	Price - US$ per unit	Price - US$ per 1 ton
Materials:				
Wood - hardwood	m^3	2	5.45	10.90
Chemicals and additives:				
Phenol resin - solid	kg	20	0.311	6.22
Paraffin	kg	10	0.146	1.46
Oleic acid	kg	0.9	0.224	2.01
Liq. ammonia	kg	0.5	0.02	0.10
Alum	kg	10.0	0.6	10.31
Operating Expenses:				
Electricity	kWh	900	0.017	15.80
Fuel (Masut)	t	0.05	200.0	10.05
Water	m^3	10.0	0.005	0.05
Spares and maintenance, est.				9.50
Staff labour, est. 120 workers	man hours	12	0.98	11.76

4. Administrative Staff

	No.	Monthly Salary -US$	Total - US$
General Manager	1	1,000	1,000
Engineer	1	500	500
Chemist	1	500	500
Sales Manager	1	400	400
Accountant	1	400	400
Bookkeeper	2	300	600
Laboratory Assistant	1	300	300
Clerk	5	200	1,000
Storekeeper	1	200	200
Secretary	1	150	150
Telephone Operator	1	100	100
Truck driver	4	100	400
Security	12	70	840
			6,390 x 12
			1,278
			76,680

5. Supervisory Staff and Labour

Supervisor	3	400	1,200
Foreman	4	300	1,200
Highly Skilled	25	200	5,000
Skilled	48	150	7,200
Semi-skilled	15	100	1,500
Unskilled	25	70	1,750
			17,850 x 12
			214,200
Welfare fund 10%			21,420

6. **Fixed Capital Investments**

	US$	
Land: 140,000 m^2 at US$ 0.03	4,200	
Site improvements and roads - estimated	30,000	34,200
Buildings and Civil Works:		
Factory buildings US$ 60/m^2, 6,000 m^2	360,000	
Administrative offices - 300 m^2	18,000	
Staff quarters - estimated	200,000	
Excavations - estimated	15,000	
Foundations	150,000	
Water basin and cooling pond	25,000	
Water towers	50,000	
Stores	90,000	
Sewage disposal	15,000	
Silos, oil tanks, piping	25,000	
Electric illumination and fittings	-	
Materials handling	150,000	
Fire protection	30,000	
Heating and cooling	30,000	1,158,000
Furniture, Fittings, Equipment: (offices, stores, changing rooms)	30,000	30,000
Trucks and Transport Means	50,000	50,000
Machinery and Spares:		
C and F costs to harbour	2,800,000	
Marine Insurance - 1¼%	34,000	
2 years spare parts	450,000	3,284,000
Handling and Transport to Site	10,000	10,000
Designs, Drawings, Know-how:		
Suppliers' fees	150,000	
Local consultants' fees at 7% total civil costs	80,000	230,000
		4,796,200

.../...

Erection:		
Suppliers' fees, staff costs	60,000	
Passages, living costs, etc.	50,000	
Local costs: materials and labour	500,000	610,000
Start-up and Commissioning:		
Suppliers' fees, etc.	50,000	
1 month expenses	50,000	100,00
Training of Plant Staff	50,000	50,000
Production Expenses	150,000	150,000
Contingencies 10% of above	570,000	570,000
TOTAL FIXED CAPITAL		6,276,000

7. **Production Costs of Hardboard**

Item	Costs US$ per year	Share %	Costs per ton - US$
Wood	218,000	10.7	10.90
Chemicals and Additives	206,200	10.1	10.31
Electricity	316,000	15.5	15.80
Fuel, Steam and Water	201,000	9.9	10.10
Spares and Maintenance	190,000	9.4	9.50
Staff and Labour	235,620	11.5	11.78
Administration - Overhead	84,350	4.2	4.21
Depreciation	398,140	19.8	19.90
Others (including Contingencies)	189,750	8.9	19.48
TOTAL	2,039.060	100.0	101.98

8. <u>Annual Working Expenses</u>

			[illegible]
(1)	Wood		218,000
(2)	Chemicals		206,200
(3)	Electricity		316,000
(4)	Fuel		200,000
(5)	Water		1,000
(6)	Administrative Staff		76,680
(7)	Provident Fund - 10%		7,670
(8)	Supervisory Staff and Labour		214,200
(9)	Welfare Fund - 10%		21,420
(10)	Spares		170,000
(11)	Maintenance - Material		20,000
(12)	Depreciation		
	Machinery - 10%	345,000	
	Civil Works - 3%	41,640	
	Furniture, Fittings - 5%	1,500	
	Vehicles - 20%	10,000	398,140
(13)	Insurance on Fixed Capital Items 0.08% items 2,3,5-10		4,390
(14)	Contingencies - 10% of 1,853,700		185,370
	TOTAL		2,039,060

9. <u>Total Capital Needed</u>

Fixed capital	6,276,000
Working expenses (3 months of total)	509,000
TOTAL CAPITAL INVESTMENTS	6,785,000

10. <u>Unit Costs of Production</u>

	tons		US$
Gross output per year	20,000		
Rejects - 3% per year	600		
Net output per year in sq. m 6,052,000	19,400	at US$ 146	2,832,000
Production costs per year			2,039,000
Gross profit			793,000
Percentage of total capital investment			11.7%

Unit costs:

per ton net (rounded)	105
per square meter	.34

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